Legco
For the attention of all Honorable Members of Legco 18th April 2014

Dear Hon Legco Members,

Clear the Air has recently addressed both the Panel on Environmental Affairs and the Public Works Subcommittee on matters of considerable importance regarding the Government's intended plan to extend landfills and to build a mega incinerator, that might become operational 8 years hence.

It appears that one political party is obstinately ignoring scientific and other highly relevant data provided to them and is blinkerdly supporting the Government position en masse without considering the health and environmental ramifications of such a decision, when other sensible and environmentally sound options are readily available. We urge those dissenting legislators to vote with their conscience and integrity, based on fact ,and remember their oath of office and duty of care to Hong Kong people.

Accordingly I am copying you relevant correspondence provided to those Panel members to date.
I also provide herewith self-explanatory correspondence with Dr Tim Evans PhD, who since 1994 & current to this date is the Chairman of the Wastewater Management Panel of CIWEM UK.
*(The Chartered Institution of Water and Environmental Management (CIWEM) is the leading professional body for the people who plan, protect and care for the environment and its resources, providing educational opportunities, **independent information** to the public and **advice to government**. Members in 98 countries, including Hong Kong, are scientists, engineers, ecologists and students.)*

As can be seen in the correspondence, CIWEM international worldwide policy position statement (of course including Hong Kong) supports and recommends the use of food waste disposers / diverters and use of the sewage system for the handling of food waste.

Dr Evans's impressive CV demonstrating his considerable expertise is attached for Hon Members' reference.

Instead of condemning Hong Kong to a hasty, misinformed, irretrievable damage to the environment and toxic future that will pollute our air, kill our children, add a million tonnes of CO_2 into the atmosphere per annum and rely on ever increasing landfills and expensive man-made islands in the sea for toxic ash dumping, Legco needs to compel Government to instigate an independent study on the proven viability of removing 40+ % of our daily domestic MSW (food waste) from the waste stream, using CIWEM's worldwide recommended modus operandi.

The proposed scheme using domestic and industrial Green Bin collections / transfer station garburators / sewage system transport and disposal is endorsed by the world experts at CIWEM UK and 98 worldwide branches and is their worldwide policy (even for their Hong Kong Branch) to endorse the use of food waste diverters and the existing sewage system to easily handle the food waste, instead of trying to burn it.

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Of course this CIWEM policy adoption would then leave dry recyclable products in the waste stream to create new recycling industries and employment here. Is this not common sense and fulfilling Legislators' duty of care to the people of Hong Kong under their Oath of Office ?

What should be happening by priority:

1 Source separation of waste legislation
2 Recyclables' source separation legislation
3 Green bin collection scheme provided by Government territory-wide for separated food waste and yard waste Transported to transfer stations and industrially garburated, the resultant ultra-wet puree poured into the sewage system for disposal. The daily 3,400 cubic meters food waste amount is inconsequential to the system's 2.7 million cubic meters daily waste water load capability at Stonecutters plant alone by 2016.
4 Recyclables' collection scheme provided by Government territory-wide Grants to form new recycling industries and gainful employment - Green Tseung Kwan O and Tuen Mun instead of toxic dumps
5 Waste charging legislation only after the above measures are in place
6 Plasma plants sited alongside current landfills to reverse mine the landfills and destroy unusable construction waste converting it into usable inert Plasmarok road aggregate – can also handle hazardous waste, carcasses, bird flu virus using plasma arc torch destruction at the temperature of the sun
7 Consider carbon neutral Solena type production of bio fuels using remaining non-recyclable MSW as the feedstock (see link below)

http://www.waste-management-world.com/articles/2014/04/video-ba-plasma-gasification-waste-to-jet-fuel-facility-set-for-take-off-in-essex.html

This common sense course of action means there is no need to extend landfills nor for a cancer causing / CO_2 emitting toxic incinerator which the IPCC's most recent report has lambasted as being twice as polluting and environmentally destructive than a coal fired power station.

Kind Regards,

James Middleton

Chairman
Clear the Air NGO

Bio of Dr Tim Evans PhD (for Members' ease of reference)
1994 – present Chartered Institution of Water & Environmental Management www.ciwem.org
Chairman of the Wastewater Management Panel.
http://www.ciwem.org/policy-and-international/policy-position-statements/food-waste-disposers.aspx

Qualifications and professional institutions
University of Newcastle upon Tyne, UK B.Sc.(Hons) 2:1 Soil Science (B.Sc.Chemistry)
University of Wisconsin, Madison, USA M.S. Soil Science
University of Newcastle upon Tyne Ph.D. Soil Science
Chartered Chemist
Chartered Environmentalist

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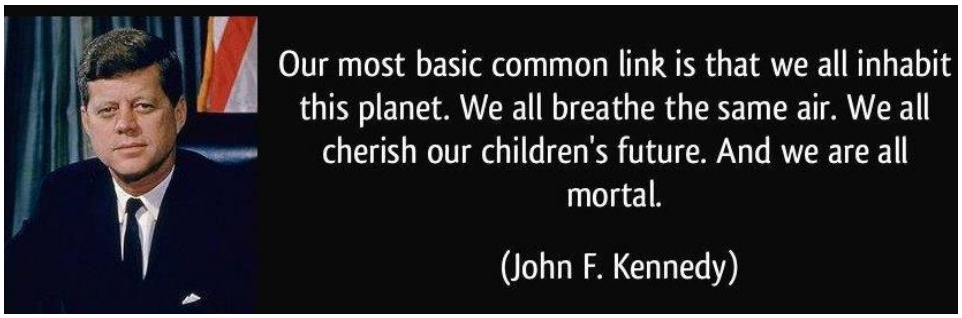
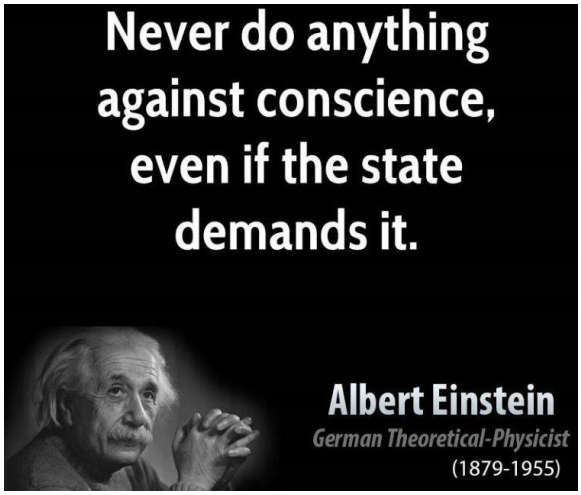
Chartered Water and Environmental Manager
Fellow of the Chemical Society
Fellow of the Chartered Institution of Water & Environmental Management
Member of the British Society of Soil Science
Member of the American Society of Soil Science
Member of the American Society of Agronomy
Member of the Royal Institute of Chemistry
Member of the International Fertiliser Society
Member of the Society of Chemical Industry
Member of the Water Environment Federation (Editorial Advisory Board, Biosolids Technical Bulletin)
Member of the International Water Association
Fertiliser Advisers' Certification & Training Scheme
Competent Person (for managing composting plants)
Member of the Select Society of Sanitary Sludge Shovellers
Member of the Sustainable Organic Resources Partnership





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From: Tim Evans
Sent: 17 April, 2014 02:04 AM
To:
Cc: 'Alastair Chisholm'; 'Laura Grant'
Subject: RE: Inquiry on FWDs

Dear James,

I have read "Some Food For Thought" **and agree with the analysis**. It is a good report. There are some additional points:

- **Ground food waste would increase the carbon content of the wastewater relative to the content of nitrogen and phosphorus, which would assist treatment of the wastewater**. As the report notes, treatment starts in the sewers so the composition of the wastewater that arrives at a wastewater treatment works (WwTW) is different from the composition of the wastewater that was discharged into the sewer. **Treatment of normal wastewater (without ground food waste) is carbon limited.**
- I do not know what would happen to Styrofoam in a food waste disposer (FWD). Plastic film just balls up in the grind chamber, maybe Styrofoam would do the same thing. Particles cannot leave a grind chamber until they are small enough to pass through the exit holes; I suspect that Styrofoam would not grind; I'll have to try it! If it does grind, there would be no benefit of additional screens at WwTW because the particles would be too small (2mm or less).
- Trials of FWDs (it would be helpful if they were called diverters rather than disposers) have found participation rates in excess of 80%, even 96%, which is much greater than rates for source-separated solid waste, which people tell me seldom reach 80% in the UK even for separate houses and much less in high-rise buildings.

Regarding the Environment Bureau's report "A FOOD WASTE & YARD WASTE PLAN FOR HONG KONG 2014-2022", it is of course obvious that we need to reduce over-buying of food by education and by discouraging discounts for multi-buys of perishable foods, but as the report notes, even when this has been accomplished, some food waste is inevitable – stalks, peelings, damaged parts, etc. One solution will not fit all situations. Some enthusiasts will use on-site treatments like Bokashi but they are likely to be a tiny minority. Some people will store their food waste and take it to separate collection bins but experience has shown the participation rates plateau at less than 80% even in separate houses and it plateaus at a much lower percentage in apartment buildings.

We think of Germany as being exemplary in biowaste management but a report (attached) by the German Ministry for the Environment, Nature Conservation and Nuclear Safety and the Federal Environment Agency in 2012 concluded "more than half the people in the country [Germany], do not use a bio-waste bin." So even German citizens would benefit from having a choice of solutions.

The Plan for Hong Kong says correctly "The journey will not be easy because success depends on public acceptance and large-scale community mobilization to participate in waste separation." The annex Evaluation of Food Waste Treatment Methods says *"Grinding up food waste and disposing of it via the sewerage system: it would have adverse impact on the sewers and sewage treatment works. Large scale practical experience especially for multi-storey buildings is lacking and inconclusive internationally. Some cities have banned such practice"*, **this is incorrect**. Jonathan Mattsson has conducted extensive CCTV analysis of the sewer system where 50% of households use FWD (papers attached). He surveyed about

140 lengths of sewer totalling more than 10 km at times of low wastewater flow and concluded that none of the deposits observed was of operational significance, that the scoring of the deposits was not correlated with the intensity of upstream installation of FWD and neither was sewer corrosion**. My own research into the impacts at sewage treatment works shows that FWD have no detrimental effect and probably have an overall beneficial effect on nutrient removal:**
Evans, T.D.: Andersson, P.: Wievegg, A.: Carlsson, I. (2010) *Surahammar – a case study of the impacts of installing food waste disposers in fifty percent of households*. Water Environ. J. **241** 309-319
Evans T.D. (2012) *Domestic food waste* -*the carbon and financial costs of the options*. Municipal Engineer. Proc. I.C.E. **165** 3-10

The data in Moisture%HKfoodwaste.pdf confirm that the C:N ratio is about 25:1 and would thus relieve the carbon limitation of treating sewage which is normally only 5:1 in the absence of ground food waste or a carbon-rich trade waste. 70% moisture and 90% organic matter is quite typical for food wastes.

Neither CIWEM's Wastewater Management Panel nor its Waste Management Panel, which reviewed the FWD PPS, have seen any reason to change the conclusions of the PPS. The PPS was a consensus document with no dissenters. It could be updated in the light of research published since it was produced (such as that reported here) but that would not change the conclusions;

- FWD give citizens a choice of how they can divert food waste from landfill, they are convenient and hygienic and because of this the satisfaction rate is high
- FWD enhance the yield of dry recyclables (glass, plastic, paper and metal) and/or the calorific value of residual waste
- FWD do not affect sewers adversely
- FWD do not increase the cost of wastewater treatment or affect WwTW adversely
- Where sludge is treated by anaerobic digestion, FWD increase the yield of biogas

I hope this is useful; if you think I can be of further assistance, please let me know**. I am Chairman of the Wastewater Management Panel** but have not had the opportunity to discuss this with the Panel so cannot speak for its members.

Regards

Tim

Dr Tim Evans
TIM EVANS ENVIRONMENT
Stonecroft, Park Lane, Ashtead, Surrey, KT21 1EU, UK

From: Laura Grant
Sent: 26 March 2014 16:33
To:
Cc: Alastair Chisholm
Subject: Inquiry on FWDs

Hi Tim,
We've had an inquiry on food waste disposers. I'm not sure if you will be able to comment on the specific etc but it looks as though they want us to endorse their suggestion for implementing FWDs in Hong Kong to what must be their environment dept.

Is this something you would be able to help with at all?

Thanks
Laura

Laura Grant BSc MSc MCIWEM
Policy Adviser, CIWEM

From: Dr. Simon Festing
Sent: 26 March 2014 09:53
To: Laura Grant
Subject: FW: Legislative Council Panel on Environmental Affairs: Special meeting on 22 March 2014 Shek Kwu Chau Incinerator

Laura – with attachments. Simon

Dr Simon Festing
Chief Executive, CIWEM

From: James Middleton
Sent: 26 March 2014 06:32
To: Dr. Simon Festing
Subject: Legislative Council Panel on Environmental Affairs: Special meeting on 22 March 2014 Shek Kwu Chau Incinerator

Dear Dr Festing, 26/3/2014

We are an NGO Charity in Hong Kong run by volunteers.
Our website is www.cleartheair.org.hk

We have read and totally agree with CIWEM's policy statement on the use of food disposers for the treatment of food waste. See our report 'Some Food for Thought' attached.
Our adviser is a technical director /engineer from a locally based international engineering and environmental consultancy, who is completely in agreement with CIWEM's stance.
I attach self-explanatory information for you showing how Hong Kong Government thinks that use of the sewerage system is not appropriate for Hong Kong.
40% of daily household domestic waste is food waste.

The food waste moisture content is 90% for local wet market food waste and 78% for Mall food waste (Government data) versus only 30% water content in Europe.

Hong Kong has many high (30 storey +) rise buildings and estates rather than houses; the Government's position is that if every household had a sink disposer the building drains might get clogged.
We consider this would not happen, would immediately remove 40% of daily load on our landfills and necessary trucking etc.
Our counter to this Government point is that there is currently no Green Bin collection system here which should be instigated asap.
Food waste from estates, houses and rural houses could be deposited in Green Bins , collected by Government and delivered to transfer stations where industrial garburators would puree the ultra wet food waste that would be then fed into the existing sewerage system.

There are 11 waste water treatment plants in Hong Kong and an existing massive sewerage system (Hong Kong always overbuilds everything) . The largest CEPT tanks operation is at Stonecutters island which has 75% of HKG's waste water capacity.

By 2016 the capacity of Stonecutters waste water reception will be a maximum 2.75 million cubic meters per day. The current daily top load of Stonecutters is only 1.3 million cubic meters per day.
Our point being that adding 3,500 cubic meters (Hong Kong's current daily food waste amount) of ultra wet pureed food waste to the system would be inconsequential and our consultant agrees.

Can you see any drawbacks to our suggestion which is in line with CIWEM policy position ?

Kind regards,
James Middleton
Chairman
www.cleartheair.org.hk

About the writer / expert:

TIM EVANS ENVIRONMENT **Services**

Description http://timevansenvironment.com/

TIM EVANS ENVIRONMENT is independent. It is not linked to any particular technology and although it does work for technology providers it is independent of them. Its objective is to give impartial, confidential advice to clients in order that they are able to achieve sustainable, cost-effective solutions that use the technology that is most appropriate for their particular situation.

This is based on many years' experience of actually working with and managing a wide range of technologies for wastewater treatment, biosolids and residuals treatment, recycling, farming and other land uses.

A key principle is that solutions must comply with current (and reasonably anticipated future) legal requirements, and that this compliance should be demonstrable. On top of this the concerns and perceptions of stakeholders should be recognised. If recycling is

involved there should be a market for the material being produced, and there should be due diligence and an awareness of emerging issues.

Work to date has included:-

- Designing and managing sustainable biosolids recycling that was fully traceable and compliant with all legal requirements and met all time and financial targets.
- Internal benchmarking to identify opportunities for quality, efficiency and cost improvements.
- Field trials into the effects of biosolids and composts on the yields and quality of crops, soil metals, earthworm populations and effects on soil microorganisms.
- Risk evaluation and development of good practice protocols for the use of wastewater biosolids and other organic residuals as soil improvers based on the principles of Hazard Analysis and Critical Control Point (HACCP) so as to enable strict-liability latent-defect insurance, including gradual pollution, for a period of 25 years.
- Conducting HACCP analyses for biosolids and waste processes from prevention of pollution by control at sources, through treatment to the planning and application of biofertilisers to land. Designing internal control questionnaires and training their personnel so that they are enabled to conduct internal audits and gap analyses and to roll out HACCP across their companies.
- Advising technology providers on opportunities for new treatment technologies for organic residuals, benchmarking them against their potential competitors, SWOT analyses and in particular the likely impact of emerging legislation.
- Standards for composted materials
- A scoping study for a stakeholder partnership for using organic resources on land, this involved stakeholder meetings, drafting a business plan and a residential workshop.
- Re-evaluating a biosolids strategy to provide a sustainable solution that was affordable and practicable in the context of local geography, climate and farming and that uses appropriate technology.
- Contributing to a multidisciplinary team advising on a politically acceptable solution for first time sewerage scheme in an arid region with high quality tourism, that made the best use of all available resources for financing the lifetime of the scheme.
- Designing safe compliant composting systems.
- Advising on emerging legislation.
- Strategic and organisational studies for new biosolids and residuals facilities.
- Design and costing a food waste recycling facility producing biofertiliser and biogas by anaerobic digestion
- Formulating peat-free products for gardeners based on composted materials. Designing the packaging, market research, launching these fast moving

consumer goods onto the wholesale market and managing production, sales and distribution.
- Designing land drainage to intercept up-slope seepage and under-drainage to remove surface water
- Advice on phosphate recovery and ammonia treatment from process liquids.
- Environmental impact study of the contribution food waste disposers can make to household waste management
- Advice on residuals management for a wastewater treatment plant dedicated to a large petrochemical and industrial complex and preparation of a code of practice.
- Developed the Airbeam Roller Stockpile Cover (patented) the practicable solution to safe containment of stockpiles

Projects to date have been in Brazil, Cyprus, Egypt, England, Ireland, Nigeria, Slovakia, Scotland and USA.

Case Studies

- Process Design
  - Anaerobic Digestion
  - Composting
  - N-recovery
  - P-recovery
  - HACCP
- Marketing & branding
- Topsoil & land reclamation
- Land application
- Food waste disposers
- Perry Oaks Clearance
- Expert Witness

Downloads

http://timevansenvironment.com/

Evans, T.D.: Andersson, P.: Wievegg, A.: Carlsson, I. (2010) Surahammar – a case study of the impacts of installing food waste disposers in fifty percent of households. Water Environ. J. in press

Evans T. D. (2009) Guide to the Use of Wastewater Biosolids in Agriculture

Evans T.D. and Thompson, A. (2009) *Recovering ammonium fertiliser – an alternative to blowing it away.* Proc. 14th European Biosolids and Organic Resources Conf., November 2009, Lowe P.(ed), Aqua Enviro, Leeds, UK

Evans T.D. (2009) *Peak phosphorus – conserving the world's most essential resource*. Proc. 14th European Biosolids and Organic Resources Conf., November 2009, Lowe P.(ed), Aqua Enviro, Leeds, UK

Evans T.D. (2009) *Using composted biosolids as a peat replacement*. Proc. 14th European Biosolids and Organic Resources Conf., November 2009, Lowe P.(ed), Aqua Enviro, Leeds, UK

Evans, T.D. (2008) *An independent review of sludge treatment processes and innovations*. Proc. Australian Water Assoc. Biosolids Specialty IV Conf. 11-13 June, Adelaide

Evans, T. D. (2007)*Environmental Impact Study of Food Waste Disposers*: a report for The County Surveyors' Society & Herefordshire Council and Worcestershire County Council, published by Worcestershire County Council.

Evans, T.D. (2007) *Recovering ammonium and struvite fertilisers from digested sludge dewatering liquors*. Proc. IWA Specialist Conference: Moving Forward – *Wastewater biosolids sustainability*. June 2007. Moncton, NB, Canada

Evans, T. D.; Boor, M. and MacBrayne, D. (2007) *Biofertiliser plant design – food waste to biofertiliser and biogas*. Proc. 12th CIWEM European Biosolids & Biowastes Conference, 13-15 November 2007 AquaEnviro, Manchester

Evans, T.D. (2005) *Does The Brand Say It All? Is the Professional Market the same as the Fast Moving Consumer Goods Market?* 10th CIWEM AquaEnviro European Biosolids & Biowastes Conference, 13-16 November 2005

Evans, T.D. (2003) *The potential benefits of applying HACCP to organic residuals recycling processes*. Water Environment Federation 17th Annual Residuals & Biosolids Conference, 19-22 February 2003, Baltimore

Evans, T.D., Jepsen, S.-E., Panter, K. P. (2002) *A survey of anaerobic digestion in Denmark*. 7th CIWEM AquaEnviro European Biosolids & Organic Residuals Conference, 18-20 November 2002

Publications and Conference Papers

Evans T.D. (2012) Comment on Iacovidou, E.; Ohandja, D.-G. and Voulvoulis, N. (2012) Food waste disposal units in UK households: The need for policy intervention. Science of the Total Environment 423 1- 7 Science of the Total Environment **437** 433–434 DOI: 10.1016/j.scitotenv.2012.07.042

Evans T.D. and Smith, S.R. (2012) *Bioassay of biosolids in an operational scale field trial*. Proc. 26th Water Environment Federation, Annual Residuals & Biosolids Conference, 25-28 March, Raleigh NC

Evans T.D. (2012) *Biosolids in Europe*. Proc. 26th Water Environment Federation, Annual Residuals & Biosolids Conference, 25-28 March, Raleigh NC

Evans T.D. (2012) *Cambi Agronomics*. Proc. 26th Water Environment Federation, Annual Residuals & Biosolids Conference, 28 March, Raleigh NC

Evans T.D. (2012) *Domestic food waste -the carbon and financial costs of the options*. Municipal Engineer. Proc. I.C.E. **165** 3-10

Evans T.D. (2011) FOG management. Water & Sewerage Journal 2011 (4) 27 & 29

Evans T.D. (2011) Sludge treatment and dewatering. Water & Sewerage Journal 2011 (4) 39 & 41

Evans T.D. (2011) *Biosolids in Europe*. Proc. 16th European Biosolids and Organic Resources Conf., November 2011, Horan, N.J.(ed), Aqua Enviro, Leeds, UK

Evans T.D. and Smith, S. R. (2011) *Bioassay of biosolids in an operational scale field trial*. Proc. 16th European Biosolids and Organic Resources Conf., November 2011, Horan, N.J.(ed), Aqua Enviro, Leeds, UK

Evans T.D. (2011) *Airborne transmission – what does science tell us?* Proc. 16th European Biosolids and Organic Resources Conf., November 2011, Horan, N.J.(ed), Aqua Enviro, Leeds, UK

Evans T.D. (2011) *Building confidence in land application of organic resources, gaining and maintaining market share*. Proc. 16th European Biosolids and Organic Resources Conf., November 2011, Horan, N.J.(ed), Aqua Enviro, Leeds, UK

Evans T.D. (2011) *Cambi Agronomics*. Cambi Academy associated with 25th Water Environment Federation, Annual Residuals & Biosolids Conference, 22-25 June Sacramento, CA

Evans T.D. (2011) *Cambi applications / Success stories*. Cambi Academy associated with 25th Water Environment Federation, Annual Residuals & Biosolids Conference, 22-25 June Sacramento, CA

Evans T.D. (2011) *Resource management and the Phosphate Cycle*. CIWEM Metropolitan Branch and Norton Rose. 29th March 2011

Evans T.D. (2011) *Sustainable biowaste*. CIWEM Metropolitan Branch, University of Hertfordshire. 9th February 2011

Evans, T.D. (2011) *Retrofitting Green Infrastructure For Rainwater - What's Stopping Us?* report of FWR WaPUG workshop. FWR, Marlow, England

Evans T.D. (2010) *Fertilisers - vital for food, fi bre and carbon capture but increasingly scarce, especially phosphate.* Scanning the Agricultural Horizon to 2050. SCI, 30 November 2010 Syngenta, Bracknell, UK

Evans, T.D.: Andersson, P.: Wievegg, A.: Carlsson, I. (2010) *Surahammar – a case study of the impacts of installing food waste disposers in fifty percent of households*. Water Environ. J. **241** 309-319

Evans T.D. (2010) *Agricultural uses of treated organic resources: 101 agronomy, quality assurance and confidence building – a review*. Proc. 15th European Biosolids and Organic Resources Conf., November 2010, Lowe P.(ed), Aqua Enviro, Leeds, UK

Evans T.D. (2010) *Wastewater Management – An Additional Paradigm*. 4th European Water and Wastewater Management Conference. 27-28 September, Leeds, UK

Evans T.D. (2010) *The Limits Of The Sewerage Network – Workshop and Round Table Discussion*. 4th European Water and Wastewater Management Conference. 27-28 September, Leeds, UK

Evans T.D.; Andersson, P.: Wievegg, A.: Carlsson, I. (2010) *Case Study of the Impacts of Installing Food Waste Disposers in Fifty Percent of Households in Surahammar, Sweden*. IWA World Water Congress, 20-23 September, Montreal, Canada.

Evans T.D. (2010) *Untying the Wastewater Knot: Resource Recovery and Waste to Energy*. BlueTech Innovation Forum, June 7th San Francisco

Evans T.D. (2010) *Renewable energy and landfill diversion - recognising people's behaviours*. Water& Environment 2010 CIWEM's Annual Conference. Olympia Conference Centre London -28-29 April

Evans T.D. (2010) *Renewable energy and landfill diversion - recognising people's behaviours*. FutureSource, 29th April 2010, Excel Centre, London

Evans T.D. (2010) *Biorenewable fuel and fertiliser - can there be a level, science-based regulatory playing field?* SCI, 24th March 2010 FERA, York

Evans T.D. (2010) *Kitchen food waste, the options and their consequences*. CIWEM Metropolitan Branch and Norton Rose. 9th March 2010

Evans T.D. (2009) *Using composted biosolids as a peat replacement*. Proc. 14th European Biosolids and Organic Resources Conf., November 2009, Lowe P.(ed), Aqua Enviro, Leeds, UK

Evans T.D. (2009) *Peak phosphorus – conserving the world's most essential resource*. Proc. 14th European Biosolids and Organic Resources Conf., November 2009, Lowe P.(ed), Aqua Enviro, Leeds, UK

Evans T.D. and Thompson, A. (2009) *Recovering ammonium fertiliser – an alternative to blowing it away*. Proc. 14th European Biosolids and Organic Resources Conf., November 2009, Lowe P.(ed), Aqua Enviro, Leeds, UK

Evans T.D. (2009) *Climate Change Impacts Of Food Waste Diversion To Anaerobic Digesters*. 1056-1076 Proc. 23rd Water Environment Federation, Annual Residuals & Biosolids Conference, 3-6 May, Portland OR

Evans T.D. (2009) *Peak phosphorus*. CIWEM Metropolitan Branch. 29th January 2009

Evans T.D. (2009) *Recovering ammonium and struvite fertilizers from digested sludge dewatering liquors* Resource Recovery Not Wastewater Treatment Conference. 22nd January 2009, London, Aqua-Enviro

Evans, T.D. (2008) *Nutrient and carbon recovery from household and food biowastes.* Int'l. Fert. Soc. Proc. **635**, York, UK

Evans, T.D. (2008) *Agricultural trends – use of organic resources – how do they fit?* Proc. 13th European Biosolids and Organic Resources Conf., November 2008, Lowe P.(ed), Aqua Enviro, Manchester, UK

Lagerberg, ; Evans, T.D.; Manocher Asaadi, M. (2008) *Quality protocols for biosolids – securing the future.* Proc. Australian Water Assoc. Biosolids Specialty IV Conf. 11-13 June, Adelaide

Evans, T.D. (2008) *An independent review of sludge treatment processes and innovations*. Proc. Australian Water Assoc. Biosolids Specialty IV Conf. 11-13 June, Adelaide

Evans, T.D. (2008) *Perception, marketing and acceptability*. European Water Assoc. Workshop on Knowledge and Practices of Using Treated Sewage Sludge on Land, 15-16 April, Pembroke College, Cambridge

Lagerberg, I; Evans, T.D.; Manocher Asaadi, M. (2008) *Quality protocols for biosolids – securing the future.* Proc. 22nd Water Environment Federation, Annual Residuals & Biosolids Conference, 30 March - 2 April, Philadelphia

Evans, T. D. (2008) *Sludge fit for purpose*. Water & Sewerage Journal 2008-1 27-30 www.waterjournal.co.uk

Evans, T.D. (2008) *Soil quality assurance – New British Standard & best practice guidance*. Proc. EnviroLink Northwest, Soils in the Developed Landscape Conf. 10-11 March, Liverpool.

Evans, T.D. (2007) *Food waste – global warming potentials of the options*. Proc. 12th CIWEM European Biosolids& Biowastes Conference, 13-15 November 2007 AquaEnviro, Manchester

Evans, T. D.; Boor, M. and MacBrayne, D. (2007) *Biofertiliser plant design – food waste to biofertiliser and biogas.* Proc. 12th CIWEM European Biosolids & Biowastes Conference, 13-15 November 2007 AquaEnviro, Manchester

Evans, T.D. (2007) *Sludge and Biosolids Management*. AWE International 39-43

Evans, T.D. (2007) *Recovering ammonium and struvite fertilisers from digested sludge dewatering liquors*. Proc. IWA Specialist Conference: Moving Forward – Wastewater biosolids sustainability. June 2007. Moncton, NB, Canada

Evans, T. D. (2007) *Environmental Impact Study of Food Waste Disposers*: a report for The County Surveyors' Society & Herefordshire Council and Worcestershire County Council, published by Worcestershire County Council.

Evans, T.D. and Eadon, A.R. (editors) (2006) *Workshop On Urban Run-Off Modelling -Why Not Do It Properly?* report of FWR WaPUG workshop, 8th March 2006, Coleshill. FWR, Marlow, England

Evans, T.D. (2006) *Sludge dewatering performance – a survey of real operational performance. Floculants & Coagulants Conference*. Intertech Pira International, Budapest, 29-30 November 2006

Evans, T.D. (2006) *Treating dewatering liquors – is physico-chemical better than biological? Can a problem be turned into an asset?* 11th CIWEM AquaEnviro European Biosolids & Biowastes Conference, 13-15 November 2006

Evans, T.D. (2006) *Sludge dewatering performance – a survey of real operational performance*. 11th CIWEM AquaEnviro European Biosolids & Biowastes Conference, 13-15 November 2006

Evans, T.D.; Chilro, N. and Cherry, R.C.A. (2006) *Applications of hi-tech fabric structures for sustainable sludge management.* International Water Association, Sustainable sludge management: state of the art, challenges and perspectives. Moscow 29-31 May.

Evans, Tim; Boor, Mike; and Cherry, Richard (2006) *Airbeam roller stockpile covers patents pending - practicable and re-usable solutions for containment, preventing odors and rewetting by rain and for enhancing fecal coliform die-off*. Water Environment Federation 20th Annual Residuals & Biosolids Conference, Cincinnati, 12-15 March.

Evans, T. (2006) *Sheep Reared on Sewage Sludge-Treated Pasture: Flawed Conclusions*. Environmental Health Perspectives **114** (2) February 2006

Chilro, N.; Tang, C. and Evans, T.D. (2006) *A New Approach to Sludge Storage: The Airbeam Roller Stockpile Cover (ARSC)* Sludge 14 Conference, University of Surrey

Evans, T.D. (2005) *Cap reform, cross-compliance, and biosolids and biowastes* 10th CIWEM AquaEnviro European Biosolids & Biowastes Conference, 13-16 November 2005

Evans, T.D. (2005) *Does The Brand Say It All? Is the Professional Market the same as the Fast Moving Consumer Goods Market?* 10th CIWEM AquaEnviro European Biosolids & Biowastes Conference, 13-16 November 2005

Evans, T.D. (2005) *Organic Matter In Soils: Maintenance And Application - Research Into Practice.* CIWEM Conference, The Land-use and Water Series; Integrating Water and Soil Strategies - Translating Research into Action. 12 October, 2005 SOAS, London

Evans, T.D. and Eadon, A.R. (editors) (2005) *CSO Screens – A Design and Installation Review*. report of FWR WaPUG workshop, 6th July 2005, Cropston. FWR, Marlow, England

Evans, Tim; Boor, Mike; and Cherry, Richard (2005) *Practical Stockpile Storage. A British study examines different techniques to contain biosolids stockpiles.* WEF Biosolids Technical Bulletin **10** (3) 1-6

Evans, T.D.; Boor, M.; Cherry, R. (2004) *Stockpile-covers that are practicable and re-usable - for containment, to prevent odours and rewetting by rain and to enhance E. coli die-off*. 9th CIWEM AquaEnviro European Biosolids & Biowastes Conference, 14-17 November 2004

Evans, T.D. (2004) *Bioaerosols from organic wastes – what's the problem?* 9th CIWEM AquaEnviro European Biosolids & Biowastes Conference, 14-17 November 2004

Evans, T.D. (2004) *Sustainable Organic Resources Partnership* Recycling organic residues on agricultural land – opportunities, facts and fears. Levy Boards Workshop. Harper Adams Agricultural College. September 2004

Evans, T.D.; Lowe, N.; Matthews, P (2004) *Sustainable biosolids - welcomed practice through community partnership and the consequential economic benefits.* Water Science & Technology Vol **49** No 10 pp 241–249

Evans, T. D. (2004) *Apparatus and method for preserving material*. Patent Application Number GB0415602.2 The Patent Office www.patent.gov.uk

Evans, T.D. (2004) *Urban Rainfall & Run-Off* (ed) report of FWR WaPUG workshop, 30th April 2004, Coleshill. FWR, Marlow, England

Evans, T.D. (2004) *An overview of the issues relating to intermittent discharges.* Improvement Programmes for Combined Sewer Overflows and Other Intermittent Discharges. CIWEM conference, 23 June 2004, SOAS, London

Evans, T.D. (2004) *Soils 101*. Water Environment Federation 18th Annual Residuals & Biosolids Conference, 22-25 February 2004, Salt Lake City

Evans, T.D. and Johnston, A.E. (2004) *Phosphorus and crop nutrition: principles and practices*. In Phosphorus in Environmental Technologies: Principles and Applications. Valsami-Jones, E. (ed) IWA Publishing, ISBN 1 84339 001 9. London

Evans, T.D. (2004) *Design Criteria & Performance Standards For Urban Drainage Systems: Is Historic Practice Still Good Enough?* (ed) report of FWR WaPUG workshop, 24th September 2003, CoventryFWR, Marlow, England

Evans, T.; Lowe, N. and Matthews P. (2004) *Sustainable biosolids - welcomed practice through community partnership and the consequential economic benefits.* Water Science & Technology Vol 49 No 10 pp 241–249

Jones, K.C. and Evans, T.D. (2004) *Organic contaminants' behaviour in soil: decomposition, form and long-term phenomena.* Sustainable land application conference. 4-8 January 2004, Lake Buena Vista, Florida, USA.

Evans, T.D. and Lowe, N.R. (2004) *Partnership for Sustainable Use of Organic Resources on Land.* Sustainable land application conference. 4-8 January 2004, Lake Buena Vista, Florida, USA.

Evans, T.D. and Lowe, N.R. (2003) *The Sustainable Organic Resources Partnership goes live.* 8th CIWEM AquaEnviro European Biosolids & Organic Residuals Conference, 23-26 November 2003

Evans, T.D.; Lambkin, D.; Nortcliff, S.; White, T. (2003) *Monitoring results depend on the precision of sampling horizontal – sampling sludges, soils and treated biowastes*. 8th CIWEM AquaEnviro European Biosolids & Organic Residuals Conference, 23-26 November 2003

Evans, T.D. (2003) *Hazard Analysis and Critical Control Point (HACCP)for Composters* ISBN 0-9532546-6-6 The Composting Association, Northampton , England

Evans, T.D. (2003) *Introduction to Hazard Analysis and Critical Control Point (HACCP).* Composting Association Conference - Composting Animal By-Products and Catering Waste 14th July 2003, London

Evans, T.D.; Lowe, N.; Matthews, P (2003) *Sustainable biosolids - welcomed practice through community partnership and the consequential economic benefits.* Wastewater Sludge As A Resource p. 369-376 (ed. Odegaard, H.) Proceedings of International IWA Conference Biosolids 2003, 23-25 June 2003 Trondheim, Norway

Evans, T.D. (2003) *UK practice in treatment of municipal and industrial sludge*. The Institution of Engineers of Ireland Treating Industrial and Municipal sludge with Lime Conference, 15th May 2003, Carlow, Ireland.

Evans, T.D. and Lowe, N.R. (2003) *Partnership for sustainable use of organic resources on land*. CIWEM East Anglia Branch Conference 4th March 2003 Peterborough

Evans, T.D. (2003) *Independent review of retrofitting Cambi to MAD*. Water Environment Federation 17th Annual Residuals & Biosolids Conference, 19-22 February 2003, Baltimore

Evans, T.D. (2003) *The potential benefits of applying HACCP to organic residuals recycling processes*. Water Environment Federation 17th Annual Residuals & Biosolids Conference, 19-22 February 2003, Baltimore

Evans, T.D. and Lowe, N.R. (2002) *Partnership for sustainable use of organic resources on land*. European Wastewater Management and Environmental Compliance Forum 9-11 December 2002, IIR, London

Evans, T.D. (2002) *Urban Flood Route Prediction - Can We Do It?* (ed) report of FWR WaPUG workshop, 26th September 2002, Solihull. FWR, Marlow, England

Bruce A.M. and Evans, T.D. (2002) *Sewage sludge disposal: operational and environmental issues*. Review Of Current Knowledge FR/R0001, June 1999, Revised and Updated December 2002, FWR, Marlow, England http://www.fwr.org/

Godley, A.R.; Evans, T.D.; Alker, G.; Davis, R.D. (2002) *Research analysis of the market for lower grade composted materials in the UK*. ISBN: 1 84405 034 3 WRAP, Banbury, UK.

Evans, T.D., Jepsen, S.-E., Panter, K. P. (2002) *A survey of anaerobic digestion in Denmark*. 7th CIWEM AquaEnviro European Biosolids & Organic Residuals Conference, 18-20 November 2002

Evans, T.D. and Lowe, N.R. (2002) *Partnership for sustainable use of organic resources on land. 7th* CIWEM AquaEnviro European Biosolids & Organic Residuals Conference, 18-20 November 2002

Evans, T.D.; Godley, A.R.; Alker, G.; Davis, R.D. (2002) *Standards and market Potential for composted materials*. 7th CIWEM AquaEnviro European Biosolids & Organic Residuals Conference, 18-20 November 2002

Evans, T.D. (2002) *A perspective of attitudes to use and disposal of sewage sludge in Europe, now and in the future.* Seminar on the Management and Treatment of Sludge from Drinking Water Treatment Plants and Sewerage Treatment Plants in Portugal. APDA (Portuguese Water and Wastewater Association) & APEA (Portuguese Environmental Engineering Association) 27-28 June 2002, Lisbon

Evans, T.D. (2002) *An update on standardisation work in CEN/TC 223*. European Commission workshop on biological treatment of biodegradable wastes – technical aspects. 8-10 April 2002, Brussels

Evans, T.D. (2001) *Use of biosolids and organic residuals a marketing centric view.* 6th CIWEM AquaEnviro European Biosolids & Organic Residuals Conference, 12-14 November 2001, Wakefield, England

Evans, T.D. (2001) *The potential benefits of applying HACCP to organic residuals recycling processes.* 6th CIWEM AquaEnviro European Biosolids & Organic Residuals Conference, 12-14 November 2001, Wakefield, England

Evans, T.D. (2001) *Water treatment and sludge management.* "Linking Knowledge and Society" a Euro-CASE workshop, Royal Academy of Engineering, 20 Sept. 2001, London

Evans, T.D. (2001) *Marketing of sludge and quality assurance.* European Water Association Workshop on Sewage Sludge Disposal 10-12 September 2001, Vienna

Evans, T.D. (2001) *Stakeholder power causes better biosolids.* Water & Sewerage J. **3** 29-30

Evans, T.D. (2001) *Economical challenges towards sustainable sludge management* Euro-CASE Workshop "Wastewater sludge as a challenge" 25 June 2001, Vienna, Austria

USEPA (2001) *Workshop on emerging infectious disease agents and issues associated with animal manures, biosolids and similar by-products.* Cincinnati, Ohio, USA 4-6 June 2001

Evans, T.D. (2001) *An update on the Sludge Directive* IQPC conference "Sewage Sludge 2001" 29-30 May 2001, London

Evans, T.D. (2001) *Labelling& Specification* and *Safety considerations for soil improvers and growing media, and the biowaste initiative.* BSI Seminar "Standards for Soil Improvers and Growing Media", 5 April 2001, BSI, London

Evans, T.D. (2001) *The journey to sustainable treatment and use or disposal of wastewater biosolids* International Symposium on the Recycling and Reuse of Sewage Sludge, Dundee 19-20 March 2001

Jeanmaire N. Evans, T.D. (2001) *Technico-economic feasibility of P-recovery from municipal wastewaters.* Environmental Technology 2001

Evans, T.D. (2001) *Implications of within-WwTP P-recovery for biosolids management: biosolids volumes, N:P ratio & recycling (agronomic, LCA and economic implications) – a European perspective.* Second international conference on recovery of phosphates from sewage and animal wastes Holland, 12-13 March 2001

Evans, T.D. (2001) *Composting - There's going to be a lot more of it about! What does this mean for the Grounds Manager?* Institute of Groundsmanship Annual Conference 30 March to 3 April 2001

Evans, T.D. (2001) *An update on developments in regulations affecting biosolids in the European Union* Water Environment Federation 15th Annual Residuals & Biosolids Conference, 21-24 February 2001, San Diego

Evans, T.D. (2000) *Developments in regulation, controls and liabilities for the use of biosolids and other organic residuals on land.* 5th European Biosolids and Organic Residuals Conference CIWEM/AquaEnviro, 20-22 November 2000, Wakefield

Evans, T.D. (2000) *A comparison of international standards for beneficial use of biomaterials – can we see where we might be going?* CIWEM Journal 2000

Evans, T.D. (2000) *Biosolids and residuals – innovations*. Water & Environment Manager **5**(5) 18-19

Evans, T.D. (2000) *Biosolids and residuals – perception is reality*. Water & Environment Manager **5**(4) 34-36

Evans, T.D. (2000) *A comparison of international standards for beneficial use of biomaterials – can we see where we might be going?* Wastewater Treatment: Standards and Technologies to Meet the Challenges of the 21st Century. CIWEM/AquaEnviro 4-7 April 2000, Leeds

Evans, T.D. (2000) *Integrating biosolids into agriculture* The Future of Biosolids Recycling. CIWEM East Anglian Branch 22 March 2000, Cambridge

Evans, T.D. (2000) *Meeting the end of sea disposal of sludge in England and Wales and milestones in biosolids recycling* Water Environment Federation 14th Annual Residuals & Biosolids Conference, 27 February – 1 March 2000, Boston

Evans, T.D. (2000) *An International Perspective on the Sludge Directive Working Document.* IBC 16-17 February 2000, London

USEPA (1999) *Operations and design to control ultimate recycling and disposal odors of biosolids workshop"* Bolger Centre, Potomac, Maryland, USA 16-18 November 1999

Evans, T.D. (1999) *Do biomaterial recyclers need externally audited quality assurance and insurability?* 4th European Biosolids and Organic Residuals Conference CIWEM/AquaEnviro 15-17 November 1999

Evans, T.D. (1999) *Biosolids recycling – satisfying the needs of stakeholders – legal compliance is not enough.* IWA conference "Disposal and utilisation of sewage sludge: treatment methods and application modalities" 13-15 October 1999, Athens

Lasaridi, K.E.; Stentiford, E.I.; Evans, T. (1999) *Windrow composting of wastewater biosolids: process performance and product stability assessment.* IWA conference "Disposal and utilisation of sewage sludge: treatment methods and application modalities" 13-15 October 1999, Athens

Evans, T.D. (1999) *Biosolids and residuals in Europe.* Water Environment Federation 72nd Annual Exhibition & Technical Conference on Water Quality and Wastewater Treatment, 9-13 October 1999

Evans, T.D. (1999) *Managing odour during biosolids recycling: a case study*. CIWEM "Control & prevention of odours in the water industry"

Evans, T.D. (1999) *The Benefits of Externally Audited Quality Assurance and Certification of Insurability* IQPC Conference "Sewage Sludge Treatment & Use" 21st – 22nd July 1999.

Evans, T.D. (1999) *Opportunities and Challenges for Recycling Biosolids and Other Organic Residuals*. ET '99

Evans T.D. (1998) *Biosolids for the third millennium* IQPC Conference "Sewage Sludge Treatment & Disposal" 14-15 December 1998

Evans T.D. (1998) *Biosolids recycling for the third millennium* IAWQ International Symposium on Management and Operation of Environmental Control Systems in the Chemical and Petrochemical Industry, Salvador, Brazil November 1998

Evans T.D. (1998) *Biosolids for the third millennium* Aqua-Enviro 3rd European Biosolids & Organic Waste Conference November 1998

Evans T.D. (1998) *The roles of standards and biosolids in land reclamation in* "Land reclamation: achieving sustainable benefits" Fox, Moore, McIntosh (eds) Balkema, Rotterdam

Evans T.D. (1998) *New approaches to the use of biosolids in Thames Water - a step change.* Water Environment Federation 12th Annual Residuals & Biosolids Conference, Seattle.

Evans T.D. (1998) *New approaches to the use of biosolids in Thames Water - a step change*. IQPC

Evans T.D. (1998) *Turbo-charging digesters to sterilise biosolids* CIWEM Metropolitan Branch

Smith, S.R. Woods, V. Evans, T.D. (1998) *Nitrate dynamics in biosolids-treated soils. I. Influence of biosolids type and soil type*. Bioresource Technology **66** 139-149

Smith, S.R. Woods, V. Evans, T.D. (1998) *Nitrate dynamics in biosolids-treated soils. II. Thermal-time models of the different nitrogen pools.* Bioresource Technology **66** 151-160

Smith, S.R. Woods, V. Evans, T.D. (1998) *Nitrate dynamics in biosolids-treated soils. III. Significance of the organic nitrogen, a twin-pool exponential model for nitrogen management and comparison with the nitrate production from animal wastes*. Bioresource Technology **66** 161-174

Evans, T.D. Smith, S.R. Woods V. (1997) *Soil microbial biomass - its response to biosolids*. 2nd Aqua-Enviro European Biosolids & Organic Residuals Conference Nov'97

Evans, T.D. (1998) *The Agricultural Use Of Biosolids (Sewage sludge)* Fertiliser Society **409**

Evans, T.D. (1997) *Waste Disposal* British Society Of Soil Science "Sustaining Our Soils" 6th March 1997

Evans, Tim; Rainbow, Arnie (1997) *Wastewater biosolids to garden centre products via composting*. International Symposium "Composting and use of composted materials in horticulture" 5-11 April 1997

Evans, T.D. (1994) *TERRA ECO·SYSTEMS - Quality Management and Beneficial Use of Biosolids* "The management of water and wastewater solids for the 21st century: a global perspective" Water Environment Federation 19-22 June 1994 Washington DC

Evans, T.D. (1994) *European standards and wastewater biosolids recycling* "European Conference on Sludge and Organic Waste" 12-15 April 1994 Wakefield

Evans, T.D. (1994) *TERRA ECO·SYSTEMS - operational experience of biosolids recycling, quality control and marketing* "European Conference on Sludge and Organic Waste" 12-15 April 1994 Wakefield

Evans, T.D. (1993) *Wastewater biosolids recycling* "The EU Urban Waste Water Directive - Identifying the Opportunities & Treats" IBCS December 1993

Evans, T.D. (1993) *TERRA ECO·SYSTEMS - Recycling Wastewater Products*, IWEM Paper 12 October 1993

Smith, S.R.; Tibbett, M. and Evans, T.D. (1992) *Nitrate accumulation potential of sewage sludges applied to soil.* Aspects of Applied Biology **30** 157-161

Evans, T.D. and Leal, J.R. (1980) *Silver:silver halide electrode construction and preparation*. Lab. Practice **29** 846-847

Evans, T.D. 1980 *The interfacial electrochemistry of goethite (α-FeOOH) Part II Ion adsorption and HSAB: mercury is "soft" but goethite is "hard".* J. Electroanal. Chem. **111** 247-252

Evans, T.D., Leal, J.R. and Arnold, P.W. (1979*) The interfacial electrochemistry of goethite (α-FeOOH) especially the effect of CO_2 contamination.* J. Electroanal. Chem. **105** 161-167

Evans, T.D. (1976) *Interfacial electrochemistry of goethite (α-FeOOH)* Ph.D. Thesis University of Newcastle upon Tyne.

Evans, T.D. (1971) *Reactions of phosphate with some ferruginous Brazilian soils.* M.S. Thesis University of Wisconsin

Evans, T.D. and Syers, J.L. (1971) *An application of autoradiography to study the spatial distribution of ^{33}P-labelled orthophosphate added to soil crumbs*. Soil Sci. Soc. Amer. Proc. **35** 906-909

Syers, J.K., Evans, T.D., Williams, J.D.H. and Murdoch, J.T. (1971) *Phosphate sorption parameters of representative soils from Rio Grande do Sul, Brazil*. Soil Sci. **112** 267-275

CURRICULUM VITAE

Dr Tim Evans

BSc, MS, PhD, CChem, MRSC, FCIWEM, CEnv, FACTS

Summary
Soil Scientist. Recognised internationally as an independent expert in the treatment and management of organic residuals. Specialist in resource recovery, technology evaluation, recycling and biogas. Quality assurance, marketing and selling.

Career History

1999 – present Principal and founder of an independent consultancy (TIM EVANS ENVIRONMENT www.timevansenvironment.com) which aims to provide cost effective and appropriate solutions for clients, especially in the areas of biosolids and residuals management and recycling. Commissions have included:

- fully costed outline design for a 30,000 t/year anaerobic digestion plant converting food waste to biofertiliser and biogas with renewable electricity generation
- environmental impact assessment of food waste disposers compared with separate solid waste collection and composting or AD including the carbon footprint of each
- integrated plant for stripping nitrogen and phosphate physico-chemically from dewatering liquors to make mineral fertilisers
- strategic evaluation of biological and physico-chemical treatments for side-stream treatment of process liquors in wastewater treatment works
- technology assessment and advice to companies on potential development areas for their businesses including competitor analysis and routes to market also to clean-tech fund managers on companies' potentials
- impacts (cost and environmental) of eliminating phosphate from detergents and separately the impact on wastewater treatment works of substituting other surfactants for phosphate
- WRAP (Waste and Resources Action Programme) framework contracts for training composters and AD operators in marketing and selling and for monitoring capital support projects for progress, risk, expenditure and performance
- training in effective selling
- report on centralised co-digestion in Denmark where biogas was part of the national energy strategy
- expert witness in legal cases
- composting – developing plans and procedures for "merchant facilities" for quality assured composting and recycling
- environmental liability insurance – operating protocols to enable 25-year strict-liability, latent-defect insurance for land treated with biosolids and organic residuals,
- Quality Protocol for Biosolids, a UKWIR research contract
- application of Hazard Analysis and Critical Control Point (HACCP) to biosolids management and to composting
- preparing HACCP plans for manufacturers and operators of waste treatment processes and plants
- "Hazard Analysis and Critical Control Point (HACCP) for Composters" published by The Composting Association ISBN 0-9532546-6-6
- land drainage - survey and diagnosis to cure flooding
- green infrastructure for rainwater management
- marketing and operational advice for biosolids and compost producers to improve the sustainability of their programmes
- markets and standards for composted materials
- market research, launching and developing the Sustainable Organic Resources Partnership to build trust, share information and develop good practice by consensus amongst stakeholders.
- "Layman's guide to the use of sludge in agriculture" for the European Commission DG Environment.
- liaising with the European Commission on development of legislation for sludges, soils and biowastes including end of waste criteria and the Thematic Strategy for Soil Protection.

- Workpackage leader for sampling sludges, treated biowastes and soils in HORIZONTAL, an international research consortium.
- organising and administering conferences
- develop and sell Airbeam Roller Stockpile Covers (patented) an easily deployed, reusable system for covering, preserving and containing materials, especially those that are not loadbearing.

Consultancies whilst with TIM EVANS ENVIRONMENT and Thames Water have included Brazil, Cyprus, Egypt, England, Ireland, Nigeria, Scotland, Slovakia and USA.

1986 – present Work in several CEN and BSi committees. Currently

- past-Chairman (to 2005) of CEN/TC 223 "Soil improvers and growing media".
- Convenor of CEN/TC 308 "Characterisation of sludges" WG3,
- Past-Vice-Chairman of CEN SABE (Strategic Advisory Board on Environment).
- Formerly member of CEN/TC 260 "Fertilisers and liming materials - TG Organic fertilisers" (now dormant) and CEN Soil Team (now superseded by CEN/TC 345 "Soil Quality").
- Chair of BSi mirror committees to CEN/TC223 and 308 also member of mirror committees to CEN/TC 260 and 345. Leading development of British Standards for topsoil and for subsoil

2002 – present Foundation for Water Research www.fwr.org – Technical Secretary to the Wastewater Research and Industry Support Forum, which shares research information and debates aspects of concern and interest in the wastewater area. I have facilitated several workshops on sewerage, drainage, runoff, green infrastructure, etc. and reported their proceedings, which are published by FWR. I have written the ROCK (Review of Current Knowledge) on sewage sludge and another on urban drainage.

2006 – 2009 University of Hertfordshire – Principal and Subject External Examiner for postgraduate courses in Environmental Management for Business and Water & in Environmental Management

1994 – present Chartered Institution of Water & Environmental Management www.ciwem.org – Chairman of the Wastewater Management Panel. Past chairman of Metropolitan Branch. Past Trustee and member of Council.

1999 Senior consultant at Atkins and Head of Environmental Assurance mainly involved with the venture for enabling strict-liability, latent-defect insurance for land treated with biosolids or other organic resources.

1988 – 1999 Thames Water initially designing and then managing multi-million pound engineering contracts for clearance of the site that is now the 5th Terminal for London Heathrow Airport, the busiest international airport in the world. This included negotiating programmes of work and budgets with the client, writing the contracts, recruiting Thames' team and managing the contracts. The contracts were delivered on time and within budget. The programme included environmentally controlled biosolids recycling which received quality assurance accreditation in 1992. Also in 1992 he was given responsibility for the whole biosolids recycling in the company – serving 6½ million people. The model (which others have recognised as world class) has been so successful that the operation doubled in size by organic growth.

One part of this recycling programme was creation of a range of products comprising growing media and a soil improver based on composted sewage sludge that are sold to gardeners through garden centres nationally. This transition into the fast moving consumer goods market required a new set of skills and continued focus on quality assurance.

He developed a distinctive branding for the biosolids and developed and stretched the brand as the recycling programme expanded.

1984 – 1988 Thames Water - Business Planner specialising in business planning for water treatment and water supply plus consolidating the plans for all aspects of the company. Also early work at condition monitoring and use of key performance indicators and critical ratios for planning investment.

He developed a vertically integrated company with Thames and two other companies manufacturing topsoil and using it in landscaping projects.

1983 – 1984 Thames Water – Technologist developing strategic plan and investment programme for the company's sewage sludge (365 wastewater treatment works of which 90 were sludge treatment centres).

1977 – 1983 Thames Water – Quality and Commercial Manager for biosolids recycling from London. This was the first environmentally controlled biosolids recycling for London it was a large and intensive operation even by today's standards, treating about 20,000 ha per year of farmland and land for restoration. It involved extensive development work and experimental work (including field and laboratory trials) into quantifying benefits and risks.

1975 – 1977 Thames Water – feasibility studies, market research and design for the operations that started in 1977.

1969 – 1975 Research Assistant at Soil Science Departments of Universities of Wisconsin, Madison, USA and Newcastle upon Tyne, UK researching the physical chemistry and spatial dynamics of sorption processes in soils, especially phosphate.

Qualifications and professional institutions

University of Newcastle upon Tyne, UK B.Sc.(Hons) 2:1 Soil Science (B.Sc.Chemistry)
University of Wisconsin, Madison, USA M.S. Soil Science
University of Newcastle upon Tyne Ph.D. Soil Science
Chartered Chemist
Chartered Environmentalist
Chartered Water and Environmental Manager
Fellow of the Chemical Society
Fellow of the Chartered Institution of Water & Environmental Management
Member of the British Society of Soil Science
Member of the American Society of Soil Science
Member of the American Society of Agronomy
Member of the Royal Institute of Chemistry
Member of the International Fertiliser Society
Member of the Society of Chemical Industry
Member of the Water Environment Federation (Editorial Advisory Board, Biosolids Technical Bulletin)
Member of the International Water Association
Fertiliser Advisers' Certification & Training Scheme
Competent Person (for managing composting plants)
Member of the Select Society of Sanitary Sludge Shovellers
Member of the Sustainable Organic Resources Partnership

Publications

Author of numerous journal articles and conference proceedings listed on www.timevansenvironment.com where some are also available to download.

http://usa.chinadaily.com.cn/business/2012-11/12/content_15916542.htm

New household appliances give home owners a better lifestyle

Updated: 2012-11-12 10:38

By Liu Jie (China Daily)

A woman cooking food at home. International electrical appliance producers, including Emerson Electric Co of the United States and Dyson of the United Kingdom, see the demand for food waste disposal units in China will be very attractive in coming years. [Photo/China Daily]

Fancy and effective designs that improve life prove to be most attractive to people

Catherine Yang insisted on installing a food waste disposal unit in her kitchen when carrying out home improvements in her new apartment in Shanghai.

"Living in the United States for nearly 10 years, I found having a food waste disposer was an indispensable household appliance in the kitchen," she said. The appliance is installed under a kitchen sink between the drain and a trap that shreds food waste into pieces small enough to pass through the plumbing and into the drain

"Around 90 percent of households in North America have food waste disposers. They keep kitchen waste out of the open air. More importantly, the waste can be recycled to generate fuel or fertilize land," said Yang, adding that she felt lucky to find the InSinkErator branded products in China.

She said the InSinkErator, made by Emerson Electric Co, was the first and is currently the largest producer of food waste disposers around the world. In the US, more than half of US families use its products.

Along with the increase in disposable income and pursuit of a higher-quality lifestyle, more and more Chinese people, especially those with decent incomes, overseas experience or who travel abroad a lot, want to buy high-end household appliances with unique designs and "green" characteristics.

Such products emerging in China include garbage disposers, bladeless electric fans as well as air cleaners that disinfect and ozone-producing devices.

Frank Bryant, international vice-president of Emerson InSinkErator, said his company entered China as early as 15 year ago. The business has been booming - sales grew 50 percent annually -

for the past five years. He attributed the good performance to not only surging demand for high-end appliances but also his company's efforts to tailor products to Chinese people.
"The diet habits and food Chinese people eat are very different from the West," said Bryant, citing high-fiber vegetable, fruit peel, bone, chicken skin and kernels as examples. "Using the same motor technology of Emerson's US products, the grinding technologies are modified in China to guarantee waste disposal is fast and the waste pieces are small enough," he said.
InSinkErator's products in China are easier to install, maintain and clean. In addition, "It's easier to recycle because we provide a component replacement service in China," said Jenny Chen, general manager of Emerson InSinkErator China.
A new series of the company's products tailored for China also adopted splash-proof technology to prevent food waste and water from splashing out of the grinding chamber. Their small size saves space, a necessary consideration for Chinese families who usually have less space than US households.
"We used our experience in the US and modified it for the Chinese market," said Bryant.

Unlike the InSinkErator, the UK high-end household appliance brand Dyson wants to push its products in China with their original designs and style.
Founded in 1992 by James Dyson, an independent designer and engineer, the company became known for its unconventional technology, designs and bold color mixtures. Its most well known products are multiple-use vacuum cleaners and bladeless fans.
Much welcomed in Europe and Japan, Dyson is expected to enter China in November via the international luxury distributor Jebsen Group.
Helmuth Hennig, managing director of Jebsen Group, said that the emerging and special-interest brands must highlight their uniqueness and the value of their distinguished designs. "Dyson needs experienced distributors like us to use our network and reputation to promote their products," he said, adding that Dyson's products will first focus on key cities and people pursuing high-quality lifestyles.
David Zhao, a communication manager at a foreign-funded industry group in China, said he bought a bladeless fan online this summer. "It's really cool - I mean the cooling effect and the appearance. Although the price may be 10 times an ordinary one, it's worth it," he said.
Due to air pollution in many key cities and chemical pollution from home improvements, many people choose to use air cleaners at home.
"There are multiple choices in our stores. Besides ordinary and economical ones, we have premium products with more specific functions, such as those that provide ozone, ion purification and essential oils," said an assistant in a Suning store in Beijing, adding that the majority of them are imported and expensive.
Wang Xiaoying, an analyst with Sinolink Securities Co, said the emergence of these kinds of high-end household appliances in China was inevitable.
"Price is not a problem for this group of people. They have money and are willing to spend it on a high-quality lifestyle," he said. "Their biggest concerns are quality and after-sales service so companies should make more effort in these areas."
InSinkErator's Bryant said his company has a good reputation for reliable quality around the world. It also has an after-sales service system in China implemented by dealers.
Wang also said that being "green" is a good selling point in China, where people's awareness of the environment is ever-increasing.
InSinkErator operates in cooperation with local governments, including Shanghai, Tianjin and Caofeidian, in Hebei province, to promote its products, enabling it to lower transportation costs, reduce pollution and increase the garbage recycling rate.

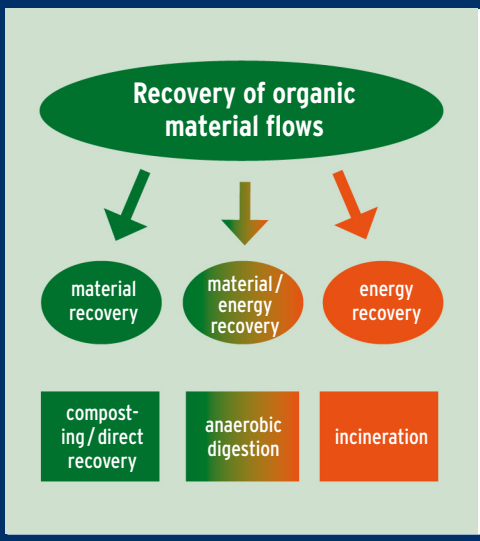
It also set up strategic partnerships with a series of big real estate developers, including China Vanke Co, Green Town Real Estate Co and Shimao Property Holding Ltd, to install its machines in newly built homes.
"So far, around 40 percent of our products are for projects and 60 percent are retailed. We expect the retailing element to surge much higher than the project sector," said Chen of Emerson InSinkErator China.
liujie@chinadaily.com.cn

Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

Umwelt
Bundes
Amt
For our Environment

Ecologically sustainable recovery of bio-waste

Suggestions for policy-makers at local authorities



IMPRINT

Published by: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)
Public Relations Division · 11055 Berlin · Germany
Email: service@bmu.bund.de · Website: www.bmu.de/english

Federal Environment Agency (UBA)
Wörlitzer Platz 1 · 06844 Dessau-Roßlau · Germany
Website: www.umweltbundesamt.de/index-e.htm

Text: Dr. Michael Kern, Thomas Raussen, Thomas Graven (Witzenhausen-Institut für Abfall, Umwelt und Energie GmbH [Witzenhausen Institute for Waste, Environment and Energy]) Dr. Claus-Gerhard Bergs (BMU, Division WA II 4), Tim Hermann (UBA, Section III 2.4)
Edited by: Dr. C.-André Radde, Sabine Neulen (BMU, Division WA II 4 – Municipal Waste)

Design: design_idee, büro_für_gestaltung, Erfurt
Printed by: Bonifatius GmbH, Paderborn

Photo credits: Cover (top left) BRS-Bioenergie GmbH, Villingen-Schwenningen; (top right) Verband der Humus- und Erdenwirtschaft e. V. (VHE), Aachen; (bottom left) Verband der Humus- und Erdenwirtschaft e. V. (VHE), Aachen; (bottom centre) Rupert Oberhäuser/BMU; (bottom right) GrafikHaus Anja Neubauer
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Date: March 2012
First Print: 2,000 copies

1 PREFACE

Germany already excels in the separate collection of bio-waste and its recovery: on average more than 100 kg of bio-waste and green waste are collected separately per person and year, which translates into a total annual amount of around nine million metric tons.

Until a few years ago, large quantities of these materials were still deposited in landfills as part of the residual unsorted waste. However, biodegradable waste at landfill sites was the key factor in the generation of greenhouse gases attributable to waste management. The turning point with regard to the waste management sector's climate impacts was reached with the separate collection of bio-waste and the removal of the remaining biodegradable elements in the residual waste through pre-treatment: the annual emissions of greenhouse gases, expressed in CO_2 equivalents, have been reduced by approximately 56 million metric tons compared with 1990 levels. That represented almost 25 percent of the total reduction in emissions of greenhouse gases achieved in Germany until 2006.

In addition, composts made from separately collected bio-waste and digestates provide an excellent opportunity to stabilise or improve the humus content of soils and to promote biological activity. Composts or composted digestates also make superb peat substitutes.

Environmental life-cycle assessments conducted in recent years have shown that optimised recovery of bio-waste can contribute yet further to protecting the climate and conserving resources.

Rotting tunnel at a composting facility

The future consequence will be that suitable bio-waste will be more used for producing energy. The new German Renewable Energy Sources Act (EEG 2012) is supporting this development with its Section 27a, which establishes specific regulations governing bio-waste. Under the Act, if electricity is generated by facilities using biogas produced by anaerobic digestion of bio-waste this electricity attracts a higher subsidy rate than if the biogas is produced by digesting other types of biomass. The precondition to this preferential treatment is that the anaerobic digestion facility is connected to a following composting stage. However, not all bio-waste is suited for anaerobic digestion or incineration, so that the exclusive composting of bio-waste without energy recovery will also continue to play an important role in the future.

In order to provide guidance in optimising bio-waste collection and use especially for local policy-makers, this booklet sets out the potential in bio-waste and the technical processes currently available for using the various categories of bio-waste. Furthermore, with the aid of a checklist local policy-makers can estimate whether optimising bio-waste recovery is practical in terms of increasing the amounts collected or the quantity of energy generated on site.

This booklet is partly based on the results of a study commissioned by the German Federal Ministry for the Environment (BMU) and the Federal Environment Agency (UBA). Although the booklet is aimed predominantly at users in Germany, it should be pointed out that the Ministry for the Environment has also set itself the task of boosting the concept of ecologically sustainable recovery of bio-waste in other countries. Also for this reason the ministry has strenuously pursued the aim of an EU bio-waste directive.

Already in May 2006 the political debate about the need for an EU bio-waste directive was restarted on Germany's initiative. The drive towards a discrete regulation for bio-waste gained strong political support from several Member States.

As a result of this alliance, a discrete Article of the EU Waste Directive 2008/98/EC commits Member States to promote the separate collection and recovery of bio-waste. The European Parliament also recognised the opportunities provided by bio-waste earlier on and is supporting EU-wide regulation of the recovery of separately collected bio-waste. Although there are hardly any other fields of climate and environmental policy where so much climate and environmental benefit can be achieved with relatively little expense, the European Commission still has no plans to formulate a specific EU bio-waste directive. Nonetheless, the Commission is actually moving ahead in this important sector of waste management. In its "Communication to the Council and the European Parliament on future steps in bio-waste management in the European Union" of May 18th 2010 it has set out an ambitious vision for the optimisation of bio-waste collection and recovery.

2 INTRODUCTION

The German government is aiming to reduce emissions of greenhouse gases in Germany, until 2020 at the latest by 40 percent against 1990 levels. This is a target that can only be reached by means of a sustainable energy sector – based on energy reduction, renewable energy generation and efficient energy use. In view of this ambitious target it is important to examine how waste management and within it also bio-waste can provide a further contribution to meeting the targets of resources, energy and climate in the future.

Waste management is already providing a substantial annual contribution to meeting climate targets with a reduction in emissions by approximately 56 million metric tons of CO_2 equivalents per year compared to 1990 levels. This has also been achieved by the waste separation in households that has been established more than two decades ago. The system of separate collection and treatment of bio-waste and green waste is one of the most advanced in Europe.

In the context of further efforts to produce renewable energy, for example from energy plants, whose cultivation is sometimes in competition with food and fodder production, combined material and energy recovery from bio-waste and green waste is now of particular interest.

Sustainable management of biogenic material flows combines material and energy recovery paths with the aim of optimising the integration of nutrients and carbon recycling, energy production, CO_2 reduction by replacing fossil fuels and cutting the demand for peat, as well as lower treatment costs with the expansion of local value added. What form optimised collection and recovery of bio-waste can take, what additional potential exists, the investments required

Whether energy crop or bio-waste, the material and energy recovery paths are similar.

Lawn cuttings as source material for compost of high quality

and how the benefits relate to the costs have become key questions for waste management, which are presented in this document.

It is not a question of seeking to promote particular processes such as composting, anaerobic digestion or thermal treatment, but of tapping the potential for use of each bio-waste type as far as possible and to that end employing the optimum combination of processes in each case.

In 2007 the German Advisory Council on the Environment (SRU) established that every year around 100 million metric tons of "biomass residues", i.e. bio-waste and similar materials are generated in Germany from areas such as forestry, agriculture or sewage and waste management. Of this about 65 percent could be technically and ecologically useful. This has a potential of four to five percent of the country's primary energy requirement. High priority should be given to exploiting this potential, a major proportion of which falls within the sphere of responsibility of local authorities.

The Federal Ministry for the Environment (BMU) already stressed in its discussion paper on ecological industrial policy (2008) the importance of expanding bio-waste collection and the use of this resource as a tool in the interest of climate change.

The EU Waste Framework Directive of December 2008 also underscores the need to make better use of bio-waste. The Directive prescribes in Article 22 that Member States shall take appropriate measures to encourage the separate collection of bio-waste with a view to their composting and anaerobic digestion.

The BMU has turned the EU Waste Directive 2008/98/EC into German law by means of the amended Closed Substance Cycle and Waste Management Act (KrWG) of February 24th 2012. The pivotal element of the new Act is the five-tier waste hierarchy given by the EU Waste Framework Directive: prevention; preparing for re-use; recycling; other recovery, e.g. energy recovery; and disposal. In future German waste management legislation will give more priority to recycling. In addition, the Act provides various measures designed to boost material recovery overall.

To that end, Article 11 (1) KrWG stipulates that, as a matter of principle, separate collection of bio-waste is to be mandatory from January 1st 2015 onwards. Further provisions can be established by statutory ordinance. These can determine, for instance, which wastes are to be considered bio-waste, which standards are to apply to separate collection and to treatment, and which criteria are to govern bio-waste recovery. Furthermore Article 12 KrWG establishes further quality assurance requirements applicable to bio-waste recovery processes, in order to ensure that such recovery follows proper procedures and causes no harmful impacts.

Anaerobic digestion plants

CASE STUDY: MUNICH WASTE MANAGEMENT COMPANY

Since the early 1990s AWM, the Munich municipal waste management company has led the field in sustainability and climate protection with an environmentally oriented concept for reducing and recovering waste.

Central to this is the universal separate collection of bio-waste. Since the introduction of the bio-waste bin the amounts collected have risen steadily, partly as a result of intensive publicity, to around 42,000 metric tons in 2011. Furthermore roughly 15,000 metric tons of garden waste can be added that has been deposited at citizens' recycling centres.

From compost heap to hi-tech facility

In the early years the main recovery path for bio-waste was via conventional composting plants. In 2003 an anaerobic digestion stage (dry fermentation by batch process) was added, which was expanded to a recovery capacity for around 25,000 metric tons of bio-waste by 2008. The aim was to have an ultra-modern process for the production of biogas as a climate-friendly fuel prior to the composting facility.

Clean energy for 1,000 households in Munich

The biogas obtained is used in the integrated cogeneration plant to produce electricity and process heat and is sufficient to provide electricity to 1,000 Munich homes all year round.

Premium potting soil for everyone in Munich

AWM uses the digestates – around 18,000 metric tons a year – to make 8,800 metric tons of compost, which is used in horticulture and to manufacture seed compost and premium potting soil. What is especially pleasing about the introduction of premium potting soil from Munich is the realisation of a cycle concept: the people of Munich bring their garden waste to the recycling centre and can take ready-made potting soil home with them.

AWM's overall contribution to climate protection

The dry anaerobic digestion plant in Munich is an example of the use of innovative technologies in the recovery of bio-waste.

With the subsequent implementation of the environmental waste management plan AWM has in the last ten years succeeded in making a significant contribution to CO_2 reduction and thus to cutting greenhouse gases. The encouraging outcome of this is that municipal waste management in Munich is contributing to greenhouse gas limitation with 822,000 metric tons of CO_2 equivalents annually. That equates roughly to the global warming potential caused by around 62,000 residents in one year.

Municipal waste management and sustainability

"With this result AWM proves beyond doubt that the environment and the economy complement each other admirably, and precisely in municipal waste management. Through long-term investment in new environmental technologies the public-sector waste management entities are not only guarantors of safe waste management, but also of targeted development in waste management towards sustainability and climate protection," declares Helmut Schmidt, deputy works manager at AWM.

Advanced strategies mean lower charges

Despite major investment in new technologies AWM was able to reduce the waste collection fees three times in succession in recent years. That means that ambitious environmental schemes and innovative plant technology can be very successfully combined with economic efficiency and socially acceptable charges.

3 QUANTITIES AND QUALITIES OF ORGANIC WASTE

3.1 Collection and quantities of organic waste

Every year considerable quantities of bio-waste from various sources are accumulated across Germany. The most important of these are discussed briefly here.

3.1.1 Bio-waste and green waste

Public-sector waste management entities, i.e. local authorities and waste disposal associations, have direct access to

- bio-waste from bio-waste bins and
- green waste (from parks and gardens)[1].

Separate collection of bio-waste and green waste from households is carried out in various ways. Typically they are collected in a bio-waste bin at the resident's home. In addition the separate collection of green waste, for example at citizens' recycling centres or by kerbside collection, is widespread.

However, despite a great deal of willingness on the part of residents to separate their bio-waste and green waste, the collection systems have not been introduced universally throughout the country.

There are 96 municipalities (out of a total of 405) which do not provide their residents with any bio-waste bin at all. This affects around 14.3 million people. 67.5 million people live in regions where bio-waste bins have been introduced. However, the actual level of affiliation is around 56 percent on average in these regions, so that approximately another 30 million Germans have no access to a bio-waste bin.

Therefore, in total almost 44 million citizens across Germany, that is more than half the people in the country, do not use a bio-waste bin.

This means that a considerable proportion of bio-waste is still disposed of via residual unsorted waste treatment and thus is only used inadequately or not at all. The resulting destruction of resource and energy potential contradicts the aims of sustainable resource use.

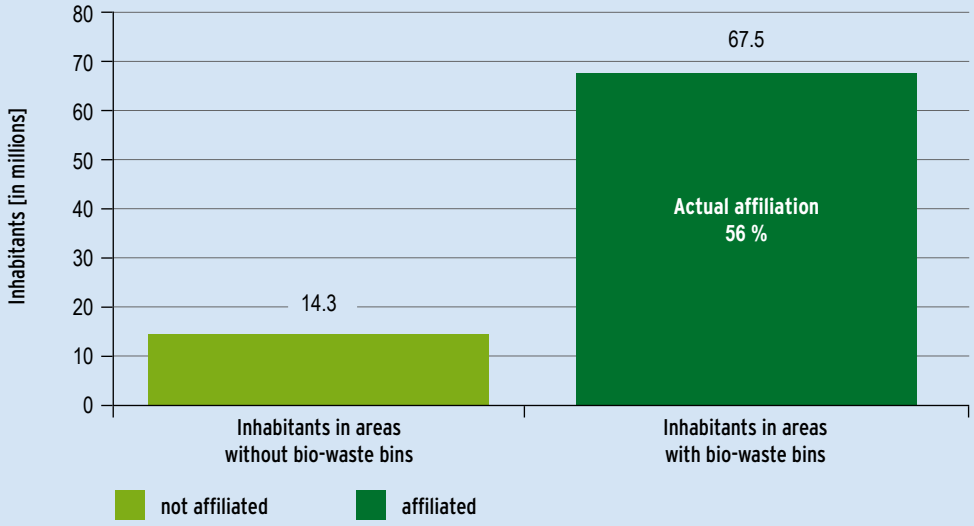
Analyses of municipal residual waste show that bio-waste and green waste in the order of 4 to 5 million metric tons can still be found in the German domestic residual waste, of which almost two million metric tons per year could be extracted by suitable methods.

1 A precise definition of types of waste can be found in the glossary at the back of the booklet.

Green waste collected selectively

Bio-waste from a bio-waste bin

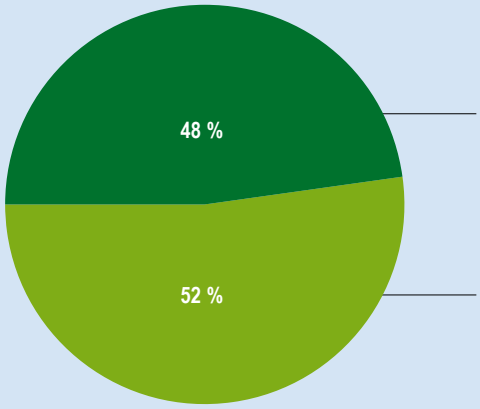
Affiliation to a bio-waste bin



Source: Federal German states waste inventories 2010 (NRW and Thuringia 2009)

Public-sector waste management municipalities without bin or ≤ 5kg /res*a organic waste are regarded as not affiliated

Percentage of separate collected bio- and green waste of the total amount of bio-waste



Total amount collected in 2010:
8,902,739 metric tons

4,272,135 t bio-waste (bio-waste bin)

4,630,604 t green waste

Source: Federal German states waste inventories 2010 (NRW and Thuringia 2009)

Bio-waste sorted out from a residual waste bin

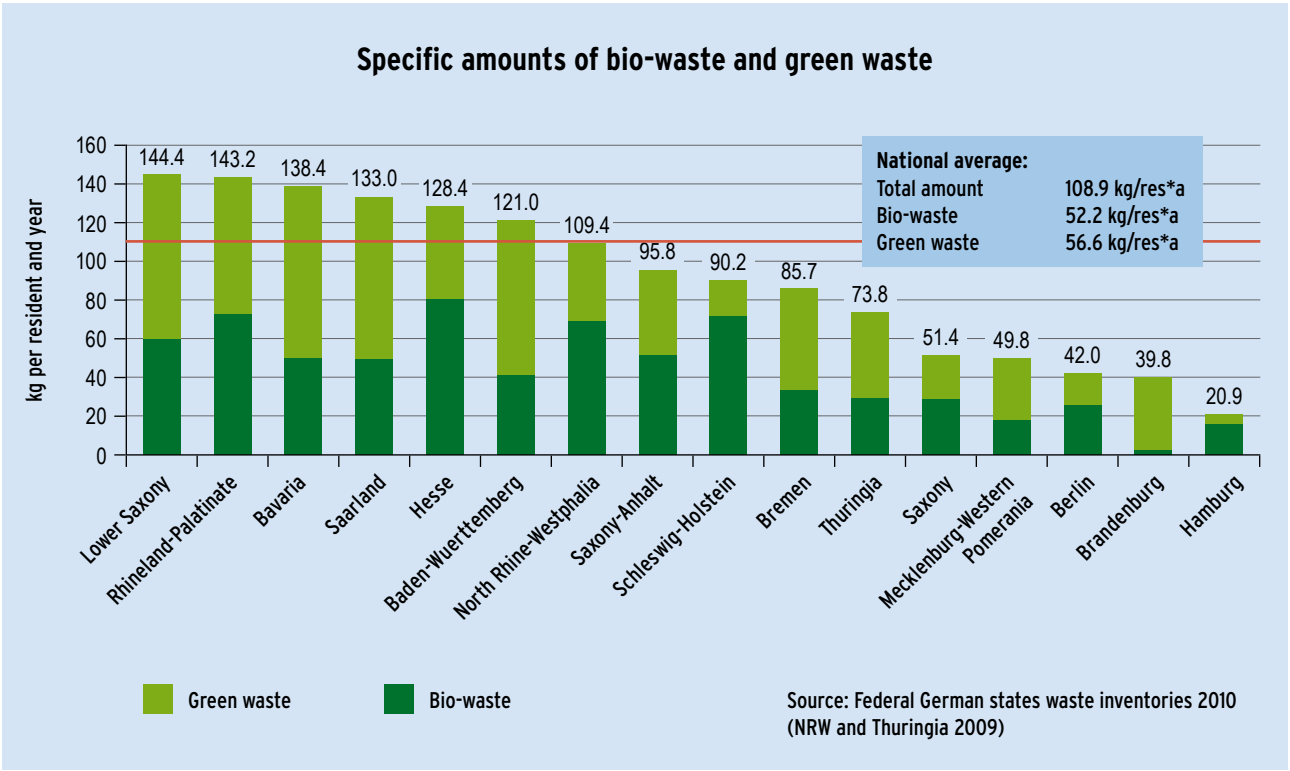
Despite the optimisation potential described, around 8.9 million metric tons of bio-waste and green waste are already collected from households annually and taken for material and/or energy recovery. That equates to approx. 21 percent of the household waste generated in Germany in 2010, which totalled approx. 43 million metric tons (Federal Statistical Office, 2012).

Public-sector waste management municipalities providing a bio-waste bin in Germany in 2010

Municipalities without bio-waste bin or ≤ 5kg /res*a

Source: Witzenhausen-Institut

Baden-Württemberg = Baden-Wuerttemberg
Bayern = Bavaria
Hessen = Hesse
Mecklenburg-Vorpommern = Mecklenburg-Western Pomerania
Niedersachsen = Lower Saxony
Nordrhein-Westfalen = North Rhine-Westphalia
Rheinland-Pfalz = Rhineland-Palatinate
Sachsen-Anhalt = Saxony-Anhalt
Sachsen = Saxony
Thüringen = Thuringia



3.1.2 Landscape maintenance material

The data situation for landscape maintenance material appears somewhat less certain. Nevertheless, one can assume that between one and three million metric tons of herbaceous and ligneous material are generated annually in Germany from maintenance work along roads and railway lines and around water bodies. The materials emerging from maintenance work performed for nature conservation purposes cannot be quantified at present.

Potential of landscape management residues

Maintenance waste materials	theoretical potential [t solid matter per year]		technical potential [t solid matter per year]	
	ligneous	herbaceous	ligneous	herbaceous
Roadside vegetation	900,000	1,100,000	250,000–550,000	100,000–150,000
Vegetation beside railways*	580,000	150,000	23,000–35,000	figures not available
Riparian vegetation	figures not available	figures not available	20,000	figures not available
Driftwood**	50,000		25,000	
Total	1,530,000	1,250,000	318,000–630,000	100,000–150,000

*) Annual amount until the end of 2014, from then onwards theoretical potential < 200,000 t solid matter per year

**) Extrapolation: water content 60 %

3.1.3 Other organic waste from industry and commerce

Apart from the waste mentioned other organic substances occur in industry, commerce, trade or agriculture which are used by recovery plants. These include for example leftover food from restaurants and large kitchens (e.g. canteens, hospitals and refectories), waste from the grocery trade, and production residues from food manufactures. Common to all of these is that they do not have to be collected by public-sector waste entities. Their collection and recovery is organised mainly by private-sector companies and will not be considered in further detail in this booklet.

Résumé:

- Currently, for each person in Germany, approximately 52 kilograms (kg) of bio-waste and 57 kg of green waste from parks and gardens are collected separately each year, with many regions collecting considerably larger amounts.
- In a number of regions biobins are not provided or only made available in some areas, which means that more than half of the citizens of Germany have no biobin.
- Further extraction of almost two million metric tons bio-waste and green waste from the residual waste is possible using appropriate methods.
- Expansion of separate collection of bio-waste and green waste, together with the materials coming from landscape maintenance, provides an opportunity to conserve fossil fuels and produce fertilisers and soil improvers.

3.2 Composition and qualities of bio-waste and green waste

Composition of waste from biobins

The composition of waste from biobins alters during the year: for one thing, the different elements of green waste from private gardens are reflected in the bins, and for another, people's consumer behaviour can be "read" from them. Whereas for example in summer more bones occur in the waste bin (barbecue waste), in winter there are more quantities of citrus fruit peel.

In winter the relative proportion of impurities in the biobin is larger, as the diluting effects of green waste are less evident than in the vegetation period. The occasional piece of plastic film that is particularly noticeable only represents a minute proportion of the total weight and can be filtered out relatively easily. However, the entry of this sort of impurity can be an indication of inadequate separation and sorting habits.

For this reason information for residents about the correct separation of materials is of considerable importance – moreover, the publicity must be adapted to the target groups. Many local authorities have had positive experiences with information geared to target groups. Examples of this are special campaign days, collaboration with the local press and also foreign language brochures.

Impurities in bio-waste

Ligneous green waste

Furthermore, the way waste collection is organised and the provision of targeted public information can considerably reduce the occasionally discussed issues of odours, flies and maggots.

Composition of green waste

The quantity of green waste and its composition is also subject to seasonal variation: the largest amounts are recorded during the vegetation period into autumn. Herbaceous material such as grass cuttings and "weeds" forms a relatively constant part of it during the growing season, while ligneous materials such as shrub and tree prunings occur mainly in winter and spring.

The same applies to waste materials from landscape maintenance.

Qualities of separately collected bio-waste and green waste

Whether the quality of separately collected bio-waste and green waste is more suitable for recovery by composting, anaerobic digestion or incineration depends, apart from the input material, on the collection system, the size of container and the regional structure.

Thus for example biobins in high-rise buildings contain mainly damp or wet kitchen waste, whereas the proportion of green waste rises with the drop in housing density and the corresponding increase in garden size.

In the case of waste from parks and gardens, it is possible to produce wood fuel from the ligneous material collected in winter. The fine material and the material collected in summer should be composted and/or anaerobically digested.

Résumé:

- The composition and quality of the biogenic waste flows varies according to the season.
- Targeted and sustained public awareness-raising work is absolutely essential in order to increase the amounts that can be collected, guarantee and improve quality and reduce the proportion of impurities.
- Bio-waste and green waste as well as materials coming from landscape maintenance are often suitable for material and/or energy use. From an energy and climate perspective the combination of different recovery paths mostly makes sense.

3.3 Possible ways of increasing the collection rate

This has already been referred to: theoretically there is still much untapped potential in bio-waste and green waste in household residual waste. Why should one consider the separate collection and use of the largest possible parts of this potential?

Two essential reasons

1. The separately collected organic waste can be used well for material and energy recovery and therefore can contribute to the conservation of mineral fertiliser reserves, peat and fossil fuels.

2. The amount of residual waste with comparatively higher treatment costs will be reduced.

The introduction or expansion of separate collections in regions without or with only limited access to biobins is fundamental. In areas with separate collections there is scope for introducing measures to raise the collection quotas and improve the quality of the material flows.

Goals to achieve

- Extraction of bio-waste and green waste from residual waste as far as possible

- Optimisation of the material and energy recovery potential by separation of the bio-waste flows for the most appropriate recovery procedure in each case.

Besides uncontrollable factors like seasonal variations, success depends amongst other things on the following specific circumstances:

Structure of the collection district
The lower the population density, the larger is the amount of generally good quality material collected. However, it should also be noted that in rural districts a comparatively high proportion of residents make their own compost.

Compulsory affiliation and use
Higher affiliation quotas result in higher collection quotas. However, the compulsory introduction of biobins involves the risk of larger amounts of impurities, especially in very dense settlement structures (town centres). In more rural areas it makes sense to permit controlled exceptions, such as home composting. In contrast, in very built-up areas it is important to examine whether the amount of impurities in the collection containers does not increase disproportionately with rising population density and whether certain areas ought to be excluded from separate collections.

There are, however, also positive examples such as that of the city of Munich, which show that with appropriate measures the quantity and quality of collected material can be increased in large residential areas as well.

Successful separate collection of bio-waste requires intensive publicity, especially in big cities.

Charging system
The most important way to achieve an increase in the amounts of bio-waste and green waste collected is through the charging system. If there is no compulsion to provide biobins, direct or indirect financial incentives to use the bins voluntarily should be considered. For example, these can be a reduction in residual waste charges for participating in bio-waste collection or the creation of a standard refuse charge without additional costs for the biobin. Various studies have shown that waste charges tailored to the specific types of waste producer can influence behaviour.

Charges based on the amount generated can be calculated using stamp or identification systems where the quantity to be disposed of is logged for each individual household and the costs are based on the actual amount of waste produced. Through such a use-based charge for emptying the unsorted residual waste bin, these systems contribute to the conscious use of the biobin for organic waste. In addition, if the collection of bio-waste is also charged by quantity, this can lead to less ligneous material being deposited in the biobin. In this case a good green waste service is a requirement, such as cluster collections of garden waste or the provision of local collection points.

However, there are no patent solutions for all types of district structure; too attractive financial incentives for biobins can also result in an increase of impurities.

Increasing the amount of green waste collection
In the case of kerbside collections of green waste from households the frequency of service can be increased and possibly the restrictions on quantities reduced. Where collection points or citizens' recycling centres are in operation, the number and accessibility of these and the opening hours are key to unlocking the potential held by green waste.

The necessity for local "bonfire days", i. e. days when burning garden waste is permitted on one's own land, should be examined critically. Restricting the burning of garden rubbish in places where it is still allowed can lead to an increase in the quantity of waste collected and can furthermore contribute to clean air and climate protection.

Public awareness-raising
Common to all these steps is that they must be accompanied by targeted publicity, aimed at specific demographic groups such as children and teenagers or foreign residents. Key elements of public awareness-raising work may include

- An explanation of the purpose of separate collection and correct waste separation
- Information about recovery paths
- Advertisements for using locally produced compost
- Information about possible uses of compost and composted digestates
- Getting people and institutions to spread the message

Résumé

- The introduction of the biobin and the provision of bins to households who previously had no access to them is generally environmentally and economically beneficial.
- The creation of a charging system appropriate to the collection structure of each district is useful, preferably with the introduction of charges for unsorted waste and biobins which fairly reflect usage.
- A broad-based green waste collection system should be established, accompanied by a bonfire ban where appropriate.
- Exceptions to the separate collection of bio-waste should only be permitted in justified cases.
- Targeted awareness-raising is an essential tool for increasing the quantity and quality of separately collected bio-waste and green waste.

Biobins

4 RECOVERY METHODS OF THE COLLECTED MATERIAL FLOWS

What happens to the separately collected bio-waste and green waste? Since the 1980s mechanical composting facilities have operated successfully in Germany for bio-waste and green waste. Not long afterwards the first anaerobic digestion plants came in operation as well, although not in the same large number. Recently, as energy prices have risen, ligneous material has been extracted from green waste to make into fuel.

4.1 Composting processes

Composting is a biological decomposition process for organic waste, in which the material is broken down by microbes and micro-organisms under aerobic conditions. The end product is compost, an organic plant nutrient and humus supplier.

Originally practised by amateur gardeners in their own gardens, composting has been used as a method of bio-waste treatment on a large industrial scale in Germany since the middle of the 1980s.

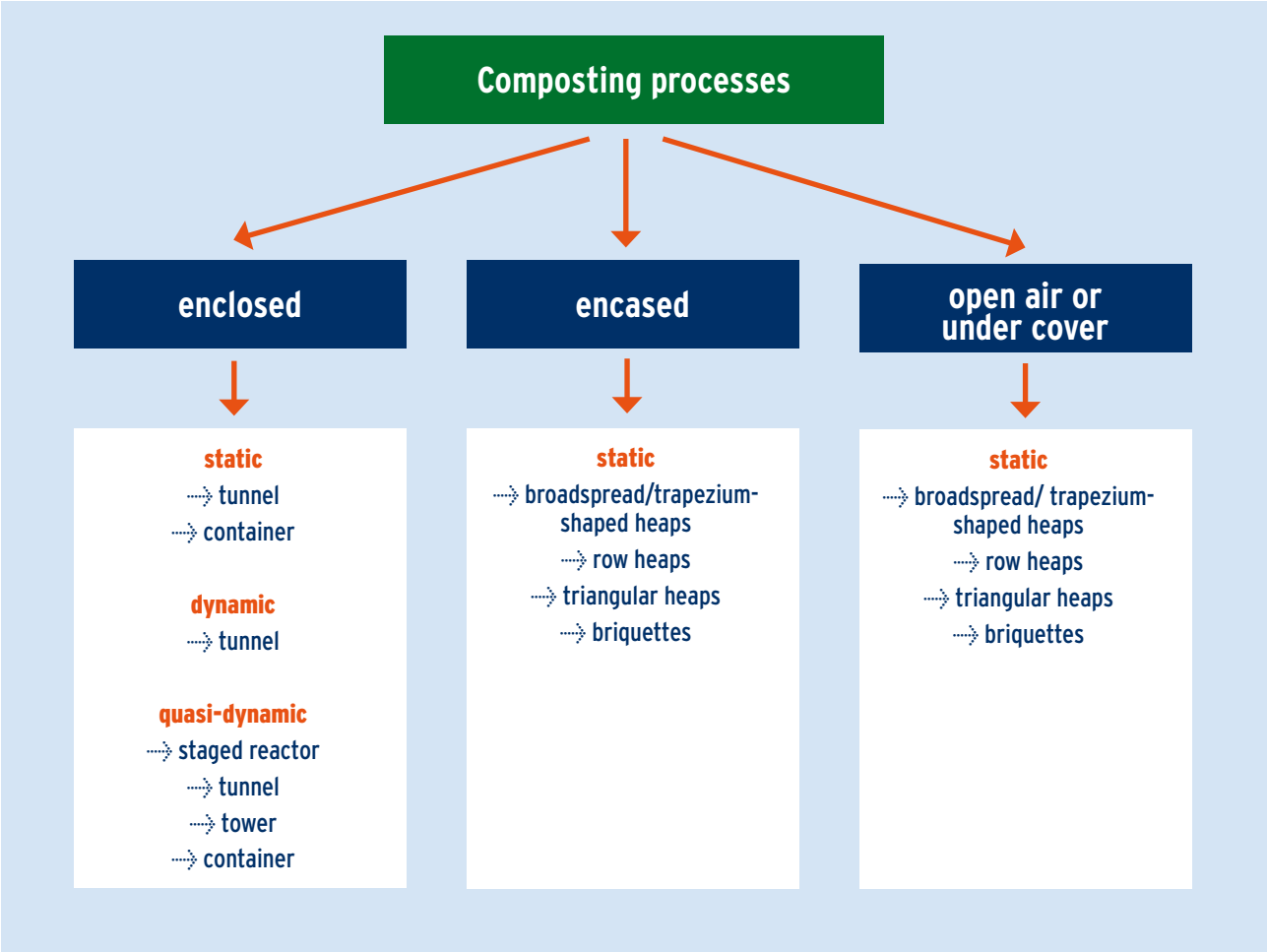
A thermo composter

The mechanical composting processes applied can be divided into various categories:

- composting in heaps (triangular, trapezium-shaped or flat stacks)
- composting in bunkers/containers
- row/tunnel composting
- composting as briquettes
- other systems

The processes differ in the way the heaps are constructed (open, covered, in containers), the type of ventilation and also the duration of the intensive rotting stage and the maturity of compost desired. If the intensive rotting system is set up for mature compost, the main and subsequent rotting phases are integrated. If the intensive rotting results in sanitized fresh compost, a second rotting stage can follow to achieve a higher degree of decomposition. In composting facilities the second stage is carried out predominantly in flat or triangular heaps.

The following diagram provides an overview of possible processes:



Intensive rotting under a semi-permeable membrane

View inside a composting container

At present nearly one thousand composting plants (of more than 1,000 metric tons throughput per year) are operating in Germany, with a total capacity of more than ten million metric tons. Of these, half are plants processing exclusively green waste and half treating both bio-waste and green waste.

The amount of bio-waste and green waste collected at present totals 9 million metric tons. This compares with the approximately ten million metric tons' processing capacity, so that even if the collection network is expanded, recovery of the additional quantities is guaranteed.

Composts are eminently suitable for use as soil improver in agriculture and recultivation but also for producing substrates and ready-to-use blended soils.

Processing the finished compost

CASE STUDY: WITZENHAUSEN COMPOSTING PLANT

Firstly, the composting plant at Witzenhausen shows that even with a fairly small input capacity of 5,000 metric tons per year high-grade compost can profitably be produced. Secondly, this plant is more or less the birthplace of mechanical composting in Germany and Europe. From 1983 onwards the first attempts at composting on an industrial scale in the country were carried out at this site by the University of Kassel at Witzenhausen.

The collected bio-waste is mixed with structural material, i.e. shredded green waste, prior to composting. This mixture is put on a covered rotting surface in triangular heaps about two metres high and thirty metres long. These are then turned twice a week with a mobile turning device. Regular temperature checks ensure a rotting process which guarantees complete pathogen reduction of the finished products. After seven or eight weeks of rotting the material is sifted and ready to use. What remains after sifting is returned to the biological process. The superior composts with the RAL quality guarantee produced in this manner are mainly distributed to agriculture in the region, but are also bought in fairly large quantities by amateur gardeners. In addition, bark mulch and high-grade potting composts are available at the plant for sale to the public.

"The composting plant at Witzenhausen is especially important to us," stresses Dirk Hesse, managing director for the operator Vogteier Kompost GmbH.

Capacity:	5,000 t bio-waste and green waste
Start-up date:	1991
Processing technology:	Composting in covered heaps, mobile turner, sifting machine, mechanical shredder, wheel loader
Employees:	2
Duration of intensive rotting:	7–8 weeks
Products manufactured:	Fresh and mature compost
Customer base/market:	Soil and compost suppliers, amateur gardeners, agriculture, local authorities
Contact:	Vogteier Kompost GmbH Kompostanlage Witzenhausen Am Burgberg | D-37213 Witzenhausen Tel.: +49 5542 71320 | Fax: +49 5542 71490 | Email: vogteier-kompost@tupag.de

CASE STUDY: WESTHEIM COMPOSTING PLANT

"We believe in quality, that's why our products don't just sell well to amateur gardeners, but to horticulturalists and landscapers too, as well as soil suppliers, fruit-growers and the local winegrowers. On top of that our composts appear in the list of products for use in organic farming," declares sales manager Ralf Schöppenthau with satisfaction.

Westheim composting plant started operating in 1999. 28,000 metric tons of bio-waste and green waste can be recovered annually into superior quality-assured compost suitable for organic farming.

In order to aerate the bio-waste properly, it should as far as possible have a loose homogeneous structure and be free from impurities. For this reason it undergoes mechanical pre-treatment in the preparation hall. After shredding and mixing the waste, sifting and removal of metals and other impurities takes place. The air in this hall is constantly extracted (negative pressure). This air stream is pumped through the floor of the rotting hall and aerates the waste. The bio filter minimises emissions from the air extracted from the rotting hall.

The intensive rotting process takes place in the rotting hall. Composting is carried out on ten heap areas, each 27 m wide and 6.5 m long, using a heap moving system. The "Wendelin" ("rotator"), the heart of the plant, turns the waste completely automatically. As the waste is turned it is watered. The rotting process is controlled by aerating and watering as necessary.

A well-developed water management system does not require connection to the public fresh and waste water system. The compost produced is removed from the rotting hall by wheel loader after eight to ten weeks and sifted to 10 mm.

Capacity:	28,000 t bio-waste and green waste
Start-up date:	1999
Process technology:	Bühler Wendelin, encased
Employees:	4
Duration of intensive rotting:	8–10 weeks
Product manufactured:	Quality controlled, 10 mm fresh and mature compost approved for use in organic farming, green waste 30 mm
Customer base/market:	Soil and compost suppliers, vegetable and wine growers, arable farming, landscaping, amateur gardeners, organic farming
Contact:	SITA Kompostwerk Westheim Zeiskamer Schneise | D-67368 Westheim Tel.: +49 7274 70290 | Fax: +49 7274 702920 Email: info@kompostwerk-westheim.de | Website: www.kompostwerk-westheim.de

CASE STUDY: RATINGEN-LINTORF COMPOSTING PLANT

All operational conditions have been created by the plant's operating company, KDM, to process organic waste from biobins, separate green waste collections and waste from gardening, landscaping and cemeteries etc. into high-quality, RAL-labelled compost.

In addition a modern composting plant with completely enclosed fully automated row composting has been constructed at the Ratingen-Lintorf site, where up to 50,000 metric tons of organic residues are processed annually into marketable composts. For preparation and production the material is shredded and sifted, metals are removed with an iron separator and finally it is sorted by hand (impurities > 60mm). Fresh and mature composts are produced.

To market the products a comprehensive network has been set up at a number of sites in the Mettmann district near Dusseldorf. This network consists of local sales points, garden centres and the company's own sites and is being constantly expanded.

"Our principal aims in recycling are a guaranteed high-quality end product for the consumer and on top of this an optimum method of dealing with organic material flows in the interests of sustainable climate protection and resource conservation," says managing director Dietmar Steinhaus. *"With this in mind we are currently considering whether to extend the composting plant to include an anaerobic digestion stage, in order to use the energy as well as the material potential of bio-waste."*

Furthermore, KDM has concentrated its activity in recent years on the processing and marketing of materials recovered from green waste and on timber as feedstock for energy production in biomass-fired combined heat and power plants. Woodchips, unseasoned wood, off-cuts etc. are used by KDM to produce high-grade fuels for woodchip-fired heating systems.

Capacity:	50,000 t (composting plant) bio-waste and green waste, 60,000 t (wood facility) seasoned and unseasoned wood
Start-up date:	1997/2009
Process technology:	Completely enclosed, automated row composting with automated turning
Employees:	16
Duration of intensive rotting:	approx. 4–5 weeks
Product manufactured:	Fresh and mature compost
Customer base/market:	Soil and compost suppliers, private gardeners, agriculture, local authorities
Contact:	KDM – Kompostierungs- und Vermarktungsgesellschaft für Stadt Düsseldorf/Kreis Mettmann GmbH Lintorfer Weg 83 | D-40885 Ratingen Tel.: +49 2102 30 22-0 | Fax: +49 2102 30 22-222 Email: info@kdm-gmbh.com | Website: kdm-gmbh.com

4.2 Anaerobic digestion processes

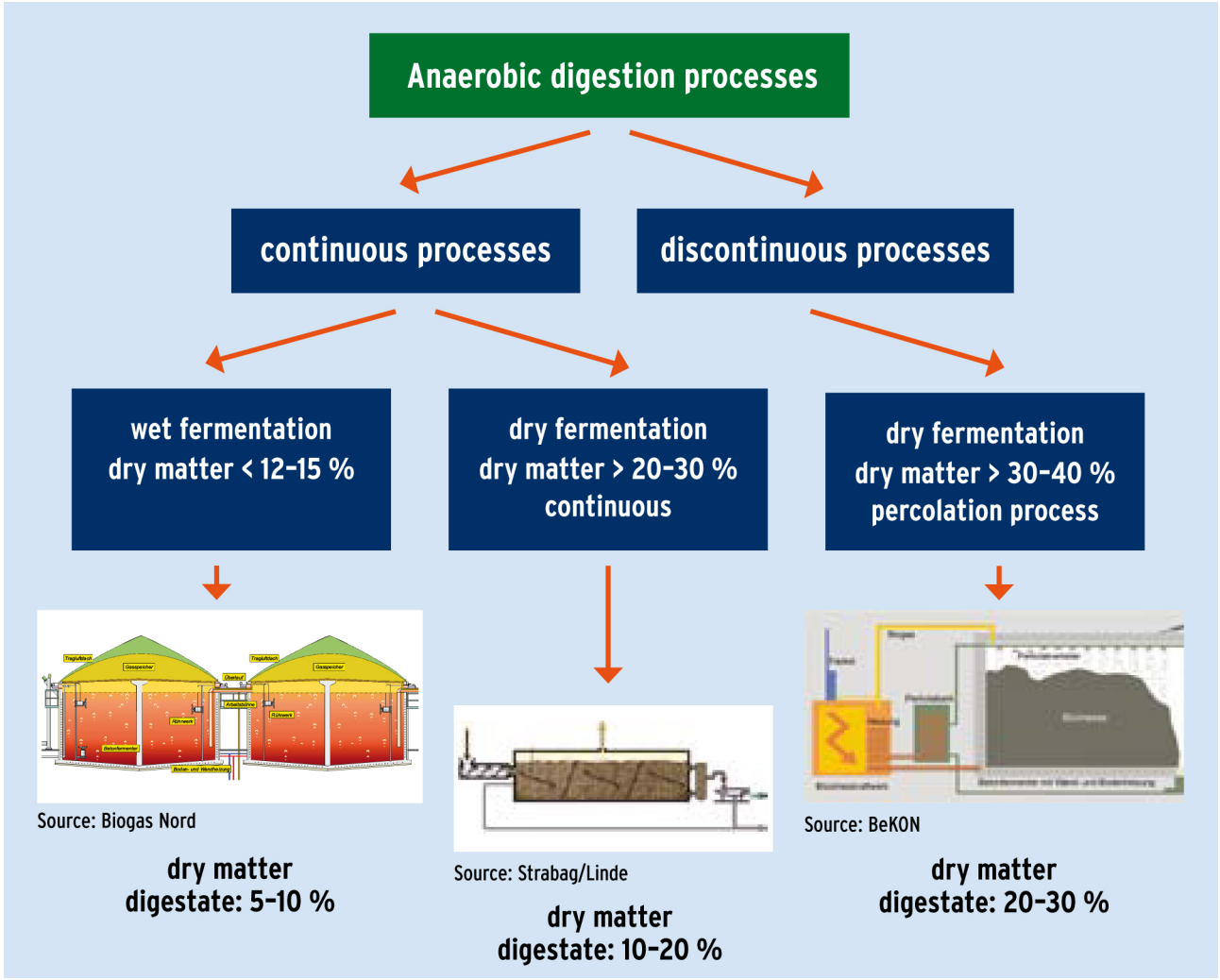
In contrast to composting facilities, bio-waste anaerobic digestion plants can also recycle liquids and paste-like material.

Unlike composting, the biological decomposition processes occur in the absence of oxygen. The most important end product of anaerobic digestion, besides a nutrient-rich digestate that can be used as a digestate product in liquid or solid form in agriculture and related areas, is biogas. Biogas can be used mainly in electricity and heat production.

Wood and other ligneous materials such as hay or straw are unsuitable for this recovery path, as the anaerobic micro-organisms hardly break these down in the anaerobic digesters.

Separately collected bio-waste as well as food scraps and the herbaceous parts of green waste, on the other hand, are generally well-suited to anaerobic digestion.

Fermenter plus biofilter



There are several thousand anaerobic digestion plants in Germany, although most are mainly intended as agricultural facilities for fermenting liquid manure and energy crops.

Digestion capacity for bio-waste is still being built up. By early 2012 around 100 sheer bio-waste digestion plants were in operation in Germany.

An important feature for distinguishing between anaerobic digestion processes is the method of operation. There are continuous and discontinuous processes.

In the continuous process bio-waste is automatically fed at regular intervals into the anaerobic digestion reactor (fermenter). This process promotes continuous biogas production of consistent quality.

In the discontinuous process the digesters are filled by wheel loader, then after several weeks they are emptied and refilled (batch operation). Biogas production is not continuous, but parallel connection of several digesters working on a staggered system can largely compensate this.

Discontinuous processes have advantages over continuous methods because of their simpler mechanical reactor systems. On the other hand, the latter require a smaller reactor volume because of their higher space-time yield and can usually be automated better than discontinuous processes.

Per metric ton of bio-waste, depending on the input quality and process, between 80 and 140 cubic metres (m^3) of biogas with a methane content of 50–65 percent is produced. The energy from this equates to 50–80 m^3 of natural gas.

In most cases the biogas is converted directly into electricity (200–300 kilowatt-hours per metric ton [kWh/t] input) and heat (likewise approximately 200–300 kWh/t input) via a cogeneration plant. As an example, an input of 20,000 metric tons of bio-waste per year suffices to operate a cogeneration plant with a rated electrical capacity of 600 kW, producing enough electricity for 1,000 to 1,500 homes. It is also possible to refine biogas to natural gas quality and feed it into the natural gas grid.

The digestates can be used directly in agriculture in liquid form or marketed as a solid digestate product after composting.

A cogeneration unit for energy production at an anaerobic digestion plant

CASE STUDY: DEISSLINGEN ANAEROBIC DIGESTION PLANT

The anaerobic digestion plant in Deisslingen recycles the separately collected bio-waste from the Schwarzwald-Baar-Heuberg region, which is made up of the districts of Rottweil, Schwarzwald-Baar-Kreis and Tuttlingen. The project is an example of successful cooperation between local authorities. The preferred anaerobic digestion technology was only economically viable on the basis of the wastes from all three districts.

The plant was constructed next to the Upper Neckar Joint Waste Water Board sewage treatment works. It is situated conveniently for vehicle access in the middle of the waste management area close to the A 81 motorway to Lake Constance. Anaerobic digestion started in 2005. Each year around 25,000 metric tons of bio-waste are processed. The biogas produced is converted into electricity in a cogeneration plant and fed into the public electricity grid. The surplus heat from the cogeneration plant is used on site to dry municipal sewage sludge. In this way almost the entire energy is used. Waste water can be discharged the short distance into the neighbouring treatment works.

"More than 2,000 homes can be supplied with electricity from our plant," says managing director Eberhard Ludwig.

All the materials to be used for anaerobic digestion are pasteurised by heat treatment. The solid digestates are sold as high-grade, quality-controlled fertilisers to farmers in the region.

Capacity:	25,000 t bio-waste
Start-up date:	2005
System provider:	1) Schwarting Umwelt GmbH i.I. 2004; 2) RosRoca Internacional, S.L., Ostfildern-Nellingen
Electrical output:	950 kW_{el}
Biogas production:	~ 3,300,000 Nm^3/a
Electricity production:	~ 5,700,000 kWh/a
Energy use:	Fed into public electricity grid; drying sewage sludge
Use of digestates:	Agricultural fertiliser
Contact:	BRS Bioenergie GmbH Eberhard Ludwig Tel.: +49 7721 92820 | Fax: +49 7721 928272 Email: ewl@brs-recycling.de

CASE STUDY: ERFURT DRY FERMENTATION PLANT

In 2009 a modern organic recycling plant was brought into service at the Erfurt-Schwerborn landfill site. Annually 18,200 metric tons of bio-waste can be converted in the dry fermentation plant into clean energy for more than a thousand homes.

Bio-waste with a high content of dry material can only be added in small quantities in conventional wet digestion plants. The process known as "dry fermentation" on the other hand allows the methanisation of bulky biomass from farming, bio-waste and local amenity sites without having to convert the materials into a pumpable liquid substrate. This makes the digester resistant to impurities such as plastic film and ligneous and fibrous components.

"Our company's extensive provision for environmentally sustainable waste management is being expanded further through the new organic recycling plant in the interests of creating a closed cycle," reports managing director Andreas Jahn. *"By embracing this biogas technology the Erfurt city works group is leading the way in the use of alternative energies."*

Certified compost for the farmers of Thuringia is produced from the digestates. The biogas plant is not only a sustainable waste management measure, but also makes an important contribution to climate protection with the energy generated. The new organic recycling plant replaces the open composting of Erfurt's bio-waste.

Capacity:	23,500 t bio-waste
Start-up date:	2009 (2008 trial operation)
System provider:	BEKON Energy Technologies GmbH & Co. KG
Electrical output:	660 kW_{el} (2 engines of 330 kW)
Thermal output (utilisable):	800 kW (2 engines of 400 kW)
Biogas production:	1,761,714 Nm^3/a (2011)
Electricity production:	3,424,772 kWh/a (2011)
Heat production:	4,305,630 kWh/a (2011); of which extracted from cogeneration: 3,104,270 kWh/a (2011)
Energy use:	Fed into Erfurt's electricity grid
Use of digestates:	Production of certified compost (2 post-rotting phases after dry fermentation, sifted to remove impurities)
Contact:	B & R Bioverwertung & Recycling GmbH | Herr Gutjahr Magdeburger Allee 34 | D-99086 Erfurt Tel.: +49 361 5644430 | Tel.: +49 361 5644430 | Email: detlef.gutjahr@stadtwerke-erfurt.de

CASE STUDY: NIDDATAL-ILBENSTADT HUMUS AND SOIL SUPPLIERS

The central composting plant for the Wetterau district, with intensive rotting, was extended in 2007 to include an anaerobic digestion stage. The motivation for this was the current climate debate, a desired increase in capacity, further reduction of odour emission and the long-term assurance of acceptance in the community. It was possible to expand the previous composting procedure involving preparation and intensive rotting in an enclosed system for a throughput of 22,000 metric tons to include anaerobic digestion without any major alterations to the existing buildings.

Now up to 29,500 metric tons of bio-waste and green waste can be processed in the plant each year. The solid digestate undergoes a further process to turn it into compost. As well as being recycled in agriculture and horticulture, it is used to manufacture soil-based composts and potting composts. The liquid digestate is used by farmers as a compound fertiliser.

Each year more than 4.5 million kWh of electricity are produced from the biogas in a cogeneration plant. The electricity, for which payment is made under the Renewable Energy Sources Act (EEG), is fed into the public grid and supplies around 1,500 homes. The heat is used for the thermophilic digestion process, heating the site buildings, providing hot water and drying woodchips. There are plans for a further external use. Through the addition of the anaerobic digestion stage an annual reduction of 3 million kg of CO_2 is being achieved – an amount that corresponds to the CO_2 sequestered by thirty hectares of forest.

Operator:	Wetterau Composting Ltd Wetterau district waste management company
System supplier:	Kompogas
Capacity:	29,500 t/a, digester 18,500 t/a
Biogas production:	120 Nm^3/t digester input
Electrical output:	625 kW_{el}
Electricity production:	4.5 million kWh/a
Energy use:	Public electricity grid, space heat and hot water, woodchip drying
Use of digestates	Agricultural use and further processing into compost, with some subsequent soil production
Contact:	Abfallwirtschaftsbetrieb des Wetteraukreises Kurt Schäfer | Dr. Jürgen Roth Bismarckstr. 13 | D-61169 Friedberg Tel.: +49 6031 90660 | Email: j.roth@awb-wetterau.de

CASE STUDY: KIRCHSTOCKACH ANAEROBIC DIGESTION PLANT

Kirchstockach's anaerobic digestion plant in Munich district came into operation in 1997. Whereas at first bio-waste recovery was the priority, now, with the improvements undertaken to the plant, optimal material and energy recovery is most important for the district. The plant, which works with a wet fermentation principle, achieves an annual throughput of over 30,000 metric tons.

After early attempts to store the energy using aluminium silicate, the dominant achievement of 2009 was the supplying of heat to nearby industrial premises. The electricity produced in the facility's own cogeneration plants is fed into the public grid.

Tests are currently being carried out to see whether the recovering of digestates could be improved. Part of it is recovered into compost and substrates in the green waste composting facility on site.

"For us operators the advantages of the wet procedure lie in the thorough removal of impurities prior to digestion. The digestion process is considerably more stable on account of the hydrolysis which takes place prior and separately from the methanisation," says operations manager Ulrich Niefnecker.

Capacity:	30,000 t bio-waste
Start-up date:	1997
System supplier:	BTA International GmbH
Electrical output:	1 MW
Biogas production:	2.3 million Nm^3/a
Electricity production:	5.0 million kWh/a
Energy use:	Own use and feed-in to grid
Use of digestates:	Compost and substrate production
Contact:	U. Niefnecker | Fa. Ganser GmbH & Co. KG Taufkirchner Str. 1 | D-85649 Kirchstockach | Email: niefnecker@ganser-gruppe.de
	M. Kischenhofer | Landkreis München Mariahilfplatz 17 | D-81541 München | Email: matthaeus.kirschenhofer@lra-m.bayern.de

CASE STUDY: BÜTZBERG BIOGAS AND COMPOSTING FACILITY

"With its facility in Bützberg, SRH, the public cleansing utility of Hamburg, is implementing a dual strategy designed to recover organic kitchen and garden waste with maximum climate and environmental benefit. SRH is capturing the value of bio-waste in a two-tier cascade: first biogas production, then compost production. This gives Hamburg's households access to clean and low-carbon energy generated from their own kitchen and garden wastes," says SRH works manager Bernd Töllner.

On December 1st 2011, SRH (Stadtreinigung Hamburg), the public cleansing utility of Hamburg, brought on stream a biogas facility at the site of its Bützberg composting plant that has the capacity to treat up to 70,000 metric tons of bio-waste collected via the more than 100,000 biobins in the city. With 21 digesters and a batch process, the combined treatment system generates some 2.5 million cubic metres of pure bio-methane each year.

The cleaned and upgraded bio-methane is fed directly into the natural gas grid that supplies Hamburg's private households. The digestates from the dry fermentation system are processed in the associated composting plant, delivering around 35,000 metric tons of high-grade compost – a much sought-after substitute for mineral fertilisers in regional agriculture and horticulture.

In addition to its comprehensive exhaust air management designed to minimise odour nuisance, the scheme for reducing methane emissions is a special feature of the dry fermentation system. The exhaust from digester shutdown, which can still contain biogas traces, is conveyed to a furnace fired with woodchips gained on site, partly from garden waste. Heat extracted from the furnace is used to raise digester temperatures to the optimal level of 38°C.

The annual output of SRH's new biogas facility saves 7,800 metric tons of carbon dioxide emissions that would otherwise arise from fossil fuel combustion. The Bützberg biogas and composting facility proves that biogas from organic waste is a clean source of energy with a bright outlook – even for a major city such as Hamburg.

Annual capacity:	70,000 t/a
Start-up date:	1st December 2011
System supplier:	Kompoferm
Biogas production:	25 million Nm^3
Energy use:	Upgrade to bio-methane and feed-in into regional main gas line
Use of digestates:	Composting
Contact:	Stadtreinigung Hamburg | Biogas- und Kompostwerk Bützberg Dr. Anke Boisch Bullerdeich 19 | D-20537 Hamburg Email: info@srhh.de

4.3 Material and energy recovery of green waste

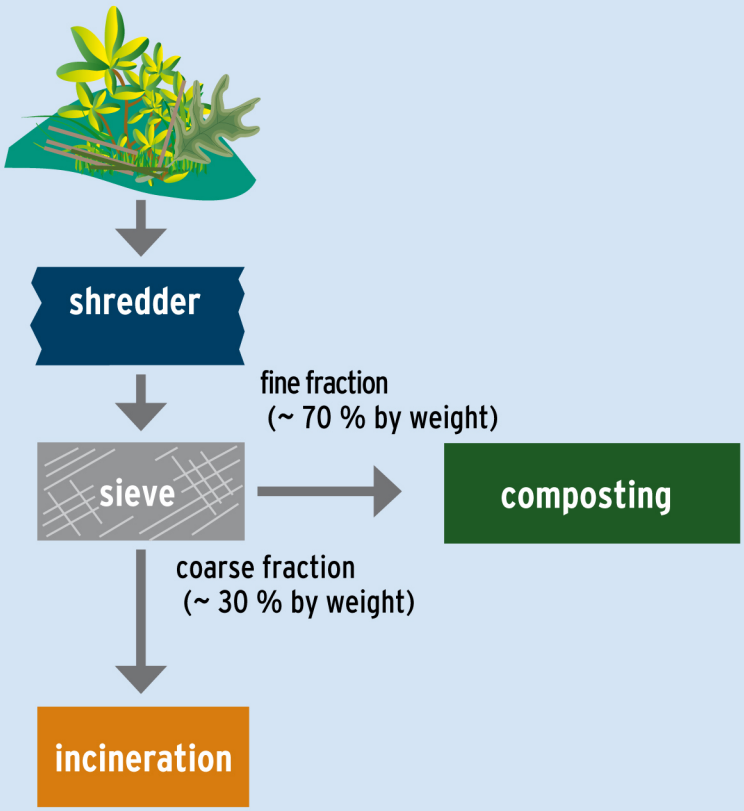
Energy recovery from unprocessed green waste is relatively difficult owing to the seasonally variable proportion of herbaceous and therefore damp waste. For this reason material recovery through the production of green waste composts is suitable for unprocessed material flows. This is especially useful given the importance of green waste composts as peat substitutes and their consequent contribution to CO_2 reduction.

If green waste is prepared before use by suitable procedures such as shredding and sifting, there is also the option of energy recovery for part of the material flow. This is done through incineration and also using the finer parts for anaerobic digestion followed by composting.

Sifting shredded green waste

The heat produced can be used, in particular for heating buildings. In addition it is conceivable that electricity and heat production could be achieved simultaneously, in order to increase overall system efficiency.

Preparation stages for separating partial streams from tree and shrub prunings for energy recovery



Around a third of green waste, especially the material generated in the winter months, can be filtered out for fuel. However, it is important to leave a sufficient amount of structural material for composting, as this is essential for aerobic decomposition to take place. If these materials are absent, higher emissions of greenhouse gases can result from the composting process or the aerobic post-treatment of digestates.

In the winter months green waste consists – to a certain extent depending on the collection system and the structures – primarily of ligneous tree and shrub prunings while in summer it is made up of the green parts of plants. This is why measurements show widely varying calorific values between 2.2 and 12.8 megajoule per kilogram (MJ/kg) for unprepared green waste from season to season. Mostly ligneous green waste with only a small amount of green parts, which can be generated through appropriate processing, has an estimated calorific value of more than twelve MJ/kg. This makes it comparable with slightly dried firewood.

Firewood from processed green waste collected in the winter months can only be used in normal woodchip combustion systems with certain limitations. The following adjustments have proved worthwhile for problem-free operation:

Incineration

- long water-cooled rack for pre-drying of material and to prevent clinker forming
- optimised primary air supply to the individual zones of the rack to ensure complete combustion

Conveyor technology

- avoidance of screw conveyors for input supply and ash removal by exclusive use of hydraulic or mechanical machinery such as scraper chain conveyors.

Résumé:

Combined energy and material recovery from organic waste flows

Material flows	Form of energy recovery	Form of material recovery
Bio-waste – separate collection	Biogas	Compost or digestates
Green waste – (30 % ligneous material)	Heat recovery**	Ash*
Green waste – (70 % herbaceous material)	Biogas	Compost or digestates
Landscape maintenance waste – herbaceous	(Biogas)	Compost or digestates
Landscape maintenance waste – ligneous	Heat recovery**	Ash*
Sifting residue from composting process	Heat recovery**	Structural material for compost

* Wood ash can be recycled as fertiliser since it contains plant nutrients. Statutory requirements must be met.
** Heat recovery can refer to heat generation or combined heat and power generation, depending on the design of the facility

CASE STUDY: ORC FACILITY IN OERLINGHAUSEN

Green waste is used to produce electricity and district heating

"We wanted to supplement this system with renewable energies from the region," is how Dipl.-Ing. Peter Blome, the managing director of Oerlinghausen public utilities, sums up the motivation for the construction of a biomass power plant with ORC technology. From the initial plans untill feeding in the first electricity took just under two years. The utilities' collaboration with a private financial investor and a local horticulture and landscaping business, which agreed to provide the input, proved invaluable in achieving this result.

Oerlinghausen public utilities have been generating their own electricity and heat for a long time, e.g. with a natural gas-fired combined heat and power plant. The heat is used via the utilities' district heating network.

What is unusual about the first ORC power station in North-Rhine-Westphalia is that the vast majority of the fuel is obtained by processing local tree and shrub prunings. When combined with other natural waste wood, this produces a cheap, good-quality fuel. The fuel generates an annual net revenue of around 500,000 euros. The fine material left after processing the wood is composted.

Rated thermal input:	4,605 kW
Net thermal output:	3,900 kW
Electrical output:	600 kW
Fuel:	13,000 t/a untreated wood, including 50 % wood from green waste
Investment:	approx. 4 million euros
Start-up date:	December 2005
Electricity production:	4.5 million kWh/a – fed into electricity grid
Net heat production:	24.5 million kWh/a – fed into Oerlinghausen public utilities' district heating network
Climate effects:	CO_2 reduction of 7,900 t/a
Contact:	Holzheizkraftwerk Oerlinghausen GmbH An der Bleiche 21 | D-33813 Oerlinghausen Website: www.stadtwerke-oerlinghausen.de

CASE STUDY: HEATING SCHOOL COMPLEXES WITH GREEN WASTE FROM HOUSEHOLDS IN THE RHEIN-HUNSRÜCK DISTRICT

"Thanks to the large quantities of tree and shrub cuttings that are collected, it became possible to implement the idea of using this material as fuel. As a result, we have made an important contribution to achieving the goal the Rhein-Hunsrück district has set itself: to become a showcase region for climate change mitigation and innovative energy strategies" explains technical director Klaus-Peter Hildenbrand.

Heat for school complexes from green waste

Since the 1990s the Rhein-Hunsrück district has done some innovative approaches to the heat supply of public buildings. In autumn 2009 the district's waste management utility (Rhein-Hunsrück-Entsorgung) started to run central heating stations in three of the district's school complexes. What makes these systems special is that they are fired exclusively with shrub and green cuttings delivered by private households. Most recently, the third of these systems began supplying heat to the Emmelshausen school complex in December 2011.

Local residents deliver tree and shrub cuttings to 120 collection points run by the district authority. This results in 130,000 cubic metres of material each year, of which around 60 percent is processed for energy recovery and about 40 percent is shredded and then used for soil improvement and erosion control in agriculture, viticulture and landscaping. Thermal energy recovery in the three biomass-fired heating stations substitutes approx. 650,000 litres of heating oil per year in the district. The Emmelshausen facility alone accounts for 220,000 litres.

This prevents a capital outflow from the region for heating costs amounting to some 600,000 euros annually. The pre-processing of the heating material is performed at a central facility at the site of the district landfill. From here the material goes to storage halls at the central heating stations and to a joint interim storage facility. Because the material contains coarse wood fractions it is not free-flowing – the technology had to be adapted accordingly. The ash proportion amounts to approx. 10–15 percent. This made it essential to design the facilities to have capacities above 550 kW and to procure robust conveyor systems. Peak-load periods are supplemented by a gas-fired boiler of a capacity of 1,040 kW. In Simmern and Kirchberg, the roofs of the central heating stations and storage halls support photovoltaic arrays totalling 64 kWp.

The three biomass-fired heating stations are a pivotal element of the Rhein-Hunsrück district's plan of action to make the transition from net energy importer to exporter – a plan that has already been fulfilled in many respects.

	Simmern station	Kirchberg station	Emmelshausen station
Net energy produced:	3,395,840 KWh/a	2,212,000 KWh/a	no data
Energy supplied:	2,870,000 KWh/a	1,715,000 KWh/a	approx. 2,618,610 KWh/a
Solid fuel boiler capacity:	850 kW	650 kW	750 kW
Peak-load boiler capacity:	1,400 kW (oil)	1,050 kW (gas)	1,040 kW (gas)
Fuel storage capacity:	2,500 m^3	1,700 m^3	2,500 m^3
Buffer storage:	30 m^3	20 m^3	28 m^3
Fuel quantity (wood):	800–1,000 t/a	500–800 t/a	700–1,000 t/a
Heating oil equivalent savings:	273,500 litres	180,000 litres	220,000 litres
CO_2 savings:	465 t	330 t	400 t
Max. distance heat grid to heating system:	600 m	500 m	300 m
Overall efficiency:	75–80 %	75–80 %	75–80 %
Investment cost incl. grid:	2.1 million euros	2.45 million euros	2.14 million euros
Buildings connected:	5 schools, 3 sports halls	3 sports halls, indoor/ outdoor swimming pool, 4 schools	4 schools + lunch room area, 2 sports halls
Contact:	Rhein-Hunsrück-Entsorgung | Hr. Günter Hackländer | Weitersheck | D-55481 Kirchberg | Email: g.hacklaender@rh-entsorgung.de		

5 ENVIRONMENTAL ASPECTS OF COMPOSTING AND ANAEROBIC DIGESTION

The just under nine million metric tons of bio-waste and green waste collected annually through segregated systems represent an important resource for energy, nutrients and humus recovery. The costs involved in collection and treatment must be set against this potential.

5.1 Quality requirements and quality assurance of the recovery of composts and digestates

Strict quality requirements are laid down for composts and digestates with regard to their impurity and contaminant content.

The statutory framework for this is provided by the German Ordinance on Bio-waste (*Bioabfallverordnung BioAbfV*), which regulates the recycling of bio-waste on soils used for agriculture, forestry or horticulture with regard to their treatment and application. For example, specifications for bio-waste suitable for material recovery, regulations on pathogen reduction and limit values for contaminant content can be found there.

The Ordinance on Bio-waste also guarantees that composts and digestates from mixed household waste are not recycled as fertilisers or soil improvers. Numerous studies have shown that bio-waste composts produced from bio-waste collected separately are of far superior quality to composts based on mixed household waste.

In order to guarantee consistent quality to consumers of the products, most composting plants and also increasingly digestion plants undergo regular and independent quality checks by a product quality association.

Product quality associations guarantee that only appropriate and safe feedstock is used for recovery.

Also they guarantee that the requirements concerning treatment, the quality of the produced fertilisers and soil improvers and their proper use are met.

Precisely for products recovered from bio-waste and green waste it is of particular importance that proof of an impartial quality control and a label to identify a quality product is given, in order to gain acceptance by customers and to strengthen the regional sales structure.

Conclusion:

Owing to statutory requirements and voluntary quality assurance of the vast majority of plants, compost and digestate products made from bio-waste and green waste are in every respect of high quality.

5.2 Composts and digestates: providers of nutrients and humus for our soils

As they contain essential plant nutrients, composts and digestion products are good organic fertilisers and excellent soil improvers. Compost and composted solid digestates are especially suitable for humus reproduction. Both solid and liquid digestates contain nutrients that are directly available to plants, whereas compost releases them gradually. This should be considered for fertiliser planning.

Composts and digestates made from bio-waste and green waste

- contribute to reduce consumption of energy-intensive synthetic mineral fertilisers, conserve resources and have a positive effect on the CO_2 balance,
- make an important contribution to humus reproduction in the soil and
- have a regulating effect on the water balance.

According to calculations by the German waste management association (*Bundesverband der Deutschen Entsorgungswirtschaft, BDE*), the potential to reduce CO_2 by using compost instead of mineral fertiliser across the whole country is almost 300,000 metric tons a year.

Increasingly compost is used by soil producers as ingredient in the manufacturing of potting composts and growing media. This also contributes to a reduction in peat use in these areas and thus also to a cut in CO_2-emission

Conclusion:

Composted bio-waste and digestates contribute to improving humus balances. Composts supply plant nutrients such as phosphor and nitrogen. Whereas nitrogen in liquid digestates is rapidly available to crops, composts release the nutrients gradually.

Energy recovery from bio-waste, combined with material recovery of the plant nutrients contained in the waste, can be regarded as a “high grade cascade utilisation”.

Utility of bio-waste in the different recovery paths

Recovery paths	Composting	Anaerobic Digestion	
Product	material – solid –	energy/material – solid –[1)]	energy/material – liquid –
Humus reproduction	+ + +	+ + +	o
Peat substitution	+ +	+ +	o
Plant nutrients[2)]:			
- nitrogen	+	+	++
- phosphor	++	++	++
- other nutrients	+	++	++
Energy, heat	(+)[3]	+ +	+ +

1) Composted digestates
2) Short- and medium-term availability
3) In energy recovery from sifting residue

Source: BUNDESGÜTEGEMEINSCHAFT KOMPOST 2008, modified

5.3 Energy balances of composting and anaerobic digestion

An important criterion for assessing biological recovery paths is the energy balance of the plant technology used, which in the final analysis has an important influence on the climatic relevance of the process.

In the case of composting the energy required to recover one metric ton of input materials depends on the complexity of the installation. Thus the energy required varies between 15 and 80 kWh (electricity and fuel) per metric ton of input according to the system type. By-products of composting and anaerobic digestion such as the sifting residue can be used in cogeneration systems and improve the energy balances.

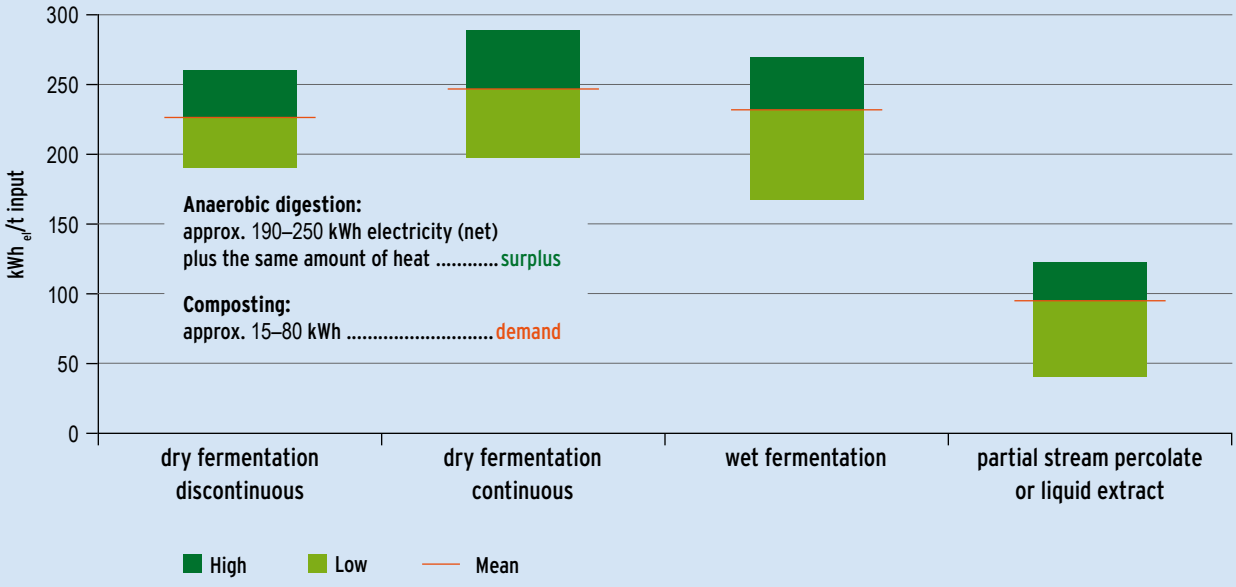
The anaerobic digestion of biological waste also consumes energy, requiring between 30 kWh and 60 kWh of electricity per metric ton of input as well as heat for the digestion process. However, by using the emerging biogas to produce electricity and heat, specific energy credits in the order of 200 kWh for both electricity and heat offset this consumption, with the result that the whole process has a clear energy surplus.

The diagram shows how the removal of suitable ligneous material from green waste combined with the composting of the herbaceous material results in a clearly positive energy balance for this recovery path.

Conclusion:

In the case of composting alone, the recovery process requires an input of energy, whereas anaerobic digestion with subsequent composting of the digestates produces energy. If efficient thermal recovery of sifted residues is carried out when composting, this recovery path can also deliver a net energy surplus.

Anaerobic digestion of bio-waste – specific net electricity yield
Comparison of biogas processes (manufacturers' figures)



Data source: manufacturers' figures for 2008 and calculations by Witzenhausen Institute

5.4 Greenhouse gas balances of composting and anaerobic digestion

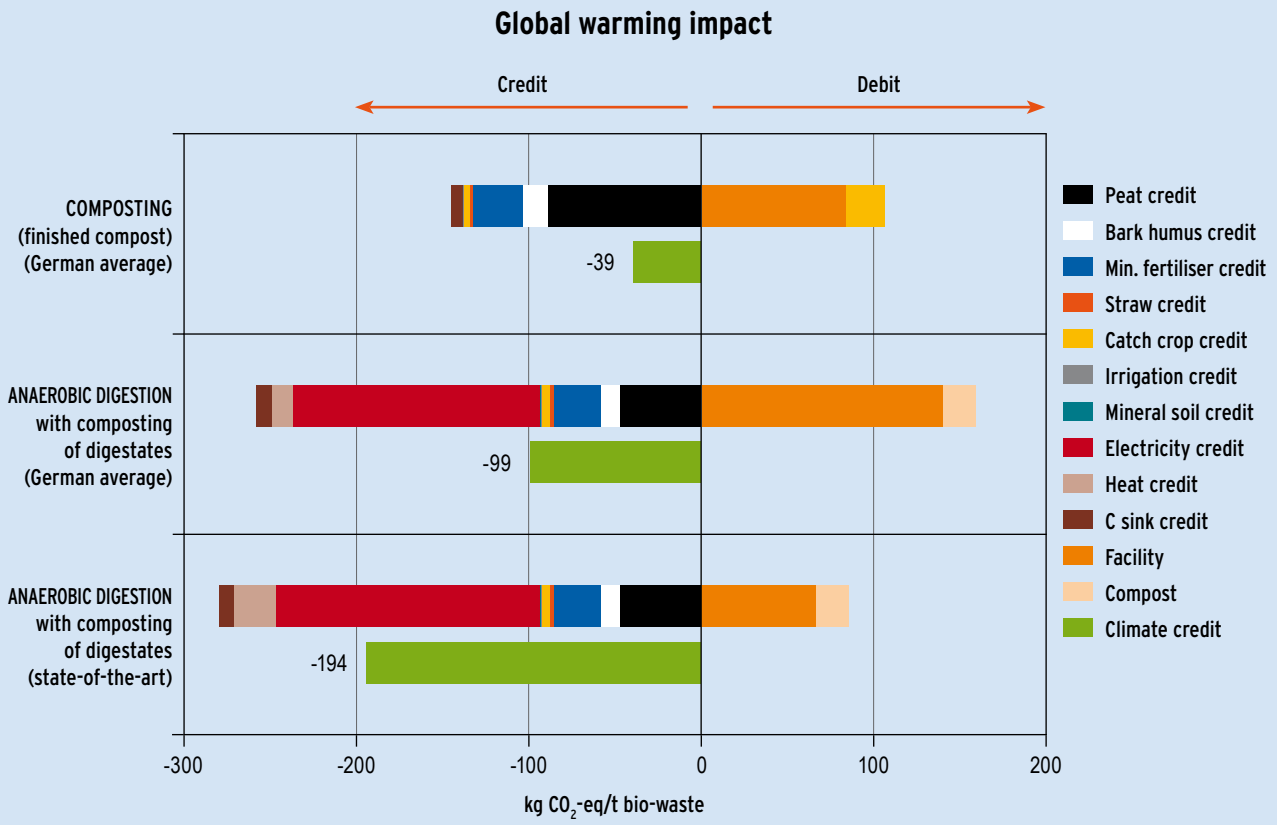
CO_2 emissions emerge from the use of fossil fuels to operate the facility and distribute composts and digestates. Although substantial amounts of carbon dioxide are released by the decomposition of organic matter during the composting of bio-waste and solid digestates, this is assessed as climate-neutral, since it was previously taken up by the plants.

Nevertheless, as a result of both composting and anaerobic digestion, depending on the processes used in the facility and the distribution of the composts and digestates, some other emissions (methane, nitrous oxide, ammonia) emerge, which must be taken into account in the greenhouse gas balance. These emissions can be offset by various types of CO_2 credit, e.g. for products substituted, such as peat and mineral fertiliser, and by direct energy credits for the electricity and heat generated.

These emissions and savings (credits), considering also the carbon sink, sum up for composting (finished compost product) in a climate credit of 39 kg CO_2 equivalents per metric ton bio-waste.

Anaerobic digestion prior composting reduces overall CO_2 emissions thanks to a substantial energy (electricity and heat) credit from biogas recovery. In this way a climate credit of approximately 99 kg CO_2 equivalents can be obtained per metric ton of bio-waste (average of all bio-waste digestion facilities in Germany). State-of-the-art bio-waste digestion technology with reduced greenhouse gas emissions even achieves a credit of approx. 194 kg CO_2 equivalents (with carbon sink).

The following diagram shows the main debits and credits from composting and anaerobic digestion in terms of CO_2 equivalents (average values, state-of-the-art). It should be noted that this diagram does not show a comprehensive environmental life-cycle analysis, but only a greenhouse gas balance.



Source: ifeu (Institute for Energy and Environmental Research) 2012: Optimising organic waste recovery (UFOPLAN 3709 33 340), modified

Liquid digestate

Dewatered digestate

Résumé:

- If bio-waste and green waste is collected and recovered separately from residual waste, high-quality soil improvers and fertilisers can be produced sustainably by treating it in composting plants or combined anaerobic digestion and composting facilities.
- The material recovery of digestates is an important renewable source of plant nutrients and humus, and is therefore essential for the greenhouse gas balance.
- The statutory framework conditions and quality control guarantee high-grade compost and digestates.
- Anaerobic digestion achieves a positive energy and climate balance due to the emerging biogas and the resulting substitution of fossil fuels.
- Composting can deliver a climate credit of 39 kg CO_2 equivalent saved per metric ton bio-waste. In the case of anaerobic digestion the climate credit amounts to approx. 99 kg (German average) or 194 kg (state-of-the-art facilities).
- Undesirable emissions of trace gases, especially methane, nitrous oxide and ammonia, must be reduced further through technical and operational measures and minimised in the whole process chain.

6 ECONOMIC ASPECTS OF BIOLOGICAL WASTE RECOVERY

Compost heap in autumn

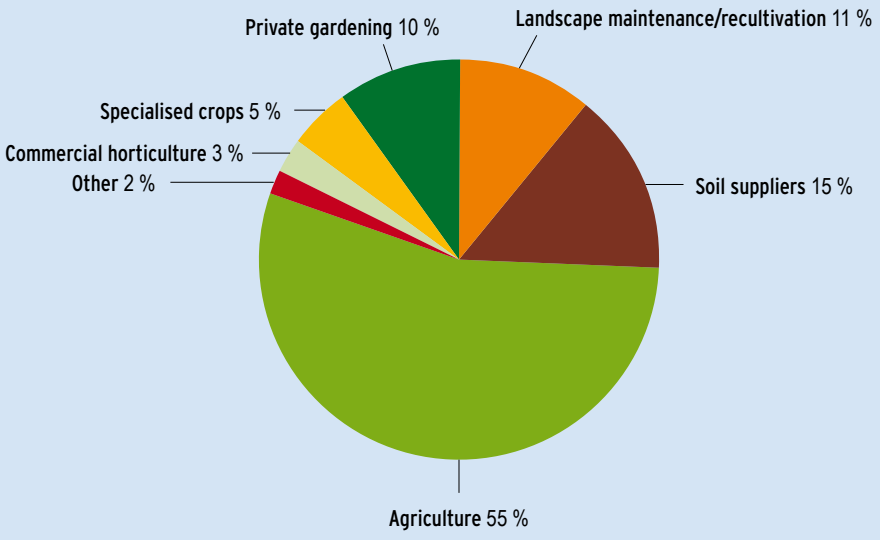
The end product: saleable top-quality compost

Compost has always been a popular soil improver in private gardens, often produced on the compost heap there. Farmers, particularly those farming organically, and market gardeners also recognise the importance of compost in providing nutrients and maintaining the soil's fertility.

6.1 Marketing of compost

Marketing channels for compost can be found in many areas, sometimes characterised by the regional structures.

Compost marketing channels



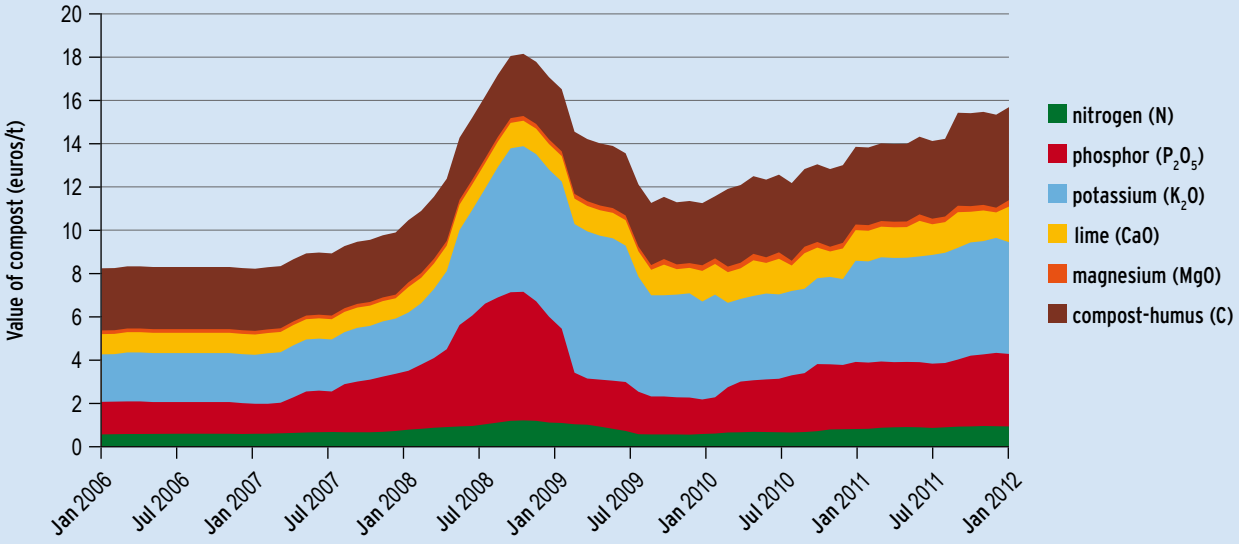
Source: German Quality Association for Compost (BGK), 2011

The economic importance of using composts in agriculture is often underestimated. However, a constantly rising demand shows that compost is rapidly becoming an attractive substitute in the wake of higher mineral fertiliser prices. While until a few years ago farmers were still paid to accept compost and composted digestates, nowadays it is usually a source of revenue.

The use of liquid digestate can be cost-neutral in arable farming areas without a large amount of livestock if transport distances are below ten kilometres.

If one considers just the fertiliser value of compost based on mineral fertiliser prices, a metric ton of compost was worth up to twelve euros in early 2012.

Development of the value of compost
Calculation of the value of compost based on mineral fertiliser prices in Westphalia-Lippe and humus values based on humus reproduction from straw (2006–2012)



Source: Humus and Soil Industry Association (Verband der Humus und Erdenwirtschaft, VHE), February 2012

Sifting composted digestates

Processed compost, ready-to-use soil improver

A successful plan for marketing compost to private and commercial gardeners is being carried out by the Main-Spessart humus works in association with the Würzburg composting plant: quality composts from regional composting facilities are refined on site into high-grade humus products such as topsoil and potting compost and sold locally through a trading partner loose or in bags under the label “Soils from Lower Franconia”.

According to Thomas von der Saal, managing director of Main-Spessart humus works: *“The product reference to the region on our composts and soils strengthens the consumers’ identification with ‘their’ region and contributes to the growing demand for regional products. High-quality regional soils enjoy greater consumer confidence and are bought by preference by a lot of customers.”*

6.2 Composting, anaerobic digestion and combination models (upstream facilities): costs and revenues

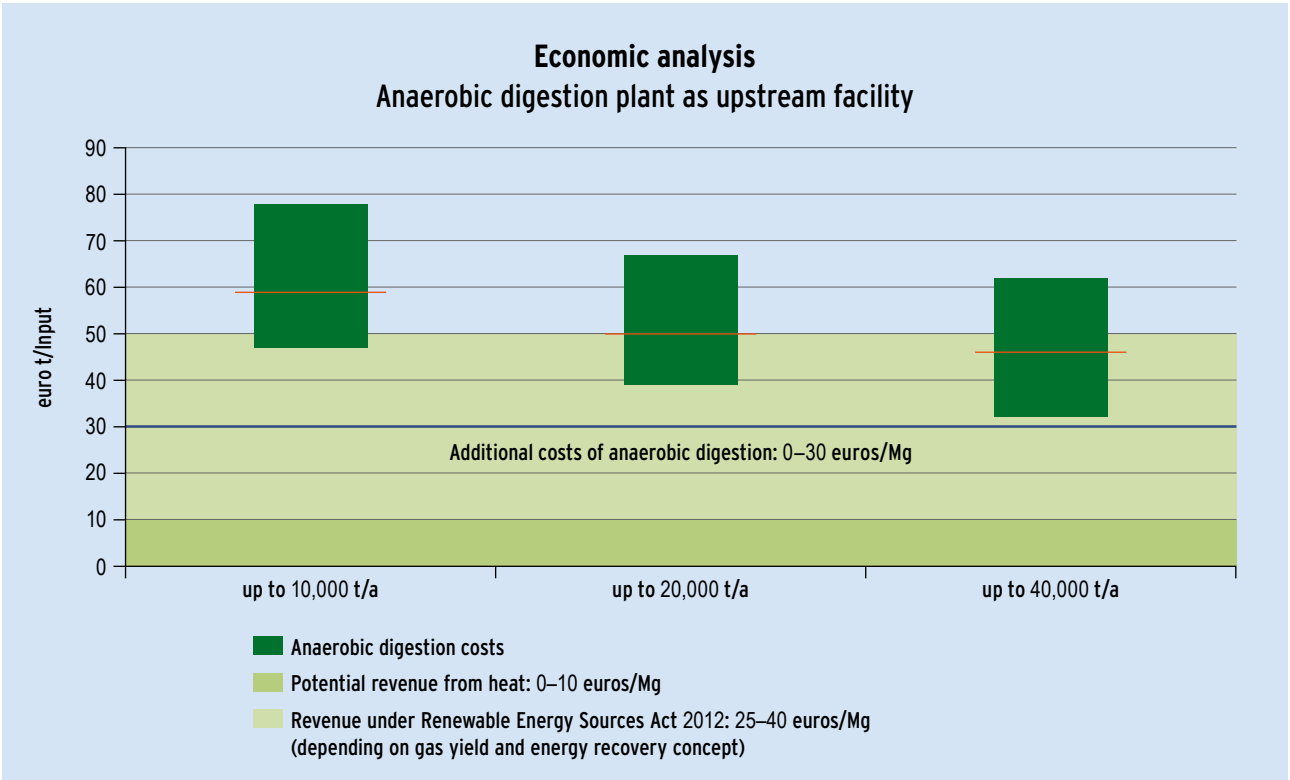
Options for the expansion of the collection of bio-waste have already been mentioned. This is usually economically sound as well, since the cost of a bio-waste composting facility or an anaerobic digester with subsequent composting is still significantly below the cost of treating residual unseparated waste. In 2011 the treatment costs for residual waste were between 70 and 150 euros per metric ton, whereas the treatment of bio-waste (composting or digestion) usually cost between 30 and 80 euros per metric ton. The cost of composting green waste was even significantly lower than that, at between 5 and 30 euros per metric ton.

As most composting facilities came into operation between the early and mid-1990s, it must be assumed that a large number of plants are due for investment in replacements. This raises the question of whether the composting facility should be renovated and optimised or whether an anaerobic digestion stage should be integrated as well.

In addition there is a significant economic incentive (see Section 7), because of the Renewable Energy Sources Act’s support for electricity fed into the grid from the digestion of bio-waste with material recovery of solid digestates.

Plants especially suitable for the integration of a digestion stage would be technically advanced bio-waste composting facilities with a minimum size of 15,000 metric tons per year or more. Ideal conditions are in place if the amount of input can be increased by a third or even half, as the existing compost plant is then used to full capacity when the digestate is processed into compost. However, the existing specific circumstances and options should be examined in each individual case. On average the increase in costs to an existing facility from the addition of a digestion stage comes out at zero to thirty euros per metric ton of bio-waste. This takes into account the revenues from selling electricity and heat. In some cases, especially with the current rising costs of bio-waste treatment, there can even be a reduction in costs. As the solid digestate is also composted, the costs in this area remain the same.

Delivering bio-waste for recovery



Résumé:

- Usually there are profits to be made by marketing composts and digestates as attractive substitutes for mineral fertilisers and soil improvers.
- Regional marketing strategies and the production of high-quality soils and substrates can contribute to an increase in compost sales.
- The increase in costs for the addition of an anaerobic digestion plant to a composting facility amounts around zero to thirty euros per metric ton of bio-waste. In some cases there can even be a reduction in costs.

Bio-waste to energy

7 FUNDING OF BIO-WASTE AND GREEN WASTE ENERGY RECOVERY PROVIDED BY THE GERMAN RENEWABLE ENERGY SOURCES ACT (EEG)

In Germany the recovery of materials and energy from biodegradable waste, is governed by several statutory rules:

- provisions of energy law designed to promote and optimise utilisation processes (such as the Renewable Energy Sources Act [EEG], or the Biomass Ordinance [BioAbfV]),
- facility-related provisions establishing requirements upon the construction and operation of facilities (such as the Federal Immission Control Act [BImSchG] and the ordinances and administrative guidelines adopted on the basis of that Act) and
- substance-related rules and regulations designed to direct material flow into economic cycles in a manner that is efficient and causes no harm (such as the Ordinance on Bio-waste or the Fertiliser Ordinance).

The requirements established by the Ordinance on Bio-waste and by fertiliser law have particular significance for the treatment and use of organic waste. This framework comprehensively regulates the permissible materials, treatment processes and recovery options.

The Act on granting priority to renewable energy sources

The Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz – EEG), in its amended version that became law on 1st January 2012, is particularly important in relation to energy recovery from bio-waste and green waste. The Act's purpose is the funding and development of renewable electricity production in Germany.

The EEG guarantees that electricity generated from renewable sources can be fed into the electricity grid.

Digester of a biogas facility

Payments [cent/kWh] for electricity generated from bio-waste made under the Renewable Energy Sources Act (EEG, 2012)

	Electricity generated from ...		
Electric capacity class	Anaerobic digestion of defined types of bio-waste (Art. 27a)	Anaerobic digestion of other types of bio-waste (Art. 27)	Thermal energy recovery from ligneous green waste (Art. 27)
≤ 150 **kW**	16.00	14.30	14.30
151–500 **kW**	16.00	12.30	12.30
501 kW– 5 **MW**	14.00	11.00	11.00
5,001 MW–20 **MW**	14.00	6.00	6.00

It further establishes a system of fees that grid operators must pay at fixed rates to renewable electricity producers. The new Section 27a EEG has now established special provisions allowing for slightly increased payments for the digestion of certain types of bio-waste.

The main preconditions to receiving a payment under the EEG are that

(1) at least 90 percent by mass of the input materials within a calendar year consist of separately collected bio-waste of the following waste code types:
- 200201 (Garden and park waste)
- 200301 (Biobin)
- 200302 (Market waste)

(2) the installations used for anaerobic digestion of bio-waste are linked directly to an installation for composting the solid digestates and

(3) the composted digestates are used for material recovery.

If these conditions and a number of further technical specifications of the facility are met, electricity attracts a payment of 16 cents/kWh$_{el}$ up to an annual electricity output of 4.38 million kWh$_{el}$ (500 kWh$_{el}$ capacity class). Electricity generated beyond that output attracts a payment of 14 cents/kWh$_{el}$ (up to max. 20 MW capacity class).

Upgrading biogas to natural gas quality and feeding it into the natural gas grid attracts a further payment. Depending on the capacity class of the biogas upgrading facility, this can amount to an additional 1 to 3 cents/kWh$_{el}$ (Article 27c EEG).

Under Article 27 electricity from the anaerobic digestion of other types of biogenic waste attracts payments between 6 and 14.3 cents/kWh$_{el}$. If bio-waste and green waste are used in wood-fired cogeneration units, the same payments for the electricity generated by such units is realized.

If certain types of biogenic waste are used, notably slurry substrate, further payment can be added to the basic level; this can amount up to 8 cents/kWh$_{el}$ according to the type of material. In order to determine the payment class for each type of input material, the Biomass Ordinance establishes substance tariff classes defined according to their material-specific energy yields.

Résumé:

The EEG has created a system ensuring that electricity generated from renewable sources can be fed into the grid. It also establishes a financial incentive system to promote innovative use of energy concepts such as the material and energy recovery bio- and green waste.

8 GUIDELINES FOR POLICY-MAKERS OF LOCAL AUTHORITIES

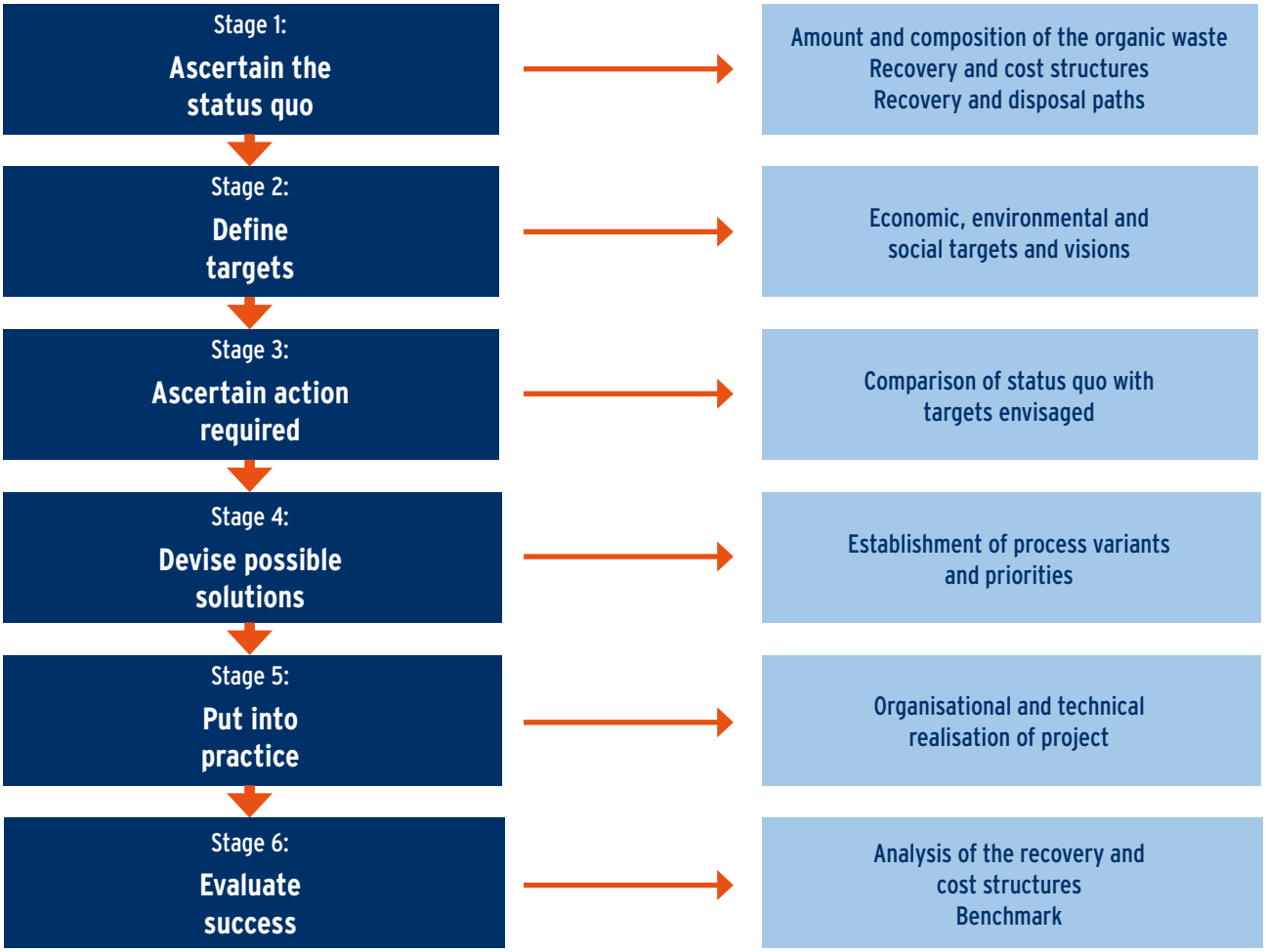
This brochure shows, with the help of case studies, that the separate collection of bio-waste and green waste and its use as a material and energy resource can make a considerable contribution towards climate protection and renewable energies. The following checklists are intended to help public-sector waste management entities to examine their

- current collection of bio-waste and green waste
- and its recovery,

and – where appropriate – to identify the need for action and improvement.

The figures used here are based on practical experience and targets.

The evaluation diagram should encourage intensive discussion on the subject of bio-waste, with the aim of optimising the recovery of bio-waste and green waste. Even where the target amounts quoted in the individual questions for bio-waste and green waste have already been achieved, further improvements in recovery can of course be considered.



Waste wood for energy recovery

TARGET:
Bio-waste and green waste are used for high-grade material and/or energy recovery

1. The recycling of bio-waste and green waste is mainly carried out locally.

2. High-grade compost or digestate is produced, making high-value material recovery possible in accordance with good professional practice.

3. Materials particularly suitable for anaerobic digestion are taken to an anaerobic digestion plant (upstream facility) and the biogas is used for electricity and heat production or processed for feeding into the natural gas grid.

4. The ligneous parts of bio-waste and green waste is separated and used as an energy resource in a biomass-fired power plant or for heat generation. In the case of bio-waste, green waste and digestates left for composting, it is important, that enough ligneous material is left to provide the structure for a low-emission aerobic decomposition.

Existing separate collection for bio-waste (biobin)

YES	NO
1. Specific amounts collected exceed 60 kg/res*a.	1. There are comprehensible reasons for not introducing a separate collection system for bio-waste (for example, because of the settlement structure).
2. More than two thirds of households are covered by the system.	2. More than two thirds of households have their own well-functioning composting systems (verified by inspection).
3. The quality of the material collected is sufficiently good (less than 5 percent impurities)	3. Very high specific collection of green waste (more than 100 kg/res*a).
4. Financial incentives for separate collection are included in the waste and charges statutes.	4. The biodegradable content of residual household refuse is less than one third (residual household refuse analysis).
5. Home composting is encouraged, but also regulated.	
6. The biodegradable content of residual household refuse is less than one third (residual household refuse analysis).	
7. The waste advisory service and publicity regularly addresses the subject of bio-waste (foreign language information sheets where necessary).	

EVALUATION

The lower the number of boxes ticked, the more thoroughly optimisation potential in bio-waste collection should be examined.	The lower the number of boxes ticked, the more thoroughly the introduction of biobins should be examined.

Existing separate collection for green waste

YES	NO
1. The green waste collection is carried out in combination with the bio-waste collection. The specific quantities collected (bio-waste and green waste) are together more than 110 kg/res*a.	1. There are comprehensible reasons for not introducing a separate collection system for green wastes.
2. Green waste (tree and shrub prunings, Christmas trees) is collected at least twice a year from residents.	2. Very high specific collection of bio-waste (biobin) (more than 100 kg/res*a) with a high green waste content.
3. All residents can take their green waste to a collection point.	3. The biodegradable content of residual household refuse is less than one third (residual household refuse analysis).
4. The collection point is easily accessible.	
5. Home composting is encouraged, but also regulated.	
6. The biodegradable content of residual household refuse is less than one third (residual household refuse analysis).	
7. The waste advisory service and publicity regularly addresses the subject of green waste (foreign language information sheets where necessary).	

EVALUATION

The lower the number of boxes ticked, the more thoroughly optimisation potential in green waste collection should be examined.	The lower the number of boxes ticked, the more thoroughly the introduction of a separate green waste collection should be examined.

9 SOURCES OF FURTHER INFORMATION

Further information can be found on the following websites:

- www.bmu.de
  Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

- www.uba.de
  Federal Environment Agency

- www.witzenhausen-institut.de
  Witzenhausen Institute (University of Kassel Faculty of Organic Agricultural Sciences at Witzenhausen)

- www.ask.eu.de
  Information portal

- www.kompost.de
  Bundesgütegemeinschaft Kompost e. V. (registered association of compost producers and suppliers)

- www.biogas.org
  German Biogas Association

- www.vhe.de
  Verband der Humus- und Erdenwirtschaft e. V. (Association of the humus and soil industry)

10 GLOSSARY

Biogas: Biogas is formed through the bacterial digestion of organic matter (biomass) under anaerobic conditions. Methane is the principal component of biogas. Biogas is found in, for instance, swamps and mires or in the digestive tract of ruminants, and can be produced from biomass in technical installations (digesters).

Bio-waste: Kitchen waste collected via the biobin, with a proportion of garden waste (Federal Statistical Office waste code number 20030104: "Biobin waste").

Digestate: Digestion residues emerging in the anaerobic phase of the digestion process.

Digestate product: Final products emerging from the separation of digestates, which are either consigned directly to reuse in agriculture as liquid digestion products or are returned to the materials cycle as a solid digestate following a composting process.

Dry fermentation[1]: Dry fermentation is a process used to produce biomass through anaerobic digestion in which the feedstock consists exclusively of solid substrates with high dry matter contents (generally above 20 percent). The fermenter content is no longer pumpable. However, it is generally stackable. The substrate is not diluted with liquids.

Green waste: Garden waste and shrub prunings (with no admixture of wet kitchen waste) collected by segregated systems (pick-up at source, and/or drop-off at recovery facility) (waste code number 200201: "Biodegradable waste from garden and park waste").

Landscape maintenance material[2]: Garden and park waste, waste emerging from landscape maintenance activities, tree and shrub clearing residues, and the plant-based component of coastal and watercourse maintenance material that fall under waste code number 200201 (Biodegradable waste).

Specific waste amount: This term refers to the untreated mass of a waste substance that arises per citizen and year. It is usually stated in kilograms per resident and year (kg/res*a).

Technical potential[1]: The technical potential is that part of the theoretical potential that can actually be tapped under the restrictions applying.

Theoretical potential[1]: The theoretical potential refers to the quantity of available energy that could theoretically be tapped in physical terms within a given period (e.g. the energy stored in plant biomass) in a region. Due to insurmountable barriers (technical, ecological, structural, administrative limits) the theoretical potential can usually only be tapped in part.

Wet fermentation[1]: Wet fermentation processes can be used to digest both liquids (generally with dry matter contents below 3 percent) and solid substrates. A defining feature is that the fermenter content is always pumpable. This state can be achieved by admixing liquids such as water.

1 Definition based on Kaltschmitt, M. et al. (2009): Energie aus Biomasse. 2nd edition, Berlin.
2 Definition based on the Bio-waste Ordinance.

PUBLICATION ORDER:

Publikationsversand der Bundesregierung
Postfach 48 10 09
18132 Rostock
Germany
Tel.: +49 1805 / 77 80 90
Fax: +49 1805 / 77 80 94
Email: publikationen@bundesregierung.de
Website: www.bmu.de/publications

This publication is part of the public relations work of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. It is distributed free of charge and is not intended for sale. Printed on recycled paper.

Bridging the gap between sewer status and new sewer inputs: A decision support tool to predict the effect of food waste disposers' effluent on small-diameter sewers

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Abstract Many European municipalities are currently considering the introduction of food waste disposers (FWDs) but are concerned that this will lead to more build-ups of deposits in sewers. Previous studies have indicated that problems arising from FWDs depend on the status of individual pipes within sewer systems. As many municipalities are also currently undertaking large inventory projects of their respective sewer systems, there exists an opportunity to assess what effects any future instalment of FWDs might have. This paper presents a decision support tool designed to classify small-diameter pipes into two categories: type 'A' and type 'B', depending on their tendency to form build-ups associated with FWDs. Three pipe characteristics were considered: inclination, sagging and wastewater load. The decision support tool was calibrated against one sewer network and validated on two others. The tool predicted a significant probability of higher levels of build-ups forming in type 'B' pipes in the calibration set and in one of the validation sets. The other validation set comprised a more heterogeneous sewer system, which included many sharp-angled manhole connections that probably prevented a more precise prediction. When compared with two other tools used for assessing self-cleansing conditions for pipes, the proposed tool was demonstrably better at predicting build-ups.
Keywords Food waste disposers; small diameter sewers; decision support tool; build-ups.

INTRODUCTION

Many sewer status assessments are being carried out around Europe. For example, the sewer system serving Oslo, Norway, is currently undergoing a major inventory. Between 100 km and 120 km of sewer line are being inspected annually using CCTV to assess the general condition of these pipes (Steinar and Gloersen, 2011). At the same time, new types of sewer inputs, such as organic material from food waste disposers (FWDs) are increasingly being considered. FWD inputs offer the potential advantage of an increase in biogas generation from anaerobic digestion at wastewater treatment plants and a reduced demand for vehicular transportation of solid waste (Bolzonella et al., 2003). However, there are also concerns regarding the possibility of elevated levels of build-ups in sewer systems due to additional quantities and types of material being introduced into sewers from FWDs (Ashley et al., 2003).

In a recent review, pipe diameter and pipe age were consistently identified as the most important factors that might affect sewer blockages (Rodriguez et al., 2012). Ugarelli et al. (2010) concluded that a concrete sewage pipe with a small diameter and shallow incline would be more likely than others to exhibit deposition problems. The main impact of the

large-scale introduction of FWDs seems to arise from their failure to grind certain high density food wastes, e.g. egg shells and bones, into sufficiently fine particles (Galil and Shpiner, 2001). Coarse fragments of these materials then settle in pipes with distinct sags and shallow inclines or form larger obstacles around sanitary waste (e.g. rags and paper tissues) (Mattsson and Hedström, 2012). Build-ups of food waste from FWDs have also been observed in pipes with distinct sags carrying low wastewater loads, and in pipes with a low load and only a gentle incline (Nedland et al., 2006; Karlsson et al., 2008). These observations indicate that it is the general status of the sewer that dictates the likely impact from FWDs. Interdependencies among three factors: pipe sagging, wastewater load and inclination, seem to be of particular importance when considering probable impacts on sewers following the installation of FWDs. However, there remains a need to establish explicit criteria that best predict those pipes in which build-up problems might arise due to the introduction of FWDs.

OBJECTIVES

The objective was to develop a decision support tool to facilitate the identification of pipes vulnerable to increased depositions due to FWD input. We focus on small-diameter sewer systems serving single family housing areas and compare the precision of the developed tool with that of two other tools already available.

METHOD

Proposed tool

The studies cited above indicate that build-ups of sediments might increase after the introduction of FWDs and, in the long-term, cause larger obstacles when at least two of the following three parameters are in unfavourable states as given in parentheses: (i) pipe inclination (a gentle incline); (ii) pipe sagging (a large extent of sag); and (iii) wastewater load (few households connected to a pipe). This framework was therefore selected as the basis for developing the decision support tool. By setting threshold values for the parameters specified above, pipes can be classified according to whether these parameters are in favourable or unfavourable states. Criteria can then be set to define whether a pipe might be at risk. If at least two of these parameters are in a favourable state a pipe is classified as type ‘A’; a pipe is classified as type ‘B’ if at least two of these parameters are in an unfavourable state, and the pipe is more prone to build-ups of finer sediments and mixed build-ups of finer sediments and sanitary waste.

A general incline of 0.2% has previously been suggested as the minimum necessary for a pipe to be able to cope with FWD output (Rosenwinkel and Wendel, 2001). For low-flow, small-diameter pipes a minimum inclination of 0.6% has also been suggested, even without considering potential problems from FWD inputs (Swedish Water & Wastewater Association, 2004). However, as no build-ups have been observed in sewer pipes with an average incline of 0.9% in the same area (Mattsson and Hedström, 2012), this value was used as an initial minimum value for the parameter *Inclination*.

The extent of sags was calculated as the accumulated sag area: $\sum$ (length of sag × depth of sag) for each pipe (Figure 1). Pipes in which no build-ups formed had an average accumulated sag area no greater than 0.07 m^2 (Mattsson and Hedström, 2012); this value was therefore set as the initial maximum value for the parameter *Pipe sagging*.

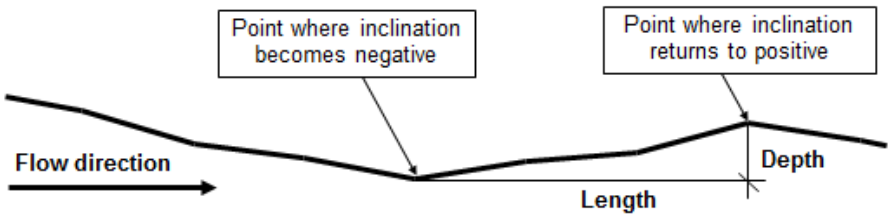

Figure 1. Calculation of sag area as the product of its length and depth. The accumulated sag area was then ascertained for each pipe. Adapted from de Maré (1995).

Material added to sewers from FWDs can create larger obstacles when combined with other sanitary waste, especially in pipes at the end, or near the end, of the sewer network (Karlsson et al., 2008; Mattsson and Hedström, 2012). This situation approximates to there being about eight single family households connected to a sewer in total (directly and from upstream); this was therefore set as the initial minimum value for the parameter *Wastewater load*.

Empirical data used to calibrate and validate the proposed decision support tool

The proposed tool was evaluated with empirical data derived from sewer networks selected from three different single family housing areas that had been inspected in a previous study (Mattsson and Hedström, 2012). Each pipe received FWD effluent from at least 50% of the households connected to the sewer. Average values of the three parameters specified above varied among the three sewer systems and are given in Table 1. Data from an area with concrete pipework were used for calibration; data from the other two areas were used for validation and termed Validation Set 1 and Validation Set 2. Both of these networks were installed in the early 1970s. To test the tool on plastic pipes, Validation Set 2 was used as a secondary validation set as it included data from plastic pipework that was installed in the network during the mid-1980s.

Table 1. General pipe characteristics for datasets derived from each of the three sewer networks and the average values for the three parameters: inclination, pipe sagging and wastewater load, based on Mattsson and Hedström (2012).

Area	Accumulated length (m)	Number of pipes	Material	Diameter (mm)	Inclination (%)	Sag area (m^2)	Load (**N^o** of households)
Calibration set	2239	50	Concrete	225	1.5	0.10	23
Validation set 1	1934	45	Concrete	225	0.8	0.14	40
Validation set 2	1941	36	Plastic	200	1.4	0.07	27

Statistical evaluation

As build-ups of finer sediments originating from the FWD could increase and, in a worst-case scenario, accumulate around sanitary waste (Mattsson and Hedström, 2012), data relating to these two types of build-up in each of the three sewer networks were analysed with Student's t-test to test whether type 'B' pipes developed significantly more build-ups than type 'A' pipes. The response parameter for the t-test was the accumulated area of build-ups of sed-

iments and sediments mixed with sanitary waste. Area was defined as the product of approximate values of length and depth of the build-up. A confidence interval of 95% was used.

Calibration of the tool

The initial parameter values used for calibration were extended to two additional levels, one below and one above the initial value, viz. 0.8% and 1.0% for pipe inclination; 0.06 m^2 and 0.08 m^2 for sag area; and 5 and 11 connected households for wastewater load. The percentage of 'A' and 'B' type pipes affected and the respective probabilities of significant differences derived from the Student's t-test (see Statistical evaluation) were calculated for 27 test runs using all possible combinations of the different parameter values.

Comparisons with other tools

To assess the precision of the proposed tool it was compared with two other tools frequently used to assess self-cleansing conditions. The first of these was the P90 assessment criteria for self-cleansing as described in the 'Swedish manual for the dimensioning of sewers' (Swedish Water & Wastewater Association, 2004); the second was the international standard EN 752:2008. The P90 decision tool includes a nomogram for shear stress and sediments derived from historical data. In this case, the fulfilment of the self-cleansing criteria can be verified according to inclination, diameter and self-cleansing flow. For pipes with a particularly low flow, the P90 tool recommends a minimum inclination of 0.6%. The EN 752:2008 standard self-cleansing criteria are: a minimum inclination of 1/pipe diamater for pipes with a diameter less than 300 mm; and a minimum inclination of 1:(pipe diameter/2.5) for pipes with special low flow conditions. Neither of these tools explicitly considers the impact of FWDs.

For both tools, all pipes in the datasets were classified as "YES" or "NO" depending on whether or not self-cleansing criteria had been satisfied. They were then subjected to the same statistical evaluation as the proposed tool. Pipes for which the P90 tool failed to give a definitive classification (defined as 'indeterminate self-cleansing condition') were excluded from further statistical analysis. However, these were relatively few and did not exceed 5% for any dataset.

RESULTS

Calibration set

The statistical evaluation of the threshold criteria used in the proposed tool is presented in Table 2. The most significant result ($p = 0.007$) was obtained with the following criteria: (i) a pipe inclination of at least 1.0%, (ii) an accumulated sag area no more than 0.07 m^2 and (iii) a wastewater load equivalent to at least eight households. These values were therefore set as the calibration standard.

Other inclines combined with different sag areas and wastewater loads were also examined but none of these generated the same level of significance or proportion of pipes that could be classified as type 'A'. By applying these final criteria from the calibration set, 66% of the pipes were classified as type 'A' and 34% as type 'B'. Two larger build-ups exceeding 2 m in

length and covering more than 15% of the cross-section of the pipe were observed in type ‘A’ pipes; both build-ups occurred adjacent to manhole connections.

Table 2. Summary of the p-values from the calibration of the three criteria. Numbers in parentheses give the percentage of pipes classified as type ‘A’. Values in bold are below the 0.05 significance level; values in bold italics indicate the results derived from the criteria selected as the calibration standard.

Sagging (m^2) ; load (N^o households)	Inclination 0.8%	0.9%	1.0%
0.06 ; 5	0.524 (72)	0.484 (70)	**0.012 (64)**
0.06 ; 8	0.368 (68)	0.338 (66)	**0.012 (64)**
0.06 ; 11	0.368 (68)	0.338 (66)	**0.012 (64)**
0.07 ; 5	0.418 (74)	0.385 (72)	**0.007 (66)**
0.07 ; 8	0.418 (74)	0.385 (72)	***0.007 (66)***
0.07 ; 11	0.418 (74)	0.385 (72)	**0.021 (68)**
0.08 ; 5	0.887 (76)	0.887 (76)	0.178 (72)
0.08 ; 8	0.887 (76)	0.887 (76)	0.071 (70)
0.08 ; 11	0.887 (76)	0.887 (76)	0.071 (70)

Validation

Applying the calibrated criteria to Validation Set 1, resulted in 49% of the pipes being classified as type ‘A’ and 51% as type ‘B’. No significantly elevated levels of sediments and sanitary waste could be observed in type ‘A’ compared to type ‘B’ pipes (t-test, $p = 0.693$). Five larger build-ups of finer sediments and sanitary waste were observed in type ‘A’ pipes. Most of these could be explained either by the proximity of manhole connections or by extreme values for one of the three criteria. However, in one case no apparent reason for the build-up could be identified.

For Validation Set 2, 58% of the pipes were classified as type ‘A’ and 42% were classified as type ‘B’. A significantly elevated level of sediments and sanitary waste was observed for the type ‘B’ pipes compared to the type ‘A’ pipes (t-test, $p = 0.018$). Two larger build-ups of finer sediments and mixed build-ups of finer sediments and sanitary waste were observed in type ‘A’ pipes. Again, the proximity of a manhole was the probable reason for one of these build-ups but there was no evident reason for the other.

Comparisons with other tools

The proposed tool was better able to predict build-ups in the Calibration dataset and Validation Set 2 than either the P90 tool or the EN 752:2008 tool (Table 3). None of the three tools successfully predicted significantly higher levels of build-ups in Validation Set 1.

Table 3. p-values from Student's t-test comparing the precision of the different tools. Numbers in parentheses give the percentage of pipes classified as type 'A'. Values in bold are below the 0.05 significance level.

Tool	Calibration set	Validation set 1	Validation set 2
Proposed tool	**0.007 (66)**	0.536 (49)	**0.018 (58)**
P90	0.336 (76)	0.247 (53)	0.064 (58)
EN 752:2008	0.301 (78)	0.103 (62)	0.147 (56)

DISCUSSION

Prediction of build-ups by the proposed tool

The proposed tool, calibrated for Calibration Set 1, was able to predict significantly higher levels of build-ups in type 'B' pipes compared to type 'A' pipes when tested against Validation Set 2, but not when tested against Validation Set 1. That the tool could not predict significantly elevated levels for Validation Set 1 was probably due to the lack of complexity in the tool's structure since the tool focused only on pipe characteristics, neglecting other potentially significant factors in a sewer network such as manhole connections. For example, following a previous analysis of blockage data from Norway, Hafskjold et al. (2004) proposed that the bend of the manhole should be considered as a factor of importance. This proposal is corroborated by some of the findings of the present study, in which larger build-ups were observed adjacent to manhole connections when other criteria being tested were not applicable.

Extreme parameter values for the three criteria also seemed to have an impact. For example, extremely low wastewater load caused larger build-ups to form at the very end of the sewer network where the first two lateral lines connect to the first manhole. As some of these pipes nevertheless satisfied the criteria for inclination and sagging, these were classified as type 'A' but were still prone to build-ups. Smaller sags, but which still satisfied the criteria for being classed as type 'A' pipes, were also important if they occurred adjacent to manholes. Larger build-ups in smaller sags just before or after a manhole were commonplace for all areas.

Criteria determined by the proposed tool

In the proposed tool, the minimum incline was 1.0%, which is the same value that the P90 tool defines as necessary for self-cleansing of lateral pipes (Swedish Water & Wastewater Association, 2004). However, this incline is steeper than the 0.2% incline deemed necessary in another study for a pipe to cope with additional material from FWDs (Rosenwinkel and Wendler, 2001). Given the framework adapted for the proposed tool evaluated in the present paper, an inclination of 0.2% or less could still be acceptable as long as the two other criteria are satisfied.

The present study determined 0.07 m^2 to be the maximum area of pipe sag for a pipe to be classified as type 'A'. An alternative classification of sags was proposed by de Maré (1995) who divided the accumulated sag area by pipe length to compensate for the fact that longer pipes are more susceptible to sags. However, in the present study the accumulated extent of

individual sags was considered to be most important in the formation of build-ups, and not a generalized value for a whole pipe.

The present study also defined the minimum number of households connected to a pipe to be eight in order to satisfy the load criterion. This would roughly correspond to a pipe positioned third to last on the network. This confirms results from a previous study on impacts of FWDs in which it was found that problems arose in the ultimate and penultimate sewer pipes in a network (Karlsson et al., 2008).

Flow conditions in small-diameter pipes

Waste transport in small-diameter pipes has previously been described as a discontinuous process where sanitary waste and other larger accumulations move down the system slowly (Ashley et al., 2004). Thus it could be argued that the sanitary waste in the present study was actually being transported downstream, albeit slowly, and was not in fact stuck in the sewer as a build-up when observed on video footage. Observations from the present study suggest that this is probably not the case for three reasons: (i) the heavy build-up of finer sediments around the sanitary waste visible in the video footage indicated that obstacles of this type had been there for some time; (ii) the level of degradation was compatible with a stationary build-up; (iii) in some cases a biofilm had developed around build-ups, indicating that these build-ups actually were stuck.

Comparisons with other tools

The proposed tool predicted build-ups of finer sediments and mixed build-ups of finer sediments and sanitary waste better than two other tools commonly used to assess self-cleansing conditions for pipes. This improvement over previous tools is probably due to the inclusion in the proposed tool of pipe sagging among the parameters for which criteria need to be satisfied. However, no standardized method was used to locate and classify sags during any actual inspection of the sewer systems; instead, post-inspection inferences were drawn from an examination of data on the available elevation curve of a pipe. Given the importance of pipe sagging in the development of build-ups, sags should be identified and graded during the course of routine pipe inspections.

CONCLUSIONS

The proposed tool demonstrates that if FWDs are not to exacerbate depositions and build-ups in pipes, two of the following three criteria must be satisfied: (i) an inclination of at least 1.0%, (ii) an accumulated sag area of at most 0.07 m^2 and (iii) a wastewater load equivalent to at least eight households. By classifying pipes as type ‘A’ or type ‘B’, the proposed tool predicted significantly higher levels of build-ups in type ‘B’ pipes for a Calibration dataset and one Validation dataset. Predictions of build-ups were not statistically reliable in a second Validation dataset due to the more heterogeneous structure of the sewer system from which those data were derived. In one instance the proposed tool performed better than two other existing tools used for assessing self-cleansing conditions in predicting build-ups. To increase the precision of the proposed tool, manhole connections should be integrated into the classification procedure. Because extreme values of the three parameters included in the proposed tool were also observed to be of importance, they should also be included among relevant criteria in future developments.

REFERENCES

Ashley, R., Bertrand-Krajewski, J.-L., Hvitved-Jacobsen, T. and Verbanck, M. 2004 *Solids in Sewers: Characteristics, Effects and Control of Sewer Solids and Associated Pollutants.* IWA Publishing, London.

Ashley, R., Crabtree, B., Fraser, A. and Hvitvedt-Jacobsen, T. 2003 European research into sewer sediments and associated pollutants and processes. *Journal of Hydraulic Engineering-Asce*, **129**(4), 267-275.

Bolzonella, D., Pavan, P., Battistoni, P. and Cecchi, F. 2003 The under sink garbage grinder: A friendly technology for the environment. *Environmental Technology*, **24**(3), 349-359.

European Standard for planning, design and operation of drain and sewer systems EN 752:2008. 2008. European Committee for Standardization,Brussels,Belgium.

de Maré, M. 1995. *Functional assessment of sewer pipes (Funktionsklassbedömning - Nytt sätt att värdera profilmätning av avloppsledningar)*. PUFF-Project LTH. Malmö.

Galil, N. and Shpiner R, R. 2001 Additional pollutants and deposition potential from garbage disposers. *Journal of the Chartered Institution of Water and Environmental Management*, **15**(1), 34-39.

Hafskjold, L. S., Kønig, A., Sægrov, S. and Schilling, W. 2004 Improved assessment of sewer pipe condition. *CityNet 19th European Junior Scientist Workshop, Lyon, 11–14 March*.

Karlsson, P., Aarsrud, P. and De Blois, M. 2008 *Recovery of nutrients from black water (Återvinning av näringsämnen ur svartvatten)*. Report no 2008-10. Swedish Water. Stockholm.

Mattsson, J. and Hedström, A. 2012. Matavfallskvarnar – *Långtidseffekter på ledningsnät (Food waste disposers – Long term impacts on sewer systems)*. Swedish Water & Wastewater Association. Stockholm.

Nedland, K., Paulsrud, B. and Rusten, B. 2006 *Effects of food waste disposers on sewers, treamtent plants and waste management (Effekter av bruk av matavfallskverner på lednings-nett, renseanlegg og avfallsbehandling).* Oslo.

Rodríguez, J. P., McIntyre, N., Díaz-Granados, M. and Maksimović, Č. 2012 A database and model to support proactive management of sediment-related sewer blockages. *Water research **46**(15), 4571–4586*.

Rosenwinkel, K. and Wendler, D. 2001 Influences of food waste disposers on sewerage system, waste water treatment and sludge digestion. *Proc. 8th Int'l Waste Management & Landfill Symp. CISA Env. Sanitary Eng. Centre, Sardinia, Italy.*

Steinar, N. and Glörsen, E. 2011 RioGis: A tool for pipe inspection and action selection for sewers. *12th Nordic Wastewater conference. Helsinki, Finland, November 14-16th, 2011*.

Swedish Water & Wastewater Association 2004. *Dimensionering av allmänna avloppsledningar (Dimensioning of common sewers)*, Swedish Water & Wastewater Association. Stockholm.

Ugarelli, R., Venkatesh, G., Brattebø, H., Di Federico, V. and Sægrov, S. 2010 *Historical analysis of blockages in wastewater pipelines in Oslo and diagnosis of causative pipeline characteristics.* Urban Water Journal, **7**(6), 335-343.

The incompatibility of food waste disposers with an aging sewer – Fact or Fiction?

Jonathan Mattsson*, Annelie Hedström **

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Introduction

In order to shred leftovers from food preparation, the use of food waste disposers (FWD) has been widely applied, primarily in Anglophone parts of the world. In Sweden, an increasing number of municipalities are contemplating an introduction of FWD due to an expected increase in biogas generation from the anaerobic digester at the wastewater treatment plant as well as a lesser demand for vehicle transportation of solid waste. However, opinions that a large scale introduction of FWD in private households may have a detrimental effect on the function of the sewer system are prevalent among water professionals. Many believe that problems relating to in particular deposits of fats, excessive growth of biofilms and build-ups of sediments are likely to increase. Especially older concrete pipes have been suggested as particularly unsuited as these have a high sand roughness. Short term monitoring of effects of FWD on the sewer system has been performed in Sweden (cf Nilsson et al, 1990) without having documented any strong negative impacts, although studies from e.g. Japan have found an increase in the build-up of sediments (Yoshida et al, 2004). No study has been found which has documented the long term impact of FWD on the municipal sewer system. In Sweden today, there are only a smaller minority of municipalities that has introduced the FWD-concept on a larger scale, among these are Surahammar situated just to the north of Västerås and Smedjebacken in southern Dalarna. The two municipalities introduced the larger part of their respective FWD in the late 90´s and the beginning of the 00´s. This paper presents preliminary results from systematically examining the effect this introduction has had on the sewer system.

Material & Method

For Surahammar and Smedjebacken, all installed FWDs were graphically plotted and then homogenous neighbourhoods consisting of singular family detached houses were selected for inspection, which roughly had a respective estate area of 1000 m^2. Similar areas which completely lacked FWDs were also selected for inspection to function as reference values. Camera trailers TC107 and TC125 were used in order to navigate and document each encountered deposit. As the study targeted different types of deposits in the sewer system, no flushing was done in advance.

To document the extent of fats, biofilms and sediments the classification system P93 (Svenskt Vatten, 2006) was applied. This system uses a visual classification procedure where a deposit is graded on a scale ranging from 1-4 reflecting how much of the cross section of the pipe it covers, a low grade indicates a small deposit and consequently a high grade indicates a larger deposit. In order to get a general grade of a separate pipe, Nilsson & Stahre (1994) have developed a weighting system that takes into account the inherent properties of different deposits as well as horizontal distribution. By combining these two evaluation strategies it was possible to calculate a final score for each pipe which then could be used for comparison purposes. As was stated previously, the main focus of the study was the distribution of fats, biofilms and sediments; thus the methodology was refined in order to target solely these categories.

146 pipes of an accumulated length of about 7000 meters were in total inspected, where the level of connected FWD ranged from all households having installed one to none. Two pipes of a cumulative length of 105 meters that were continually flushed by the municipalities were screened from the inspections. A two way interaction general linear regression model was applied to investigate the impact of 4 different factors on the final deposit score: Inclination, material (plastic and concrete), ratio of household having installed a FWD and ratio of households having installed a FWD upstream. A confidence interval of 95 % was set to determine statistical significance.

Result & Discussion

Total impact

In total 107 sites of biofilms, 74 sediment build-ups and 32 fat deposits with a cumulative length of respectively 674, 267 and 103 meters were encountered and graded (see Fig. 1).

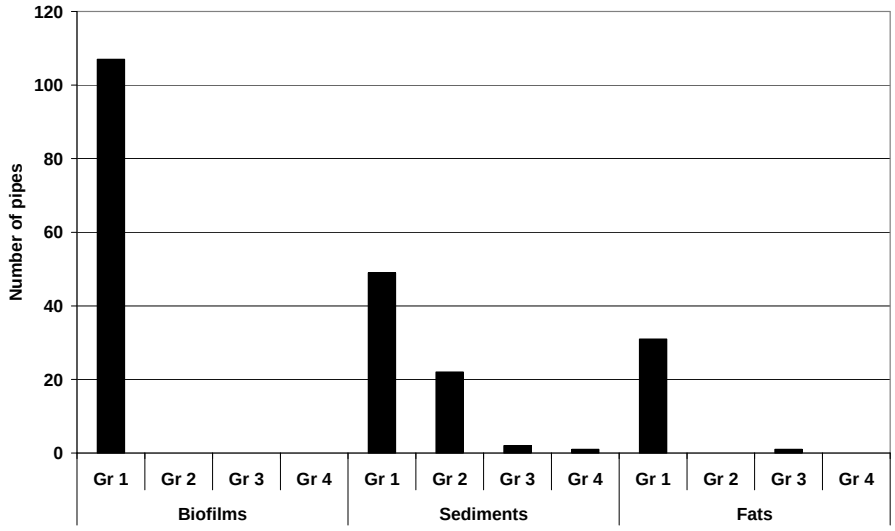

Figure 1□□vervie□ of t□e different depo□it□ according to t□eir re□pective t□pe and grade encountered in t□e □e□er □□tem of area□ □it□ detac□ed □ou□e□in □ura□ammar and □med□e□ac□en□

No clear impact can be seen on the total level of deposits from the preliminary inspections in the sewer following a 10-15 years of FWD operation. When analyzed together, no statistical significance could be established regarding pipes with different ratios of FWD in the households connected to them, as well as levels of the same device connected upstream. The material and inclination of the different pipes were neither statistically confirmed to have an impact.

That no trend was observed for the inclination in the in-data could partly be explained by a large number of sags on the pipes which allowed particles to settle and biofilm to grow although the absolute inclination was substantial which when analyzed in the described manner would cause statistical noise. There also seems to be little difference in abundance of deposits when comparing older concrete pipes to the newer plastic ones.

Biofilms

The level of biofilm was statistically confirmed ($p < 0.05$) to increase for the factors high FWD-ratio upstream and a gentle inclination. However, the interaction between high FWD-ratio upstream and a steep inclination had a statistically significant ($p < 0.05$) effect on lowering the level of biofilm. Also, the interaction between the material and the FWD-ratio upstream was documented to be statistically significant ($p < 0.05$), with concrete having the effect of lowering the level of biofilm. However, all biofilms encountered in this study were small and as such graded at the lowest level of only 1; hence the impact must still be considered minor.

In a literature review it was determined that the FWD could contribute some 22-77 % to the biochemical oxygen demand (BOD) (Galil & Shpiner, 2001). A gentle slope will, in the present circumstances, provide a beneficial environment for biofilm growth as the relatively low velocity of the water will not exert any tearing force on the formation of the same. A possible explanation for the ostensibly lower level of biofilm in concrete pipes could be that the plastic material has a strong orange colour which made the impression of biofilms more obvious during inspection. For concrete pipes the biofilm often has a greyish tone, very similar to the concrete itself, when encountered and could be hard to separate at times, this could have had an effect of underestimating the real frequency of biofilms for concrete pipes.

Sediments

No preliminary statistical conclusion could be drawn from the dispersion of sediments documented in the inspected pipes. However, egg shells unfit to be grinded in the FWD were encountered at a number of places, in particular where sags were present. A more indirect impact should also be mentioned, although no statistical significance was documented for sediments alone, the build-up of FWD sediments around other material in the sewer such as sanitary waste could also be substantial and thus facilitate to generate sewer blockings. This problem was mostly observed at the end points of the sewer system since the demand for self cleansing was not fulfilled here.

As the deposits of egg shells were widespread and have also been documented earlier as an impact after FWD-instalments (Yoshida, 2004), it seems probable that these deposits are a direct result of the FWD-introduction. When considering that material that is unfit to be grounded is documented in the sewer coupled with that as much as 30 % of other food wastes that are fit for grinding are instead thrown in the bin by the households in Surahammar (Bergh et al, 2010), the conclusion one could draw is that more information directed to the public is desirable.

Fats

The statistical analysis of the dispersion of fats generated a similar result as that of the distribution of biofilms. The factors that were statistically significant ($p < 0.05$) were a high ratio of connected FWD upstream and a gentle inclination. However, the level of fats declined when a steep inclination interacted with a high FWD-ratio upstream. As for the biofilm, almost all encountered deposits were graded as 1 which still indicated a marginal impact. Only one deposit was graded as a 3.

In a recent laboratory study of deposit formation of fats in the sewer, it was possible to determine that fat started to form after 2 days of exposure to sewer conditions (He et al, 2011), this seems to indicate that a relatively long retention time is necessary for the formation of fat deposits. This is in accordance with the findings from this study which observed more deposits of fats where the water would have a longer retention time, such as when a pipe contained numerous sags.

Conclusions

The FWD device, according to the preliminary results from this study, seems to have an impact on the condition of the sewer, albeit a minor one. The most obvious direct impact was egg shells documented in many places, especially in sags. However when analyzed together with pipes that lacked connection of FWD, no statistically significant difference was observed. The conclusion is therefore that although the FWDs have added sediments to the sewer, the amount is still comparably low to what would have been accumulated at a given spot without the FWD. As the users of FWD also have been demonstrated not to ground kitchen waste that is suitable for the device, the suggestion for future instalments would therefore be to perform informational campaigns which target what to grind. Where the inclination was low and the ratio of households having installed a FWD upstream, as well as sags on individual pipes, was high, accumulations of biofilms and fats were observed.

References

Bergh, L., Boldt, A. & Lindfors, A-K. 2010. Sammansättningsanalys restavfall [*Analysis of composition of residual waste*]. Report VAFAB Miljö. VAFAB.

Galil, N. & Shpiner, R. 2001. Additional pollutants and deposition potential from garbage disposers. *Journal of the Chartered Institution of Water and Environmental Management,* **15,** 34-39.

He, X., Iasmin, M., Dean, L. O., Lappi, S. E., Ducoste, J. J. & De Los Reyes III, F. L. 2011. Evidence for Fat, Oil, and Grease (FOG) Deposit Formation Mechanisms in Sewer Lines. *Environmental Science & Technology **45**, 4385–4391*.

Nilsson, O. & Stahre, P. 1994. *Kortbedömning av TV-inspekterade avloppsledningar : [Evaluation of TV-inspected sewer pipes]*, Stockholm :, Svenska vatten- och avloppsverksfören. (VAV)

Nilsson, P., Hallin, P O., Johansson, J. , Karlen, L., Lilia, G., Peterson, A., & Peterson, J. 1990. Waste management at the source utilizing food waste disposers in homes: a case study in the town of Staffanstorp. Department of Environmental Engineering, Lund Institute of Technology, Lund, Sweden, *Bulletin Series No* 56.

Svenskt Vatten 2006. *P93 TV-inspektion av avloppsledningar i mark ,* Stockholm, Svenskt Vatten.

Yoshida, A., Hamada, T., Yamagata, H. & Fuiju, K. 2004. Impacts of food waste disposers on sewage system. *Technical Note of National Institute for Land and Infrastructure Management***,** 69-74.

After Incineration
The Toxic Ash Problem

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April, 2005

IPEN®

KEEP THE PROMISE ELIMINATE POPs

Keep the Promise Eliminate POPs Report

After Incineration:
The Toxic Ash Problem

"Keep the Promise, Eliminate POPs!" Campaign
and Dioxin, PCBs and Waste Working Group
of the International POPs Elimination Network (IPEN) Report

http://www.ipen.org

Prague – Manchester, April 2005

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IPEN also acknowledges the essential help of Arnika staff members, Hana Kuncova, Martin Skalsky, Lenka Maskova and Kristina Beranova, graphics designer, Jakub Nemecek in the preparation of this report and Pat Costner, Senior Science Advisor, IPEN, USA.

Contents

Executive Summary and Recommendations

The Dioxin, PCBs and Waste WG of IPEN report demonstrates that waste incineration residues represent a serious threat to both local and global environment as they contain high quantities of unintentionally produced persistent organic pollutants (U-POPs) listed under Annex C of the Stockholm Convention (dioxins, PCBs and hexachlorobenzene). This study also shows that especially waste incineration fly ash and APC residues contain also high levels of other POPs not listed under Stockholm Convention (for example polychlorinated naphthalens or polybrominated dibenzo-p-dioxins and dibenzofurans etc.). It summarizes studies showing leachability of dioxins from fly ashes under conditions they are disposed off. Hot spots case studies shows that levels of dioxins in ashes from waste incineration below the level proposed as a limit for low POPs content in wastes to be adopted at first Conference of Parties to Stockholm Convention (COP1) are too high to prevent serious contamination of the environment by U-POPs.

Recommendations concerning three crucial decisions on U-POPs policy

Toolkit:

This study results don't suggest the approval of UNEP's Toolkit by COP1.

POPs levels in wastes:

Cases of dangerous contamination of the environment don't support approval of "low POPs content levels" and "levels of destruction and irreversible transformation" as they were proposed by the documents prepared within the framework of the Basel Convention to COP1.

BAT/BEP Guidelines:

High levels of POPs in waste incineration residues raise the importance of using techniques other than waste incineration and/or landfilling of wastes in these guidelines. It also raises the importance of material substitution – the replacement of materials such as PVC, a material whose presence in the combustion processes helps to create more dioxins. BAT/BEP Guidelines should be considered as work in progress at COP1.

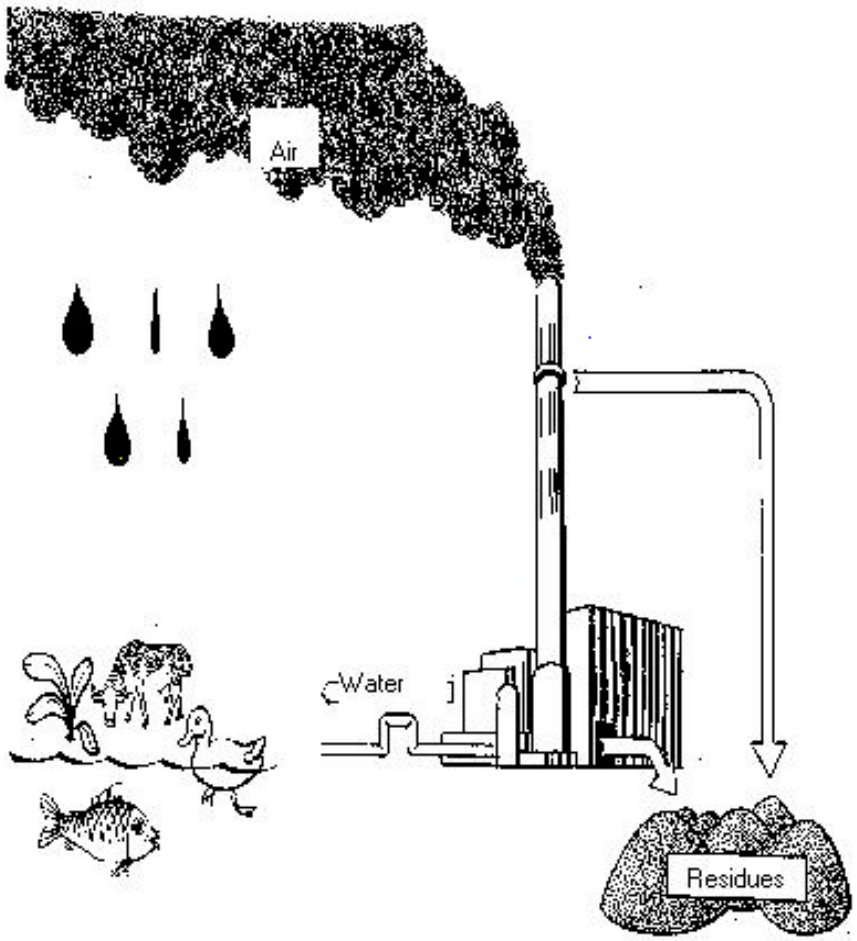
1. Introduction: Persistent organic pollutants (POPs)

Persistent organic pollutants (POPs) harm human health and the environment. POPs are produced and released to the environment predominantly as a result of human activity. They are long lasting and can travel great distances on air and water currents. Some POPs are produced for use as pesticides, some for use as industrial chemicals, and others as unwanted byproducts of combustion or chemical processes that take place in the presence of chlorine compounds.

Today, POPs are widely present as contaminants in the environment and food in all regions of the world. Humans everywhere carry a POPs body burden that contributes to disease and health problems. Dioxins, DDT or polychlorinated biphenyls (PCBs) are capable of causing hormonal defects in very low quantities and they threaten reproduction systems of people and animals. (They have for instance a negative impact on male fertility). They also damage the human immune system and some of them cause cancer. They are not soluble in water, but in lipids. This characteristic helps them bioaccumulate in the fatty tissue of animals.

The international community has responded to the POPs threat by adopting the Stockholm Convention in May 2001. The Convention entered into force in May 2004 and the first Conference of the Parties (COP1) will take place on 2 May 2005.

The Stockholm Convention is intended to protect human health and the environment by reducing and eliminating POPs, starting with an initial list of twelve of the most notorious, the "dirty dozen." Among this list of POPs



Picture 1: Basic POPs releases flows from waste incinerator.

there are four substances that are produced unintentionally (U-POPs): polychlorinated biphenyls (PCBs), hexachlorobenzene (HCB), polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) The last two groups are simply known as dioxins.

The goal of the ***"continuing minimization and, where feasible, ultimate elimination"*** was established for U-POPs listed in Annex C of the Stockholm Convention.[a] There are several steps that should help Parties to Stockholm Convention to comply with this goal. Almost all are under Articles 5 and 6 of the Stockholm Convention.

The first Conference of the Parties to Stockholm Convention (COP1) will be held this year in Uruguay, four years after Convention was created.

Several key topics will be discussed at COP1 that reflect how the Convention will work. There are three important decisions waiting for delegates at COP1 related to U-POPs:

1) Guidelines on Best Available Techniques and Best Environmental Practices - BAT/BEP (related to Article 5 of the Stockholm Convention),

2) Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (related to Article 5 of the Stockholm Convention) and

3) "levels of destruction and irreversible transformation of POPs in waste" and "low POPs levels in waste" (related to Article 6 of the Stockholm Convention).

These three topics are also very closely related to fly ash and other waste incineration residues and will be discussed in the final parts of this report.

Annex 1 to this report includes more detailed profiles of the group of U-POPs listed in Annex C of the Stockholm Convention.

2. POPs and waste incinerators

A wide range of POPs is produced in waste incinerators, as unwanted by-products of the combustion process. Therefore, the Stockholm Convention lists waste incinerators in Annex C among *"source categories have the potential for comparatively high formation and release of these chemicals*[b] *to the environment"*. The basic possibilities of releases of toxic substances from waste incinerators are demonstrated at Picture 1.

[a] polychlorinated biphenyls (PCBs), hexachlorobenzene (HCB), polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs), last two groups are called simply as "dioxins"

[b] Chemicals listed in Annex C of the Stockholm Convention, which are PCDD/Fs, PCBs and hexachlorobenzene so far.

The incinerators themselves are usually much more complicated devises, as shown by the diagram at Picture 2, and in any incinerator many ways can be identified through which POPs may get further into the environment. The amounts of dioxins and further POPs produced by a specific waste incinerator also differ, depending on the conditions of the incineration of wastes. A number of studies investigated formation of dioxins in incinerators.

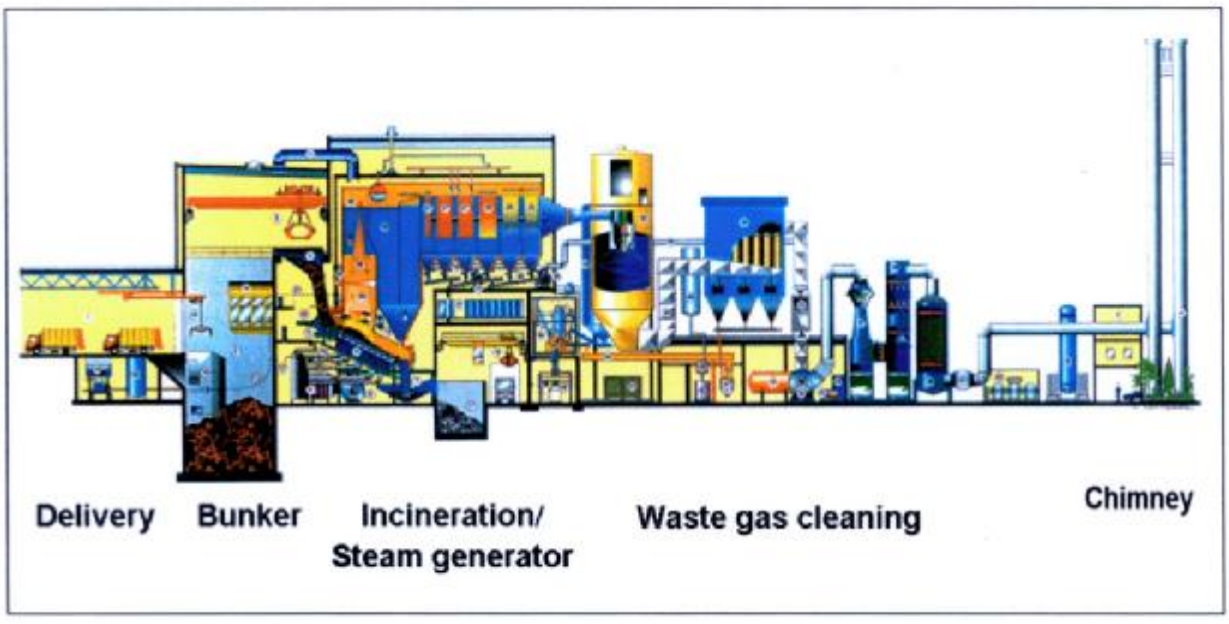
Three pathways have been proposed so far to explain the formation of PCDDs/PCDFs during incineration:
- high temperature pyrosynthesis[1];
- low temperature de novo formation from macromolecular carbon and organic or inorganic chlorine present in the fly ash matrix[2], and
- formation from organic precursors[3] in which fly ash has an important role as a catalyst.

Although all these mechanisms have been known for many years, some detailed reaction mechanisms were studied in more recent studies due to the extreme complexity of the fly ash matrix.[4, 5]

Formation of further POPs during incineration of wastes was not examined in such detail as it was done in the case of dioxins. Some studies focusing on examination of coplanar PCBs, which are included into the value of the total TEQ[6], concluded that these chemicals might be formed by similar reactions as PCDD/Fs[7].

Similar imbalance exists concerning the attention paid to releases into the various components of the environment. Until now, the highest attention has been paid to releases into the air, whereas the content of POPs in wastes and waste waters has been left aside for a long time. A help in solving this problem should have been provided by the Stockholm Convention, which, in contrast to protocol on POPs to the LRTAP Convention, concentrates on releases into all components of the environment, and does not deal solely with releases into the air. In spite of that, the tool prepared by UNEP Chemicals for national inventories of POPs in many cases still ignores or underestimates releases to water, land and in residues, as will be shown in one of the following chapters.

Picture 2. Typical municipal solid waste incinerator Source: European Commission 2004.



3. Waste incineration residues

Combustion is a thermal process during which organic waste materials change their chemical composition and break down into basic atoms after being exposed to high temperatures in the presence of oxygen. The flue gases, as well as dust particles which are not captured by filters are emitted into the air by the stack (chimney). And, large quantities of waste water from wet flue gas filter devices as well as from fly ash treatment are discharged in the environment.

Inert materials in the solid waste stream, such as stony materials, and most metals, which are incinerated together with the organic waste fraction are not combustible, and will fall through the grate slits of the furnace, and end up in the bottom ash at the end of the incineration process. Approximately 25% of the quantity of municipal solid waste (MSW) fed to the grate furnaces ends up as bottom ash after the combustion process. Bottom ash is also known as “slag”.

Fly ash are small dust particles in flue gases, and are captured by electrostatic precipitators (ESP-filters) after the flue gases leave the boiler. Fly ash are also known as 'ESP-ash'. Approximately 1 to 5 % of the quantity of municipal solid waste fed to the grate furnaces ends up as fly ash after the combustion process. [8]

Table 1: Modern incinerators produce a range of residues[c].

Generic Residue	Origin	Specific Residue
Bottom Ash / Slag	Heterogeneous material discharged from the burning grate of the incinerator.	Grate Ash
	Material that falls through the burning grate to be collected in hoppers below the furnace	Grate riddlings
Heat Recovery Ash	Particulate ash removed from heat recovery systems	Boiler ash Economiser ash Superheater ash etc
Fly Ash	Particulate matter removed from the flue gas stream prior to the air pollution control (APC) system, not including the heat recovery ashes	Electrostatic precipitator (ESP) dust Cylcone dust
APC (Air Pollution Control) Residues	Dry and semi dry scrubber systems involving the injection of an alkaline powder or slurry to remove acid gases and particulates and flue gas condensation/reaction products. Fabric filters in bag houses may be used downstream of the scrubber system to remove the fine particulates	Scrubber residue Bag house filter dust
Combined Ash	Combination of any of the above residues, most common is mixing of bottom ash with APC residues.	Mixed ash

[c] Adapted from WRc/ETSU Report. Reports on potential for use of MSWI bottom ash, for the DTI Ref B/RR/00368/REP/. Harwell, Oxford 1996

A third residue of waste incineration is boiler ash. Small ash particles attach to the boiler, and are removed by mechanical knocking devices, or are manually removed during periods of maintenance work. Less than 0,1% of the quantity of municipal solid waste fed to the grate furnaces is collected as boiler ash.

If an incinerator is equipped with (wet) flue gas filter devices (scrubbers), various (solid) residues are produced, i.e. scrubber salts, filter cake, sludge, and gypsum.

Summarising: After incineration approximately 26 - 40 % of combusted solid waste will remain as solid residues. Quantification of residues will be discussed more detailed in Chapter 4.

Combustion of liquid (toxic) waste results in much lower quantities of solid residues, because of the lower amount of solid substances in the liquid waste.

What types of wastes are produced can be understood also from the three following examples of incinerators operated in the Czech Republic:

SPOVO Ostrava. Industrial wastes incinerator SPOVO in Ostrava is the only incinerator in the Czech Republic which holds a icense to incinerate wastes with high content of PCBs. Data about the incinerator are taken from its operating rules. The technology consists of a combustion chamber - rotation furnace, electrostatic filter, acidic and alkaline gas washer, hose filter and of the technology for lowering of nitrogen oxides (so-called DENOx).

The incinerator produces the following wastes:
- *slag and boiler ash from the rotation furnace (cat. No. 190111)*
- *fly ash, captured by the electrostatic filter (cat. No. 190113)*
- *sludge with the content of heavy metals from the filter press located after treatment of waters from the acidic gas washer (cat. No. 190105)*
- *gypsum from the alkaline washer (cat. No. 190105)*
- *used activated carbon from the hose filter (cat. No. 190110)*
- *wastes formed during repairs of lining (cat. No. 190111)*

The incinerator with the capacity of 10.000 tons per year consumes 1.134 tons of calcium hydroxide and 140 tons of activated carbon and transforms them into hazardous waste. The contaminated activated carbon is incineratedin the incinerator itself.

Medical waste incinerator in the Hospital of Rudolph and Stephanie in Benešov u Prahy.
This incinerator is an example of a small technology with a capacity of 1000 tons per year. Data thereon are taken from the plan for reduction of emissions, because the technology does not meet all requirements arising from transposition of European regulations concerning waste incinerators. Its equipment should be completed by the end of the year 2004.

The technology consists of pyrolysis and combustion chamber, hose textile filter for capturing solid particles and simple two-stage treatment of flue gases. This treatment consists of quench (cooling of flue gases by water), and of alkaline lye washer.

The incinerator produces the following wastes:
- *waste from pyrolysis (cat. No. 190118)*
- *dust from cleaning of chambers (cat. No. 190104)*

- solid waste from treatment of flue gases (cat. No. 190107)
- waste waters are discharged by the incinerator into the sewer system without treatment

The facility was built in the year 2000. In spite of that, the limit for emissions of dioxins was not met. In the year 2001, the limit of 0.1 ngTEQ/m^3 was exceeded ca 19x, in the year 2002 even 65x.

Hazardous waste incinerator in Lysá nad Labem. This incinerator has the maximum capacity of 3500 tons per year. Data thereon are taken from the plan for reduction of emissions and from the operating rules. At present, also the EIA process for completion of its waste management equipment is under way. The incineration space consists of a rotation furnace and two post-combustion chambers. Treatment of flue gases has several stages. At first, the flue gases are cooled, then a sorbent (a mixture of lime and activated carbon, trade name Sorbalite) is added thereto. Subsequently, the mixture is introduced into a reactor, where flue gases and sorbalite are mixed with each other. From the flue gases, solid portions (fly ash and sorbalite) are filtered off in a sleeve textile filter. Finally, the flue gases enter quench and alkaline washer, where they are washed with water and lye. Wash waters from the washer are further treated in a filter press and by filtration through CINIS ash.

The incinerator produces the following wastes:
- ash and slag and fly ash from the post-combustion chambers (cat. No. 190111, 190113)
- mixture of sorbalite and fly ash from the sleeve filter (cat. No. 190107)
- sludge with the content of heavy metals from the filter press located after treatment of waters from the gas washer, it is re-burnt (cat. No. 190105)

The incinerator with the capacity of 3500 tons per year consumes 40 tons of sorbalite and 2 tons of CINIS ash (it is part of sludge from the filter press). Wastes, produced during repair works, are not specified.

Physical properties of ash residue fractions may be affected by such factors as:
- MSW composition;
- front-end processing of the waste prior to incineration;
- facility design and operation including combustion temperature;
- air pollution control (APC) measures etc.[9]

Higher content of dioxins and further POPs in wastes produced by incinerators may be, naturally, expected in air pollution control residues (APCR). Their content in slag and ash is increased by mixing with fly ash or with boiler ash. But this is a relatively frequent practice, as will be shown on several examples. Boiler ash contains higher concentrations of POPs, which, however, by far do not reach the concentrations found in APCR. On the other hand, ash and slag may contain relatively high concentrations of heavy metals.

P. Littaru and L. Vargiu studied process of dioxins formation in fly ash in two municipal waste incinerators in Italy[10]. They concluded that *„The highest PCDD/F contents have been found in fly ash at temperatures of 150–200 °C, below the de novo synthesis peak temperature, so that the enrichment of particulates in PCDD/Fs must be caused by adsorption from gas to solid phase. PCDD/F ratios in fly ash tend to increase with decreasing temperatures until reaching values well in excess of 1.7, the average furan/dioxin ratio for MSWI emissions, revealing that a major portion of PCDF is adsorbed on the solid phase… These phenomena of adsorption/desorption on fly ash deposits in flue gas treatment lines must be accounted for in the mass balance and in the evaluation of PCDD/F emission levels…… PCDD/Fs appear to be generated on fly ash deposits in flue gas treatment lines of MSWIs by the de novo synthesis mechanism. PCDD/F content in fly*

ash increases as temperatures in the treatment lines decrease, confirming previous findings about temperature as the major controlling parameter in PCDD/F formation."

Italian study confirmed that combustion is not the main source of PCDD/Fs in MSWIs, and that PCDD/Fs do not seem to be generated directly by waste combustion. Based on its findings the effectiveness of postcombustor units in destroying PCDD/Fs needs to be reconsidered. This conclusion is supported by findings of the M. Chang and J. Lin who studied influence of activated carbon injection on total dioxins releases[11]. They came to the conclusion that activated carbon injection can indeed effectively decrease concentrations of dioxins in gas, but it increases the total emissions of dioxins (including dioxins in fly ash and gas) from municipal waste incinerators.

Similarly as in waste incinerators, POPs are formed also in other combustion facilities. Therefore, also wastes produced, for example, by metallurgical plants, present serious risk of contamination of the environment by POPs. Use of slag from metallurgical plants caused one of „dioxins scandals" in Germany[12].

4. How much dioxins do the wastes from incinerators contain?

An important question, which has to be answered when we speak about wastes produced by incinerators, is: How much dioxins do these wastes contain? The magnitude of problems connected with these wastes depends on the answer to this question. If the amount was negligibly small, then it would not be necessary to be further concerned with the problems of these wastes. Answers to this question are different.

Picture 3: Balance of PCDD/Fs releases into different environment compartments from MWI Liberec.

For example, Dyke and Foal[13] identified MSW incinerator residues as the largest dioxin release to land in the U.K., noting as follows: *"Residues from the incineration of MSW can lead to significant releases."*

Sakai and Hiraoka[14] determined the total dioxin output per metric ton of municipal solid waste (MSW) incinerated when fly ash was treated by a thermal dechlorination process. However, their findings also allow calculation of the total dioxin output per ton MSW when fly ash is not detoxified, as is typically the case in most countries. With untreated fly ash, a dioxin output factor of 857.8 ug TEQ/ton MSW can be calculated for one set of samples and 507.7 ug TEQ/ton MSW for the other. In the first case, flue gas contributes 0.05 percent of the total TEQ output

while fly ash contributes 99.9 percent. In the second case, flue gas contributes 0.0004 percent of the total TEQ output and fly ash, 99.5 percent. These values can be compared to a study of European MSW incinerators by Huang and Beukens[15] in which flue gas was found to contribute 11.8 percent of total dioxin output, while fly ash contributed about 56.7 percent.

We have tried to calculate this balance roughly also for municipal waste incinerator in Liberec (see Chapter 8.2.1). We can say for sure that gaseous emissions contribute ca 3 % to the total dioxins production of this incinerator. The remaining 97 % are present in mixed bottom ash. In this case, it is complicated to estimate the exact contribution of APC residues.

But it is possible to roughly estimate the contribution of dioxins contained in the separated slag, which is ca 4.5 %. This would mean that APC residues contribute ca 92.5 %. Similar calculation for dioxin-like PCBs is not available, as PCBs are not commonly measured even in air releases.

Fly ashes and further residues from flue gases treatment form the highest proportion of dioxins releases to the environment: between 56 and 99.5 %. Usually, gaseous emissions contribute to dioxins burden from waste incinerators by the lowest per cent (this can be estimated between 0.0004 and 12 %). Releases of dioxins contained in fly ashes represent a serious threat to the environment. Therefore, it is important to determine *„low POPs level"* for the content in wastes according to Article 6 of the Stockholm Convention, in order to prevent releases of these toxic substances into the environment. Success of the Stockholm Convention in elimination of POPs can be based on correct setting of this limit. As shown by the case studies in Chapter 8., *„low POPs levels"*, as they were approved and adopted at the sixth Conference of Parties (COP6) of the Basel Convention, 25–29 October 2004, do not guarantee protection of the environment from POPs contamination.

Talking about dioxins and dioxin-like PCBs observed in ashes we find a wide range of measured levels. For PCDD/Fs we found in previous studies observed levels between 36 ng I-TEQ/kg dry matter[16] to 2,100,000 ng I-TEQ/kg d.m.[17] Boiler ash contains lower levels of dioxins (level of 11.3 ng I-TEQ/kg was measured in Liberec).[18] Mixed bottom ash can carry high levels of dioxins (up to 2300 ng I-TEQ/kg d.m.[19]), while bottom ash and/or slag don't have such high levels.: 0.64 - 150 ng I-TEQ/kg d.m. were observed in municipal waste incinerators in England and Wales.[20] We did not find a lot of data about dioxin-like PCBs in fly ash, only from Taiwan where measurements with results ranging from 61.1 to 2,983.4 ng I-TEQ/kg,[21] were recorded, and from Germany with levels found in the range of between 10 - 640 ng WHO-TEQ/kg. Also PCBs in general are seldom measured in waste incineration residues. In fly ash their levels range between (from less than 1,000 to 23,000 ng/g d.m. were measured in UK[22]).

5. Leaching question of POPs in fly ash

After emissions of dioxins into the atmosphere were successfully lowered in the up-to-date incinerators, the idea has predominated that these toxic substances are fixed in fly ash to the extent that it is essentially unnecessary to pay too high attention to management of wastes produced by the incinerators. During negotiations on permits for waste incinerators, this argument is often stated in official documents, and it is passed on among officials who issue the corresponding permits. Authorities in a significant number of countries thus do not pay any attention to the facts where APC residues end and how they are treated. The authorities are satisfied with submission of a certificate confirming that the incinerator handed over the material to an authorized company. They are satisfied with the same statement also in documentation submitted during procedures of permit granting in EIA or IPPC processes.

The idea of a complete impossibility of leaching of toxic substances from slag, ash, and APC residues is based on a number of studies which have worked, and repeatedly

work, at leachability of heavy metals from these materials.

The leachability tests performed recently may not be applied to substances of dioxin type, because their behavior changes depending on the changes of the characteristics of the environment. The leachability tests of wastes performed commercially are, in most cases, generally carried out in ideal laboratory conditions and do not correspond to the behavior of wastes in the environment where they are deposited. Therefore, the chemists themselves call for change of these procedures. For example, M. Podhola from Institute of Chemical Technology, Prague in his study of stabilized wastes stated: *„A specifically prepared leachability test may be considered more suitable. Such test should stimulate conditions of subsequent deposition of the waste, if these conditions are known. Obviously, it is not possible to carry out these tests exclusively in the commercial manner. Apparently, they will have to be carried out in cooperation with research establishments.“*[23]

Older studies on behavior of dioxins in soils supported the original idea of strong fixing of dioxins in fly ash and ash. Italian study from 1986 reported that the Seveso soil profiles did not show a significant translocation of the PCDD/F in the soil environment.[24] German study from 1992 showed that only a little movement was found within 8 years in the surroundings of two industrial plants in southwest Germany and there was no appreciable loss of PCDD/F.[25] Another German study asserted that only highly chlorinated congeners were detected in the solution obtained from leaching experiments following the method of the German DIN 38414 test etc.[26]

However, newer studies disprove the idea of strong fixing of dioxins in fly ash and ash or slag. Takeshita and Akimoto[27] proposed the leachability of PCDD/F from fly ash by rain using a fly ash column. They showed that PCDD/F associated with water-soluble salts such as NaCl and $CaCl_2$ in the ash were eluted in the beginning of the elution, whereas those associated with slightly water-soluble particles such as calcium hydroxide were eluted in the latter half. Another report from 1995 focused on leaching of dioxins from fly ash and soils under fire-extinguishing water activity suggested that fire-extinguishing water use resulted in significant amounts of PCDD/F in the leachate.[28]

Korean scientists Yong-Jin Kim, Dong-Hoon Lee a Masahiro Osako studied PCDD/Fs leachability under circumstances comparable to those in landfills theoretically and in laboratory conditions. In theoretical review, it was shown that dissolved humic matters (DHM) could influence the actual solubility and leachability of PCDD/F. The higher concentration of DHM showed the higher leachability of PCDD/F. In the leaching test, three different DHM concentrations and pHs of solutions were adopted to fly ash samples imaging the various characteristics of municipal solid waste leachate. It was proved experimentally that the leachability of PCDD/F increased with increasing DHM concentration in all pH conditions. The highest leachability was shown at the highest pH. Isomer distribution patterns of PCDD/F in all leachates were similar.[29]

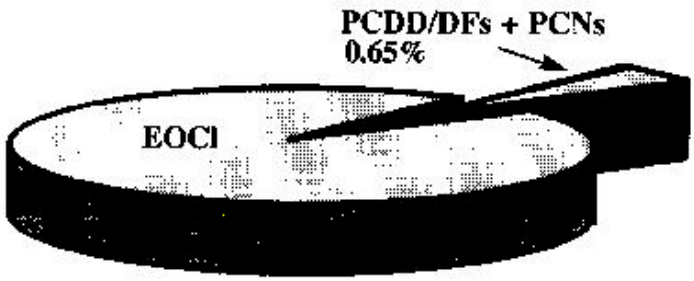
A previous study of these scientists states that a mixture of bottom ash and fly ash shows a higher leachability of dioxins.[30] This leads to the opinion that DHM are formed due to the presence of non-combusted carbon in bottom ash. The results also show several shortcomings in procedures of waste testing, because dioxins behave differently than heavy metals. Because of that, the authors of the study propose to rethink certain methods of testing.[31]

Sakai, Urano and Takatsuki published another study focused on leaching of dioxins and PCBs from fly ash. Leaching tests with and without surfactants were conducted in order to understand the influence of surfactant-like substances on POPs leaching. In those tests, LAS (Linear Alkylbenzene Sulfonate) and humic acid was used as surfactant-like substances. Shredder residues from car/electrical goods recycling and fly ash from a municipal solid waste (MSW) incinerator were used in content analyses and leaching tests. Furthermore, an experiment was carried out to understand the influence of fine particles to the leaching concentration of POPs. The results of the leaching tests indicate that surfactant-like substances increase the leaching concentration of POPs, and fine particles related closely to the transporting behavior of POPs.[32]

6. Other POPs observed in ashes

Waste incineration residues are formed by process of combustion of different kinds of wastes. They should contain plenty of chemicals as such. There will be difference in distribution of different chemicals between slag/bottom ash and fly ash/APC residues. It is necessary to say that if analysis for PCDD/Fs and/or PCBs content in ashes is rare, than analysis for other chemicals is very sporadic. There are several studies filling this gap a bit.

Picture 4. Distribution of PCDD/Fs and PCNs value comparing to rest of EOXs found in fly ash sample from one of Japanese municipal waste incinerators. Source M. Kawano et al.[38]



Japanese experts team led by M. Kawano studied distribution of PCDD/Fs, polychlorinated naphthalens (PCNs) and EOX in waste incineration ashes (fly ash and bottom ash). [33] PCNs have high chronic toxicity potential in animals[34] and exhibit the same binding affinity with the aryl hydrocarbon receptor (AhR) as non-ortho PCBs[35]. Kawano et al. found that order of content of these chemicals was EOX> PCDDIDFs>PCNs in the fly ash samples from MWI. Picture 4 shows balance between studied chemicals in one of fly ash samples. "The results of calculation show a very small amount of known organochlorines like PCDD/DFs and PCNs to have been present as a fraction of EOCI (see Picture 4). This is implies that a large part of EOCI is composed of unknown compounds." stated M. Kawano et al.

Noma et al. studied PCNs formation during Neoprebne FB combustion in simulated MWI conditions and measured levels in fly ash as well as bottom ash in a range from 0.17 to 0.96 ng/g and from 0.95 to 1.7 ng/g respectively.[36]PCNs in ashes[d] sampled from Japanese incinerators ranged from 0.74 ng/g to 610 ng/g.[37]

In German study focused on a comparison between chemical analysis data and results from a cell culture bioassay was found that with MWI fly ash samples the bioassay of the extract resulted in a two- to fivefold higher estimate of TCDD equivalents (TEQ) than the chemical analysis of PCDDs/Fs and PCBs. However, the outcome of both methods was significantly correlated, making the bioassay useful as a rough estimate for the sum of potent PCDDs/Fs and dioxinlike PCBs in extracts from MWI fly ash samples. The remaining unexplained inducing potency in fly ash samples probably results from additional dioxinlike components including certain polyaromatic hydrocarbons (PAHs) not analyzed in this study. The hypothesis that emissions from MWI of hitherto unidentified dioxinlike compounds are higher by orders of magnitude than emissions of potent PCDDs/Fs and dioxinlike PCBs could not be confirmed.[39]

Levels of PAHs observed in waste incineration fly ashes by M. Till et al. ranged between 0.05 ug/g and 0.99 ug/g. Higher levels were found in fly ashes from cematorium, wood combustors and noble metal recycling facility (up to 536.4 ug/g).[40]

H. R. Buser et al. conducted study focused on polychlorodibenzothiphenes (PCDTs), the sulfur analogues of the PCDFs. In H. R. Buser

[d] both bottom and fly

Picture 5: Surrounding of Turkish hazardous waste incinerator Izmit with sampling site of free range chicken eggs, which were found highly contaminated by PBDEs. Photo by: Bumerang and Greenpeace.

et al. study from 1991 is stated: "*Since incineration is one of the main sources for the environmental occurrence of PCDDs and PCDFs, the additional presence of PCDTs may have some implication ,particularly because of the presence of 2,3,7,8-tetra-CDT."*[41] Tetra- and penta-CDTs were detected in fly ash from two MSWIs and from an electric-arc furnace of a car shredding facility. Rather complex isomeric profiles were found with tetra- and penta-CDTs predominating, at levels up to 25 and 30 ng/g.[42] The toxicology of the PCDBTs is not yet known but it can be supposed that like chlorinated dioxins and furans these compounds are biologically active.[43]

Also other organic compounds were observed in waste incineration residues from Izmit HWI. Some of them are listed in analytical results of chemical analysis of sampled ashes conducted by Greenpeace Research Laboratories.[44] See them in Appendix 2.

Burning of the waste containing brominated flame retartands quite often presented in the waste of plastic consumer products leads to formation of polybromodibenzodioxins and polybromodibenzofurans (PBDD/Fs) and/or to polybromochlorodibenzo-dioxins and polybromochlordibenzo-furans (PBCDD/Fs). Burning of polybrominated diphenylethers (PBDEs) in waste incinerators can lead to significant releases of this persistent organic pollutant, because they are not decomposed by waste incineration under low temperatures for example. High levels of these compound were found recently in chicken eggs sampled nearby HWI in Izmit (Turkey) at site on Picture 5.[45]

Chatkittikunwong & Creaser studied flyash from three municipal and medical waste incinerators for chlorinated as well brominated dioxins in 1994 for example. They found total PBDD/PBDF and polybromochloroDD/DF levels detected in MWI ranged between 2.3 to 3.5 ng/g and in medical waste incinerator 1.2 ng/g.[46]

It is clear that waste incineration residues contain whole range of organic pollutants and we can count many of them to the family of persistent organic pollutants. Some of them appear in ashes because of their presence in wastes (PBDEs for example) while the others can occur in ashes as POPs by-products. PCNs, PBDD/Fs , PCBDD/Fs and PCDTs are examples of second case. Some of these compounds were found in significant levels in the environment and waste incineration residues can be their significant source.

The pattern of toxicity of PCNs resembles that of TCDD. Recent work has been done to determine the relative potency of PCNs - mixtures as well as individual congeners - in fish, birds and mammals. The potency of several PCN congeners is in the same range as some PCB congeners.[47] These findings about

PCNs toxicity call for listing at least this group o chemicals under Annex C of the Stockholm Convention and for their inclusion into national POPs inventories.

7. Country case studies

7.1 Waste incineration residues in Netherlands

7.1.1 History of dioxins in Dutch milk

The Lickebaert polder is an agricultural area north-east of Rotterdam-harbour in the Netherlands. In 1989, tests showed high levels of dioxin in milk and cheese samples. As a result of the enormous media coverage and publicity, the Dutch government promptly ordered cow's milk and meat from the affected Lickebaert area to be collected systematically and destroyed.[48] A health protection measure that lasted until the end of 1994. During these five years the production and sales of dairy products in the Lickebaert area was prohibited. And, the government started a nationwide research program to get detailed information about dioxin contamination of cow's milk in other regions. For this purpose cow's milk was examined in the vicinity of all Dutch waste incinerators and cable burn facilities. [49]

The nationwide research program showed that dioxin output of all waste incinerators have been too high as well as dioxin levels of cow's milk. Further, the research program suggested that the high dioxin output from waste incinerators could be responsible for toxic dioxin contamination of cow's milk and meat. In February 1990, Dutch government ordered that cow's milk and meat from a second contaminated area (near the waste incinerator of the city of Zaanstad, north of Amsterdam) should be collected systematically for destruction. Further, the production and sales of dairy products in that 'Zaanstad-area' was prohibited. [50, 51]

As a result of the nationwide research program four municipal waste incinerators were ordered to close down immediatedly. And, in 1993 and 1994 two other municipal waste incinerators had to shut down. Surprisingly, the AVR-Rotterdam incinerator that was held responsible for the contamination of dairy products in the Lickebaert area received permission to continue its operation. The amount of waste incinerated dropped from about 2983 kilotons in 1990 to 2957 kilotons in 1995 (because of re-use and prevention and because of incineration capacity available, the incinerator of Roosendaal was out of business for renewal in 1995).[52]

Despite the serious concerns of citizens against waste incineration, the Dutch government continued their policy to triple the incineration capacity in 2000.[53, 54] However, strong citizens protests forced government to drop a few new incinerator proposals, and to close down another existing incinerator. Although citizens protest have been successful in preventing the building of a few new incinerators, others have been build. And, despite the fact, that the government was not successful in increasing the incineration capacity as initially planned, waste incineration has become a major route for waste disposal in the Netherlands.

We try to show the problems related to handling waste incineration residues in developed European country in this case study. This case study and data in it are based on study conducted for IPEN Dioxins, PCBs and Waste WG. [55]

7.1.2 Waste incineration residues in Netherlands: introduction to the real issue

The Netherlands incinerates roughly 38% of its municipal waste yet has relatively high rates of recycling of municipal waste at approximately 25%.[56, 57] In 1999 a total of 6,965 ktonnes of waste (excluding contaminated soil, dredging spoil and manure) was incinerated.[58] The Netherlands have the largest installations in Europe for municipal waste incineration with a medium capacity of 460 kt/a.[59] In 2000 there were 11 MWI in operation in the Netherlands.

In 1995, the Dutch government issued a directive with environmental specifications for

construction materials, which include all materials that are used for building houses, offices, factories and roads.[60] Although waste incineration fly ash and bottom ash should come to meet the limits (like all other construction materials and residues), the government decided that fly ash and bottom ash are exempt from this obligation. As a result, fly ash and bottom ash can be used almost without any restriction.[61] Looking at levels of different chemicals in waste incineration residues from Netherlands showed in Table 2 this is not a good practice for protection of environment.

Table 2. Average composition of fly ash and bottom ash from Dutch waste incinerators in 1997 (in milligrams per kilogramme). For bottom ash numbers of analyzed samples were not available.[a, a, a, a]

	Average levels in fly ash (mg/kg)	**Number of samples analyzed**	**Average levels in bottom ash (mg/kg)**
aluminium (Al)	30,294	17	not defined [b)]
arsenic (As)	97	17	19 - 23
cadmium (Cd)	379	17	2 - 8
chromium (Cr)	231	31[a)]	235 - 296
copper (Cu)	1,154	17	669 - 3212
mercury (Hg)	2	17	0,03 - 0,2
lead (Pb)	7,671	17	1086 - 1637
molybden (Mo)	50	17	5 - 11
Substance	88	30[a)]	40 - 86
selenium (Se)	9	17	0,4 - 0,5
strontium (Sr)	245	17	not defined [b)]
tin (Sn)	1,007	17	62 - 77
vanadium (V)	30	27[a)]	40 - 52
wolfram (W)	77	17	not defined [b)]
zinc (Zn)	22,488	17	1239 - 2125
bromine (Br)	997	17	not defined [b)]
chlorine (Cl)	74,471	17	1050 - 2445
fluor (F)	57	17	not defined [b)]
dioxins (PCDD) and furans (PCDF)	0.0024 (in I-TEQ)	17	below detection limit

[a)] between 1986-1995
[b)] Not defined = no measurement carried out

7.1.3 Fly ash

The annual production of fly ash is ranging from 79000 - 81000 tons in the Netherlands. The fly ash production is quite steady because the quantity of incinerated waste has not been changed for the past few years. The annual production of boiler ash has decreased from 8800 tons in 1999 to 3800 tons in 2002.[62]

Approximately 35000 - 40000 tons of annual fly ash production is used as filler material for asphalt production. However, since fly ash is produced during the year, but asphalt is manufactured mainly during summer, and other filler materials compete with fly ash, not all fly ash can be disposed of as filler material in asphalt.[63, 64] During the life time of asphalt toxic substances can be dispersed into the environment, as a result of leachate. To our knowledge no study was carried out on this topic.

Approximately 44000 - 46000 tons of annual fly ash production is landfilled in the Netherlands, or exported to Germany and dumped in old salt and coal mines. [65] In 2002, 29500 tons were exported, in 2003, 45000 tons. Most of the boiler ash is exported to Germany as well.[66, 67]

For the landfill disposal route, the fly ash is packed in so called large plastic bags and piled up in separate sections of common landfill sites. To stabilize the big bags, sand is squirted, or washed between the bags to fill the hollow spaces. Alternatively, a fly ash mixture is used as top cover for common landfill sites.

After the big bags are piled up in the separate sections of the landfill site, the water that is used to squirt, or wash the sand between the bags get into contact with the fly ash, accellerating the leachate process. Moreover, heavy pressure exerted on the landfill can make big bags burst, increasing the leachate process any further. Also the fly ash mixture that is used as top cover for common landfill sites can rupture after heavy pressure exerted on the lower layers of the landfill will increase tension in the top cover. As a result, rain water easily get in contact with the waste landfilled below the cover layer, reinforcing the process any further.[e]

7.1.4 Bottom ash

In the Netherlands, the annual production of bottom ash is approximately 1.200.000 tons. The bottom ash production is quite steady because the quantity of incinerated waste has not been changed for the past few years.

In 2002, 770.000 tons were used for road beddings, and hardening surfaces of industrial sites. This is much lower compared to previous years, when 820.000 up to 1.340.000 tons have been dumped under roads. Waste incinerators have storage facilities for periods during which road building activity is lower. However, the drop in 2002 is not a result of a small demand for road works, but because of growing concern about the negative environmental impact of dumping bottom ash under roads. Road constructors have been increasingly reluctant to further use bottom ash for road construction. In consequence of this growing concern, the quantities in stock at incinerators have increased to 1.028.000 tons by the end of 2002, which is almost as much as annual production.[68]

Small quantities of bottom ash are landfilled on common landfill sites and exported respectively. In the past few years the annual quantities landfilled ranged from 700 to 12.500 tons. In 2002 and 2003 3,200 and 2,300 tons of bottom ash respectively were exported.

Similar with fly ash, the use of bottom ash as a bedding for roads brings the ash easily into contact with other (non hazardous) materials used for road construction, like sand and stones. But, inevitable, roads need to be reconstructed, or repaired, and the old road debris that need to be removed contains elevated levels of toxic substances. Mixture of bottom ashes, fly ashes and other materials can increase leachability of dioxins from these materials as dissolved humic matters content increases. [69]

7.1.5 Inventories of dioxins in fly ash and bottom ash

In the Netherlands, fly ash is a major route for dioxin releases from waste incineration to the environment. In 1991, the National Institute of Public Health and Environmental Protection (Dutch EPA) estimated the quantity of dioxins in fly ash and bottom ash for 1020 g I-TEQ/year and 8.5 g I-TEQ/year respectively. Since 1991, the incineration capacity has been increased from 2760 kilotons to 5200 kilotons in 2000. For 2000 the quantity of dioxins in ash is estimated 2671[f] g I-TEQ/year.[70, 71]

Compared to fly ash, which is the main carrier for dioxins in residues from waste incineration, dispersion of dioxins in the environment by bottom ash was considered to be small. Heavy metals in bottom ash pose a much bigger burden for the environment.

According to information from the operators of the Dutch waste incinerators in 1997 [72] , and based on annual production of fly ash, annual dioxin quantity in ashes is estimated 190 - 195 g I-TEQ. These figures differ strongly from the official estimates from Dutch EPA, and University of Amsterdam.

[e] for more information about leaching fly ash ability look at Chapter 5

[f] this figure includes dioxins in bottom ash and filter residues.

7.1.6 Conclusion

The disposal of fly ash and bottom ash, in asphalt, road beddings, landfill sites and salt and coal mines contributes to an increased dispersion of hazardous substances in the environment, some of them, like dioxins, classified as persistent organic pollutants (POPs). It is not surprisingly that with this on-going annual burden, the background levels of dioxins in the Netherlands remain high, and, according to the Health Council of the Netherlands, the recommended (health protecting) levels for humans and in some cases for ecosystems are being exceeded. [73]

7.2 Other EU Member States

Economic expenditures connected with management of residues produced by incinerators differ in the individual EU Member States, depending on differing practice in the individual countries, and also depending on differing conditions (including economic ones). These differences are shown in Table 3. The following two Chapters summarise information on legislation concerning management of waste incineration residues in two EU Member States, Austria and Sweden, information concerning this issue in both the United Kingdom and the Czech Republic are present in Chapter 8 „Hot spots case studies".

Table 3: Costs of operators of municipal waste incinerators connected with treatment of bottom ash and wastes resulting from flues gases treatment in EU countries. Source: Eunomia 2001.[a]

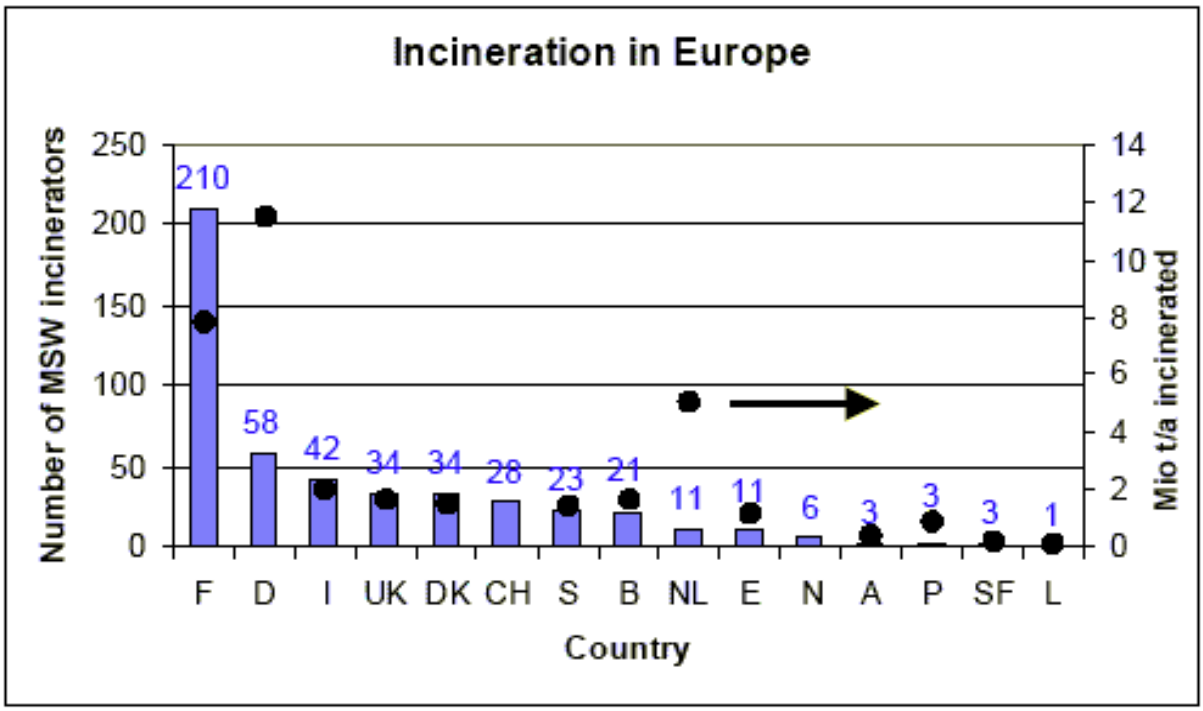
Country	**Bottom ash, slag EURO/t**	**APC residues EURO/t**	**Note**
Austria	63	363	-
Denmark	34	134	-
Germany	28.1	255.6	including fly ashes
Italy	75	129	including fly ashes
Luxembourg	16	8	-
United Kingdom	used as construction material	90	-

7.2.1 Austria

In Austria, management of wastes produced by incinerators is regulated by two directives, namely by the Directive on Waste Incineration, and by the Directive on Landfilling. The first of these Directives[74] requires facilities incinerating and co-incinerating wastes to minimise the amount and harmfulness of wastes produced by them, and to carry out analyses thereof (determining the amount of harmful substances both in the wastes and in the leachate from the wastes). Documents concerning the analyses must be kept for one year, at least, and must be given at disposal to authorities. In the case that the limit for dioxins (100 ng I-TEQ/kg) in the wastes is exceeded, then the wastes must be treated in order to reduce this value below the limit. Further, according to the Directive, formation and dispersion of dust from these wastes must be prevented during transport and intermediate storage.

According to a communication from the Austrian Ministry of the Environment, dated May 2004, filter cake from treatment of gases, and a part of fly ash, are handed over to Germany. The second part of fly ash, as well as bottom ash, are landfilled, or solidified and then landfilled. Activated carbon from flue gases treatment is incinerated. Gypsum from wet flue gas washers is landfilled, solidified and then landfilled, or used as a construction material.[75]

Picture 6: Number of municipal waste incinerators and amount of incinerated municipal waste in European countries in 2000. Source: UBA 2002.[a]



7.2.2 Sweden

In 1999, 22 incinerators were in operation in Sweden. They incinerated, in total, 1.9 million tons of waste. This amount included 1.3 million tons of municipal waste and 100 thousand tons of waste wood. The remainder was formed by hazardous (industrial) waste. In the same year, the incinerators produced 370 thousand tons of bottom ash which contained 5 to 10 I-TEQ PCDD/Fs. Further, ca 50 thousand tons of wastes from flues gases treatment were produced by the incinerators. These wastes contained, in average, 2 to 3 ng/g PCDD/Fs. In 1999, all Swedish incinerators released 3 g I-TEQ PCDD/Fs into the atmosphere (in 1985, this was 90 g Eadon TEQ PCDD/Fs). The amount of dioxins (PCDD/Fs) in wastes from flue gases treatment was many times higher: 110 - 120 g I-TEQ.

According to results of analyses of wastes from flue gases treatment produced by 6 Swedish incinerators, carried out in 2002, the average concentration of dioxins in the wastes was 0.2 ng I-TEQ/g (median being 0.22 ng I-TEQ/g).[76]

7.3 Pakistan - medical waste incineration

Medical waste incineration is quite a common treatment for medical wastes in Pakistan. Medical waste is burned in small scale waste incinerators without any air pollution control devices (APC) and/or with a very simple one.[77] The residual ash is buried at general dump sites like this near Charsadda road which this study focuses on and/or in deep holes with very poor or no insulation to prevent the leaching (leaking) of toxic substances from the ashes into underground water resources (for example in Shifa Internationals Hospital, Islamabad or in SK Cancer Hospital, Lahore - see photos at Pictures 7 - 11).

A small scale waste incinerator located in LRD Hospital, Peshawar (Pictures 7 and 8) contributes to the quantity of residual ash dumped at the Charsadda road dump site, where this ash was observed to be a potential source of dioxin contamination in free range chicken eggs collected from near village. [78]

The LRD Hospital incinerator is one of 4 located within the North Western Frontier Province. It was built using the Chinese

company Minama technology with two chambers without any air pollution control equipment (APC). It burns selected infectious waste from the hospital and runs for 4 - 8 hours per day with the exception of Sunday when it does not work at all. This is common in almost all other medical waste incinerators in Pakistan resulting in many start up and cool down operations occurring during the week. The LRD Hospital waste incinerator was built in 2001 and is already obsolete. It burns about 250 kg of infectious waste per day. These are figures for small scale medical waste incinirators using one kiln.

There are non-combustion alternatives to waste incineration which can avoid U-POPs releases as required by one of major aims of the Stockholm Convention. In Tabba Heart Institute, Karachi there is already a suitable alternative to an incinerator installed, an autoclave. Findings of this study support this method of dealing with medical wastes as a solution that makes Stockholm Convention aims achievable.

Situation in Pakistan gives representative picture of more developing countries (in India and/or Kenya).

Pictures 7 and 8: Medical waste incinerator in LRD Hospital, Peshawar. Small scale medical waste incinerator, typical for Pakistani hospitals. Photo by: Jindrich Petrlik.

Pictures 9 - 11: Waste incineration residue in the deep hole - storage built in the area of hospital. Cover of similar hole in another hospital. Double chamber kiln in one of Pakistani medical waste incinerators. Photos by: Jindrich Petrlik

8. Hot spots case studies

8.1 Hot spots and incineration residues in United Kingdom

There are currently 17 municipal waste incinerators in the UK[g], of which Edmonton is the biggest. Thirty-three new ones were under construction or in various stages of planning at the beginning of 2001[79]. The Byker Combined Heat and Power waste incinerator located in the city of Newcastle upon Tyne burnt refuse-derived fuel (RDF).

Since 1998, waste companies in UK have been using less hazardous 'bottom ash' collected in incinerator grates and selling it to be mixed with asphalt or concrete and used in building projects.

The operators of both Byker and Edmonton incinerators had been illegally mixing this bottom ash with the more toxic fly ash from the air pollution control devices (APC).

The scandal surrounding the dumping of toxic incinerator ash on Newcastle upon Tyne allotments and footpaths in 2001 revealed that incinerator operators across Britain may have been breaking the law while avoiding the cost of disposing of toxic ash in special hazardous waste landfills by selling it to be "recycled" into building projects.

Amazingly while the UK's Environment Agency was gathering evidence to procecute the operators of the Byker incinerator for spreading a mixture of fly and bottom ash in areas around Newcastle upon Tyne, it had full knowledge that the operators of the Edmonton

[g] 2 in Scotland, 1 in Jersey, 1in Wales and rest is located in England. About two-thirds of incineration capacity in England was according to study carried out by Environment Agency in 2002 concentrated around London and the West Midlands.

Table 4: PCDD/F levels in ash, soil and eggs in allotments with poultry in I-TEQ in pg/g (source Pless-Mulloli et al.[a])

Allotment name	Ash	Soil 30cm	150cm**	Eggs No.	Type	Fat basis	Distance from ash in m
• Allotments, which have received incinerator ash							
Blaney Row	150	7	N/A	3	H	4.4	0,20
				1	H	0.8	0
				1	H	8.9	20
Branxton A	3000	95	49	3	H	25	0
				3	B	56	0
Branxton B	3000	272	90	3	H	17.5	10,15
Brunswick	373	11	N/A	3	H	7	20
Coxlodge	4224	27	28**	3	H	1.5	30
Denton Dene	1636	34	N/A	2*	H	25	0,0
Hulne Terrace	910	14	N/A	3	H	31	0,10,20
				1	H	29	0
				1	H	0.4	10
				1	H	3.6	20
St. Anthony's	20	23	25**	2*	H	27	0,20
				2	D	9	0,0
Westmacott Street	2123	45	20	3	H	18	0,0,30
				1	H	5.6	0
				1	H	19.4	0
				1	H	2.9	30
Controls							
Hawthorn Farm	na	-	-	3	H	0.2	na
Pets Corner***	na	-	-	3	H	20	na

Notes to Table 4: H= Hen, B= Bantam, D= Duck, *one egg broken in transport, **samples from Environment Agency (EA) analysis program, sampling was done in parallel to this study, but strategy for analysis was to include all 30cm and 150cm samples, na=150cm samples only analyzed if 30cm sample above 40pg/g I-TEQ, ***The egg sample at Pets Corner was taken as control, but turned out to have contamination with PCDD/F. This was due to overflows of a stream contaminated with sewage sludge.

incinerator in North London had been mixing fly and bottom ash for 30 years (until August 2000) and was simultaneously sitting on a working Ash Group with the operators encouraging the use of similar mixed ash as road aggregate, breeze block type building bricks, and hard core in car parks.[80]

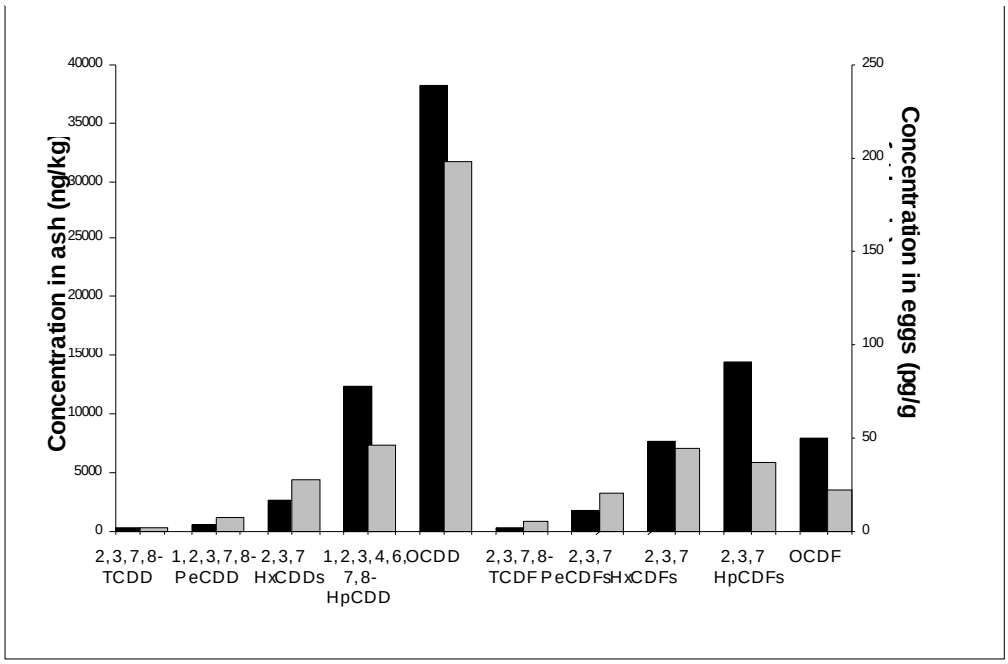
In December 2001, air pollution control residues leaked during unloading at the Castle Environmental plant due to a fault in the pipework. The dust was damped down after instructions from the Agency.

The plant installed for mixing wastes and powders were provided, in 4 cases, with suitable extraction and dust abatement equipment; in the other plant, no extraction was installed, but other dust suppression procedures were used. One plant had been the subject of occasional dust complaints from members of the public.

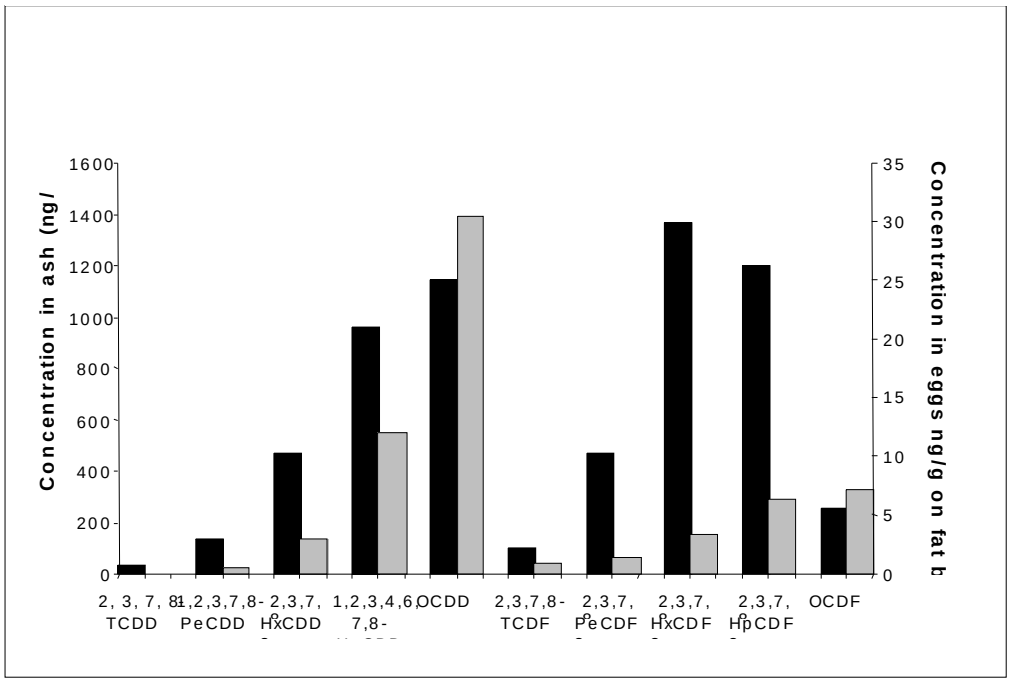
8.1.1 Newcastle

In the years 1994 - 1999, an estimated 2000 tons[81] of fly ash and bottom ash from the Byker incinerator were spread on food producing land, farms, flower beds, school playing fields, bridal pathways and footpaths around Newcastle. Tanja Pless-Mulloli et al.[82] of Newcastle University studied the influence

Picture 12: Westmacott Street: ash 2123ng/kg I-TEQ, incinerator pattern, eggs 18pg/g I-TEQ lipid basis, incinerator pattern, chicken have access to ash



Picture 13: Coxlodge: ash 4,224 ng/kg I-TEQ incinerator pattern, eggs 1.5 pg/g I-TEQ lipid basis non-incinerator pattern, chicken do not have access to ash



of its use on contamination of soil and poultry. They examined a number of factors that could influence the level of dioxins contamination. The results of their study are summarised in Table 4. Concentrations of dioxins found in the mixed ash ranged from 0.02 to 9500 ng (in I-TEQ).

Seventeen out of 19 egg samples from allotments which had received ash showed levels of contamination well in excess of barn held supermarket eggs. 17 out of 19 egg samples from allotments, which had received incinerator ash showed influence of ash in the pattern of contamination (see Picture 12). The weighted

average of all egg samples was 16.4pg/g I-TEQ. The weighted average for those samples, which showed the incinerator pattern in the egg samples was 22.2pg/g I-TEQ.

Wastes showing dioxins concentrations 750 - 3.5-times lower than "low POPs level" for dioxins[83] set out by the Basel Convention, used in Newcastle for reconstruction of footpaths, have resulted in contamination of poultry eggs which on average, exceeded 5.5 to 7-times the limit for the content of dioxins in eggs set out later in the European Union.

8.1.2 Edmonton

The operators of Edmonton MWI were supplying mixed ash to construction block manufacturers and to replace aggregate for road construction and car parks knowing full well it contained as much as 3,600ng/kg to 10,800ng/kg of dioxins. Therefore the level of dioxin contamination in this fine mixed ash would be in excess of 1100ng/kg, significantly higher than the 200ng/kg, (peaking at 900ng/kg) left as a result of spraying Agent Orange in Vietnam, where they are still reporting birth defects and elevated dioxin levels in human tissues 30 years after the spraying ceased. [84]

Typically, the mixed ash was mixed with 1 – 3% cement, 25 – 50% furnace bottom ash, for example from a power station, 25% aggregates and water. The amount of mixed ash in a typical block varied from about 10% to 25%. Blocks containing mixed ash from two different manufacturers have been identified, sampled and analysed for dioxins.

There is evidence of fly ash from Edmonton as high as 10,800ng/kg I-TEQ and calculations showing the final levels of dioxin in mixed ash as being 771ng/kg I-TEQ. Further tests on dioxins in fly ash from UK plants were in the region of 6,600 and 31,000ng/kg[85].

Results of four analyses show a range 117 – 390 ng ITEQ/kg of dioxins in the blocks. Tests conducted by the BBC documentary programe *Newsnight* 7on a sample block made from 30% of Edmonton ash showed 343ng/kg. [86] By contrast, blocks incorporating Edmonton bottom ash with no electrostatic precipitator ash, would be expected to contain less than 4ng ITEQ/kg. Table 2 shows the dioxin concentrations found in a range of construction blocks and bricks in Edmonton

Table 5: Dioxin concentrations in construction materials

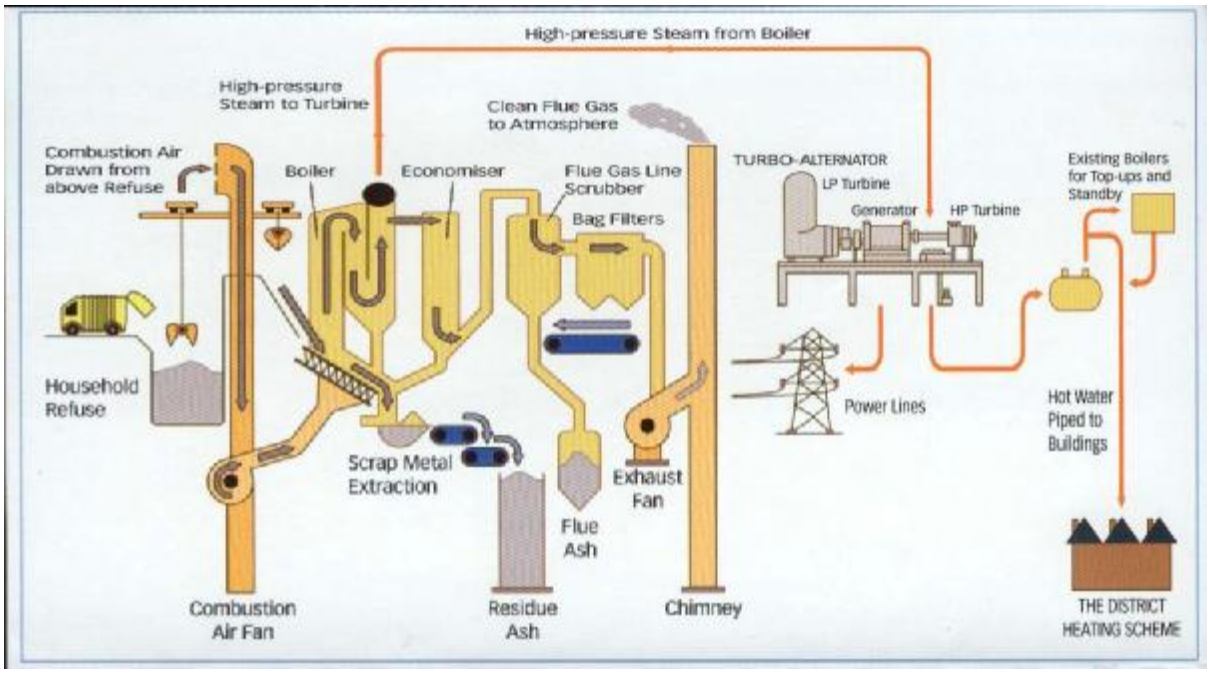
Construction blocks	ng ITEQ/kg	Bricks	ng ITEQ/kg
Thermalite	1.5	Chesterton	1.4
Hem PQ/7a	3	Leicester	1.7
Lignicite	1	Fletton	0.9
GGBS Ash	1	Other	
Celcon	2	Ordinary Portland Cement	0.5 to 1
Stock Brothers. Breeze	12	Pfa ex Ratcliffe	6.7
Durox	10	Pfa ex Drax	2.8
blocks from Edmonton mixed ash	117 to 390	blocks from Edmonton bottom ash	expected 4* measured 23**

Notes: * Calculated by EA report[87] authors. Based on the average dioxin concentration in Edmonton bottom ash of 10 ng/kg ITEQ[h].

** One block reported only to contain bottom ash from Edmonton was analysed and found to contain 23 ng/kg ITEQ dioxins.

[h] See Annex 18 in EA 2002: Solid Residues from Municipal Waste Incinerators in England and Wales. A report on an investigation by the Environment Agency, May 2002

Picture 14. Edmonton. Most current UK plants have a conventional grate, superheater, economiser, semi-dry scrubber with lime and activated carbon injection followed by a bag house as shown in the schematic below (with the generally optimistic addition, in this case, of the district heating system!). Edmonton is an unusual configuration because the acid gas removal plant and the new bag house were 'bolted onto' the existing electrostatic precipitator system.



8.2 Hot spots and incineration residues in the Czech Republic

Fly ash, bottom ash and other wastes from incinerators in the Czech Republic have been deposited in hazardous waste landfills for many years. In 1997 a decree of Law on wastes set a limit on the dioxin content in wastes of 10 ug/kg. Wastes exceeding this limit would have to be stabilised and then deposited in a speacialised hazardous waste only landfill. Simultaneously with the introduction of this law, the fees for depositing wastes on hazardous waste landfills increased significantly.

The sum of these measures have resulted in the operators of waste incinerators looking for ways to avoid paying these high landfill fees for fly ashes and for the means to avoid measurements of dioxins in fly ashes. Due to the benevolence of the state authorities they have been successful in both these aims as documented by the case of the municipal waste incinerator in Liberec in further text.

Arnika Association in its previous report on waste incineration residues estimated amounts of dioxins content in produced waste incineration ashes in 2002. Municipal waste incinerators released 20 g I-TEQ of dioxins in residues. Estimation of dioxins level released in ashes from hazardous waste incinerators[i] in the Czech Republic ranged between 7.5 and 150 g I-TEQ. These calculations were based on the official figures about waste production in the Czech Republic for 2002 and the range of measured levels of dioxins in waste incineration residues.[88] Large range of measured levels of dioxins in fly ashes from hazardous waste incinerators (see Annex 2) is the reason for large range of dioxins produced by hazardous waste incinerators.

8.2.1 Liberec

The municipal waste incinerator in Liberec began operations in 1999. It is designed in such a way that fly ash is mixed with bottom ash. The incinerator, having a capacity of

[i] including medical waste incinerators too

Picture 15: Municipal solid waste landfill in Košťálov, where the mixed ashes from MWI in Liberec were dumped for long time without any pretreatment. Photo by: Vítězslav Roušal.

96.000 tons of wastes per year, produces between 25 and 40 thousand tons of this ash mixture yearly[j]. Despite this mixture exceeding the limit for dioxin contamination as set out in the law[89], the incinerator was allowed to deposit the ashes on a municipal waste landfill in the year 2000.

The situation has changed since then as new law on wastes and a decree have cancelled the limit set for the content of dioxins in wastes. They have set out that fly ashes from waste incinerators must be, without any measurements, stabilised and then deposited on hazardous waste only landfills. Simultaneously, the operators of the Liberec incinerator, the company Termizo, obtained a certificate allowing the mixture of fly ash and bottom ash to be sold as a construction material.

The Ministry of the Environment of the Czech Republic set out orientation limits for the decontamination of old ecological burdens in 1996. There is no doubt that if sometime in the future the sites where the mixed ashes from the Liberec incinerator has been deposited are checked for the content of dioxins, they will most certainly exceed the limit B[k] set out by the binding methodical instruction of the Ministry. Exceeding limit B in soils is considered a serious pollution problem having a negative influence on human health and individual components of the environment and as such requires further measures being taken.

Increased levels of dioxins in eggs and meat of free-range poultry have been caused by concentrations of dioxins that were 10x (and sometimes even 100x) lower than this limit.

It is impossible at this moment in time to establish whether the described use of the mixture of ashes from the incinerator in Liberec has resulted in increased concentrations of dioxins in soils and animals because the location of the dumping sites is secret and known only to Termizo. These sites are unknown even to state authorities in charge of environmental supervision.

8.2.1.1 The case of the incinerator in Liberec, Guidelines on BAT/BEP and limits for the content of POPs in wastes

Concerning the treatment of residues from municipal waste incinerators, the "Guidelines on Best Available Techniques and Best Environmental Practices (BAT/BEP)", proposed to be adopted by COP 1 of the Stockholm Convention, state the following: *"Bottom and fly ash from the incinerator must be properly handled, transported and disposed of. Covered hauling and dedicated landfills are a common practice for managing these*

[j] Specific amounts for years 2001 - 2003 are shown in Table 8.

[k] Limit B = 0.1 ug I-TEQ/kg dry weight

residues. Particularly if reuse of the residues is contemplated, an evaluation of the content and potential environmental mobility of chemicals listed in Annex C is required, and guidelines adopted by the Basel Convention and subsequently adopted by the Conference of the Parties of the Stockholm Convention should be followed. Periodic analysis of the ash can also serve as an indicator of incinerator performance or the introduction of illegal or unpermitted wastes or fuels (for example, the detection of high metal content in the ash as a result of burning construction debris in an incinerator permitted to burn only virgin wood).

Scrubber effluents, including the filter cake from wet flue gas cleaning, is regarded as hazardous waste in many countries and must be properly treated and disposed of. If the concentration of chemicals listed in Annex C or other toxic materials (for example, heavy metals) is sufficiently high, these materials may be consigned to landfilling as hazardous waste."

from fly ashes produced by the waste incinerator in Liberec.

The BAT principle is also used in the EC Directive about Integrated Pollution Prevention Control. In the case of the incinerator in Liberec, an operating license has been already issued according to this Directive[90]. Not only did the competent authority fail to prevent the mixing of fly ash and bottom ash, it failed to establish a duty to make measurements of hexachlorobenzene and PCBs in fly ash and other wastes produced by the incinerator.

8.2.1.2 Calculation of releases of PCDD/Fs contained in wastes produced by the incinerator into the environment

In contrast to similar plants in the Czech Republic, measurements of dioxin contents were carried out in wastes produced at the Liberec incinerator. The basic results of these

Table 6. : Results of measurements of dioxin contents in bottom ash and fly ash in Liberec[a, a].

Type of waste	Measurement No. 1 ug I-TEQ/kg	Measurement No. 2 ug I-TEQ/kg
bottom ash (2911)	0.00437	0.0197
treated fly ash (2912)	0.362	0.363
mixed bottom ash with treated fly ash (2913)	0.062	0.066
boiler ash (11249)*	0.0113	-

In the case of the Liberec incinerator, satisfying this text in practice will not result in any change to the better. It will continue to be able to use the mixture of bottom ash and fly ash as a construction material. Why? Because the "Guidelines on BAT and BEP" refer to the "*guidelines adopted by the Basel Convention*". According to them, it is not necessary to treat the waste in any special way if it does not contain dioxins in concentrations higher than 15 ug I-TEQ/kg dry weight. Table 6 shows levels of dioxins found in wastes produced by the Liberec municipal waste incinerator. In the case of the adoption of the POP levels according to Basel Convention, the Stockholm Convention will fail to protect public health and the environment from releases of dioxins

measurements are shown in Table 6. In addition to these, the level of 0.2136 ug I-TEQ/kg was found in the mixture of fly and bottom ash[91]. The operator of the incinerator somehow had the mixture of ashes reclassified as waste that does not have hazardous characteristics and since the year 2001 have possessed a certificate according to which this mixture can be marleted as a construction material.

Any mixture of fly ash and bottom ash will contain high concentrations of dioxins, which, in the case of fly ash used in Newcastle, resulted in the contamination of eggs and poultry in the vicinity of where it was spread.[92]. Therefore, such ashes should be

included into the calculation of total releases of PCDD/Fs into the environment.

UNEP prepared a proposal of "Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases", with an attached 'tool' for the calculation of total releases of dioxins into the environment with emission factors. We have tried to use this Toolkit to calculate the amounts of PCDD/Fs in the wastes produced by the Liberec incinerator. The result is shown in Table 7. Following this we made the same calculation using known information concerning the amounts of wastes produced by the Liberec incinerator on the levels of dioxins found in these wastes. Data for waste waters, as well as for filter cake, are not available[l].

For calculations concerning the year 2003, only estimates of releases of PCDD/Fs in product/material, for which the mixture of fly and bottom ash was certified could be made. Our calculations were based on data of waste production given by the incinerator in an application for issuance of IPPC certificate. Information on the calculations are contained in Table 7.

Table 7: Calculation of PCDD/Fs releases per year for MWI in Liberec based on UNEP's Toolkit and on real measurements.

	Annual release						Total annual release in g TEQ/a
	g TEQ/a Air	g TEQ/a Water[a]	g TEQ/a Land[a]	g TEQ/a Products	g TEQ/a Fly ash	g TEQ/a Bottom Ash	
Toolkit	0.048	0	0	0	1.44	0.144	**1.584**
Reality 2002a	0.0898	?	?	0	0.3828	8.2780	**8.7506**
Reality 2002b	0.0898	?	?	0	0.3828	2.4030	**2.8756**
Reality 2003a	0.037	?	?	8	0.4203	0.1440	**8.6013**
Reality 2003b	0.037	?	?	2.25	0.4203	0.1440	**2.8513**

In each of the cases calculation according to real values has been carried out in two variants designated "a" and "b", in view of the fact that levels of dioxins found out in the mixture of fly ash with bottom ash differ significantly. The real amount of dioxins contained in this waste is likely to be somewhere between both variants.

Table 8: Amounts of residues produced by MWI in Liberec per year[a].

Type of waste	Amounts of produced waste per year		
	2001	2002	2003
Filter cake (19 01 05)	1085,22	1051,44	1154,8
Waste water from flue gases treatment etc. (19 01 06)	106,12	121,54	21,5 *
Bottom ash (19 01 12) **	33 703,92	38 754,17	2316,09 ***
Other ashes (mainly boiler ash; 19 01 13)	128	113	92

* only amount transferred out of the plant included - waste water treated at plant's waste water treatment facility is not included in this number

** there is also treated fly ash included in this figure

*** biggest part of this waste has been used as product (construction material) since the beginning of 2003, so that the filter cake contains much higher level of dioxins than in our calculation.

[l] For our calculation, we have used the concentration of dioxins found in treated fly ash and for the filter cake. In reality, it can be expected

In the case of the calculation according to the Toolkit[93], in comparison with calculation based on measured values vastly different numbers were obtained. This was a result of several factors:

1) The Toolkit supposes much lower amount of residual wastes after the combustion of one ton of solid municipal waste.

2) The Toolkit does not consider the mixing of fly and bottom ash. This resulted in much lower level of dioxins in bottom ash being set.

3) Emission factors for releases of PCDD/Fs into the environment are given as simple numbers without ranges.

The difference between the calculation according to the Toolkit and reality will continue to increase after concentration of dioxins in waste waters from Liberec are known. These are not taken into account in the case of municipal waste incinerators in the Toolkit.

Despite the calculations here concerning only one municipal waste incinerator in the Czech Republic, it can play an important role on the calculation of total releases of dioxins into the environment because this incinerator forms 1/4 of the total capacity of municipal waste incinerators in the Czech Republic. Comparison of the real values found with the theoretical calculation according to the Toolkit document the significant shortcomings of this as a 'tool.' In this particular case its use would result in the underestimation of wastes produced by the Liberec incinerator and its dioxin content.

Picture 16: Sampling of sediments in surroundings of an old coal mine Jan Šverma near Lampertice at the beginning of 2004. Photo by: Jindřich Petrlík.

8.2.2 Lampertice

There have been black coal mine workings under the highest Czech mountains Krkonose (German synononyma Riesengebirge) in the northeast part of the Bohemia since the 16th century. The oldest underground mine was later called Mine Jan Šverma and is located between the town of Žacléř and the village of Lampertice (see map). This mine was closed sometime around 1990.

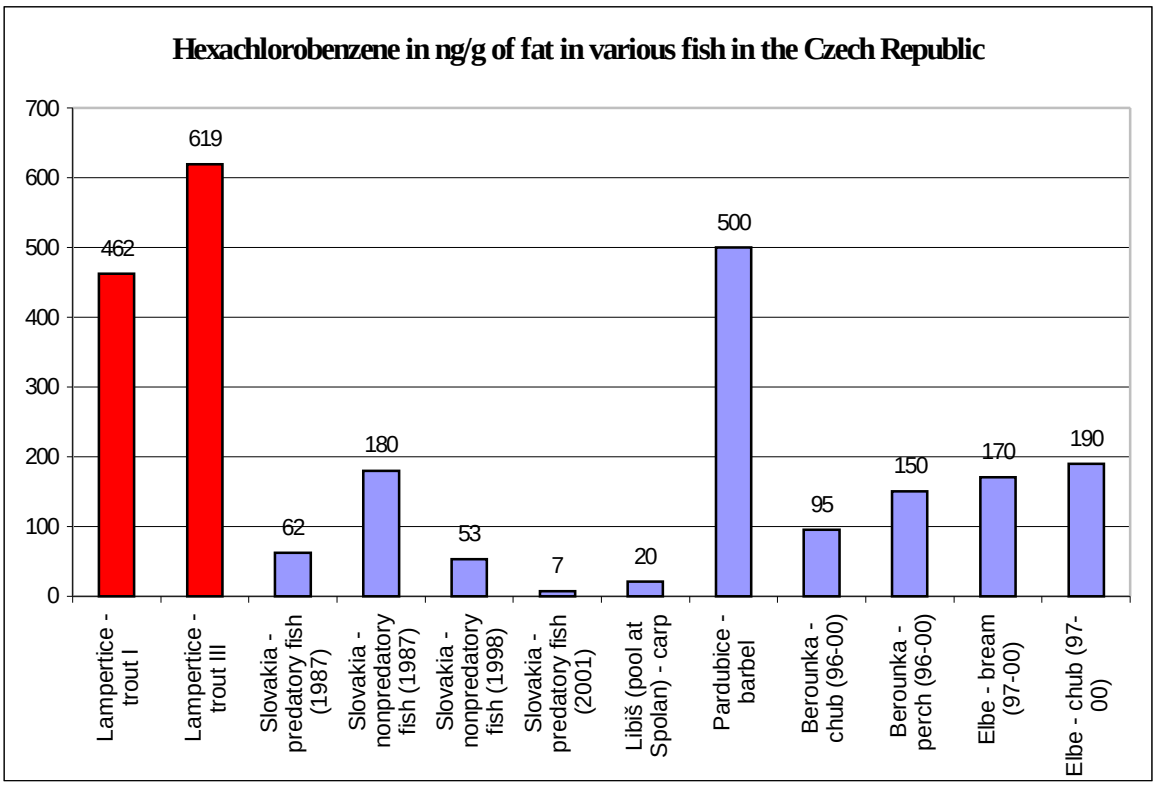
The mine is located in an area with typical under-mountain landscape with a wild Lampertický creek. There is also a complicated underground water system that, according to the experts of the GEMEC Union company, doesn't leak/leach from the mine. However local people who worked in the mine don't trust this opinion and say that the situation is much more complicated than most people believe. The Mine itself is located next to the Czech - Polish boarders, so any changes in the environment could well have transboundary impact.

It is common practice that these old mines are filled with different materials to prevent surface landscape movements. We have chosen this particular mine for our hot spot report as it has been filled with different types of wastes, including wastes showing POPs patterns. According to records of state environment control insitutions the waste incineration residues were stored in this mine in amounts up to 7000 tons per year.[94]

The basic argument of the GEMEC Union company is that the technology used is safe and that the leaching of toxic substances deposited in the mine does not occur. However, the results of tests of sediments from Lampertice stream showed that in one place (below a discharge from the waste water treatment plant in the premises of the mine), the dioxins concentration is ten times the amount of the lowest value found in the area (this is a tributary of Lampertice stream "U Kirschů", which drains the south part of the spoil heap). The measured values show without doubt the necessity and importance of a thorough environmental impact assessment of the chosen method of re-cultivation or liquidation of the underground mine.

At the first half of year 2004 the Arnika Association published results of analysis of four trouts samples for different POPs. From the analysed substances, the trout from Lampertice contained the highest values of hexachlorobenzene in comparison with the other locations in the Czech Republic as showed from the comparison presented in the graph at Picture17.[95] Also the value of indicator congeners of PCBs in the case of trout I was relatively high, this value being lower, but also significant, in the case of trout III. comparison with values found in Slovakia in the years 1987 - 2001.[96]

Picture 17: Graph showing comparison of concentrations of hexachlorobenzene measured in fat of fish from different localities.



8.3 Barangay Aguado, Philippines

Barangay Aguado is "home" to a controversial "Thermal Oxidizer Plant" operated by Integrated Waste Management Inc. (IWMI). A typical incinerator had operated in the same site for over four years. The IWMI incinerator is a "pyrolytic waste oxidizer" from Canada-based EcoWaste Solutions Inc., with a capacity of 10 tons/day. Apart from treating biomedical waste coming from client hospitals in Metro Manila, the IWMI incinerator also accepts and burns illegal drugs such as amphetamines seized from drug syndicates.

Picture 18: Protest action opposing the construction of the IWMI waste incinerator in Barangay Aguado, Philippines. Photo by: Green Cavite.

The IWMI "Thermal Oxidizer Plant" was formally inaugurated in September 2003, in apparent defiance of the ban on medical waste incineration that took effect under the Clean Air Act in July 2003.

The IWMI claims that the residual ash is safe based on test procedures that do not measure dioxins. Tests conducted in 1998 for EcoWaste Solutions technology show significant levels of dioxins in the ash at 23 ng TEQ/kg of waste.[97]

NGO representatives present at the official launch of the IWMI facility were told that the bottom ash is mixed with cement to make concrete blocks. The hollow blocks, as they are called in the Philippines, are also mixed with industrial waste, i.e., shredded computer hardware scraps, which could also be the source of high levels of polybrominated diphenyl ethers (PBDEs) [98] observed in eggs sample from Philippines.

The communities, including Barangay Aguado and nearby Brangays, are possibly the most affected by the continued operation of the IWMI waste incinerator. The lack of a secured facility for containing the incinerator ash, and its use for making concrete blocks could only aggravate the spread of toxic pollutants into the air, water and soil. The vicinity map shows the existence of waterways (two rivers and a creek), a common source for water and fish, not far from the IWMI waste treatment plant.[99]

Free-range chicken eggs collected near the medical waste incinerator in Barangay Aguado showed levels of dioxins[m] that exceeded the European Union (EU) limit by more than 3-fold. Additionally the level of PCBs in the eggs[n] exceeded the proposed EU limit. The levels of 7 PCB congeners did not exceed regulatory limits but were the seventh highest observed among 20 samples analyzed during IPEN's global biomonitoring project.[100] The reasons for this substantial level of PCBs are not clear. The three egg sampling sites were approximately half a kilometer northeast of the incineration plant.

Comparing the dioxin congener pattern from eggs collected in Barnagay Aguado with data measured for different kinds of sources from other countries indicates that medical waste incineration (including fly ash and air releases) is the likely source of the dioxins found in the eggs. Data from other types of dioxin sources such as metallurgy and/or local heating using wooden materials show different patterns of dioxin congeners.

[m] 9.68 pg WHO-TEQ/g of fat
[n] 3.30 pg WHO-TEQ/g of fat

9. Waste incineration residues questions and the Stockholm Convention

9.1 How much is a "LOW" content of POPs?

The content of POPs in waste is one of focuses of the Stockholm Convention in which Article 6 states: "Measures to reduce or eliminate releases from stockpiles and wastes" -- instructs the Stockholm Conference of Parties to cooperate closely with the appropriate bodies of the Basel Convention to:
"*establish levels of destruction and irreversible transformation necessary to ensure that the characteristics of persistent organic pollutants … are not exhibited";*
"determine what they consider to be the methods that constitute environmentally sound disposal"; and
"work to establish, as appropriate the concentration levels of the chemicals listed in Annexes A, B and C in order to define the low persistent organic pollutant content" below which POPs wastes need not undergo destruction or irreversible transformation, but are to be disposed of in an environmentally sound manner.

In response to Article 6, the Basel Convention Open Ended Working Group (OEWG) undertook the task of preparing a series of guidelines on wastes consisting of or containing POPs. The first two guidelines in the series – "General Technical Guidelines for Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Persistent Organic Pollutants," and "Technical Guidelines for Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Polychlorinated Biphenyls, Polychlorinated Terphenyls or Polybrominated Biphenyls" -- were approved and adopted at the sixth Conference of Parties (COP6) of the Basel Convention, 25–29 October 2004. [101, 102]

The Basel Convention Technical Guidelines has proposed levels of most POPs in wastes/residues that trigger the requirement for destruction or irreversible transformation of 15 ppb (in I-TEQ) for PCDD/Fs and 50 ppm for all other POPs listed in Annexes to Stockholm Convention. Low POP content levels as required in Article 6 of the Stockholm Convention are proposed at the same levels. Delegates at COP1 will have the opportunity to tighten these guidelines so that they provide greater protection to human health and the environment.

The proposed levels are not based on practical experience or on current knowledge about the levels in POPs wastes in relation to recorded examples of high environment and food chain contamination.

It is shown in this study that the majority of residues from waste incineration contain levels of dioxins that are below the proposed low POP content as well as bellow the level that requires further treatment to ensure that "*the characteristics of persistent organic pollutants … are not exhibited"*. Does this mean that use of waste incineration residues cannot harm the environment and public health?

Looking at the examples in this study the clear answer on this question is NO! The level established for dioxins (PCDD/Fs) at 15 ug I-TEQ/kg is very high if we consider one example from UK, where waste incineration fly ash was spread on the allotments and poultry was contaminated by unacceptably high levels of dioxins. Fly ash spread on the allotments contained levels of dioxins in the range of 0.020 - 4.224 ug I-TEQ/kg dry matter and contamination by this waste led to contamination of poultry eggs up to 56 pg WHO-TEQ/g on lipid base.[103] EU limit set up for dioxins content in eggs is at 3 pg WHO-TEQ/g on lipid base, which was exceeded by almost all eggs samples from Newcastle upon Tyne measured after this accident .

There are more documented cases of unsafe treatment of the wastes containing POPs which led and/or contributed to increased levels of POPs in the environment and food chain. Some of these were recently documented by series of studies on hot spots in different countries. These studies showed elevated levels of dioxins and other U-POPs in collected free

range chicken eggs sited near the hot spots. In some of these cases the high levels of dioxins were found to be related to wastes containing POPs. For example: the case of chicken eggs sampled in Philippines near a medical waste incinerator in Barangay Aguado where incineration residues are used for production of concrete "hollow blocks". The eggs collected near the incinerator showed very high levels similar to the waste incineration residues pattern of dioxin congeners. [104] Another case of eggs found with high dioxin contents in the mentioned studies is those taken from near the chlorinated waste disposal area of the poorly controlled chlorine chemical industries in Dzerzhinsk.[105]

The case of the village Lampertice in the Czech Republic shows that to allow POPs waste to be stored in the areas of old coal mines and the handling of these wastes in these areas can lead to serious threats of the environment. Here one of the highest levels of hexachlorobenzene in fish was recorded, a find that is most probably a result of the dumping of large quantities of wastes containing POPs,the including waste incineration residues and sewage sludge from the chlorine chemical industry.[106]

The myth about non-leachable dioxins (and other U-POPs) from ash, (which is to blame for new findings as shown in this study), together with the proposed limits for POPs content in waste under the Stockholm Convention can and will (if accepted), undoubtedly lead to unacceptable contamination by POPs and goes against the very essence of the treaty. Not only that. The Basel Convention Technical Guidelinse proposed levels of POPs in waste undermines some national legislation efforts.

In Japan, after a few serious dioxin incidents at incineration facilities, resulting in some facilities shut down, the government published a new act, effective since April 2000, in which levels of dioxins and conplanar PCBs in fly ash are regulated.

The limit for dioxins and dioxin-like PCBs content in fly ash was set by that regulation at level of 3 ng TEQ/g, what is 5-times lower in comparision to the proposed level for adoption at COP1 of the Stockholm Convention.[107] Similarly "destruction and irreversible transformation" level for dioxins content in waste is contrary to the Czech legislation. Levels of PCDD/Fs content in the soils which requires clean up of the area where this limit is not met is 10 ug/kg[o] for industrial zones and 0.5 ug/kg for living urban zones, both in I-TEQ. For seven PCB congeners these limits are 30 and 5 mg/kg. respectively, for organochlorine pesticides these levels are 10 and 2.5 mg/kg.[108]

9.2 Dioxins in ashes according to Dioxin Toolkit

UNEP has developed a basic tool to help parties to the Stockholm Convention develop their national POPs inventories which focused on dioxins. This Dioxin 'Toolkit' get its name from the longer "Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases".[109] Countries can calculate basic dioxins releases from different sources on this inventory and address major sources to comply with the aims of the Stockholm Convention to minimise and where feasible, to eliminate U-POPs. From these consequences we can see how important the Toolkit is. If a calculation is wrong, then it might well happen that a country, together with international agencies, will invest large resources without the expected result, which are as large a decrease of dioxins releases into the environment as possible.

When looked at the Toolkit suggested figures to calculate the dioxins releases through waste incineration residues and compared them with some real measurements. One comparison shown in Chapter 8.2.1.2 focused on the Liberec Municipal Waste Incinerator as a hot spot.
The main results of our comparison are:

In the case of calculation according to the Toolkit[110], and the calculations based on measured values, very different numbers were obtained. This was caused by several facts:

[o] This and following Czech limits are per kg of dry matter.

1) The Toolkit supposes the much lower amount of residual wastes after combustion of one ton of solid municipal waste.

2) The Toolkit does not suppose that mixing of bottom ash with fly ash would occur. Therefore, much lower levels of dioxins in bottom ash is set.

3) Emission factors for releases of PCDD/Fs into the environment are given as simple numbers without ranges.

The difference between the calculation according to the Toolkit and reality will still increase after the concentration of dioxins in waste waters from Liberec are known. These are not taken into account at all in the case of municipal waste incinerators [in the Toolkit].

There was published a comprehensive number of data about waste incineration residue production and dioxin levels in them in England and Wales.[111] We used this data to calculate dioxin releases in waste incineration residues produced by eleven municipal waste incinerators in England and Wales and their emission factors[p] for incineration residues. This calculation was based on measured maximum levels of dioxins in the residues is in Table 9.

We have tried to compare the emission factors calculated from the average and maximum levels of dioxins in waste incineration residues from England and Wales with those used for state of art municipal waste incinerators in UNEP Toolkit (= MWI class 4). The emission factors calculated from the real life data are quite different from emission factors used in UNEP Toolkit (see Table 10). For fly ash the emission factor used in UNEP Toolkit is 15 ug I-TEQ/kg, while the emission factors calculated from real life data is between the range of 23 to 70 ug I-TEQ/kg. Therefore, using the UNEP Toolkit can lead to a serious underestimation of PCDD/Fs released in APC residues from MWI. For England and Wales this difference is almost 20 g I-TEQ of dioxins per year, which is one third of all dioxin releases in fly ash. The main reason for the large difference is the underestimation of the percentage of APC residues compared to waste burnt. The UNEP Toolkit estimates a 1 - 2 % of APC residues produced compared to burnt waste, while the reality in MWI in England and Wales was 3.32 % value.

The examples shown in this study lead to the simple and worrying conclusion that the UNEP Toolkit is seriuosly flawed and simply doesn't provide the correct emission factors for the calculation of dioxin releases in waste incineration residues even in developed countries. One is deeply concerned for the populations of developing countries with scant data about levels of POPs generated by waste incineration should they be using such a flawed tool to estimate the sources and emission releases in their countries.

The results of this study most definatly don't suggest approval of UNEP's Toolkit by COP1.

[p] "emission factors" describe release of PCDD/PCDF to each medium per unit of activity (*e.g.,* µg I-TEQ/ton) - this is definition in UNEP Toolkit. These emission factors are calculated from measured levels of PCDD/Fs, quantitaties of emmitted medium for which the emission factor is calculated and quantitative data about activity (= burnt waste per year for waste incineration)

10. Conclusions and Recommendations

Waste incineration residues represent a serious threat to both local and global environment as they contain high quantities of persistent organic pollutants (POPs) listed under Annex C of the Stockholm Convention (dioxins, PCBs and hexachlorobenzene) as unintentionally produced POPs. A goal of the ***"continuing minimization and, where feasible, ultimate elimination"*** was established for these chemicals in the Convention. There are several steps that should help Parties to the Stockholm Convention to comply to this goal. Almost all are under articles 5 and 6 of the Stockholm Convention (see Annexes to this text) and will be discussed at the first Conference of Parties to the Convention (COP1). Topics discussed in this study are related to several of these steps.

1) UNEP's Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases

In state of art waste incinerators fly ashes and APC residues contain between 55 % and 99.5 % of all released dioxins as was shown by a number of examples in this study. In developed countries where these wastes were counted they contributed by several tenths of grams of dioxins in I-TEQ to the overall releases of these toxic chemicals. As we have shown in the study counting these releases using the UNEP's Toolkit[112] leads to a large underestimation of the amount of dioxins released in wastes produced by waste incineration.

a) The Toolkit assumes much lower amounts of residual wastes after the combustion of one ton of solid municipal waste.

b) The Toolkit does not consider that the mixing of bottom ash with fly ash would ever occur. Therefore, much lower levels of dioxins in incineration bottom ash is set.

c) Emission factors for releases of PCDD/Fs into the environment are given as simple numbers without ranges.

Dioxins and furans levels observed in fly ash in a range from 36 ng I-TEQ/kg [113] to 2,100,000 ng I-TEQ/kg d.m.[114]

2) Basel Convention versus Stockholm Convention

"Levels of destruction and irreversible transformation of POPs in waste" and "Low POPs levels in waste"

POPs require guidelines for management and disposal but the proposed Basel Convention levels of most POPs in wastes that trigger the requirement for destruction or irreversible transformation are quite permissive at 15 ppb (in I-TEQ) for PCDD/Fs and 50 ppm for all other POPs listed in Annexes to Stockholm Convention (see "General technical guidelines …."). Delegates at COP1 will have the opportunity to tighten these guidelines so that they provide greater protection to human health and the environment.

For example, level established for dioxins (PCDD/Fs) at 15 ug I-TEQ/kg is really high if we consider the example from the UK. Here waste incineration fly ash was spread on the allotments and poultry kept on these sites was contaminated by high levels of dioxins. The fly ash spread contained levels of dioxins in the range of 0.020 - 4.224 ug I-TEQ/kg dry weight and its consumption by the chickens led to the contamination of poultry eggs up to 56 pg WHO-TEQ/g on lipid base.[115] The EU limit for dioxins content in eggs is 3 pg WHO-TEQ/g on lipid base, which was exceeded by almost all the eggs samples from Newcastle measured after this irresponsible action.

The decision taken by Conference of Parties to Basel Convention on the levels of destruction and irreversible transformation is equally as irresponsible and doesn't comply with the Stockholm Convention definition and requirements in its article 6. No ***"levels of destruction and irreversible transformation"*** were established "***to ensure that the characteristics of persistent organic pollutants as specified in paragraph 1 of***

Annex D are not exhibited;" as required in article 6 of the Stockholm Convention. Basel Convention technical guidelines redefined ***"levels of destruction and irreversible transformation"*** instead.

The myth about non-leachable dioxins (and other U-POPs) from ash, which is to blame for new findings as shown in this study, together with limits for POPs content in waste under the Stockholm Convention proposed can lead to unacceptable contamination by POPs, going against the aim of the treaty. Not only that. By the Basel Convention Technical Guidelinse proposed levels of POPs in waste undermine some national legislation efforts.

3) BAT/BEP Guidelines

Looking at these facts it is unbelievable how the use of these materials is out of control to the extent they are in many countries. There are plenty of studies showing the use of waste incineration fly ash as construction materials based on leaching analysis for heavy metals. This practice is in strong disagreement with one of goals of the Stockholm Convention and several hot spots cases presented in this study shown that uncontrolled use of fly ash as construction materials can lead to serious damage of the environment and threaten the health of communities living in the vicinity and surrounding areas where this material was used and/or where this material is produced. Therefore we suggest the use of non-combustion chemical treatment methods that lead to real POPs destruction into BAT/BEP Guidelines and to consider the proposed Guidelines as work in progress.

4) New POPs

Dioxins were not the only toxic organic chemical studied. PCBs and hexachlorobenzene in waste incineration residues were also look at. Many of these chemicals show the same and/or similar behavior as those already listed under Annex C of the Stockholm Convention. These findings suggest these should be added those listed in Annex C, especially the polychlorinated naphthalens (PCNs), polybrominated dioxins and furans (PBDD/Fs and PCBDD/Fs) and polyaromatic hydrocarbons (PAHs). Also the presence of brominated flame retardants (PBDEs and HBCD) in waste incineration residues suggests these chemicals should also be added to those listed under Stockholm Convention, Annex B.

5) The precautinary principle is included in the Convention and applied to the issue of waste incineration residues. This leads to the recommendation that the best available technique and best environmental practice are used to prevent the production of such wastes. It also means the preferencial use of technologies other than waste incineration and/or landfilling and that chlorinated and brominated compounds lead to chlorinated and brominated POPs occuring suggesting the substitution of materials containing these chemicals.

Table 9: Measured maximum levels of dioxins in waste incineration residues from municipal waste incinerators, other data about MWI residues and calculated maximal emission default factors for MWI in England and Wales. Based on data published in EA 2002. [116]

Municipal waste incinerator	Bolton	Coventry	Dudley	Edmonton	Nottingham	Lewisham	Sheffield	Stoke on Trent	Teesside	Birmingham	Wolverhampton	Sums (average) *
Waste burnt in tonnes	30300	201446	99492	500730	159817	437850	103644	201752	213839	335959	119011	2403840
Bottom ash in tonnes	11904	33148	21132	157582	37938	107923	39852	50001	76724	77054	28830	642088
Bottom ash in % of burnt waste	39.29	16.46	21.24	31.47	23.74	24.65	38.45	24.78	35.88	22.94	24.22	26.71
APC residues in tonnes	1353	7194	4178	15858	7328	14840	3333	6472	5848	8717	4650	79771
APC residues in % of burnt waste	4.47	3.57	4.20	3.17	4.59	3.39	3.22	3.21	2.73	2.59	3.91	3.32
PCDD/Fs in bottom ash in ng I-TEQ/kg	13.0	10.5	7.8	23.0	4.9	4.3	52.0	21.0	12.0	7.4	6.4	4.3 - 52.0
PCDD/Fs in bottom ash g I-TEQ/year	0.15	0.35	0.16	3.62	0.19	0.46	2.07	1.05	0.92	0.57	0.18	9.74
PCDD/Fs in APC residues in ng I-TEQ/kg	330	2591	1125	5800	697	720	1200	823	370	1364	2753	330 - 5800
PCDD/Fs in APC residues in g I-TEQ/year	0.45	18.64	4.70	91.98	5.11	10.68	4.00	5.33	2.16	11.89	12.80	167.74
Emission factor / bottom ash in ug I-TEQ/t	5.11	1.73	1.66	7.24	1.16	1.06	19.99	5.20	4.31	1.70	1.55	4.05
Emission factor / APC residues in ug I-TEQ/t	14.74	92.53	47.24	183.68	31.96	24.40	38.59	26.40	10.12	35.39	107.57	69.78

Notes: * average of % of residues of burnt waste (both APC and bottom ash), range of maximum levels of PCDD/Fs measured in residues, (both APC and bottom ash), **average default factors**

Table 10: Emission default factors calculations for MWI in England and Wales based on data from EA 2002.[117] Comparison with emission default factor and basic data for its calculation from UNEP Toolkit. [118]

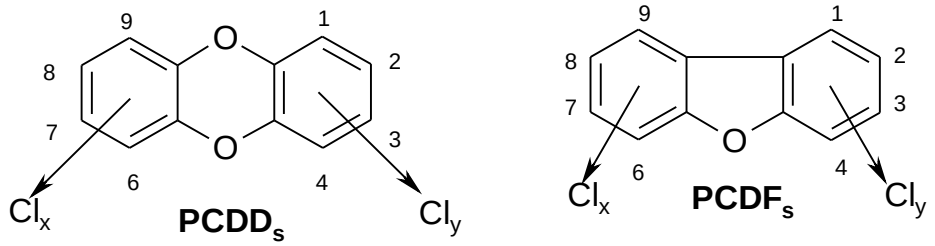
Type of estimates / calculations	Based on measured max. levels	Calculated from average max. level	Calculated from median max. level	Based on measured average levels	Calculated from medium of average levels	Calculated from median of average levels	UNEP Toolkit - class 4
Waste burnt in tonnes	**2403840**	2403840	2403840	**2403840**	2403840	2403840	**2403840**
Bottom ash in % of burnt waste	**26.71**	26.71	26.71	**26.71**	26.71	26.71	**10 - 20**
APC residues in % of burnt waste	**3.32**	3.32	3.32	**3.32**	3.32	3.32	**1 - 2**
PCDD/Fs in bottom ash in ng I-TEQ/kg	**4.3 - 52.0**	14.8	10.5	**2.5 - 25**	7.4	5.0	**5.0**
PCDD/Fs in bottom ash g I-TEQ/year	**9.7**	9.5	6.7	**4.8**	4.7	3.2	**3.6**
PCDD/Fs in APC residues in ng I-TEQ/kg	**330 - 5800**	1615.7	1125.0	**270 - 2800**	993.2	700.0	**1000.0**
PCDD/Fs in APC residues in g I-TEQ/year	**167.7**	128.9	89.7	**94.3**	79.2	55.8	**36.1**
Emission factor / bottom ash in ug I-TEQ/t	**4.1**	3.9	2.8	**2.0**	2.0	1.3	**1.5**
Emission factor / APC residues in ug I-TEQ/t	**69.8**	**53.6**	**37.3**	**39.2**	**33.0**	**23.2**	**15.0**

Annex 1. Chemical profiles of U-POPs

Dioxins and Furans

Structure and properties

Dioxins (polychlorinated dibenzo-p-dioxins, or PCDDs) and furans (polychlorinated dibenzofurans, or PCDFs) are two groups of chemicals with similar chemical structures **(Picture 2.1)** each varying according to the number and position of chlorine atoms attached to the dioxin or furan moiety. There are 75 different dioxins and 135 different furans. The number and placement of their chlorine atoms also determines their physical, chemical, and toxicological properties.



Picture 2.1 Structure of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDDs/Fs)

Dioxins show very low solubility in water (especially the ones that are highly chlorinated), and low volatility, they are readily absorbed on the surface of solid particles, and decompose very slowly. As a result of these characteristics, Dioxins are found primarily in soil, sludge and sediments, and in very limited amounts in the dissolved form in surface or other waters. Due to a high distribution coefficient, (known as Kow), they are able to bioaccumulate in the adipose tissues of animals and people.

Sources

Among the most significant dioxin sources are waste incinerators (including municipal waste incinerators), iron ore sintering plants, production and use of the wood preservative pentachlorophenol, and pulp and paper mills using chlorine for the bleaching process. PCBs are the most significant potential source of furans, a fact that underlies the concern about accidental burning of PCBs.

Toxicity

A number of types of cancers, as well as total cancer incidence, have been related to accidental and occupational exposure to one particular dioxin, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), the most toxic of the dioxins. (See references at the end of the Annex) In their recently published book, Schecter and Gasiewicz note that recent data ". . . provide evidence for reproductive, developmental, and immunotoxic effects in humans." In addition, an increased prevalence of diabetes and increased mortality due to diabetes and cardiovascular diseases has been reported. In children exposed to dioxins, effects on neurodevelopment, neurobehavioral and effects on thyroid hormone status have been reported at exposures at or near background levels. At higher exposures, due to accidental exposure (Yusho and Yu Cheng populations), children exposed transplacentally to dioxins show skin defects (such as chloracne), tooth mineralization defects, developmental delays, behavior disorders, decrease in penile length at puberty, reduced height among girls at puberty and hearing loss.

Dioxins and furans persist for long periods and everyone is exposed to them. They enter the human body by ingestion, inhalation, and skin penetration. The most important route for human exposure to dioxins is food consumption, contributing more than 90% of total exposure, of which products of fish and other animal origins account for approximately 80%.

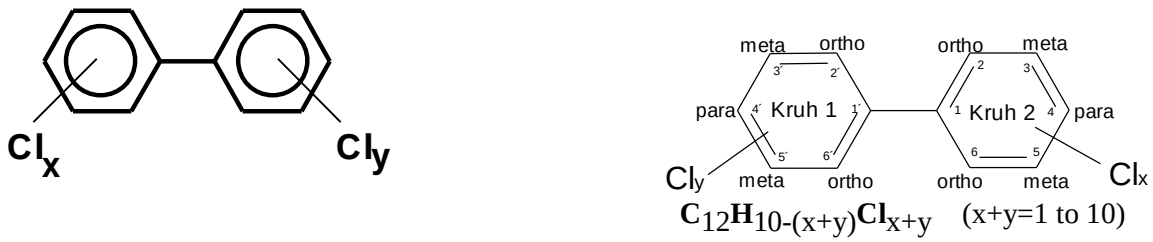
Forty specialists from 15 countries met at the headquarters of the World Health Organization (WHO) in Geneva from 25 to 29 May 1998 to

evaluate the risks which dioxins might cause to health. After ample debate, the specialists agreed on a new tolerable daily intake range of 1 to 4 picogrammes/kilogram body weight. The experts, however, recognized that subtle effects may already occur in the general population in developed countries at current background levels of 2 to 6 picogrammes/kilogram body weight. They therefore recommended that every effort should be made to reduce exposure "…to the lowest possible level."

Polychlorinated biphenyls (PCBs)

Structure

PCBs are organic compounds which have hydrogen atoms on the biphenyl skeleton replaced, to various extents, by chlorine atoms. The number of chlorine atoms in the molecule can range from 1 to 10, and theoretically 209 isomers (congeners) of PCBs can exist (Picture 2.2). However, only about 100 congeners prevail in industrially produced mixtures of PCBs. The proposed Toxic Equivalency Factors from the World Health Organization for dioxin-like PCBs range over four orders of magnitude.



Picture 2.2 Structure of polychlorinated biphenyls

Sources

The chemical stability and heat resistance of PCBs led to their extensive intentional use in two types of applications:

1) closed uses – dielectric fluids in electrical equipment such as transformers, capacitors, heat transfer and hydraulic systems; and
2) open uses – as pesticide extenders, sealants, in carbonless copy paper, industrial oils, paints, adhesives, plastics, flame retardants and to control dust on roads. This use was widely banned in the 1970s.

In the 1970s, countries of the Organization for Economic Co-operation and Development (OECD) restricted the use of PCBs to closed systems. Manufacture for export to non-OECD countries continued in Europe until 1983. Currently, 16 countries prohibit the import of PCBs, whereas six others allow the import of PCBs only under special circumstances. However, PCBs are in use in numerous countries worldwide.

Monsanto, Bayer, DSW-VEB, Caffaro, S.A. Cros, Prodelec and others produced PCBs intentionally under various trade names including "Arochlor", "Pyrochlor", "Asbestol", "Askarel", "Bakola", "Chlorinol", "Chlorphen", "Fenochlor", "Dykanol", "Orophene", "Clophen", "Pyranol", "Saft-T-Kuhl" and "Sovol".

PCBs are created as unintentional by-products from many of the sources that generate dioxins. They are produced during the combustion of organic materials containing chlorine as well as during the manufacture of various chlorine-containing chemicals, such as ethylene dichloride. A study of PCB release from unintentional sources found that industrial coal combustion produced significant levels of PCBs expressed as TEQ, though they represented only a small fraction of the total PCBs. [119] Other unintentional sources include municipal waste incineration, electric arc furnaces, shredders, sinter plants, cement plants, crematoria, and coal-based power stations. [120 121 122]

Releases

A major source of PCBs expressed either as mass or TEQ is leakage from capacitors and transformers. Ongoing releases of PCBs to the environment occur from fires, spills, and leaks from closed systems; evaporation or leakage

from landfills or PCB storage sites; incineration of waste containing PCBs (which were once used in a wide array of consumer products); and incomplete incineration of waste PCBs. PCBs released to the environment can be accompanied by the presence of dioxins.

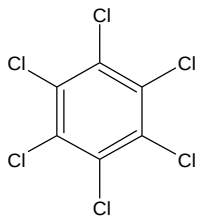
Toxicity

PCBs are classified as probable human carcinogens (group 2A) by IARC and produce a wide spectrum of adverse effects in animals, including reproductive toxicity and immunotoxicity. Prenatal exposure to PCBs is associated with reduced concentration and poorer verbal, pictorial, and auditory working memory in humans. The most common route of PCB entry into humans is ingestion of contaminated food, including fish; however, PCBs may also be inhaled and absorbed through the skin. PCBs are extremely persistent and accumulate, especially in adipose tissues. They are bioaccumulated from water and river sediments by algae and plankton and thereby enter food chains. The distribution coefficients between water and fat for the individual congeners of PCBs are so high that experimental fish kept for a longer time in water contaminated by trace concentrations of PCB concentrated these substances in their bodies up to a thousand-times. The distribution of PCBs in the bodies of fish is not uniform. For example, in carp, they accumulate especially in adipose tissues, head, central nervous system, gallbladder, and other internal organs. In contrast, concentrations in blood and smooth muscles are significantly lower.

Hexachlorobenzene - HCB

Structure and properties

HCB (Picture 2.3) is a white crystalline solid or crystal and is used as a fungicide.



Picture 2. 3: Stucture of HCB

HCB is a very stable, low volatile compound of lipophilic nature showing low solubility in water, and considerable ability to accumulate in adipose tissues of organisms and to absorb on surfaces of solid particles. It decomposes only very slowly in the environment. In the scientific literature, chlorinated phenols are mentioned as its decomposition products. These properties of HCB result in long persistence in the environment and its entry into food chains.

Sources

HCB was originally introduced in 1940's as a seed-dressing for cereal crops to prevent fungal disease. HCB is used as fungicide, disinfectant, and as a starting or intermediate raw material during production of certain chemicals (pentachlorophenol, some chlorinated aromatic compounds). As an industrial chemical, it is used, for example, in production of pyrotechnic products, synthetic rubber and aluminum. For its fungicide properties it was used for treatment of wheat and onion, and for seed treatment. HCB has also been used in various industrial processes, for example, as a fluxing agent in the manufacture of aluminum and as a dispersing agent in the production of rubber for tires. HCB was voluntarily cancelled for use as a pesticide in 1984 in the U.S. and is no longer commercially manufactured as an end product in that country. It is also banned in India and Japan and its use is restricted in several other countries. However, it may still be in use in several countries.

HCB also produced as an unintentional by-product of combustion processes involving chlorinated compounds (for example, during waste incineration or in metallurgy) and as a by-product in the manufacture of certain chlorinated pesticides (such as lindane) and industrial chemicals (for example, in chlorine chemistry or during chlorine bleaching of pulp). In this latter group are chlorinated solvents, such as carbon tetrachloride, perchloroethylene, trichloroethylene and chlorinated benzenes.

Toxicity

HCB is toxic to both humans and animals when long-term exposure occurs. Its main health effect is liver disease. HCB is also

known as an endocrine disruptor and probable human carcinogen (2B category according to IARC ranking). Human exposure to HCB may occur through several pathways including consumption of dairy products or meat from cattle grazing on contaminated pastures; consuming low levels in food, eating or touching contaminated soil; drinking small amounts in contaminated water; inhaling low levels in contaminated air; drinking contaminated breast milk from exposed mothers; occupational exposure from the use or production of HCB; and exposure to HCB as a by-product from other industrial processes, such as waste incineration.

References:

Agency for Toxic Substances and Disease Registry (ATSDR). 1998. Toxicological profile for chlorinated dibenzo-p-dioxins (CDDs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Agency for Toxic Substances and Disease Registry (ATSDR). 2002. Toxicological profile for hexachlorobenzene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Brouwer, A., Ahlborg, U., van Leeuwen, F., Feeley, M., 1998. Report of the WHO working group on the assessment of health risks for human infants from exposure to PCDDs, PCDFs and PCBs. Chemosphere 17: 1627-1643.

Buckley-Golder, D., 1999. Compilation of EU Dioxin Exposure and Health Data. Prepared for European Commission DG Environment and UK Department of the Environment Transport and the Regions. Abingdon, Oxfordshire, UK: AEA Technology.

DeVito, M., Birnbaum, L., Farland, W., Gasiewicz ,T. 1995. Comparisons of estimated human body burdens of dioxinlike chemicals and TCDD body burdens in experimentally exposed animals. Environ Health Perspect 103(9):820-831

Faroon, O., Keith, L., Smith-Simon, C., DeRosa, C., 2003. Polychlorinated Biphenyls: Human Health Aspects. Geneva: World Health Organization.

Fiedler, H., Hutzinger, O., Welsch-Pausch, K., Schmiedinger, A. 2000. Evaluation of the Occurrence of PCDD/PCDF and POPs in Wastes and Their Potential to Enter the Foodchain. Final Report. Study on behalf of the European Commission, DG Environment Bayreuth, Germany: University of Bayreuth.

Gasiewicz, T., 1997. Exposure to dioxin and dioxin-like compounds as a potential factor in developmental disabilities. Mental Retardation and Developmental Disabilities Research Reviews 3: 230–238.

Jacobson JL, Jacobson SW. 2003. Prenatal exposure to polychlorinated biphenyls and attention at school age. J Pediatr 143:780-788

Schecter, A., Gasiewicz, T. (Eds.), 2003. Dioxins and Health, Second Edition. ISBN: 0-471-43355-Wiley, New York.

Watanabe, S., Kitamura, K., Nagahashi, M. 1999. Effects of dioxins on human health: a review. J. Epidemiol. 9:1-13

International Programme on Chemical Safety, 1998. Hexachlorobenzene Health and Safety Guide. IPCS Health and Safety Guide No. 107. Geneva: World Health Organization

International Programme on Chemical Safety, 1997. Hexachlorobenzene. Environmental Health Criteria 195. Geneva: World Health Organization

Annex 2: Overview of POPs content in ashes

Table 1: PCDD/Fs - Fly ash

Country	Type of incinerator	Year/date of measurement	Specification	Type of value (mean, med, max, min etc.)	Measured level in ng/kg (I-TEQ) of dry weight	Source of information
Turkey - Izmit	haz./medical waste	April 2000	ESP ash		280	13
Thailand	MWI	1997 - 2001	APC residue		228	10
Thailand	MWI	1997 - 2001	APC residue		380	10
Thailand	MWI	1997 - 2001	APC residue		686	10
Thailand	MWI	1997 - 2001	fly ash	average conc.	431	10
Thailand	MWI	1997 - 2001	fly ash	average conc.	468*	10
Czech Republic	Haz. waste incinerator	not specified	fly ash		860	
Russia - Moscow	MWI	1998	electrostatic filter ash		1160-5890	21
Russia - Moscow	MWI	1998	ceramic filter ash		8590-12050	21
Russia - Moscow	MWI	1998	heat exchanger ash		950	21
Czech Republic	Haz. waste incinerator	before 2003	fly ash		82400	19
Czech Republic	waste incinerator	1999	fly ash		1153,1	2
Czech Republic	waste incinerator	2000	sorbalit (APC residue)		1400	2
Czech Republic - Lysa nad Labem	Haz. waste incinerator	2000	sorbalit (APC residue)	range	2190-6310	25
Czech Republic - Liberec	MWI	2000	fly ash after it was treated		362	27
Czech Republic - Liberec	MWI	1999	boiler ash		11,3	2
Czech Republic	waste incinerator	2000	fly ash	range	1100-3000	2
Czech Republic	waste incinerator	2004	fly ash		930	7
UK - Bolton	waste incinerator	2001	fly ash		460	2
Germany	MWI	1994	fly ash	range	110-2300	9
UK Byker/Blucher allotment - Newcastle	MWI	199?	fly ash		9500	24
Germany	MWI	1997	fly ash	range	440-11200	26

Table 1 continued

Japan	small scale incinerators and MWI	1998	fly ash	range	2000-2100000	11
Taiwan	MSW, 450 t/24 hours, dry scrubber + fabric filter	1998	fly ash	range	256-2526	14
Taiwan	MSW, 300 t/24 hours, electrostatic precipitators+ wet scrubber	1998	fly ash		6953	14
Taiwan	MSW, 300 t/24 hours, electrostatic precipitators+ wet scrubber	1998	fly ash		1592	14
Taiwan	MSW, 75 t/24 hours, semidry scrubber + fabric filter	1998	fly ash		23795	14
Taiwan	MSW, 30 t/16 hours, semidry scrubber + ESP	1998	fly ash		28917	14
Taiwan	Medical waste incin., 3.6 t/8 hours, venturi wet scrubber	1998	fly ash		13266	14
UK - England and Wales	MWI	2002	fly ash	range	200-5800	5
Sweden	waste incinerators	1999		range	2000-3000	20
Japan	MWI	2001	fly ash pellets		862	12
Sweden	MWI	2002	APC residue	average conc.	200	1
Netherlands	waste incinerators		fly ash		2400	17
Italy	MWI	2003	fly ash		58056	15
Italy	MWI	2003	fly ash		6473	15
Italy	MWI	2003	fly ash		36	15
Czech Republic - Klasterec nad Ohri	HWI/MWI	1999	fly ash		21400	23
Korea	MWI	2003	fly ash		6726	22
UK	waste incinerators	1996	fly ash	range	191-1820	8

Table 2: PCDD/Fs - Bottom ash and mixed ashes

Country	Type of incinerator	Year/date of measurement	Specification	Type of value (mean, med, max, min etc.)	Measured level in ng/kg (I-TEQ) of dry weight	Source of information
Thailand	MWI	1997 - 2001	bottom ash		10	9
Thailand	MWI	1997 - 2001	bottom ash		5	9
Thailand	MWI	1997 - 2001	bottom ash		6	9
Thailand	Medical waste incinerator	1997 - 2001	mixed bottom ash		1410-2300	10
Thailand	MWI	1997 - 2001	bottom ash	average conc.	7	10
Thailand	MWI	1997 - 2001	bottom ash	average conc.	8*	10
Thailand	Medical waste incinerator	1997 - 2001	mixed bottom ash	average conc.	1390	10
Thailand	Medical waste incinerator	1997 - 2001	mixed bottom ash	average conc.	1980*	10
Russia _ Moscow	MWI	1998	bottom ash/slag		30-55	21
Czech Republic - Liberec	MWI	2000	bottom ash/slag		4,37	27
Czech Republic - Ostrava	Haz. waste incinerator	2000	furnace slag		0.16-0.17	18
Czech Republic - Ostrava	Haz. waste incinerator	2000	furnace slag		2.9-3.6	18
UK - Bolton	waste incinerator	2001	bottom ash		1,6	3
UK - England and Wales	MWI	2001	bottom ash	range	0.64-23 (150)	5
Sweden	waste incinerators	1999	bottom ash/slag	average conc.	13.5-27	20
UK - Shefield	MWI	2001	bottom ash/slag	max. levels	122, 150	5
Thailand	Crematory	1997 - 2001	composite ash	individual sample	44	10
Czech Republic - Liberec	MWI	2000	mixed fly ash/bottom ash	individual sample	213,6	6
Czech Republic - Liberec	MWI	2000	mixed fly ash/bottom ash	individual sample	62	27

Table 3: PCDD/Fs - Waste water treatment sludge + other residues

Country	Type of incinerator	Year/date of measurement	Specification	Type of value (mean, med, max, min etc.)	Measured level in ng/kg (I-TEQ) of dry weight	Source of information
Thailand	Medical waste incinerator	between 1997 - 2001	sludge from the wastewater treatment		517-708	10
Thailand	Brass smelter	between 1997 - 2001	wastewater treatment sludge	average conc.	8625	10
Thailand	Brass smelter	between 1997 - 2001	wastewater treatment sludge	average conc.	9168*	10
Thailand	Medical waste incinerator	between 1997 - 2001	mixed flyash sludge	average conc.	629	10
Thailand	Medical waste incinerator	between 1997 - 2001	mixed flyash sludge	average conc.	703*	10
Thailand	Brass smelter	between 1997 - 2001	wastewater treatment sludge	range	8567-8683	10

Table 4: Other POPs measurements in different residues

Country	Measured chemical	Type of incinerator	Year/date of measurement	Specification	Type of value (mean, med, max, min etc.)	Measured level in ng/kg (I-TEQ) of dry weight	Source of information
Germany	PCB (ng WHO-TEQ/kg)	MWI	1997	fly ash	range	10-640	26
Germany	EROD (ng TEQ/kg)	MWI	1997	fly ash	range	660-49970	26
Japan	PCN	small scale incinerators and MWI	1998	fly ash	range	740-610000	11
Taiwan	Coplanar PCB (ng I-TEQ/kg)	MSW, 450 t/24 hours, dry scrubber + fabric filter	1998	fly ash	range	61.06-405.54	14
Taiwan	Coplanar PCB (ng I-TEQ/kg)	MSW, 75 t/24 hours, semidry scrubber + fabric filter	1998	fly ash		2942,44	14
Taiwan	Coplanar PCB (ng I-TEQ/kg)	MSW, 30 t/16 hours, semidry scrubber + ESP	1998	fly ash		2983,42	14
Taiwan	Coplanar PCB (ng I-TEQ/kg)	Medical waste incin., 3.6 t/8 hours, venturi wet scrubber	1998	fly ash		590,85	14
Taiwan	Total I-TEQ	MSW, 450 t/24 hours, dry scrubber + fabric filter	1998	fly ash	range	320-2932	14
Taiwan	Total I-TEQ	MSW, 75 t/24 hours, semidry scrubber + fabric filter	1998	fly ash		26737	14
Taiwan	Total I-TEQ	MSW, 30 t/16 hours, semidry scrubber + ESP	1998	fly ash		31900	14
Taiwan	Total I-TEQ	Medical waste incin., 3.6 t/8 hours, venturi wet scrubber	1998	fly ash		13857	14
Taiwan	Total I-TEQ	Electrical power plant	1998	fly ash		605	14
Taiwan	Total I-TEQ	Electrical power plant	1998	fly ash		63	14
UK	PCB	Waste incinerators	1996	bottom ash	range	less than 1000-8900	8
UK	PCB	Waste incinerators	1996	fly ash	range	less than 1000-23000	8

Annex 3: Analytical results for individual samples taken in Izmit Hazardous Waste Incinerator (Turkey) by Greenpeace Research Laboratories

Sample Number: MI0064

REFERENCE NUMBER: TU001

SAMPLE TYPE: INCINERATOR BOTTOM ASH

Location: Kocaeli, Izmit, Turkey

Sampling Date: 05.04.00

Sample Information: Sample collected from slag/bottom ash commercial rotary kiln slagging plant type, Izmit Solaklar Koyu Mevkii waste incinerator.

ORGANIC ANALYTICAL RESULTS

Analysis method: GC/MS screen

Number of compounds isolated: 60

Compounds identified to better than 90%:

1,1'-Biphenyl, 2,2',3,4,4',5'-hexachloro- (PCB-138)	SIM only
1,1'-Biphenyl, 2,2',4,4',5,5'-hexachloro- (PCB-153)	SIM only
1H-Indene, 2,3-dihydro-	
Benzene, 1,2,3,5-tetramethyl-	
Benzene, 1,2,3-trimethyl-	
Benzene, 1,2,4-trimethyl-	
Benzene, 1,2-dimethyl-	
Benzene, 1,3,5-trimethyl-	
Benzene, 1,3-diethyl-	
Benzene, 1,4-dichloro-	SIM only
Benzene, 1-ethyl-2-methyl-	
Benzene, 1-ethyl-3,5-dimethyl-	
Benzene, 1-methyl-2-(1-methylethyl)-	
Benzene, 1-methyl-4-(1-methylethyl)-	
Benzene, 2-ethyl-1,3-dimethyl-	
Benzene, 2-ethyl-2,3-dimethyl-	
Benzene, propyl-	
Bicyclo[4.2.0]octa-1,3,5-triene	
Cycloeicosane	
Diphenylmethylene-cyclopropane	
Eicosane	
Heneicosane	
Heptacosane	
Naphthalene	
Naphthalene, 1,3-dimethyl-	
Naphthalene, 1,5-dimethyl-	

Naphthalene, 1,6-dimethyl-
Naphthalene, 1-methyl-
Naphthalene, 2,3,6-trimethyl-
Naphthalene, 2-methyl-
Phenanthrene, 4-methyl-
Phenol, 3-methyl- SIM only

Compounds tentatively identified:

1-Octadecene
1-p-Menthen-8-yl acetate
28-nor-17beta(h)-Hopane
Benzene, (1-methylpropyl)-
Benzene, 1,2,3,4-tetramethyl-
Benzene, 1-ethyl-2,3-dimethyl-
Benzene, 1-ethyl-3-methyl-
Benzene, 1-methyl-2-propyl-
Benzene, isopropyl-
Decane, 2-methyl-
Decane, 2-methyl-
Docosane
Eicosane, 9-octyl-
Heptadecane
Heptane, 2,6-dimethyl-
Hexadecane
Isoquinoline, 1,2,3,4-tetrahydro-
Octadecanoic acid, 2-[(1-oxohexadecyl)oxy]ethyl ester
Pentadecane, 2-methyl-
Tetradecane
Tricosane

Sample Number: MI0065

REFERENCE NUMBER: TU002

SAMPLE TYPE: INCINERATOR ASH (ESP)

Location: Kocaeli, Izmit, Turkey

Sampling Date: 05.04.00

Sample Information: Sample collected from electrostatic precipitator, Izmit Solaklar Koyu Mevkii waste incinerator.

ORGANIC ANALYTICAL RESULTS

Analysis method: GC/MS screen

Number of compounds isolated: 13

Compounds identified to better than 90%:

1,1'-Biphenyl, 2,2',3,4,4',5'-hexachloro- (PCB-138)	SIM only
1,1'-Biphenyl, 2,2',4,4',5,5'-hexachloro- (PCB-153)	SIM only

Compounds tentatively identified:

5-Eicosene, (E)-
5-Undecanone, 2-methyl-
6H-Purin-6-one, 1,7-dihydro-
Hydroxylamine, O-decyl-
Nonadecane
Octadecane

Sample Number: MI0067

REFERENCE NUMBER: TU004

SAMPLE TYPE: ECONOMISER ASH

Location: Kocaeli, Izmit, Turkey

Sampling Date: 05.04.00

Sample Information: Sample collected from incinerator heat exchanger, Izmit Solaklar Koyo Mevkii waste incinerator.

ORGANIC ANALYTICAL RESULTS

Analysis method: GC/MS screen

Number of compounds isolated: **12**

Compounds identified to better than 90%:

1,1'-Biphenyl, 2,2',3,4,4',5'-hexachloro- (PCB-138)	SIM only
1,1'-Biphenyl, 2,2',4,4',5,5'-hexachloro- (PCB-153)	SIM only
Benzene, 1,4-dichloro-	

Compounds tentatively identified:

Octadecane, 3-ethyl-5-(2-ethylbutyl)-

References for Annex 2

1. Asplund, L. 2004: Unpublished answer on request for information sent to Arnika via e-mail. April 2004.

2. Axys Varilab (1999-2000): Protokoly č. 209/1, 262/1, 193/1 a 237/1. Zaslepené kopie částí protokolů (bez udání místa odběru).

3. CPL Report 01/269A revision 15th August 2001

4. CETA-VUOS 2000: Protokol 323. CETA - VÚOS Pardubice, 21. 8. 2000.

5. EA 2002: Solid Residues from Municipal Waste Incinerators in England and Wales. A report on an investigation by the Environment Agency, May 2002

6. Ecochem 2000: Zpráva č. 6279B: Shrnutí výsledků laboratorních zkoušek. Praha 24. 7. 2000.

7. Ecochem 2004: Protokol č. 2144/1/2004. Zaslepená kopie protokolu (bez udání místa odběru).

8. ETSU 1996: Správa B/RR/00368/REP.ETSU/DTI.

9.Federal Register 1994 (AD FRL 5068-5), Municipal Waste Combustors.

10. Fiedler, H. 2001: Thailand Dioxin Sampling and Analysis Program Report. Prepared by UNEP Chemicals. In cooperation with PCD, GTZ, Euro Chlor. Produced within the framework of the Inter-Organization Programme for the Sound Management of Chemicals (IOMC). UNEP Geneva, September 2001.

11. Kawano, M., Ueda, M., Matsui, M., Kashima, Y., Matsuda, M., Wakimoto, T. : Extractable Organic Halogens (EOX: Cl, Br and I), Polychlorinated Naphthalenes and Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ashes from Incinerators Located in Japan. Organohalogen Compounds, Vol. 36 (1998), 221 - 224.

12. Kobylecki, R. P. Ohira, K., Ito, I., Fujiwara, N., Horio, M. 2001: Dioxin and Fly Ash Free Incineration by Ash Pelletization and Reburning. Environ. Sci. Technol. 2001, 35, 4313-4319.

13. Labunska, I., Brigden, K., Johnston, P., Santillo, D. & Stringer, R. 2001: Concentrations of heavy metals and organic contaminants in ash collected from the Izmit hazardous/clinical waste incinerator, April 2000. Greenpeace Research Laboratories Technical Note 09/00, January 2001

14. Ling, Y.-C., Hou, P. C. C. 1998: A Taiwanese study of 2,3,7,8-substituted PCDD/DFs and coplanar PCBs in fly ashes from incinerators. Journal of Hazardous Materials 58 (1998) 83-91.

15.Littarru, P., Vargiu, L. 2003: Generation of PCDD/F in fly Ash from Municipal Solid Waste Incinerators. Journal of the Air & Waste Management Association Volume 53:914–917, August 2003.

16. Meij, R., te Winkel, H. ????: Health aspects of coal fly ash. Fly Ash Library Home: www.flyash.info.

17. MVW 1999: LCA AVI-vliegas: studie naar de milieu-effecten van verschillende be- en verwerkingsmogelijkheden voor AVI-vliegas. Ministerie van Verkeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Dienst Weg- en Waterbouwkunde, September 1999.

18. Ocelka, T. a kol. 2000) Protokoly č. 2037 A a 2038 A s přílohami. (Rozbory vzorků strusky z spalovny MCHZ Ostrava). 28. 8. 2000 OHS Frýdek - Místek.

19. Pekarek, V. 2003: Technology of Catalytic Dehalogenation of POPs Compounds. Přednáška na konf. „Nespalovací technologie k likvidaci perzistentních organických látek (POPs)“, Praha, leden 2003. Shrnutí publikováno ve sborníku International Workshop on Non-combustion Technologies for Destruction of POPs, Praha 2003.

20. RVF: Dioxins removed from the ecocycle – waste incineration fixes toxins. RVF report. Source: http://www.rvf.se

21. Semenov S. Yu., Smirnov V. N., Zykova G. V., Finakov G. G. 1998: PCDD/PCDF - Emission From Moscow Municipal Solid Waste Incinerator. Organohalogen Compounds, Vol. 36 (1998), 301 - 305.

22. Song, G.-J., Seo, Y. C., Kim S. C. 2003: Reduction and Behavior of PCDDs/Fs in Fly Ash from Municipal Solid Waste Incinerator by Low Temperature Thermal Treatment. Organohalogen Compounds, Volumes 60-65, Dioxin 2003 Boston, MA.

23. Stach, J., Pekarek, V., Grabic, R., Lojkasek, M., Pacakova, V. 2000: Dechlorination of polychlorinated biphenyls, dibenzo-p-dioxins and dibenzofurans on fly ash. Chemosphere 41 (2000) 1881-1887.

24. Tangri, N. 2003: Waste Incineration: A Dying Technology. GAIA, Manila - Berkeley 2003.

25. TESO 2000: Protokol o autorizovaném měření emisí č. T/453/00/00_SP. TESO, Praha 2000.

26. Till, M., Behnisch, P., Hagenmaier, H., Bock, K. W., Schrenk, D. 1997: Dioxinlike Components in Incinerator Fly Ash: A Comparison between Chemical Analysis Data and Results from a Cell Culture Bioassay. Environ Health Perspect 105:1326-1332 (1997).

27. Tuma, M. 2000: Zpráva č. 7707: Shrnutí výsledků laboratorních zkoušek. Ecochem, Praha 2000.

28. Vereniging van Afvalverwerkers 1998: Gemiddelde samenstelling AVI vliegas van alle AVI's in 1997. Vereniging van Afvalverwerkers 1998, June 1998

References

[1] Ballschmiter, K., Zoller, W., Buchert, H., Class, Th., Fres, Z. 1985: Anal. Chem. 322, 587.

[2] Millingan, M.S., Altwicker, E. 1993: Environ. Sci. Technol. 27, 1596.

[3] Dickson, L.C., Lenoir, D., Hutzinger, O., 1989: Chemosphere 19, 277.

[4] Takasuga, T., Makino, T., Tsubota, K., Takeda, N., 2000. Formation of dioxins (PCDDs/PCDFs) by dioxin-free fly ash as a catalyst and relation with several chlorine-sources. Chemosphere 40:1003-1007.

[5] Littarru, P., Vargiu, L. 2003: Generation of PCDD/F in fly Ash from Municipal Solid Waste Incinerators. Journal of the Air & Waste Management Association Volume 53:914–917, August 2003.

[6] WHO-ECEH and IPCS 1998: Assessment of the health risk of dioxins: re-evaluation of the Tolerable Daily Intake (TDI). WHO Consultation, May 25-29 1998, Geneva, Switzerland. WHO European Centre for Environment and Health, International Programme on Chemical Safety.

[7] Ling, Y.-C., Hou, P. C. C. 1998: A Taiwanese study of 2,3,7,8-substituted PCDD/DFs and coplanar PCBs in fly ashes from incinerators. Journal of Hazardous Materials 58 (1998) 83-91.

[8] Watson, A. 2001: Review of Incinerator Bottom Ash BybPublic Interest Consultants for Greenpeace UK. November 2001.

[9] Watson, A. 2001: Review of Incinerator Bottom Ash BybPublic Interest Consultants for Greenpeace UK. November 2001.

[10] Littarru, P., Vargiu, L. 2003: Generation of PCDD/F in fly Ash from Municipal Solid Waste Incinerators. Journal of the Air & Waste Management Association Volume 53:914–917, August 2003.

[11] Chang, M., Lin, J. 2001. Memory effect on the dioxin emissions from municipal waste incinerator in Taiwan. Chemosphere 45: 1151-1157

[12] Wittsiepe, J., Schrey, P., Hack, A., Selenka, F. und Wilhelm, M. (2001) Comparison of different digestive tract models for estimating bioaccessiblity of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F) from red slag „Kieselrot“. Intern. J. Hyg. Envrion. Health 203, 263-273.

[13] Dyke, P., Foan, C. 1997. A review of dioxin releases to land and water in the U.K. Organohalogen Compounds 32: 411-416.

[14] Sakai, S., Hiraoka, M. 1997. A study of total PCDDs/.Fs release to environment from MSWI. Organohalogen Compounds 31: 376-381.

[15] Huang, H., Beukens, A. 1995. On the mechanisms of dioxin formation in combustion processes. Chemosphere 31 (9): 4099-4117

[16] Littarru, P., Vargiu, L. 2003: Generation of PCDD/F in fly Ash from Municipal Solid Waste Incinerators. Journal of the Air & Waste Management Association Volume 53:914–917, August 2003.

[17] Kawano, M., Ueda, M., Matsui, M., Kashima, Y., Matsuda, M., Wakimoto, T. : Extractable Organic Halogens (EOX: Cl, Br and I), Polychlorinated Naphthalenes and Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ashes from Incinerators Located in Japan. Organohalogen Compounds, Vol. 36 (1998), 221 - 224.

[18] Axys Varilab 1999-2000: Protokoly č. 209/1, 262/1, 193/1 a 237/1 (Protocols No. …).

[19] Fiedler, H. 2001: Thailand Dioxin Sampling and Analysis Program Report. Prepared by UNEP Chemicals. In cooperation with PCD, GTZ, Euro Chlor. Produced within the framework of the Inter-Organization Programme for the Sound Management of Chemicals (IOMC). UNEP Geneva, September 2001.

[20] EA 2002: Solid Residues from Municipal Waste Incinerators in England and Wales. A report on an investigation by the Environment Agency, May 2002

[21] Ling, Y.-C., Hou, P. C. C. 1998: A Taiwanese study of 2,3,7,8-substituted PCDD/DFs and coplanar PCBs in fly ashes from incinerators. Journal of Hazardous Materials 58 (1998) 83-91.

[22] ETSU (1996). Properties and utilisation of MSW incineration residues. Report B/RR/00368/REP.ETSU/DTI

[23] Podhola, M. 2004: Ur?ování ?asové stability solidifikát?. (Determination of time stability of solidificates.) VŠCHT Praha 2004.

[24] Ratti, S.P., Belli, G., Lanza, A., Cerlesi, S., Fortunati, U.G., 1986. The Seveso Episode: time evolution properties and conversion factors between different analytical methods. Chemosphere 15, 1549-1556.

[25] Hagenmaier, H., She, J., Lindig, C., 1992: Persistence of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in contaminated soil at Maulach and Rastatt in Southwest Germany. Chemosphere 25, 1449-1456

[26] Fischer, J., Lorenz, W., Bahadir, M., 1992. Leaching behavior of chlorinated aromatic compounds from fly ash of waste incinerators. Chemosphere 25, 543-552

[27] Takeshita, R., Akimoto, Y., 1991. Leaching of polychlorinated dibenzo-p-dioxin and dibenzofurans in fly ash from municipal solid waste incinerators to a water system. Arch. Environ. Contam. Toxicol. 21, 245-252.

[28] Schramm, K.-W., Merk, M., Henkelmann, B., Kettrup, A., 1995: Leaching of PCDD/Fs from fly ash and soil with fireextinguishing water. Chemosphere 30, 2249-2257.

[29] Kim, Y., Lee, D., Masahiro, O. 2002: Effect of dissolved humic matters on the leachability of PCDD/F from fly ash - Laboratory experiment using Aldrich humic acid. Chemosphere 47 (2002) 599-605

[30] Masahiro, O., Kim, Y., Lee, D. 2002: A pilot and field investigation on mobility of PCDDs/PCDFs in landfill site with municipal solid waste incinerator residue. Chemosphere 48 (2002) 849-856.

[31] Masahiro, O., Kim, Y., Lee, D. 2002: A pilot and field investigation on mobility of PCDDs/PCDFs in landfill site with municipal solid waste incinerator residue. Chemosphere 48 (2002) 849-856.

[32] Sakai, S., Urano, S., Takatsuki, H. 1997: Leaching behaviour of PCDD/Fs and PCBs from Some Waste Materials. Waste Materials in Construction: Putting Theory into Practice, Elsevier, pp.715-724 (1997)

[33] Kawano, M., Ueda, M., Matsui, M., Kashima, Y., Matsuda, M., Wakimoto, T. 1998: Extractable Organic Halogens (EOX: Cl, Br and I), Polychlorinated Naphthalenes and Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ashes from Incinerators Located in Japan. Organohalogen Compounds, Vol. 36 (1998), 221 - 224.

[34] Crookes, M. J., Howe, P. D. 1993: Environmental hazard assessment: Halogenated naphthalenes, Toxic Substances Division, Department of the Environment, Wafford,England, 32, 1993.

[35] Hanberg, A., Wem, F., Asplund, L., Haglund. E., Safe, S 1990: Swedish dioxin survey: Determination of 2,3,7, 8-TCDD equivalent factors for some polychlorinated biphenyls and naphthalenes using biological tests. Chemosphere, 1990, 20, 1161-1164.

[36] Noma, Y., Giraud, R., Sakai, S. 2004: Polychlorinated Naphthalene (PCNs) behavior in the thermal destruction process of wastes containing PCNs. Organohalogen Compounds, Volume 66 (2004), 1035 - 1042.

[37] Kawano, M., Ueda, M., Matsui, M., Kashima, Y., Matsuda, M., Wakimoto, T. 1998: Extractable Organic Halogens (EOX: Cl, Br and I), Polychlorinated Naphthalenes and Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ashes from Incinerators Located in Japan. Organohalogen Compounds, Vol. 36 (1998), 221 - 224.

[38] Kawano, M., Ueda, M., Matsui, M., Kashima, Y., Matsuda, M., Wakimoto, T. 1998: Extractable Organic Halogens (EOX: Cl, Br and I), Polychlorinated Naphthalenes and Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ashes from Incinerators Located in Japan. Organohalogen Compounds, Vol. 36 (1998), 221 - 224.

[39] Till, M., Behnisch, P., Hagenmaier, H., Bock, K. W., Schrenk, D. 1997: Dioxinlike Components in Incinerator Fly Ash: A Comparison between Chemical Analysis Data and Results from a Cell Culture Bioassay. Environ Health Perspect 105:1326-1332 (1997).

[40] Till, M., Behnisch, P., Hagenmaier, H., Bock, K. W., Schrenk, D. 1997: Dioxinlike Components in Incinerator Fly Ash: A Comparison between Chemical Analysis Data and Results from a Cell Culture Bioassay. Environ Health Perspect 105:1326-1332 (1997).

[41] Buser, H.-R., Dolezai, I.S., Wolfensberger, M., Rappe, C. 1991: Polychlorodibenzothiophenes, the Sulfur analogues of the Polychlorodibenzofurans Identified in Incineration Samples. Enviro. Sci. Technol., Vol. 25, No. 9, September 1991, pp. 1637-1643

[42] Buser, H.R. 1992: Identification and sources of dioxin-like compounds: I. Polychlorodibenzothiophenes and polychlorothianthrenes, the sulfur-analogues of the polychlorodibenzofurans and polychlorodibenzodioxins. Chemosphere, Vol. 25, Nos. 1-2, pp. 45-48, 1992.

[43] Sinkkonen, S., Paasivirta, J., Koistenen, J., Tarhanen, J. 1991:Tetra- and pentachlorodibenzothiophenes are formed in waste combustion. Chemosphere, Vol. 23, No. 5, pp. 583-587, 1991.

[44] Labunska, I., Brigden, K., Johnston, P., Santillo, D. & Stringer, R. 2001: Concentrations of heavy metals and organic contaminants in ash collected from the Izmit hazardous/clinical waste incinerator, April 2000. Greenpeace Research Laboratories Technical Note 09/00, January 2001

[45] VSCHT 2005: Protocol of analysis No. LN 3622 - 3637. VSCHT - Institute of Chemical Technology, Prague, March 2005.

[46] Chatkittikuinwong, W., Creaser, C. 1994: Bromo-, bromochloro- and dibenzo-p-dioxins and dibenzo-furans in incinerator flyash. Chemosphere, 29:559-566, 1994.

[47] van de Plassche, E., Schwegler, A. 2002: Polychlorinated Naphthalenes. (Summarising material for UN-ECE). Royal Haskoning, The Netherlands, 2002.

[48] Schrijer, D. J. 1992: Het ontstaan en verloop van de dioxine-affaire. Provincie Zuid-Holland, January 1992

[49] Schoevers, A. 2004: Environmental pollution by dispersion of solid residues from waste incineration; the legacy of ignorance. Case study of persistent hazardous pollutants in fly ash and bottom ash in the Netherlands. Report prepared for IPEN Dioxins, PCBs and Wastes Working Group by Waste & Environment, Rijswijk, Netherlands, February 2004.

[50] National Institute of Public Health and Environmental Protection 1993: The combustion of municipal solid waste in the Netherlands; emissions occurring during combustion, dispersal of dioxins and the associated risks. National Institute of Public Health and Environmental Protection, February 1993.

[51] National Institute of Public Health and Environmental Protection 1994: Emissions of dioxins in the Netherlands. National Institute of Public Health and Environmental Protection, February 1994.

[52] Lulofs, K. 2000: Adjustments in the Dutch domestic waste incineration sector in the context of the European Directive 89/429/EEC. A case study on national implementation, environmental effectiveness, allocative efficiency, productive efficiency and administrative costs.Research Paper 2000-B-6. University of Twente Center for Clean Technology and Environmental Policy.

[53] LCCA 1989: Voorstel tot vernieuwing van het afvalstoffenbeleid. Landelijke Coordinatie Commissie Afvalbeleid (LCCA), July 1989.

[54] Afval Overleg Orgaan 1992: Tienjarenprogramma Afval 1992-2002. Afval Overleg Orgaan, August 1992

[55] Schoevers, A. 2004: Environmental pollution by dispersion of solid residues from waste incineration; the legacy of ignorance. Case study of persistent hazardous pollutants in fly ash and bottom ash in the Netherlands. Report prepared for IPEN Dioxins, PCBs and Wastes Working Group by Waste & Environment, Rijswijk, Netherlands, February 2004.

[56] Office for Official Publications of the European Communities 2003: Waste Generated and Treated in Europe – Data 1990-2001, Office for Official Publications of the European Communities, 2003.

[57] Greenalliance, Creative policy packages for waste: Lessons for the UK, October 2002.

[58] VROM 2001: Incineration Factsheet. Ministry of Housing, Spatial Planning and the Environment, June 2001.

[59] DFIU/IFARE 2002: Draft Background Document on the sector Waste incineration in preparation of the 7th EGTEI panel meeting 17th of December, 2002 in Paris. Prepared by DFIU/IFARE, Karlsruhe.

[60] Stichting Natuur en Milieu 1992: Vuilverbranding 2, April 1992.

[61] Schoevers, A. 2004: Environmental pollution by dispersion of solid residues from waste incineration; the legacy of ignorance. Case study of persistent hazardous pollutants in fly ash and bottom ash in the Netherlands. Report prepared for IPEN Dioxins, PCBs and Wastes Working Group by Waste & Environment, Rijswijk, Netherlands, February 2004.

[62] Vereniging van Afvalverwerkers 2003: Jaarverslag 2002; monitoring reststoffen van verbranding van afval en zuiveringsslib. Vereniging van Afvalverwerkers, June 2003.

[63] Ministerie van Verkeer en Waterstaat 1999: LCA AVI-vliegas: studie naar de milieu-effecten van verschillende be- en verwerkingsmogelijkheden voor AVI-vliegas. Ministerie van Verkeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Dienst Weg- en Waterbouwkunde, September 1999.

[64] Ministerie van Verkeer en Waterstaat 1999: Brief aan Stichting Afval & Milieu met informatie over toepassing van AVI bodemas bij de aanleg van rijkswegen tussen 1989 en 2002 Ministerie van Verkeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Dienst Weg- en Waterbouwkunde, February -19 - 2004.

[65] Schoevers, A. 2004: Environmental pollution by dispersion of solid residues from waste incineration; the legacy of ignorance. Case study of persistent hazardous pollutants in fly ash and bottom ash in the Netherlands.

Report prepared for IPEN Dioxins, PCBs and Wastes Working Group by Waste & Environment, Rijswijk, Netherlands, February 2004.

[66] Buser, M., Rott, J. 1998: Bergeversatz von Sonderabfaellen in deutschen Salzbergwerken: Evaluation der heutigen Beseitigungs- und Versatzpraxis im Zusammenhang mit den Exportantraegen fuer Abfaelle aus der Schweiz, 1998

[67] Vereniging van Afvalverwerkers 2003: Jaarverslag 2002; monitoring reststoffen van verbranding van afval en zuiveringsslib. Vereniging van Afvalverwerkers, June 2003.

[68] Vereniging van Afvalverwerkers 2003: Jaarverslag 2002; monitoring reststoffen van verbranding van afval en zuiveringsslib. Vereniging van Afvalverwerkers, June 2003.

[69] Kim, Y., Lee, D., Masahiro, O.: Effect of dissolved humic matters on the leachability of PCDD/F from fly ash - Laboratory experiment using Aldrich humic acid. Chemosphere 47 (2002) 599-605

[70] University of Amsterdam 1996: Sources of dioxins in the Netherlands. Onderzoeks- en Adviescentrum Chemie, Arbeid, Milieu, University of Amsterdam, 1996

[71] Schoevers, A. 2004: Environmental pollution by dispersion of solid residues from waste incineration; the legacy of ignorance. Case study of persistent hazardous pollutants in fly ash and bottom ash in the Netherlands. Report prepared for IPEN Dioxins, PCBs and Wastes Working Group by Waste & Environment, Rijswijk, Netherlands, February 2004.

[72] Vereniging van Afvalverwerkers 1997: Gemiddelde samenstelling AVI vliegas van alle AVI's in 1997, June 1998.

[73] Schoevers, A. 2004: Environmental pollution by dispersion of solid residues from waste incineration; the legacy of ignorance. Case study of persistent hazardous pollutants in fly ash and bottom ash in the Netherlands. Report prepared for IPEN Dioxins, PCBs and Wastes Working Group by Waste & Environment, Rijswijk, Netherlands, February 2004.

[74] 389.Verordnung:Abfallverbrennung-Sammelverordnung

[75] Holzer, Ch. 2004: Reaction to Arnika's querry about current management of waste incineration residues in Austria from the Austrian Ministry of the Environment.

[76] Asplund, L. 2004: Reaction to Arnika's querry about current management of waste incineration residues in Sweden from the Swedish Ministry of the Environment.

[77] Khan, H. N. 2001: Pakistan country report. Waste Not Asia 2001, Taipei, Taiwan. Prepared by Environmental Pollution Unit, WWF-Pakistan, Lahore,

[78] SDPI, Arnika, IPEN Dioxin, PCBs and Waste WG 2005: Contamination of chicken eggs near the dump site on the edge of Peshawre, Pakistan. by dioxins, PCBs and hexachlorobenzene. Available at www.ipen.org 24 April 2005.

[79] Greenpeace 2001: Official report into Newcastle incinerator ash dumping provokes fears of more dumping scandals, Greenpeace UK Press Release, 13-01-2001.

[80] Ryder, R. 2001: No Smoke Without A Liar. The Ecologist, Vol 31 No 8, October 2001.

[81] Pless-Mulloli, T., Air, V., Schilling, B., Paepke, O., Foster, K. 2003: Follow-up Assessment of PCDD/F in Eggs from Newcastle Allotments. University of Newcastle, Ergo, Newcastle City Council, July 2003.

[82] Pless-Mulloli, T., Schilling, B., Paepke, O., Griffiths, N., Edwards, R. 2001: Transfer of PCDD/F and Heavy Metals from Incinerator Ash on Footpaths in Allotments into Soil and Eggs.

[83] Basel Convention: General technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (2004)

[84] Ryder, R. 2001: No Smoke Without A Liar. The Ecologist, Vol 31 No 8, October 2001.

[85] Cains et al 1996

[86] Ryder, R. 2001: No Smoke Without A Liar. The Ecologist, Vol 31 No 8, October 2001.

[87] EA 2002: Solid Residues from Municipal Waste Incinerators in England and Wales. A report on an investigation by the Environment Agency, May 2002

[88] Havel, M., Petrlík, J. 2004: Toxický odpad ze spaloven: nebezpečný soused. (Toxic waste from waste incineration - dangerous neighbour). Arnika - Toxics and Wastes Programme. Prague, August 2004.

[89] Letter of Children of the Earth of March 8, 2001 & Ecochem 2000: Report No. 6279B: Summary of results of laboratory testing. Prague, July 24, 2000.

[90] Regional Authority of the Liberec Region 2005: Integrated license to the operator of a plant: the company TERMIZO, joint stock company, Liberec. Issued on January 17, 2005 under No. KULK/5761/2004.

[91] Ecochem 2000: Report No. 6279B: Summary of results of laboratory testing. Prague, July 24, 2000.

[92] Pless-Mulloli, T., Edwards, R., Paepke, O., Schilling, B. 2001: Full technical report. PCDD/PCDF and heavy metals in soil and egg samples taken from Newcastle allotments: assessment of the role of the Byker incinerator. Newcastle upon Tyne: University of Newcastle, 2001.

[93] UNEP 2005: Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases. 2nd edition, February 2005.

[94] Petrlík, J., Havel, M. 2005: POPs in the mine Jan Šverma near Lampertice and its neighbourhood. International POPs Elimination Project – IPEP, www.ipen.org, Prague, April 2005.

[95] Arnika 2004: Press release from 2nd April 2004 (V rybě z Lampertic bylo hodně toxického hexachlorbenzenu). Available at http://www.arnika.org.

[96] Petrlík, J., Havel, M. 2005: POPs in the mine Jan Šverma near Lampertice and its neighbourhood. International POPs Elimination Project – IPEP, www.ipen.org, Prague, April 2005.

[97] Cavite Green Coalition, Ecological Waste Coalition, GAIA, HCWH, Arnika, IPEN Dioxin, PCBs and Waste WG 2005: Contamination of chicken eggs from Barangay Aguado, Philippines by dioxins, PCBs and hexachlorobenzene. Available at www.ipen.org 21 April 2005.

[98] VŠCHT 2005: Protocol of analysis No. LN 3622 - 3637. Analysis of Brominated Flame Retardants (BFRs) in eggs. Vysoká škola chemicko-technologická v Praze (VŠCHT) Institute of Chemical Technology, Prague, Department of Food Chemistry and Analysis, March 2005.

[99] Cavite Green Coalition, Ecological Waste Coalition, GAIA, HCWH, Arnika, IPEN Dioxin, PCBs and Waste WG 2005: Contamination of chicken eggs from Barangay Aguado, Philippines by dioxins, PCBs and hexachlorobenzene. Available at www.ipen.org 21 April 2005.

[100] DiGangi, J., Petrlik, J., Costner, P., Weinberg, J. 2005: The Egg Report. Contamination of chicken eggs from 17 countries by dioxins, PCBs and hexachlorobenzene. "Keep the Promise, Eliminate POPs!" Campaign and Dioxin, PCBs and Waste Working Group of the International POPs Elimination Network (IPEN) Report, Chicago - Prague, April 2005. Available at www.ipen.org 25 April 2005.

[101] General technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants. Basel Convention Report on the implementation of the

decisions adopted by the Conference of the Parties at its sixth meeting UNEP/CHW.7/8/Add.1/Rev.1, 26 October 2004

[102] Technical guidelines for environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls (PCBs), polychlorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs). , Basel Convention Report on the implementation of the decisions adopted by the Conference of the Parties at its sixth meeting UNEP/CHW.7/8/Add.2/Rev.1, 26 October 2004.

[103] Pless-Mulloli, T., Edwards, R., Schilling, B., Paepke, O. 2001b: Executive Summary. PCCD/PCDF and Heavy Metals in Soil and Egg Samples from Newcastle Allotments: Assessment of the role of ash from the Byker incinerator. (Includes comments from Food Standards Agency, Environment Agency). 12 February 2001. University of Newcastle.

[104] Cavite Green Coalition, Ecological Waste Coalition, GAIA, HCWH, Arnika, IPEN Dioxin, PCBs and Waste WG 2005: Contamination of chicken eggs from Barangay Aguado, Philippines by dioxins, PCBs and hexachlorobenzene. Available at www.ipen.org 21 April 2005.

[105] Eco-SPES, Eco Accord, Arnika, IPEN Dioxin, PCBs and Waste WG 2005: Contamination of chicken eggs from the Dzerzhinsk region, Russia by dioxins, PCBs and hexachlorobenzene. Available at www.ipen.org 20 April 2005.

[106] Petrlík, J., Havel, M. 2005: Persistent organic pollutants in the Mine Jan Šverma near Lampertice and its neighbourhood. IPEP Report, Prague, 2005.

[107] General technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants. Basel Convention Report on the implementation of the decisions adopted by the Conference of the Parties at its seventh meeting UNEP/CHW.7/8/Add.1/Rev.1, 26 October 2004

[108] MOE CzR 1996: Metodický pokyn MŽP. Věstník MŽP 3/1996. Praha.

[109] UNEP 2003: Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases. 1st edition, May 2003.

[110] UNEP 2003: Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases. 1st edition, May 2003.

[111] EA 2002: Solid Residues from Municipal Waste Incinerators in England and Wales. A report on an investigation by the Environment Agency, May 2002

[112] UNEP 2005: Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases. 2nd edition, February 2005.

[113] Littarru, P., Vargiu, L. 2003: Generation of PCDD/F in fly Ash from Municipal Solid Waste Incinerators. Journal of the Air & Waste Management Association Volume 53:914–917, August 2003.

[114] Kawano, M., Ueda, M., Matsui, M., Kashima, Y., Matsuda, M., Wakimoto, T. : Extractable Organic Halogens (EOX: Cl, Br and I), Polychlorinated Naphthalenes and Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ashes from Incinerators Located in Japan. Organohalogen Compounds, Vol. 36 (1998), 221 - 224.

[115] Pless-Mulloli, T., Edwards, R., Schilling, B., Paepke, O. 2001: Executive Summary. PCCD/PCDF and Heavy Metals in Soil and Egg Samples from Newcastle Allotments: Assessment of the role of ash from the Byker incinerator. (Includes comments from Food Standards Agency, Environment Agency). 12 February 2001. University of Newcastle.

[116] EA 2002: Solid Residues from Municipal Waste Incinerators in England and Wales. A report on an investigation by the Environment Agency, May 2002

[117] EA 2002: Solid Residues from Municipal Waste Incinerators in England and Wales. A report on an investigation by the Environment Agency, May 2002

[118] UNEP 2005: Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases. 2nd edition, February 2005.

[119] Conolly C. 2001. Speciation of the UK polychlorinated biphenyl emission inventory, A report produced for Department for Environment, Food and Rural Affairs, the National Assembly for Wales, the Scottish Executive and the Department of the Environment in Northern Ireland, AEAT/R/ENV/0001 – Issue 1.

[120] Conolly C. 2001. Speciation of the UK polychlorinated biphenyl emission inventory, A report produced for Department for Environment, Food and Rural Affairs, the National Assembly for Wales, the Scottish Executive and the Department of the Environment in Northern Ireland, AEAT/R/ENV/0001 – Issue 1.

[121] Lutharddt P, Mayer J, Fuchs J. 2002. Total TEQ emissions (PCDD/F and PCB) from industrial sources, Chemosphere 46: 1303-1308.

[122] Alcock, R., Behnisch, P., Jones, K., Hagenmaier, H. 1998. Dioxin-like PCBs in the environment-human exposure and the significance of sources. Chemosphere 37:1457-1472.

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Legco Finance Committee
Public Works Subcommittee
15th April 2014

Dear Hon Legco Members,

The IPCC **Intergovernmental Panel on Climate Change** has just issued its report on Climate Change and what Governments must change in order to stop global warming effects. The full report is downloadable here:
http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf

The massive climate damaging effect of the worldwide emissions of CO_2 are clarified within the report. The IPCC message is quite clear: the world must use more nuclear sources and gas instead of coal for power generation and must reduce CO_2 emissions drastically.

As well as highly toxic emissions to air, a waste incineration plant emits 1 tonne of CO_2 greenhouse gas for every 1 tonne of MSW that it burns (as well as leaving 30% by weight of toxic ash that needs treatment and landfilling). This disaster would add more than 1 million tonnes of CO_2 to the atmosphere per year.
Allowing Government to build this backward technology goes contrary to the advice of the hundreds of world experts and scientists and 200 Governments that have backed the IPCC report.

This Panel should be guided by the combined advice of the world experts towards recycling and away from burning of biomass MSW.

http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/5_3_Waste_Incineration.pdf
CONCLUSIONS
The incineration of municipal waste involves the generation of climate-relevant emissions. These are mainly emissions of CO2, but also of N2 O, NOx, NH3, and organic C, measured as total carbon. CH4 is not generated in waste incineration during normal operation. It only arises in particular, exceptional, cases and to a small extent (from waste remaining in the waste bunker), so that in quantitative terms CH4 is not to be regarded as climate-relevant.
In waste incineration plants, CO2 constitutes the chief climate-relevant emission and is considerably higher, by not less than 102, than the other climate-relevant emissions.
In Germany the incineration of 1 Mg of municipal waste in MSW incinerators is associated with the production/release of about 0.7 to 1.2 Mg of carbon dioxide (CO2 output).

http://www.bloomberg.com/news/print/2014-04-03/air-pollutants-from-biomass-burning-exceeds-coal.html
Bloomberg

Air Pollutants From Biomass Burning Exceeds Coal

By Andrew Childers - Apr 3, 2014

Bloomberg BNA — Facilities burning biomass emit more air pollutants, including carbon dioxide, per megawatt-hour than those that burn coal, according to a Partnership for Policy Integrity report.
The April 2 report, *"Trees, **Trash,** and Toxics: How Biomass Energy Has Become the New Coal,"* examined 88 Clean Air Act permits issued to industrial sources that burn biomass.

It found that sources burning biomass emit 50 percent more carbon dioxide per megawatt of electricity generated than coal-burning sources.

Download the report here: (37 Mb)
http://www.pfpi.net/wp-content/uploads/2014/04/PFPI-Biomass-is-the-New-Coal-April-2-2014.pdf

Additionally, the report stated that **even the cleanest-operating biomass facilities emit 150 percent more nitrogen oxides, 600 percent more volatile organic compounds, 190 percent more particulate matter and 125 percent more carbon monoxide than coal on a per megawatt-hour basis.**
The report calls for the Environmental Protection Agency to set more stringent air pollution standards for burning biomass to generate electricity.

"Compounding the problem, bioenergy facilities take advantage of gaping loopholes in the Clean Air Act and lax regulation by the EPA and state permitting agencies, which allow them to emit even more pollution," the report said. "Electricity generation that worsens air pollution and climate change is not what the public expects for its scarce renewable energy dollars." Half of the 88 facilities analyzed had avoided prevention of significant deterioration entirely by obtaining synthetic minor permits. Those permits establish emissions restrictions to keep sources below the level that would require more extensive pollution controls.

Carbon Neutrality Defended

The report questions the forestry industry's assertion that burning biomass is effectively carbon-neutral because those emissions would be released eventually once the plant matter decomposed. The report argued that decaying plant matter would release its emissions much more slowly than burning biomass. However, the forestry industry defended biomass as a carbon-neutral fuel source.
The EPA has begun to permit greenhouse gas emissions from sources burning biomass after the U.S. Court of Appeals for the District of Columbia Circuit in 2013 vacated a rule that had temporarily exempted them from the permitting requirements.
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Yours sincerely,

James Middleton

Chairman
Clear the Air NGO

http://www.theguardian.com/environment/2014/apr/12/ipcc-report-world-must-switch-clean-sources-energy

IPCC report: world must urgently switch to clean sources of energy

UN panel's third report explains how global dependence on fossil fuels must end in order to avoid catastrophic climate change

- The Guardian, Saturday 12 April 2014

An open-cast coal mine and power station near Grevenbroich, Germany. After concluding that global warming is almost certainly man-made and poses a grave threat to humanity, the UN-sponsored expert panel on climate change is moving on to the next phase: what to do about it. Photograph: Martin Meissner/AP

Clean energy will have to at least treble in output and dominate world energy supplies by 2050 in order to avoid catastrophic climate change, a UN report is set to conclude on Sunday.

The report produced by hundreds of experts and backed by almost 200 world governments, will detail the dramatic transformation required of the entire globe's power system, including ending centuries of coal, oil and gas supremacy. Currently fossil fuels provide more than 80% of all energy but the urgent need to cut planet-warming carbon emissions means this must fall to as little as a third of present levels in coming decades, according to a leaked draft of the Intergovernmental Panel on Climate Change (IPCC) report seen by the Guardian.

There is heavy emphasis on renewable energy, such as wind and solar power, and cutting energy waste, which together need hundreds of billions of dollars of investment a year. But despite the scale of the challenge, the draft report is upbeat: "Since [2007], many renewable energy technologies have substantially advanced in terms of performance and cost and a growing number have achieved technical and economic maturity, making renewable energy a fast growing category in energy supply," the report says.

It also highlights that the benefits of clean energy, particularly in reducing deadly air pollution and providing secure energy supplies, "outweigh the adverse side effects". The IPCC report is the last part of a trilogy compiled by thousands of the world's most eminent scientists which gives the most definitive account of climate change to date. The first report, released in September, showed climate change was "unequivocally" caused by human activity and prompted Ban Ki-moon, the UN secretary general, to say: "The heat is on. Now we must act."

The second, published in March, warned that the impact of global warming, from extreme weather to reduced food production, posed a grave threat to humanity and could lead to wars and mass migration. The International

Energy Agency said the IPCC's work showed "the urgent need of enabling a global transition to clean energy systems".

The report will address how to avert the worst dangers by cutting carbon emissions, which have been rising despite the global recession of 2007-08.

Nuclear power is cited among the low-carbon energy sources needed, but the draft report warns it "has been declining since 1993" and faces concerns about "safety, nuclear weapon proliferation risks, waste management security as well as financial and regulatory risks". Another way to produce low-carbon energy is to burn fossil fuels but capture and bury the carbon emissions. The IPCC experts note that, unlike renewable energy, this technology "has not yet been applied at a large, commercial scale".

The draft report concludes that increasing carbon emissions are due to rising coal use, along with increasing demand for energy from the world's growing population. But it notes that policies implemented to cut carbon emissions will also cut the value of fossil fuel reserves, particularly for coal. It also says increased use of gas could cut emissions in the "short term", if it replaces coal.

China's vast coal burning represents a huge challenge but a new analysis from Greenpeace, published on Friday, suggests it may have reached a turning point. "The range of coal caps and anti-smog measures put in place by the Chinese authorities could see the country cut its carbon emissions by more than twice the UK's annual footprint by 2020, making it possible for global carbon levels to peak before climate change spirals out of control," said Li Shuo, Greenpeace East Asia's climate and energy campaigner.

On Thursday, Nobel peace prize winner Archbishop Desmond Tutu called in the Guardian for an anti-apartheid-style campaign against fossil fuel companies. "It is clear that [the companies] are not simply going to give up; they stand to make too much money," he wrote.

Over half a trillion dollars a year are spent subsidising fossil fuels – six times more than spent supporting renewable energy – and US president Barack Obama and other leaders have pledged to phase these out. The draft IPCC report states this could be done without harming the poor: "Many countries have reformed their tax and budget systems to reduce fuel subsidies, that actually accrue to the relatively wealthy, and used other mechanisms that are more targeted to the poor."

The draft report runs counter to some of the UK's key energy policies. It states that decarbonising electricity is key to cost-effective cuts in emissions, but the coalition government voted down a plan to do this by 2030. The report also warns that building high-carbon energy infrastructure developments will lock societies into high emissions and may be "difficult or very costly to change", but UK ministers are strongly pushing shale gas exploration. The UK's carbon plan includes significant burning of biofuels and biomass (usually wood), which is supposed to be carbon neutral. But the IPCC report says scientific debate about whether biofuels cut emissions "remains unresolved" and that without policy safeguards "large scale bioenergy deployment could increase emissions".

Friends of the Earth's executive director, Andy Atkins, said: "We can only avoid catastrophic climate change if we reduce our dependency on fossil fuels – we're already on track for four degrees warming, which will be impossible for human society to adapt to. We have the technology to prevent dangerous climate change. What we lack is the political will of our leaders to strongly champion renewable power and energy efficiency." Li said: "We stand at a fork in road. One way leads to more dependence on dwindling fossil fuels that are wrecking our climate and damaging our health; the other to a world powered by a booming clean energy sector that is already driving growth and creating jobs. The sooner we act, the cheaper it will be."

http://www.theguardian.com/environment/2014/apr/13/un-climate-change-report-on-how-to-cut-emissions-live-coverage

UN climate change report on how to cut emissions – live coverage

Join our live coverage as the Intergovernmental Panel on Climate Change releases its report on reducing global greenhouse gas emissions

-
  - Karl Mathiesen
  - theguardian.com, Sunday 13 April 2014 14.33 BST

IPCC Working Group III co-chairs Youba Sokona, Ramon Pichs-Madruga, Ottmar Edenhofer and chairman Rajendra Pachauri (L-R) attend a news conference to present Working Group III's summary for policymakers at The Intergovernmental Panel on Climate Change (IPCC) in Berlin. Photograph: Stefanie Loos/Reuters

9.29am BST

Climate change report released today

Hello and welcome to our coverage of the release of the Intergovernmental Panel on Climate Change's (IPCC) roadmap for avoiding catastrophic global warming.

Today's report, *Mitigation of Climate Change,* is the third installment in the UN climate body's fifth assessment report (AR5). The first two sections have asserted that climate change is "unequivocally" caused by humans and will cause destruction and massive social upheaval if nothing is done to cut emissions. The third part, which will be released this morning at a press conference in Berlin, attempts to plot the course for the emissions reductions that will avoid the worst effects of climate change. Leaked versions of the report allow for a rare and slender ray of hope. The message from the panel is: where there's a will, there's a way. But it will take an energy revolution which utterly change the way in which we power the planet.

The Guardian's head of environment, **Damian Carrington**, is in Berlin covering the release. He wrote yesterday the report would conclude that clean (particularly renewable) energy output must at least treble in order to provide enough energy to supplant the world's reliance on fossil fuels.

The report, produced by hundreds of experts and backed by almost 200 world governments, will detail the dramatic transformation required of the entire globe's power system, **including ending centuries of coal, oil and gas supremacy.**

Currently fossil fuels provide more than 80% of all energy but the urgent need to cut planet-warming carbon emissions means this must fall to as little as a third of present levels in coming decades, according to a leaked draft of the Intergovernmental Panel on Climate Change (IPCC) report seen by the Guardian.

There is heavy emphasis on renewable energy, such as wind and solar power, and cutting energy waste, which together need hundreds of billions of dollars of investment a year.

Stay with me over the coming hours as I report on the press conference (starting at 11am Central European Time) and the reaction to this landmark document.

Updated at 9.31am BST

9.43am BST

What is the IPCC?

The Intergovernmental Panel on Climate Change (IPCC) is the UN organ charged with providing assessment on climate change. It was established in 1988 "to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts", its website says.

Currently 195 nations, most of the world's population, are members of the IPCC. Through their membership, nations acknowledge the validity the Panel's findings, making it an important basis for policy.

The body does not conduct research itself, rather it compiles and reviews the latest work of thousands of scientists and delivers it to the global community. Its work is seen as the most comprehensive and authoritative source of knowledge about climate change.

What are AR5 and the working groups?

According to the IPCC, one of its main responsibilities is "the preparation of comprehensive Assessment Reports about the state of scientific, technical and socio-economic knowledge on climate change, its causes, potential impacts and response strategies".

Its fifth assessment report (AR5) is being released in four installments (of which today is the third). The IPCC has commissioned three "working groups" to create the first three parts. The fourth is a synthesis report.

Each working group focussed on a unique aspect of climate change.

- Working group I, The Science of Climate Change, assessed the current state of climate science. I found that human emissions were fundamentally responsible for observed warming of the climate.
- Working group II, Impacts, Adaptation and Vulnerability, looked at the how climate change would impact the world's environment and societies. It warned that the results of unchecked emissions would be catastrophic.

- Working group III, Mitigation of Climate Change, is charged with assessing the alternatives for global emissions reduction. Leaked drafts indicate the IPCC will call for an enormous global effort to shift the production of energy away from fossil fuels.

Updated at 9.53am BST

9.47am BST

The Guardian's **Damian Carrington** is at the press conference in Berlin. If you'd like to watch it, it is will be streamed on the IPCC's site at 11am local time.

9.51am BST

While we are waiting for the flood of news reports, commentary and the press conference itself, here are some key quotes from a leaked version of the report's final draft.

"The upward trend in global fossil fuel related CO2 emissions is robust across databases and despite uncertainties (high confidence)."

“Economic and population growth continue to be the two main drivers for increases in global fossil fuel CO2 emissions over 2000-2010, outpacing the decline in energy intensity”

“Without explicit efforts to reduce GHG emissions, the fundamental drivers of emissions growth are expected to persist despite major improvements in energy supply and end-use technologies”

“The majority of scenarios reaching [safe] atmospheric concentration levels are characterized by a tripling to nearly a quadrupling of the share of zero- and low-carbon energy supply from renewables, nuclear energy and fossil energy with CCS by the year 2050 relative to 2010 [about 17%].”

"The next two decades present a window of opportunity for urban mitigation as most of the world’s urban areas and their infrastructure have yet to be constructed." [The Guardian's **Suzanne Goldenburg** reported on this on Friday - At-risk cities hold solutions to climate change: UN report].

"Reduction of subsidies to fossil fuels can achieve significant emission reductions at negative social cost (robust evidence, high agreement)."

Updated at 9.56am BST

10.12am BST

The press conference has begun

The press conference begins with the opening statement from chairman of the IPCC, **Dr Rajendra K Pachauri**.

He says effective mitigiation will not be achieved if the world acts independently. The global response "requires an unprecedented level of international coopeoration".

If we want to limit temperature increase to 2c by the end of this century, there would have to be large cuts in emissions. Tripling to nearly quarduraling of zero to low co2 energy supply will almost get us there.

"A high speed mitigation train would need to leave the station very soon and all of the world will have to get on board."

10.15am BST

Youba Sokona, co-chair of working group III says the report is a roadmap "designed to safely navigate through shallow water and above steep cliffs".

He says the report provides a detailed comprehensive map of the future and is therefore highly important as a basis for policy making.

Updated at 10.16am BST

10.15am BST

The Guardian's head of environment, Damian Carrington, is in Berlin covering the conference. He says the IPCC has concluded that "catastrophic climate change can be averted without sacrificing living standards".

The authoritative report, produced by 1250 international experts and approved by 194 governments, dismisses fears that slashing carbon emissions would wreck the world economy. It is the final part of a trilogy that has already shown that climate change is “unequivocally” caused by humans and that, unchecked, it poses a grave threat to people and could lead to lead to wars and mass migration.

Diverting hundred of billions of dollars from fossil fuels into renewable energy and cutting energy waste would shave just 0.06% off expected annual economic growth rates of 1.3%-3%, the Intergovernmental Panel on Climate Change (IPCC) report concluded.

“It is actually affordable to do it and people are not going to have to sacrifice their aspirations about improved standards of living,” said Professor Jim Skea, an energy expert at Imperial College London and co-chair of the IPCC report team. “It is not a hair-shirt change of lifestyle at all that is being envisaged and there is space for poorer countries to develop too,” Skea told the Guardian.

10.22am BST

235 authors from 58 coutries have contributed to the report says co-chair **Ramon Pichs-Madruga**.

Co-chair **Ottmar Edenhofer** is presenting the report's key findings.

He shows the graph I posted earlier saying the last decade has seen a growth in the rate of emissions - despite efforts to reduce them. CO2 emissions have more than doubled since 1970. This is driven by economic and population growth.

Updated at 10.24am BST

10.31am BST

Edenhofer says the business-as-usual scenario will lead to 3.7C to 4.8C rise in temperature before 2100.

If we are to stay within 2C," we need to bring the mitigation train on track". This would involve a fundamental upscale of low and zero carbon emission energy sources. It would also strongly depend on the removal of CO2 from the atmosphere.

Putting off mitigation action will make it more difficult to achieve less than 2C warming later. It will lead to greater reductions requirements and greater costs.

Reaching 450ppm of carbon in the atmosphere by 2011, which is considered to be a safe level of carbon, will only lead to a reduction in global consumption growth by 0.06% per year.

10.37am BST

Edenhofer says: "We need a new investment flow in particular sectors. In particular energy, renewables and in some parts of the world, nuclear."

This is a global commons problem, he says: "Effective mitigation will not be achieved if individual agents, countries, firms, individuals, advance their interests independently of others."

"This report shows there are some steps to resolve this issue... It provides hope, modest hope."

Updated at 10.46am BST

10.44am BST

Edenhofer is asked by the BBC what his major message is and why we should feel hopeful.

"My first message is, emissions are still increasing and they are increasing with an increasing growth rate."

While the report is not policy prescriptive, he says: "We need an international carbon price and inter-nation cooperation.

On hope, he says: "We are not saying this is a free lunch, but climate policy could be a lunch worthwhile to buy."

10.58am BST

11.00am BST

There is a question on the main points of contention. Pachauri says it saying the strength of the IPCC process comes from the interaction between the policy and scientific communities.

Damian Carrington from the Guardian asks about the 0.06% cost mentioned in the report - is it affordable?

Edenhofer says we cannot say in the report if it affordable or not. You have to carry out a cost-benefit analysis, which is difficult because of the uncertainties around the impacts, the ethical considerations and the risks. But what we can say is that these cost numbers are within the range of other economic policies. He says it is up to the

public and decision makers to decide if it is affordable or not. But he would say: "It does not cost the world to save the planet."

Pachauri says the question of affordability is very difficult to answer because it is difficult to assess the cost of a human life or the benefit of avoiding climate change.

11.10am BST

Edenhofer: "The IPCC has not said that carbon capture and storage is without cost and without uncertainties - such as uncertainties over the global storage capacity."

You can get you copy of the report here.

11.15am BST

Edenhofer is asked why the report avoided recommending particular reductions for particular countries.

He says the IPCC felt it would be inappropriate to prescribe specific allocations to countries because the goals can be achieved under many different burden sharing scenarios. He said it would be up to countries to find the most effective and just way to achieve emissions reductions.

Pachauri says the cost estimates are consistent with the AR4 report.

11.20am BST

Edenhofer is asked which scenarios required a carbon price.

"The carbon price was not an assumption, it was a result of some of the scenarios." Meaning some of the scenarios required a carbon price to achieve their results.

Q: What happens if some major polluters do not take action, should the rest of the world carry on?

Pachauri says this is the role of the UNFCC negotiating process. It is not the role of the IPCC to take the failure to act into consideration.


IPCC Working Group III co-chair Ottmar Edenhofer. Photograph: Stefanie Loos/Reuters

Updated at 11.35am BST

11.24am BST

The press conference has now ended but stay with us as we gather reaction from climate scientists, policy makers and the media.

Pachauri was asked twice which areas of contention lead to materials being left out of the 29 page summary for policy makers published today. Twice he has dodged the question. But Damian Carrington said today:

Objections from rich nations saw the complete removal of a section stating that hundred of billions of dollars a year would have to be paid by developed countries to developing countries, to ensure they grow their cities and economies in a non-polluting way.

Other objections, from major fossil fuel producing nations including Saudi Arabia, led to the weakening of statements that ending the huge subsidies paid for oil, gas and coal would help reduce emissions. But the final document retained the conclusion that policies to cut carbon could devalue fossil fuels reserves.

Updated at 11.29am BST

11.29am BST

Who is responsible for carbon emisssions?

AP reporter Karl Ritter has done some number crunching from the report on the key issue of past and present responsibility for emissions. This will be a major factor in discussions between nations at the UN climate conference in Paris in 2015, which will seek to establish who's responsibility it will be to pay for the transition to a low carbon world.

Current emissions

At the time of the IPCC's previous climate assessment, in 2007, the U.S. was the world's top carbon polluter. It has since been overtaken by China, which now accounts for one-quarter of global emissions because of its rapidly expanding economy. The U.S. is No. 2 with 17 percent, followed by India (6.6 percent), Russia (5.1 percent) and Japan (3.7 percent).

Historical emissions

If you count back to when the Industrial Revolution started in the 18th century, the U.S. is the undisputed No. 1, accounting for nearly 28 percent of the world's cumulative emissions from energy and industry. China's share is 9.9 percent, Russia's 6.9 percent, Britain's 5.9 percent and Germany's 5.6 percent. Western countries rank high because they have been burning coal and oil for much longer than the rest of the world.

Per capita

Putting emissions in proportion to population size also puts Western countries - and oil and gas-rich Gulf states - at the top of the table. In per capita emissions, Australians, Canadians and Americans exceed 20 tons of carbon per year - more than twice as much as the Chinese. "Overall, per-capita emissions in the highly industrialized countries ... remain, on average, about five times higher than those of the lowest income countries," the draft report says.

Consumption

The main way of counting emissions is by looking at where they are released. But some say you get a better picture of what's driving emissions by looking at consumption patterns. As the IPCC puts it: "A ton of steel produced in China but exported to the United States results in emissions in China when the fundamental demand for the steel originated in the U.S." Accounting for emissions based on where a product is consumed rather than where it's manufactured still puts China at the top, but with a narrower gap to the U.S. China accounts for 21.9 percent of global consumption emissions, while the U.S. accounts for 18.1 percent.

By sector

Energy production is the biggest source of emissions, representing about one-third of the world total. Of the fossil fuels, coal generates the highest emissions, followed by oil and then natural gas. Agriculture, forestry and other land use accounts for 24 percent of total emissions. Other big sectors include transport (13 percent) and buildings (7 percent).

Future

The IPPC gives a range of trajectories for global emissions, but doesn't break them down by country. However, it notes that nearly all growth in emissions is expected to occur in developing countries, as their populations grow and they try to catch up economically with the industrialized world. Developing countries say that's why they shouldn't have to face as strict emissions targets in a new treaty as industrialized nations. The latter say at least the biggest developing nations, including China, India and Brazil, must also make significant cuts. Both sides will likely point to selected statistics and projections in the IPCC report.

Updated at 11.29am BST

11.36am BST

The IPCC report. Photograph: Stefanie Loos/Reuters

11.43am BST

As reaction begins to flow in, the Guardian's reporters have already published a series of articles analysing various aspects of the report.

Damian Carrington says: IPCC climate change report: averting catastrophe is eminently affordable

Catastrophic climate change can be averted without sacrificing living standards, according to a landmark UN report published on Sunday. It concludes the transformation required to a world of clean energy and the ditching of dirty fossil fuels is eminently affordable.

Robin McKie and **Toby Helm** said in the Observer: UN urges huge increase in green energy to avert climate disaster

David Cameron's commitment to the green agenda will come under the fiercest scrutiny yet this week when top climate-change experts will warn that only greater use of renewable energy – including windfarms – can prevent a global catastrophe.

Guardian US environment correspondent **Suzanne Goldenberg** looked at the role cities would have to play in reducing emissions: At-risk cities hold solutions to climate change: UN report

It is already taking shape as the 21st century urban nightmare: a big storm hits a city like Shanghai, Mumbai, Miami or New York, knocking out power supply and waste treatment plants, washing out entire neighbourhoods and marooning the survivors in a toxic and foul-smelling swamp.

Now the world's leading scientists are suggesting that those same cities in harm's way could help drive solutions to climate change.

11.48am BST

Green groups reaction - "The age of renewable energy starts now"

This report is being heralded as vindication for many green groups because the UN panel has found that the renewable agenda supported almost unequivocally by the environment movement is the road to climate redemption. They are queuing up to ram home the message.

Kaisa Kosonen, senior political advisor for Greenpeace International, said:

"Renewable energy is unstoppable. It's becoming bigger, better and cheaper every day. Dirty energy industries are sure to put up a fight but it's only a question of time before public pressure and economics dictate that they either change or go out of business. The 21st century will be the 'age of renewables'."

Samantha Smith, leader of the WWF's Global Climate & Energy Initiative said:

"The IPCC report makes clear that acting on emissions now is affordable, but delaying further increases the costs. The energy sector is by far the largest emitter of greenhouse gases and, therefore, is the key battleground of change.

"We know more effort is needed, and quickly. Delaying new mitigation efforts will make it much harder to transition the world's energy systems to a sustainable, equitable and low-emissions future."

Friends of the Earth executive director Andy Atkins said:

“Bold international action to cut our use of fossil fuels is urgently required to steer the planet away from catastrophic climate change.

“If we’re to avoid levels of climate change that will be impossible to adapt to, governments must stand up to the fossil fuel industry and plug in to the huge potential of clean renewable power.

“Rich nations must take the lead by rapidly weaning themselves off coal, gas and oil and funding low-carbon growth in poorer countries.

“The IPCC report is clear: we already have the technologies to make the journey to safe, clean energy. But the clock is ticking, we must act now.”

Li Shuo, climate and energy campaigner at Greenpeace China, said:

“China could break the deadlock in UN climate talks by presenting an ambitious new target with binding emission cuts. If China leads, the US and the EU will have no excuse for not being more progressive. The test of whether governments are willing to act on the IPCC’s findings or turn their backs on public concern will come during next year’s climate treaty talks in Paris.”

Karsten Smid, climate and energy campaigner at Greenpeace Germany, said Germany, which plans to cut carbon emissions by 40% by 2020, was setting the pace in the new age:

“Germany’s energy revolution is a practical reality and an example to the world. Clean energy owns the future. Politicians and investors need to catch up.”

Jennifer Morgan, World Resources Institute’s climate and energy program director and a review editor on the report said:

“We have the tools—now we need to use them. The report shows that by phasing out fossil fuels and significantly ramping up investments in renewable energy, we can reduce climate risks. At the same time, these actions would deliver benefits like cleaner air, new jobs, and more reliable domestic energy sources.

“World leaders can take decisive actions, like limiting power plant emissions in the United States to capping coal use in China. In the lead up to the UN climate summit in September, government officials can announce concrete steps to shape a low-carbon future. Governments can deliver strong commitments that will lead to an ambitious, universal climate agreement by 2015."

WWF's Samantha Smith on the key findings of the report.

Updated at 12.22pm BST

11.58am BST

Transport Environment says the IPCC confirmed today that transport will become the largest source of CO2 emissions by 2050 in a business-as-usual scenario, making it a key area for policy considerations. Transport accounted for 27% of final energy use in 2010 and could double by 2050 due to demand growth in emerging economies.

A TE spokesperson said:

“Thanks to EU regulations CO_2 emissions from new cars are now falling, but the progress on trucks and vans is glacial. The IPCC report stresses the urgency of taking new initiatives to tackle vehicle emissions, but the European Commission’s response is to repeatedly delay promised strategies to regulate car and van emissions after 2020 and to start addressing soaring emissions from trucks.”

12.14pm BST

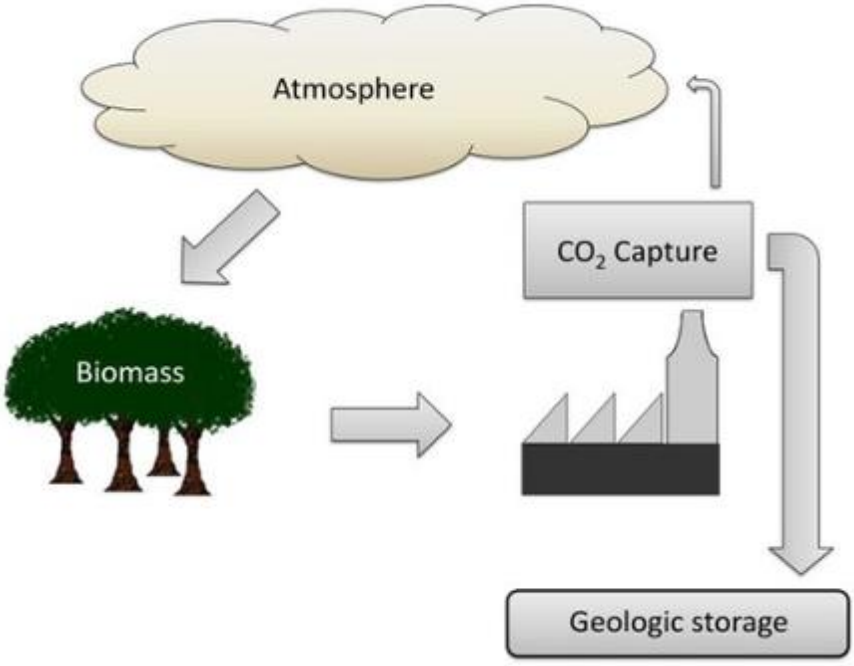
Carbon capture and storage is on of the more divisive aspects of today's report and generated some discussion in the last week because the leaked final draft contained the lines:

"Carbon capture and storage (CCS) technologies could reduce the life-cycle GHG emissions of fossil power plants (medium evidence, medium agreement)."

"Combining bioenergy and CCS (BECCS) could result in net removal of CO2 from the atmosphere (limited evidence, medium agreement)."

"Bioenergy could play a critical role in stabilizing climate change...The scientific debate about the marginal emissions of most bioenergy pathways, in particular around land-mediated equilibrium effects (such as indirect land use change), remains unresolved (medium evidence, low agreement). The potential, costs and risks of BECCS are subject to considerable scientific uncertainty (low evidence, medium agreement)."

The technology is currently not developed, leading to large uncertainty about its potential to contribute to emissions reduction. It involves catching carbon dioxide as it is produced by an industrial process and storing it indefinitely underground. When used in bioenergy production, such as the burning of wood, this has the advantage of actually removing CO2 from the atmosphere.



The bio-energy with carbon capture and storage (Beccs) carbon cycle circuit breaker. Photograph: BBC

But many green groups don't like the technology. Almuth Ernsting, co-director of bio-energy watchdog Biofuelwatch told the Guardian this week:

"The technology is the dangerous spawn of two very bad ideas: it brings together the false premises and injustices of the bio-energy debacle with the risky, costly and unproven notion that we can bury carbon dioxide out of sight. That hardly seems a hopeful formula for calming the climate crisis. Such techno-fix fantasies will be welcomed by oil companies because they distract attention from the obvious solution of cutting fossil fuel use."

Neil Edwards, reader in Earth Systems Science at the Open University, said today:

"Such transformative changes remain eminently possible, but concerted action is needed. In particular, BECCS (bio-energy with carbon capture and storage) is a critical component of most strong mitigation scenarios, allowing negative effective emissions, but is still not demonstrated at large scale."

Stuart Haszeldine, Professor of carbon capture and storage at the University of Edinburgh, said:

“Extraction and combustion of fossil carbon can only continue if that easy energy is matched, tonne for tonne, by the recapture and storage of carbon. It doesn't matter if that is by Carbon Capture and Storage (CCS), by Bio Energy Capture and Storage (BECCS), by direct air capture, or by enhanced mineral weathering – all of these will be needed."

Dr Hannah Chalmers, lecturer in power plant engineering and carbon capture at the University of Edinburgh, said:

"The scientists of the IPCC have produced an excellent overview of the importance of developing and deploying a broad range of low carbon technologies. The UK has well-advanced plans to accelerate the deployment of carbon

capture and storage (CCS) as part of its wide-ranging reforms of the UK electricity market. This report confirms that this support is timely and has an important role to play in global CO2 emissions mitigation efforts.

"The increased emphasis given to the likely role of 'negative' emissions technologies that draw CO2 from the atmosphere is important. They could be essential to allow climate change mitigation to be delivered in ways that are acceptable to society. Some technologies are available today, but there is scope for improvement and also scientific breakthroughs in this area. Members of the UK CCS Research Centre are among the scientists currently working hard to ensure that priority technologies and effective strategies for using them are rapidly developed and implemented."

Updated at 1.19pm BST

12.14pm BST

Last-minute objections from rich countries scrapped a proposed section, which called for hundreds of billions of dollars every year to be paid to developing countries by developed countries, says the Guardian's **Damian Carrington**. This funding would have helped countries to develop their cities and economies without massive increases in carbon emissions.

Chukwumerije Okereke, an author on the report told the BBC this was a result of the "marginalisation" of developing country views in the IPCC process. He said that poorer nations were underrepresented on the panel. Around 30% of authors for the report came from the developing world.

"The argument has been shifting away from the view that the developed countries, who have been mainly responsible for the problem, should take leadership in solving it, to this centre-ground view that we are all in it together and we all have to do our share.

"In effect, this is shifting the burden onto the developing countries and is holding them down from developing; quite frankly this is reinforcing historical patterns of injustice and domination."

In response to the report, green groups called for climate justice. Oxfam's climate expert Jan Kowalzig said:

"Emissions are rising fastest in emerging economies and in the interest of their poorest citizens on the front line of climate change, they must play a bigger role than in the past. But rich countries cannot simply pass the buck - they must do their fair share by both slashing their emissions faster and finally providing the financial support for climate action in poor countries they have promised."

"If we fail to act on climate change, the chance of eradicating hunger from our world may be lost forever. This report shows cutting emissions sufficiently comes at little cost, so we have no excuse for letting that happen.

Christian Aid's senior climate change advisor, Mohamed Adow, said:

"The world's poorest nations are in need of economic development. But they need to be helped to leapfrog dirty energy and develop in a way which won't entrench their poverty by making climate change worse. With technological and financial help they can harness their natural, clean, energy resources and improve the lives of millions."

12.19pm BST

During the press conference, Damian Carrington asked co-chair Edenhofer about shale gas' role in the future of energy production.

Updated at 12.19pm BST

12.32pm BST

US political reaction

World leaders are declining to comment directly, passing the honour to their energy or science advisors. Assistant to the US president for science and technology **John P. Holdren** said:

The facts are clear—the more we and other countries do to curb climate change *and* prepare for the climate-change impacts that can no longer be avoided, the less suffering will be inflicted on our communities and on our children and grandchildren.

The IPCC's new report highlights in stark reality the magnitude and urgency of the climate challenge. It shows, even more compellingly than previous studies, that the longer society waits to implement strong measures to cut greenhouse-gas emissions, the more costly and difficult it will become to limit climate change to less than catastrophic levels.

The Obama Administration is committed to leading efforts to address this global challenge, both by example and by persuasion. And through the concrete steps laid out in President Obama's Climate Action Plan, real progress is already being made.

Democratic **U.S. Senator Barbara Boxer**, chairman of the Senate Environment and Public Works Committee echoed Holdren's statement:

"The newest IPCC report shows a wide range of options to cut carbon pollution, including the use cost-effective clean energy. The longer we wait to act, the harder and more expensive it will be."

Updated at 12.35pm BST

12.34pm BST

UK political reaction

Meanwhile, in the UK, energy secretary **Ed Davey** has told Sky News:

The UN climate change report is a stark warning that the world is "looking down the precipice".

He said it showed the UK should be "should be doing absolutely everything", although he argued the coalition has already "done more on the green economy than any predecessor" because it has doubled renewable electricity.

However, Davey acknowledged there were tensions within the coalition over green energy, including "a current discussion about onshore wind", which the Conservatives want to cap. Any cap on onshore wind could undermine the fight against climate change and end up increasing bills.

"The danger of that is you wouldn't be tackling climate change as effectively as you could, and actually you'd end up putting up people's bills because onshore wind is the cheapest," he said.

Updated at 1.58pm BST

12.35pm BST

EU political reaction

EU commissioner **Connie Hedegaard** said:

''The report is clear: there really is no plan B for climate change. There is only plan A: collective action to reduce emissions now. And since we need first movers to set a plan into motion, we in Europe will adopt an ambitious 2030 target later this year. Now the question is: when will YOU, the big emitters, do the same? The more you wait, the more it will cost. The more you wait, the more difficult it will become.''

12.57pm BST

The IPCC report says divesment from fossil fuels is one path for reducing their consumption.

In an article for the Guardian last week, **Archbishop Desmond Tutu** wrote:

"We live in a world dominated by greed. We have allowed the interests of capital to outweigh the interests of human beings and our Earth. It is clear [the companies] are not simply going to give up; they stand to make too much money."

"People of conscience need to break their ties with corporations financing the injustice of climate change. We can, for instance, boycott events, sports teams and media programming sponsored by fossil-fuel energy companies."

On divestment, Jamie Henn, 350.org strategy and communications director said:

“The report makes it clear that in order to meet their agreed goal of keeping global warming below 2°C, governments need to get serious about leaving fossil fuels in the ground. That means stopping carbon-intensive infrastructure projects, like the Keystone XL pipeline, and shifting investments out of the fossil fuel industry and into solutions.”

350.org European Divestment Coordinator Tim Ratcliffe said:

“Investors now have scientific evidence that if you put your money into fossil fuels you are complicit in wrecking our future. We know that 80% of fossil fuels need to stay underground in order to avoid a climate catastrophe. The fossil fuel industry however is spending billions every year to find yet new reserves, spread misinformation about climate change, corrupt political progress and block clean energy solutions. ExxonMobil, for example, recently spelled out that they are determined to burn through all the carbon they have and can get hold of.”

Updated at 12.59pm BST

1.00pm BST

The IPCC has launched its press release:

“Climate policies in line with the two degrees Celsius goal need to aim for substantial emission reductions,” working group III co-chair Ottmar Edenhofer said. “There is a clear message from science: To avoid dangerous interference with the climate system, we need to move away from business as usual.”

1.19pm BST

Scientific reaction

The Science Media Centre has put together a wrap of the reaction from climate scientists and those working in the mitigation field.

Dr Dan Osborn, independent consultant and former chair of the evaluation panel for the AVOID research programme, said:

"This report illustrates the challenges the world faces on mitigation but it could be good news for those businesses and countries willing to lead the way on all kinds of low-carbon technologies. Burning oil and gas will be frowned on by future generations because this resource is valuable for other purposes. The sooner we start on mitigation the lower adaptation costs will be. Relying on a non-existent Plan B is not a wise option. Time to act is limited. The world must not put its head in the sand. Global action is needed to reduce emissions whilst there is still time."

Dr Neil Edwards, reader in earth systems science at the Open University, said:

“The WG3 SPM highlights a number of key issues: Firstly, where we are in terms of mitigation and where we need to be (to have a good chance of respecting the 2C limit) are still a long way apart. The changes needed to bridge the gap include transformative, non-incremental changes, particularly of the energy system and behaviour in areas such as energy efficiency, modes of mobility, and potentially diet changes. Such transformative changes remain eminently possible, but concerted action is needed."

William Powrie, dean of the Faculty of Engineering and the Environment, University of Southampton, said:

“Behaviour change and economic instruments will be as important as technological innovation; all should be viewed as opportunities rather than threats. Action must be swift, decisive and above all global. The report leaves no doubt that we really are in the last chance saloon as far as addressing climate change is concerned.”

Prof Stephen Long, from the Department of Crop Sciences at the University of Illinois, wrote a long and interesting critique of the report's findings in relation to land use. I have published the full version here.

“In ‘approaches to climate change mitigation’ the report espouses high ideals to which we can all agree, and that no policymaker would dare deny. However, these ideals are far from achieved in today’s business-as-usual operations. The danger here is that we will be, and as evidenced by much legislation around biofuels and bioenergy between AR4 and AR5, holding new mitigation options to higher standards than business-as-usual. Such statements also encourage development of policies around imagined rather than proven issues. The result is obvious, maintain business-as-usual – it is so much easier.

“The section on ‘Agriculture, Forestry and Other Land Uses (AFOLU)’ clearly failed to see the elephant in the room. Output of primary foodstuffs such as grain and seed needs to increase 70% by 2050 to keep pace with demand. We are failing to increase yields per unit land area to achieve this goal. If we do not address this problem first, then the

result is obvious: we will spill over on to less productive and less sustainable land which will prevent or even reverse other mitigation options of afforestation, bioenergy, and soil improvement."

Prof Godfrey Boyle, emeritus professor of renewable energy at the Open University and reviewer for parts of the WG3 report, said:

“In the light of this enthusiastic IPCC endorsement [of renewables], it is disappointing that the European Commission’s recent policy proposals for growth in renewables are unambitious and unspecific. Post-2020, the EU will abandon its existing country-specific renewable targets, aiming instead for a modest Europe-wide target of 27% of energy from renewables by 2030. So instead of setting a leading example to the world by moving rapidly towards a low carbon future, the developed nations of Europe are in danger of falling well short of the IPCC’s latest standards.”

Dr Jeremy Leggett, associate fellow at Oxford University’s Environmental Change Institute, said:

“It is useful to see so many experts agree that the electricity sector can be completely decarbonised as a major contribution to keeping global warming below unacceptable danger levels, but many of us on the front lines of renewable energy would say that the IPCC has underestimated the speed with which our technologies, in concert with energy efficiency, can displace fossil fuels in the years ahead.

“Similarly, growing numbers of financial analysts would say that the IPCC has given inadequate consideration to the soaring capital expenditures of carbon-fuel companies, and the extent to which that constraint can help drive capital to the declining-cost technologies that dominate the renewables family.”

Dr Shaun Fitzgerald of Girton College, Cambridge University, said:

“The report states, ‘Cutting emissions from electricity production to near zero is a common feature of ambitious mitigation scenarios. But using energy efficiently is also important.’ What is intriguing is that the energy efficiency argument is often the second point, perhaps the after-thought. The world of energy is a set of scales - demand and supply. It is obvious that by cutting demand, or at least stemming the growth in demand, the issue of how to supply CO2 friendly power is made easier."

Prof Tim Benton, UK champion for global food security and professor of population ecology at the University of Leeds, said:

"Agriculture and forestry are responsible for about a quarter of all GHG emissions and there is significant scope to reduce this. Perhaps the most important route is via reducing deforestation – which is occurring widely for production of palm oil and soy – and increasing afforestation.

“Farming can become more ‘climate smart’ by, for example, increasing carbon storage in soils and this may have a range of other benefits for sustainability and resilience. Changing our diets, especially eating less meat, may have significant impacts, as will reducing our wastage of food."

Mike Hulme, professor climate and culture at King's College London said:

"This WG3 report draws attention to a range of methods for removing CO2 from the atmosphere, including afforestation, carbon capture and storage (CCS) and other means for removing CO2 from the atmosphere (CDR). It is good to see these methods analysed alongside policy measures to change the energy supply mix, since the former may have value in the future in a broad policy portfolio. The SPM makes no mention of unwelcome and

risky technologies to reduce incoming sunlight through solar climate engineering - and this is a good thing. Such solar radiation management (SRM) technologies offer only chimerical solutions to the inadequate policy goal of limiting global warming to no more than 2 deg Celsius."

Updated at 3.08pm BST

1.21pm BST

Damian Carrington, the Guardian's head of environment, has sent this dispatch from Berlin, where the mood sounds positively jovial - a sharp contrast to the usual feeling of impending armageddon that has accompanied AR5's previous installments.

Behind the scenes most of the IPCC people I have spoken too are pretty positive about the report and the final summary. As ever, politics intervened in the final draft with, for example, a line stating that 70% of carbon emissions comes from just 10 big countries being deleted.

Any hint of attributing blame for climate change is intensely sensitive, because the international negotiations to tackle the problem will ultimately have to decide who will cut emissions, by how much and who will pay. The IPCC people say they have set out the choices and now the politicians will have to make the choices about fairness.

Saudi Arabia, I'm told, played its customary role in objecting to any negative mention of fossil fuels, and the final language in the summary was weakened as a result. But all the statements remain in the main report.

Perhaps the reason the IPCC people are fairly upbeat is that they have had some sleep. Unlike previous IPCC report press conferences, this one was delayed a day, meaning time for recovery from the all-night negotiating sessions.

One IPCC author, Reyer Gerlagh, an economist at the University of Tilburg in the Netherlands, put the 0.06% annual cost of tackling climate change in perspective for me, by considering how accurately economic growth can be measured: "You could almost say that statistically, you can't measure 0.06%."

Updated at 1.26pm BST

1.35pm BST

PricewaterhouseCoopers have released an analysis of the report.

Dr Celine Herweijer, partner on sustainability and climate change, said the "Working Group 3 report on mitigation explains how to avoid the crash. But it also suggests that the brakes are not working".

"Fundamentally, the latest IPCC reports show that not only are the costs to act affordable if we do so early, but that we all lose if we fail to respond adequately. Uncertainties due to a handful of nascent economic models are not excuses for inaction. Policy-makers and business leaders have a mandate to act under the weight of the evidence at hand. This evidence suggests urgent and bold action is a must at the national and international level."

"The IPCC has provided some estimates on the global scale of the costs, both for reducing emissions (WG3) and for the impacts of climate change (WG2). Unfortunately they cannot be compared and used as a decision to act. What is certain is that the costs to act only become more expensive the longer we wait."

On carbon regulation and competitiveness, PwC climate policy economist, Lit Ping Low, said:

"There is a pre-conception that carbon regulations impose undue costs on industry. But across all sectors, businesses are often faced with all sorts of regulations so carbon regulation is not exceptional. Indeed, for some companies and industries, particularly those with medium energy intensities, carbon costs are considered relatively immaterial compared to other costs, but a price signal can still drive tangible carbon reduction actions. The important thing for businesses is to have transparency, clarity and fairness in the costs they face."

On emissions reduction, Jonathan Grant, director of sustainability and climate change, said:

"Delayed action on climate change and reducing our emissions tends to involve a substantially more difficult pathway from 2030 onwards, or have a larger reliance on carbon dioxide removal (CDR) technologies which are today in their infancy (i.e. bioenergy with CCS or even geoengineering). PwC's Low Carbon Economy Index(LCEI) estimated that we could limit emissions to around 30 GtCO2e by 2030 through reducing carbon intensity by 6% a year, every year. This has never been achieved globally and even in 2012 our analysis questioned the viability of the 2 degree target without a radical economic and policy transformation."

"A key message from the IPCC is that energy efficiency improvements and the switch from coal to gas would not be sufficient to deliver the scale of changes required. Indeed, our LCEI analysis shows that globally, almost all of the recent changes in carbon intensity can be attributed to improvements in energy efficiency, suggesting that other measures are yet to be adopted more widely. Nevertheless progress is still visible particularly for renewable energy, and more technologies are approaching technical and economic maturity to be deployed at scale. The challenge is about the rate of that deployment. Three G20 countries achieved more than 25% growth in renewable energy consumption in 2012, another 10 countries achieved between 10% and 25% growth."

Updated at 1.40pm BST

1.38pm BST

The Prince of Wales's Corporate Leaders Group, a coalition of companies, including Acciona, Coca-Cola Enterprises, EDF Energy, Shell, Tesco and Unilever, said today the report was welcomed by the corporate community:

"This latest report from the IPCC is the one that many businesses have been waiting most eagerly to read – here is the latest scientific analysis of the solutions that we can employ to limit the stock of atmospheric greenhouse gases and the consequent climate change. The report contains some stark home truths about the scale of the challenge and the progress we're making to date. Rather than slowing and declining, greenhouse gas emissions are rising at a faster rate than ever before and no country has plans in place that are sufficient to keep warming below the globally agreed limit of 2°C.

"Many leading businesses are well aware of the need for a collective wake up call. The Trillion Tonne Communiqué, already signed by over 90 companies from 5 continents, and with fast-growing support, calls for an increase in the pace and scale of action. Specifically, the signatories urge policy makers to take a number of significant actions in line with the science of the IPCC, including setting a timeline for phasing out greenhouse gas emissions before the end of the century, designing a credible strategy to transform the energy system, and creating a plan to manage reliance on fossil fuels, especially coal."

1.43pm BST

UK energy secretary Ed Davey has released a statement.

“The risk is too great to stop here. We need a worldwide, large-scale change to our energy system if we are to limit the effects of climate change.

“I call for international leaders to work together with enforced vigour to reduce carbon emissions and secure an ambitious legally binding global agreement in 2015”.


Ed Davey says 'we need a worldwide, large-scale change' to avoid catastrophic climate change. Photograph: Danny Lawson/PA

Updated at 1.44pm BST

1.48pm BST

The World Resources Institute has released a handy analysis of today's report: 6 Things You Need to Know About Reducing Emissions. I'll list the headlines here but they have more detail on their site.

1) Without Explicit Action, We Could See More than 4°C of Warming.

2) Limiting Warming to 2°C Is Still Possible.

3) Staying Within the Carbon Budget Requires Immediate Action.

4) We’ll Need to Phase Out Emissions Entirely in the Long-Term.

5) We’ll Need Action from All Regions of the World.

6) Shifting to a Low-Emissions Pathway Requires a Large-Scale Transformation.

1.54pm BST

More reaction

US Secretary of State **John Kerry** said**:**

"Unless we act dramatically and quickly, science tells us our climate and our way of life are literally in jeopardy. Denial of the science is malpractice. There are those who say we can't afford to act. But waiting is truly unaffordable. The costs of inaction are catastrophic."

Sir Brian Hoskins, director of the Grantham Institute for Climate Change, Imperial College London, said**:**

"The science shows us that we need substantial and sustained reductions in greenhouse gas emissions if we are to limit the risks posed by climate change… Potential competitiveness issues, affecting a small number of very energy intensive industries, can be handled. We should stop wringing our hands and just get on with it."

Professor Lord Stern of the London School of Economics, who wrote an authoritative economic analysis of climate change in 2006, said**:**

"The transition to sustainable low-carbon economic development and growth is an opportunity not just to avoid potentially catastrophic climate risks, but also to reap other benefits from cleaner and more efficient technologies, such as reductions in local air pollution. If we embark on such a transition, we are likely to discover new technologies and ways of organising production, consumption and cities that would bring costs down radically."

Stephanie Pfeifer, chief executive of the Institutional Investors Group on Climate Change, representing 88 of Europe's largest investors worth €7.5 trillion:

"At the UN summit in September, world leaders can agree the basis for a global climate deal which signals a serious, long-term commitment to a climate framework which supports low-carbon investment. Acting now to put the world on a low-carbon growth path is achievable, economically beneficial, and will help economies avoid the substantial adaptation costs and large uncertainties faced in the event of severe climate change."

2.19pm BST

Summary

- **The IPCC report, *Migating Climate Change,* was released today.** It detailed the path by which the worst effects of climate change can be avoided and global warming, including how the world can avoid breaching the 2C limit agreed by world leaders in Copenhagen in 2009.
- **The report is from the last of three IPCC working groups**, the first two looked at the the state of climate science and the impacts of unchecked climate change.
- It was **produced by 1250 international experts** and approved by 194 governments.
- The report found that **carbon emissions were still growing** and the rate of growth was increasing.
- However mitigating the effects of climate change would **only limit global consumption growth by 0.06%** - a relatively tiny amount.
- If we want to limt temperature increase to 2c by the end of this century, there would have to be large cuts in emissions, said IPCC chair **Rajendra K Pachauri.**Tripling to nearly quarduraling of zero to low co2 energy supply will almost get us there.
- **A business-as-usual scenario** will lead to 3.7C to 4.8C rise in temperature before 2100.
- Working group III co-chair **Ottmar Edenhofer** said the report contained **"hope, modest hope"** and that **"it does not cost the world to save the planet".**
- **Renewable energy** was seen as the major energy production platform in a sustainable future.
- **Carbon capture and storage, nuclear, bioenergy and shale gas** were mentioned alongside renewables as necessary contributers to the global energy mix.

- **Last-minute objections from rich countries** scrapped a proposed section, which called for hundreds of billions of dollars every year to be paid to developing countries by developed countries.

Reaction

- US Secretary of State John Kerry said**:** “Unless we act dramatically and quickly, science tells us our climate and our way of life are literally in jeopardy. Denial of the science is malpractice. There are those who say we can’t afford to act. But waiting is truly unaffordable. The costs of inaction are catastrophic.”
- UK energy secretary Ed Davey said: “The risk is too great to stop here. We need a worldwide, large-scale change to our energy system if we are to limit the effects of climate change.
- Green groups pushed home the message that renewable energy would be the major platform of future energy generation in a low carbon world.
- Pricewaterhouse Coopers said: The "report on mitigation explains how to avoid the crash. But it also suggests that the brakes are not working".
- Some scientists agreed with the IPCC finding the carbon capture and storage may have a role to play in mitigating climate change.
- Lord Deben, chair of the UK's independent Committee on Climate Change said: "How can we expect poor countries to join in the battle against climate change unless we accept that we owe our wealth partly to pollution."
- World Resources Institute said that without action, we could see more than 4C of warming, but that 2C was possible with immediate action.

ClearTheAir 爭氣行動
www.cleartheair.org.hk

Legco Public Works Subcommittee 10th April 2014

Dear Legco Members,
The Government will imminently seek initial funding approval to extend our landfills and for funding of a mega incinerator from the Finance Committee, represented by this Panel.

The DAB party has sided with the Government presumably as a tit-for-tat on another matter at the Panel on Environmental Affairs stage on this proposal, in the same way the DAB opposed the preventive health measure to try and stop youth smoking by increasing tobacco excise tax. It seems that DAB party does not care one iota for the health of Hong Kong people and even the health of their own children.

At no stage has the Government sought to disprove the overwhelming available peer reviewed evidence that proximity to incinerators, even modern ones, results in cancers and deaths the closer the inhabitants are to the incinerator. Neither it seems, have Legislators pressed them on this important life and death point. A simple Google search 'incinerator proximity dioxin cancer death' reveals abundant peer reviewed reports with numerous other links shown in those pages.

http://www.ncbi.nlm.nih.gov/pubmed/23160082	Europe
http://www.ncbi.nlm.nih.gov/pubmed/15242064	Japan
http://www.ncbi.nlm.nih.gov/pubmed/20581259	France
http://www.ncbi.nlm.nih.gov/pubmed/24076993	Italy
http://www.ncbi.nlm.nih.gov/pubmed/23727903	Taiwan

Similar reports are available on 'landfill proximity emissions – cancer – health - leachate'

http://www.ncbi.nlm.nih.gov/pubmed/12152892	Japan

The Government of Hong Kong for years has been a NATO proponent – that is **N**o **A**ction **T**alk **O**nly. Flashy Blueprints promised a lot and produced little, only hot polluted air and broken promises. More than 3,000 people a year die as a result of Hong Kong pollution.

The Government now seeks to start a waste charging scheme without first having provision of means for people to even voluntarily recycle their waste and for that recycled waste to be collected and utilised. Under this charging scheme even voluntary source separated waste would get dumped together in landfill and the volunteers charged, nil recycling would happen. This is manifestly wrong.

What the Govt should be doing is to approach Legco for **Source Separation of Waste legislation** first. Forcing people to recycle their domestic waste separates food waste and recyclables. The dry recyclables can create a whole new local recycling industry and increased employment. In tandem the Government needs to have a recyclable materials collection scheme in place for the whole of Hong Kong, not just Govt housing estates.

Once these are in place, by all means the Government can initiate a waste charging scheme for what is left after the food waste and recyclables are removed from the daily stream.

Contact : chair@cleartheair.org.hk Tel 26930136 Fax 26027153
8/F Eastwood Centre - 5, A Kung Ngam Village Road - **Shaukeiwan**

What should be happening in Hong Kong and is not:

1 Legislate source separation of waste , food waste and recyclables
2 Name a date to move to 'Zero Waste' like San Francisco http://www.sfenvironment.org/zero-waste
3 SAR- wide daily collection of recyclables to supply new local recycling industries and employment
4 Green Bin free collection of food waste like Santa Monica , UK, Australia, Europe
http://www.smgov.net/Departments/PublicWorks/ContentRecycling.aspx?id=16222
5 Utilisation of industrial garburation of food waste and use of the in situ sewerage system (CIWEM worldwide policy)
6 Reverse mine our landfills back to beneficial usage using plasma gasification
http://www.petcore-europe.org/content/belgian-company-leads-way-landfill-mining
7 Use plasma gasification plants to destroy end of life construction waste and convert into usable inert Plasmarok to replace imported road aggregate and construction sand

The Government's waste recycling figures are in disarray – the reason being they were exposed as fake after China erected **'Operation Green Fence'** http://earth911.com/general/operation-green-fence/ Container loads of overseas trash were passing through Hong Kong enroute to China and those statistics were being used to show a '48%' *local* recycling rate. Hong Kong's actual real local recycling rate is probably 20% below that figure and reliant on scavengers instead of Government policy.
Building an incinerator and extending landfills is not necessary if we have a capable source separation and recycling systems in place and this is where Hong Kong should be heading. If the myopic backroom staff of ENB that have served three different ministers so far had their blinkers removed we could have had the recycling system in place by now instead of their pet incinerator project concept which is already 1 ½ decades old. It is never too late to start and this is where they should be directed to use their blinkers – **RECYCLING.**
Approving the landfill /incinerator option is abject surrender and the definitive end of constructive recycling and recycling industry employment growth in Hong Kong. Incinerators are voracious demand-wise and issue more dioxins when they start up or shut down or burn wet feedstock. The proposed chimney stack height will deposit toxic pollutants to all parts of Hong Kong, Macau and PRD.
Mass burn incinerators reduce unsorted feed-stocks by up to 90% in volume but 30% by weight remains per day as toxic ash and fly ash especially since without sorting, chlorine, cadmium and lead batteries contaminate the ash – meanwhile 70% of what is burned goes into the air – baghouses and precipitators cannot catch PM1 and PM2.5 toxic particulates THAT KILL. This ash requires landfilling and will result in the Government coming cap in hand at a later stage to build man-made ash lagoons in the sea at the cost of billions of dollars. **This is a Bad, Bad, Bad idea.**

FOOD WASTE

More than 40% of our daily domestic waste is ultra-wet 90% water food waste that is mixed with, taints and renders useful recyclables unusable – **since we have no Source Separation legislation**.
We have previously copied this panel and the panel on Environmental Affairs the **CIWEM** worldwide recommended solution for the treatment of food waste. Self-explanatory information is attached for ease of reference. The Government's Mr Elvis Au, himself a CIWEM member has seen fit to pooh-pooh the idea, saying it would not work here. ***Should the Public Works Committee Panel believe Elvis Au on his unproven unsubstantiated word, or rather the wealth of engineering knowledge of CIWEM that normally advises Governments in 98 countries of the world through their local branches, including Hong Kong?*** **We posed the current situation to CIWEM Head Office in UK and here is their reply:**

From: Laura Grant [mailto:lgrant@ciwem.org]
Sent: Tuesday, April 01, 2014 6:11 PM
To: dynamco@netvigator.com
Subject: RE: Legislative Council Panel on Environmental Affairs: Special meeting on 22 March 2014 Shek Kwu Chau Incinerator
Dear James,
Thank you for your email. Based on the information you have provided I cannot see a problem with the proposal and it is in-line with CIWEM's position, although it may depend on the capacity of the sewer system.
In CIWEM's experience there hasn't been an increase in sewer blockages associated with FWDs provided that fats, oil and grease are not entered into the sewer system. FOGs shouldn't be entered under any circumstances, whether there the use of FWDs or not.
I would imagine your proposal should be subject to trials first and this may help make your case to the government.
Kind regards,
Laura
Laura Grant BSc MSc MCIWEM
Policy Adviser, CIWEM
T: +44 (0)20 7831 3110

From: James Middleton [mailto:dynamco@netvigator.com]
Sent: 26 March 2014 06:32
To: Dr. Simon Festing
Subject: Legislative Council Panel on Environmental Affairs: Special meeting on 22 March 2014 Shek Kwu Chau Incinerator
Chartered Institution of Water and Environmental Management (CIWEM)
106-109 Saffron Hill, London, EC1N 8QS Tel: 020 7831 3110 Fax: 020 7405 4967
Dr Simon Festing Chief Executive simon@ciwem.org
http://www.ciwem.org/policy-and-international/policy-position-statements/food-waste-disposers.aspx
CIWEM Policy Statement on Food Waste disposers
http://www.ciwem.org/knowledge-networks/branches/hong-kong.aspx

Dear Dr Festing, 26/3/2014
We are an NGO Charity in Hong Kong run by volunteers.
Our website is www.cleartheair.org.hk
We have read and totally agree with CIWEM's policy statement on the use of food disposers for the treatment of food waste.
See our report 'Some Food for Thought' attached.
Our adviser is a technical director /engineer from a locally based international engineering and environmental consultancy, who is completely in agreement with CIWEM's stance.
I attach self-explanatory information for you showing how Hong Kong Government thinks that use of the sewerage system is not appropriate for Hong Kong. 40% of daily household domestic waste is food waste.
The food waste moisture content is 90% for local wet market food waste and 78% for Mall food waste (Government data) versus only 30% water content in Europe.
Hong Kong has many high (30 storey +) rise buildings and estates rather than houses; the Government's position is that if every household had a sink disposer the building drains might get clogged.
We consider this would not happen, would immediately remove 40% of daily load on our landfills and necessary trucking etc.
Our counter to this Government point is that there is currently no Green Bin collection system here which should be instigated asap. Food waste from estates, houses and rural houses could be deposited in Green Bins , collected by Government and delivered to transfer stations where industrial garburators would puree the ultra wet food waste that would be then fed into the existing sewerage system.
There are 11 waste water treatment plants in Hong Kong and an existing massive sewerage system (Hong Kong always overbuilds everything) . The largest CEPT tanks operation is at Stonecutters island which has 75% of HKG's waste water capacity.
By 2016 the capacity of Stonecutters waste water reception will be a maximum 2.75 million cubic meters per day. The current daily top load of Stonecutters is only 1.3 million cubic meters per day. Our point being that adding 3,500 cubic meters (Hong Kong's current daily food waste amount) of ultra wet pureed food waste to the system would be inconsequential and our consultant agrees. Can you see any drawbacks to our suggestion which is in line with CIWEM policy position ?

Accordingly this Panel should be guided by CIWEM's advice and delve further into this solution, (through CIWEM or independent consultants) a solution which has the necessary infrastructure already in place other than to install industrial garburators at Green Bin collection stations.

Applying common sense, working towards a Zero Waste programme , recycling and use of the existing infrastructure for our food waste would drastically reduce the amount of daily waste to landfill – and the Government must know this – but hypocritically the truth does not suit their outdated policy.

Hence they seek the alternative, to extend landfills and to mass-burn non source-separated recyclables and food waste which at 2 MJ/kg calorific value is non-combustible (combustion requires 7 MJ/kg) – hence more energy would be needed to destroy the food waste by burning than any resultant energy that could be recovered. Does that make any sense ?
What quality of compost or fish food can be recovered from expensive anaerobic digestion food waste that is 78% water (Mall waste) and 90% water (Wet market waste)?

http://www.bmj.com/content/348/bmj.g2351 IPCC report
Incinerators create massive amounts of CO2 in addition to toxic pollutants. It is for this reason that Denmark is making a paradigm shift away from incineration and towards recycling.
http://cphpost.dk/news/denmarks-carbon-bomb.1181.html *Denmark's carbon bomb*

whereas Hong Kong seeks to revert to the stone ages. 

The Government should be sent back to set **Source Separation** laws in place, to setup the Green Bin recycling scheme and to pursue recycling of the remaining dry usable waste before taking the easy and retrograde landfill/incineration caveman option.
Moreover the Govt wanted to use EU incinerator standards instead of the stricter US EPA.
US EPA: Commercial and Industrial Solid Waste Incineration Units: Reconsideration and Final Amendments; Non-Hazardous Secondary Materials That Are Solid Waste; Final Rule
http://www.gpo.gov/fdsys/pkg/FR-2013-02-07/pdf/2012-31632.pdf

Stand up for the health of Hong Kong people and deny the funding request – otherwise your conscience, yours and your children's health will suffer.

Yours sincerely,

James Middleton
Chairman
www.cleartheair.org.hk

Legco Panel on Environmental Affairs
Legco Finance Panel Public Works Subcommittee 25th February 2014

Dear Members,
We previously wrote to you with our suggestion for food waste handling in Hong Kong. (see attached document 'Some Food for Thought').

This failed to attract any response from the ENB so we wrote to the Chief Secretary asking her to appoint consultants to look into our idea; here is the unhelpful reply:

From: cso@cso.gov.hk [mailto:cso@cso.gov.hk]
Sent: Wednesday, February 12, 2014 6:06 PM
To: dynamco@netvigator.com
Subject: Letters to the Editor, January 30, 2014
Dear Mr Middleton,
Thank you for your emails of 31 January and 1 February to the Chief Secretary for Administration. Contents of your emails are noted and passed to the Environment Bureau for reference.

(Miss Jenny Wong)
Assistant Secretary
Chief Secretary for Administration's Office

Subsequently last week the ENB held a media conference to publish its latest policy document: 'A Food Waste and Yard Waste Plan for Hong Kong 2014 – 2022'
http://www.enb.gov.hk/en/files/FoodWastePolicyEng.pdf

At ANNEX on page 30 of the above document it states:

Miscellaneous methods• Some volume reduction; • Some useful end products if treatment is completed • Usually for small scale operation • Usually require second stage treatment or involve high operational cost
Grinding up food waste and disposing of it via the sewerage system: ***it would have adverse impact on the sewers and sewage treatment works. Large scale practical experience especially for multi-storey buildings is lacking and inconclusive internationally. Some cities have banned such practice***

CIWEM http://www.ciwem.org/about.aspx
The **Chartered Institution of Water and Environmental Management** (CIWEM) is the leading professional body for the people who plan, protect and care for the environment and its resources, providing educational opportunities, independent information to the public and advice to government. Members in 98 countries include scientists, engineers, ecologists and students. The Hong Kong branch of CIWEM is shown at:
http://www.ciwem.org/knowledge-networks/branches/hong-kong.aspx
http://www.ciwem.org/knowledge-networks/branches/hong-kong/committee.aspx
Miss Winnie Leung of HK Govt EPD is a committee member of CIWEM Hong Kong.

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No doubt numerous other ENB and EPD engineer officials are members of CIWEM and should accordingly follow CIWEM's policies.

http://www.ciwem.org/policy-and-international/policy-position-statements/food-waste-disposers.aspx
Here is CIWEM Hong Kong's listed policy of Food Waste Disposers

http://www.ciwem.org/knowledge-networks/panels/wastewater-management/food-waste-disposers.aspx
Here CIWEM outlines its Policy Position Statement on Food Waste Disposers and the beneficial use of the sewage system to transport macerated food waste.
I have attached the CIWEM document from the link and highlighted the most relevant paragraphs for your ease of reading.

Summary of CIWEM Policy Statement:

3. Ground food waste is valuable biogas substrate.
4. In-sink FWDs are an environmentally acceptable option for separating food waste at source and conveying it to treatment and use via existing infrastructure.
5. In-sewer processes can reduce or remove dissolved load before it reaches wastewater treatment works (WwTW).
6. The global warming potential of FWD to public sewer and AD is as good as kerbside to AD and better than centralised composting, incineration or landfill.
7. Exclusive emphasis on kerbside collection of source segregated biowaste has been mistaken.
8. A diversity of environmentally valid options for biowaste will ensure as many citizens as possible are willing to participate.
9. FWDs are an opportunity for cost saving to society as a whole.
10. Regarding the management of food waste, 'one size' will not fit all; home composting fits some, kerbside collection fits others and FWD fit others, especially (but not exclusively) people in flatted properties

Conclusions of CIWEM Policy Statement

1. CIWEM considers the evidence demonstrates that FWDs are valid tools for separating kitchen food waste at source and diverting it to treatment, use and recycling via the existing infrastructure and that they offer the opportunity for cost savings compared with other routes.
2. CIWEM considers that FWDs offer the opportunity for wider participation in resource recovery from wastes by a greater proportion of the population than has been the case with exclusive advocacy of kerbside collection, which whilst acceptable to some, is not acceptable to all.

Obviously the Policy Statement from the expert organisation CIWEM which embraces FWD, also adopted by CIWEM Hong Kong, contradicts the above Policy Document which states:

***Grinding up food waste and disposing of it via the sewerage system:** it would have adverse impact on the sewers and sewage treatment works. Large scale practical experience especially for multi-storey buildings is lacking and inconclusive internationally. Some cities have banned such practice*

Accordingly we would suggest the Legco Panel direct Government to seek advice from CIWEM and reconsider their seemingly non-expert conclusion, especially when Hong Kong food waste is of a higher water content resulting in less solids to macerate than European like putrescibles. Also to give consideration of incorporating AD plants at waste water plants as in the UK proven examples:

http://www.waste-management-world.com/articles/2012/12/40-000-tpa-food-waste-to-biogas-plant-opened-at-bristol-sewage-works.html

04 December 2012

Mansfield based biowaste to biogas technology developer, Monsal has completed the installation of the first UK anaerobic digestion food waste facility to be located at a sewage sludge treatment plant in the UK. The facility, located in Bristol, will be operated by Wessex Water subsidiary GENeco and will produce around 10 GWh of electricity per year - enough to power 3000 homes.

According to Monsal the plant will treat some 40,000 tonnes food waste collected from homes, supermarkets and businesses across the south west - preventing it from going to landfill.

Wessex Water has operated anaerobic digestion at Bristol sewage treatment works for a number of years and generates around 30 GWh of renewable energy from sewage sludge and produces 250,000 tonnes of high-nutrient fertiliser which is used by farmers instead of in-organic fertilisers.

He said: "Water companies using their expertise in treating sewage can provide a significant boost to the expansion of waste food anaerobic digestion in this country," explained Defra minister David Heath as he officially opened the plant. According to GENeco the amount of energy produced allows Bristol sewage treatment works - the largest in the south west - to be carbon neutral and self-sufficient from an energy perspective, which helps to drive down operating costs.

Wessex Water chairman Colin Skellett added: "We are building anaerobic digestion plants at other sites in our region due to the environmental benefits they offer and because they help tackle the problem of growing electricity and waste disposal costs. Monsal said that it completed installation of the new food waste plant in under a year.

WASTE & WATER: THE PERFECT PARTNERS?

http://www.waste-management-world.com/articles/print/volume-13/issue-1/features/waste-water-the-perfect-partners.html

Monsal's food waste digestion plant at Deerdykes in Scotland is one of only 3 plants in the UK to comply with PAS110 digestate specification

Following an Office of Fair Trade Market Study into Organic Waste Treatment Services, which highlights how to increase efficiency and competition in the market for sewage sludge and other organic waste treatment, exciting opportunities are emerging for waste companies. Charlotte Morton explains.

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The Office of Fair Trade (OFT) Market Study, commissioned by water services regulator Ofwat, identified that Ofwat regulations were inhibiting competition in sludge treatment between water companies, as well as reducing the likelihood of water companies and other waste companies becoming involved in wider organic waste treatment. The OFT has put forward recommendations for Ofwat to review economic regulations and design a framework which can deal with the issues that discourage competition and provide Water and Sewerage Companies (WaSCs) with a cost of capital advantage over other waste companies for treating organic wastes.

The volume of organic wastes that need to be treated in the UK is growing due to an increasing population and more stringent regulations designed to reduce organic wastes being sent to landfill. Consequently, it is important that growth in the organic waste treatment industry is promoted.

As in other areas, there is also increasing momentum behind making the best use of the resources we currently throw away. Defra's Waste Review (June 2011) identified that, for the treatment of food waste, Anaerobic Digestion (AD) offers the greatest environmental benefit of any treatment option. Making household and business waste available for digestion – by segregating the organic fraction at source – also increases the value of other recyclables in the waste stream by removing sources of contamination.

In addition to the 16 million tonnes of food we throw away each year, organic waste comes from two other sources. These are agricultural wastes, such as slurries and manures (around 90 million tonnes in the UK in 2008), and sewage sludge (around 1-2 million tonnes dry weight).

Most sludge (60% - 65%) is treated in sludge treatment centres located at wastewater treatment works, and governed by one of ten WaSCs. Other organic wastes tend to be treated by a large number of companies and farms of various sizes and structures. For the purpose of this article and in accordance with the OFT Market study these businesses will be referred to as 'waste businesses'.

Government incentives

Although **anaerobic digesters have been a feature of sewage treatment sites for decades**, there is a renewed level of energy and interest behind the sector. By utilising bacteria to break it down, AD is able to treat organic waste and produce a digested fertiliser as well as renewable energy, which allows WaSCs to gain access to Government incentives for renewable energy generation. In the financial year ending in 2011, 73% of sludge treatment was through AD and WaSCs obtained a total of £27million from incentives.

The OFT says that increased competition between industries could boost efficiency

The potential to gain access to Government incentives is also likely to increase with the recent introduction of the Renewable Heat Incentive (RHI) and the growing opportunities to develop gas-to-grid injections as pioneered in the water industry by Didcot Water Treatment plant. These gas-to-grid injections could be replicated at large facilities all over the country, resulting in hundreds of megawatts of power, in the form of gas, being pumped into the national grid. From the perspective of the UK's future energy mix, this is of huge significance. While renewable electricity generation has the greatest prominence, it is often forgotten that a third of the UK's final

energy consumption is of gas. Decarbonised energy therefore cannot be a reality without low carbon gas: even with their existing facilities, water and sewerage companies could be at the forefront of this energy revolution.

AD has been less commonly employed to treat other organic material (there are only 72 non-water AD plants in the UK), with slurries typically spread straight to land and food waste sent to landfill. However, recent policy developments have made the sending of organic waste to landfill more difficult, with escalating landfill tax creating a strong incentive for local authorities and businesses to find other treatment options. Consequently, waste companies now have to consider alternative ways of treating and recovering or disposing of organic waste.

Competition needed

To date AD plants designed to treat other organic wastes have typically been built either on farm or industrial sites. The sewage sludge treatment market, as a monopoly for local water and sewerage companies, exists in isolation from it. However, the OFT Market Study noted that "given the similarities in the technologies and systems used to treat, and recover or dispose of, sewage sludge and other organic waste, there is clear potential for competition between suppliers of treatment for each type of waste."

Competition within and between industries can be an inexpensive way to increase efficiency and innovation, providing significant benefits to consumers through lower prices and better quality of goods and services and/or greater choice. It could make use of existing assets and locations, and ensure that waste does not have to be transported long distances at great carbon and financial cost.

However, the Market Study observed that currently there is limited competition between WaSCs to treat sludge, and between WaSCs and waste companies to treat either sludge or other organic wastes. The study identified a number reasons for the lack of competition in the treatment of organic wastes, including differences in environmental regulation, there only being limited existing spare capacity (about 20%) for WaSCs to expand and there being a need for competition to exist locally as organic wastes can only be transported short distances (sludge can be transported at most around 50 km, while for other organic waste the distance which it can be transported economically depends on the energy potential of the waste). However, the main barrier the OFT identified as inhibiting competition in the treatment of organic waste are the economic regulations of Ofwat.

Regulations

Under the current regulations, if WaSCs are to carry out an unregulated activity (such as processing other organic wastes) but use their regulated business assets to carry out these activities, WaSCs are required to allocate some costs to the unregulated activities or to charge a 'transfer price'. Stakeholder engagement by the OFT demonstrated that this was perceived as complicated and time-consuming and thus very few WaSCs have undertaken the procedure.

Ofwat's economic regulations also discourage other waste companies from investing in facilities to treat waste other than sewage. Regulations enable WaSCs to borrow at a lower cost of capital than is available to waste companies, creating a potential market distortion. Capital costs for WaSCs building new facilities for other organic waste treatment at sewage treatment centres are also often lower, and planning permission and public agreement easier to obtain for WaSCs than for other waste companies as the infrastructure would be built on an already approved site and the public believes the treatment of sludge is necessary, whereas the treatment of other organic wastes is considered a business venture. It is therefore vital for Ofwat to create a balanced regulatory environment to ensure that competition between water and waste companies is fair.

The OFT Market Study identified changes to economic regulation as the "crux of any package of remedies", if the necessary competition within, and growth to, the organic waste treatment industry is to be realised. If Ofwat decides to follow the advice of the OFT and review economic regulations, WaSCs would be able to look into expanding their facilities to treat other organic wastes as well as sewage sludge (either separately or co-digested). This would not only aid the Government in reducing waste but would increase the incentives

brought in by the WaSCs **as other organic waste tends to have a higher energy content than sludge, so generates more biogas.**

The future

Ofwat is expected to announce its full response to the Market Study in April this year. This should include clarity on the future of the economic regulatory regime, and will clearly be of keen interest to both the water and waste industries. Defra's white paper on the future of the water industry, published in December 2011, suggested that the department would look carefully at elevating sustainability alongside economic regulation as a key directive for Ofwat. Many water companies have already started to act to unleash their potential in this area. GENeco, a subsidiary of Wessex Water, operates a biogas-powered VW beetle from gas generated at its Avonmouth plant and Northumbrian Water will commission its second advanced digestion plant in the summer, on the banks of the Tyne at Howdon. A change in Ofwat's economic regulation could lead to substantial growth in the renewable energy generated by water companies. It could cause a fundamental shift in the relationship between water and waste companies, and open up huge potential for novel projects and joint ventures. Organic waste is a hugely valuable resource, and the UK needs to get the most out of it. Expanding the use of anaerobic digestion both inside and outside the water industry is the only way to do this. Charlotte Morton, is chief executive of the UK's Anaerobic Digestions and Biogas Association. Web: www.adbiogas.co.uk

The Avonmouth Solution

A state of the art food waste processing facility that will have the capacity to receive up to 40,000 tonnes of food waste per year is now under construction at GENeco's 300 million litre per day **Bristol Sewage Treatment works** in Avonmouth. The plant will begin accepting food waste deliveries from autumn 2012. AD specialist, Monsal had previously upgraded the digestion plant for sewage sludge using an advanced pre-treatment technology that now generates 4 MWe from biogas. The process optimises the conditions for sewage sludge digestion in two separate vessels; thereby optimising gas production and making it one of the most efficient digestion plants in the country. GENeco has chosen to build on its digestion expertise by constructing a new food waste treatment facility.

The latest development will be the first large scale food waste treatment facility in the UK located at a sewage works. It will offer supermarkets and other local producers a cost effective and sustainable solution for treating their packaged and unpackaged food and catering waste. The GENeco food waste plant is based on the Monsal technology platform which is also operational at the Deerdykes plant for Horizons Environment. Key facts about the Avonmouth site

- Sewage sludge capacity PA 40,000 Tonnes Dry solids
- Food Waste capacity PA 40,000 Tonnes Wet solids
- Number of digesters 10
- Renewable power capacity 5.75 MWe Aidan Cumiskey is managing director of Monsal

Kind regards,

James Middleton

Chairman

8/F Eastwood Centre - 5, A Kung Ngam Village Road - Shaukeiwan, Hong Kong

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Food Waste Disposers

Purpose

This Policy Position Statement outlines the main issues relating to the use of food waste disposers (FWD) in the management of food waste from domestic kitchens. FWDs are installed beneath sinks to separate food waste at source and grind it in order that it can be treated via the wastewater collection and treatment system. FWDs are an alternative to disposing food waste with solid waste. The issues include the effect of food waste on the wastewater system, diversion of food waste from landfill to recycling (CEC, 2008a), avoidance of extra vehicle movements for separate collection, avoidance of vermin attraction, improving yield of dry recyclables and avoidance of storing putrescible food waste in or close to kitchens with its associated health and odour implications.

CIWEM calls for:

1. Policies and strategies should be evidence based.
2. In addition to providing energy, anaerobic digestion (AD) conserves the nutrients from the feedstock into the digestate and using this digestate on land helps to maintain soil organic matter and complete nutrient cycles.
3. Ground food waste is valuable biogas substrate.
4. In-sink FWDs are an environmentally acceptable option for separating food waste at source and conveying it to treatment and use via existing infrastructure.
5. In-sewer processes can reduce or remove dissolved load before it reaches wastewater treatment works (WwTW).
6. The global warming potential of FWD to public sewer and AD is as good as kerbside to AD and better than centralised composting, incineration or landfill.
7. Exclusive emphasis on kerbside collection of source segregated biowaste has been mistaken.
8. A diversity of environmentally valid options for biowaste will ensure as many citizens as possible are willing to participate.
9. FWDs are an opportunity for cost saving to society as a whole.
10. Regarding the management of food waste, 'one size' will not fit all; home composting fits some, kerbside collection fits others and FWD fit others, especially (but not exclusively) people in flatted properties.

The Chartered Institution of Water and Environmental Management (CIWEM) is the leading professional body for the people who plan, protect and care for the environment and its resources, providing educational opportunities, independent information to the public and advice to government. Members in 98 countries include scientists, engineers, ecologists and students.

Context

The food waste disposer (FWD) was invented in 1927 by architect John W. Hammes of Racine, Wisconsin, USA to be a convenience for his wife. In 1938 his company started manufacturing and selling FWD. Some cities in USA mandated FWD for all new build residential properties. FWD fit the standard drain outlet hole of kitchen sinks. They comprise a 'grind chamber' which has perforated walls; the floor is a spinning disc with lugs that throw food scraps against the wall by centrifugal force. There are no knives in a FWD so it cannot cut plastic or fingers. FWDs operate with a stream of cold water that conveys the ground food waste through the drains. Particles cannot escape the grind chamber until they a small enough to pass the outlet screen.

Today approximately 50% of households in the USA have a FWD; in some cities more than 90% have them. Initially sewerage engineers in the USA were apprehensive that the output of FWDs might affect sewers and/or wastewater treatment adversely but a review of experiences in about 300 municipalities concluded their fears were unfounded (Atwater, 1947). New Zealand and Australia also have high rates of installation at more that 30% and more than 20% respectively. Installation in EU Member States (MS) is 5% or less. However the density of installation in commercial kitchens is very much greater. Generally domestic food waste in the EU is dealt with as part of the solid waste system; however in some MS interest in FWD is growing for reasons discussed below.

European policy (CEC, 2008a) advocates the "waste hierarchy" priority order of options: prevention; preparing for re-use; recycling; other recovery, e.g. energy recovery; and disposal. The EU Landfill Directive (CEC, 1999) requires MS to reduce the amount of biodegradable waste disposed to landfill in order to reduce methane emissions. Methane (CH_4) has 25-times the climate change effect of carbon dioxide (CO_2) over 100 years (IPCC, 2007). The EU also aspires to change from a disposal society to a recycling society.

Quested and Johnson (2009) estimated 5.8 million t/year of food waste is collected by local authorities in the UK, mainly in the residual waste stream (general bin). This equates to 230 kg/household.year. Europe has given emphasis to separate [kerbside] collection of biowaste for many years but even so a large proportion of biowaste is still in mixed waste (CEC, 2008b), this makes resource recovery more difficult. The European Commission's Green Paper (CEC, 2008b) on biowaste says that only 30% of biowaste is separately collected and treated biologically. Clearly, many citizens remain unwilling to participate in separate kerbside collection.

'Kerbside' collection of source segregated wastes requires the solid waste from domestic and commercial premises to be stored in separate containers, collected separately and taken to treatment facilities. Dry recyclables (paper, glass, plastic and metal) can be segregated mechanically after collection but their value is reduced if they are contaminated with wet food waste. The biodegradable fraction of solid waste is generally composted or anaerobically digested (AD). CH_4 from AD is used as renewable energy and the digestate as soil improver. Separate collection often necessitates extra truck traffic, especially during summer when it is not acceptable to store biodegradable waste for long periods prior to collection because of odour.

Discussion

1. Experience from other MS with a longer history of kerbside collection of source segregated food waste than the UK's shows clearly that some citizens are unwilling to participate (e.g. Kegebein et al., 2001) and also that diligence about excluding physical contaminants declines (Riedel, 2008). Waste managers report non-participation is especially problematic in 'flatted' properties.
2. Home composting might be ideal but many households are unwilling or unable to do this. Smith and Jasim (2009) showed that fears about CH_4 emission for poor home composting are exaggerated. They found people who composted food waste compensated by putting their more difficult to compost garden waste in the kerbside bin, consequently there was little reduction in the mass of biodegradable waste collected, but the character changed.
3. FWDs use water to transport the ground food waste out of the grind chamber and through the drainage system. Some field studies to measure water use by households with and without FWD showed water use is related to food preparation events, not to the number of people in a household. Two studies from Sweden (Nilsson et al., 1990 and Karlberg & Norin, 1999) and one from Canada (Jones, 1990) were unable to detect any influence of FWD installation on the per-capita volume of water used. The Swedish studies found water use decreased during the period when FWD were used but they concluded it would not be appropriate to attribute this directly to the fact that FWD had been installed. The Canadian study concluded the influence on water use was not significant within the overall "noise" in measured water use. The largest field study into FWD was in New York City, it involved 514 apartments with FWD compared with 535 apartments without FWD. They were in 4 different localities to reflect some of the city's diversity. The survey comprised 2014 people in total; it concluded the average water use attributable to FWD was 6.9 l/hhd.day [1] (New York City DEP, 1999). Evans et al. (2010) found the flow into a WwTW did not change significantly between the time when there were no FWD and when 50% of the 3700 households used FWD. On the basis of these and other studies, 6 l/hhd.day (one flush of a modern toilet) would be a conservative (upper) estimate of additional water use, this is of no consequence to sewer hydraulic capacity and negligible in terms of sewage pumping or water resources.
4. Domestic FWD have a 350 to 750 W motor. Based on field studies of usage, the annual electricity consumption is about 3 kWh/hhd.year.
5. Kegebein et al. (2001) estimated that where the ground food waste is treated by AD, the electricity generated from the biogas would be 73 kWh_e/hhd.year. Evans et al. (2010) found that when 50% 0f households used FWD, the biogas increased by 46% (P=0.01) and that this equated to 76 kWh_e/hhd.year. In 2005, 64% of the UK's sewage sludge was treated by AD, by 2015 this will have increased to 85%.
6. Thermal electricity generation uses about 80 litres water/kWh_e, the UK's average electricity generation emission factor is 0.541 $kgCO_2e/kWh_e$, thus the offset from the electricity from biogas is 6000 l water and 41 $kgCO_2e/kWh_e$ this is a net annual benefit of 3900 l water and 40 $kgCO_2e$ per household.
7. Kegebein et al. (2001) measured the particle size distribution of FWD output using two mixtures of foods and also waste from the university's cafeteria. They found 40-50% of the output was <0.5 mm, 98% was <2 mm and 100% was <5 mm by

[1] hhd = household

sieve analysis; between 15 and 36% of the output was in their 'dissolved' fraction. They observed sediment-free transport at 0.1 m/s, which is well within design standards for sewers (0.48 - 0.9 m/s - Ashley et al., 2004). Nilsson et al. (1990) simulated 15 years of FWD use using a mixture of foods that included 8.5% w/w lard and 1.7% w/w margarine, they found no blockage. They also compared apartment buildings with and without FWD and found no difference in their sewers by CCTV inspection [others have reported similar CCTV results].

8. Combined sewer overflows (CSO) are the 'safety valves' on sewers so that when stormwater exceeds the hydraulic capacity of sewerage, the excess wastewater can be released with minimum harm. CSOs are fitted with 6 mm screens; clearly the output of FWDs will not block 6 mm screens but when CSOs do discharge, FWDs will add to the load in the discharge, albeit mitigated by in-sewer processes (see 12 below) and into rivers in spate. The answer to preventing CSO discharges is minimising the input of surface water.

9. Fat, oil and grease (FOG) should never be poured down drains. Instructions on the installation and use of FWD contain information to this effect. FOG blockages in sewers are a significant issue but a conclusion from analysing FOG samples collected from around the USA was that FWD were not implicated (Ducost et al., 2008 and private communication Keener, K. Purdue University, 2010).

10. The unintended consequences of obliging people to store food waste might be nuisance [odour and vermin] and exposing them to health risks. The British Pest Control Association considered that since 98% of the ground food waste is <2 mm, it would not be detectable by rats (Adrian Meyer private communication 2005). In contrast spilled and poorly contained food on the surface does attract rats, gulls and other scavengers. Wouters et al. (2002) reported that keeping separated food waste in kitchens increases bioaerosols and allergens compared with mixed waste that contains food waste; they concluded this is a respiratory risk to susceptible individuals.

11. Life cycle assessments in Australia, Israel and USA have all concluded that FWDs discharging to public sewers are good solutions for food waste. Evans (2007) reviewed the 100-year Global Warming Potentials (GWP) of different options and found the GWP of delivering segregated food waste to anaerobic digestion (AD) via FWD and the sewers was equivalent to kerbside collection and transport to AD by road (≈ -170 $kgCO_2e$/t food waste). Both routes to AD were better than composting, incinerating or landfilling (-14, +13 and +740 $kgCO_2e$/t food waste respectively). The incineration and landfilling scenarios both included energy recovery. The composting scenario was based on a survey of in-vessel plants in Netherlands that pre-dated the Animal by-Products Regulation (CEC, 2002) – compliance with ABPR would have increased energy and carbon use. The FWD route saved the local authority (Herefordshire and Worcestershire) more than £19 /hhd.year (based on their 2005 audited data) but [at the time] the cost transfer to wastewater treatment was unknown.

12. The question of cost transfer was resolved by comparing the influent monitoring data for the WwTW that serves Surahammar in Sweden for the period when there were no FWDs with the period when 50% of households used FWDs (Evans, et al., 2010). 24 hour composite samples of influent had been collected 4 weekly (generally on Wednesdays); the average loadings of BOD_7, COD, N and NH_4^+ all decreased but the differences were not statistically significant. Average annual biogas increased by 46% (P=0.01). This is consistent with the earlier finding (when only 30% of households had FWD) that electricity use in activated sludge had not increased (Karlberg and Norin, 1999). There had been no cost transfer, indeed

were value is obtained from biogas, FWDs confer a financial benefit. Evans et al. (2010) hypothesised that biofilms on the sewer walls had acclimated to the changed wastewater composition and biodegraded the dissolved load, aided by the relative increase in carbonaceous matter from the food waste. Battistoni et al. (2007) from a field study in Italy also concluded that the additional carbonaceous matter aids nutrient removal. Generally, domestic sewage [without FWD] has an excess of nitrogen and phosphate compared with carbon and therefore carbon (e.g. methanol and/or acetic acid) has to be purchased for biological nutrient removal in wastewater treatment unless there is a non-domestic discharger of C, such as a brewery.

13. FWDs do add to biosolids production but the increase is small. Food waste is typically 70% moisture and 90% volatile solids. It is very biodegradable; the volatile solids reduction during AD is about 90%. Thus, 1 t food waste (fresh weight) contributes about 50 kgDS to digestate production, which is recycled as part of the biosolids recycling programme with all of its proven safeguards.
14. Some municipalities have banned FWDs but on examination bans have been based on apprehensions and fears about adverse consequences and have been rescinded when objective assessments have been made. New York City rescinded its 17 year ban following field study (New York City DEP, 1999). Since 2008 both Stockholm, Sweden and Milwaukee, USA have encouraged FWD installation and use because they want to increase biogas production at their WwTWs.

Key Issues

1. Food waste is one of the largest fractions of household waste and it is the most difficult to manage because it has a high moisture content, sticks to dry recyclables (which reduces their potential for recycling), attracts pests and becomes malodorous.
2. Removing food waste at source unlocks the potential for recycling other fractions (Yang et al., 2010). Some citizens will practice home-composting, others will participate in kerbside collection but experience has shown that some (especially in flatted properties) will do neither of these. FWDs are a means of separating food waste at source and conveying it to treatment using existing infrastructure.
3. CIWEM considers that a diversity of environmentally acceptable options is needed for managing food waste so that there is maximum participation. A substantial body of published research demonstrates that FWDs are an environmentally acceptable option and that the reasonably expected fears of adverse consequences are unfounded. The GWP of FWDs delivering to AD [the dominant form of sludge treatment, by weight, in the UK] is as good as delivering food waste to AD by kerbside collection by trucks and better than centralised composting, incineration [EfW] or landfill.
4. CIWEM considers emphasising kerbside collection of source segregated food waste to the exclusion of other options has been a mistake because experience from around the world has shown that a sizeable proportion of the population do not participate.
5. CIWEM applauds the water utilities in the UK for increasing AD and biogas utilisation and for using such a large proportion of the biosolids on land (83% in

2008/09 for England and Wales) to conserve organic matter and complete nutrient cycles.

6. FWDs save at least £30 /hhd.year for food waste collection and treatment or disposal and appear to have little or no effect on the cost at WwTW, probably because of in-sewer acclimated biofilms. There is negligible impact on water resources. Where there is AD and biogas utilisation, FWDs contribute to wastewater treatment financially.
7. CIWEM considers that in this, as in all other aspects of water and environmental management, policy and strategy should be evidence-based.

Conclusions

1. CIWEM considers the evidence demonstrates that FWDs are valid tools for separating kitchen food waste at source and diverting it to treatment, use and recycling via the existing infrastructure and that they offer the opportunity for cost savings compared with other routes.

2. CIWEM considers that FWDs offer the opportunity for wider participation in resource recovery from wastes by a greater proportion of the population than has been the case with exclusive advocacy of kerbside collection, which whilst acceptable to some, is not acceptable to all.

3. CIWEM considers food waste and other organic residuals should [wherever possible] be treated and then used on land to conserve soil organic matter and complete nutrient cycles. The use of biosolids and other organic resources on land should be viewed from the perspective of the soil rather than from the origins of the materials. It is important to move to a holistic view of all aspects of organic resource production, use, soil protection, countryside stewardship, water protection, air protection and crop and livestock production. CIWEM considers there is scope for simplified, proportionate, science-based regulation of all organic resources and for co-treatment.

February 2011

References

Ashley, R.M.; Bertrand-Krajewski, J.-L.; Hvitved-Jacobsen, T. and Verbanck, M (2004) *Solids in sewers: characteristics, effects and control of sewer solids and associated pollutants.* IWA Publishing, London.

Atwater, R.M. (1947) The Kitchen Garbage Grinder. Editorial *Amer. J. Public Health* **37** 573-574

Battistoni, P.; Fatone, F.; Passacantandoa, D. and Bolzonella, D. (2007) Application of food waste disposers and alternate cycles process in small-decentralized towns: a case study. *Water Research* 41 893 – 903

CEC (1999) Directive on the landfill of waste. (1999/31/EC) Council Directive. *Journal of the European Communities* 16.7.1999 No L 182/1

CEC (2008a) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. *Journal of the European Communities* 22.11.2008 No L 312/3

CEC (2008b) *Green Paper On the management of bio-waste in the European Union*. COM(2008) 811 final, Brussels, 3.12.2008 {SEC(2008) 2936}

Ducoste, J.J.; Keener, K. M.; Groninger, J. W.and Holt, L. M. (2008) Fats, roots, oils, and grease (FROG) in centralized and decentralized systems. *Water Environment Research Foundation*. IWA Publishing, London.

Evans, T. D. (2007) Environmental Impact Study of Food Waste Disposers: a report for The County Surveyors' Society & Herefordshire Council and Worcestershire County Council, *published by Worcestershire County Council.* www.timevansenvironment.com (accessed 3 Nov 2010)

Evans, T.D.: Andersson, P.: Wievegg, A.: Carlsson, I. (2010) Surahammar – a case study of the impacts of installing food waste disposers in fifty percent of households. *Water Environ. J.* **241** 309-319

IPCC (2007) Climate Change 2007 - Intergovernmental Panel on Climate Change Fourth Assessment Report (AR4) *Cambridge University Press, UK*. http://www.ipcc.ch [accessed 19 Oct 2010]

Kalberg, Tina & Norin, Erik, VBB VIAK AB. Köksavfallskvarnar – effekter på avloppsreningsverk, En studie från Surahammar. *VA-FORSK RAPPORT 1999-9*.

Kegebein, J.; Hoffmann, E. and Hahn, H.H. (2001) Co-Transport and Co-Reuse, An Alternative to Separate Bio-Waste Collection? *Wasser. Abwasser* 142, 429-434

New York City DEP (1999) The impact of food waste disposers in combined sewer areas of New York City.

Nilsson, P.; Lilja, G.; Hallin, P.-O.; Petersson, B. A.; Johansson, J.; Pettersson, J.; Karlen, L. (1990) *Waste management at the source utilizing food waste disposers in the home; a case study in the town of Staffanstorp.* Dept. Environmental Engineering, University of Lund.

Quested, T. and Johnson, H. (2009) *Household Food and Drink Waste in the UK*. Report prepared by WRAP. Banbury.

Riedel, F. (2008) Turning contaminated waste into clean renewable energyand PAS110 compost – an overview of the interengineering biowaste process. Proc. 13th European Biosolids & Organic Resources Conference & Workshop. Aqua-Enviro, Wakefield

Smith, S.R. and Jasim, S. (2009) Small-scale home composting of biodegradable household waste: overview of key results from a 3-year research programme in West London. *Waste Management & Research* 27: 941–950

Wouters, I.M., Douwes, J., Doekes, G., Thorne, P.S., Brunekreef, B. and Heederik, D.J. (2000) Increased levels of markers of microbial exposure in homes with indoor storage of organic household waste. *Appl. Environ. Microbiol.* 66: 627-31

Yang, X.; Okashiro, T.; Kuniyasu, K. and Ohmori, H. (2010) Impact of food waste disposers on the generation rate and characteristics of municipal solid waste. J. Mater. Cycles Waste Manag. 12:17–24

Note: CIWEM Policy Position Statements (PPS) represent the Institution's views on issues at a particular point in time. It is accepted that situations change as research provides new evidence. It should be understood, therefore, that CIWEM PPS's are under constant review, and that previously-held views may alter and lead to revised PPS's.

Dear Hon Cyd Ho and members of the Panel on Environmental Affairs 2013-14,

15th October 2013

UPDATED Version

Dealing with our wet food waste

The big problem with Hong Kong's ultra-wet food waste (WFW) is…..

- It's very wet and difficult to handle (90% water content in wet market food waste, 70-75% water content in malls and restaurant WFW)
- It requires more energy to burn than it inherently contains. http://www.massbalance.org/downloads/projectfiles/1826-00237.pdf (p.8) *European food waste 4.2 MJ/kg calorific value (CV*) but European food waste has on average only 30% moisture content, so HK WFW will be even lower (CV). Hong Kong has the wettest worldwide putrescible waste w/ 90% moisture levels from wet markets & avg 70+% domestic WFW versus 56% Korea, 50% Japan, 30% Europe.
  Anaerobic digestion is an appropriate treatment for putrescible wet food waste(WFW), not incineration. The Government's "Bury 'N Burn" waste '*plan*' is for 3 incinerators & extended landfills – however you cannot combust low CV /high moisture WFW without co-combusting additional higher CV feedstocks, (thus defeating recycling efforts) since at least 6 MJ/kg CV in the feedstock is needed for combustion.
  http://www.waste-management-world.com/articles/2013/07/is-waste-to-energy-to-answer-for-india.html

  But Hong Kong can consider another method…… methane generating food waste is the smelly and obnoxious component of MSW ; *48% of HKG daily MSW is putrescible waste (42.3% wet food waste / 1.6 % yard waste / 4.3% used nappies + cotton wool)*
- WFW is a health hazard as it generates methane – methane is 21 times more damaging to the environment than CO_2 so it is flared off at the landfills 24/7.

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- It is the prime reason why we need to employ so many Refuse Collection Vehicles (RCV's) to clear the problem daily from HKG's WSW generators
- It is the reason why odorous RCV's get a bad name
- It accounts for many of the RCV trips per day, 48% of HKG's daily MSW is putrescible waste
- RCV's spill stinky leachate on the road
- Were food waste not present in MSW we could reduce waste collection frequency and its weight and significant costs to handle, transport and landfill.

So why not remove food waste at source and before it gets into the MSW ?

This would:

- Avoid the smell at collection points and landfills
- Avoid the smell from RCV's on the roads
- Improve public health
- Reduce the need to clean the roads
- Enable MSW to remain dry and more easily recycled and/or plasma gasified / syngas converted to bio diesel or aircraft / ship fuels
- Reduce the frequency of RCV trips
- Make people more aware of the packaging and food waste they generate

So how do we progress?

(instead of stepping backwards with HKG ENB's Bury 'N Burn Blueprint)

At present we are planning to introduce two anaerobic digestion organic waste treatment facilities (OWTF) for 200 tpd & 300 tpd (Total 500 tpd WFW) These will generate about 7.5 MW of power using anaerobic digestion that converts the waste to sugars and then gas to drive turbines but these will generate about 50 tpd of low quality compost as a result. Where is all the low grade compost going to go? No-one will buy it. **Do we need to spend this money ?**

Altogether the OWTF's will cost about $HK 3 billion to build and well over $HK 250 million per year to operate and ***will treat only a miserable 12.5% of the almost 4,000 tonnes food waste generated each day,*** mainly from hotels, wet markets, food stalls and the catering industry as well as residential units.

The remainder of the food waste problem could be avoided and many of the issues

identified above could be eliminated if we were to make hotels, restaurants, caterers, markets, businesses etc and individuals responsible for processing their own food waste.

The best choice of course would be not to waste food in the first place. However, we are an affluent society in Hong Kong and can afford to bin half the food we buy and we no longer have pigs to feed…

So..

Why not make every restaurant, wet market, business, caterer, hotel and household responsible for sorting food waste at source and disposing of their own food waste as it is generated **using waste disposal shredding (garburator) units with outfalls linked to the existing sewerage system ?**

It would foster a sense of responsibility and everybody could get involved and feel good about doing the right thing. Even easier than taking the lift down to the ground floor and walking to the garbage area. A garburator system needs to be inexpensive to install and operate when compared with housing costs and it should not require fancy new technology.

So, consider making sink outlet WFW shredding disposal units mandatory in households and industrial garburator units in restaurants, hotels, hospitals, schools and the catering industry, businesses etc, & connected to the sewage system. The DSD waste water sewage handling system is already there and capable of accepting it.

Phase 1- every hotel, restaurant, food business, hospital and wet market management etc would have industrial sized food waste shredding units - extending to Phase II Govt housing estates next, then Phase III to the rest of HKG households that have a legal sewage connection, so there would be no discrimination.

For those premises not connected to the existing sewage system such as village houses there would be a **GREEN BIN** collection scheme, charged for at sewage rates, which would be delivered to neighborhood industrial WFW shredding disposal units connected to the existing sewage network.

GREEN BIN

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Shrieks of horror ! we cannot do that, Government will rant *(because they never thought about it whilst blindly idolising their regurgitated 'Bury ' N Burn Blueprint')*

OK let's check the feasibility then……

http://www.biwater.com/Articles/325198/Biwater/BW_Home/waste_water/waste_water_projects/Stonecutters_Island_STW.aspx

Stonecutters treatment plant is designed to handle up to 2,764,800 cubic meters of waste water sewage per day by 2016, albeit DSD advise it will be 2.45 million tonnes per day. Stonecutters currently handles approx 1.6 million cubic meters of waste water (1.6m tonnes per day) of which the remaining sludge is approx 800 (eight hundred) tonnes per day. Disposing of a few extra thousand cubic meters of shredded WFW (70-90% water content) would add a very small additional load to Stonecutters capability to process additional sewage above the current 1.4 million tonnes load per day, since between 70%-90% of the 3,500 tonnes WFW is already water anyway!

The Stonecutters sewage treatment plant is ideally suited to handle such a relatively small additional quantity (3,500 tpd WFW) and is already operational.

Such a small increment of the incoming sludge would be negligible and it would all have calorific value (CV) so it would benefit the new Tsang Tsui sludge incineration process we have already implemented (at least once it's commissioned) and it will generate power

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which is already being negotiated to be fed into the grid.

The Big Advantage with this proposal will however be……

It uses existing facilities and technology but more importantly the pre-processing will be done by hotels, restaurants, caterers, fast food outlets, businesses, hospitals, wet markets, Government and private estates and at least 2 million households, - everybody doing their bit and thereby using existing end of line reception resources and diverting the vast majority of daily MSW from landfills!

Excellent…! we will mobilize the entire population and they will feel "good" about doing the right thing (they even do not have to walk to the garbage area with it any more) **provided the idea is marketed correctly.**

So where do we go from here…….

Government Departments are highly adept at passing the responsibility buck.
CEDD at Area 137 Wan Po Road handles Hong Kong's 18,000+ tpd (reusable fill) construction waste for export.

So let's suggest ENB pass on their WFW problem to DSD…. ENB has a great incentive to do this and for DSD, this would be minimal fuss, just slightly more dehumidified sludge to be shipped to Tsang Tsui sludge incinerator each day- The garburator scheme could even win brownie points for the beleaguered Government of CY Leung.

Make it Free

The funds will be easily recovered by the reduced handling costs and landfill benefits
Provide vouchers not cash subsidies for every household from the Budget surplus to install a sink waste disposal unit from appointed installers (paid by voucher) and make them mandatory to install and to use. (1 x Govt provided free garburator voucher per household … HKG people love freebies even if they are mandatory)

Non households, hotels and catering business outlets etc must buy their own commercial units and be inspected by FEHD under licensing conditions.

Next: Charge heavily for WFW disposal from the general public dumped at garbage collection points… and instead propose the use of private sector WFW collectors for **GREEN BIN** contents to dedicated reception points for disposal in each neighborhood for shredding and feeding into the sewage system. Government could actually pay for this collection service since the reduced number of current RCV trips and transfer stations would cover the costs of WFW GREEN BIN collections

We would need to deal with glass recycling. Glass has a very low calorific value (0.7 MJ/kg) Govt should encourage a new local recycling business to keep people at the bottom end of the chain employed. Glass can be ground to produce a substitute for aggregate in concrete products., Alternatively glass could be plasma gasified to produce an inert vitrified molten slag that can be used as a construction aggregate substitute given that all our building aggregate here is imported. Likewise plasma gasification could treat the construction waste that cannot be recycled and convert it to usable vitrified inert aggregate.

So with a new direction and using existing operating end-of-line reception facilities at Stonecutters we can handle our existing and future WFW, which is almost half of our daily MSW.

The other half of the daily MSW can be locally recycled as RDF (Refuse Derived Fuel) thus providing more local jobs and then sold to Europe as high CV feedstock in the interim; Europe considers MSW as a commodity feedstock for its overcapacity incinerator networks and which relies on same for its electricity and heat generation.

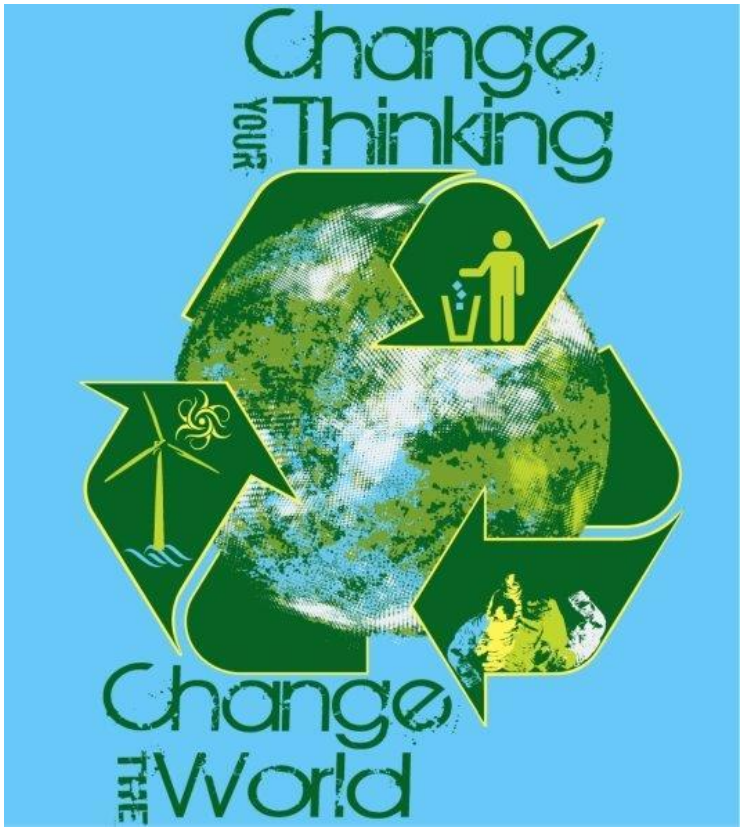
This will give Hong Kong breathing space to commission enhanced landfill mining at its landfills using plasma gasification technology that can produce bio diesel and bio fuels for airlines and Ocean Going Vessels (OGV's our biggest source of pollution).

MAJOR BENEFITS

The resultant resumed former landfill land (270 hectares) can be used for local public housing units instead of waiting 50 years (with maintenance costs of the closed sites) after

the closure of the landfill, as at present due to subsidence and methane problems.

Message for Hong Kong Government



Yours sincerely,

James Middleton

Chairman

www.cleartheair.org.hk

Technical Update October 2013

Update as provided by our technical engineer advisors. 15th October 2013 in response to public queries:

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The whole point about separately processing the easily biodegradable 3,500 cubic meters per day wet food waste component of the waste stream at source is to ensure that the ultra wet, smelly and potentially unhealthy elements are removed before they contaminate the remaining bulk of the waste.

Having removed food waste, the remainder of the recyclable waste stream remains dry and is much more easily dealt with, allowing the dry waste component to be reused or recycled in a much more efficient manner (thus creating new business recycling opportunities and jobs in areas like Tuen Mun, which could become **Green Tuen Mun** instead of a fly ridden smelly landfill Tuen Mun.)

Even those unrecyclable parts of the dry waste, the residues from the reusing and recycling processes, can be retained in a sufficiently dry state such that their calorific value remains high and, under these circumstances, the gasification or plasma gasification Syngas process can be beneficially used to produce electrical power in a Green way i.e. we can avoid the recourse of having to burn fossil fuels or adding recyclables to co-combust food waste in a Neolithic incinerator in a pathetic attempt to burn water, thus requiring more increased energy above what can be extracted from the process, thereby avoiding unlocking historically sequestered CO2 into the atmosphere where the vast majority of world scientists believe it leads to global warming.

It can be emphasised that efficient disposal in a fluidised bed + plasma reactor converting recently formed organic materials is sustainable. Recycling recently generated carbon content in the waste does not involve changing the volume of carbon in the dynamic carbon cycle. This is contrary to releasing sequestered carbon into the atmosphere by burning fossil fuels which is not sustainable and leads to the global warming events we are experiencing.

In answer to recent public queries:

Addition of special bacteria at the CEPT sewage treatment plant to the pulped food waste is NOT necessary.

http://www.biwater.com/Articles/325198/Biwater/BW_Home/waste_water/waste_water_projects/Stonecutters_Island_STW.aspx

The processes involve quite normally occurring bacteria which are encouraged to participate as part within the sewage treatment process by placing them in a stable and favourable

environment whilst they are dosed with “food” comprising raw, semi digested and fully digested components.
Food waste, when it is placed with sewage, as is proposed, will be digested by the same types of bacteria as are present in our own digestive systems and are excreted along with the food waste from our own digestion processes. Hence, we might conclude that the same bacterial processes will occur as the sewage passes down the pipes to the treatment plant as occurs in our own digestive systems whether the sewage comprises digested food or raw waste food. (which food waste in Hong Kong’s situation has a massive water content level already, being in excess of 70% water for Mall waste and 90% water for wet market food waste)
The critical factor here is to pulp and thereby dilute the waste sufficiently so as not to inundate the bacteria and to allow sufficient time for the bacterial digestion processes to occur en-route before the waste reaches the treatment plant where residues are separated by the sedimentation process to leave the sludge and processed water.
(A mesh screen at the sewage plant would possibly be required to sort any floating Styrofoam food packaging that might remain after the pulping process)

In Hong Kong the sludge will shortly be incinerated at Tsang Tsui fluidised-bed plant rather than being placed in the landfill, while the processed water, as at present, will be returned to the sea where yet more natural bacterial digestion processes occur, eventually resulting in the next cycle of the food generation process.
This is the ultimate recycling process and has evolved over many millions of years with mankind being an integral part of the top end of the process. In the modern sewage treatment process, engineers have harnessed the naturally occurring bacterial processes and have nurtured them to enhance their ability to deal with the huge volumes of waste which need to be dealt with and arise from urbanisation and placing too many people in too small a space for traditional nature to deal with on its own.

Despite Stonecutters plant being able to easily handle all our daily 3,500 cubic meters of wet food waste in minutes, Hong Kong has 10 additional sewage plants and pipe delivery networks that could also be enlisted to do the like actions:

This concept is totally viable.

It reduces the mal-perceived need for landfill extensions and retrograde lethal polluting incineration plants as promoted by the ENB.

It will create new jobs in areas currently opposed to landfill extensions.

It will promote recycling instead of burning and resultant necessary toxic ash landfill and costs.

It will obviate the need for expensive man-made islands as the new ash lagoons required by incinerators ad infinitum.

It makes sense, something currently lacking in the ENB's tunnel vision for our waste blueprint.

It uses readily available in-situ sewage networks and will cost little to setup the pulping at Transfer stations.

It complies with 2012 Panel on the Environment's directions to Government: (*still ignored by the administration*) and is shown below for your ease of reference:

http://www.legco.gov.hk/yr12-13/english/panels/ea/papers/ea0527cb1-1079-2-e.pdf

13. Details of the funding proposals for the three landfill extension projects are set out in LC Paper No. CB(1)1369/11-12(01) which is hyperlinked in the Appendix. According to the

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Government, IWMF would require some seven years for reclamation, construction and commission, while landfill extension would need a few years for site preparation works. In this connection, the IWMF Phase I project and the landfill extension projects should be pursued as a package to ensure that Hong Kong could maintain environmental hygiene and handle waste properly and timely. Deliberations by the Panel on the funding proposals for landfill extension are summarized in the ensuing paragraphs.

15. The Panel held another special meeting on 20 April 2012 to continue discussion on the funding proposals. Noting that many measures pertaining to the Policy Framework had yet to be implemented, members were opposed to the reliance on landfills for waste disposal in view of the associated environmental nuisances, as well as the long lead time and cost incurred from restoration of landfills. They stressed the need for a holistic package of waste management measures (including waste reduction, separation and recycling) with waste incineration as a last resort and better communication between the two terms of Government on environmental policies, in particular on the need for incineration. They also urged the Administration to identify other suitable outlying islands for IWMF and promote the local recycling industry. In view of the foregoing, members did not support the submission of the funding proposals to the Public Works Subcommittee for consideration.

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4.1.2 Waste Quality

4.1.2.1 The characteristics of Organic Waste in Hong Kong have been investigated in a number of surveys as described in the following. The Contractor shall note that the information provided under Clauses 4.1.2.2 to 4.1.2.4 of the Specification Part A is for Contractor's reference only and will not form part of the Contract. The Employer is not responsible for the accuracy of the data.

4.1.2.2 In 2005, the quality and quantity of food waste produced by a selected group of generators had been investigated. The characteristics of the food waste from the selected generators are shown below.

Composition of Food Waste in Hong Kong

Parameter	Public markets	Hotels	Food factories	Shopping malls
Moisture (%)	74.8	70.2	60	70.4
Total Organic Matter (%TM)	87.7	95	92	88.1
Total Organic carbon (%TM)	49.4	55.6	50.0	49.6
Kjehldal Nitrogen (%TM)	2.6	2.9	5.6	5.0
C/N ratio average (-)	25.5	21.1	9.6	16.7
C/N ratio range (-)	9.7-39.0	15.7-17.7	7.5-13.9	12.2-22.2
Arsenic (As, mg/kg)	< 0.10	< 0,10	< 0,10	< 0,10
Cadmium (Cd, mg/kg)	1.83– 5.08	0.78- 2.09	0.86- 1.83	1.17- 4.71
Chromium (Cr, mg/kg)	1.73- 23.1	2.34- 5.41	0.98- 1.92	1.25- 33.0
Copper (Cu, mg/kg)	3.07- 15.9	2.73- 5.20	2.68-3.14	2.12- 11.0
Mercury (Hg, mg/kg)	<0.010	< 0.010	< 0.010	<0.010
Nickel (Ni, mg/kg)	2.87- 20.0	4.20- 5.41	1.44-2.51	2.09- 13.5
Lead (Pb, mg/kg)	2.1- 12.6	1.27– 6.69	0.99- 1.92	1.27- 8.72
Selenium (Se, mg/kg)	0.58- 1.19	0.41- 0.93	0.30- 0.52	0.30- 1.96
Zinc (Zn, mg/kg)	8.98- 45.8	9.41- 15.5	9.03- 15.5	23.2- 64.7

4.1.2.3 In 2008, an investigation was conducted to study the nature of the organic material and the form and type of Inert Materials presented in the Organic Waste. The investigation revealed that there existed 5-20% of inert material among the waste during waste generation stage. Plastics were the major component of Inert Materials in combination with some glass or broken pottery.

4.1.2.4 In 2009, a study on Organic Waste composting conducted revealed that the results of heavy metal content were consistent with the data presented in Clause 4.1.2.2 of the Specification Part A. Other important characteristics of the Organic Waste in Hong Kong such as moisture content, volatile solids concentration and nitrogen content had also been investigated and the findings are summarized below.

Main Constituents of Organic Waste in Hong Kong

Parameter	Public Markets from FEHD	Public Markets from The Link	Food Industries / Hotels / Shopping Malls	Street-level Eateries
Moisture (%)	78	90	63	79
Total Organic Matter (VS as %TM)	88	86	94	93
Kjehldal Nitrogen (%TM)	4.1	4.6	3.6	4.9

A FOOD WASTE & YARD WASTE PLAN FOR HONG KONG 2014-2022

Environment Bureau

February 2014

CONTENTS

Message from the Chief Executive

"Waste Not" is one of my deepest personal beliefs and I try to live by it. Reducing food waste is a subject I feel particularly strongly about. I frequently discuss topics such as avoiding food waste at source and separating out food waste from other waste for recycling. My family and I have considerable hands-on experience on a small scale at our home. This experience has deepened my passion for working with the people of Hong Kong to change our wasteful habits. If we all spend a bit more time and effort, we can significantly reduce food waste in Hong Kong.

My Election Manifesto includes a clear commitment to "promote food waste reduction, encourage the business and industrial sector to undertake sorting of their waste at source, build more organic waste recycling and treatment facilities, and encourage the full use of recycled resources such as compost".

I congratulate the Environment Bureau on publishing this blueprint on food and yard waste which articulates Hong Kong's stance with respect to organic waste and how the Government is tackling the issue. To succeed, we require everyone's support at each step along the way. The journey is complicated, as it involves many aspects and there are many details to be worked out. All this will take time, but there should be no doubting our commitment to reduce food and yard waste.

CY Leung

Chief Executive
Hong Kong Special Administrative Region

Special Messages from Principal Officials

"One of my responsibilities in this term of Government is to provide steer to the Environment Bureau in the overall mainstreaming of organic waste reduction and treatment. The Steering Committee to Promote Sustainable Development of the Recycling Industry that I chair, among other duties, provides an internal platform to align more effectively the work of Government departments in waste management, including the management of organic waste."

Carrie Lam Chief Secretary for Administration

"Public money and food alike are scarce resources. Consistent with the principle of fiscal prudence, we should avoid and reduce food waste."

John C Tsang Financial Secretary

"Proper handling of waste is a challenging task, including enactment of new legislation and amendment of existing ones. We all share a responsibility to reduce food waste at source. I will give my full support and practise food waste reduction."

Rimsky Yuen, SC Secretary for Justice

"If Hong Kong is truly to deal with our large quantities of food waste, households will need to take on the responsibility to firstly avoid and reduce food waste, and when the food waste recycling system incrementally develops, separate their food waste. Colleagues responsible for public housing management will promote food waste reduction in the coming years to dovetail with the Government's overall food waste programme."

Professor Anthony Cheung Secretary for Transport and Housing

"As the Chinese saying goes, 'One should know that every single grain on the plate is the fruit of hard work'. Cherishing food is a traditional Chinese virtue. For urban dwellers living in densely populated cities nowadays, it is all the more necessary to reduce food waste. We support launching the environmental protection projects at district level to promote the 'Food Wise' culture and waste reduction."

Tsang Tak-sing Secretary for Home Affairs

"There are issues which we can talk about; yet food waste reduction is beyond negotiation. Let's work together to achieve our shared goal – to reduce food waste right from this meal!"

Raymond Tam Secretary for Constitutional and Mainland Affairs

"Hong Kong, as a bustling city, generates around 9 000 tonnes of municipal solid waste every day. Food waste accounts for about 40% (i.e. 3 900 tonnes) of them, equalling the weight of about 250 double-decker buses. The community has therefore put in large amount of land resources and public money to handle the waste. Let's join hands to find ways to reduce food waste and save social resources."

Professor KC Chan Secretary for Financial Services and the Treasury

Special Messages from Principal Officials

"I am particularly interested in making the fullest and best use of surplus edible food by redistributing and donating it to people in need. I understand from non-governmental organisations (NGOs) engaged in food donation and poverty alleviation that there should be huge potential in this respect if the supply and demand chains can be better coordinated. I look forward to wider tripartite collaboration involving NGOs, the business sector and the Government in unleashing this potential!"

Matthew Cheung Kin-chung Secretary for Labour and Welfare

"The catering and hospitality sector in Hong Kong is highly sophisticated and vibrant. Regardless of whether an establishment caters for budget or luxury customers, food wasteage is to be discouraged. Members of the sector participating in the Food Wise Hong Kong Campaign are to be commended for their efforts."

Gregory So Secretary for Commerce and Economic Development

"The disciplinary forces could be at the forefront of changing behaviour in how to deal with food waste. I am encouraged by the early success in one of our correctional institutions, which has the potential to be up-scaled."

TK Lai Secretary for Security

"I am pleased to collaborate with the Secretary for the Environment to see how schools can help further reduce food waste. I noticed that some schools' effort has borne fruit, and I am very proud of it."

Eddie Ng Secretary for Education

"I will call upon all civil servants to practice food avoidance and reduction. I believe civil servants and their families can play an important role in changing community behavior."

Paul Tang Secretary for Civil Service

"Promoting food donation is worthy of support from different sectors of the community. To facilitate the work of food donation agencies, the Centre for Food Safety has issued the 'Food Safety Guidelines for Food Recovery' for their reference."

Dr WM Ko Secretary for Food and Health

"I support the Environment Bureau's work in handling yard waste. The Development Bureau will assist relevant departments to implement yard waste reduction measures from planting design to maintenance stages."

Paul Chan Secretary for Development

Preface

We all know we need to change our habits so that we can live more sustainably. Treasuring our resources is essential to achieving environmental sustainability.

We have set a goal for Hong Kong that by 2022, we will reduce our per capita municipal solid waste disposal rate by 40% using 2011 as the base. This means each one of us must work hard to reduce our daily waste at home, at school, at work and even when we recreate.

One thing that we can all do is to become much more aware of the food we buy and eat, and to treasure our good fortune to have sufficient food to nourish us. By avoiding food waste, we will play our part for the environment to ease further pressure on the world's food system when so many individuals and families still face hunger all over the world, and even in affluent Hong Kong.

Our grandparents and parents were more careful in how they handled food. They did not over-buy or throw away leftovers when Hong Kong was a less wealthy society – now that we have wealth and also knowledge, we should be proud of adopting "Use Less, Waste Less" practices because we know better.

Our *Blueprint for Sustainable Use of Resources 2013-2022* published in May 2013 articulates our strategy on waste management to reduce, recycle, treat and dispose of waste. This document addresses Hong Kong's organic waste – namely food waste and yard waste. This is a companion document to the Blueprint, and articulates the specific strategy for tackling food and yard waste. I urge you to read both of them and join hands with us for this cause.

Just remember that when you leave food in your bowl; when you prepared or ordered too much food; when food is spoiled because you forgot to eat it – these all generally gets thrown away and end up in our landfills. So, take more care not to waste. Don't be a Big Waster.

KS Wong
Secretary for the Environment

February 2014

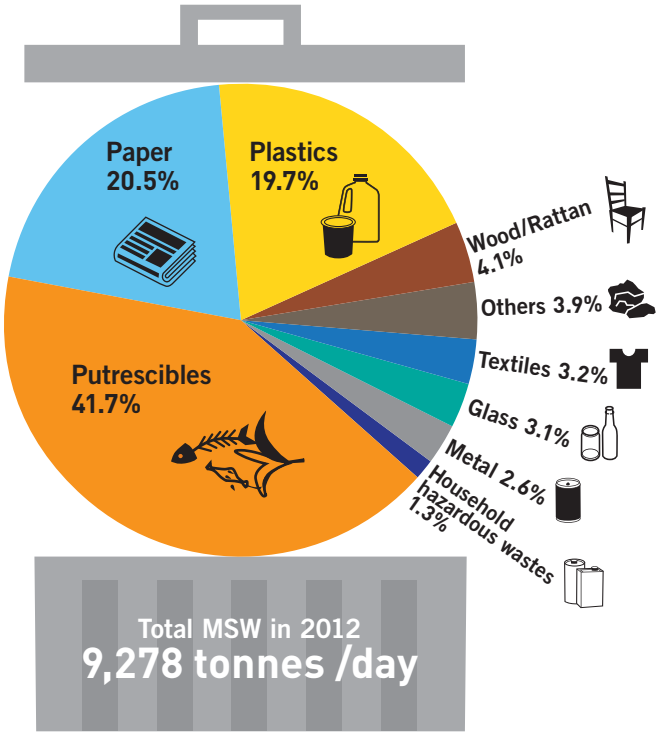
1 Our Vision for Reducing Food Waste

"Use Less, Waste Less"

Our overall vision is to "Use Less" and "Waste Less" of the earth's resources through instilling an environmentally-sustainable culture into Hong Kong people's daily lives.

Our *Blueprint for Sustainable Use of Resources 2013-2022* (the Blueprint) published in May 2013 provides a broad picture of our plan and strategy to deal with waste with a view to reducing impact on our environment. As stated in the Blueprint, the starting point of our new policy is to adopt a different attitude to waste in Hong Kong: our waste stream contains a treasure trove of useful resources, much of which can be reused, recycled and recovered.

Figure 1 Composition of MSW in Hong Kong, 2012



Overall Waste Reduction Target

Our target is to reduce the Municipal Solid Waste (MSW) disposal rate to landfill by 40% on a per capita basis by 2022 using 2011 as the base.

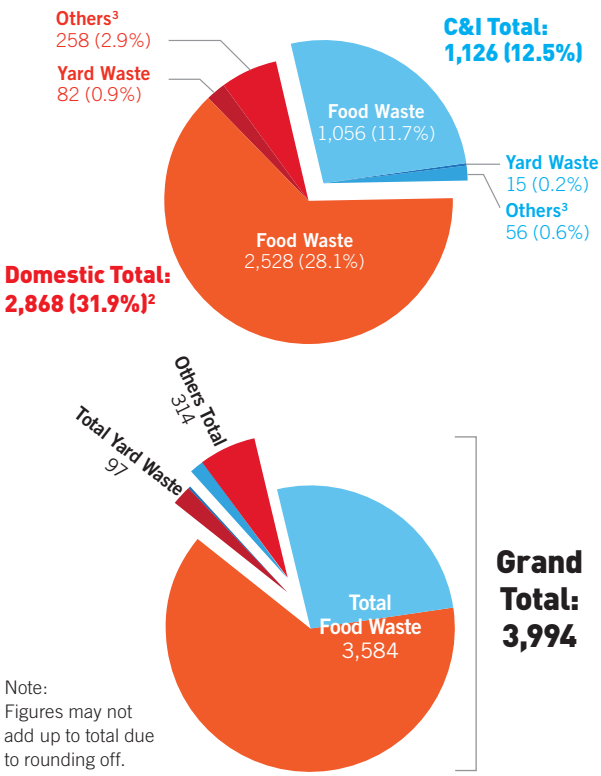
Of the approximately 9,000 tonnes of MSW that is thrown away at landfills everyday, some 40% are made up of "putrescibles",[1] which are various types of organic waste that decompose and create odour. It is mainly made up of food waste (around 90%) but includes some other waste, such as yard waste and personal care cotton products.

Food Waste

Among organic waste in Hong Kong, food waste constitutes the majority of putrescible waste. Food waste is any waste, whether raw, cooked, edible and associated with inedible parts generated during food production, distribution, storage, meal preparation or consumption of meals.

1. "Monitoring of Solid Waste in Hong Kong – Waste Statistics for 2011", https://www.wastereduction.gov.hk/en/materials/info/msw2011.pdf.

Figure 2 **Breakdown of Putrescible Waste in 2011**
tonnes/day (% of MSW)[2]



Note:
Figures may not add up to total due to rounding off.

Hong Kong's food waste

In 2011, our base year, Hong Kong people threw away about 3,600 tonnes of food waste every day – two-thirds came from households (around 2,500 tonnes) and one-third from food-related commercial and industrial (C&I) sources (around 1,100 tonnes).

Our food waste disposal is equivalent to throwing away the weight of approximately 250 double-decker buses every 24 hours or nearly 100,000 double-decker buses every year. Reducing the quantity of food waste is critical to Hong Kong achieving our overall waste reduction target by 2022.

Hong Kong is not alone in producing large quantities of food waste. Figure 4 shows other cities with developed economies also generate significant quantities of food waste. Thankfully, there is a growing realization that food waste prevention and reduction should be high on the policy priorities of municipal authorities.

Everyone a Recycler

Everyone consumes food – at home, at work or dining out – so each one of us can play an active role to reduce food waste at source. Hong Kong also has many C&I enterprises involved in the food business, such as food factories, operators of restaurants, fast food outlets, cafes, canteens, hotels, supermarkets, food markets, bakeries, groceries, fruit stalls, butcheries and all types of food producers and retailers. Institutions that provide food, including hotels, restaurants, schools and colleges providing meals to students, hospitals providing meals to patients and airlines to passengers, as well as companies that provide staff meals, could play an active part to reduce food waste.

What is food waste?

Rotten fruit and vegetables
Fish and poultry organs and intestine, meat trimmings and residues
Fruit and vegetable peelings, cores, pips, garnishes
Meat, fish, shellfish shells, bones
Food fats, sauces, condiments
Soup pulp, Chinese medicinal pulp
Egg shells, cheeses, ice cream, yogurts
Tea leaves, teabags, coffee grounds
Bread, cakes, biscuits, desserts, jam
Cereals of all types e.g. rice, noodles, oats
Plate scrapings and leftover of cooked food
BBQ raw or cooked leftovers
Food past its use-by-date
Pet food

2. Average MSW disposed of in 2011 was 8,996 tonnes per day.
3. Other putrescible waste includes personal care cotton products, such as diapers.

Figure 3 Average daily disposal quantity of food waste in Hong Kong (2003-2012)

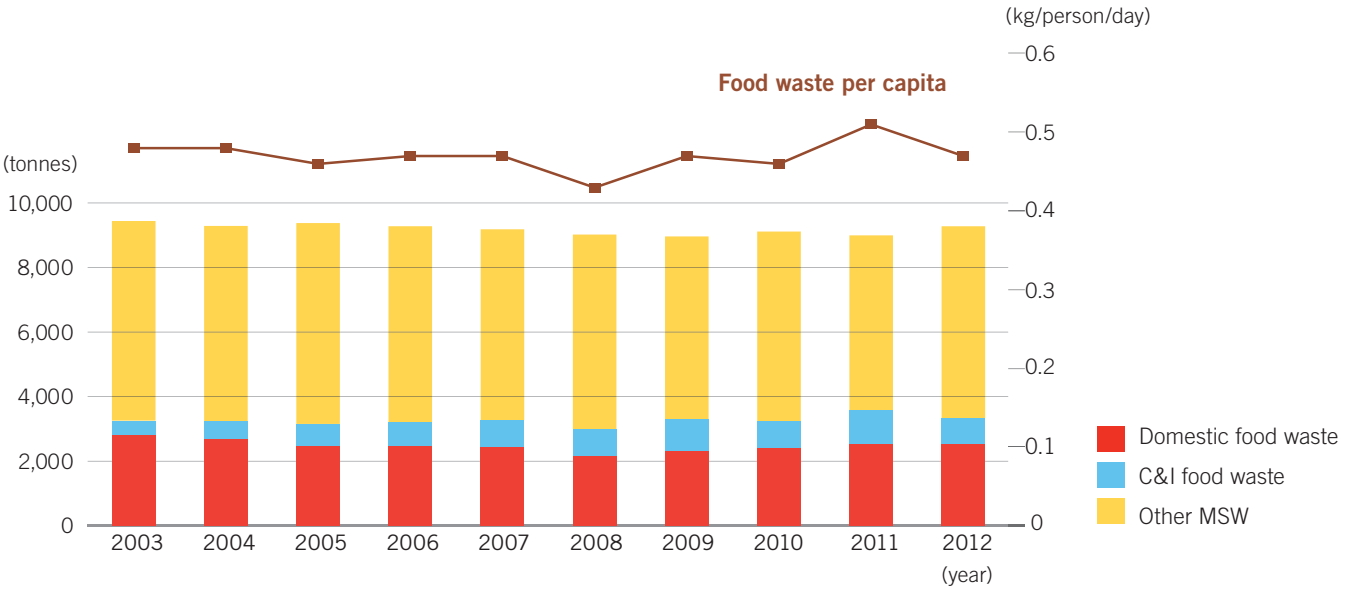
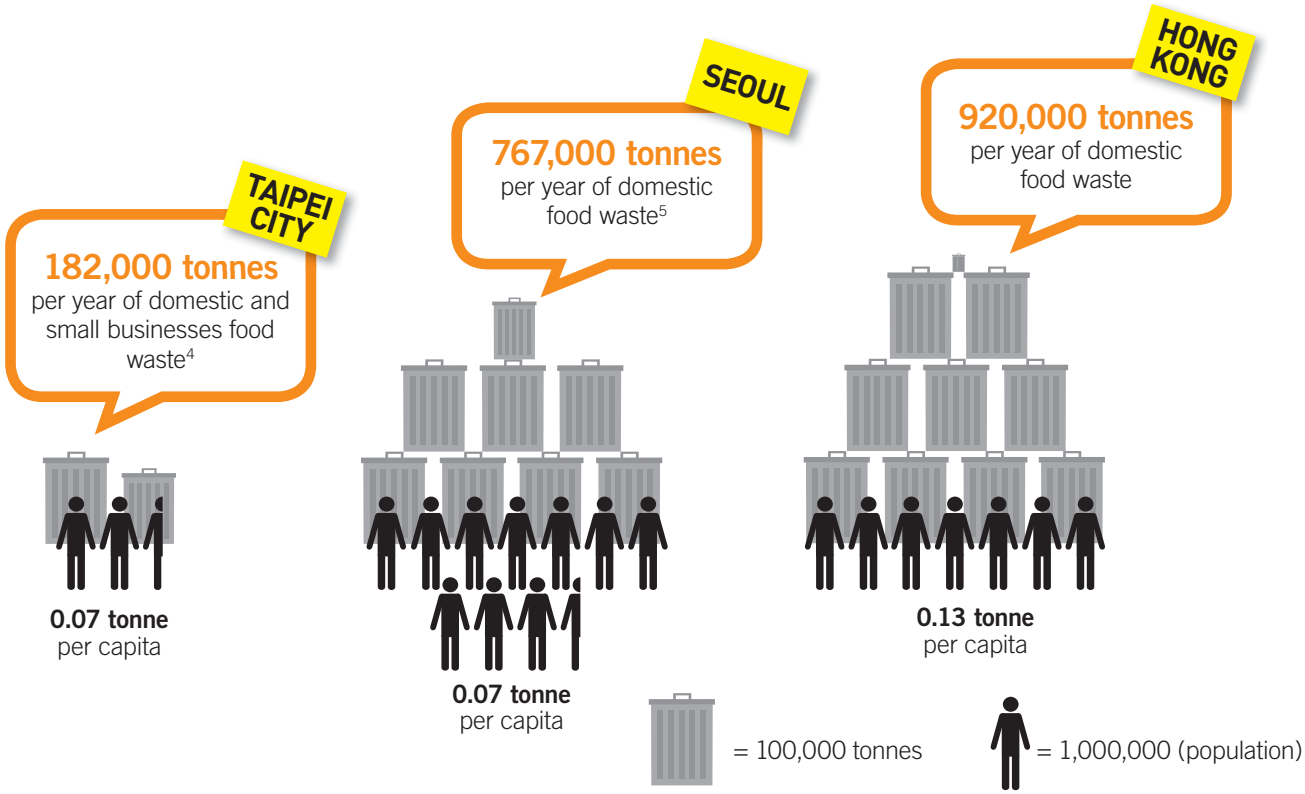


Figure 4 Food waste of Hong Kong and other cities from domestic sources (per year)



4. Taiwan environmental authority, 2011; the tonnages includes food waste from small businesses. The population in Taipei is about 2.6 million.

5. Ministry of Environment, South Korea, 2011. The population in Seoul is about 10.5 million.

2 Our Target and Strategy for Food Waste

Diverting food waste from landfills

Our target is to cut down the amount of food waste that goes to landfills by at least 40% by 2022. This means our goal is to reduce our food waste to landfills from around 3,600 tonnes a day to around 2,160 tonnes a day (a reduction of about 500,000 tonnes per year) over the course of about eight years. This is an ambitious goal and it can only be achieved with public support and active participation.

The prevention and reduction of food waste to landfill has multiple direct and indirect benefits. It will help to reduce various resource use associated with food production, cut greenhouse gas (GHG) emissions, recover useful resources from food waste, reduce the social cost of handling and treating food waste, and better utilize the capacity of landfill and waste-to-energy facilities.

Strategy to achieve our target

Our strategy for food waste has FOUR main components:

- **Mobilize the community**
  - Prevent and reduce food waste at source (i.e. before food become waste)
  - Donate surplus food to people

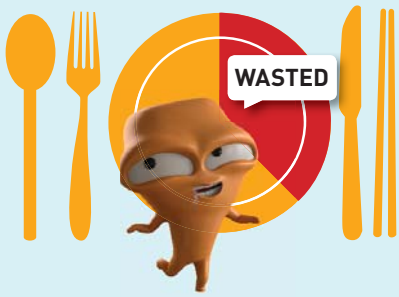
- **Promote food waste separation**
  - Incentivize separation

- **Recycle and treat separated food waste**
  - Turn food waste into renewable energy
  - Convert food waste residue to compost to create a soil supplement

- **Treat non-separated food waste and final disposal**
  - Provide MSW waste-to-energy treatment that includes non-separated food waste for recovery of energy
  - Disposal as last resort at landfills

Direct and indirect benefits of food waste prevention and reduction

Preventing and reducing food waste saves resources and cut environmental impacts. According to UNEP, roughly a third of the food produced in the world for human consumption is wasted or lost every year, amount to 1.3 billion tonnes annually. This amounts to a major squandering of resources, including land, water, energy, labour and capital that had gone into producing the food, and needlessly produced GHG, expediting climate change.[6]



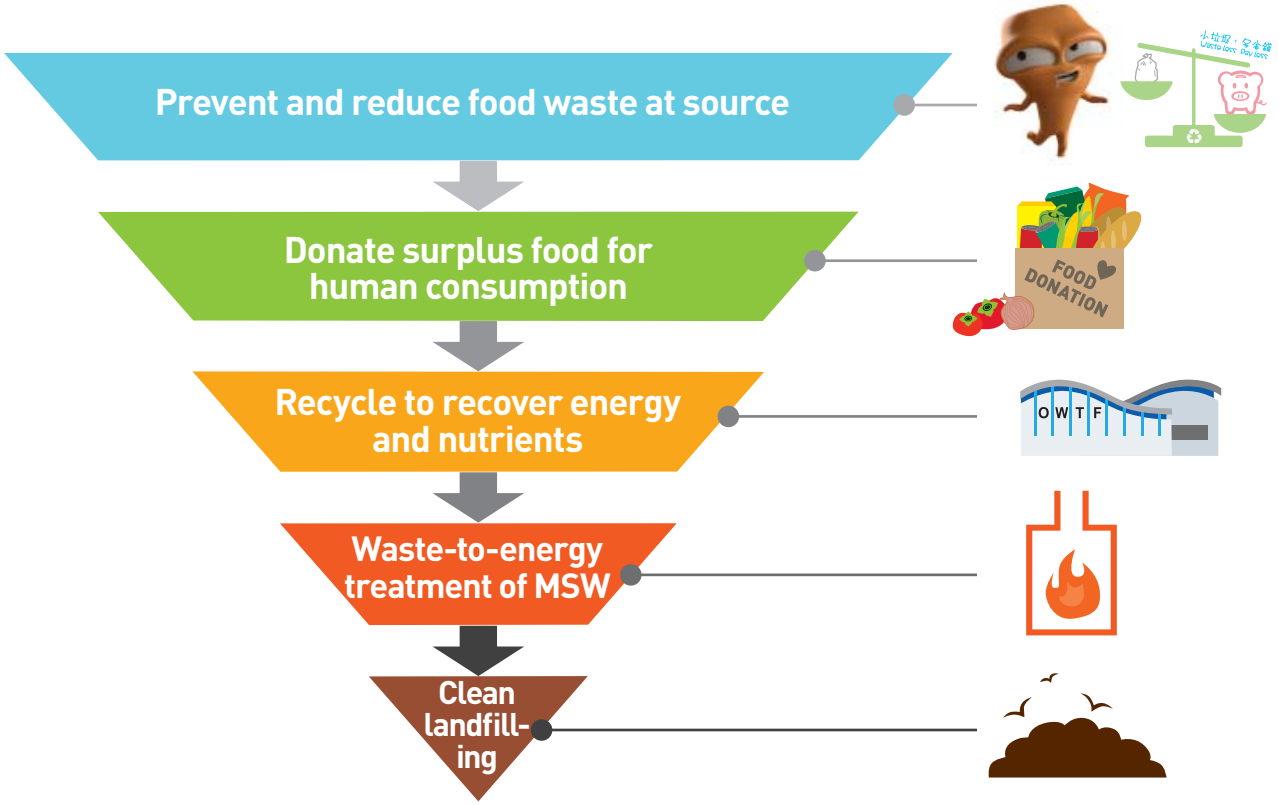
6. UNEP, "Food Waste Facts", http://www.unep.org/wed/quickfacts/.

Emphasis on food waste-to-energy

Our plan is to recycle food waste mainly into renewable energy because Hong Kong can use large quantities of energy either in the form of biogas or electricity. Food waste could also be treated to recover nutrients in the form of compost as side product for landscaping or agricultural applications but Hong Kong has limited capacity for such uses.

Figure 5 provides a picture of food waste management options according to a hierarchy of their importance. Chapter 3 deals with the prevention and reduction of food waste, as well as donation of surplus food; Chapter 4 deals with separation and collection of food waste; Chapter 5 addresses recycling of food waste; and Chapter 6 deals with the treatment and disposal of MSW where food waste has not been separated, collected and recycled. Chapter 7 deals with yard waste.

Figure 5 Food waste management hierarchy



3 Food Waste Avoidance

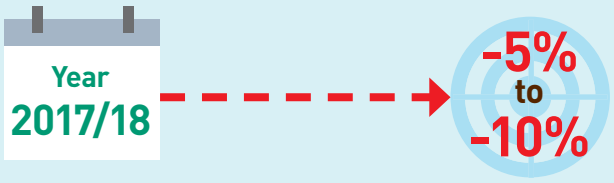
The most important step in reducing food waste is to avoid creating it in the first place.

Rethink and Community Mobilization

Hong Kong people need to rethink our relationship with food. By focusing on our real need for nutrition, we can choose to avoid over-buying, over-ordering and over-preparing food that is then dumped because we cannot use or consume it all. Once we rethink our habits as individuals, households and businesses, we can change and not waste precious food.

Our main social mobilization campaign is the Food Wise Hong Kong Campaign. It is designed to galvanise the community, from individuals to households to C&I operators, to avoid and reduce food waste at source. Using overseas experience as a guide, we anticipate this campaign may help Hong Kong to avoid about 5% to 10% of food waste by 2017/18.[7]

Food Wise Hong Kong Campaign



On 3 December 2012, we set up the Food Wise Hong Kong Steering Committee to drive leadership in food waste avoidance and reduction through working with leaders in this field in order to formulate and oversee the implementation of the Food Wise Hong Kong Campaign. The campaign was formally launched on 18 May 2013.

The campaign has a variety of activities, ranging from articulating and disseminating best practices in the C&I sector to working with government departments, schools and non-governmental organisations (NGOs) in order to expand participation. The campaign is also facilitating food donation for dual purposes of caring for the disadvantaged and waste reduction.

Food Wise Ambassadors from the community and organization have been recruited since the launch of the Campaign. Training will be provided to help Ambassadors to spread the key messages and practical tips about food waste reduction across the community. By end 2013, over 450 Ambassadors have been recruited. A Food Wise Charter has also been established. By end 2013, over 320 organisations, including various trades, non-governmental organisations and government departments have signed the Charter to show their support for the Campaign and to commit to reducing food waste.

Based on the actual effect of the campaign, we would keep in view the need for any further policy measures to incentivize the reduction of food waste generation.

7. The estimate of 5% to 10% from avoidance is derived from the British experience, where the national average reduction achieved after a period of intense public education was 2% but in the best districts 14% was achieved. We are using 5% to10% as a possible estimated outcome.

Disney/Foodlink event

Ma On Shan Ling Liang Primary School

Sing Yin Secondary School

Food waste reduction successes

The Environment Bureau and **Education Bureau** jointly launched the Green Lunch Charter in February 2010 to encourage schools to reduce food waste and the use of disposable lunch boxes. The Environment and Conservation Fund (ECF) has also reserved $150 million to support existing schools to retrofit facilities in order to portion meals on site, while new school premises will be designed to enable on-site meal portioning as a standard feature.

A good example is **Ma On Shan Ling Liang Primary School**, which involves daily volunteer parent helpers. About 720 participating students join the programme, while 170 students bring their own packed lunch. The school has also set up a small on-site composter to convert food waste into fertilizer which is used for their own school organic farming. The programme results in substantial reduction in disposable lunch boxes and utensils, with 90% waste reduction from lunch. After the implementation of the scheme, the school generates about 4.5 – 6 kg of food waste per day, or about 0.006 – 0.008 kg per student.

Sing Yin Secondary School set up its own environmental policy and introduced knowledge and skills for practising a wide range of measures by students and staff. As regards food waste reduction, the school has set up food waste recycling facility and other green initiatives, such as working with the school's food kiosk operator to avoid and reduce food waste. In the past, the operator would prepare extra lunch boxes every day to meet contingent needs but that often resulted in a surplus that ended-up having to be dumped. The new practice offers soup noodles and other snacks to meet extra demands as they arose, thus avoiding food waste.

In September 2013, **The Chinese University of Hong Kong** launched a two-year "Love Food Hate Waste @CUHK", which is a food waste education campaign. The university envisages the campus becoming a 'living laboratory' for food waste reduction and recycling. The campaign takes a multi-pronged approach and initiatives included the operation of food waste composters and other food waste recycling methods, micro film production and distribution of food and beverage coupons to students who have finished all their food.

The Lo Wu Correctional Institution has an average of 75% of its inmates participating in the Waste No Food Scheme since April 2013. The project enhanced environmental awareness and encouraged the reduction of leftover food. Upon enrolment to the scheme, the persons in custody volunteer to receive a reduced portion of their staple food (rice, chapatti or potatoes). The scheme has avoided 500 bowls of rice having to be dumped every day (i.e. around 100 kg). The institution also installed an on-site food waste composting system with a daily capacity of 100 kg which turns fruit peels, vegetable leaves and meal leftover into organic compost for greening purposes.

Since September 2011, **the Health Care Food Service Team at the Pamela Youde Nethersole Eastern Hospital** has reduced patients' meal portions by 20% and prepare meals according to actual demand. This initiative has resulted in 42 tonnes of food waste reduction (i.e. around 115 kg per day) and a saving of several hundred thousands per year. This team won the Hospital Authority's Outstanding Team Award in 2013.

The MTR Corporation Limited has launched an incentive scheme that is expected to achieve a 15% reduction in food waste by participating food and beverage tenants in 18 months' time.

A New Core Value

Early results show there is sympathy within the community to avoid food waste. With strong and sustained public communication, and with the commitment of the C&I sector, we can make food waste avoidance a core Hong Kong value – that is, it becomes a fundamental aspect of our lifestyle and a value we are proud to practise and display. It is not too hard to imagine that by encouraging a new "Food Matters" culture that it can help Hong Kong's catering and hospitality C&I sector, as well as the community as a whole, to innovate.

Food Donation

Surplus edible food could be redistributed for human consumption. Throwing food away deprives someone else from being nourished by it and is a sheer waste of resources. Momentum of food donation is building up in Hong Kong. NGOs operate food banks, redistribute dry foodstuffs, as well as take cooked food from eateries to community centres. There are also NGOs that use surplus produce from fresh food markets either for distribution or for preparing hot meals in community kitchens for the needy.

Hong Kong's food donation NGOs are becoming increasingly adept at observing good hygiene practices. Furthermore, in August 2013, the Government's Centre of Food Safety issued a set of food safety guidelines for food recovery, where it sets out food safety principles that should be applied to food donated to charity, regardless of the types and sources of food. Some NGOs have also entered into food donation agreements with their donors to deal with food safety liability issues.

We wish to strengthen our support of the work of NGOs to increase the collection of surplus food from the C&I sector, such as supermarkets, fresh food markets, restaurants, clubs and hotels. NGOs may consider applying for the ECF to support food donation projects that could help reduce waste to landfill.

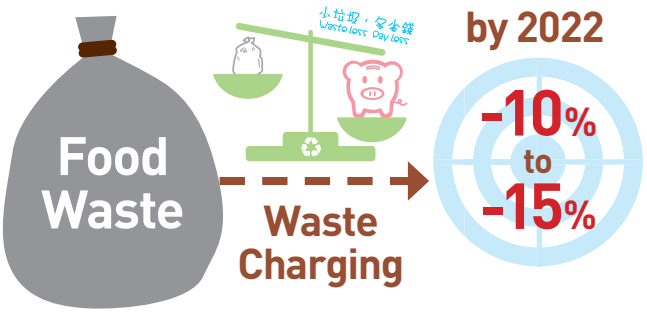
4 Separation and Collection of Food Waste

In the long run, food waste that cannot be avoided should be recycled as far as possible. Successful food waste recycling requires the waste to first be separated from other types of MSW and then collected for delivery to recycling facilities. Food waste that has been mixed with other types of waste is contaminated and cannot be recycled. The separation and collection of food waste is therefore a critical aspect of any food waste recycling system.

Waste Charging

Our intention is to implement a quantity-based MSW charging scheme by 2016/17. With quantity-based waste charging, people will seriously rethink their consumption and disposal behaviour and become much more conscious about the environmental consequences. We can pay less by throwing away less. Experience from other parts of the world, including Taipei City and Seoul, shows that implementation of quantity-based waste charging provide powerful economic incentive for people and various trades to reduce avoidable waste and to separate recyclables from the waste stream.

With waste charging, Hong Kong's overall MSW should drop by a good margin over the course of several years.[8] We estimate that MSW charging could further reduce the quantity of food waste by a further estimated 10% to 15% between 2017 and 2022. Together with reduction at source by the Food Wise Hong Kong Campaign, as well as the establishment of Organic Waste Treatment Facilities (OWTFs – see Chapter 5), we expect Hong Kong could achieve some 40% food waste reduction by 2022.



Public consultation in 2012 showed Hong Kong people support the concept of quantity-based MSW charging. On 24 January 2014, the Council for Sustainable Development (SDC) completed a four-month public engagement and will draw up recommendations on how quantity-based MSW charging may be implemented in Hong Kong, which will help us to take the initiative forward. We will carefully consider the SDC's recommendations and draft the necessary legislative proposals as soon as possible for the Legislative Council's scrutiny.

Source separation of food waste

There are TWO categories of food waste in general:

Pre-consumer food waste
Waste from industrial food processing (vegetative and animal food waste)
Vegetative food waste (vegetable and fruit trimmings, spoiled produce)
Animal food waste (fish, meat, diary)

Post-consumer food waste
Served food that has been left uneaten (plate scraping, uneaten buffet/salad bar food etc.)

The food manufacturing and cooking process often requires the use of cooking oils. This is a separate form of waste derived from food but it is not counted as part of our food waste statistics (see below).

Often found among food waste are soiled food packaging and food service ware (e.g. plastic eating utensils, plastic containers and wooden chopsticks). Removing them first would be most helpful.

To recycle food waste requires a THREE-step strategy – **separation, collection and recycling**. Each step is a major operation in itself and then each of the steps needs to be properly aligned for good results. This chapter deals with the first two steps and the next chapter with the third step.

8. In Taipei City and Seoul, about 20% reduction in waste generation was achieved after several years of imposing quantity-based MSW charging and publicity. We are assuming a similar level of reduction could be achieved in Hong Kong through the Food Wise Hong Kong campaign and quantity-based MSW charging.

Food waste source separation

Source separation is the pre-requisite for effective recycling of waste into useful resources.

Waste generators should be responsible for separating their food waste. Thus, a food processing business, such as a factory making cakes or food sauces should put in place a system whereby the pre-consumer food waste arising from its business is separated out for subsequent collection. Likewise, a restaurant can have a system whereby its pre-consumer and post-consumer food waste is also separated from other waste for collection.

Both the food processing factory and the restaurant can also separate out the oils and fats it produces.

C&I food waste

In preparation for recycling food waste on a large scale, we have gained experience on food waste source separation with the C&I sector over the past few years through the operation of the Kowloon Bay Pilot Food Waste Composting Plant and the Food Waste Recycling Partnership Scheme. The plant was initially used in 2008 to treat food waste from the venues hosting the Olympic and Paralympic Equestrian Games, after which EPD started the Partnership Scheme with C&I participants to collect source-separated food waste for delivery to the Kowloon Bay plant. Today, the scheme has over 120 participants. From 40 tonnes in 2008, the plant treated 283 tonnes in 2012. While this is a useful pilot scheme to help us gain knowledge, it is recycling less than 0.1% of Hong Kong's total C&I food waste.

The compost produced from the plant is being used by the Leisure and Cultural Services Department (LCSD) for the many community gardens it cares for. So far, 24 tonnes of compost has been provided for its use.

Household food waste

The Housing Authority has conducted food waste recycling trial schemes at 14 public housing estates by phases since 2011, involving nearly 1,000 families to encourage the cultivation of food waste separation habits and food waste recycling.

In addition, in 2011, EPD launched the Food Waste Recycling Projects in Housing Estates to raise awareness on food waste reduction and to install composters. As of December 2013, 37 of them have received funding under the ECF to install composters at the estates. Education programmes organised by these estates would cover about 81,500 households, of which about 4,100 would participate in food waste source separation and recycling. It is expected that a total of 1,300 tonnes of food waste (i.e. 3-4 tonnes per day) would be recycled each year and 260 tonnes of compost would be produced annually, which can be used as fertilizers by the estates for their plants and gardens. From data collected, the Project has created an impact on changing behaviour, as reflected by the notable reduction in food waste generation by participating households.

District food waste schemes

We also have district-based programmes at Kwun Tong, Tsuen Wan, Tuen Mun and Wong Tai Sin. In the first case, we started the Food Waste Reduction Programme in 2011 in collaboration with the Kwun Tong District Council and the property management of a shopping mall, whereby customers at eateries are encouraged to minimize and separate food waste, which is then recycled at an on-site composter.

As at June 2013, about 108 tonnes of food waste (i.e. over 0.1 tonne per day on average) has been recycled, and about 20 tonnes of compost produced for gardens in the district.

In March 2012, the Islands Food Waste Recycling Scheme was launched on Cheung Chau and at Yung Shue Wan on Lamma Island. It aims to educate and motivate restaurants, food premises and hostels for the elderly to reduce, separate and recycle food waste by means of composting. Up to the end of 2013, about 194 tonnes of food waste (i.e. about 0.3 tonne per day on average) had been recycled, and about 21 tonnes of compost produced for local use.

Up-scaling on quantity

We are gathering data and reflecting on experience from all the C&I participants, housing estates and districts so as to assess the effectiveness of all the abovementioned schemes. This will help us identify how to broaden the implementation of food waste separation in Hong Kong. In addition, we would initiate a study on the appropriate means of organic waste collection and delivery in Hong Kong in 2015.

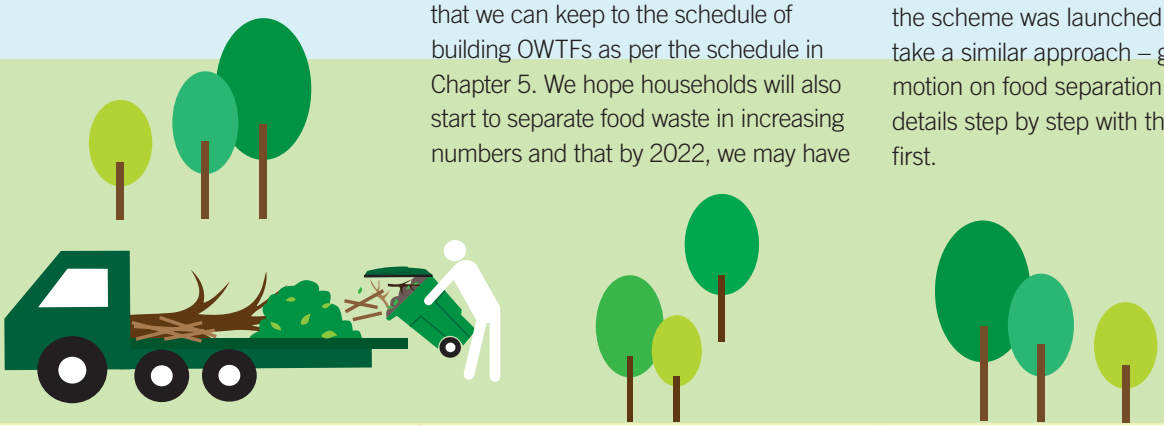
By 2018-19, our aim is for about 50% of our C&I food waste to be recycled, rising to 60% by 2022 for the C&I sector, assuming that we can keep to the schedule of building OWTFs as per the schedule in Chapter 5. We hope households will also start to separate food waste in increasing numbers and that by 2022, we may have 250,000 households (i.e. around 11% of all households in Hong Kong) participating.

To achieve this magnitude of increase from where we are today requires massive social mobilization, as well as collaboration with food-related businesses and estate managers. *The Food Wise Hong Kong Campaign* will work hard to mobilize all stakeholders and the public. We are ready to support more programmes and we expect food separation to increase progressively in scale when MSW charging is in place.

Needless to say, Hong Kong must make long term plans to involve the community to reduce and separate food waste so that a very large number of households will be involved beyond 2022.

Voluntary or mandatory separation?

Examples from overseas show there are successful cases in adopting the voluntary and mandatory approach. Some jurisdictions, such as South Korea, first adopted the voluntary approach to get society used to a new way to deal with food waste and to learn from the process before mandating food waste separation. After all, to be able to draft the appropriate legislation, it is necessary to articulate how it is to be done. In the case of South Korea, legislation only came about 7 years after the scheme was launched. Our view is to take a similar approach – get the wheel in motion on food separation and iron out the details step by step with the community first.



Collection and delivery of food waste

Transporting food waste requires special attention. Food waste collection vehicles are needed to ensure there is no leakage or odour. In future the vehicles will likely be different from the ones operating in Hong Kong today transporting MSW. Thus, a new fleet of food waste vehicles will need to be used or the existing fleet will need to be upgraded.

Once food waste has been separated from other MSW, it can be collected and delivered to the food waste recycling facilities. Our plan is for C&I establishments to be responsible for separating their food waste from their other MSW and deliver the separated food waste to the recycling facilities discussed below.[9]

The collection of food waste from domestic sources is more challenging than for C&I establishments because there are many types of residential dwellings. We will initiate a study on the food waste collection and delivery to consider the different types of circumstances in Hong Kong, including dwellings with/without storage space for separated food waste and C&I establishments, the collection and delivery arrangement, the suitable types of vehicles, appropriate ancillary and supporting facilities for any on-site interim storage, the appropriate arrangement for prioritization in the collection and delivery of food waste as well as the social, institutional and resource implications.

Separation and Collection of Used Cooking Oil and Grease Trap Waste

Separation and collection of used cooking oil (UCO) and grease trap waste (GTW) has become an established practice in the C&I sector as there is value in the UCO itself and the GTW is required to meet the effluent discharge standards under the Water Pollution Control Ordinance[10] and also because of the growth of Hong Kong's burgeoning biodiesel industry. Hong Kong's 20,000 plus eateries and food businesses generate an estimated 20,000 tonnes of UCO each year and about 175,000 tons of GTW. These quantities of waste are not counted as part of our food waste, so they are in addition to it.

In the case of UCO, many restaurants separate it from other forms of kitchen waste and sell it to collectors. The collectors range in size from traditional small waste collectors covering a small geographical area, to large collectors, which collects from more than 10,000 outlets every month. The waste oil is aggregated for use as a raw material for local biodiesel production or export for production overseas.

In the case of GTW (oil and grease in wastewater), it is collected by specialised collectors from the grease traps which all commercial kitchens are required to install. Before GTW can be used as a raw material, it must first be treated in one of Hong Kong's two GTW separation facilities where the oil is extracted for use as a raw material for biodiesel production and the residual wastewater treated to the required environmental standards. The first separation facility was built by the Government at the West Kowloon Transfer Station in 2006, and the second facility is built by one of the biodiesel producers. Together, Hong Kong has the capacity to treat about 1,000 tonnes of GTW a day.

9. Currently, C&I establishments are responsible for delivering their waste either to reduce transfer stations (RTS) or landfills.
10. Grease and oil that is allowed to enter the sewer system causes problems by separating from the wastewater and accumulating on the inside of sewer pipes. Over time, these deposits get larger as more grease and other solid material builds up. Grease deposits reduce the capacity of sewer pipes and cause sewage overflows, offensive odour and an unhealthy environment. The cleaning of grease deposits from sewers is difficult and can be dangerous and is carried out at considerable cost. Therefore, in many areas of Hong Kong there are limits set by the Water Pollution Control Ordinance on the amount of grease and oil that can be allowed to pass to sewer.

5 | Treatment and Recycling of Food Waste

OWTF Network

In light of the fact that Hong Kong generates a very large amount of food waste each day, and that food waste in general decomposes quickly and is unsuited to compaction at RTS for long-haul transport, the most suitable method to recycle food waste is to create a network of recycling plants. This approach enables food waste to be transported quickly from population centres to the facilities that are not too far away thereby reducing potential nuisance.

Preferred technology

We have reviewed many types of technology for treating food waste to assess their suitability for Hong Kong (see Annex). As Hong Kong has a large need for energy, our policy is to treat the city's collected food waste to produce energy using anaerobic digestion as the core technology. This process also produces residue that could be processed to become compost or fertilizer as side-products but our goal is to turn waste into energy and maximize energy production since Hong Kong has limited use for compost and fertilizer but can use large amounts of energy.

Social mobilization

Hong Kong people are becoming more and more conscious about reducing food waste. We expect this trend to gather strength with the spread of awareness raising programmes promoted by us and also by community groups in the coming two years, as well as after MSW charging is in place. The key is to get food-related C&I operators and householders to separate their food waste from other MSW.

As noted in the previous chapter, we have been promoting food waste separation for some time, where the collected food waste has been recycled into compost. Apart from the Kowloon Bay Pilot Food Waste Composting Plant and collaborating with the C&I sector, we also launched a number of schemes for households and other sectors. In the case of our household schemes for on-site composting, the daily capacity for individual estates is in the range of around 50 kg to 100 kg. Schools and some institutions have also installed small on-site composters, most of which have daily capacities of 5 kg to 100 kg. While the pilot plant and on-site composters handle very small quantities, the goal is to get people used to separating food waste. More organizations, schools and residential establishments are interested to start their own on-site programmes.

Expectation and Capacity Mismatch

Going forward, our challenge is to continue to promote food waste reduction at source as our priority, while increasing the social momentum to separate waste as we start to build the network of OWTFs, although the first one will only be ready in 2016. Indeed, it will take some years before Hong Kong has the recycling capability to deal with approximately 50% of the city's food waste. There could well be a mismatch between public expectation to participate in food waste separation schemes and the availability of treatment capacity, especially for households.

Anaerobic digestion technology

Anaerobic digestion is a process where micro-organisms are used to breakdown organic matter in the absence of oxygen.[11] Recycling food waste using this method is low carbon and produces biogas (a source of renewable energy similar to natural gas) as well as a residue that can be processed for use as compost or fertilizer. The energy produced can be used to run the facility and for the surplus energy to be exported. For example, we estimate OWTF1 can produce up to 14 million kWh of surplus electricity, which is equivalent to the electricity used by some 3,000 households.

This technology is now mature and the optimal capacity for an OWTF is in the range of 100 to 300 tonnes per day.

11. There are other technologies to treat food waste, such as composting, waste decomposing into waste water, dehydration and the Bokashi method, but they cannot compare with the advantages of large-scale anaerobic digestion facilities.

Network of Organic Waste Treatment Facilities (OWTFs)

We envisage Hong Kong needs to build a network of around five to six OWTFs between 2014 and 2024 with a total recycling capacity of about 1,300-1,500 tonnes per day. The first facility (OWTF1) at Siu Ho Wan (North Lantau) is already under tender and will cater for 200 tonnes of food waste per day. It is a government-funded Design-Build-Operate (DBO) project and is expected to become operational in 2016.[12]

There are currently two other possible sites for OWTFs to be built. The Environmental Impact Assessment (EIA) for OWTF2 has been done and it needs to be taken forward expeditiously using the established DBO arrangement.

The EIA for OWTF3 will also be taken forward as quickly as possible. As for further facilities, suitable locations still need to be identified.

We welcome the private sector to participate in the development of further OWTFs. We are open to options and proposals from the private sector either on sites identified by the Government or other sites proposed by the private sector.

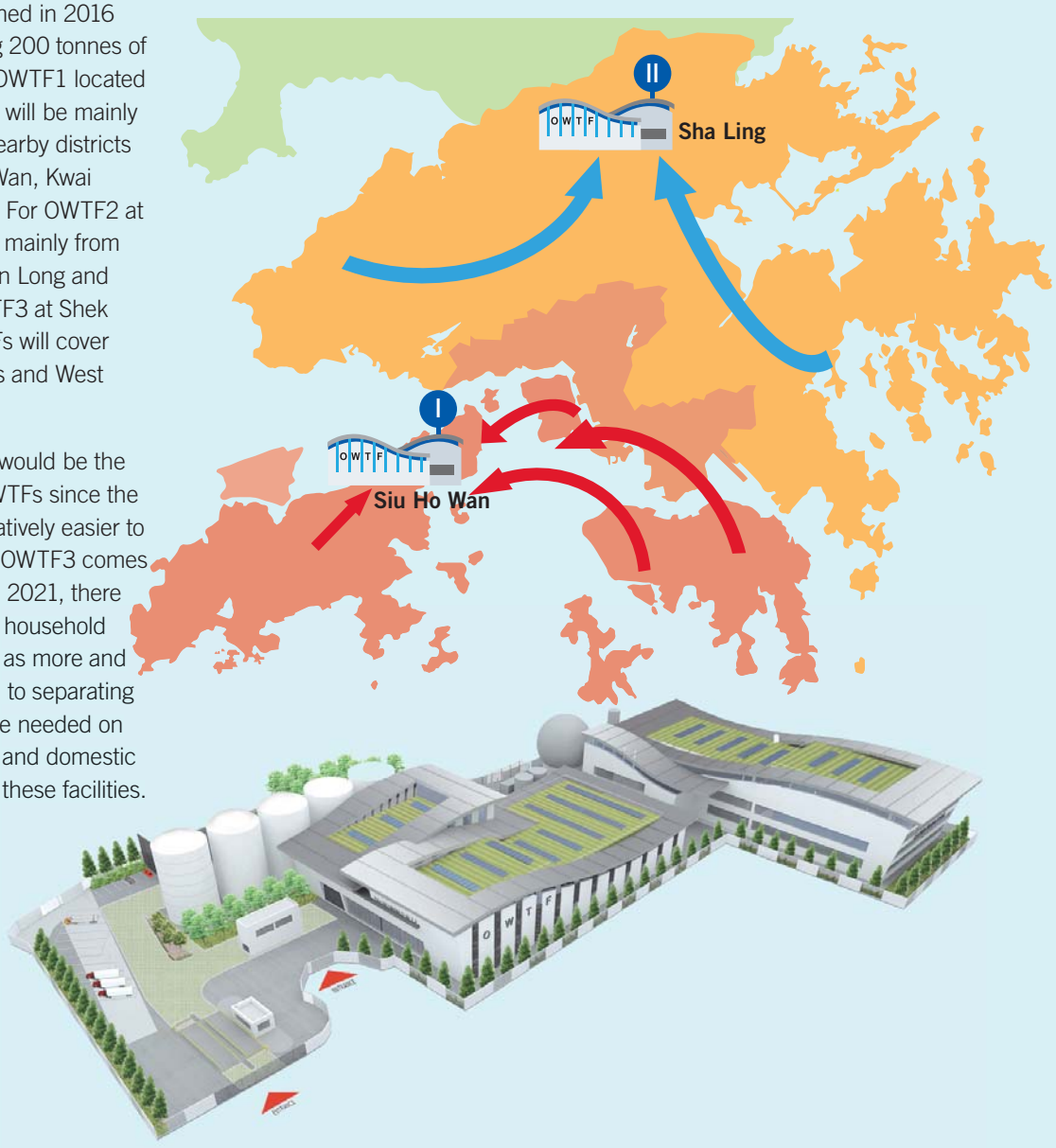
12. The contractor is engaged through open tender to conduct detailed design, carry out the construction works and operate the facility upon completion for 15 years.

One possible measure is to continue to encourage, facilitate and subsidise households to do small scale on-site or off-site composting (or other off-site treatment) so that residents continue food waste separation practices. As for on-site composting, since most estates have limited space, such an arrangement will have limited potentials however. Off-site composting may have better potentials, such as for the collected food waste to be taken to sites like the Kowloon Bay pilot plant as a stop-gap arrangement. While it is not easy to find suitable sites for this purpose, we are open to ideas from the community. What we need is for the network of OWTFs to be built as quickly as possible. It is often not appreciated that weight for weight, on-site composting is much more expensive than OWTFs.

C&I sector before households?

OWTF1 will be commissioned in 2016 with a capability of treating 200 tonnes of food waste a day. For the OWTF1 located in North Lantau, the users will be mainly from Lantau Island, and nearby districts including Tsing Yi, Tsuen Wan, Kwai Chung and West Kowloon. For OWTF2 at Sha Ling, the users will be mainly from Sheung Shui, Fanling, Yuen Long and Shatin. Together with OWTF3 at Shek Kong, the first three OWTFs will cover most of the New Territories and West Kowloon.

We expect the C&I sector would be the first to use the first two OWTFs since the food waste from C&I is relatively easier to be separated. By the time OWTF3 comes on stream possibly around 2021, there will be greater demand for household food waste to be recycled, as more and more households get used to separating waste. Adjustments may be needed on how best to distribute C&I and domestic food waste for recycling at these facilities.



Participation by Private Sector and Universities

Hong Kong needs to build urgently a network of OWTFs with due speed in order to meet our disposal at landfill reduction target by 2022. Moreover, we also wish to ensure that the public would not become discouraged if in future their separated food waste could not be recycled due to a lack of OWTF capacity.

In order to build up Hong Kong's ability to separate and recycle food waste, we welcome private sector participation. OWTF1 and 2 will be taken forward using the established DBO arrangement. We are open to adopting different types of private sector participation mode for future OWTFs with a view to building them as soon as practicable while maintaining high technological and operational standards. For future OWTFs, we are open to proposals from the private sector either on sites identified by the Government or on sites proposed by the private sector.

On-site composting – several challenges

Doing on-site recycling of food waste into compost is not the most suitable solution in Hong Kong because of our dense urban environment and operational challenges.

Space constraint

Not every housing estate has the space to put one or more composter on-site (see below on scale). In terms of treatment capacity, on-site composting is not the best solution for Hong Kong.

Expertise and quality

Proper operational expertise is required to keep the composter working optimally, and professional managers may be necessary. The lack of expertise will affect the quality of the compost output, which will in turn affect whether users will be willing to use the compost.

Potential nuisance

Potential hygiene and odour issues may create nuisance and complaints, especially if the food waste handling process is not up to scratch. The composting operation should better be carried out away from residents.

Cost efficiency

The operating cost per tonne of treating food waste by on-site composters is far from cheap. Indeed, it could be ten times more than operating an OWTF due to scale and the constant need to sustain good management. It can cost from around HK$10,000 to even HK$20,000 to treat one tonne of food waste taking a small 100 kg composter as example. The cost comparisons on page 21 are derived from local measures experimenting with composters.

Damage of paddles and composting chamber

Leachate from odour removal device

Compost not suitable for planting

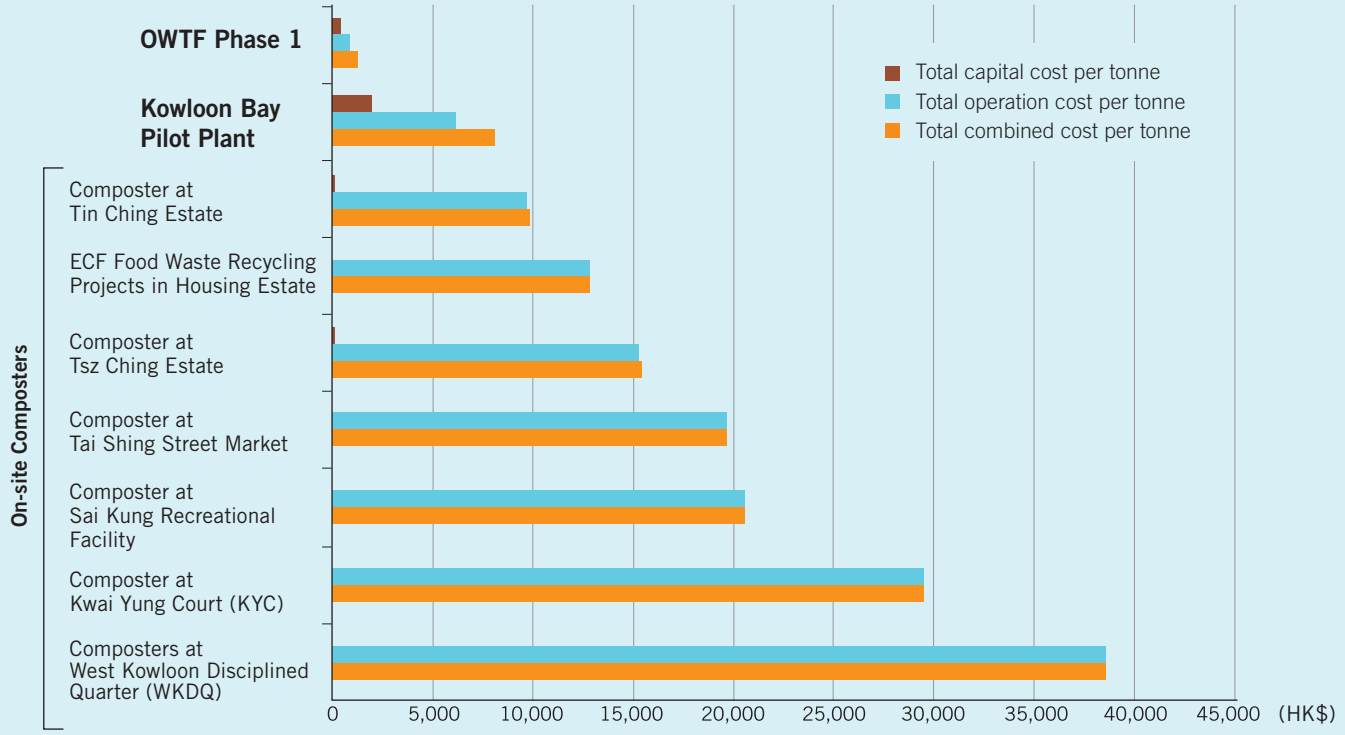
Issue of scale

Buildings and estates

A typical Hong Kong household produces just over 1 kg of food waste per day. Thus, a typical residential block of 50 floors with 8 households per floor produces about 400 kg of food waste per day. Let's say 50% of the households separate their waste, including food waste, which means there is 200 kg of food waste to recycle each day. Approximately 15 sq m will be needed for one composter with a capacity of 100 kg that also allows room for operation. Many standalone buildings will not have sufficient space to do on-site composting. Even large estates may not be able to find sufficient or suitable space. That said, for new building, efforts are being made to encourage a more facilitating design for food waste recycling (e.g. through BEAM Plus).

Outlying Islands and remote communities

Take Cheung Chau as an example. Its residence produces about 6 tonnes of food waste per day. There are currently two composting facilities there capable of handling 200 kg and 100 kg each day per day. Assuming a 50% recycling rate, there is a need to find suitable space for 15 to 30 composters on the island, which is difficult. As Cheung Chau is now served by an outlying island RTS, food waste generated in Cheung Chau can be transported to one of the future OWTFs nearby for recycling and treatment. Thus, for outlying islands with RTS or remote areas with road access, food waste could still be transferred to one of the OWTFs for recycling and treatment.



Biodiesel

an encouraging example of private sector-led food waste recycling

Biodiesel made from UCO is known as a second-generation biofuel. In the past several years, Hong Kong has seen the establishment of three factories to convert UCO or GTW to biodiesel. This represents private-sector led capital investment totalling about HK$1.5 billion. Their combined production capacity is about 150,000 tons per annum of biodiesel. This end product can be exported and also used in Hong Kong. Biodiesel can be blended with diesel to reduce pollutant emissions from vehicles, ships and machinery.

Local Technology

innovation in biological treatment of food wastes

We are paying close attention to local research and experimentation with food waste treatment technologies, some of which are supported by ECF funding. For example, university researchers are looking at how to increase the energy potential of food waste using anaerobic digestion, as well as developing composting techniques to reduce odour and nitrogen loss that can also improve the quality of the end product. Experiments are also on-going on how to reduce composting time. We will keep in view the progress of local research and consider incorporating successful experience into our food waste management projects.

6 The "Leftovers" for Disposal

Despite everyone's efforts, there will still be a considerable amount of food waste that are not separated and mixed with other waste that will be treated with other MSW. Using overseas experience as a guide, even with sustained efforts, there will likely still be over 50% of our food waste that will be mixed in with the city's MSW.[13] By 2022, about 3,000 tonnes of our MSW will be treated at a new Integrated Waste Management Facility (IWMF) each day, assuming it can be built in time. The rest will still have to be landfilled.

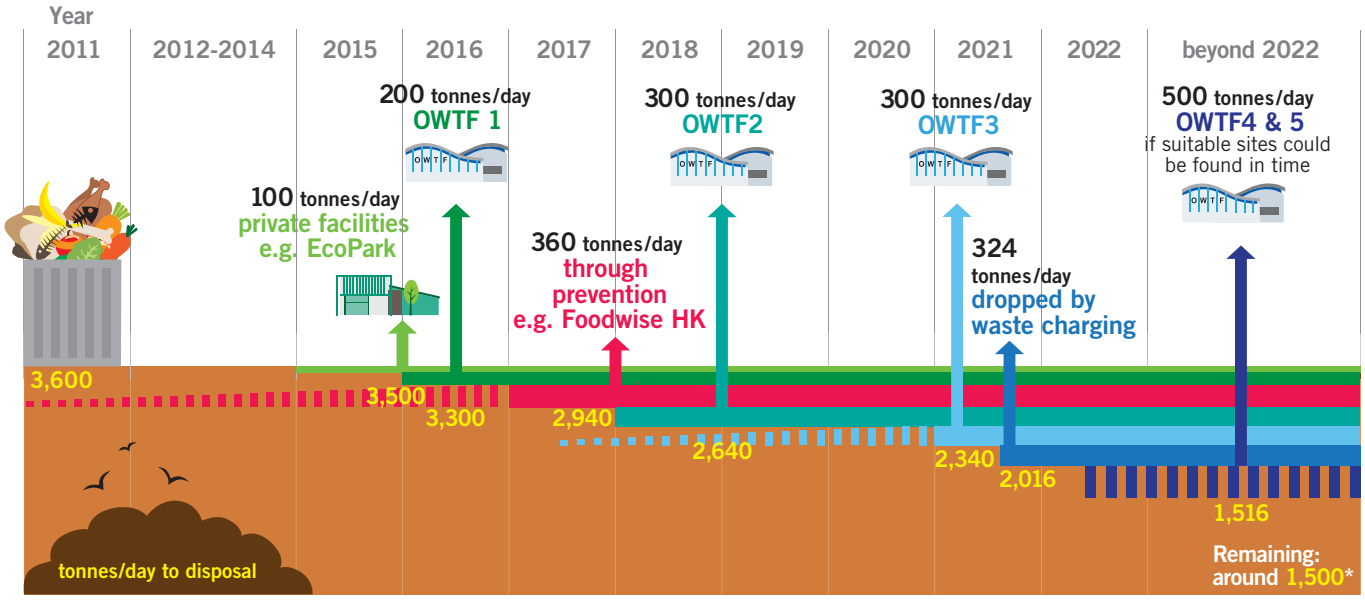
Assuming a relatively constant local population and keeping the same food waste disposal rate, even if we can achieve roughly 5% to 10% reduction through food waste prevention, and another 10% to 15% reduction from waste charging, plus having a network of several OWTFs with the capacity to recycle about 1,300 tonnes of food waste, Hong Kong will still have about 1,500 tonnes of food waste mixed in with the city MSW to deal with.[14] This remaining portion represents un-separated, contaminated food waste.

The assumptions in Figure 6 are ambitious and optimistic but highly dependent on the successful mobilization of the community to separate waste, implementation of quantity-based MSW charging by 2016/17, development of an effective collection and delivery system for source-separated food waste, and the continuous adding of OWTFs. Any change will increase the quantity of "leftover".

Achieving Our Food Waste Reduction Target

The above presents a reasonable plan to achieve the target of at least 40% reduction of food waste to landfills by 2022 using 2011 as the base. However, community support of the programme of action is as important as our commitment to the target. The success of achieving the target hinges upon the measures highlighted in Chapters 3, 4 and 5 so that citizens, organisations and the Government can each play their part to reduce, separate and recycle food waste.

Figure 6 Projected Reduction in Food Waste Volume



* About 2,000 tonnes of food waste still to be dealt with if OWTF4 and 5 cannot be built in time.

13. In Taipei, even with pay per bag system implemented since early 2000, food waste recycling programme and having pig feed as an outlet for food waste, the food waste recovery rate achieved is about 44%, less than 50%. Other cities in Taiwan have achieved much less than that, with some cities only achieved less than 20% food waste recovery rate.
14. As can be seen in other countries, any further reduction of the "leftover" food waste would require much stronger policy measures such as a sufficiently high level of waste charge to incentivize further behaviour changes or a total ban of food waste at landfills. Implementation of such measures in Hong Kong would need much longer time for the community to discuss and achieve consensus and would also depend on the initial operational experience of the waste charging scheme.

7 Dealing with Yard Waste

Our Yard Waste Strategy

Yard waste is also known as green waste or garden waste, which consists of all types of vegetation waste matters. This type of waste decomposes gradually in nature. Woody material is also combustible.

Hong Kong has not focused on yard waste up until recently. While we are designing an overall waste-to-resources programme for all types of waste, in the area of yard waste, we still have information gaps although we are already working on filling them.

Our strategy to deal with yard waste is to collect data, promote reduction at source, encourage separation and collection, and find the best ways to treat the unavoidable portion.

We are taking a coordinated approach within the Government to collect data and promote best practices through an inter-departmental working committee led by Environment Bureau. We will introduce best practices to the public sector and major generators of yard waste in the C&I sector in due course. We will provide periodic updates on progress.

Types of yard waste

Amount Going to Landfills

About 127 tonnes[15] of yard waste is disposed of at our landfills each day, which make up about 1.5% of Hong Kong's total MSW going to landfills.

The major generators of yard waste are various government departments and commercial establishments with extensive plantings and landscaping. These government departments include Leisure and Cultural Services Department, which manages public parks and gardens as well as maintains roadside trees and landscaped areas along non-expressway public roads outside country parks; Housing Department (HD), which manages public areas in housing estates; Highways Department (HyD), which is involved in road construction, improvement and maintenance works, as well as the associated vegetation maintenance within the boundary of expressways and roadside slopes under its purview; and Architectural Services Department (ArchSD), which is involved in building projects and vegetation maintenance on slopes under its purview.

The Agriculture, Fisheries and Conservation Department's (AFCD) total annual yard waste tonnage is 1,400 tonnes of which only 80 tonnes (i.e. 5%) have to end up in landfills since much of the yard waste can be dealt with within the country parks it manages.

Yard waste reduction

We are calling upon government departments to contribute to yard waste reduction at source through two key measures:

- Minimizing using plants that are just displayed during festivals (e.g. Christmas and Chinese New Year). Replanting plants are also encouraged. For example, the Food and Environmental Hygiene Department (FEHD) has been doing so with unsold flowers and plants from the Lunar New Year Fair; and

- When designing landscaping areas to consider how to minimize yard waste generation, such as through reducing the use of annuals. We will publish Practice Notes on Yard Waste Reduction to help improve how Hong Kong deals with this type of waste.

Yard waste separation and collection

Separation of yard waste is straight forward. We need to develop the habit of doing it, and collection needs to be organized systematically so that the waste can be properly treated. The practice of separate collection of yard waste should of course be promoted in tandem with the development of facilities capable of treating yard waste properly (see below).

Collection and Replanting of Potted New Year Citrus Plants To Reduce Domestic Waste

To boost environmental awareness of reducing and recycling domestic waste at source among the public rental housing (PRH) tenants, the Hong Kong Housing Authority (HA) launched a pilot scheme to collect and replant disposed citrus plants after Chinese New Year. The pilot scheme was well received by over 30 participating estates and more than 1,000 pots of citrus plants were collected. To keep up the momentum in reducing waste, the scheme would be extended to all some 160 PRH estates.

15. The figure is based on the relevant data in the "Monitoring of Solid Waste in Hong Kong – Waste Statistics for 2011" plus further estimated amounts from various government departments.

Households: As most households do not have gardens in Hong Kong, the amount of yard waste generated by individual households is very small. A typical household may occasionally dispose of cut flowers and leaves from indoor potted plants. As we will have major programmes to urge householders to separate food waste, their yard waste can be separated with the food waste for collection. The larger quantities of yard waste may arise from landscaping and gardens of private housing estates.

C&I: Since there are relatively few privately managed commercial establishments with extensive gardens, plantings and landscaping (such as Ocean Park, Hong Kong Jockey Club and Disneyland), source separation and collection for them should not present a major problem. For general commercial buildings, they can also better source separate their yard waste and organize for its collection. As the job in commercial buildings is normally carried out by cleansing or gardening contractors, commercial property management may introduce relevant requirements in their contracts with them. It just needs to be organized and the Government will help raise public awareness.

Public sector: Government departments will lead the way in developing best practices in yard waste separation and collection. The best practices can then be shared with the community.

Yard waste treatment

There are various treatment methods for treating yard waste, some of which are more suitable for Hong Kong than others:

Natural degradation: Space permitting, yard waste can be left in situ or taken to a place where it can be left to degrade over time. While a natural decomposition process is appropriate for yard waste arising from country parks to degrade within country parks, it is much more difficult to do this elsewhere as the decomposition process takes considerable time.[16] However, government departments are looking at where there may be space for natural degradation but we expect only limited capacities to be available. Where there is space, we support natural degradation in situ.

Peach Blossom Tree Recycling Campaign

In 2014, the Environmental Protection Department (EPD) and the Hong Kong Environmental Protection Association have jointly organised the Peach Blossom Tree Recycling Campaign. The EPD and Food and Environmental Hygiene Department set up a network of 50 collection points in all the districts of the territory to expand the Campaign to cover individuals and households. All the peach blossom trees collected were delivered to the waste wood recycler in the EcoPark, Tuen Mun for recycling into wood fuel pellets (a useful type of renewable energy) and composting materials with a view to raising the public's awareness in waste reduction and relieving the pressure on landfill disposal.

16. AFCD is unlikely to be able to accommodate more yard waste apart from its own in country parks. There are also concerns on the likely impact on biodiversity and invasion of unwanted species and disease if yard waste came from other sources.
17. Care should be exercised for excluding diseased plants for reusing as mulch or compost. In particular for plants affected by Brown Root Rot disease, they should be properly treated according to the guidelines promulgated by the Tree Management Office of the Development Bureau, which are available from the Trees website (www.trees.gov.hk).

Composting: Space permitting, composting is also a viable means to treat yard waste. It is environmentally friendly and cost effective if composters can be located near larger sources of yard waste, such as some of the bigger sites managed by LCSD, large housing estates, and the large commercial establishments. Where the waste has to be collected and transported, the Government currently has two sites with limited composting capacities – EPD's Kowloon Bay Pilot Composting Plant noted in Chapter 4 and EPD's Animal Waste Composting Plant at Ngau Tam Mei (with a maximum design capacity of 40 tonnes/day). There may be a possibility to increase capacities, which we will examine. The capacities of these plants may be combined with that for the OWTFs (see below). Yet, it should be noted that this method takes time and it becomes inefficient for large volumes of yard waste especially where land space is a major constraint.

Anaerobic digestion: The OWTFs noted in Chapter 5 can also have some capacity dedicated to deal with yard waste. We will assess whether and how this may be done as part of our overall plan for building the OWTF network. Together with the two composting plants noted above, it should be possible for about 35 tonnes of yard waste to be treated per day.

Reuse and Recycling: Wood waste and plants displayed during festive seasons (e.g. Christmas trees and peach blossom trees) may be sorted and recycled as a fuel material, such as being turned into wood pellets or wood fuel. Wood waste may also be reused as mulch after proper treatment.[17] A tenant at the EcoPark is able to operate such a process with a capacity of 2 tonnes per day currently, which may be increased to about 10 tonnes in the future.

8 Conclusion

Together, the Government, the people and businesses of Hong Kong has the opportunity to significantly reduce the amount of food we waste each day. Our success will mitigate the environmental and economic impacts of the MSW management system. To be successful, however, we all need to change our daily behaviour by reducing food waste at source. Through committed and sustained individual and corporate actions, and through complementary government policies and programmes to incentivize food waste reduction, and in time separation and collection, as well as to provide the necessary infrastructure for recycling and treatment, we believe Hong Kong can achieve the target of reducing food waste to landfill by 40% by 2022.

We cannot emphasize enough the very tight timetable we have set for dealing with a large variety of actions that needs to be successfully accomplished in order to achieve our target. Any changes will set us all back in our timeline. The journey will not be easy because success depends on public acceptance and large-scale community mobilization to participate in waste separation. Studies and trials are necessary to examine what will work in Hong Kong. There will no doubt be many views and suggestions about how to do it well and debates over the institutionalisation of methods and systems for different types of circumstances, such as low-rise and high-rise households, urban and rural areas, as well as factors relevant to the C&I sector. Beyond everyone's effort to reduce waste, we need the community to work through many challenges with us in the spirit of collaboration if Hong Kong is to be successful in transforming how we deal with food waste.

Furthermore, a critical step is the implementation of MSW charging in 2016/17, as well as the speedy construction of the OWTF network. We recognize we still need to present the public with Hong Kong's MSW charging plan and that the political process to bring it to fruition must be gone through, where there could well be a diversity of views. At this stage, we are heartened by the public's acceptance of the concept of waste charging. As for creating the OWTF network, we have tendered OWTF1 and will make a decision on selecting the operator soon. In order to stay with our timetable, we need to move ahead expeditiously with OWTF2. To proceed with the other ones, we re-emphasize our desire to work with the private sector to explore how we may be able to speed-up the construction of more plants, and also to find available sites for them.

"Through committed and sustained individual and corporate actions, and through complementary government policies and programmes to incentivize food waste reduction, separation and collection, as well as to provide the necessary infrastructure for recycling and treatment, we believe Hong Kong can achieve the target of reducing food waste to landfill by 40% by 2022."

This document represents the start of a new journey for Hong Kong. At Environment Bureau, we wish to see Hong Kong people taking pride in "Everyone being a Recycler" and in adopting a "Food Matters" culture that will spread through our society and become one of our core values. Hong Kong is famous for our good food. Yes, we can eat well but we must not waste. Let us all adopt these practices as a part of how we wish to live. Hong Kong's catering sector can be well-known for not only providing good food but also how they minimize and recycle food waste. With infrastructure established and the culture of Food Wise taking root in the community, the coming 10 years will lay a solid foundation for us to plan ahead for the future.

Annex

Evaluation of Food Waste Treatment Methods

Option	Strengths	Weaknesses	Remarks
Anaerobic Digestion	• Highly suitable for wet biodegradable organic waste • Possible energy recovery in the form of biogas • Useful end product in the form of compost	• Longer start-up time to develop high biomass inventory • Relatively slow process rate • Only limited to biodegradable waste	• A promising biological treatment technologies with wide applications worldwide • Great demand in HK for the biogas or energy as product of the treatment
Aerobic Composting	• Suitable for various types of biodegradable organic waste • Useful end product in the form of compost	• Longer start-up time to develop high biomass inventory • Relatively slow process rate • Limited to biodegradable waste • Relatively large area requirement • Difficult in odour control	• Biological treatment technologies with wide applications worldwide • Likely limited demand in HK for the compost product
Conversion to solid biofuel	• Energy and resource recovery • Can be employed as a supplementary fuel in conventional boilers	• High operation cost • Not cost effective for source separated biodegradable organic waste • No markets identified for Refuse Derived Fuel	• Treatment by mechanical sorting and drying • Excessive drying required as organic waste has a high moisture content • Demand for the solid biofuel in HK is uncertain
Conversion to liquid biofuel	• Sustainable use of resources • Replacement for fossil transport fuels or used to generate heat and power on site	• High operation cost • Not cost effective for mixed food waste • Advanced / complex technologies required, some of which are still experimental	• Thermochemical/ Biochemical/Mechanical process • Production of liquid biofuel is largely concentrated on the agricultural industry, with ongoing research using waste biomass as feedstock • While there are existing facilities producing biofuel from pre-segregated oil in Hong Kong, the technology for mixed food waste is potentially complicated and unproven
Conversion to Fish Feed	• Useful end product in the form of fish feed	• Nutritional needs vary between fish species • Inconsistent feedstock and difficulty in managing quality control • Limited market in HK	• Involve sorting and sterilization treatments • Offensive Trade License might be required • Not a prevalent practice in other countries

Option	Strengths	Weaknesses	Remarks
Conversion to Animal Feed	• Useful end product in the form of animal feed	• Potential spreading of infectious animal diseases • Inconsistent feedstock and difficulty in managing quality control • May contain excessive amounts of trace minerals or substances which may be harmful to animal health e.g. excessive amounts of preservatives and salt • Only limited to food waste with known sources and compositions • Limited and declining market in HK	• Involve sorting and sterilization treatment • All feed provided to the animals must fulfill the Public Health (Animals ad Birds)(Chemical Residues) Regulation, Cap.139(N) • In Europe, the Animal By-product Regulations (ABR, EC 1774/2002) identified catering waste as potential risk materials that is not suitable for processing animal feed. Some other countries such as Canada and Australia also ban recycling food waste to feed farmed animal
Miscellaneous methods	• Some volume reduction; • Some useful end products if treatment is completed	• Usually for small scale operation • Usually require second stage treatment or involve high operational cost	Including the following : • **Bokashi:** fermented food waste required to be buried within soil for second stage fermentation • **Dehydration:** dehydrated food waste still need to go through decomposition before usage as compost. High energy demand for dehydration • **Biological (e.g. earthworm, black soldier fly, etc.):** under trial or relatively small scale operation. Potential ecological concerns if foreign species are introduced • **Grinding up food waste and disposing of it via the sewerage system:** it would have adverse impact on the sewers and sewage treatment works. Large scale practical experience especially for multi-storey buildings is lacking and inconclusive internationally. Some cities have banned such practice

Abbreviations

AFCD	Agriculture, Fisheries and Conservation Department
ArchSD	Architectural Services Department
BDO	Build Design and Operate
C&I	commercial and industrial
ECF	Environmental and Conservation Fund
EIA	environmental impact assessment
EPD	Environmental Protection Department
FEHD	Food and Environmental Hygiene Department
GHG	greenhouse gases
GTW	grease trap waste
HyD	Highways Department
HD	Housing Department
IWMF	Integrated Waste Management Facility
LCSD	Leisure and Cultural Services Department
MSW	municipal solid waste
NGOs	non-government organizations
OWTFs	Organic Waste Treatment Facilities
UCO	used cooking oil
SDC	Council for Sustainable Development