CB(1)1109/13-14(33)

From: Caroline Casse <
To: "yspang@legco.gov.hk" <yspang@legco.gov.hk>
Date: 08/03/2014 21:16
Subject: Objection of the Incinerator for S. Lantau

Dear Distinguished Members,

I am writing to register the strongest possible objection to the IWMF (Integrated Waste Management Facility) proposed by the Environmental Protection Department for the following reasons:

The Assistant Director of the Environmental Protection Department is not listening to his peers (The Citizens and Legislative Council Members of Hong Kong) and is insistent on pressing ahead with his flawed plan. I hope he is professional enough to take heed of the following.

There are two key issues:

1) The exhausting of landfill sites in Hong Kong and the need for extension.

2) The need to reduce waste sent to landfill.

The IWMF Plan proposed does not in entirety solve any of the above key issues and would necessitate the need for Extension of Landfill. The use of a Mass Burn Incinerator (MBI) would only encourage an appathy for the need to reduce waste. The MBI will also send 1/3rd of what is burnt to landfill, It will also be costly to run due to the treatment and need to dispose of the fly ash. This MBI will be a financial burden on Hong Kong not only in initial costs but also running costs because no product is produced apart from small amounts of electricity.

All the data provided by the EPD has recently been proven to be false. The Recycling rates are false! Even the proclaimed prevailing wind direction is false (meaning there will be an impact on Hong Kong's air quality)! The statistics about the Incinerator are produced by engineers and sponsored by questionable links with a bank that supports the building of incinerators (I refer to the letter by Dr Martin Williams on the 27th February 2014 published in the SCMP). I therefore believe on closer inspection, what's claimed will also be false. Any Hong Kong Citizen can see through the data and therefore any Hong Kong Citizen can see this IWMF will be a mistake and I could argue a fatal one at that!

What do I propose:

I believe like everyone else, that a multi pronged attack on waste needs to be implemented. The biggest issue is organic (food) waste, some 50% of the daily waste Hong Kong generates. This waste is the first of a series of Reduce Reuse and Recycle initiatives that have been proposed by various parties. This would reduce Hong Kong's waste and would extend the life of the landfill sites. If this initiative alone was instigated in 2011, the council would not be voting on the need to extend landfill sites.

Recycling needs to be effectively implemented and increased. This would be done by bringing in a waste charging initiative already supported by the EPD. However it has only been a trial. The effect of the charging scheme would be similar to the levy on plastic bags. It would immediately gain support and the change in the output of waste and the amount of recycling would be significant. Also further negating the need for a vote on extension of landfill.

Finally "Gasification" needs to be considered as a way to reduce waste and tackle the landfill issue. The problem is the EPD's plan chooses an incinerator (the wrong incinerator). It also chooses the wrong location. The EPD has tried to show that their proposed incinerator is the best choice with proven results. But too much research and submissions from other parties proves that it is not the best. The other better alternative has been proven in multiple countries all over the world. The alternative is Plasma arc or Gasification. These are not incinerators as the process is different. Please refer to the attached submission fromThe New Territories Concern Group (NTCG). This is far supperior and will tackle the two key issues I raised above. It will reduce and even reclaim existing landfill sites with the ability to back mine MSW. It will provide no residue that needs to go to Landfill instead it will provide a harmless construction aggregate that currently Hong Kong imports. The benefits of Plasma arc and the proposal I suggest is included. Additionally there will be a benefit of no emissions compared with the (MBI) proposed by the EPD.

In addition to the above, I have a submission from "Solena" (Attached). This company is so remarkable that they are willing to build a gasification plant that can also take 3000TPD of MSW (As per (attached) their proposal to the EPD back in 2011). There will be no residue or pollutants that need to go to landfill. The proposal if started by 2016 can be up and running before the original time frame that the EPD's proposal puts forth but at considerably less cost! But the most amazing thing is Solena can make Bio Fuel from MSW. Solena can make 30 million Gallons/year of Bio Fuel and sell that on to either Aviation or Marine companies. This will ensure that this plant can reduce tipping fees by upto 50% and can be self sufficient and profitable by selling its product of Bio Fuel to Hong Kong's largest Airline which is very interested in this alternative to pricey fossil fuels. As detailed in the report, Solena has proven results and already has clients including British Airways and Qantas. With Hong Kong being a hub for transport, to make money out of waste by turning it into Bio Fuel is purely good business and good for Hong Kong. The European Enviromental Bureau has published a recent report (attached), detailing the importance of using waste as a resource to create bio fuel and increase revenue and jobs for the region. This is the future for Europe, so why can't it be the future for Hong Kong. The benefit is Win Win for all! No waste goes to land fill and no emissions all while building a sustainable industry.

If the Gasification plant is installed in the most efficient location (as suggested by Solena) and used in combination with the other initiatives suggested. Hong Kong's waste will no longer be a liability. Instead it will be an asset that can produce energy, reclaim the landfill sites returning them to other land use available for the Government of Hong Kong and it's citizens. The Gasification plant would be cost free to tax payers of Hong Kong due to the ability to sell its product of Bio Fuel all from our waste! The cost and likely time to input all these initiatives would be cheaper and faster than the IWMF plan the EPD are suggesting. This would further mean that no extension to Landfill is necessary and Hong Kong's waste will be reduced. Clearly common sense and smart business says this proposal is far better for all concerned.

I therefore believe this application should be recommeded for REFUSAL, Reject the IWMF proposed by the EPD. Demand a re-submission that includes Gasification and immediately implements

waste reducing,
charging/ recycling and food waste separation and treatment initiatives. These initiatives will ensure reduced waste to landfill and negate the need for extension and will deal with Hong Kong's waste problem and contribute to clean air initiatives without hindering them.

Sincerely,

Caroline Casse EIA - Comments from Solena Fuels (Dec 15 2011).pdf

European Environmental Bureau Report-2.pdf NTCG Gasification comparison to Incineration.pdf

About Solena Fuels, LLC.

Solena Fuels, LLC. ("Solena") is building a sustainable jet and marine fuels platform to directly provide industrial end users - such as airlines and shipping companies – price competitive alternatives to fossil fuel sourced energy. We use our proprietary technology to convert any type of biomass, including municipal solid waste, into a renewable synthetic gas ("BioSynGas") which is subsequently upgraded into a synthetic, certified drop-in liquid fuel that replaces fossil fuel-based energy. Solena's biomass-to-liquids ("BTL") facilities are all standardized to allow for scaled economics, low costs and feedstock flexibility.

Introduction

Having reviewed the "Integrated Waste Management Facilities Environmental Impact Assessment Report" documentation, which is currently undergoing the Public Consultation Phase, and associated documents as listed below, Solena is pleased to submit the present document with its comments for the consideration of the Director of Environmental Protection of the EIA Ordinance and other officials.

List of Documentation Reviewed:

- Engineering Investigation and Environmental Studies for Integrated Waste Management Facilities Phase 1 – Feasibility Study. Environmental Impact Assessment Report
- Legislative Council Brief - Development of the Integrated Waste Management Facilities
- ACE-EIA Paper 6/2011 and associated Annexes
- Confirmed Minutes of the 166th Meeting of the Advisory Council on the Environment held on 14 December 2009 at 2:30 pm
- Paper WMSC 01/10. Integrated Waste Management Facilities Sorting and Recycling Plant

The listed documents show that the major problems challenging the City of Hong Kong are the limited amount of land that can be used to safely landfill MSW and the projected large increases in MSW production. At present, these wastes are currently being generated at a rate of 19,000 tonnes per day.

Solena believes that the mass burn incineration technology preliminarily chosen to solve the waste and landfill space problems (i) is not efficient in recovering energy and therefore increases the costs of waste disposal, (ii) is an open loop system which causes the production of toxic air emissions which must be scrubbed at high costs and which cannot be completely eliminated, and (iii) it produces large amount toxic bottom and fly ash, which requires special costly landfilling after they have been rendered inert by a costly post-incineration inertization process. Therefore, Solena is of the opinion that the proposed IWMF is employing an obsolete combustion technology, which is very damaging to the environment, may worsen climate change and does not entirely solve the problems posed by the lack of landfilling space and increased production of MSW.

Solena Fuels Proposal

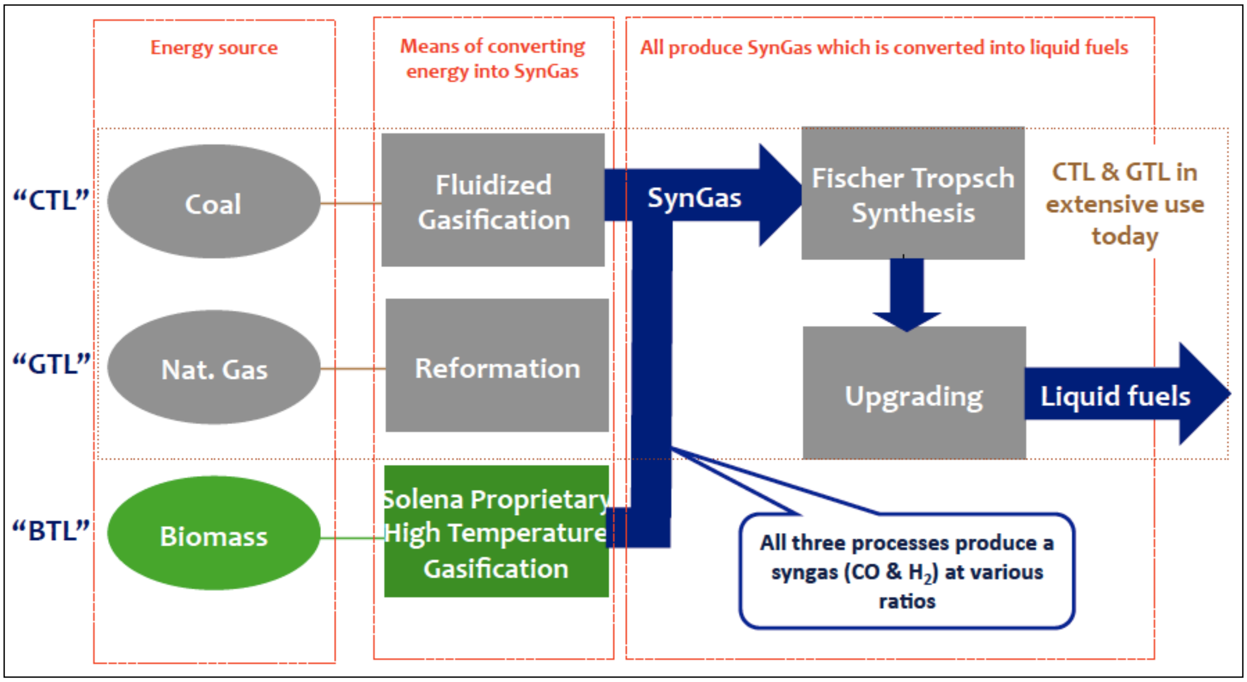
To solve the problems of increasing volumes of waste and lack of enough landfill space in Hong Kong, Solena proposes an innovative and well-vetted solution such as its waste Biomass-To-Liquids ("BTL") facility, which is based on the Fischer-Tropsch synthetic fuels industrial platform enhanced with Solena's patented high temperature gasification technology and process.

Solena's Biomass-To-Liquids solution can process 3,000 tonnes per day of raw Municipal Solid Waste ("MSW") and produces over 30 million gallons of biofuels per year and 22 MW net of renewable baseload electricity (plus 55 MW of its own parasitic load that is auto-consumed) while producing no toxic SVOC emissions or solid waste effluents that need to be landfilled. As such, the Solena BTL facility is highly efficient in energy recovery by converting both the chemical hydrocarbon energy as well as the sensitive heat energy in the MSW into a high demand sustainable transport liquid fuels and clean electricity, respectively.

By producing the carbon neutral sustainable aviation fuels ("Bio Synthetic Paraffinic Kerosene") and partnering with Hong Kong largest local airline as long term fuel purchaser, Solena will be able to privately finance the facilities while offering substantial reductions in waste disposal costs to the City of Hong Kong. Specifically, since Solena's BTL plants are privately funded and obtain revenues from the sale of its advanced biofuels and renewable power, the cost of operation and capital costs are offset, which can translate into significant savings to the city-state of Hong Kong both in capital investment and in waste disposal fees, as the BTL facility can offer savings of up to 50% in tipping fees.

Solena's solution is based on the historically and successfully proven Fischer-Tropsch synthetic fuels platform, currently in use today to produce advanced biofuels from coal or natural gas, enhanced with Solena's proprietary high temperature plasma gasification technology to enable the conversion of waste biomass into sustainable biofuels. Figure [1] below illustrates the different routes currently being used to produce synthetic fuels from different sources.

Figure [1]
Certified Synthetic Fuel Production Platform



Solena's facility would require approximately 8 Hectares of land and will not produce any toxic ash or solid waste effluents. The BTL plant's power production system will produce an exhaust composed mainly of nitrogen, oxygen and moisture. In addition, the exhaust is virtually free of SO_X and particulate matter, has low NO_X levels, no mercury or volatile metals. The facility will produce small quantities of vitrified slag, which can be used in making concrete, road fill, bricks and other manufacturing uses. The US EPA considers it an inert and safe material. In addition, the plant can be designed to fit into the existing space on one of the proposed sites or alternatively at one of the existing landfills without high buildings and it will be free of odor.

Equally important, Solena's BTL facility is a zero-landfill solution, i.e., the facility does not produce any solid waste. Thus there will not be a requirement to take any material to a landfill. All waste destined to the landfill, which would normally decompose into a more potent GHG such as methane, would be avoided when disposed in the BTL facility. Additionally, since the majority of the CO and H_2 (synthesis gas) are converted into FT fuels (BioJetFuel, Renewable Diesel or BioNaphtha), the plant drastically reduces the emissions of green house gases by at least 50% less than the incinerator currently being proposed. Moreover, the CO_2 in the gas turbine exhaust is considered to be carbon neutral. In summary, Solena offers a system and process that (i) is pollution free both from toxic air emissions and GHGs, (ii) does not require any landfills, and (iii) will produce large amounts of high value advanced biofuels and renewable baseload power.

Current Developments

Solena's utilizes a team of highly reputable world-leading companies such as General Electric, Honeywell, UOP, and Fluor to bring its bioenergy platform to market worldwide. The first of such BTL plants is scheduled to begin construction in London, England by Q1 of 2013. The London project, in partnership with British Airways as project partner and fuel off-taker, will be built in East London and will start production of BioJetFuel in 2015. Two of London's largest waste management companies will be providing the MSW/RDF feedstocks.

In addition, Solena was selected by the City of Rome Waste company AMA to build a similar sized BTL facility for BioJetFuel production for Alitalia, the plant will be built within a refinery located in front of the Malagrotta Rome landfill; a Solena BTL facility in Sydney for Qantas Airlines with one of Australia's largest waste providers; one BTL facility at the Arlanda Airport in Stockholm, Sweden for SAS Airline; and in San Francisco, CA, US with a consortium of North American airlines led by American Airlines, United Continental Airlines, FedEx, JetBlue, Lufthansa, Air Canada, with waste supply by the Recology group. All of these projects will be of the same standard size and capacity as that of London and will be built and operating by 2015, 2016, and 2017.

In Hong Kong, Solena is in discussions with the largest local airline company to develop its BTL facility with the same throughput and fuel production capacity as described above. In order to meet the 2018 timeframe indicated in the IWMF EIA Report, Solena would need to begin construction no later than 2016. This provides ample time for Solena to develop the necessary partnerships with local entities, finalize the engineering works and obtain the necessary environmental and construction permits. This will allow Solena to offer a solution to Hong Kong's challenging problems in the same time frame, if not earlier, than the proposed IWMF. It should be noted as well that by 2016 Solena will have 4 to 5 Industrial BTL plants in operation (London, Rome, Sydney) or under construction (Stockholm and San Francisco), thus providing industrial construction and commercial operational track record and mitigating risks to the project partners in Hong Kong.

Benefits of Solena's Waste-Biomass-to-Advanced-Biofuels Plant

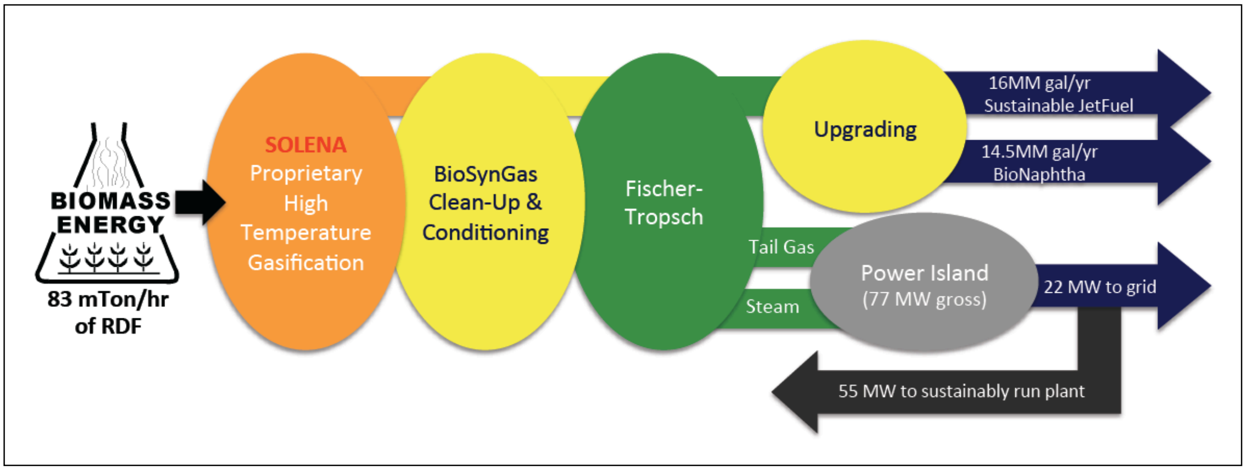
Solena's proposed waste-biomass-to-advanced-biofuels facility represents the following benefits to the local community, the environment, as well as to the city-state of Hong Kong:

- Zero-landfill solution for waste disposal challenges – no need for post-processing and disposal of toxic fly and bottom ash.
- Use of innovative and well-vetted technology platform currently in use today.
- Highly efficient and non-polluting conversion of waste biomass into highly demanded products.
- Privately funded facility – revenues from sale of advanced sustainable fuels offset capital and operation costs.
- Substantial reduction of up to 50% in waste disposal costs to the city-state of Hong Kong.
- Same waste processing capacity as the proposed IWMF.
- Faster timeframe for commencing of operations and smaller footprint than the proposed IWMF.

BTL Plant description

Solena's BTL facility consists of five integrated processing "islands": (i) MSW Reception and Processing Island; (ii) Solena's proprietary high-temperature gasification; (iii) BioSynGas conditioning; (iv) Fischer-Tropsch ("FT") processing & upgrading; and (v) power production. The facilities are designed to produce (i) 16 million gallons of sustainable aviation fuel; (ii) 14.5 million gallons of sustainable naphtha; and (iii) 77 MW of sustainable electricity (of which 55 is consumed by the facility and 22 is exported/sold to the grid). Each of the processing islands are illustrated in Figure [2] below and described hereunder.

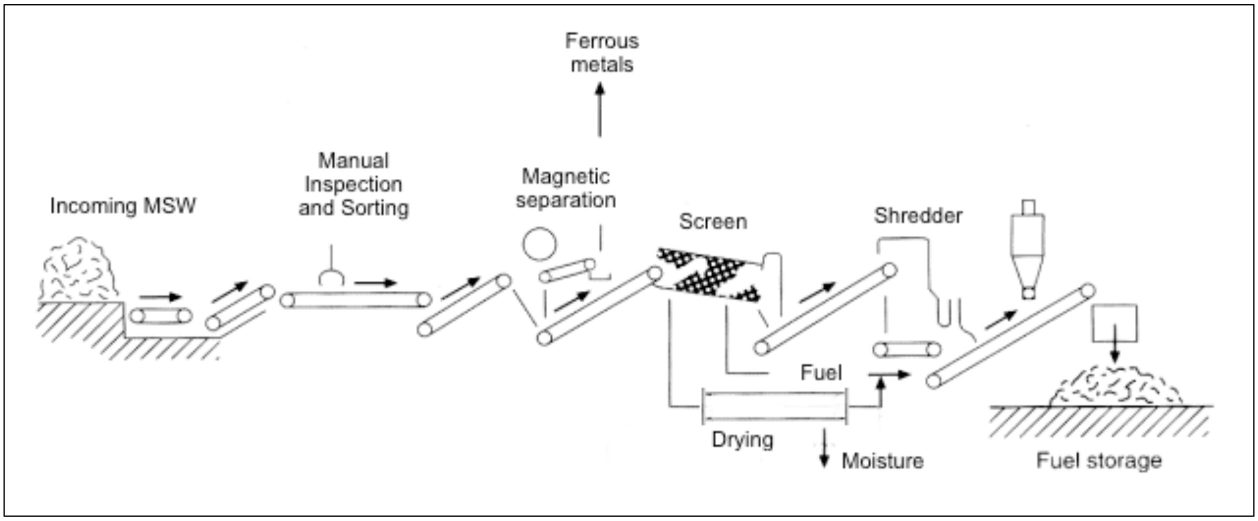
Figure [2]
Integrated Processing Blocks of Solena BTL Solution



Mixed MSW Reception and Processing Island

Solena's BTL plant receiving mixed MSW will incorporate a reception and MSW processing island. The purpose of this pre-treatment area is two fold: (i) to optimize the overall efficiency of the BTL facility by removing most of the inert materials (mainly metals and glass) and (ii) to control, sample and analyze the quality of the feedstock sent to the gasification process. To achieve these goals, the incoming mixed MSW will be first sorted using both manual separation, which also serves as a first recycling process for glass containers or bottles and other bulky items, and then using mechanical industrial methods such as magnetic separators and trommel screens, which are commonly used in MSW processing plants due to their high degree of effectiveness and efficiency. Following the separation stages, the waste streams will be sized (5 cm. to 10 cm.) and dried (to approximately 20% moisture content), thereby producing a refuse-derived fuel, which is ideally suited for the gasification process (calorific content of 16 MJ/kg). Figure [3] below illustrates the RDF production process. As a result of the inert materials and moisture being removed from the mixed MSW, it is estimated that the incoming 3,000 tonnes per day of mixed MSW will be reduced to approximately 2,000 tonnes per day of RDF, which are then fed to the four gasification reactors, each rated at 500 tonnes per day.

Figure [3]
Schematic of the MSW to RDF production process

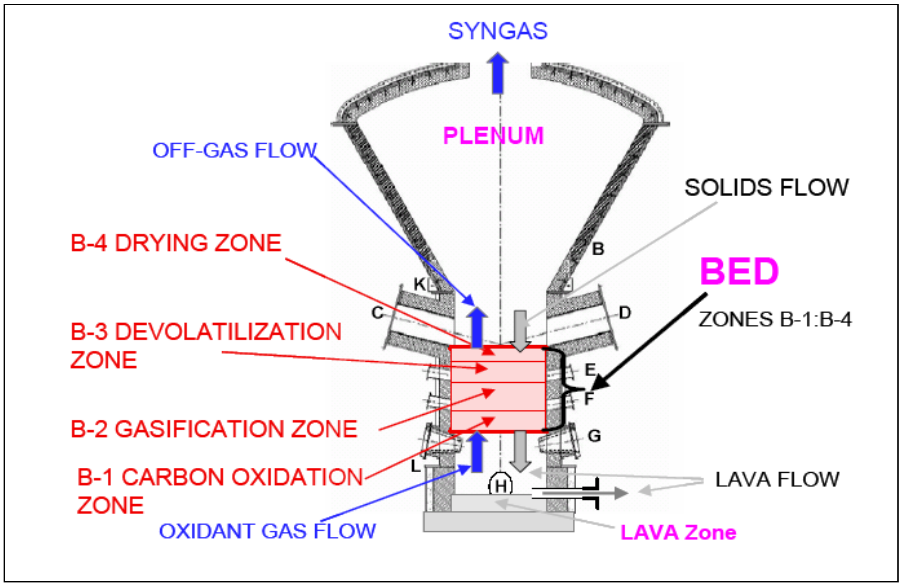


Solena Proprietary High Temperature Gasification Island

The second processing block in Solena's BTL solution is its proprietary high temperature gasification system. This processing block receives the waste biomass via screw feeders, which deliver the feedstock to one of four Solena Plasma Gasification Vessels ("SPGV"). Each SPGV is rated at 20 tonnes of RDF or a waste biomass feedstock per hour and hosts three independent plasma heating systems each. The plasma jet generates an extremely high temperature that heats a catalytic bed, which forms the base of Solena's counter-current, fixed bed gasification process. The resulting even distribution of high temperature heat across the cross section of the SPGV dissociates organic hydrocarbon materials into basic elemental gases while at the same time all the inorganic inert materials are melted into an inert and non-leachable "slag". This process of thermal de-polymerization of organic materials and melting of inorganic materials by means of high temperature plasma energy is Solena's patented gasification system.

The SPGV is illustrated in the schematic in Figure [4] below with details of the gasification zones.

Figure [4]
Schematic Section of Solena's Plasma Gasification Vessel



The SPGV efficiency and functionality is based on its capacity to deliver reliable and instant high temperature heat through the plasma arc torch heating system. Plasma is a very high temperature ionized gas. It is considered to be the fourth state of matter and it exists in nature, for example, in stars and lightning. In the plasma gasification process, the plasma field is produced in a controlled environment via a plasma torch. Historically, man-made plasma has been produced in a controlled environment that is capable of generating temperatures in excess of 5,000º C through plasma arc torches, in both a transferred and non-transferred arc mode.

Solena's technical team has been continuously extending its know-how and intellectual property through extensive research and development and two pilot facilities. The patents are based on the knowledge developed during tests campaigns at these facilities.

BioSynGas Conditioning Island

Upon exiting the gasification island, the BioSynGas produced in the Gasification Island is sent to the BioSynGas conditioning island through a BioSynGas duct that is the interface between the two Islands. The BioSynGas is free of tar, soot, or medium to long chain hydrocarbons. BioSynGas composition is continuously monitored at the BioSynGas duct level. Entering the BioSynGas Conditioning Island, the BioSynGas is rapidly cooled and filtered to ensure that any remaining volatile metals, and/or particulate matter are removed. Moreover, any acidic gases such as hydrogen chloride (HCl) and hydrogen sulfide (H_2S) are removed to meet FT process' technical specifications and ensure that the BioSynGas does not damage the Fischer-Tropsch catalyst. Once the BioSynGas is cooled, it is passed through a scrubbing system for acid gas removal. The BioSynGas treatment process train removes acid gases and ensures that the BioSynGas meets or exceeds the fuel gas specifications required by the FT provider. This process typically involves a hydrogen chloride absorption system, a compressor and a sulfur removal system to remove hydrogen sulfide and traces of carbonyl sulfides. Once the

BioSynGas has been cleaned, it is passed through a series of filters and moisture separators to condition it before it is delivered to a hydrogen separation and purification unit to provide the FT process and the LFTL/wax upgrading unit with pure hydrogen. At that point, the conditioned BioSynGas is sent into the FT processing island.

FT Processing Island

Upon exiting the BioSynGas conditioning island, the BioSynGas is fed into the FT processing island. The FT processing island consists of processing the cleaned BioSynGas through a slurry bed reactor whereby the BioSynGas is converted – via a chemical synthesis reaction that is exothermic – into various hydrocarbons such as soft wax, hard wax, and a light Fischer-Tropsch liquid (once cooled). All FT systems must utilize a catalyst that is appropriate for the type of synthetic gas being processed. Solena's BioSynGas is ideally suited for iron-based catalysts since these are more efficient when used with a synthetic gas with a H_2 to CO ratio of 1. In addition, these iron-based catalysts are less expensive than a majority of FT systems in use today, which utilize cobalt-based catalyst. The waxes and liquids produced within the FT processing island are subsequently upgraded into liquid fuels (jet or marine and naphtha) via the FT wax upgrading process.

Used extensively in the refining industry today, the FT wax upgrading process combines hydrocracking and hydrotreating to convert the FT waxes into various liquid fuels. After filtering, the FT products are heated in a wax pre-heater, mixed with the recycled stream from the FT reactor unit and flashed in the heavy wax flash drum to remove residual light ends, such as carbon monoxide, carbon dioxide and nitrogen. The processed streams are subsequently separated into the jet or marine fuel and naphtha. The residual flashed gas free of impurities is routed to the power production block.

Power Production Block

The FT processing island produces a tail gas that is a combustible fuel suitable for driving gas turbines in combined cycle. As such, the FT tail gas is used within the BTL facility for power generation. After the FT tail gas has been combusted with excess air in the gas turbine generator, the temperature of the combustion products (i.e. the exhaust gas) is high because of the combustion process. The large flow of hot exhaust gases is passed through a heat recovery steam generator (HRSG) where the heat energy in the exhaust gases is used to generate steam. The steam generated by the HRSG is then used to drive a steam turbine in combined cycle for generating additional electrical energy. In addition to the steam produced in the combined cycle, there are other instances in the plant where steam is produced (hot BioSynGas heat recovery and FT process exothermic reaction). This steam is also sent to the combined cycle's steam turbine to maximize power production and energy efficiency of the plant.

Feedstock Versatility

Independently with Dr. S. Camacho, a former NASA scientist, in the renowned PTC Research Triangle of North Carolina, USA and in conjunction with Dr. S. Dighe at Westinghouse Plasma center in Pittsburgh, Solena has tested, treated and analyzed hundreds of biomass and waste streams at industrial capacity to establish its database and to develop the SPGV process for BioSynGas manufacturing. These tests and/or treatment periods were performed on behalf of clients and in conjunction with Solena's research and development efforts. The feedstock streams successfully treated and gasified by the plasma systems include all of those listed below in Table [1].

Table [1]
Feedstocks Successfully Processed by Solena Group

Biomass	Municipal Type Waste	Industrial Waste
Agricultural / Grain Biomass	Municipal Solid Waste	Asbestos Fibers
Wood and Forestry Biomass	Automobile Tires	Contaminted Materials
Treated Wood	Car Fluff	Contaminated Fines, Soils & Landfill
Mixed Source Biomass & Waste	Sludge & Harbor Sediment	Liquid PCBs
Pathological Biomass	Hospital/Medical Biomass/Waste	Paints & Solvents

It should be noted that due to the robustness and fuel flexibility of Solena's process, the proposed BTL facility will, as described above, be able to accept raw, mixed MSW into the plant. However, although the high temperature gasification process is perfectly capable of gasifying raw MSW, Solena has determined that the efficiency gained by processing refuse-derived fuel instead of unsorted municipal solid waste warrants incorporating a mechanical sorting process prior to the gasification process. Therefore, in order to increase the efficiency of the process and thus the profitability of the plant, Solena would incorporate a sorting facility into its standard BTL Plant design that will to sort out the recyclable and inert materials in the incoming MSW.

Well-Vetted High Temperature Gasification Solution

More than 10 years of developing, testing and refining the SPGV technology and solutions has allowed Solena Fuels' team to collect, compile and analyze a significant amount of material data. The Company has used this data to design and develop its patents and proprietary steady state gasification computer model in order to simulate system performance and design control systems to regulate and monitor each BioEnergy Plant.

Solena's proprietary data includes information such as:

- the SER (Specific Energy Requirement) for each biomass and waste stream, i.e. the amount of energy required within the plasma system to completely gasify and vitrify a ton of the specific biomass stream;
- the cost of operation per ton of a specific biomass or waste stream;
- the behavior of each biomass and waste stream within a plasma reactor;
- the optimum capacity of the plant for each biomass or waste stream;
- the heat and material balance for each biomass stream;
- the characteristics and composition of the BioSynGas generated by the biomass stream under plasma SPGV conditions;

- the energy content of the fuel gas and the energy recovered from the gas either in the form of electricity or liquid fuel, etc.;
- the characteristics and safety of the vitrified slag (e.g., TCLP limits, etc.);
- the environmental impact of the Solena BTL Solution;
- the air pollution control/gas scrubbing system required for each biomass stream; and
- the optimum biomass and waste condition/composition to generate the maximum energy within the BioSynGas recovery.

Based on experience and process testing, the Solena technical team was able to refine the SPGV process in order to maximize its technical efficiency and cost-effectiveness. Prior to Solena's developments, plasma technology pyrolysis required over 1,000 kWh of electricity to handle one ton of feedstock. Through extensive research and modification of the design of the reactor and refining the process control system, Solena has made the SPGV process nearly ten times more efficient than traditional plasma pyrolysis technology (with SPGV requiring only 150-200 kWh per ton of biomass). A single modular reactor can handle from 145 tonnes per day for a small system to 500 tonnes per day for a large system and reactors can be strung together in various configurations such as the four reactors we use for the BTL solution.

The extensive experience of the Solena team and the aforementioned critical data will help minimize technology risk and help establish Solena as an industry leader in sustainable, synthetic fuel production.

Specific Comments to the Executive Summary of the above mentioned IWMF EIA Report

Page 1: Introduction:

Under section 1.1, it is indicated that the Incineration Facility is intended to be constructed and operated under a design-build-operate model. The Solena facility briefly described above would also be under a contract for design-build-operate of the Biomass Fuels Facility (BFF).

The Solena plant will use only a gasification process that initially will process the 3,000 tonnes per day of the MSW with recyclables removed (1.1.1.2). A recycling facility would be built on the front-end of the plant to remove inorganic material that the City wants recycled. If there is no market for recyclables, the Solena plant would size and process all the MSW. Most importantly, Solena's biomass-to-liquid fuels and power facility will not produce any dioxins, furans, or their precursors and not produce any flue gas. The high operating temperature of the gasification process ensures all organic molecules are depolymerized and the resulting off-gases reform into the BioSynGas. As such, and because the system is a closed loop in which the syngas is then converted to advanced biofuels, (as opposed to an incineration open loop, which vents the flue gas to the atmosphere), Solena's BTL plant enhances public health and safety and protection of air and water around the facility.

In 1.1.1.3, it is noted that Hong Kong now depends on three landfills, which will reach capacity in 2014, 2016, and 2018. Solena can build the described BTL facility at each landfill processing more 3,000 tonnes per day of MSW and producing 30 million gallons of advanced sustainable biofuels and 22 MW of renewable baseload electricity. Using this approach the landfills would not fill as quickly and therefore have an extended life. The plants can process new incoming waste or previously landfilled waste (mining the landfill to extract waste) thereby reducing the overall volume of the landfills and eliminate the need for additional extension of the landfills. This approach would not succeed with an incinerator since the incinerator would produce a significant amount of ash, which still requires post-processing and landfilling. In addition, the incinerator can only produce small amounts of power since it only takes advantage of the sensible heat energy of the waste whereas a Solena gasification plant would produce power much more efficiently because the BTL process uses both the sensible heat energy as well as the chemical energy in the waste by converting it into a syngas fuel.

In 1.1.1.5, it is stated that Hong Kong must move quickly to solve its waste management problems. With the Solena system construction can be completed over 24 months from the time it is permitted and financial closing achieved, hiring over 1000 construction workers during that period and over 200 full time employees. In other words, Solena can expedite and move quickly on plant construction once the site is permitted. Moreover, Solena brings with it a major local airline as a project partner and fuel off-taker, who would be committed to purchasing the sustainable biofuels produced at the BTL plant.

In 1.1.1.6, there is a listing of benefits, which the City appears to be satisfied with.

In relation to the bulk reduction of waste volume, it should be noted that although incineration reduces the volume of waste processed, it does so at the expense of producing toxic fly and bottom ash. Incinerators typically produce ash in large quantities – approximately 20% of the incoming dry matter comes out in the form of ash, which requires costly post-processing and landfilling. Therefore, the incineration facility does not solve the problem of decreasing landfill space. In contrast, Solena's BTL process converts all the incoming waste into advanced biofuels and slag. As noted above, slag is an inert material with commercial applications in the construction industry and does not require landfilling.

With regards to energy recovery, as noted above, the IWMF incineration process is an open loop process which relies solely on the sensible heat energy of the incoming materials by burning them and therefore wastes most of the energy contained in the waste by releasing its carbon content into the atmosphere in the form of CO_2. In contrast, Solena's closed loop high temperature gasification system, converts the heat energy content of the waste into BioSynGas, thus keeping all the carbon within the process in the form of CO for the subsequent production of advanced biofuels through the Fischer-Tropsch system. As such, the Fischer-Tropsch facility enhanced with high temperature gasification technology is vastly superior in energy recovery efficiency.

With regards to the greenhouse gas reduction, it should be noted that, like the IWMF, the Solena BTL facility will also use the available MSW thus obtaining the same benefits in reduction of green house gases on the input side. However, since the BTL plant is a closed loop system that keeps all the carbon within the system (instead of emitting large amounts of CO_2 to the atmosphere like the IWMF would do), it reduces GHG emissions further by up to 50%.

produces liquid biofuels instead of

2.2.1.3: The Solena gasification system will process 3,000 tonnes per day of MSW using 4 gasification reactors rated at 500 tonnes per day of refuse-derived fuel ("RDF", refuse-derived fuel will be produced on-site from the 3,000 tonnes per day of MSW at a sorting facility which will convert the MSW into 2,000 tonnes per day of RDF).

The BTL plant can meet the emission limit of NO_X for the State of California of 57 mg/m^3, which is stricter than the 100mg/m^3 that is proposed for the incineration plant. Indeed, the U.S. Federal standard of 100mg/m^3 is much better than the referenced 200mg/m^3 EU standard, but the California standard is stricter to all other NO_X standards in the world. It is also important to note that the Solena plant will produce advanced biofuels in addition to renewable power, which an incinerator cannot do.

2.2.1.6 The table shows the air emission limits for the IWMF that the incinerator is required to meet. It is important to note that a Solena gasification plant not emit any of the pollutants listed, except lower volumes of NO_X.

2.2.2.1 As stated at the TTAL site, the incineration unit will require 11 hectares, of which 1.2 hectares are a pond habitat for Litter Grebe. A comparable Solena BTL plant requires 8 hectares and therefore it would not require to 'decommission' the 1.2 Ha of pond habitat. Instead of building a plant at the Island and disrupting the habitat and attempting to build an artificial island that again will have adverse impacts on the habitat and the surrounding water, Solena suggests that instead the Hong Kong government should consider building plants at the three landfills as noted above. This would be a less expensive approach since all the work on the Island TTAL site and creating an artificial island SKC will be very expensive and will have adverse impacts on the environment whereas land around the current landfills is zoned as industrial, has an existing infrastructure of roads, power lines, etc. and the addition of three plants would not be intrusive and have a considerably smaller environmental impact.

In section 2.2.3.3 the IWMF clearly state that "the bottom ash, fly ash and air pollution control residues produced from the incineration process will be collected for treatment and disposed of at the WENT landfill or its extension *if they have met the disposal requirements.*" If the landfill has not met the requirements to dispose of the toxic materials produced by the IWMF in large quantities (approximately 20% of the dry matter will become bottom and fly ash, i.e., 390 tonnes per day), the IWMF will have no place to dispose of these toxic solid waste effluent, thus forcing the facility to stop production. Even if the WENT landfill met the requirements, the IWMF would still require costly post treatment of the bottom and fly ash and disposal at landfill. Therefore the IMWF has higher waste processing costs (need to pay for toxic bottom and fly ahs inertization processes and disposal costs) and clearly does not solve the challenging problems that the City of Hong Kong is facing. In contrast, the BTL plant proposed by Solena does not produce any solid waste effluent and the cost of MSW disposal is substantially reduced.

In section 2.3.1.1 it is noted that the IWMF would be ready for commissioning by 2018 - 2019. As noted above the Solena BTL facility could meet or exceed this timeframe and start operations earlier. In order to do so, Solena would need to begin construction no later than 2016, which allows ample time for the project development activities to take place. Therefore, a Solena BTL facility could start accepting Hong Kong's MSW earlier than the proposed IWMF and offer lower disposal costs.

3.1.3 Evaluation of shortlisted Sites: The site selection criteria are exacting, but based on preconceived idea that a plant would be industrial and ugly. I would like to refer you to Solena Fuels' website (www.solenafuels.com), where a video shows a rendering of a proposed plant near Prague, CZ Republic. This plant is modern, fits into the local area and is not an eye-sore like most industrial facilities. Because the plant is exceptionally clean in all respects, such a facility in the Hong Kong area should be very acceptable and could open other sites that were passed by because of concerns about plant design and not being able to fit into the architecture of the surrounding community, which is probably true for an incinerator, but not for Solena's proposed BTL facilities.

3.1.3.11 S5-Tsang Tsui Ash Lagoons. This site would also be ideal for the construction of Solena's BTL plant as described above.

3.1.3.13 S6-Tuen Mun Area 38 would be suitable for a Solena BTL plant, especially since it is so close to the WENT landfill. Solena's plants would easily meet air quality requirements. This plant would not require water front space since all the waste would be easily hauled by truck to the plant from the nearby WENT landfill.

3.2.1.2 and 3.2.1.3 (In the technology selection) In general, the incineration technologies discussed are not innovative and utilize limited and inefficient XIX century designs. The discussion about gasification is uniformed, e.g., a plant for General Motors was commissioned in 1987 in Defiance, Ohio, with the capability of processing 50 to 100 tonnes per hour in one reactor. As indicated above, Solena will be able to accept and process the 3,000 tonnes per day of mixed MSW and convert it into sustainable biofuels and baseload renewable power. Solena's BTL plant will incorporate four reactors rated at 500 tonnes of RDF per day each (2,000 tonnes per day of RDF would be produced on site from the incoming 3,000 tonnes of mixed MSW). As described above, the high operating temperatures (up to 4,000 degrees Celsius) insure that all inorganics melt and organics are dissociated into basic gases, i.e., hydrogen and carbon monoxide, forming a BioSynGas, which is then used as feedstock for a Fischer Tropsch unit to produce 30 million gallons per year of advanced biofuels and 22 MW net of renewable power. This is Solena's basic design for over 15 BTL plants currently being implemented around the world.

3.2.2.2 While environmental, engineering, and cost considerations are important; it is a fatal flaw to exclude visual impacts, employment opportunities, public health, and public acceptance because some options are thermal treatment technologies. In almost all cases the public opposes incineration because of health impacts, damage to the environment, and potential climate change risk. In addition, design of incinerators is limited and does not have the flexibility of design found in gasification plants, which can easily blend into the architecture of the surrounding community as referenced above for the plant in Prague, CZ.

3.2.3.1 In Table ES5, Summary of Option Evaluation for Thermal Treatment Technologies is flawed and shows little or no understanding of gasification technology and how it functions. For example, under flexibility, gasification is given a least favorable mark because of "the ability to tolerate a fluctuation of the MSW characteristics." On the contrary, Solena's gasification technology and process is very robust and fuel flexible since it can easily treat a broad range of organic material derived from MSW. With regards to the land requirements and system complexity criteria, again this shows lack of understanding of gasification technology. A gasification plant would have almost the same requirement as a moving grate incineration unit and probably have a lower capital and operating costs. A typical Solena gasification unit combined with a FT unit to produce biofuel and renewable power would have income streams from the biofuels and the power, as well as the vitrified slag. This would enable the facility to recover its capital costs quickly and operating costs are also low.

Therefore, Solena disagrees with the results of Table ES5 – Summary of Option Evaluation for Thermal Treatment Technologies, which are most likely due to the lack of knowledge of Solena's technology and process. In turn, Solena presents the following Table [1] for your consideration:

Table [1]
Revised Table of Option Evaluation for Waste Disposal Processes

CRITERIA	MOVING GRATE INCINERATION	FLUIDIZED BED INCINERATION	GASIFICATION	SOLENA BIOMASS TO LIQUIDS
Air Emissions	High	High	Low	Low
Flexibility	Medium	Low	High	High
Power Production Efficiency	Low	Low	High	High
Reliability (Unit Capacity)	10-920 TPD	10-80 TPD	100 – 500 TPD	100-500 TPD
Reliability (Plant Capacity)	20-4,300 TPD	10-200 TPD	100 – 3,000 TPD	3,000 TPD
Reliability (Suppliers)	Many	Limited	Medium	High
Land Requirements & System Complexity	Medium	High	Low	Medium
Op. Experience w/ Mixed MSW treatment	High	Medium	Medium	Medium
Capital Costs	High	High	Medium(1)	Medium(1)
Operating Costs	High	High	Medium(1)	Medium(1)
Waste Disposal Costs	High	High	Low	Low
Overall	Less Favorable	Least Favorable	More Favorable	Most favorable

3.2.3.2 It is asserted that moving grate incineration is more favorable, even though it is extremely inefficient and not cost effective, than gasification because the latter technologies are of much smaller scale. This clearly is not true given the example above of the GM plant that has been processing up to 2,500 tonnes per day since it became operational in 1987. In addition, Solena gasification will not have scale up risks since the required plant size has been operational over 20 years. One cannot justify a technology such as moving grate on the basis it has been in operation for over 100 years, because it has never been cost effective, efficient, and is a heavy polluter causing possible climate change, damage to the environment with heavy pollution of toxic chemicals, and causing major health problems to surrounding communities and harming wildlife.

The statement that a moving grate is more tolerant of fluctuation of MSW characteristics is clearly not true. Anyone with experience with moving grate incineration should acknowledge that high moisture content and large quantities of plastics can cause a shutdown, which is clearly not the case with Solena gasification technology.

The statement that moving grates incineration needs less land than gasification on the basis that the latter needs more land for treatment units. Just as a single example of how false this statement is, the Solena biofuels plant in London requires less than 10 hectares and no additional landfilling. One must take into account the area needed by the incineration facility to landfill the ash it produces.

The justification about the number of gasification vendors is also false. Clearly old and inefficient technologies go out of business, but new and better technologies are entering the market. In any case, the decision is not going to be made on the basis of the number of vendors in the market, since Solena alone can handle Hong Kong's MSW problems with a superior gasification system producing power and biofuels. The problems with other gasification technologies cannot be related back to Solena's gasification technology or process, as they are fundamentally different in design and operation philosophy.

The statement about capital and operational costs of a moving grate Vs. gasification system shows a lack of knowledge about new gasification plants producing biofuels and renewable power, both of which a moving grate system would find almost impossible to produce comparable power levels and of course could not produce biofuels.

3.2.3.3 This statement again shows little understanding of gasification. A Solena gasification plant produces no flue gas. Of course moving grate incineration systems can attempt to capture toxic gases, mercury, bottom and fly ashes, but at a huge expense and without guarantees on efficiency of dioxins removal. Without producing flue gas and no pollution, Solena's gasification system has lower capital and operating costs, which enable it to function without creating pollution or toxic ash, which an incinerator needs to send to a landfill, thus increasing operating costs and therefore, costs of waste disposal.

3.2.3.6 For the Advisory Council meeting on the ACE held on 14 Dec. 2009, one can only assume that the Council had no objections to moving grate incineration technology because it was not given a full and complete presentation on the cost effectiveness, efficiency, and benefits associated with Solena's gasification process and production of biofuels and renewable power as described herein.

3.2.4.1 MBT technology has flaws, which were identified. However, it would be a waste of money to build even a small-scale unit. Clearly what is needed, which has been adopted in

Europe and the U.S., is an efficient technology process to separate recyclables from MSW and creating a valuable refuse derived fuel (RDF), which has a broad range of use and easily fits feedstock needs for a gasification plant.

3.2.4.3 Instead of worrying about how to separate recyclables and where such a process can be built, the City should let the private sector come up with a RDF solution. Waste haulers in the UK and Europe have done this very successfully. Such a facility would not then need to be included in the IWMF land requirement.

4.2.1.3 With a Solena gasification system there is no need for a SCR because NO_X levels will be low and meet the emission standard for NO_X without the need for post-combustion cleaning. If necessary, with an SCR, Solena's system could lower NO_X levels to 51 mg/m^3.

4.2.4.2 With a Solena gasification system, no toxic bottom ash, toxic fly ash, or air pollution control residues would be produced. Therefore, there would be no landfill requirement for toxic ash.

4.2.4.3 Of course, there will be no land contamination with Solena's gasification system.

4.2.5.1 With Solena's gasification, a biofuels plant could be built on a smaller tract of land, i.e., 8 hectares instead of 11 hectares, which means less impact on the environment.

4.2.7 Health Impact: There is no discussion of the health impacts of fugitive emissions of dioxins, furans, and their precursors, as well as volatile metals including mercury. Many of these are considered to be carcinogenic.

4.2.10 Landfill Gas Hazard. For Solena landfill gas is not a hazard. The gas could be captured and used. Of course, since Solena's gasification plant would help alleviate the need for landfilling and there would be less methane gas being generated by the landfill.

4.3.1.2 With Solena's gasification plant there would be no pollution created, no odor released, and the overall green plant would be very clean and beneficial to the workers and local community.

4.4.1.3 With Solena's gasification plant an advanced air pollution system would not be required and a SCR most likely would not be necessary saving on capital and operational costs. In addition, no dioxins, furans, or their precursors would be created.

4.3.4.1 Time and money could be saved by building smaller plants at the three existing landfills or at abandoned landfills instead of trying to build islands. Also small volumes of inorganic waste captured in the separation process could be processed in the gasification unit and melted into an inert vitrified slag, which has many industrial uses.

4.3.5 Ecology: waters around the islands and the area near SKC are too important in terms of habitat for the Finless Porpoise and other species to expose them to an incineration plant, which will be producing toxic ash and emissions not healthy to human or animal life. These toxic materials will escape into the ecosystem as has happened elsewhere, which is why the construction of incineration plants is such a rare event in other countries. As an example, Denmark has recently rejected a proposed modern incineration plant on the basis of its CO_2 emissions[1], which were deemed to high and damaging to the environment. Instead, the Danish government will focus its efforts in other recycling activities while looking for other alternatives. The 198 coral colonies would be of special concern.

4.3.6.1 Fisheries This is another example of why it is so risky to try to build such a plant on the proposed sites. The City would be better served if smaller plants were built at three existing and operating landfills or abandoned landfills.

5.1.1.1 The EIA is quite comprehensive. However, because it is so uninformed about Solena's plasma gasification process and production of biofuels and renewable power, the evaluation process may no be providing the City with all the information it needs to make a decision.

Specific comments on Paper WMSC 01/10: Integrated Waste management Facilities Sorting and Recycling Plant

Paragraph 2: Since almost all countries in the world have great concerns about incineration of wastes it is not clear why Hong Kong would want such a primitive method of treating wastes, which is very expensive to build and operate with very low cost effectiveness and efficiency. Moreover, incinerators of this type are notorious for creating vast volumes of contaminated and toxic ash, which must be landfilled using special and expensive methods. In addition, such incinerators also bellow large volumes of contaminated emissions containing dioxin, furans, volatile metals, mercury, and cadmium just to name a few besides equally huge volumes of carbon dioxide that is not carbon neutral, and other gases that only help to worsen climate change. Of course, this array of toxic emissions and pollutants not only harms the immediate environment, but surrounding areas of land and water causing immense damage to the environment and adversely impact human, animal, and fish health. Since a gasification system such as used by Solena Fuels can easily avoid all these problems and produce useful alternative biofuels and renewable power, it is not clear why such an inferior burner technology was selected for the IWMF. Hong Kong should aspire to greater things and be the showplace for the world and attract more tourists to an even cleaner and safer environment.

It is not clear why 3,000 tonnes per day was selected for one plant. This will only concentrate all the problems mentioned above. Why not have three Solena gasification plants producing biofuels and treating 3,000 tonnes per day each and producing 30 million gallons of advanced sustainable aviation fuel annually, as well as 22 MW net of renewable power each. These could be built easily at the three active landfills or at abandoned landfills, all of which are located on stable land, zoned industrial, and easily used to treat the wastes and produce biofuels and power without further harm to the environment and lessen the increase of climate change.

[1] http://www.architizer.com/en_us/blog/dyn/35348/big-ski-slope-denied/

Re sorting and recycling, most countries turn this over to private companies who have determined how to produce a harmless refuse derived fuel that meets the caloric and moisture content needs of a gasification plant producing biofuels and renewable power. If this is not acceptable, Solena has a design for a sorting and compacting plant, briefly described above, that can easily be built on the front end of a gasification unit. Incidentally if there is no market for the recyclable, then Solena's system is so robust, it can process all the organic and inorganic waste.

Regarding paragraph 8, a gasification plant using RDF would solve these problems and eliminate the need for MBT.

Regarding paragraph 9, I addressed this sorting and recycling issue above. Without such recycling, the incinerator problem would have an availability of less than 50% since it would have a hard time processing the inorganics, plastics, etc. On page 4, number (iii), it is important not to compare incineration to a recycling and sorting plant. This is not a meaningful comparison. Solena's front-end system mentioned above would be much smaller. In fact, it would probably be smaller than one hectare. And cost about $5 million and very low sorting/operation costs because it would be partially automated and use employees to sort. Of course, Solena's design eliminates odor and dust. Re (iv), the easy solution is to gasify all the waste.

WASTED

EUROPE'S UNTAPPED RESOURCE

An Assessment of Advanced Biofuels
from Wastes & Residues

Supported by:

ANALYSIS

CHRIS MALINS, Fuels Lead, ICCT
STEPHANIE SEARLE, Researcher, ICCT
ANIL BARAL, Senior Researcher, ICCT
DAVID TURLEY, Lead Consultant, Biobased Feedstocks, NNFCC
LUCY HOPWOOD, Lead Consultant, Bioenergy, NNFCC

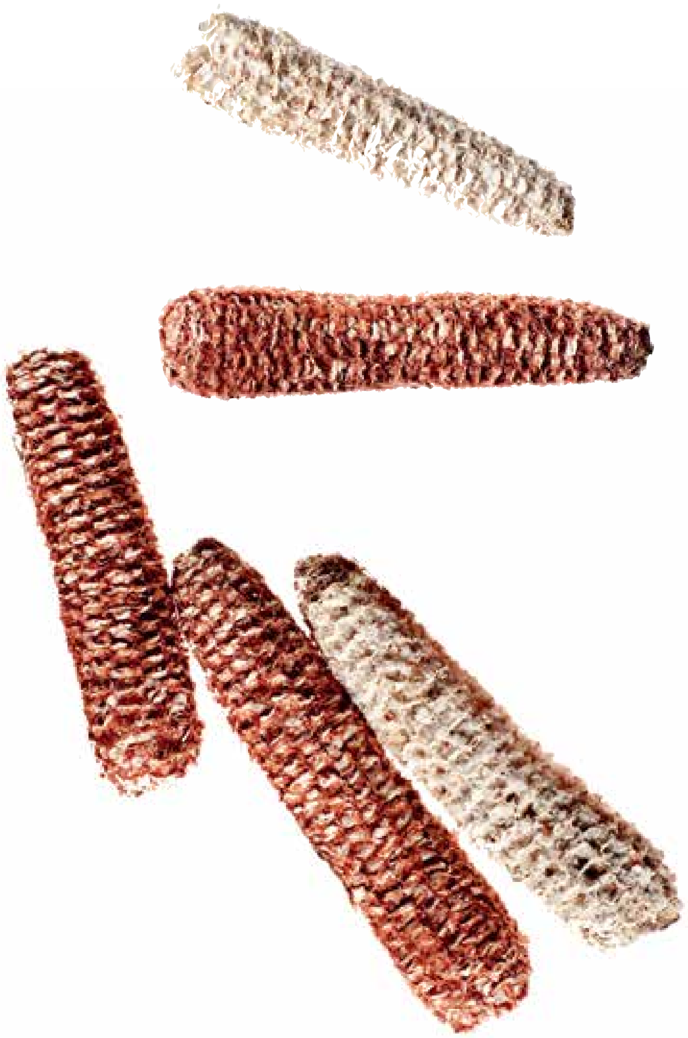
INDEPENDENT REVIEWERS

DAVID BALDOCK, Executive Director, IEEP
BEN ALLEN, Senior Policy Analyst, IEEP
BETTINA KRETSCHMER, Senior Policy Analyst, IEEP

PROJECT COORDINATOR

PETE HARRISON, Deputy Director Transport, ECF

Summary



Key findings:

- If all the wastes and residues that are sustainably available in the European Union were converted only to biofuels, this could supply 16 per cent of road transport fuel in 2030. (Technical potential).
- If advanced biofuels from wastes and residues are sourced sustainably, they can deliver GHG savings well in excess of 60 per cent, even when taking a full lifecycle approach.
- Safeguards would be needed to ensure this resource is developed sustainably, including sustainable land management practices that maintain carbon balances and safeguard biodiversity, water resources and soil functionality.
- If this resource were utilized to its full technical potential, up to €15 billion of additional revenues would flow into the rural economy annually and up to 300,000 additional jobs would be created by 2030.
- While some combinations of feedstock and technology will require short-term incentives, others are close to being competitive and require little more than policy certainty.

There is a pressing need to transform the way in which society uses energy

Europe could cut the carbon-intensity of transport fuels, reduce spending on oil imports and boost the rural economy by developing sustainable advanced biofuels from wastes and residues.

There are currently concerns that wastes and residues are available in insufficient quantities to make a meaningful or cost-effective contribution to fuelling transport. This in-depth analysis concludes that advanced biofuels from wastes and residues, if mobilized in a sustainable manner, can make a sizeable contribution to reducing European dependence on imported oil.

This study starts with a precautionary approach and only focuses on wastes and residues that were viewed by all project partners as sustainable. The main conclusion is that if all the sustainably available resources were converted only to road transport fuel, the technical potential could equal 16 per cent of demand in 2030.

Commercializing this resource could also create hundreds of thousands of jobs, both in building and operating refineries and in collecting the resources to feed them.

Meanwhile, the potential CO_2 savings range from 60 to 85 per cent in most cases, making a significant contribution to EU climate goals.

The latest review of evidence by the Intergovernmental Panel on Climate Change (IPCC) reports with high confidence that rising levels of CO_2 are warming oceans, melting ice and turning oceans more acidic. Global average temperatures are projected to be 2.6-4.8° Celsius (C) higher than at present by the end of this century if emissions continue to rise at the current rate.

Although emissions from other sectors are generally falling, road transport is one of the few sectors where emissions have risen rapidly in recent years. The transport sector is on track to become the EU's biggest source of CO_2 by 2030 according to the European Commission.

While significant gains have been made in recent years to improve vehicle efficiency, there is also much that can be done to reduce the carbon intensity of energy used in transport. Alternative energy carriers, such as hydrogen, natural gas, biofuels and batteries are part of this picture, in cases where life cycle assessments (LCAs) show genuine CO_2 reductions.

Creating more advanced biofuels from wastes and residues, which might otherwise be left to decompose, offers one opportunity to reduce the carbon-intensity of transport fuels without creating significant impacts on food commodity markets or land resources. Such advanced biofuels also fulfill the role of improving European energy security and providing an additional revenue stream to farmers and forest owners.

Questions remain unanswered about the sustainability of "wastes and residues", many of which are not truly wasted, as they have existing uses that would be displaced by their use as biofuel feedstocks. Furthermore, there has been little research to date on what volumes of these wastes or residues might realistically be mobilized in an economically viable manner without unintended consequences.

Previous life cycle assessments have overlooked potentially important sources of emissions, such as soil carbon loss, any need to use extra fertilizer if removing residues and indirect emissions caused by diverting residues and wastes from their existing uses. The CO_2 savings from forest residues are complex to estimate, as there are uncertainties around their decomposition rate if left in forests or the impacts on soil carbon. The above issues are taken into consideration in this project by using a comprehensive carbon accounting approach. Equally pressing are questions about the costs and economics of the advanced technologies required to convert such wastes and residues into liquid transport fuels.

This project has shed light on such questions. An expert panel has been convened of environmental NGOs, energy analysts and companies with direct experience in technologies to produce advanced biofuels. These experts have examined the sustainability of converting wastes and residues to biofuels; the availability of the most sustainable resources; the economic impact if this resource is fully converted to transport fuel; and the business-case for doing so.

The project found that many advanced biofuels from wastes and residues can make a significant contribution to mitigating climate change, even when accounting for losses to soil carbon and the need for additional fertilizer. Forest residues, known as slash, were found to deliver CO_2 savings of around 60 per cent, provided steps are taken to minimize soil carbon losses. Savings might be found to be lower or higher depending on the accounting approach taken for emissions from decomposition of slash. Timber-processing residues such as sawdust were found to deliver savings of around 75 per cent while still accounting for displacement effects.

Higher greenhouse gas savings were found to come from agricultural residues, reaching 80 per cent in cases where indirect emissions due to displacement effects can be minimized. Municipal solid waste was found to deliver the highest greenhouse gas savings of all, well in excess of 100 per cent due to the possibility of avoiding decomposition to methane in landfill sites.

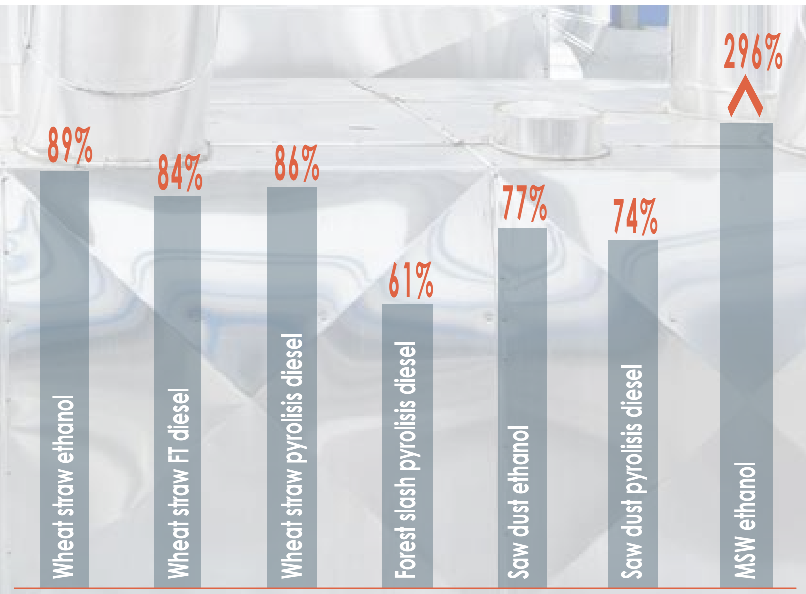
While Europeans generate around 900 million tonnes of waste paper, food, wood and plant material each year, only a fraction of this can be considered available, because much of this material has existing uses. A good example is sawdust, a "waste product" of timber production that is then used to make products such as fiberboard. The crop residues such as leaves and stalks that remain after cereal harvesting are "waste" from the perspective of food production, but are often used in other areas of agriculture including mushroom cultivation and bedding for livestock.

Some wastes and residues do not have industrial uses, but still provide valuable environmental services. The twigs and leaves left over from felling trees for timber return carbon and nutrients to the soil to support future tree growth. Some plant residues from harvesting food crops should be left on the ground to maintain soil structure and fertility.

Diversion of these materials from their current uses will have potentially negative secondary impacts, and therefore not all of the 900 million tonnes identified above can be mobilized. In general, it makes sense to use a cascading approach to wastes and residues, prioritizing re-use or recycling and acknowledging that the value of this material is more than simply its energy content. Accounting for the various industrial uses and sustainability restrictions, about a quarter of this cellulosic material is available for energy use between now and 2030 – about 220 million tonnes per year in total.

FIG 1.1

GHG savings potential from selected wastes and residues, compared to fossil diesel and gasoline



To put this into context, if all of Europe's sustainably available cellulosic biomass from wastes and residues was converted to transport fuel only, at current conversion rates, this technical potential would equal 16 per cent of road fuel in the EU by 2030.

Aside from fuels made from biogenic wastes and residues, there is also high potential to produce fuels from other feedstocks, such as used cooking oil or industrial waste gases. Currently, around 1.1 million tonnes of used cooking oil is being converted each year to low-carbon fuel in the EU, with potential to expand.

There are other more novel methods of producing advanced biofuels that utilize carbon-rich wastes from industry (such as the steel industry) that are beginning to scale to commercial levels. For example, today, steel production in Europe accounts for 8 per cent of the EU's CO_2 emissions. Production of ethanol from European steel mill residues alone could amount to around one-third of the EU's Renewable Energy Directive target of 10 per cent biofuels in transport by 2020 - around 8 million tonnes of oil equivalent (Mtoe) - according to some estimates.

Europeans generate around 900 million tonnes of waste paper, food, wood and plant material each year

1 million tonnes of
Used Cooking Oil
(+ imports)

40 million tonnes of
Forest Slash

FIG 1.2

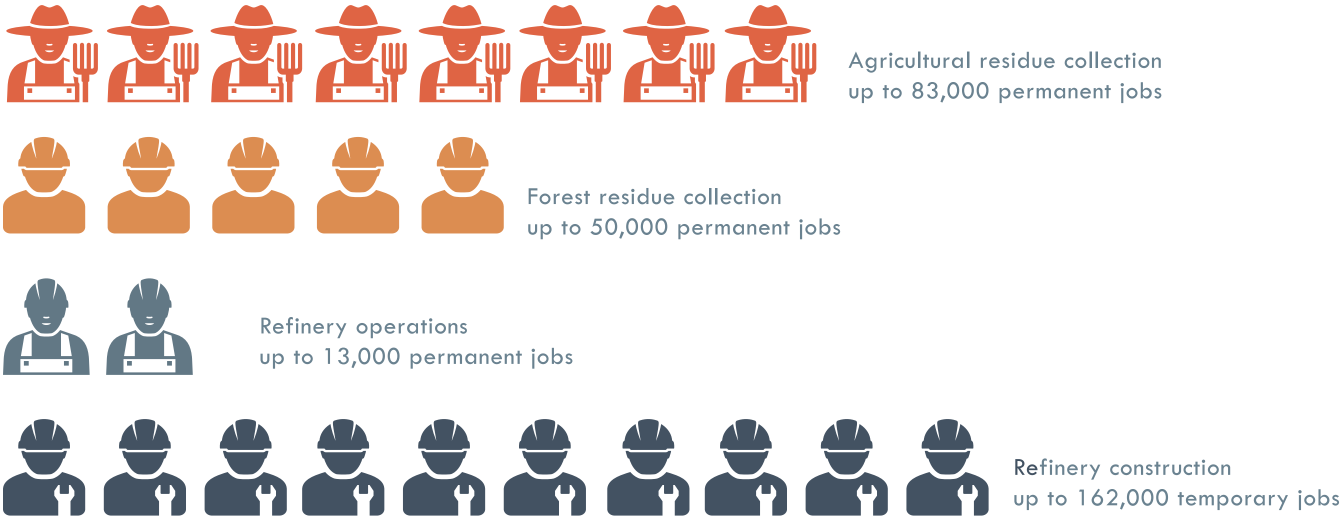
Sustainable availability of wastes and residues in the EU in 2030

44 million tonnes of
Municipal Solid Waste

139 million tonnes of
Crop Residues

FIG 1.3

High-end estimates of additional employment from fully utilizing wastes and residues for conversion to advanced biofuels



The economic analysis in this project showed that many of the biofuel processes from wastes and residues could be mobilized with incentives at similar levels to those offered for the start-up of first generation biofuels from food crops. In some countries, the cost of agricultural residues might remain high at around €70-80 per tonne, posing a barrier to development, but there are many regions where costs are low. The economics of biofuels derived from municipal solid waste are more compelling, because of the relatively low feedstock cost.

It is not possible to determine how much of the technical potential for biofuels from wastes and residues will be met, but if investors realized the full technical potential identified here, up to €15 billion annually would flow into Europe's rural economy and up to 133,000 permanent jobs would be created in feedstock collection and transport. In addition, construction of these biofuel plants would require up to a further 162,000 temporary workers, and operation of these plants would create up to a further 13,000 permanent jobs.

It should be recognized that in reality there would also be competition for feedstocks within the energy sector – particularly for heating or electricity generation – so all of the above estimates should be understood as the upper limits. In the future, policymakers might need to consider the relative value of low-carbon mobility versus other demands on biomass resources.

On the other hand, the employment estimates represent only the direct jobs from feedstock collection, transport and processing. Additional indirect employment would flow though machinery suppliers, fuel suppliers and other ancillary industries, significantly increasing the overall impact in the EU.

Policy

The EU transport sector should be made more sustainable and lower in GHG emissions, primarily by improving energy efficiency and by reducing the carbon intensity of energy used in transport. There is a significant role in this transition for sustainably produced advanced biofuels, which can achieve the triple-win of cutting GHG emissions, improving energy security and boosting rural incomes.

This project has found that significant volumes of wastes and residues could be mobilized as biofuels without creating sustainability issues, provided safeguards are put in place. Many of the conversion pathways are already close to being competitive under the right conditions, but commercialization is being held back by policy uncertainty.

Commercialization now depends on political leadership and adequate policies, as it must be acknowledged that new innovative technologies are not yet cost competitive against their fossil alternatives, which still receive subsidies and have profited from over a century of optimization. Compounding the investment problem, the ongoing global financial and economic crisis has made investors and lenders more risk averse.

It is the role of policymakers to create policy certainty to foster innovation and to ensure that Europe achieves its environmental, economic and energy objectives. Full lifecycle accounting of emissions should be the tool that under-pins the mitigation of CO_2 from transport fuels. This should apply equally to all types of energy used in transport, including biofuels, hydrogen, fossil fuels and electricity.

Decarbonization targets, such as those in the EU Fuel Quality Directive (FQD), play a useful role in reducing the carbon-intensity of transport fuels in a cost-effective manner.

The FQD is the primary tool to reduce the carbon-intensity of transport fuels in 2020, and it should become increasingly ambitious beyond 2020.

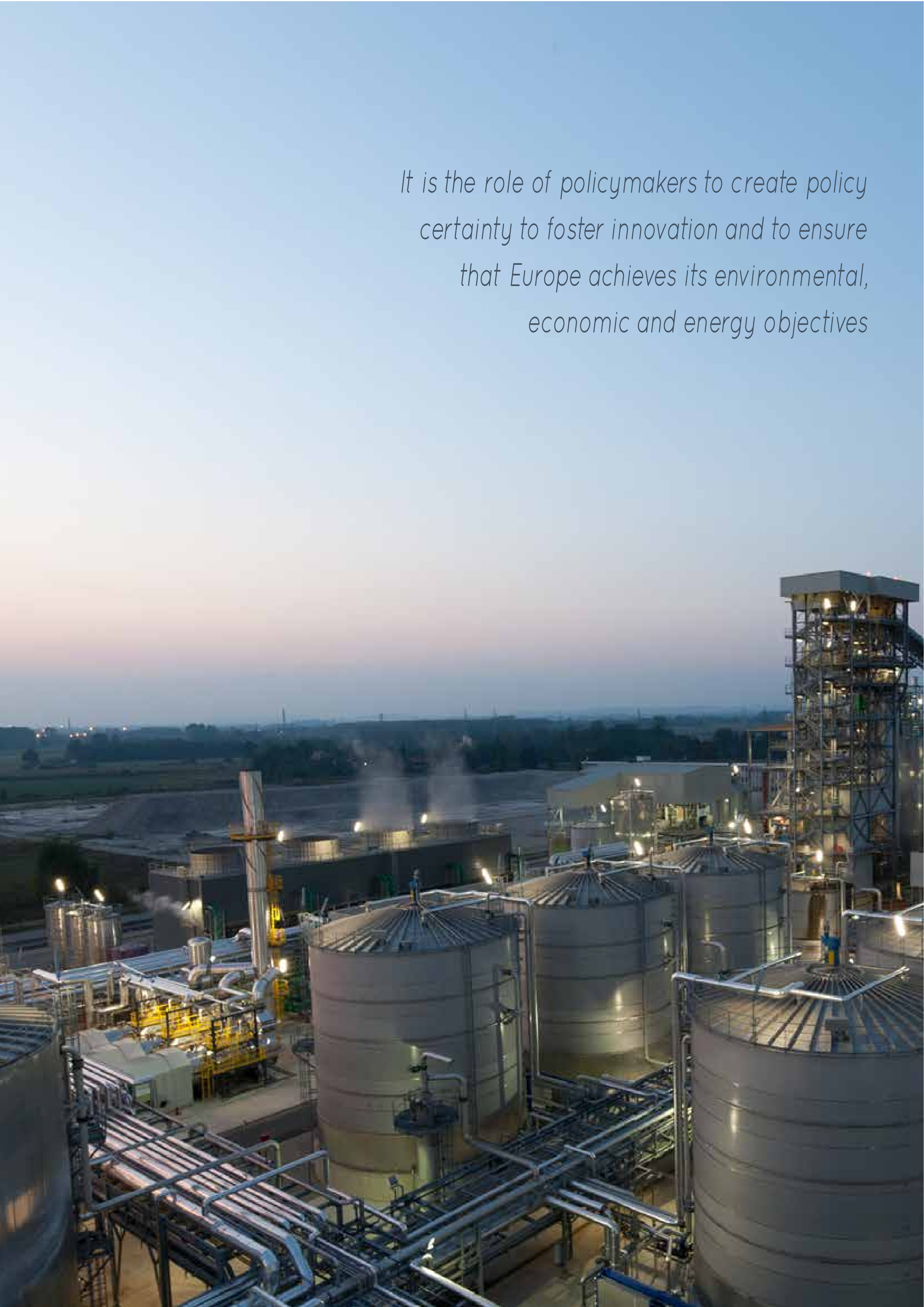
Policy mechanisms to drive advanced biofuels into the market should be based on a thorough understanding of the volumes that are sustainably available and the indirect impacts that might occur from exceeding those volumes. Sustainability criteria must be in place to direct investment towards the most sustainable resources.

The organizations in this project therefore call on the European Parliament and Council of Ministers to deliver a sustainable, stable policy framework to decarbonize transport without delay.

Financial mechanisms will also play an important future role. The proposal to set up a new Public Private Partnership (PPP) to support bio-based industries is a step in the right direction. The estimated budget of this new initiative is €3.8 billion. The EU will contribute €1 billion from the Horizon 2020 programme budget, while industrial partners will commit €2.8 billion. The PPP should help demonstrate the efficiency and economic viability of advanced biofuels and other bio-based products.

The PPP under Horizon 2020 is a starting point that needs to be complemented with other funding sources in order to support advanced, first-of-a-kind commercial-scale biofuel plants. To do so, it would benefit from being combined with structural funds, particularly in Central and Eastern Europe. If such countries connect both funding opportunities, they will benefit from the innovation and economic opportunities while making use of structural funds that are currently underspent.

It is the role of policymakers to create policy certainty to foster innovation and to ensure that Europe achieves its environmental, economic and energy objectives



This chapter summarizes the project's findings on the GHG impact of biofuels from wastes and residues, which are described in greater detail in the paper "Assessing the climate mitigation potential of biofuels derived from residues and wastes in the European context" Baral A, Malins C, 2014 International Council on Clean Transportation

Sustainability

Advanced biofuels from wastes and residues have the potential to deliver high levels of GHG savings, but not all residues can be used sustainably.

This project only considers processes and feedstocks that would deliver significant GHG savings and does not look into feedstocks that were excluded due to sustainability concerns.

Biofuels from wastes and residues have been shown in previous Life Cycle Assessments (LCAs) to deliver high CO_2 savings. Estimates of carbon intensities have ranged from around -25 grams of CO_2 equivalent per megajoule (g CO_2e/MJ) at the low end to 40g CO_2e/MJ at the high end, compared to fossil fuels at around 84g CO_2e/MJ[1,2].

However, previous studies have often overlooked important sources of emissions, such as soil carbon loss, any need to use extra fertilizer if removing residues, and indirect emissions caused by diverting residues and wastes from their existing uses. For forest residues, there is also the issue that in some climates the residues decompose slowly and act as a temporary carbon sink. This has an impact on the potential carbon savings from mobilizing such residues for conversion to advanced biofuels.

The above issues are taken into consideration in this project by using a comprehensive carbon accounting approach. Three biofuel pathways are considered: biochemical ethanol, Fischer-Tropsch (FT)-diesel and pyrolysis diesel.

Biochemical ethanol processes use enzymes to break cellulose down into simple sugars, such as glucose, which are then converted into ethanol. To prepare the cellulosic feedstock for enzymic conversion, it is usually pre-treated with acid, alkali or steam.

During the FT process, feedstocks are gasified at temperatures of more than 700°C in the presence of limited amounts of oxygen and/or steam. This syngas is then converted into diesel and gasoline in the presence of catalysts and at temperatures of 150-300°C.

During pyrolysis, a feedstock is subjected to elevated temperatures in the absence of oxygen, resulting in bio-oil, bio-char, and pyrolysis gases. Bio-oil can be upgraded via hydrocracking to break it down into lighter hydrocarbons for diesel and gasoline.

GHG impact of harvesting

Agricultural and forest residues are important for returning carbon and nutrients to the soil and to help maintain soil fertility, reduce soil erosion and contribute to soil carbon. Hence, residue removal, even when done in line with sustainable practices, is likely to negatively impact soil carbon sequestration potential, a conclusion supported by both empirical and modelling studies[3]. The negative impact on soil organic carbon from residue removal can to some extent be mitigated by agricultural practices such as no-till, manure application or use of cover crops.

This project bases its assumptions for agricultural residues on a long-term empirical study where wheat straw removal was analyzed over a period of 22 years at a site in the UK[4]. It is acknowledged that the assumptions are based on limited data, and additional empirical evidence covering a wider geographical range would be extremely valuable.

Advanced biofuels from wastes and residues have the potential to deliver high levels of GHG savings, but not all residues can be used sustainably

When forest residues are left behind, especially in colder climates like Europe, decomposition occurs slowly, providing a temporary carbon sink if not harvested for biofuels. For example, between 2 and 30 per cent of the carbon stored in twigs and branches (known as slash) may still remain sequestered after a period of 25 years in Northern European countries[5].

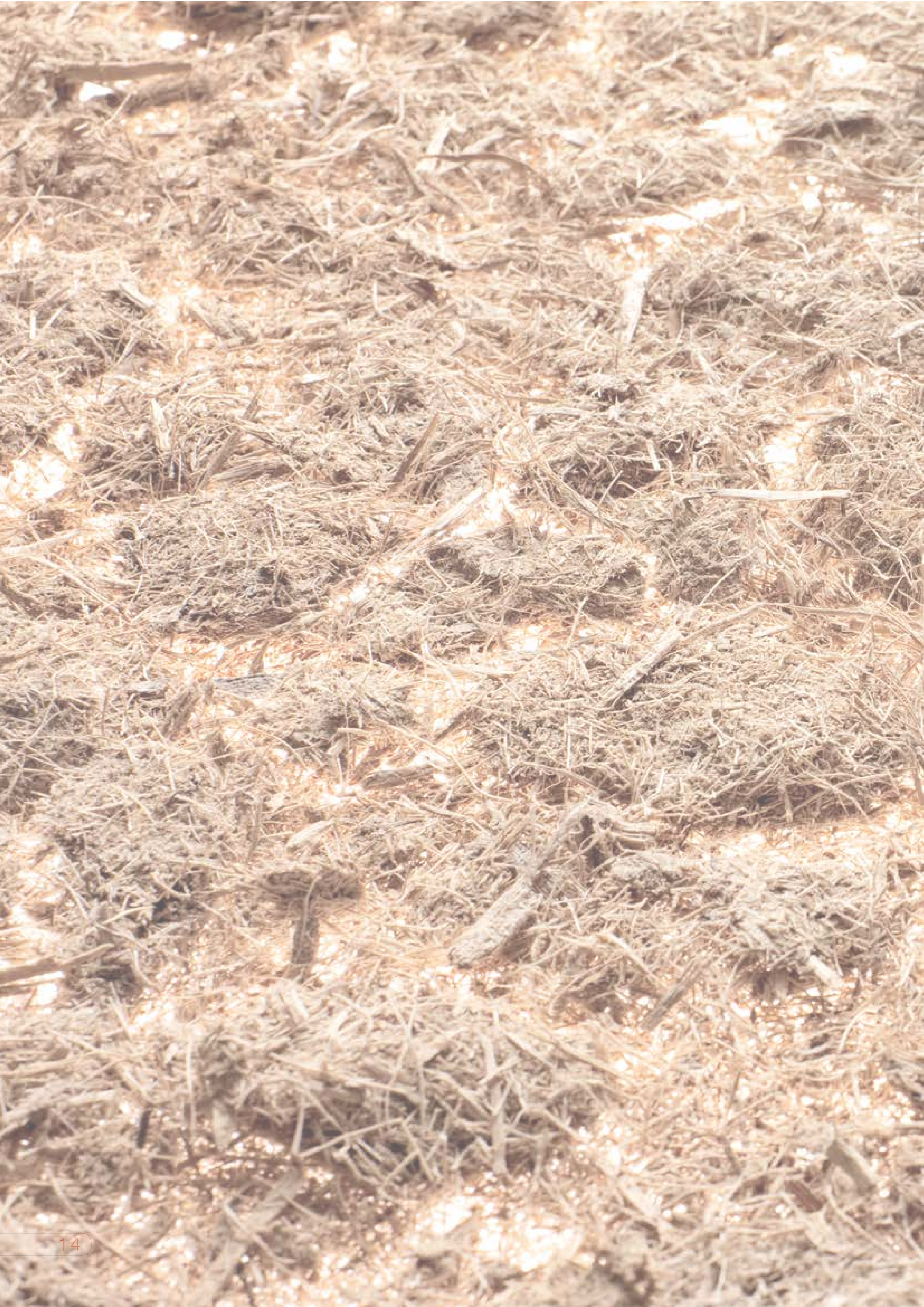
The carbon in un-decomposed forest residues would be released if used for bioenergy, and thus this can be seen as a carbon loss when considering emissions over a 20-year project timeframe. If the timeframe considered were longer, the estimated carbon loss would be smaller. This analysis assumes that 10 per cent of slash will remain un-decomposed at 20 years if not removed for biofuel production.

Previous analysis shows a wide range of results for soil carbon loss. Several empirical studies fail to find evidence of a statistically significant increase in soil carbon loss from the removal of slash[6,7].

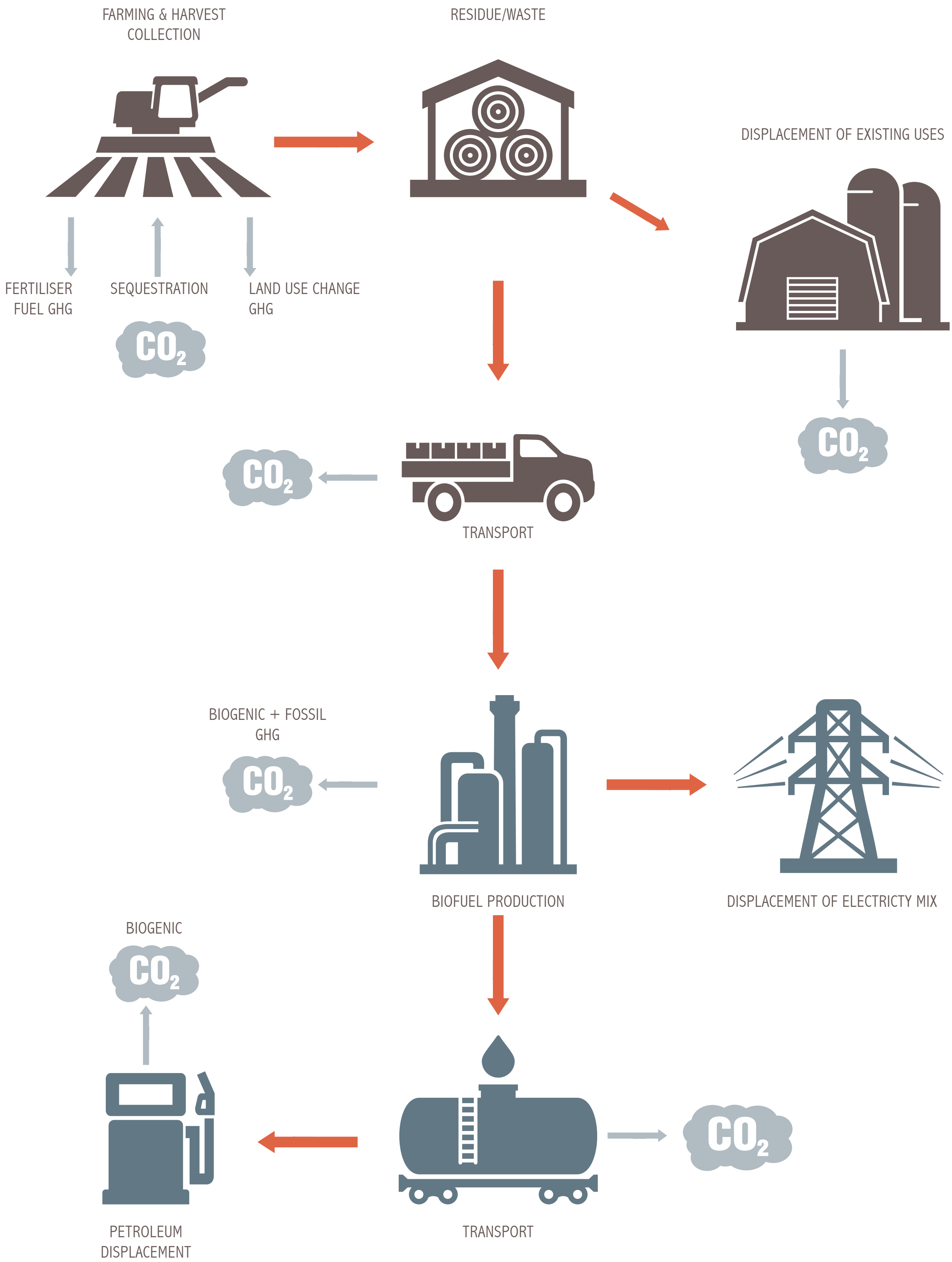
However, several modelling studies do suggest that slash removal might lead to increased soil carbon loss[8,9,10]. In the absence of clear evidence, this study assumes no carbon loss for slash removal in the central case, but it also examines a sensitivity case where 3 tonnes of carbon per hectare is lost.

Since both agricultural residues and (to a lesser extent) slash contain macro-nutrients such as nitrogen, phosphorous and potassium, their removal from fields or forests results in loss of nutrients that would otherwise return to the soil. This implies that to maintain soil fertility, inorganic fertilizers, manure or other residues should be applied to compensate for nutrient loss. N_2O emissions from fertilizers have a particularly significant climate impact.

While in some cases farmers might choose not to fully replace lost nutrients, the analysis in this project calculates the emissions associated with full nutrient replacement.



SYSTEM BOUNDARY FOR LCA OF BIOFUELS FROM WASTE & RESIDUES



GHG impact of displacement

Many types of residues already have uses, ranging from straw for livestock to woodchips for fibreboard to incineration for energy. Depending on the degree to which each resource is already utilized, diverting these resources for use as biofuel feedstock could cause displacement effects leading to indirect GHG emissions.

Although in principle feedstock demand could be met through using unused residues, in the real world it is likely that a certain portion of biofuel may come from residue that has already been collected for other purposes. In line with the conservative approach taken in this project, it is assumed in this LCA that half of the utilized agricultural residues come from increased collection and the other half come from displacing existing uses.

By contrast, for slash there is no existing use, and therefore no displacement is considered. For sawdust, it was assumed that all use for biofuels leads to displacement, as sawdust is currently burned for electricity or used in construction materials and furniture.

Where existing uses are displaced, the analysis in this project assumed the shortfall would be compensated by using either Miscanthus or willow. In reality, there would be a wide spectrum of possible downstream displacement effects and responses, and this is an area where further analysis would be valuable.

Miscanthus is a fast-growing perennial crop that has a relatively high expected yield of about 8 tonnes per hectare in large-scale commercial plantations. Provided food prices remain significantly higher than Miscanthus prices, farmers are likely to plant Miscanthus on land that is not used for food production. Miscanthus sequesters significant amounts of carbon into the soil via its roots and this outweighs the other emissions, such that the overall emissions factor is negative over a 20-year timeframe (-0.4g CO_2e/MJ). The carbon intensity would be significantly higher if planted on fertile agricultural land, due to indirect land use change.

In the case of willow, the emission factor is positive (9g CO_2e/MJ), since carbon sequestration is not large enough to offset the emissions from its farming, harvest and transport.

While displacement impacts generally lead to increased carbon intensity, the converse is true when conversion of residues to biofuel prevents them from decomposing to the potent GHG methane. In many parts of Europe, municipal solid waste goes to landfills, where it would decompose to methane. Therefore, its conversion to biofuel offers significant additional GHG savings. For this pathway, the displacement GHG emissions for ethanol from municipal solid waste amount to -225g CO_2e/MJ. Similarly, leaving rice residues to decompose would lead to methane release, and therefore converting rice straw to bioethanol generates a significant GHG credit.

While displacement impacts generally lead to increased carbon intensity, the converse is true when conversion of residues to biofuel prevents them from decomposing to the potent greenhouse gas methane

Life Cycle Assessment Results

Most of the biofuels from wastes and residues examined in this project were found to deliver significant GHG savings compared to fossil fuels.

Biofuels derived from agricultural residues were found to offer GHG savings of around 80 per cent in most cases, ranging from 73 per cent for rapeseed straw ethanol to 173 per cent for rice straw ethanol, when compared to diesel or gasoline at 83.8g CO_2e/MJ. Even if avoided methane is overlooked for rice straw ethanol, it still delivers GHG savings of around 80 per cent.

When using agricultural residues via the FT-diesel pathway, GHG savings ranged from 77 per cent for rapeseed straw to 176 per cent for rice straw. Similarly, diesel obtained from fast pyrolysis of agricultural residues led to GHG savings of 80 per cent for rapeseed straw to 140 per cent for rice straw. Forestry slash offers reasonable carbon savings depending on the pathway chosen, reaching as high as 61 per cent for pyrolysis diesel.

For sawdust, GHG savings range from 74 per cent in the pyrolysis diesel process to 78 per cent in the biochemical ethanol process. This is despite the significant displacement emissions when sawdust is diverted from existing uses to biofuel production. Without the displacement effects, GHG savings could reach almost 100 per cent. GHG savings are even more significant for municipal solid waste due to the GHG credit for avoided methane, leading to GHG savings as high as 296 per cent.

In conclusion, the evidence presented in this chapter shows that many advanced biofuels from wastes and residues can make a significant contribution to mitigating climate change, even when taking account of losses to soil carbon, displacement effects and the need for additional fertilizers.

Many advanced biofuels from wastes and residues can make a significant contribution to mitigating climate change, even when taking account of losses to soil carbon, displacement effects and the need for additional fertilizers

This chapter summarizes the project's assessment of which waste and residue feedstocks are most sustainable and in what volumes. A more detailed analysis can be found in the paper "Availability of cellulosic residues and wastes in the EU", Searle S and Malins C, 2013 International Council on Clean Transportation

Availability

Availability of crop residues

Considerable volumes of crop residues are produced in the EU, including field residues such as stems and leaves of grain crops, and processing residues such as chaff, husks and cobs. This study assesses availability of the EU's 12 most produced crops using data from the Food and Agriculture Organization of the United Nations Statistical Division (FAOSTAT) (2002-2011).

With modern harvesting technology – combine harvesters that cut, separate and thresh the grain – almost all residues remain in the field. However, not all residues should be considered available for bioenergy. It is widely acknowledged that a fraction of residue should remain in the field to maintain moisture, reduce erosion and protect soil carbon, nutrients and soil structure. In addition, a fraction of residues are currently collected and have other uses, mainly for animal bedding.

Unfortunately, there have been relatively few experimental studies in the EU on the impact of removing residues, and a review of those studies that have been undertaken found significant variation[11]. In the absence of a detailed evidence base, this study relies on the current "best practice" of leaving one-third of total residues in the field, as advised by the EU Joint Research Centre[12]. This is consistent with the current practice of many European farmers, but it is important to stress that the ideal residue retention rate varies by location, soil type, slope, erosion, precipitation patterns, etc., and should be determined on a local level.

A proportion of those crop residues that remain available have existing uses, such as bedding and fodder for livestock, mushroom cultivation and other various horticultural uses. The proportion of residues used for livestock rearing varies widely between European countries, with estimates as high as 42 per cent in the UK (ADAS) and as low as 11 per cent for the EU overall[13]. The wide variance in estimates is likely to reflect regional differences in farming techniques. This project conservatively assumes that one-third of available residues have existing uses. While this approach might result in an underestimate of availability, it allows reasonable confidence that this quantity of material is indeed sustainable.

Based on the assumption that one-third of residues must remain in the field to maintain soil quality, and one-third must be left for existing uses, this study estimates that around 122 million tonnes of agricultural residues are currently sustainably available. Estimates of future availability are extrapolated onwards from the European Commission's 2012 projections of increased agricultural production to 2022. In 2030, this study estimates 139 million tonnes of agricultural residues will be sustainably available, broadly in line with a recent estimate of 155 million tonnes[14].

These numbers are also within the range of other estimates, from 35-53 million tonnes at the low end[15] to 182-229 million tonnes at the high end[16].

Availability of forestry residues

During logging, a significant fraction of the tree – leaves, small branches and stumps – is discarded. These forestry residues are bulky, difficult and expensive to collect and transport, and currently have little commercial value. However, if the market for renewable energy made collection profitable, some of this material could be made available.

The ratio of residues to harvested wood varies widely with species and harvesting technique, but there is consensus in the forestry sector that, on average, about half of any tree is discarded[17]. Scientific literature estimates residues are in the range of 30-50 per cent[18,19,20].

This study uses the assumption from Mantau (2012)[21] that 24 per cent of the tree is discarded as residues, on the grounds that this is a recent publication that is likely to reflect modern harvesting techniques in Europe, and also that it provides a conservative estimate in line with the priorities of this project.

Total residue availability was calculated from FAOSTAT records of EU roundwood production from 2002-2011, leading to an estimate that around 80 million tonnes of forestry residues are produced annually in the EU.

Using all the residues from forestry would mean that nutrients, which are concentrated in the leaves, are no longer returned to the soil, resulting in lower tree growth in subsequent years[22,23,24,25,26,27,28]. Leaving stumps to protect against erosion and leaves to return nutrients to the soil would help mitigate these impacts. Current practice is to leave the needles and leaves in the forest when branches are collected. To estimate forestry residue availability, this study has assumed that it is sustainable to harvest 50 per cent of available residues if combined with good land management practices.

Over the last decade, timber harvesting remained broadly constant. While population growth would suggest an increase in future harvesting, there is also some evidence of a decline in per-capita use of timber. Meanwhile, the long-term growth of competing uses of biomass for heat and electricity generation to meet the EU Renewable Energy Directive remains unclear. This study therefore assumes that sustainable availability of forestry residues in 2030 remains broadly unchanged from today – at around 40 million tonnes per year.

Municipal Solid Waste

European households dispose of around 150 million tonnes of biogenic material each year – mostly discarded wood, paper, food and garden waste. Some of this material is then recovered and recycled or incinerated for heat and power. In many EU countries, the rest is permanently disposed of, typically to landfills. The fraction of waste that can most sustainably be used for biofuel is that which would not otherwise be recovered for any use – in particular that which would otherwise be landfilled.

Generation of Municipal Solid Waste is projected to continue increasing (EEA, 2011), but rates of recycling are increasing at a faster rate, leading to an overall decrease in available volumes between now and 2030.

Paper and cardboard is usually discarded after 1-2 years, and about 81.5 million tonnes were consumed in Europe in 2011, according to the Confederation of European Paper Industries. The waste hierarchy prioritizes recycling above energy recovery because materials are considered to have a higher value when recycled than that reflected by their raw energy content alone, so use of the recycled fraction of municipal solid waste is not considered sustainable. About two-thirds of paper and cardboard is either recycled, composted or incinerated with energy recovery.

Nevertheless, about 17 million tonnes a year of paper waste are estimated to be sustainably available, reducing to around 12 million tonnes annually by 2030 as recycling rates improve. Estimates of the wood fraction of Municipal Solid Waste, for example discarded furniture or renovation debris, are in the range of 26-57 million tonnes per year[29,30]. Of this, around 40 per cent is recycled into other products and around 50 per cent is burned for energy, leaving just under 10 per cent available as a potential feedstock for advanced biofuels. Therefore, about 6 million tonnes a year of wood waste are estimated to be sustainably available in 2030.

Households and businesses also produce a considerable amount of cellulosic material in the form of unused food and garden waste, such as lawn and tree cuttings, with previous estimates in the range of 50 million tonnes per year. Recycling and composting are likely to increase in future years, such that around 44 million tonnes of household and garden waste is estimated to be available in 2030.

Used Cooking Oil

There is already significant and sustainable conversion in the EU of used cooking oil (UCO) to biodiesel. In some countries, such as Germany, there are existing controls on UCO disposal, and using more of it as biofuel feedstock could have some displacement impact. However, in general UCO is still an under-utilized resource. Processing into biofuel can therefore be expected to deliver significant GHG reductions.

It is challenging to find reliable data on the size of the future potential market, due to the fact that the industry collects from a widely distributed network of restaurants. This is especially the case in developing countries. Nevertheless, there is clearly a large resource and potential for expansion. Industry analysts estimate that more than 1.1 million tonnes of UCO was consumed in Europe in 2013. Similarly, the United States Department of Agriculture (USDA) reports consumption of 1.225 million tonnes of UCO feedstock in Europe[31].

Of this volume, about 700,000 tonnes per year are estimated to come from within the EU, but there are also substantial imports of UCO. Eurostat reported over 250,000 tonnes of imported UCO in 2012, largely coming from the United States. Increased collection in the future is likely to be offset by more efficient use. Major growth in UCO supply is therefore likely to require the introduction of home collection, which would require some behaviour change. If cost-effective, supply could also come from harvesting oils from wastewater, which could offer significant environmental co-benefits.

There is also a large potential for increased imports, as in many regions UCO collection is poorly established. In Turkey, for instance, one estimate suggests that only a tenth of the waste oil produced is being collected. In the UK, UCO from 47 countries was used as a feedstock last year[32]. A robust chain of custody and proof of origin – for instance through one of the certification schemes operating in the EU currently[33] – would be needed to prevent malpractice and safeguard the credibility of the UCO fuel market.

Conclusions

A significant volume of wastes and residues are generated in Europe each year – around 900 million tonnes. However, much of these "waste" streams are already being used as low-value inputs for industrial and agricultural processes and cannot be diverted to bioenergy production without secondary impacts on downstream markets. Some proportion of these "wastes" play a valuable environmental role in protecting soil quality, preventing erosion and supporting biodiversity. Taking these points into consideration, this project estimates that 223-225 million tonnes of biomass is technically available as a feedstock for advanced biofuels. To put this in context, if all this material were converted to biofuel at current yields, it could supply 36.7 Mtoe per year of liquid fuel, equivalent to 12 per cent of current road fuel consumption, or 16 per cent of projected consumption in 2030.

There will in reality be competition between different energy users. To ensure this resource is deployed most effectively, policymakers might in the future need to make choices regarding the value of low-carbon mobility versus other demands.

This chapter summarizes an analysis by the National Non Food Crop Centre (NNFCC), which is presented in greater detail in the report "Use of sustainably-sourced residue and waste streams for biofuel production in the European Union: rural economic impacts and potential for job creation", NNFCC, 2014

Economics

Crop residues

Wheat and barley straw are commonly traded in Europe for use in the livestock sector. Small amounts are also used in the horticulture sector. While straw is a relatively low-bulk density product, this does not prevent intra-EU trading, which has involved transport of significant tonnages across long distances.

In areas of high demand, straw can be collected on up to 80 per cent of the barley area and 60 per cent of the wheat area. If not collected and removed, it is typically ploughed back into soil.

There are a number of issues that affect the price of agricultural straw residues, such as transport costs and the impact of weather on supply. As an example, Figure 5.1 shows the variability in wheat straw costs experienced in the UK in recent years.

Wheat and barley straw prices also vary significantly between EU Member States. Cereal straw is scarce in the Netherlands and straw prices are high, at around €110-120 per tonne, reflecting that most straw is imported. Prices in eastern and southern Europe can be as low as around €25-40 per tonne, reflecting lower labour costs.

Where straw is being used for heat and electricity, buyers have developed long-term supply contracts with growers. These offer longer-term security to farmers, but the price on offer can be €20-30 per tonne below that on the open market. The development of advanced biofuels creates opportunities to develop more efficient supply chains, supplying reliable markets with long-term contracts for straw.

A straw price of €60-80 per tonne (delivered) is a reasonable estimate for northern Europe, and €30-40 per tonne would be more typical for southern and eastern Europe. Cost for collection, transport and replacement fertilizer can amount to €30 per tonne. Taking all these issues into account, the actual profit margin for the farmer is likely to be only a few euros per tonne at residue prices of €30-40 per tonne, although this margin rises to €28-43 per tonne in areas where farmers can charge €60-80 per tonne for straw.

Forestry Residues

The largest reserves of forest residue resources are to be found in Finland, France, Germany, Poland, Spain and Sweden. However, with the exception of Finland and Sweden, these residues are currently not collected. Where costs have been estimated, these tend to be higher in Northern Europe, reflecting the mechanized approach adopted for collection, and lower in Eastern Europe where labour costs are lower.
Harvest residues are typically collected in bundles and then either stored or chipped at the roadside. Efficiency can be improved by chipping at a central 'receiving plant' before onward shipping to the end user.

Different collection techniques and supply chains lead to wide variation in estimates of cost. The PIX Bioenergy Forest Biomass index, which is based on real material trades in Finland, shows prices of €62.5 per tonne, but other studies show costs as low as €25 per tonne, especially in areas of low labour cost. Transport of forest residues adds around €8-12 per tonne to the delivered price for a trip of up to 100 kilometres (km)[34]. It is uneconomic to transport chips more than 200km over land. These costs are in line with current market prices for industrial wood chips of around €59-65 per tonne[35].

Municipal Solid Waste

Given the wide range of contaminants in municipal solid waste, biofuel plants are likely to rely on a steady stream of pre-sorted waste, known as Refuse Derived Fuels (RDF). RDF, in addition to wood and paper, will also contain plastic and other fossil-derived combustible materials that cannot easily be removed by recycling processes. Only a proportion of the feedstock, and therefore any biofuel produced from it, can therefore be classed as 'renewable'. However this is typically much greater than 50 per cent, and can be as high as 80 per cent, depending on the sorting and separating technologies used.

Use of RDF is compatible with advanced conversion processes utilizing thermochemical conversion, but its heterogeneous nature makes it less suitable for biochemical processes. Waste handlers and processors incur charges to dispose of such waste via landfill, and therefore biofuel operations might be able to charge a gate fee in the range of €20-40 per tonne for accepting the material. The low end of this range is typical for areas where RDF is currently used for power generation, indicating that increasing bio-energy investment could ultimately lead to lower gate fee revenue for accepting RDF.

Impact of feedstock costs

The business case for advanced biofuels from wastes and residues is highly dependent on access to a cheap and reliable supply of feedstock. Figure 5.2 shows the economic incentives that would be required to make biofuels from agricultural or forestry residues competitive with those made from food crops. In regions where feedstocks are cheapest (€30-40 per tonne), little or no incentives are required to make biochemical ethanol cost-competitive with first generation biofuels. By contrast, in regions with high feedstock costs (at €80 per tonne), this industry is unlikely to take off without sustained incentives.

Biofuels derived from municipal solid waste are cost-competitive even with zero gate fee receipts. In cases where they could charge gate fees at current levels of around €20-46 per tonne, the ethanol or FT-diesel produced should be saleable at a competitive price (see Figure 5.3). However, compensation is required to cover the lower value fossil-derived biofuel produced as a co-product (from fossil contaminants in the waste stream, which are likely to be traded at a discount to bioethanol).The barriers to investment are largely a result of policy uncertainty and investor attitudes to risk associated with technologies that have not been demonstrated at large scale.

Impact on the rural economy

Up to €15 billion could flow into the European rural economy if all the available agricultural and forest harvest sustainably resources could be utilized at the price-range identified (€40-80 per tonne for agricultural residues and €40-65 per tonne for forest harvest residues). This would flow back through the whole feedstock supply chain, including the supporting logistics operators, machinery suppliers, contracted equipment suppliers, etc.

Taking account of the costs beyond the farm gate – mainly replacement fertilizer and transport – net revenues of up to €5.2 billion annually would flow to the farming community. In the case of forestry, the net return would be up to €2.3 billion annually.

This project has also sought to estimate the amount of employment that would be created in rural economies as a result of utilizing wastes and residues for advanced biofuels. Using typical work-rates in the agricultural and haulage sectors, it was estimated that 470-680 workers would be needed annually to process 1 million tonnes of feedstock over a year. Previous studies in Scandinavia[36,37] have estimated between 340-620 workers would be required to shift 1 million tonnes of forestry residue, although it should be noted that Scandinavian forestry systems are highly mechanized and would therefore be at the low end of the range of employment intensity.

FIG 5.1

Seasonal and annual variation in UK big bale wheat straw average price (£ per tonne ex-farm, good quality) (source: UK Hay and Straw Traders Association)

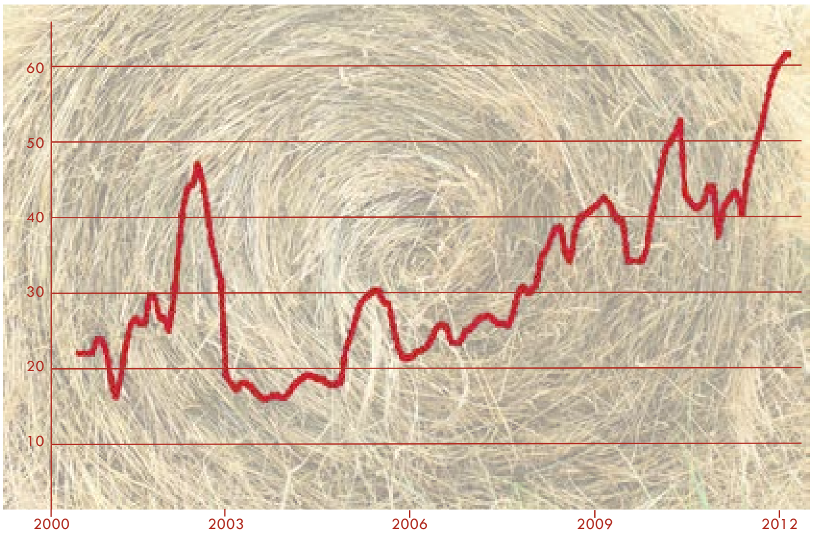


FIG 5.2

Effect of feedstock price (€ per tonne) on the incentive required over and above the anticipated base fuel market price to achieve an internal rate of return (IRR) of 10,15 and 20 per cent for biochemical ethanol processes using agricultural or forestry residues.

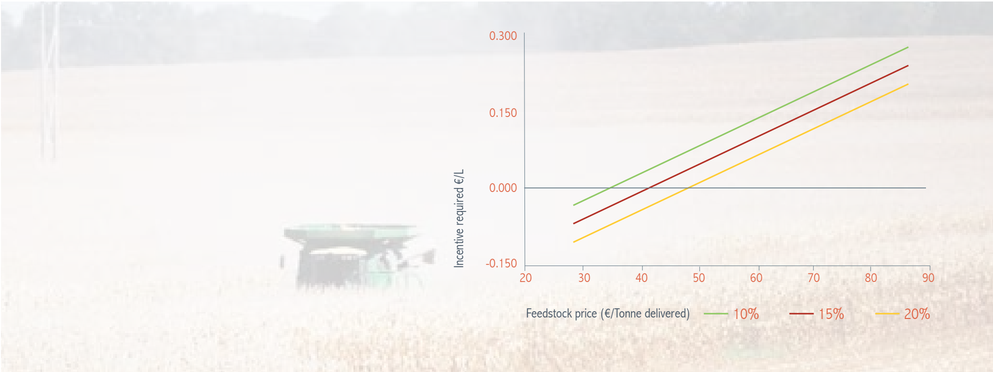
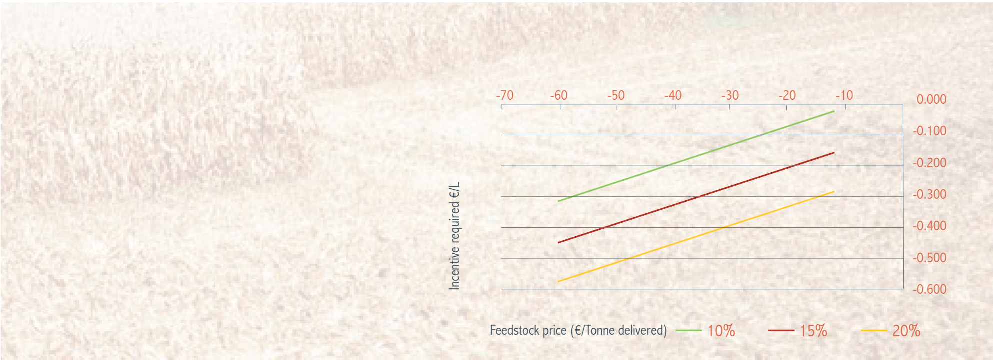


FIG 5.3

Effect of feedstock price (€ per tonne) on the incentive required over and above the anticipated base fuel market price to achieve an IRR of 10,15 and 20 per cent for FT-diesel process using municipal solid waste.



As with most refining of fuels, there is low labour intensity associated with operating a bio-refinery (around 50-80 full time employees per plant), but significant levels of temporary employment are created during the construction phase. For example, the Vivergo wheat-to-ethanol plant, which recently opened in the UK, created about 1,000 jobs in its construction phase.

Based on the level of feedstock availability estimated in Chapter 4, it is possible to estimate the full potential for job creation from developing an advanced biofuels industry in the EU using sustainable wastes and residues as feedstock. To make full use of this resource, in the range of 87-126 thermochemical biofuel plants would be needed, each requiring around 300,000 tonnes of feedstock annually. Alternatively, in the range of 105-162 biochemical ethanol plants would be needed for around 150,000 tonnes required annually.

On this basis, 56,000 to 133,000 permanent jobs would be created in the rural economy if the full potential of wastes and residues were developed in the agricultural and forestry sectors. In addition, construction of these biofuel plants would require 87,000 to 162,000 temporary workers. Operation of these plants would create 4,000 to 13,000 permanent jobs.

It should be noted that in reality, competition will be high from the heat and power sector, and utilization is unlikely to take off in all regions. Furthermore, reaching this scale would require a sharp increase in investment. Therefore the real creation of direct jobs will be much lower than the full potential.

These represent only the direct employment associated with feedstock collection, transport and processing. Additional indirect employment would flow though machinery suppliers, fuel suppliers and other ancillary industries, significantly increasing the overall employment impact in the EU.

Conclusions

This analysis highlights that it is feasible to develop a biofuel industry based on use of agricultural and forest residues, which in the case of the cheapest feedstocks could become cost-competitive with only modest incentives. Such fuels would have the added advantage of avoiding land-use change impacts. Similarly, refuse-derived biofuels could be cost-competitive without further support, as long as feedstocks are available at little or no cost. However, some support would be required to compensate for the lower returns anticipated for fuels derived from the fossil component of refuse.

Chapter 4 demonstrated that converting all the sustainably available wastes and residues to road transport fuels could in theory deliver technical potential of 16 per cent of demand in 2030 if a rapid and large scale investment programme could be put in place. However, in reality the volumes would be lower due to problems mobilizing the entire resource at reasonable cost and investing in the large number of biorefinery plants required.

While utilising all of the available resource might be viewed as optimistic, achieving just 2 per cent of EU road transport fuel in 2020, as suggested by the European Parliament, would be less challenging.

Such a level would secure up to an additional 38,000 permanent jobs in the rural economy and 3,700 more jobs in biofuel refineries, with the potential to return up to €1.1 - 2.4 billion in net revenues to the agricultural and forestry sectors.

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This synthesis report is based on the following three publications:

"Assessing the climate mitigation potential of biofuels derived from residues and wastes in the European context" Baral A, Malins C, 2014 International Council on Clean Transportation.

"Availability of cellulosic residues and wastes in the EU", Searle S and Malins C, 2013 International Council on Clean Transportation.

"Use of sustainably-sourced residue and waste streams for biofuel production in the European Union: rural economic impacts and potential for job creation", NNFCC, 2014.

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NT CONCERN GROUP

新界關注大聯盟

垃圾處理技術報告

2013 年 11 月 23 日

Resolute in New Territories 屹立新界	Caring for Hong Kong 關顧全港
Campaigning for consensus 凝聚共識	Striving for the common goals 達至大同

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目錄

（I） 前言

新界關注大聯盟（“大聯盟”）於 2013 年 5 月 4 日成立，我們是一個非政治組織，純粹關心香港事務，匯聚各界好友意見，搭建議政平台。在監察政府各項施政方針之時，亦同時協助政府施政，平衡社會利益，舒緩各方壓力和矛盾，最後達至和諧共融的狀況。

今次我們出訪荷蘭的阿姆斯特丹、鹿特丹及英國的倫敦，就是爲了構建與海外華僑的連繫，加強了解他們的生活情況，同時解答他們關心的議題，比喻他們新生一代的居港權的問題。

與此同時，我們亦趁此機會考察海外不同處理廢物的方法，例如焚化爐，氣化基地、及等離子氣化基地，以便我們日後向香港政府提交有關研究方案，供其參考有關應對香港現時的重要議題- 廢物處理的方法。

今次歐洲考察團的報告分爲兩部分，而今次發表的報告屬於第一部分，有關垃圾處理；而第二部分關於海外華僑的居港權報告，將會在稍後時間發表。

（II） 新界關注大聯盟背景

「新界關注大聯盟」於 2012 年 9 月 30 日由 11 位村民及村長爲僭建申報計劃而成立，最初名爲「爭取新界屋宇僭建物合法化關注大聯盟」，政府自推出「新界村屋僭建物申報計劃」後，引起了社會廣泛討論和強烈反對聲音。該計劃違反“無罪推論”絕非合理，而沒有提供實際長遠解決方法，相信受影響業戶人數絕不單只三萬，實際數字有可能超過十萬以上。

雖然鄉議局對此事一直表示關注，但未能爲居民和業戶向政府爭取得到更大的保障措施，相反轉變爲協助政府執法，有見及此，居民和業戶於去年十月初成立了關注組，自行發起「爭取新界屋宇僭建物合法化」運動，希望可以在建制外向政府主動表達意見，而關注大聯盟就在此種情況下形成。

在 2013 年 4 月 5 日一次聚會中，出席者有感而發，大家需多見面及爲新界各方面爭取，包括推動村代表薪酬調整運動。2013 年 5 月 4 日宣佈改名爲「新界關注大聯盟」及成立會議，就政府發展新界的政策和事務上，無論是僭建、丁屋、填海、交通或大廈管理等等大小事情，都會發揮監察作用，爲市民發聲，協助政府推動更均衡施政方針，舒緩各方的壓力與矛盾，就現時新界的政策和事務發表意見。

鄧鎔耀主席在會議中報告，未來〝小雨點的行動〞將會包括整個香港，特別是新界事務，並以提升村代表薪酬爲其中一個重要工作。何君堯律師在會議中亦宣佈大聯盟宗旨及組織架構，當晚出席與會者共 55 人。

A) 大聯盟宗旨

大聯盟須根據香港法例第 151 章社團條例登記註冊（牌照號碼：CP/LIC/SO/19/49006），其宗旨是：－

(1). 向政府爭取：-
  (a). 擴闊現時政府所倡議的 19 項適意設施範圍；
  (b). 修改現時建築物條例，加設住宅改造之簡易申報程序，並容許業戶進行合法改建；
  (c). 將 2011 年 6 月 28 日以前在丁屋增建的非嚴重違規構築物變爲合法化。

(2). 向政府反映新界居民對政府發展新界政策的意見以及加強溝通連繫工作；

(3). 向政府爭取村代表合理薪酬和津貼調整；

(4). 向政府爭取改善居民生活環境設施；

(5). 連繫各區居民或非政府組織，提高守望相助意識，加強各界聯誼活動；

(6). 統籌及連繫各鄉村和各區成立的類似目標的關注組。

B) <u>架構</u>

執委會轄下設有以下五個專責工作小組，分別負責以下特定工作：

(1). 屋宇適意設施小組：負責有關丁屋僭建及申報計劃事宜，爭取修改現時建築物條例；

(2). 新界關注組：負責研究新界整體發展政策工作；

(3). 權益小組：負責處理有關鄉村或屋宇權益的工作、爭取調整村代表薪酬和津貼調整；

(4). 社區活動小組：負責組織文娛活動、關注大廈業主權益、聯繫非政府機構，加強各界關係及安排聯誼活動；

(5). 行動支援小組；負責組織、支援其他小組工作。

C) 執委會成員 Committee Members

Executive Committee / 執委會

1. 鄧鎔耀主席
Chairman-
Tang Yung Yiu

2. 曾樹和副主席
Vice Chairman-
Tsang Shu Wo

3. 鄧德森副主席
Vice Chairman-
Tang Tak Sum

4 許卓豪司庫
Treasurer-
Hui Cheuk Ho

5. 文光明秘書
Secretary-
Man Kwong Ming

6. 何君堯公關
Public Relations-
Ho Kwan Yiu

7. 文中慶執委
Executive Committee member-
Man Chung Hing

8. 周振勤執委
Executive Committee member-
Chau Chun Kun

9. 馮應祥執委
Executive Committee member-
Fung Ying Cheung

10. 張日華執委
Executive Committee member-
Cheung Yat Wah

D) 訪問團名單及個人簡歷 CV of the Delegation and Researchers

1. 鄧鎔耀 (Ronnie Tang) 	主席 Chairman	多年來，鄧鎔耀一直專注於公司業務發展，業務覆蓋不同行業，如環保、農業發展、物業等範圍。鄧鎔耀亦熱心社區事務，促進八鄉和諧發展，其公職包括： 1. 八鄉北環境關注組創會主席 (2012 至今) 2. 八鄉橫台山村代表 (1999-2011) 3. 香港汽車遊樂會主席 (2003 至今) Ronnie Tang has for many years been focused in business development. He has been involved in different businesses. Ronnie also participates warm-heartedly in providing his services to the community, promoting the harmonious development of Pat Heung. Other public duties include 1. Founding Chairman of Pat Heung North Environment Attention Group (2012 to present) 2. Village Representative in Wang Toi Shan Pat Heung (1999-2011) 3. Chairman of Hong Kong Paradise Of Motor Cars (2003 to present)
2. 文光明 (Kenny Man) 	秘書 Secretary	文光明於英國 Lancaster 大學畢業後，成爲工程師，投入行業發展。文光明於 2011 年，參選區議會選舉，並以 1,865 票成功當選，成爲元朗新田區區議員。 Upon graduating from Lancaster University, UK, Kenny Man leads a successful career as an engineer. In 2011, Kenny stood in the District Council elections where he won by 1,865 votes, becoming the District Councillor for San Tin, Yuen Long in New Territories.
3. 何君堯 (Junius Ho) 	公關及策略顧問 Public Relations	何君堯（Junius K.Y. Ho），執業律師，是何君柱律師樓的高級合夥人之一，主理訴訟及商業部門，亦同時兼任廣州辦事處首席代表。 何君堯於 1988 年取得香港執業律師資格，其後分別在 1995 年及 1997 年取得新加坡和英國及威爾斯執業律師資格，2003 年被委任爲中國委託公證人。於 2011 年，何君堯獲安格裡亞魯斯金大學頒授榮譽法學博士學位。 從 1995 年起，何君堯積極參與香港律師會相關業界發展工作，除了身爲香港律師會前任會長和現任

		理事之外，何君堯也參加了多項公職和社會工作包括： 1. 新界屯門良田村原居民村代表 2. 第二十一屆屯門鄉事委員會主席 3. 屯門區議會議員 4. 新界鄉議局第三十三屆執行委員會當然執行委員 5. 產品環保責任上訴委員會主席 6. 香港足球總會 2011 至 2015 年度獨立董事 7. 匯蝶公益有限公司（註冊慈善機構）創會人 Mr. Junius K. Y. Ho, is a Senior Partner of Messrs. K.C. Ho & Fong, Solicitors & Notaries in charge of their Litigation and Commercial Practices. He is also the Principal Representative of their Guangzhou Office. Apart from being a solicitor in Hong Kong, Junius is also qualified as a solicitor in Singapore and England and Wales since 1995 and 1997. In 2003, he was appointed as a China-Appointed Attesting Officer. Junius was awarded with the honorary degree of Doctor of Laws by Anglia Ruskin University in 2011. Apart from serving his own legal profession and being President of the Law Society of Hong Kong (2011/2012), he also serves, inter alia, the following various Government and advisory boards:- 1. Village representative of Leung Tin Village, Tuen Mun 2. Chairman of Tuen Mun Rural Committee 3. District Councillor of Tuen Mun District Council 4. Ex Officio Executive Member of the 33rd Executive Committee of Heung Yee Kuk 5. Chairman of Product Eco-responsibility Appeal Board Panel 6. Independent Director of Hong Kong Football Association from 2011 to 2015 7. Founder of Butterflyers Association Limited, a charitable organisation.
4. 文中慶 (Rix Man) 	執委 Executive Committee member	文中慶是公司董事，並投入社區工作，專注與不同團體的聯誼交流，建立廣大的人際關係網絡。其公職包括： 1. 新田蕃田村村代表(1999 至今) 2. 元朗區體育會董事(2011 至今) 3. 惇裕學校法團董事會校董 4. 江西省海外交流協會理事

		Rix Man is a Company Director and is heavily involved in providing his services to the community. He is involved with many different groups and has therefore established a wide international network of friends. His other public duties include: 1. Village Representative of San Tin Fan Tin Tsuen 2. Director of Yuen Long District Sports Association (2011 to present) 3. Member of the Council of Tun Yu School
5. 郭逸駿 (Harry Kwok) 	統籌員 Coordinator	郭逸駿畢業於香港中文大學，主修政治與行政學系，現時爲何君堯議員的私人助理，同時兼任新界關注大聯盟的統籌員。 Harry Kwok graduated from the Chinese University of Hong Kong, where he majored in the Government and Public Administration. He is now the personal assistant to Mr. Junius Ho as well as a volunteer coordinator in the NT Concern Group.
6. 鍾偉基 (Vincent Chung) 	研究員 Researcher	鍾偉基出生於蘇格蘭，於羅伯特哥頓大學(2007-2012)及史崔克萊大學(2012-2013)修讀法律學位。他在 2013 年 8 月於何君柱律師樓受聘爲法律輔助人員。他在提供法律工作外，亦爲新界關注大聯盟進行有關等離子氣化技術的研究工作。 Vincent Chung was born in Scotland and studied at Robert Gordon University, Aberdeen (2007-2012) and studied at University of Strathclyde, Glasgow (2012-2013). He has been a paralegal at K.C. Ho & Fong since August 2013. He currently carries out his legal duties as well as researching on Gas Plasma Technology on behalf of the NT Concern Group.
7. 何俊螢 (Charlotte Ho) 	研究員 Researcher	何俊螢現時於香港中文大學主修環境科學學系，亦爲新界關注大聯盟進行有關等離子氣化技術的研究工作 Charlotte Ho is majoring in Environmental Science at the Chinese University Hong Kong and currently researches on Gas Plasma Technology on behalf of the NT Concern Group.

(III) 行政摘要

香港每人平均每日的都市固體廢物量爲 1.27 公斤，而香港政府在它最近發表的香港資源循環藍圖 2012－ 2022 中，表明 2022 年前要將上述數字減低 4 成，即 0.8 公斤。藍圖中提出會加強 3Rs 及推行垃圾徵費計劃，而環境局預計在 2022 年，55% 的垃圾將會被回收，23% 及 22% 的垃圾則分別會被焚化及放置在堆填區上。

現時新界西北的屯門堆填區、新界東北的打鼓嶺堆填區及新界東南的將軍澳堆填區分別佔地 110、61 及 100 公頃，並會在 2019、2017 及 2015 年前逐步飽和。爲了擴展屯門堆填區約 200 公頃，政府申請 3,530 萬的撥款，研究擴建有關的技術可行性，而整個計劃可能會用近 90 億港元。打鼓嶺及將軍澳堆填區則會分別擴展 70 及 43 公頃，總成本共約 80 億港元。但是，相關計劃亦引起社區人士的不滿和憤怒。

當局現正提出興建能夠每日處理 3,000 公噸垃圾的大型焚化爐，將坐落於石鼓洲對出海岸的人工島，或在屯門曾咀。如在石鼓洲興建，政府需要動用 100 億港元填海，興建焚化爐則需 150 億。政府認爲，焚化技術可以將廢轉能及十分潔淨，所以是解決香港污染問題的最佳選擇。

但我們認爲焚化技術弊多於利，並不適合在香港應用。轉廢爲能需要焚燒垃圾，但在有氧氣的情況下，850℃ 的高溫燃燒會製造出二噁英、有毒飛灰(2%)及底灰（22%)。灰燼需要經過特別處理後才能運送到堆填區，未能真正減輕堆填區的壓力。有關的焚化爐計劃正受司法覆核挑戰，所以開始運作的時間會推遲至 2022 年，而擴展堆填區、填海及興建焚化爐將會花費納稅人高達 420 億港元。簡而言之，焚化爐令港人不滿，亦會破壞環境，費用甚巨。

另一方面，等離子氣化技術及熱解氣化相比焚化，明顯是更佳的選擇。自然的等離子平時都可以在閃電中見到，而等離子穿過氣體時便會產生電能，將溫度提升至超過 5,000℃，成爲等離子氣化技術的能源。

該技術產生出合成氣，經過處理後可以成爲電力、噴射燃料、熱能及蒸氣等。其中一種副產品－ 泥渣(Slag)可以加工成爲安全的建築混合物。加上該技術可以創造工作機會，可見等離子氣化是一個達至共贏的技術。等離子氣化不會製造無用的剩餘物料，所以無須堆填區，甚

至可以將現有的堆填區進行土地回墾。同時，它在運作時不會產生廢氣。對政府而言，等離子氣化工房只需佔地 30 畝，花費 72 億元便可每日氣化 2,000 噸的垃圾，在屯門曾咀興建可以是一種解決垃圾問題的答案。如果進行試驗計劃，等離子氣化技術只須 3 年，即在 2017 年前，便可每日處理 300 公噸垃圾，令屯門成爲綠色功能城市，協助政府早 5 年完成 2022 年的藍圖目標。該技術以單組件運作，在不同公司成功運作，例如 Solena Fuels, Westinghouse Plasma Corp, Advanced Plasma Power 及 Tetronics。這種技術已應用超過 30 年，並不如政府稱般不成熟。

因此，我們希望政府能小心、合理及有智慧地選擇一個能讓社會各方都能勝利的解決辦法。等離子氣化／熱解氣化技術或者是其中一個答案！

(IV) 報告全文

1 簡介

1.1 世界各地的廢棄物棄置量十分龐大，尤其在發達國家，這個現實的問題令人擔憂。爲了有效而且長久地解決這個問題，香港政府必須採納有效的廢棄物管理策略和系統。

1.2 在香港資源循環藍圖 2013-2022(“藍圖”)，政府希望將現時每日人均都市廢物棄置量由現時 1.27 公斤減至 2022 年的 0.8 公斤。[1]

1.3 不同國家及香港都普遍採用的主要環保概念是“三個 Rs”（Reduce, Ruse, Recycle），可以達到減廢目的，其含意如下：

(a). 減少： 從一個製造商以及從消費者的角度，由源頭開始使用更少的資源;

(b). 再用： 在棄置或回收前重用，考慮廢棄物可否再次以不同目的使用，就如餅乾盒；以及

(c). 回收：分類、收集舊資源以製造新的物品。[2]

有時恢復（Recovery）（“垃圾發電而產生的能源”）和棄置垃圾於堆填區（最不可取）也會被用到。在這份報告中，三 R 亦包括將恢復和棄置這兩個概念。

1.3 香港現有的三個堆填區預計將在 2015 年至 2019 年飽和。[3]政府提出的解決方案，表面上遵循 3R，但只是以先導模式來延長廢物分類（經過反復的公眾諮詢後）和嘗試引入廢棄物收費制度來敷衍社會上對環保的要求。但政府在本質上，是希望以擴建堆填區和/或製造一個世界上最大的焚燒廠，每天處理 3000 公噸城市生活垃圾。此計劃將於 2022 年左右投入使

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[1] http://www.enb.gov.hk/en/files/WastePlan-E.pdf

[2] http://www.nrdc.org/thisgreenlife/0802.asp 及 http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2012/07/25/000333037_20120725004131/Rendered/PDF/681350WP0REVIS0at0a0Waste20120Final.pdf

[3] http://www.enb.gov.hk/en/files/WastePlan-E.pdf p.6.

用。然而，擴建堆填區計劃瀕臨觸礁，因爲今年較早前被立法會延遲審議，而石鼓洲焚化計劃亦因司法審查而被拖延。

1.4 新界關注大聯盟在訪問歐洲期間，親眼目睹了歐洲準備投入運作的熱能技術。我們認爲這是對香港廢棄物管理更合適的解決方案。氣化技術有以下 3 個關鍵的好處：

(a). 安全：不會排放二噁英或其他毒氣。最近的科學研究顯示焚化爐釋放的氣體在不同程度上危害人體健康;

(b). 有經濟利益：只要每日它可以以每日處理超過 300 公噸廢物或以上，便可產生利潤。（而建議案中的焚化廠預計有逐年增加的巨大虧損）；

(c). 有效配合堆填：氣化技術生產出的副產品沒有毒害，可以即時用作建築原料。而建議案中的焚化爐需要將有毒殘留物玻璃化，然後才可送往垃圾堆填區。

（惰性泥渣）[4]

事實上，歐洲和美國都有採用氣化技術，改良和回復舊有的堆填土地，爲後代回復綠色環境，所以這技術可以應用於土地特別稀缺及珍貴的香港。

1.5 建基於這些調查結果，氣化技術可以爲香港在解決廢物問題上創造一個共贏的局面，因此我們建議政府進一步考慮氣化技術，並嘗試於 2017 年進行試驗計劃。

1.6 對環境的好處

1.6.1 等離子氣化及／或連同氣化的熱解不會產生有毒剩

[4] http://www.httcanada.com/asbestos.html

餘物質，所以屬於較佳的技術；而排放物方面亦較焚化技術少，所以是較潔淨的解決垃圾問題的方法。再者，氣化技術不會產生需要棄置堆填區的剩餘物質，甚至容許進行回復土地。

1.7 對社區的好處

1.7.1 使用氣化技術的工廠佔地較少，而且不會有 150 米高的大煙囪，所以周邊社區不會有厭惡性的影響。相反，有關技術如在屯門試驗，可以爲屯門居民帶來更多的工作機會，亦可以爲當地居民提供電費優惠。另外，回復堆填區可以將土地轉回爲正常用途，爲社區提供有用的土地。

1.8 對政府的好處

1.8.1 氣化技術不需政府投入大量資源，反而有更大的成果。例如，若氣化工廠設置於屯門污水處理廠旁邊，政府便不需爲焚化爐填海而浪費數十億元。同時，氣化技術可以解決堆填區飽和及需要擴展的壓力。引入新技術刺激香港的企業家精神及增加就業，爲經濟發展提供動力。加上政府對當地社區及香港投入資金以建造氣化工廠，令屯門成爲綠色功能城市，更可以令香港繼續保持競爭力、創新及接受新思維的國際樞紐。再者，相比堆填區會引起鄰近城市的反感，氣化技術可以減少圍繞珠江三角洲的污染問題

1.9 我們稱氣化技術爲共贏策略，配合三 R。如此一來，香港就可以更安全、高效和有利地管理其廢物，並同時回復堆填區（政府目前堅持擴建）的珍貴土地而另作用途。

1.10 我們相信，現時的 3R 策略可以通過獎勵，鼓勵市民將廢棄物用於回收或用作他用。例如，當家庭和企業回收廢鐵罐、玻璃瓶等，政府可以獎勵小額金額，進一步加大分類和資助廢棄物回收、再用、減少。因此，我們相信三個 R （recycling, re-use and reduction）策略應該被重新命名爲四 R（recycling, re-use，reduction and reward）策略。

2 報告背景

2.1 我們認同政府要盡快推行公平和合理的垃圾徵費，因爲在多年的公眾諮詢後，我們認爲政府不應以沒有諮詢爲籍口而推遲立法。廢棄物收費計劃的立法應在未來 6 個月內提交立法會並於明年年底（2014 年）實施。

2.2 我們也同意政府有關延長廢棄物分類回收的建議。同時，我們看不出有任何理由，有關計劃不能推展於全港。政府有權力向立法會提出強制廢棄物分類的法案，並有充足資源提供相應的基礎設施。例如政府有能力可以於明年年底（2014 年）前，提供每家每戶一個免費的分類垃圾桶以及組織有系統的廢物收集團隊。上述計劃如能在全港實施，可以爲目前處於貧困線以下的家庭提供適切的就業機會。而政府最近的香港貧窮情況 2012 報告估計，低於貧窮線的人口佔全港的八分之一。

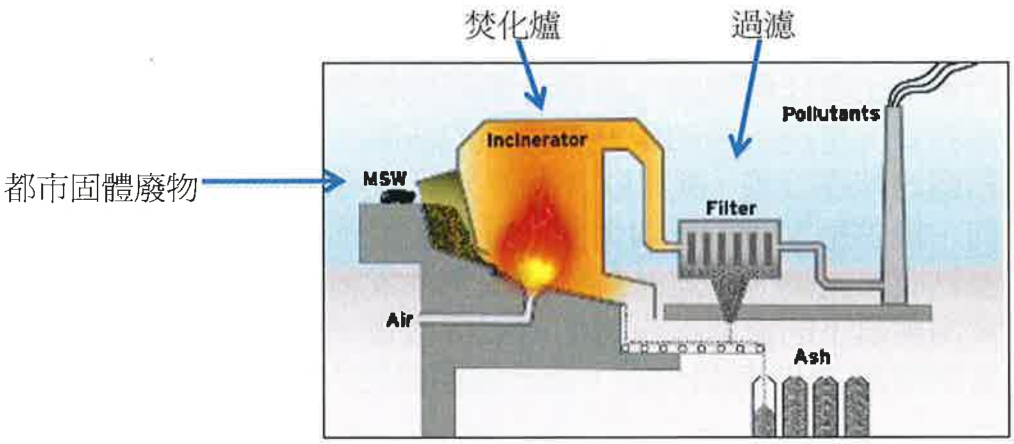
2.3 根據政府統計，加強有機廢物分類作另外處理，如通過多層污水處理，將大大減少 44%送往垃圾場的廢棄物的數量，同時減輕在堆填區內難聞的氣味。當然，這方法亦有效舒緩目前擴建垃圾堆填區的壓力。

2.4 剩下的問題是我們應如何對待和處理剩餘的廢棄物。政府提出香港需要擴建堆填區，是因爲焚化爐（擬議的 30 年週期內產生百萬公噸）所產生的有毒殘留物，必須在堆填區處理和傾倒。我們相信現時有比焚化爐處理更先進的技術去處理廢棄物。此技術不會排放有毒物質，亦不會產生垃圾，需要堆置於堆填區。這些技術將不需要堆填區擴建計劃，但可以拯救現時堆填區的土地，增加香港珍貴的土地。他們將可以讓政府以零成本達到目的。這些技術將爲目前香港的廢棄物危機提供一個共贏的解決方案，以維護香港的未來。爲了方便起見，我們使用涵蓋性術語“等離子氣體”來描述等離子氣化及氣化熱解技術。

2.5 有關焚燒和等離子氣體之間的分別，請見附錄（附錄 7.1-焚化與等離子氣化）[5]以及下面的段落：

[5] http://www.futurenrg.net/technology/plasgasification.htm 及 http://www.dovetailinc.org/files/u1/PlasmaGasificationPresentation.pdf

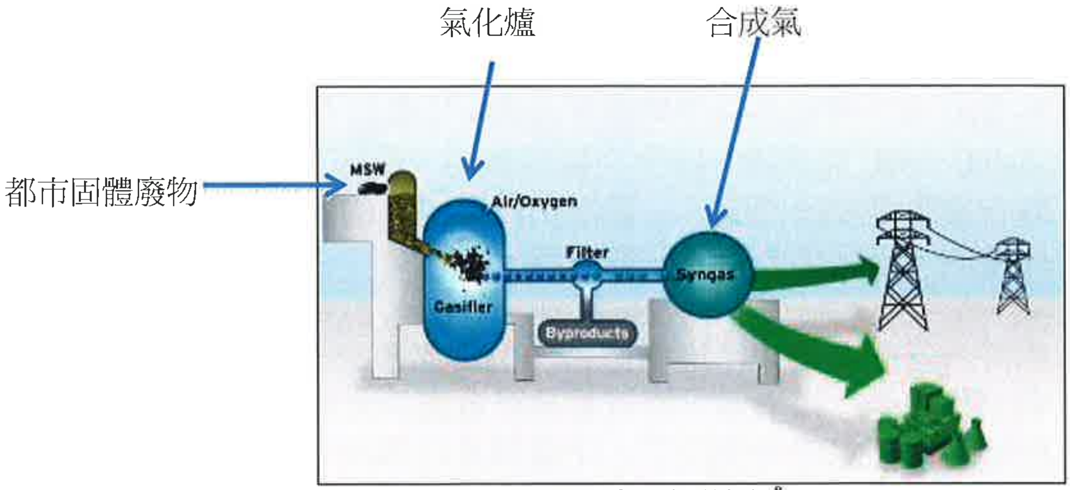
2.5.1　下圖顯示基本的焚化過程。 固體廢棄物和大量的空氣進入焚燒室。在充分燃燒後，剩下來的污染物物才能被過濾。焚化爐亦需要一個大煙囪（約 150 米高度），在釋放廢氣到大氣前，盡可能過濾雜質。同時，副產品飛灰亦會出現，飛灰必須在特殊的垃圾堆填區小心處理。而焚燒產生的熱量可用於發電。



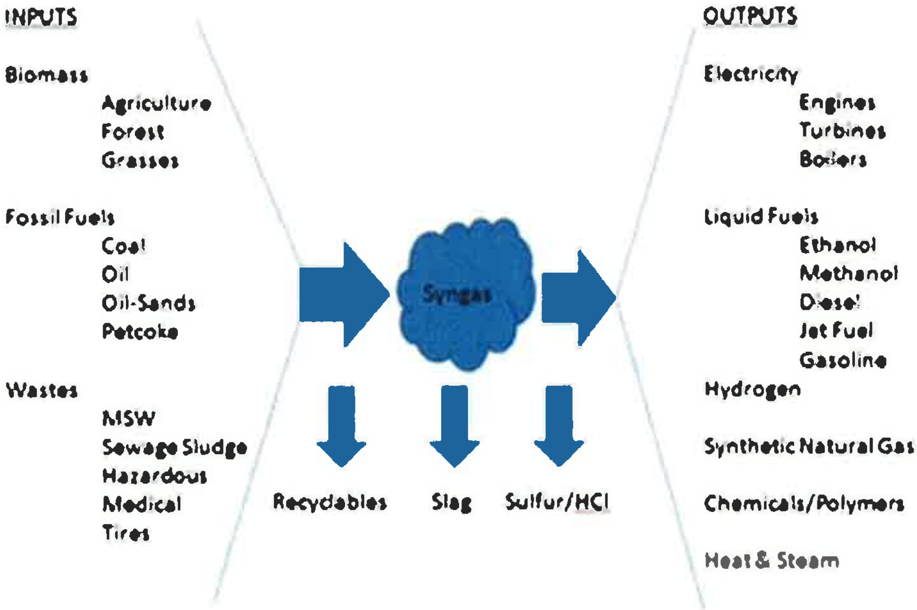
（一般焚化過程）[6]

2.5.2　等離子氣化與焚化過程類似，從下圖中一個簡化的離子氣化過程可以看出。固體廢棄物進入氣化室後，會因極高溫度而分解成最基本的成分。這個過程沒有空氣/氧氣的成份。在使用等離子氣化技術時，當電能穿越氣體時，會產生出等離子（即極高的熱能，可在閃電中測試到，最高可超過 5,000°C），啓動及輔助氣化的運作，令過程更具效率。[7]通過濾系統後，合成氣便會產出。

[6] https://www.gasification.org/page_1.asp?a=87 (由短片中抽出)
[7] http://gasification.org/page_1.asp?a=84



（一般等離子氣化的過程）[8]



(合成氣的產出及副產品圖示) [9]

2.5.3 相關的熱力及能量在收集以後，會提供給工廠作爲能源。而在安裝（地下）管道以後，附近 25 平方公里[10]的社區都可以享受到較便宜的電費，如在暖水池、老人院及商業機構。

2.6 香港的環保政策應以多管齊下的方式，去配合香港的特殊情況及充分地利用現存的技術和基礎設施。

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[8] https://www.gasification.org/page_1.asp?a=87 (由短片中抽出)

[9] 可見於 http://www.waste-management-world.com/articles/print/volume-10/issue-4/features/plasma-gasification-clean-renewable-fuel-through-vaporization-of-waste.html

[10] 請閱讀“RAV Water Treatment” 的部分

2.7 在 2011 年，香港每日平均產生 9,000 公噸都市固體廢物[11]及約 13,400 公噸[12]廢棄物。即使在徵收費用、做好分類以及特別處理有機廢棄物的情況下，香港仍會有殘餘的廢棄物，需要另外處理，否則仍要棄置在堆填區上。

2.8 爲符合三個 R 要求，堆填應是一個別無他法的最後選擇。堆填浪費香港珍稀土地，所以香港社會應只允許在無法使用其他垃圾技術處理的情況下，才選擇進行填埋（見附錄 7.2-三 Rs）。

2.9 在 2006 年，由於污染或完全飽和的關係，13 個香港堆填區已被關閉。其中多數被檢定安全的堆填區，已經被重新建設成休閒設施。現時位於新界西屯門、新界東北打鼓嶺及新界東南的將軍澳的三個堆填區均正常運作，但其容量在 2015 年和 2019 年之間將達到飽和。[13]三個堆填區佔地面積分別爲 110，61 及 100 公頃。[14]

2.10 政府提出擴建堆填區來解決這個問題，但因爲社會反對聲音激烈，政府已自行撤回在將軍澳的建議，而餘下兩個地點的方案亦不成功。不過，立法會工務小組委會員本來於 7 月 2 日投票決定是否撥款 3,500 萬港元研究擴展屯門堆填區的可行性，而未來的擴展費用預計將達 90 億元。[15]如果工務小組當時真的同意撥款，屯門、打鼓嶺及將軍澳堆填區將會大幅擴展多 200、70 及 43 公頃[16]，而後兩者總共的擴建費用爲 80 億元。[17]提出擴建堆填區的方案不合邏輯，因爲香港土地是稀缺資源，理應能得到更好的利用，而非放置垃圾。

2.11 政府最終是否將這個花費約 180 億港元的擴建計劃通過是一回事。[18]但政府同時希望興建大型焚化爐，作爲擴建堆填區不可或缺的一部分，亦意味著政府沒有考慮大局。政府沒有研

[11] http://www.enb.gov.hk/en/files/WastePlan-E.pdf
[12] http://www.info.gov.hk/gia/general/201309/25/P201309250437.htm
[13] http://www.epd.gov.hk/epd/english/environmentinhk/waste/waste_maincontent.html
[14] http://www.legco.gov.hk/yr05-06/english/sec/library/0506in37e.pdf
[15] http://www.scmp.com/news/hong-kong/article/1349309/government-press-plans-expand-two-landfill-sites
[16] http://www.legco.gov.hk/yr12-13/english/panels/ea/papers/ea0527cb1-1079-1-e.pdf
[17] http://www.scmp.com/article/996194/incinerator-bigger-landfills-cost-hk23b
[18] http://www.scmp.com/news/hong-kong/article/1268868/tseung-kwan-o-landfill-expansion-faces-defeat

究其他方案，只是固執而逐步地推行這個花費至少 150 億以上港元、需時七年的大型焚燒爐[19]。石鼓洲人工島填海工程(將會距離指定保育區的 10 米內，將耗資約 80– 100 億港元[20])

(黃色爲擬建的石鼓洲大型焚化爐的選址）[21]

建成日期預計於 2022 年，而每年需要政府 3530 萬元來運作。[22]然而，目前有市民提出司法覆核，阻礙興立焚化爐方案。它也在去年被立法會的環境諮詢委員會否決。然而，目前有市民提出司法覆核，阻礙興立焚化爐方案。它也在去年被立法會的環境諮詢委員會否決。

2.12 另外，政府亦考慮於曾咀煤灰田上興建焚化爐，鄰近現時同樣使用焚化技術的污水處理廠。若擬建的焚化爐成功落實，它將每日處理 2,000 噸的垃圾[23]，而建造費將會高達 50 億港元。[24]

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19 http://www.scmp.com/news/hong-kong/article/1317862/families-could-pay-hk74-month-dump-waste-says-consultation-paper

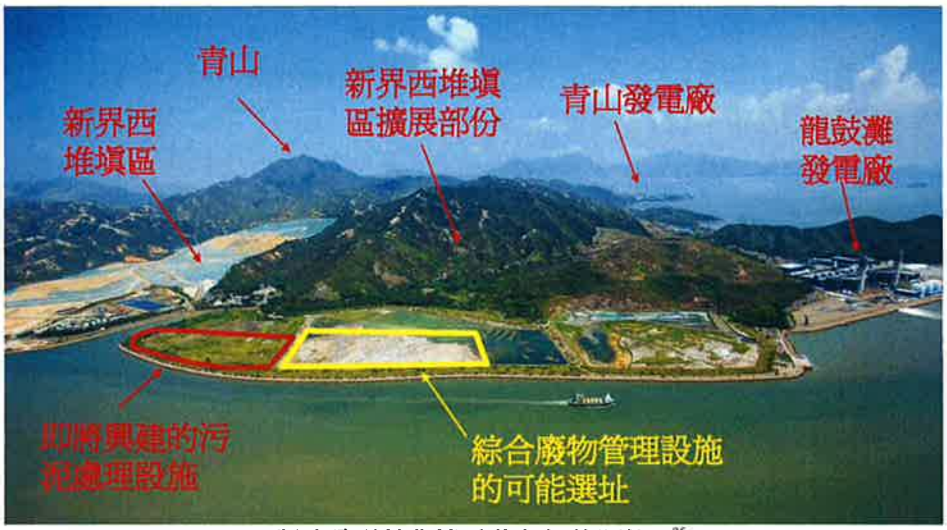
20 http://www.scmp.com/article/996194/incinerator-bigger-landfills-cost-hk23b 及 http://www.scmp.com/article/997235/costly-incinerator-will-be-waste-money（基於填海 16 公頃土地的預算成本）

21 http://www.epd.gov.hk/epd/tc_chi/environmentinhk/waste/prob_solutions/WFdev_IWMF.html

22 http://www.scmp.com/article/996194/incinerator-bigger-landfills-cost-hk23b

23 http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/WFdev_TMSTF.html

24 http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/WFdev_TMSTF.html



(擬建曾咀焚化爐（黃色）的照片) [25]

(黃色爲擬建焚化爐所在地- 曾咀，紅色爲擬擴建的 200 公頃堆填區)

2.13 無論任何地點，如曾咀或石鼓洲，政府對於焚化爐的大力支持，都是假設和建基於 2009 年年底的調查報告。[26]現在的廢物處理技術較 2009 年，已經有了重大革新。例如氣化或等離子氣化技術已經十分進步，在氣化後不會剩下約 22%的底灰(焚化後的副產品) [27]，因此無須擴展堆填區，甚至有回復堆填區的可能。

2.14 政府當局提出，城市生活垃圾不需要預先處理或分類便可進入焚化爐 。這意味著將所有廢棄物，不論可否回收，都會投入焚化爐處理。同樣地，等離子氣化技術也可以處理未經分

[25] http://www.epd.gov.hk/epd/tc_chi/environmentinhk/waste/prob_solutions/WFdev_IWMF.html

[26] Advisory Council on the Environment- "Integrated Waste Management Facilities Technology Review and Associated Facilities"- ACE Paper 22/2009

[27] 請閱附件 7.3- 數據（雖然氣化會製造 12%灰）

類的廢棄物，但產生出的能源如電力，氫氣和噴氣燃料的能量不會達至最高水平，但泥渣的數目將更多[28]，能有效減少入口的建築混合物數量。[29]（按我們理解，香港十分依賴建築混合物的入口[30]，而透過這個步驟來產生混合物，會優勝過在工場製造）[31]。所以它也繞過第二個和第三個 R,即重用和回收，直接跳到到次選的回收和處理。

2.15 政府環境局最近公佈“香港 2013 至 2022 年循環資源藍圖”（藍圖）[32]中，提倡惜物、減廢的概念。基本上，藍圖道出政府的願景、明確了介定香港面對的機遇和挑戰，並提供了一個 2022 年之前的行動綱領、目標以及廢物管理的架構。

2.16 雖然藍圖對香港廢物問題有幫助，但政府不接受新的概念，未能掌握大局。相關部門堅持認爲焚燒是唯一有效的辦法，不承認世上已存在其他創新和合理的廢物處理方法，未能達至資源的可持續性。等離子氣化並不是一種處於開發階段的技術。爲了進一步檢視大規模的可行性，我們建議政府可以以屯門爲測試點，進行爲期 2 年的試驗運作，處理運往屯門堆填區的垃圾。這類試驗計劃不會影響政府藍圖及時間表，更可以避免現時興建大型焚化爐因司法訴訟所導致的延遲。

[28] http://www.futurenrg.net/technology/plasfaq.htm

[29] http://www.edb.gov.hk/attachment/en/curriculum-development/kla/pshe/references-and-resources/geography/article-geological_resources.pdf

[30] http://www.epd.gov.hk/epd/SEA/eng/files/Quarry%20Study%20Brief%20(Part%20Version%20covering%20SEA).pdf

[31] http://www.academia.edu/800697/The_Application_of_recycled_aggregate_for_the_urban_sustainability_of_Hong_Kong_construction_industry

[32] http://www.enb.gov.hk/en/files/WastePlan-E.pdf

3 調查

3.1 通過此次歐洲調查之旅，新界關注大聯盟親眼目睹第一手資訊，瞭解各種設施的操作以及與不同的管理人員交談，得到確定的事實和數字。

3.2 WSS Infocard System(“WSS”)[33]

3.2.1 此種垃圾分類系統於 2003 年在荷蘭運作，採納了特殊的儲存庫 (Units)，而大部分的服務在後來被外判出去。

3.2.2 儲存庫基本上埋在地下，只有頂部露出地面。儲存庫均採用類似“八達通卡”的計分系統，以太陽能作爲電力。當用戶將卡放在機上的讀卡器，垃圾便可根據相關類型分類，而得到適當的處置。在量度數據後，WSS 會在每月月底向當地居民發送信件，鼓勵或教育用戶有關廢物分類的做法。

3.2.3 我們的代表團參觀了一個在萊斯韋克（Rijswijk）的住宅區，看到了 WSS 的機械車如何將分類好的儲存庫廢物運送。機械垃圾車使用機械爪，慢慢提起儲存庫，而周圍的平版裝置便會彈起，避免傷及路人。一旦儲存庫放在廢棄物收集車上，底部的扁平版便會打開，將垃圾投入卡車內。然後，儲存庫的護翼會返回到其原來的閉合位置，並且小心翼翼地返回原來位置。整個過程耗時約 10 至 15 分鐘。

[33] WSS Infocard Systems at Rijswijk, the Netherlands with Managing Director, Mr. Paul van Alphens. Visited 18/09/13.

(機械車正在拉起位於地下的 WSS 垃圾儲存庫)

3.3 RAV Water Treatment（“RAV”）[34]

3.3.1 RAV 從 70 年代起運營，是 AVR-AFVALVERWERKING BR（“AVR”）集團的一部分。最近它被長江實業集團有限公司收購。[35]它在荷蘭有兩個位置，一個在 Rozenburg，另一個在 Duiven，都是採用焚化技術、生物能源技術和水處理或堆肥。

3.3.2 當焚燒廠運行時，廠內溫度介乎於 850℃ 和 1000℃ 之間[36]，並需要氧氣才能燃燒垃圾。其中一個二惡英產生的原因是焚化爐燃燒大量垃圾，而二噁英在焚燒爐啓動和關閉時產生最多。現時，荷蘭境內的垃圾都會在這兩個焚化爐被處理。荷蘭同時都進口不少來自歐洲的垃圾，例如愛爾蘭等，令焚化爐可以以最佳水平運作。正因如此，該廠坐落在一個港口，道路四通八達。由於周邊沒有太多的住宅區，所以即使是最大型煙囪也不會有太大的視覺衝擊。

3.3.3 除了二噁英，呋喃和二氧化碳的排放，含毒的飛灰和

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[34] RAV Water Treatment at Rozenburg, the Netherlands with the Director. Visited 16/09/13

[35] http://www.scmp.com/business/companies/article/1262719/li-ka-shing-buy-dutch-waste-firm-us126b

[36] http://europa.eu/legislation_summaries/environment/waste_management/l28072_en.htm.

底灰也是焚化爐的副產品。 RAV 知道飛灰會嚴重污染環境，所以需要特殊堆填技術來處理，便用混凝土來混和以減少污染。金屬可以從底灰中萃取，然後可重用於加固土壤，鋪設鐵路和輔助混凝土。

3.3.4 熱能及蒸氣可以用作發電及支援附近 25 平方公里的社區使用。

（新界關注大聯盟的成員、荷蘭朋友及 RAV 職員）

（RAV 焚化爐的大煙囱）

3.4 Advanced Plasma Power（“APP”）[37]

3.4.1 APP 坐落在英格蘭的西南部的斯溫頓（Swindon），屬於兩階段的等離子氣化廠，使用石墨電極。作爲一個測試中心，APP 會爲客戶測試他們預先分類的垃圾廢物（垃圾衍生燃料（RDF）），並提供詳細的分析結果。它的視覺衝擊是相對較低的，外部看起來像一個倉庫。

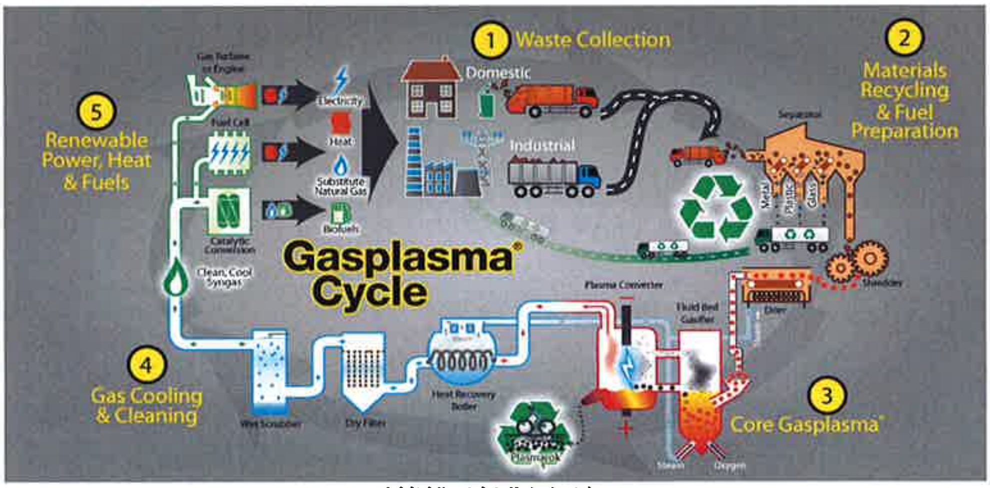
3.4.2 氣化爐運作時，會在 1500℃ 無氧的爐內，等離子氣體會產生強烈的熱量和紫外線（“UV”），令爐內達到

[37] Advanced Plasma Power at Swindon, UK with Sales Director, Mr. Steven Gill and Sales Consultant, Ms. Vicky Jones. Visited 19/09/13.

約 5,000˚C 或 5,273˚Kelvin 的最高溫度（太陽表面溫度是 5,504˚C 或 5,778Kelvin）。由於氣化爐會利用紫外線來分解有害氣體的排放，所以產生的氣體都十分潔淨（只可以為 10 億份之 1 來量度）。

3.4.3 當使用切碎至 10mm 的塑膠和橡膠，與 RDF 一起乾燥，熱值也比較高。垃圾衍生燃料會經過採用 850˚C 的流化床運行環境的氣化爐，產生飛灰和氣體，然後通過等離子轉換器，利用石墨電極來破開及打磨爐內的空氣，而製造出潔淨的合成氣。這種合成氣可以用作噴氣燃料[38]，液化石油氣或家庭炊事用氣等等。產出的飛灰會被玻璃化，變成等離子石(Plasmaroc)，其硬度比花崗岩還高，可用於道路建設。由於等離子石產生時是處於熔融狀態，所以它還可以被模塑成所需的材料。

3.4.4 一旦開始操作，工廠便可以自我持續工作，能源不斷循環使用。



（等離子氣化圖示）[39]
1. 收集垃圾
2. 物料回收及燃料準備
3. 氣化核心
4. 氣體冷卻及潔淨
5. 可再生能源、熱能及燃料

[38] http://www.solenafuels.com/index.php/projects
[39] http://www.advancedplasmapower.com/solutions/process-overview/

3.5 New Earth[40]

3.5.1 該地點位於英格蘭西南部的埃文茅斯（Avonmouth）。該廠採用熱解及氣化技術進行兩階段的垃圾處理，主要目標是生產電力。廠房第 1 期在 2013 年 2 月投入運營，而第 2 期仍在興建。氣化廠旁邊有一個超市儲存廠房，New Earth 與超市達成協議，New Earth 負責處理超市產生的垃圾廢物，而 New Earth 廠房所產生的電力將會供給超市使用。New Earth 本身也沒有很大的視覺衝擊，看起來像一個堆放了 30 米高的聚光器的倉庫。

3.5.2 熱解過程使用了 New Earth 先進熱能（"NEAT"）技術，它可以在一個受控的燃燒環境下處理不可回收的垃圾衍生燃料，因此不存在產生二惡英的問題。過程中產生出來的富碳注入氣化爐後，便會產生出蒸氣，從而釋放動力，而最後得到熱解和合成氣。另外，有一個氣旋室亦需要安裝以清潔合成氣。

3.5.3 此廠只需在啓動時投入能源，之後的運作自我維持。

3.5.4 每生產一兆瓦的電力，該廠就能要求雙倍的可再生能源義務點數（ROC， 由英國政府頒發），以證明他們已經達到他們的[再生]義務[41]，每點價值大約￡40 至￡46 英鎊[42]。英政府會每周幾次到場抽出樣辦檢測，以確保公司已達到可再生能源的標準。

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[40] New Earth at Avonmouth, UK with Business Development Director, Mr. Graham Lockyer and Technical Director, Mr. Scott Edmondson. Visited 20/09/13.

[41] http://www.biomassenergycentre.org.uk/portal/page?_pageid=77,20190&_dad=portal&_schema=PORTAL , http://www.bloomberg.com/news/2013-02-13/u-k-sets-renewables-obligation-buy-out-price-at-42-02-pounds.html and https://www.ofgem.gov.uk/environmental-programmes/renewables-obligation-ro.

[42] https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/the-renewables-obligation-ro

（New Earth 組件）[43]

3.6 Air Products[44]

3.6.1 "世界上最大的可再生能源工廠位在英國，它採用先進的氣化 EFW 技術" [45]。這個工廠包括 Tees Valley 第 1 期和第 2 期（"TV1" 和 "TV2"）,估計分別在 2014 及 2016 年完工並投入營運。由於建設工程尚未完成，代表團只能訪問 Air Products 的英國總部。總部坐落在英國東南部的 Hersham。 TV1 和 TV2 等離子氣體廠將運用單一階段過程，將不可回收的 RDF 轉換爲電能。興建 2 座工廠的土地屬於填海土地，當中使用的建築材料有玻璃化後的爐渣，而它的外觀看起來像一個倉庫。

3.6.2 有關技術是在無氧室使用石油焦炭（"焦炭"），而火炬會確保燃燒物完全轉化無機材料爲合成氣，或融化的無機材料爲熔渣。這個過程能自給自足。通過這過程，合成氣體會被清洗，同時經過氣體渦輪機，並產生電力。

3.6.3 TV1 和 TV2 項目得到英國政府的支援[46]，雙方簽署了多項協議。Air Products 能收到英國政府 30%的補貼，

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43 http://www.waste-management-world.com/articles/2013/06/13-mw-rdf-pyrolysis-gasification-plant-starts-up-in-avonmouth.html

44 Air Products UK Headquarters at Hersham, UK with Regional Manager-EMEA, Mr. Duncan Snelling, Business Manager, Ms. Lisa Jordan and Principal Research Engineer, Dr. Andrew Shaw. Visited 20/09/13.

45 http://www.airproducts.co.uk/teesvalley/

46 http://www.letsrecycle.com/news/latest-news/energy/work-starts-on-2018world2019s-largest2019-gasification-plant

而英政府亦保證津賠能維持 20 年，以及每當生產一兆瓦電力時能得到雙倍的再生能源義務點數。

1. 分解組件　2.氣化過程　3. 合成氣潔淨　4. 能源潔淨

（Air Products 等離子氣化的過程）[47]

3.7 爲此，新界關注大聯盟從多個廢棄物管理廠獲得多組數據（見附錄 7.3-數據）。這些客觀數據能有效幫助我們比較等離子氣化技術與現時香港政府宣導的焚燒技術的優劣（見附錄 7.1-焚化與等離子氣化）。

3.8 我們可以清楚地看出，雖然焚化爐能處理更多的都市固體廢棄物，但它的成本比等離子氣體技術多出一倍。相反，若建設雙倍的等離子氣化技術工廠意味著等離子氣化可以處理同樣的生活垃圾量，但可節省至少 4%，即約港幣 6000 萬元的建築成本。此外，等離子氣化的設施如超過“寄生負荷“（從處理過的生活垃圾中提取能量，以保持機構運行），便可以在有盈利的基礎上運營。目前的等離子氣化技術的負載量雖低於焚化爐，但政府倡導的焚化爐，將會逐年虧損約 3,530 萬港元。

[47] http://www.airproducts.co.uk/teesvalley/industrial_gas_facility.htm

（Air Products 氣化組件）[48]

48 http://premierconstructionnews.com/2013/09/24/a-breath-of-fresh-air/

4 分析及箇中問題

4.1 新界關注大聯盟原則上同意政府的藍圖，但不能同意其提出之方案。然而，政府在對香港的廢物管理作出決定時，必須站在公平的基礎上，考慮不同類型的政策措施。爲了服務公眾，爲了公眾健康，爲了優美環境以及公眾利益，政府必須拋開只有唯一解決方案之偏見。

4.2 政府已經採取幾乎是危言聳聽的策略，只強調必須緊急處理垃圾廢物的情況。然而，面對反對的聲音以及其他障礙，香港實際上十分落後，只用堆填焚化來處理垃圾。政府提出在2022年，即9年後，建成大型焚化爐。 未到那個時候，當前的堆填區很可能已經飽和而需要擴建。

4.3 環境保護署（環保署）認爲只有焚化爐才能處理每日3,000公噸的城市生活垃圾，但他們未認知到，焚燒爐需要源源不斷的未分類垃圾，因此將需要從其他國家進口廢棄物而滿足焚化爐的運作需求。這變相忽略任何合理進行回收的可能性。而燃燒未分類的垃圾，完全與政府的資源循環使用哲學相違背[49]。未分類垃圾肯定會包含了食物，當中有更高的濕度(高達90%)，需要更大比例的能量來燃燒[50]。因此，政府現時將香港擬建的焚化爐與歐洲已做好分類，只有15% 濕度的焚化爐比較，用錯誤的數據誤導了公眾有關香港焚化爐的的效能[51]。

4.4 環保署也無向公眾提及，當啓動和關閉焚化爐時，將會產生最高水平的二噁英和呋喃。剩餘的有毒產品-飛灰，“是被歐洲廢物目錄列爲其中一種絕對有害物質”[52]。若不小心處理也會對環境造成危害，導致在附近的地下水和生態系統受破壞。開啓和關閉焚化爐將會加速附近生物，包括附近居民的死亡。飛灰在後期處理（即必要的玻璃化）[53]後，將不能避免地增加了它的質量和體積，估計爲10%至30%，因此仍需要特殊堆填。特殊堆填相比現有的'正常'的垃圾堆填區，不僅需

[49] http://www.scmp.com/comment/letters/article/1347824/sticking-shek-kwu-chau-incinerator-best-option
[50] http://news.newclear.server279.com/wp-content/uploads/2013/10/SomefoodforthoughtUpdated.pdf
[51] http://www.wtert.eu/default.asp?Menue=13
[52] http://www.ecomed.org.uk/content/IncineratorReport_v3.pdf
[53] http://www.ecomed.org.uk/content/IncineratorReport_v3.pdf

要額外費用，而且會對香港的生態系統造成不良影響。[54]

4.5 等離子氣體技術，在無氧的氣化器中，使用極高溫度的熱能，將不能回收的廢物衍生燃料分解成爲基本元素，即氫、一氧化碳和水。有機化合物會被轉換成合成氣和無機化合物（如金屬）， 在熔化反應器中融化成惰性、無毒花崗岩產物，然後便可以安全地作爲建築材料使用。危險物質如二氧苣類氣體和微粒將在這個技術過程中被去除，沒有焚化技術的危險性。

4.6 等離子氣體技術已在全球各地的商用工廠被使用[55]，至少有 30 年歷史。該技術已經成功在中國、日本、美國和英國運用[56]，以替代產生有毒副產品焚化爐技術。

4.7 政府只能理解到的事實如下 "...在處置都市固體廢棄物中，具有商業規模的工廠只有 ECO,在日本歌志內市，它於 2003 年開始運作，每天處理 50/50 的都市固體廢物混合物，約 165 公噸。[57] " 它在 2012 年 12 月停止運作。雖然在它在營運初期有技術問題，這很快就被解決。而這個氣化爐操作最終停止的原因是缺乏必須的來源原料[58]。反而氣化爐能達到廢物分類及善用資源的原則，不同於任何垃圾都能焚燒的焚化爐。使用焚化爐只會與政府現時提出的 3R 背道而馳。"燒垃圾表面上容易，相比分類、重用及回收似乎較便宜。但當它們一燒後，它們便不能再被使用 – 它們已經消失了！" [59]

4.8 英國政府與 Air Products 有多項協議，英國政府估計在 2014 年投入運營的 TV1 項目能每日處理高達 1000 公噸的垃圾，以及產生高達 50 兆瓦（總共）的電能源供高達 50,000 個家庭每年的電用量，換言之，政府將會資助此廠至少 20 年的運營。

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54 http://www.scmp.com/comment/insight-opinion/article/1305807/delay-disclosing-toxic-run-makes-landfill-expansion-harder

55 Such as Westinghouse Plasma Corp., Advanced Plasma Power, Tetronics, Solena Fuels, Air Products and New Earth Advanced Thermal to name but a few

56 http://www.airproducts.co.uk/teesvalley/technology.htm

57 Letter to NT Concern Group dated 19th August 2013 and signed by the Director of Environmental Protection Department, P.H. Lui.

58 Independent Waste Technology Report of The Alter NRG/ Westinghouse Plasma Gasification Process published in 2008 by Juniper Consultancy, p.40.

59 http://www.davidsuzuki.org/blogs/science-matters/2013/09/incinerating-trash-is-a-waste-of-resources/

英國政府對此項技術相當有信心，確信它能通過英國和歐盟嚴格的環保標準，英國政府亦已簽署了另一項就 TV2 項目的協議。

4.9 香港政府反駁等離子氣化技術的原因是認爲任何氣化爐目前只能處理 300 公噸的垃圾。但環保署沒有否等離子氣體技術是逐個計算的，所以實際上意味著可以通過安裝額外的廠房而增加規模，相比於堆填區及焚化爐廠的建設規模，難度不大。

4.10 若任何人單純地從 2009 年的一篇論文中以偏頗的看法，只挑選對焚化爐有利而等離子氣體技術有弊的論點，是完全不公正及不公平的。現時的技術已經進步，但政府卻忽略了時代轉變。等離子氣體的技術已經被至少 6 個不同的獨立的行業的專家所採用，如：RW 貝克（R.W. Beck），ENSRl AECOM 公司，AMEC，Golder Associates，日本島津化工技術研究所（Shimadzu Techno Research）和瞻博諮詢公司(Juniper Consultancy) [60]。另外，Fichtner 諮詢公司亦認同有關技術。[61]

4.11 一個每日處理 150,000 公噸垃圾的等離子氣體試點廠佔地 10 畝，可以最早於 2017 年運營。政府沒有花費資金成本（須簽訂的協議），便可證明其技術的優點和每日處理 400 公噸或更多垃圾的能力。政府建一個或多個這樣的試點氣化廠有什麼不妥呢？規模爲每日處理 70 萬公噸（2,000 公噸）垃圾的氣化廠只需約 30 個月建成，相比焚化爐，節省政府 4 年時間以及至少 0.6 億港元。

4.12 環保署曾經承認 18%從焚化爐排放顆粒物有毒，所以政府以往不會進行試點焚化廠項目，以免危害市民健康。[62]但相反，政府提出了建造這個昂貴的大型焚燒爐作爲“試驗廠”，拿香港珍貴的時間以及納稅人的金錢作一場賭博。

60 http://www.westinghouse-plasma.com/wp-content/uploads/2013/04/WPC-SoQ-March-2013-NDA-Not-Required-Final.pdf

61 http://www.advancedplasmapower.com/solutions/proven-technology/

62 http://www.epd.gov.hk/epd/english/resources_pub/policy/files/White_Paper-A_time_to_act.pdf

5 當地社區

5.1 焚化爐計劃選址在屯門、長洲和大嶼山，居住於附近的社區可能受影響，市民已經強烈抗議。一位長洲居民提出司法覆核，並提出上訴。而且，不少關心環保的非政府組織已經加入了這些反對聲音，大家都非常擔心該焚化爐的方案會破壞整個香港生態和健康。

5.2 此外，目前屯門有環保園和垃圾堆填區，可以成爲氣化技術的試點，甚至是全面推行的地方 。在屯門的後花園中，有這種創新的技術，屯門可以轉型成爲一個先進環保技術區域，同時，工廠會向當地居民提供就業機會和刺激經濟。如果這個地區、這個市鎮能認識並瞭解這個美好的廢棄物管理系統的所有優點，並知道它會幫助建立一個綠色的城市，那爲什麼政府會害怕見到呢？選址、技術、原料已經準備好，而小規模的試驗計劃足以證明氣化技術的效能、成本效益及好處，並可以在將來擴展。

6 建議和結論

6.1 從此次研究以及歐洲研究團中可以知道，政府必須儘快實現三個 R 政策，提升香港人的環保意識。若加入適當的獎勵（Reward）成爲 4R, 我們相信政策會更可行。

6.2 無論是採用焚化爐技術或等離子氣體技術，兩種技術本身沒有鼓勵香港的人分類或減少垃圾。香港人對於垃圾的概念將會同原來一樣，沒有改變。若市民能夠徵費來改變自身行爲，將會有效減少廢棄物，屬於高壓的辦法。[63]通過適當的獎勵，作爲配套措施，亦是可取。建造必要的基礎設施亦可爲香港現行的社會貧困群體提供其最需要的就業機會。

6.3 新界關注大聯盟倡導等離子氣化技術，其中包括他們參觀的各種廢棄物管理廠，包括焚化爐、熱解和氣化技術。代表團的結論是，氣化技術是一個更清潔的技術，從一開始就鼓勵廢棄物分類，亦鼓勵第二次回收。公平徵收垃圾費可激勵市民減少產生垃圾。由於氣化技術沒有製造底灰等，所以不用繼續傾倒垃圾到堆填區,同時能生產更潔淨的能源，二氧化碳排放量較低，沒有產生的二噁英和其他副產品，惰性的泥渣成功應用於基建工程中，沒有對環境造成危害。

6.4 政府必須拿出勇氣和信心，等離子氣化技術已不再處於起步階段。相反，它已被使用了許多年，並提供本地的就業機會。採用等離子氣化技術將可以令香港出售能源、生產清潔燃料、鼓勵垃圾堆填區復原，並最終達到土地復墾的可能。

6.5 爲幫助政府考慮採用替代技術，屯門環保園位址應被考慮作爲等離子氣化的試驗工廠地點。試驗計劃可以在可負擔及可行的時間內，不會延遲處理香港的垃圾危機。一個小試點只能爲香港龐大的垃圾問題解決一小點，但足以證明此技術的成功及避免擴建堆填區的需要，甚至達到回復現有堆填區的最後目標。無論如何，眼見看爲真。這不僅解決選址問題，而且也能將屯門打造成功能齊全、創新、現代綠色之區。同時，這亦可促進政府、私人機構、非政府組織及社區的共同

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63 http://www.scmp.com/news/hong-kong/article/1317862/families-could-pay-hk74-month-dump-waste-says-consultation-paper.

合作。

6.6 此外，屯門一早應該有更環保綠化的社區，但目前所缺乏的是相應的綠色推廣和技術。政府應停止將我們的後花園-屯門視爲“方便”的傾倒垃圾地。政府應鼓助替代廢棄物管理技術的發展，最終解決堆填區問題及最後達到藍圖中的減廢目標。

6.7 政府在石鼓洲建立龐大焚化爐，只是想以單一的大焚化爐短線解決大量的城市人口所產生的生活垃圾，而不是解決廢物管理－ 忽略藍圖所列的目標及未能達到 2005 年所列的目標。這亦不是將現有的資源最大化地利用。

6.8 若政府真的相信焚化爐是未來垃圾問題的出路，當局在維持時間表內的目標，亦應同時思考及實施其他有效的措施，例如氣化技術。曾咀亦被視爲潛在的選址，並完成了有關的環境評核，但政府的決定將會浪費香港人的時間、金錢、健康及環境。相反，這幅 200 公頃的土地可以用來測試等離子氣化技術及可供擴充。我們懇求政府能用透明和公平的方式考慮其他替代之廢棄物管理技術。政府當局一直與焚化技術方面的專家保持溝通，但大聯盟認爲氣化工業方面的專家，包括等離子氣化及熱解技術範疇，都應有平等的機會去講解其優劣之處，使政府可以認真考慮。

6.9 根據新界關注大聯盟歐洲考察團資料及有關的文獻搜集，我們有以下的建議：

6.9.1 我們認同環境局藍圖中的理念。不同的政策，如垃圾徵費及設立獎勵制度，用以鼓勵、提供誘因及激發香港市民參與 3Rs 的垃圾分類活動；

6.9.2 但我們不認同政府完全不考慮其他技術。難道只有焚化才是唯一及最佳的選擇？從上述討論可得知答案是否定的。等離子氣化及其他先進的熱能技術應有一個公平的機會向公眾展示其優劣之處。氣化技術可以最快在 2017 年啓動試驗技術。我們有預備好的土地(曾咀)、準備好的單組件技術及穩定的垃圾供應(因其鄰近堆填區，每日 6,000 公噸的垃圾都會送往屯門堆

填區)；

6.9.3 我們絕不認同政府擴建堆填區的計劃。相反，政府可採用此技術來達到回復堆填區土地，讓香港可以從新得到珍貴的土地資源；

6.9.4 屯門不應成爲犧牲品，政府亦不應當屯門是垃圾筒。屯門是香港的後花園，應成爲一個有作爲、功能性的綠色都市，以高科技處理垃圾，甚至將土地回墾；及

6.9.5 香港應採取主動，在珠江三角洲推動此技術的發展。成功應用後，我們相信現時的環境污染及損害可以大大減低，而香港可以在綠色科技方面，透過等離子氣化技術而影響南中國。

6.10 作爲最後的總結，垃圾和人力沒有管理好，不僅會導致人才和機會的流失，甚至是香港的競爭力災難。

給香港一個機會，給我們一個機會，給下一代一個機會。

新界關注大聯盟

2013 年 11 月 23 日

7 附錄

附錄 7.1 -焚化與等離子氣化

焚化技術	等離子氣化技術
420 億港元成本*	72 億港元成本#
3,000 至 4,000 固體廢棄物垃圾處理量 (萬公噸)	2,000 固體廢棄物垃圾處理量 (萬公噸)
副產品：飛灰和底灰	副產品：渣
不支援回墾堆填區土地，因爲灰會被置於堆填區	支援回墾堆填區土地，因爲產生的灰會被灰玻化而成爲惰性泥渣。沒有東西需要傾倒入堆填區
壓縮廢物成爲熱能及灰	將廢棄物轉換成合成氣和惰性泥渣
700℃ 至 1000℃ 之間運作	1200℃ 至 10,000+℃ 之間運作
需要碳氫燃料或氣體燃料啓動燃燒	從電力輸入啓動，但在產生足夠電力後，能自給自足
需要氧氣以燃燒	幾乎不需要氧氣，因此沒有燃燒
任何潛在的能量將會轉換爲熱能	氣體能被收集起來使用，產生各種形態的能源，如熱能、氫氣、合成氣或飛機燃料
生成 30%的灰，需要小心處置	最多 15%的剩餘廢物會變爲惰性泥渣，可以安全使用及減少混合物的入口
溫室氣體、污染物及有毒的灰排放量大	低排放

*此數字是基於對政府的綜合廢棄物管理設施基金預計於 2013 年使用

（不包括填海成本）。但有可能會因時間的延長而躍升至約港幣 18 億元的成本，因時間受最終的司法審查上訴時間決定（可能是 2014 年或以後）。總共 420 億港元的成本計及興建焚化爐的 150 億費用、100 億的填海成本、90 億擴建屯門堆填區及 80 億擴建打鼓嶺及將軍澳堆填區的費用。

此數位是參考於用於 TV1 項目和即將用於 TV2 項目投資成本（不包括填海成本，因爲空氣化工產品公司開始建設的是時候，土地已被填好，沒有填海成本的數字）。

附錄 7.2 3R 策略

減少，重用及回收

第一階段

- 藍色回收箱（廢紙）
- 黃色回收箱（鐵罐）
- 啡色回收箱
- 家居廢物

回收費用

對不分類的廢物徵收費用

第二階段

收集及回收費用

增加垃圾徵費
可以增加第二次回收的

- 金屬
- 廢紙及膠樽
- 固體廢物

第三階段

- 焚化爐
- 氣化
- 等離子氣化
- 堆填區

第四階段

焚化爐

(1W)好處:
-用熱能發電= 收入

(3L)缺點:
-環境：排放有毒物質，如二噁英、有毒飛灰、二氧化碳；底灰需要堆填區
-政府：成本高的技術
-社會：厭惡

氣化 / 等離子氣化

(3W)好處:
-轉廢為能：合成氣可轉生物燃料、氫氣及能源、泥渣=收入
-環境：無毒排放、不須堆填區處理生產的物料、回復舊有堆填區
-社區及商業機構：能源回贈本地居民

堆填區

好處:
-沼氣 (如能成功獲取)
-如介定安全後，堆填區可轉化為休閒用地

缺點:
-蠅、蟲問題
-強烈異味
-浪費土地

附表 7.3 – 資料

	規模 (畝)	輸入	輸出	垃圾處理量 (公噸每日), 排放量 (公噸每日) 以及環境標準	完工時間	模塊化	勞動力	初始成本和運營成本	內部收益率	未來發展?
RAV Water Treatment(鹿特丹)	TBC	整體 60 兆瓦，包括焚燒爐，生物處理和水處理	焚燒爐 41.5 兆瓦	-焚化 1,300 公噸 -2% 飛灰 以及 20-22%底灰 -歐盟標準(0.1ng TEQ/m3)	1 年	否	270	TBC	TBC	TBC
WSS (阿姆斯特丹)	60 升的容器× 10,000+單元	太陽能	TBC	-14% 焚化 -2% 填埋 84% 處理/回收	每 660 公升的儲存庫需要 1-2 小時	是	3 個人 500-1,000 個 660 公升的容器	TBC	TBC	第二次機會回收
APP(斯溫頓)	10	4 兆瓦	16-20 兆瓦	-每條流水線 150,000 -12,000 等離子石 (泥渣)	2 年	是	50	TBC	TBC	第二次機會回收以及土地回墾
New Earth (阿芬默)	整個工地佔 11，而焚化爐只佔 2	12 萬噸廢物衍生燃料	13 兆瓦 e/每小時	-第一期 60,000 以及 第二期 60,000 -4,800 至 6,000 灰 (轉成渣)	18 個月	是	40 (30 人主幹成員 以及 10 人管理)	TBC	未有槓杆前估計爲 20%	氣體爲引擎技術
Air Products (提賽德)	30 (可減少)	13 兆瓦	產出 50 兆瓦	-TV1 350,000 以及 TV2 350,000 -87,500 渣	27 至 30 個月	一些合成物	50 建設中有 700 人	3 億英鎊	TBC	第二次機會回收 以及土地回墾

NT CONCERN GROUP

新界關注大聯盟

NT CONCERN GROUP
新界關注大聯盟

REPORT ON WASTE MANAGEMENT

23rd November 2013

Resolute in New Territories
屹立新界

Caring for Hong Kong
關顧全港

Campaigning for consensus
凝聚共識

Striving for the common goals
達至大同

www.ntconcerngp.com   facebook: ntconcerngp

Table of Contents

(I) Foreword

Founded on 4th May 2013, the New Territories Concern Group ("NT Concern Group") is a non-political party. It acts as a platform, as a pressure group, fostering the views of the people of Hong Kong and lobbies the HKSAR Government. The NT Concern Group aims to monitor the Government's various policies and development projects and hopes to assist the Government in developing a more effective and balanced policy direction, so as to relieve the pressure and tensions of different parties and factions.

To that effect, we visited Amsterdam, Rotterdam and London primarily to form a bridge and reach out to overseas born Chinese and advise them about, inter alia, their residency rights in Hong Kong.

In addition, we took this opportunity to better understand different waste management systems by visiting the sites such as an incinerator, gasification plant and gas plasma plant as recently, waste management has been a hot topic in Hong Kong.

Under a two-part report based on its findings from the Mission to Europe, Part 1 is now submitted in relation to waste management with Part 2 in relation to residency rights in Hong Kong to be submitted at a later date.

(II) About the NT Concern Group

On 26th November 2011, the Hong Kong Government announced its revised enforcement policy against unauthorised building works (UBW) in New Territories Exempt Houses (NTEH), which are also known as Village Houses. The new implementation included the introduction of a "voluntary reporting scheme" on unauthorised building structures. The announcement of this new policy fuelled discussions and speculations in society, and also aroused extensive discontent amongst the New Territories residents. The New Territories Heung Yee Kuk, which should be a bridge of communication between the residents and the Government bodies, failed to speak up and swayed often in their positions regarding this matter. Many New Territories residents felt frustrated and disappointed by such ineffective representation.

It was against such a backdrop that the NT Concern Group was formed. On 4th May 2013, the NT Concern Group was established with the aim of creating dialogue between different sectors of community and those who are affected by the Government's policies. It aspires to be a voice for the people of the New Territories by conveying their views and suggestions to the Hong Kong Government, so that their traditional and lawful rights would be protected. In relation to the aforementioned policy, the NT Concern Group hopes to bring about the legalisation of minor UBWs that do not seriously contravene the law or pose any imminent danger to life or property. On 25th October 2012, the NT Concern Group applied to be registered as a formal society by the Hong Kong Police Force.

A) Aims

NT Concern Group: A body duly registered under the Societies Ordinance Cap. 151 (Licence No. LP/LIC/SO/19/49006) aims: -

(1.) to apply pressure on the Government in relation to:
- (a). Expansion of the 19 existing items listed in the Guidelines for Exemptions in the application for NTEH UBW exemption certificates;
- (b). Amendment of the existing Buildings Ordinance by adding a provision that provides a simple reporting mechanism, which would also allow residents to undertake legal alterations to their property;
- (c). To legalise minor UBWs in NTEHs that were constructed before 28th June 2011, given that such structures are not in serious contravention of the law;

(2.) to reflect to the Government the views and opinions on its policies regarding development in the New Territories, to increase and strengthen communication;

(3.) to obtain from the Government a reasonable allowance for the New Territories Village Representatives, with appropriate subsidy adjustments;

(4.) to obtain amenities or other facilities that would improve the living standards of New Territories residents;

(5.) to connect with New Territories residents and various non governmental organisations, in order to improve mutual awareness and to promote liaisons between these factions of the community;

(6.) to coordinate with other villages in creating groups with similar aims and interests.

B) Structure

The NT Concern Group is led by an Executive Committee, with five specialised teams to handle projects of various nature:

(1.) **Buildings and Amenities Team:** Responsible for matters regarding Unauthorised Building Works (UBWs) on New Territories Exempt Houses (NTEH), and to advocate for the amendment of the existing Buildings Ordinance;

(2.) **New Territories Concerns Team:** Responsible for analysing the overall general policy direction of New Territories development;

(3.) **Rights and Interests Team:** Responsible for dealing with the rights and interests of the village entity, and to strive for the adjustment of wages and subsidies for the Village Representatives;

(4.) **Community Activities Team:** Responsible for organising cultural activities in the community, protecting the rights of property owners, contacting non-governmental organisations to strengthen community ties, and organising various recreational activities for liaison purposes;

(5.) **Operations Support Team:** Responsible for the organisation and logistical support of the other teams' projects.

C) Committee Members

D) CV of the Delegation and Researchers

(For C and D, please refer to pages 6-7 of the Chinese Version.)

(II) Executive Summary

In 2011, 1.27kg of MSW was disposed of per capita per day and under its Blueprint, Hong Kong government aims to reduce this figure by 40% to 0.8kg by 2022. This would be achieved by implementing the Three Rs and imposing a levy. It is projected that 55%, 23% and 22% of waste produced would be recycled, incinerated and put in landfills respectively.

The current landfills at Tuen Mun in WENT, Twa Kwu Ling in NENT and Tseung Kwan O in SENT occupy an area of 110, 61 and 100 hectares respectively at which the capacity is expected to be saturated by 2019, 2017 and 2015 or earlier. A feasibility study costing HK$353 million will be carried out at Tuen Mun which would see the area expand by an additional 200 hectares at an estimated construction cost of HK$9 billion. NENT and SENT would also be extended by 70 and 43 hectares respectively at an estimated cost of HK$8 billion. The proposed expansions are understandably facing major opposition and outrage.

Government is striving for the operation of its "prized" incinerators capable of processing 3,000 tpd from 2022 on an artificial island off Shek Kwu Chau or less likely, at Tsang Tsui. The reclamation of land is estimated to cost HK$10 billion and a further estimated cost of HK$15 billion on construction of the technology. The technology is championed as it will produce EfW, it is clean and it is the best option to tackle Hong Kong's rising waste problems.

The disadvantages more than outweigh the benefits making this a losing strategy. EfW is produced after processing the MSW. However as it burns waste at 850°C in the presence of oxygen, dioxins, toxic fly ash (2%), bottom ash (22%) and carbon dioxide are discharged. The ash also requires to be disposed of carefully in landfill which is adding unnecessary strain. Judicial review proceedings have been initiated which will push the proposed operational date of 2022 back and the total sum for government's plans on expansion of the landfills and reclamation and construction of the IWMF will cost the taxpayer an estimated eye watering HK$42 billion. In short, it will cause resentment to the people of Hong Kong, it will further harm the environment and it is an extremely costly feat.

On the other hand, plasma gasification and/or pyrolysis coupled with gasification appear to hold the winning solution to Hong Kong's problem. Naturally occurring plasma is seen in lightning's flash. The plasma passing through gas will produce electrical energy capable of reaching temperatures in excess of 5,000°C and thus power the technology.

The technology produces a syngas capable of being converted to electricity and jet fuels and heat and steam being other outputs. Slag being a byproduct can be safely used as construction aggregate. In addition to creating work opportunities, the technology makes it a winning solution for the community. The environment also wins as no residue is required to be dumped in landfills and the technology can in fact back mine current landfill sites. No harmful emissions are discharged. Capable of processing about 2,000 tpd, at a cost of around HK$7.2 billion to construct, taking up an area of about 30 acres, the technology could be housed at Tsang Tsui and is also a winning answer for Government. The pilot plants capable of processing around 400 tpd could be operational within 3 years by 2017, turning Tuen Mun into a functioning green city and assisting in meeting government's aims of addressing the waste problem 5 years earlier than the IWMF would in 2022. The technology which is modular, is not immature as government claims and has been in operation for at least 30 years and used by companies such as New Earth, Solena Fuels, Westinghouse Plasma Corp, Advanced Plasma Power and Tetronics.

Government is therefore urged to choose carefully, cleverly and sensibly finding a solution which will allow everyone to win. Plasma gasification and/or pyrolysis coupled with gasification could be that answer!

(IV) Full Report

1. Introduction

1.1 The monumental accumulation of waste around the world is a near unanimous and unruly problem, which is worrisome, especially to the governments of the developed countries. To tackle this problem efficiently and indefinitely, effective waste management strategies and systems must be adopted.

1.2 Under the Hong Kong Blueprint for Sustainable Use of Resources 2013-2022 ("Blueprint"), government aims to reduce the waste produced from 1.27kg to 0.8kg by 2022.[1]

1.3 A primary hierarchy commonly adopted by different countries as well as Hong Kong and can assist in meeting the government's targets is the "Three Rs" which stands for:

(a). **reduce:-** from a manufacturer's point of view and from a consumer's point of view, use fewer resources from the onset;

(b). **reuse:-** before disposal or recycling, considering whether the item can be used again for a different purpose, i.e. a biscuit tin as storage; and

(c). **recycle:-** to be sorted, collected and processed for the making of new items from old and used resources.[2]

Sometimes recovery (of energy from waste "EfW") and disposal into landfills (being the least preferable) are also used. For the

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1 http://www.enb.gov.hk/en/files/WastePlan-E.pdf

2 http://www.nrdc.org/thisgreenlife/0802.asp and http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2012/07/25/000333037_20120725004131/Rendered/PDF/681350WP0REVIS0at0a0Waste20120Final.pdf

purposes of this report, the Three Rs will also include recovery and disposal.

1.4 Hong Kong's three landfill sites are estimated to reach capacity between 2015 and 2019.[3] The government's proposed solution whilst paying lip service to the Three Rs with pilot projects to extend waste sorting and (after repeated public consultation) introduce waste charging, is in essence to extend the landfills and/or operate one of the world's largest incineration plants capable of processing 3,000 tonnes per day ("tpd") of MSW which it proposes to make operational by around 2022. However, the landfill extension is jeopardized because Legco denied funding earlier this year; and the incinerator proposal is stalled by a judicial review currently going through the courts.

1.5 The NT Concern Group during its visit to Europe witnessed firsthand the thermal technologies now or imminently operational which seem more appropriate solutions for Hong Kong's waste management. The gasification technology appears to provide 3 key benefits:

(a). safe, emitting none of the dioxins and other toxins which recent scientific studies have shown are emitted by incinerators in levels hazardous to human health;

(b). capable of running at a profit, provided they operate at capacities of more than 300 tpd of MSW (whereas the proposed incinerator is projected to run at a steady and significant loss year on year); and

(c). landfill friendly, whereas the proposed incinerator will require toxic residues to be vitrified and then sent to landfill,

[3] http://www.enb.gov.hk/en/files/WastePlan-E.pdf

gasification produces non-toxic by-product suitable for immediate re-use as construction aggregate.

(inert vitrified slag)[4]

Indeed, these gasification technologies are now being deployed in Europe and the US to reverse landmine and reclaim land for future generations- an application which is all the more appropriate for Hong Kong, where land is an especially scarce and precious resource.

1.6 Based on these findings, which demonstrate that these alternative technologies can produce a Win-Win-Win outcome for Hong Kong in managing its waste, we propose to champion this technology to the government for their further consideration and the trialing of one or more pilot plants to be operational by 2017.

1.7 Win- Environment

1.7.1Plasma gasification and/or pyrolysis coupled with gasification are better technologies as they do not give off toxic residue. It provides a cleaner solution as the emissions are much lower than incineration. Moreover no residue will need to be disposed of in the landfills and the technology allows for reverse mining of landfills.

[4] http://www.httcanada.com/asbestos.html

1.8 Win- Community

1.8.1 It has a non-repugnant impact as it will take up a much smaller area and at the same time, it will not have a protruding chimney stack some 150 metres in height. The technology will bring employment opportunities to Tuen Mun, where it is hoped the technology will be housed. The EfW produced will also benefit the locals and save on energy bills. Furthermore, the back-mining of landfill will have a resounding result as the land is recovered and greater use could be made in the area.

1.9 Win- Government

1.9.1 Government will see that the technology costs less while achieving more, for example, there is no need to waste billions of dollars on reclamation as it could easily be housed next to the Sewage Treatment Facility in Tuen Mun. It also addresses the problem of the landfill reaching capacity and relieves the need for the expansion. The technology will bring entrepreneurial and employment opportunities thus stimulating the economy. In addition, the new service base will aid in the investment in the local area as well as Hong Kong in general and therefore afford Tuen Mun the title of a green functioning city, supporting the fact that Hong Kong remains a competitive, innovative and receptive international hub. The technology will also ease concerns over the pollution surrounding the Pearl River Delta.

1.10 We call this the Three Ws strategy- a complimentary strategy to the Three Rs policy- by which Hong Kong can manage its waste more safely, efficiently and profitably and at the same time reclaim the landfill sites (which the government currently insists on extending) for alternative use.

1.11 We believe that the Three Rs strategy should be further strengthened by offering Rewards for those who recover waste suitable for recycling or other reuse i.e., payment of small sums for recovery of cans, bottles etc., job creation schemes for home and business waste collection and separation and subvention of businesses which promote waste recycling, re-use and reduction. We therefore believe the Three Rs strategy should be rechristened the Four Rs strategy.

2 Background of this report

2.1 We agree with the government's proposal for the fair and reasonable imposition of a levy as there has been so much public consultation on this issue and see no reason for further deferral by way of further consultation. Legislation for a waste charging scheme should be brought before Legco within the next 6 months and implemented by the end of next year (2014).

2.2 We also agree with the government's proposals to extend schemes for the separation of waste. However, we see no reason why these cannot be on a territory wide basis. This government has the power to legislate for mandatory waste separation and has the financial muscle to provide the corresponding infrastructure i.e., free waste bins to every household and an army of waste collectors by the end of next year (2014). Implementation of such territory wide scheme would provide much needed employment to those currently at or below the poverty line which the government's recent report estimates at one-eighth of the population.

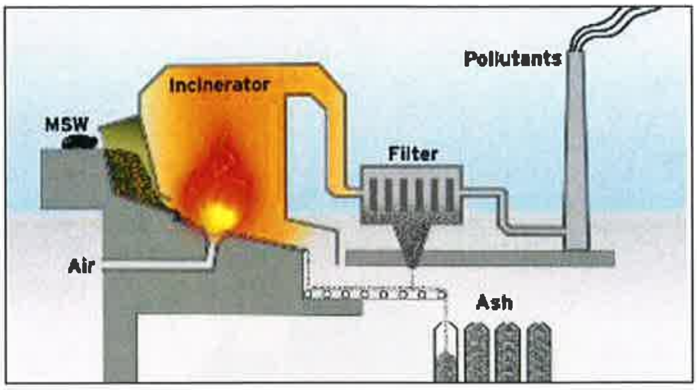
2.3 On the government's own statistics, separation of organic waste for alternative treatment e.g., processing through the Stonecutters Island sewage plant) will reduce the quantity of waste sent to landfill by 44%. It will eliminate the unpleasant smell associated with the landfill. It will therefore instantly alleviate the current pressure to extend landfill.

2.4 Questions then remain as to how residual waste should be treated and disposed of. The government proposes incineration which requires landfill extension because toxic residues from the incinerator (millions of tonnes over the proposed 30 year cycle) must be treated and then disposed of by dumping in landfills. We believe there are superior technologies which should now be deployed in preference to incineration because they are clean with no toxic emissions or residues to be dumped in landfills. These technologies will not require landfill extension but will permit landfill reclamation by reverse landmining what is already in the current landfills around Hong Kong and therefore enable the extension of the territory's landbank. They will permit this to be done at no net cost to the government. These technologies therefore represent a Win-Win-Win solution to Hong Kong's current waste crisis - a Three Ws strategy to secure Hong Kong's future. For the sake of convenience, we use the umbrella term 'plasma gas' to describe plasma gasification and pyrolysis coupled with gasification.

2.5 For the differences between incineration and plasma gas (see Annexure 7.1- Incineration vs. Plasma Gasification) [5] and the following paragraphs:

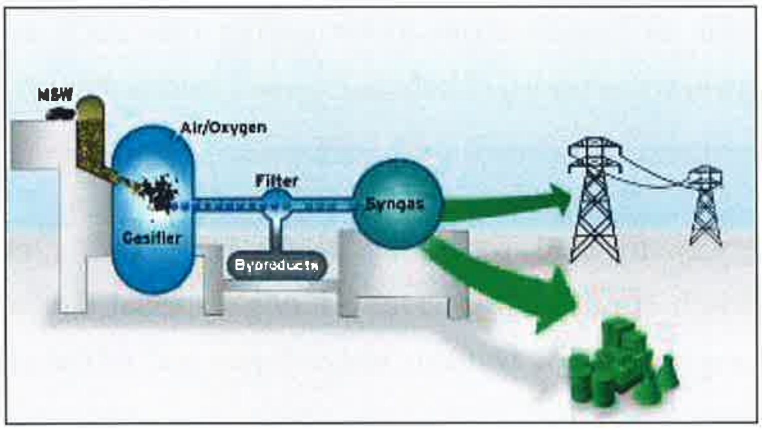
2.5.1 The below figure shows the incineration process in simple terms. MSW and a large amount of air enter the incineration chamber. Only after combustion can pollutants be filtered. A large chimney stack (around 150m in height) is required to catch as much of the impurities as possible before it is released into the atmosphere. Ash is also produced as a by-product which must be disposed of carefully in special landfills. The heat generated from incineration is used to make steam to generate electricity.

[5] http://www.futurenrg.net/technology/plasgasification.htm and http://www.dovetailinc.org/files/u1/PlasmaGasificationPresentation.pdf pp12-16.



(General incineration process)[6]

2.5.2 Similarly, a simplified plasma gasification process can be seen. MSW enters the gasification chamber and is broken down to its simplest elements under very high temperatures and little to no air/ oxygen. Using the plasma gasification technology, plasma (which is intense heat and seen naturally in lightning's flash capable of reaching temperatures in excess of 5,000°C) is produced when electrical energy travels through gas- thus beginning and assisting the gasification making it an efficient process.[7] Through a filtration system, a synthesis gas is produced.



(General plasma gasification process)[8]

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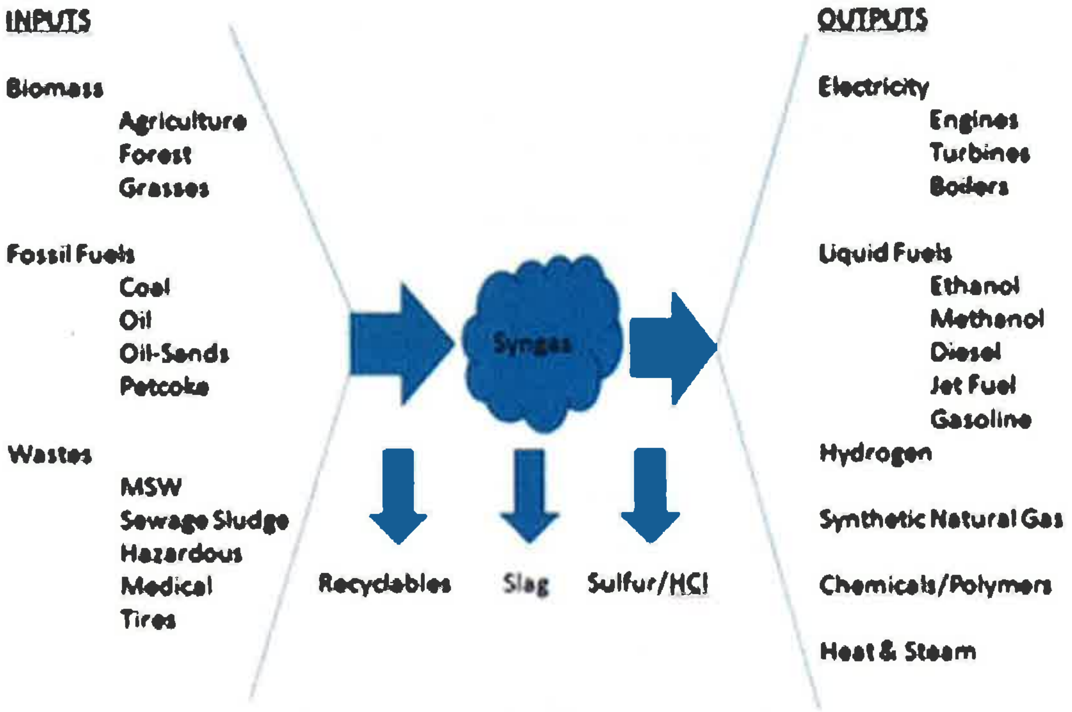
[6] https://www.gasification.org/page_1.asp?a=87 (taken from video clip)
[7] http://gasification.org/page_1.asp?a=84
[8] https://www.gasification.org/page_1.asp?a=87 (taken from video clip)



(Illustration of outputs and by-products of Synthetic gas)[9]

2.5.3 The heat and energy is recaptured and can be used to supply power to the plant. With the installation of (underground) piping, the local community within a 25km[10] parameter will be able to benefit from lower energy bills such as for heating swimming pools, elderly homes and businesses for instance..

2.6 The way forward for Hong Kong is to use a multi-pronged approach appropriate to Hong Kong's special circumstances and making best use of available technologies and infrastructure.

2.7 In 2011, Hong Kong produced on average 9,000 tpd of MSW[11] and currently produces around 13,400 tpd[12] of waste. Even if this is

[9] Reproduced from http://www.waste-management-world.com/articles/print/volume-10/issue-4/features/plasma-gasification-clean-renewable-fuel-through-vaporization-of-waste.html
[10] See below "RAV Water Treatment" section.
[11] http://www.enb.gov.hk/en/files/WastePlan-E.pdf

reduced by waste charging and sorting and alternative treatment of organic waste, it seems likely that there will be residual waste flows requiring alternative disposal if not dumped in landfills.

2.8 In line with the Three Rs, burying waste into the land, which is a scarce and precious resource in Hong Kong, should only be allowed where other waste management technologies cannot process it (see Annexure 7.2- Three Rs).

2.9 13 landfills in Hong Kong have been closed due to high levels of pollution and/or being completely filled up and undergone restoration by 2006. The majority of them, where considered safe to do so, have been converted into recreational facilities. Three landfills remain operational and are situated in West New Territories ("WENT") at Tuen Mun, North East New Territories ("NENT") at Ta Kwu Ling and South East New Territories ("SENT") at Tseung Kwan O, and are said to be quickly reaching its capacity between 2015 and 2019. [13] The respective areas occupied by each landfill site respectively are 110, 61 and 100 hectares.[14]

2.10 The government proposes landfill extensions to combat the problem but have withdrawn proposals at Tseung Kwan O and have been unsuccessful in passing landfill extension proposals at the remaining two sites due to the levels of opposition. However, 'Legco's public works subcommittee voted on July 2 to approve a HK$353 million study into the feasibility of expanding the Tuen Mun site, which would cost an estimated HK$9 billion to

[12] http://www.info.gov.hk/gia/general/201309/25/P201309250437.htm
[13] http://www.epd.gov.hk/epd/english/environmentinhk/waste/waste_maincontent.html
[14] http://www.legco.gov.hk/yr05-06/english/sec/library/0506in37e.pdf

construct'.[15] If government's proposals for landfill extensions were approved, this would see an increase of 200 hectares at WENT, 70 hectares at NENT and a total of 43 hectares at SENT[16] with the expansion of NENT and SENT costing around HK$8 billion.[17] To propose extensions of these landfills is a highly illogical position to take when land is at such a premium and could be better used.

2.11 Whether the government will eventually get approval for its landfill extension proposals (which will cost around HK$18 billion[18] in total), is just one matter. Part and parcel to landfills and their extensions are government's biased steps towards a slowly yet surely, spear-headed proposals of a mega-incinerator at a construction cost of at least HK$15 billion[19] over at least a 7 year period to build and to be housed at Shek Kwu Chau (on an artificial island 10 meters offshore in a designated conservation area and at a cost of around HK$8-10 billion[20]).

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[15] http://www.scmp.com/news/hong-kong/article/1349309/government-press-plans-expand-two-landfill-sites

[16] http://www.legco.gov.hk/yr12-13/english/panels/ea/papers/ea0527cb1-1079-1-e.pdf

[17] http://www.scmp.com/article/996194/incinerator-bigger-landfills-cost-hk23b

[18] http://www.scmp.com/news/hong-kong/article/1268868/tseung-kwan-o-landfill-expansion-faces-defeat.

[19] http://www.scmp.com/news/hong-kong/article/1317862/families-could-pay-hk74-month-dump-waste-says-consultation-paper

[20] http://www.scmp.com/article/997235/costly-incinerator-will-be-waste-money (based on the figures for the assumed cost of reclamation of 16 acres of land).

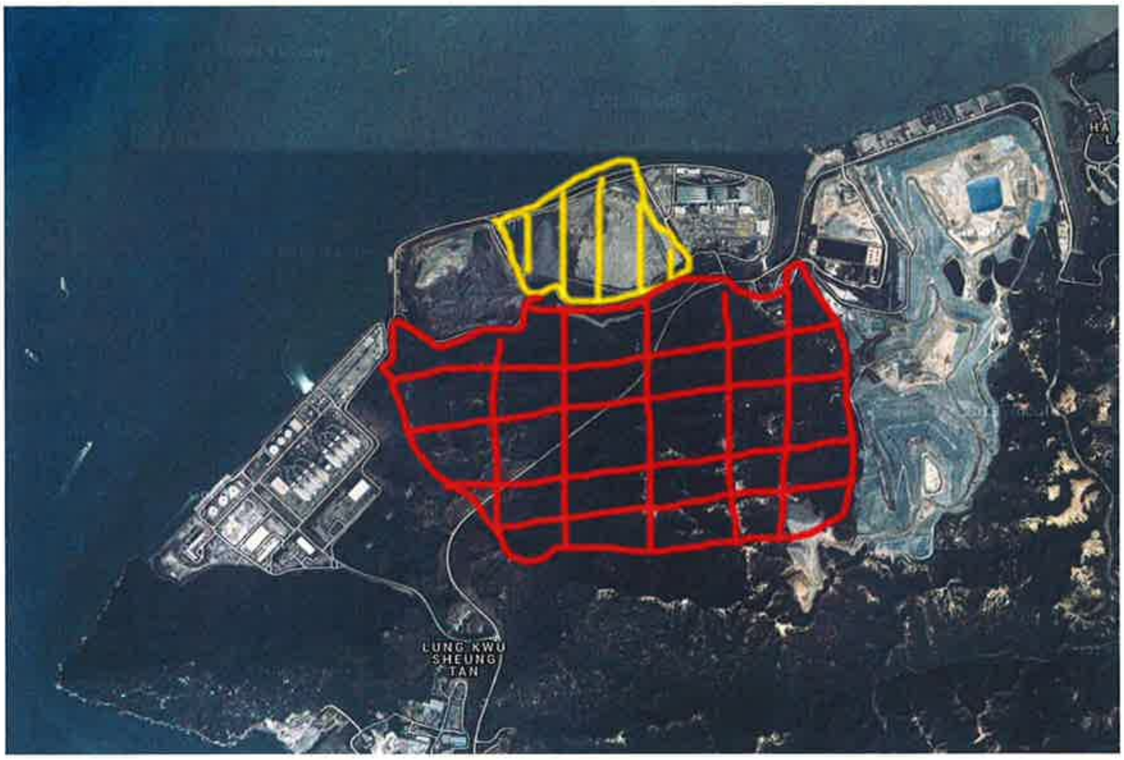
(Photo of proposed site of incinerator at Shek Kwu Chau in yellow banding)[21]

It is proposed that the operational date will be 2022 and will cost around HK$353 million a year to run.[22] However, the incineration proposal is currently subject to judicial review proceedings. It has also been rejected by Legco's Environmental Advisory Panel when submitted last year for approval.

2.12 Moreover, the government has also considered Tsang Tsui Ash Lagoon in Tuen Mun to house the incinerator next to the current site where the Sewage Treatment Facility, which also adopts incineration technology and is designed to process 2000 tonnes per day, is nearing completion[23] and which cost $5billion to construct.[24]

[21] http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/WFdev_IWMF.html
[22] http://www.scmp.com/article/996194/incinerator-bigger-landfills-cost-hk23b
[23] http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/WFdev_TMSTF.html
[24] http://www.scmp.com/article/996194/incinerator-bigger-landfills-cost-hk23b

(Photo of proposed site of incinerator at Tsang Tsui in yellow banding)[25]



(Photo of proposed site of incinerator at Tsang Tsui in yellow and proposed landfill extension of 200 hectare in red)

[25] http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/WFdev_IWMF.html

2.13 Regardless of location, the government's strong support for incineration and what appears to be an inclination to house the incinerator at Shek Kwu Chau or alternatively at Tsang Tsui Ash Lagoon, is based on findings from the end of 2009.[26] There have been substantial advances in alternative technologies since then, such as gasification and plasma gasification, which will not require the disposal of around 22% of bottom ash (as a by-product of incineration)[27] into landfills and thus negate the need for landfill extensions and indeed allow for reverse landfill mining.

2.14 It is government's championed fact that incineration of MSW will not require pre-treatment or pre-sorting of the waste which, by that account, means that all waste will be processed by the incinerator, whether it is recyclable or not. So too could plasma gas technology process unsorted waste; however, the energy such as power, hydrogen and jet fuels produced would not be as high although the levels of slag would be greater[28] which would reduce the amount of construction aggregate currently imported[29] (as we understand that there is a heavy reliance[30] of importing aggregate and the practice is of more economical benefit than to produce it)[31]. It also bypasses the 2nd and 3rd Rs i.e., reuse and recycle and jump straight to the less preferred recovery and disposal.

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[26] Advisory Council on the Environment- "Integrated Waste Management Facilities Technology Review and Associated Facilities"- ACE Paper 22/2009

[27] See "Annexure 7.3- Data" (although gasification will produce around 12% ash).

[28] http://www.futurenrg.net/technology/plasfaq.htm

[29] http://www.edb.gov.hk/attachment/en/curriculum-development/kla/pshe/references-and-resources/geography/article-geological_resources.pdf

[30] http://www.epd.gov.hk/epd/SEA/eng/files/Quarry%20Study%20Brief%20(Part%20Version%20covering%20SEA).pdf

[31] http://www.academia.edu/800697/The_Application_of_recycled_aggregate_for_the_urban_sustainability_of_Hong_Kong_construction_industry

2.15 The Environment Bureau of the government has recently published the "Hong Kong Blueprint for Sustainable Use of Resources 2013-2022"[32] ("Blueprint") which sells the concept of Use Less, Waste Less. Essentially it sets out the government's vision and identifies challenges and opportunities, it provides an action plan and targets to be met by 2022 and lastly it provides a waste management structure.

2.16 Whilst this blueprint is helpful, the government is failing to embrace new concepts and thus cannot grasp the bigger picture. Adamant that incineration is the only way of efficiently moving forward, the government does not want to recognize any other innovative and plausible EfW methods which will enhance the sustainable use of resources. Plasma gasification is not a technology in its infancy and to demonstrate its merits, Tuen Mun could be used to house a pilot plant, potentially within 2 years and will have the necessary feedstock to process from the landfill sites already in existence. It would not disrupt government's plans and time-scales under the Blueprint, unlike the mega-incinerator which is currently subject to judicial review and thus delaying construction plans by at least a year.

[32] http://www.enb.gov.hk/en/files/WastePlan-E.pdf

3 Inspection

3.1 From the fact-finding mission to Europe, the NT Concern Group was able to witness firsthand, the various facilities in operation and spoke to the different managers and directors to ascertain facts and figures about their plants.

3.2 WSS Infocard System ("WSS")[33]

3.2.1 Having begun operations in the Netherlands in 2003, the waste separation business has adopted the model such that the units are supplied with most of the services thereafter being contracted out.

3.2.2 The units are buried underground with its head above the ground. The units are powered by solar energy and technology akin to the "Octopus Card" is used. Users tap their card against the reader on the unit and the appropriate waste can be disposed according to the separation unit. Monitoring the data, WSS sends letters to the local residents at the end of each month to encourage or educate users about waste separation practices.

3.2.3 The delegation visited a residential area in Rijswijk where they saw the separated waste being collected from the WSS units. Using a mechanical claw, the unit which is underground is lifted up and flaps spring up preventing any unsuspecting passerby from falling in. Once the unit is suspended above the waste collection truck the bottom flaps are then released allowing the depositing of the waste into the truck. The flaps on the unit are then returned to its original closed position and the unit is carefully maneuvered

[33] WSS Infocard Systems at Rijswijk, the Netherlands with Managing Director, Mr. Paul van Alphens. Visited 18/09/13.

into the ground. The whole process took about 10 to 15 minutes.

(WSS waste container being lifted out the ground)

3.3 RAV Water Treatment ("RAV")[34]

3.3.1 RAV which has been in operations since the 1970s, is part of the AVR-AFVALVERWERKING B.R. ("AVR") group, recently purchased by Li Ka Shing's Cheung Kong Holdings Ltd.[35] It has two sites in the Netherlands, one in Rozenburg and the other in Duiven, both using incineration, biomass to energy technology and water treatment or composting.

3.3.2 The incineration plant operates between temperatures of 850°C and 1,000°C [36] and in the presence of oxygen. Notwithstanding, the need for oxygen is one cause for

[34] RAV Water Treatment at Rozenburg, the Netherlands with the Director. Visited 16/09/13
[35] http://www.scmp.com/business/companies/article/1262719/li-ka-shing-buy-dutch-waste-firm-us126b
[36] http://europa.eu/legislation_summaries/environment/waste_management/l28072_en.htm.

dioxin emissions, which is at its highest on start-up and shut-down of an incinerator thus there is need to process feedstock on a continual basis. As a direct result, rubbish from within the Netherlands is collected by truck and processed at one of the two sites. Rubbish is also imported from Europe by shipping cargo such as from Ireland. The site is therefore located in a port with good road links. As there are not many residential areas close by, the various numbers of chimney stacks do not have much of an immediate visual impact.

3.3.3 Besides dioxins, furans and CO_2 emissions, toxic fly ash and bottom ash are also produced as by-products. RAV, knowing that fly ash is heavily polluted, requires the fly ash produced to be disposed of in special landfill sites using concrete to contain and minimize any leeching. Metals are further extracted from the bottom ash and this ash is then used for reinforcement of soil, railways and supplement concrete.

3.3.4 The heat and steam can be used to generate electricity or can be distributed to the local community within a 25km radius.

(Members of the NT Concern Group, friends from Netherlands and staff of RAV)

(RAV Incinerator chimney stack)

3.4 Advanced Plasma Power ("APP")[37]

3.4.1 Based in Swindon in the South West of England, UK, APP is a two-stage plasma gas plant which uses graphite electrodes. It functions as a test plant for users to test their pre-sorted waste (or refuse derived fuel ("RDF")) and provides a detailed analysis of the output. Its visual impact is relatively low, with the exterior looking like a warehouse.

3.4.2 It operates at 1,500°C in the oxygen-deprived furnace and the plasma which is intense heat and ultraviolet ("UV") reaches a peak temperature of around 5,000°C or 5,273 Kelvin (the Sun's surface is 5,504°C or 5,778 Kelvin). The UV is utilized to break down the harmful gases/emissions and produces a very clean gas (cleanliness measured at 'parts of a billion').

3.4.3 Using plastic and rubber which is shredded to 10mm and dried along with the RDF, the calorific value is higher. It goes through the gasifier using a fluid bed operating at 850°C which produces ash and gases. This is then put through the plasma converter which utilizes graphite electrodes to crack and polish the gas creating a super clean synthesis gas which can be used as jet fuel[38], LPG or cooking gas, etc. The ash produced is vitrified and turned into Plasmaroc, a slag/ slack which is harder than granite and used for construction, load bearing and/or on roads. As the Plasmaroc comes out in a molten state, it can be molded into materials required.

3.4.4 The plant is efficient and self-sustaining once operations have begun.

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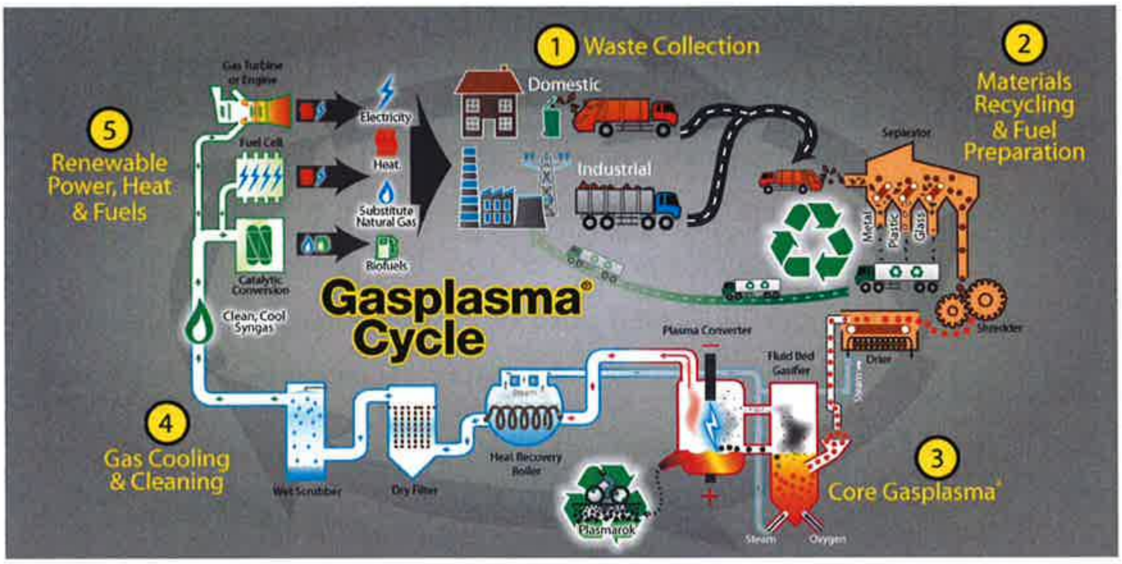
[37] Advanced Plasma Power at Swindon, UK with Sales Director, Mr. Steven Gill and Sales Consultant, Ms. Vicky Jones. Visited 19/09/13.

[38] http://www.solenafuels.com/index.php/projects



(Picture of APP plasma gasification cycle)[39]

3.5 New Earth[40]

3.5.1 The site is located at Avonmouth, also in the Southwest of England, UK. The plant uses pyrolysis and gasification technology, a two-stage process, with a focus on the production of electricity. Phase 1 was operational as of February 2013 with Phase 2 still being constructed. It is located next to a supermarket's warehouse with agreements in place for New Earth to receive the waste and the energy produced is returned to power the supermarket. New Earth itself also has a low visual impact, looking like a warehouse with an air condenser stack just 30m in height.

3.5.2 The pyrolysis uses New Earth Advanced Thermal ("NEAT") technology which allows for the processing of unrecyclable RDF in a controlled combustion environment, thus there are no dioxins produced. A carbon rich char is produced which enters the gasifier and steam and air are

[39] http://www.advancedplasmapower.com/solutions/process-overview/

[40] New Earth at Avonmouth, UK with Business Development Director, Mr. Graham Lockyer and Technical Director, Mr. Scott Edmondson. Visited 20/09/13.

injected which releases energy to get a pyrolysis and synthesis gas. A cyclone chamber is then used to clean the synthesis gas.

3.5.3 The plant requires an initial input of energy but is self-sustaining thereafter.

3.5.4 For every 1MW produced, the plant is able to claim double Renewable Obligation Certificates (ROCs) from the UK government which "are ultimately used… to demonstrate that they have met their [renewable] obligations"[41] and worth between £40 to £46.[42] Samples are taken several times a week which requires to be tested to ensure the consistent meeting of renewable obligations.

(New Earth units)[43]

[41]http://www.biomassenergycentre.org.uk/portal/page?_pageid=77,20190&_dad=portal&_schema=PORTAL , http://www.bloomberg.com/news/2013-02-13/u-k-sets-renewables-obligation-buy-out-price-at-42-02-pounds.html and https://www.ofgem.gov.uk/environmental-programmes/renewables-obligation-ro.

[42] https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/the-renewables-obligation-ro

[43] http://www.waste-management-world.com/articles/2013/06/13-mw-rdf-pyrolysis-gasification-plant-starts-up-in-avonmouth.html

3.6 Air Products[44]

3.6.1 The "world's largest renewable energy plant in the UK using advanced gasification … EfW technology"[45] will comprise of Tees Valley Phase 1 and Phase 2 ("TV1" and "TV2" respectively) is estimated to be completed and operational by 2014 and 2016 respectively. Due to the unfinished construction works, the delegation visited the Air Products UK HQ in Hersham in the Southeast of England, UK. The plasma gas plants at TV1 and TV2 will use a single stage process to convert the unrecyclable RDF to electricity. The brownfield industrial site where both plants are being constructed is reclaimed land using materials such as vitrified slag. Its external appearance looks like a warehouse.

3.6.2 With the use of petroleum coke ("coke") in the oxygen deficient chamber, the torch will ensure complete conversion of inorganic materials to synthesis gas or melting of inorganic material to slag and is self-sufficient. The synthesized gas is cleaned and put through a gas turbine and electricity is produced.

3.6.3 TV1 and TV2 have the backing of the UK government[46] with various agreements signed. Air Products receives a 30% subsidy from the UK government which is guaranteed for 20 years as well as double ROCs for every 1MW produced.

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[44] Air Products UK Headquarters at Hersham, UK with Regional Manager-EMEA, Mr. Duncan Snelling, Business Manager, Ms. Lisa Jordan and Principal Research Engineer, Dr. Andrew Shaw. Visited 20/09/13.

[45] http://www.airproducts.co.uk/teesvalley/

[46] http://www.letsrecycle.com/news/latest-news/energy/work-starts-on-2018world2019s-largest2019-gasification-plant

(Air Products plasma gasification process)[47]

3.7 To that end, different data was acquired from the various waste management sites visited (see Annexure 7.3 - Data). This has greatly assisted the NT Concern Group to compare the statistics of adopting plasma gas technology against the government's champion, incineration technology (Annexure 7.1 – Incineration vs Plasma Gasification).

3.8 It can clearly be seen that whilst the incinerator can potentially process more MSW by weight, it also costs approximately more than double what the plasma gas technology would cost. Conversely, doubling the plasma gas technology will mean that the same weight of MSW can be processed as an incinerator but at a saving of at least 4% i.e., approximately HK$0.6 billion in terms of construction cost. Furthermore, plasma gas facilities can operate profitably above parasitic load (the point at which energy extracted from the processed MSW exceeds the energy required to keep the facility running). The parasitic load for current plasma gas technologies is lower than incineration. The championed incinerator, by the government's own projections, will operate at approximately HK$353 million per year.

[47] http://www.airproducts.co.uk/teesvalley/industrial_gas_facility.htm

(Air Product's gasification unit)[48]

[48] http://premierconstructionnews.com/2013/09/24/a-breath-of-fresh-air/

4 Analysis/ Issues

4.1 The delegation agrees in principle with the government's Blueprint and does not in general, take issue with its proposals. However, the government in making its decision in combating the waste management in Hong Kong must have a range of options which can be considered on a balanced footing. All bias for one method must be put aside for the sake of the public which it serves - for their health, the environment and their best interests.

4.2 The government has adopted an almost scare-mongering tactic by emphasizing that the waste situation must be urgently tackled. Yet with the barriers faced and opposition to government's proposals, Hong Kong is actually lagging behind in its technological advances. It proposes to operate the mega-incinerator by 2022 at the earliest which is some 9 years in the future. By then, the current landfills are indeed likely to be saturated and require extension.

4.3 The Environmental Protection Department ("EPD") argues that only incineration can process 3,000 tpd of MSW; however they fail to acknowledge that the incinerator requires a continuous input of unsorted MSW; thus there will be a gradual need to import waste from other countries to appease the incinerator's hunger, entirely by-passing any recycling which can be reasonably carried out. Burning unsorted waste directly contradicts the government's "philosophy of sustainable use of resources".[49] The unsorted waste will definitely contain food content and therefore a high moisture rate (as high as 90%), requiring a greater percentage of energy to burn essentially what is water[50]- therefore not a directly analogous fact which the government can use to compare with other

[49] http://www.scmp.com/comment/letters/article/1347824/sticking-shek-kwu-chau-incinerator-best-option

[50] http://news.newclear.server279.com/wp-content/uploads/2013/10/SomefoodforthoughtUpdated.pdf

countries such as those in the European Union where the wet content of waste could be as low as 15%.[51]

4.4 The EPD also fails to make public that on start-up and shut-down of an incinerator, the highest levels of emissions such as dioxins and furans are produced. The residual output of toxic fly ash '[is] listed as an absolute hazardous substance in the European Waste Catalogue'[52] and causes harmful effects if not carefully treated, resulting in an expedited and unwarranted death sentence to all those who live nearby affected by its leaching into the water table and eco-system. The fly ash, post-treatment (vitrification, an essential process[53] which inevitably increases its mass and volume from the estimated 10% to 30%) will therefore have to be disposed into special landfills at additional cost and will even then represent a (potential) risk to Hong Kong's eco-system of catastrophic proportions, compared to the existing 'normal' landfills.[54]

4.5 Plasma gas technologies use thermal energy at a very high temperature and a gasifier which is an oxygen deprived vessel; feedstock, such as non-recyclable RDF, is broken down into its basic elements i.e. hydrogen, carbon monoxide and water. Organic compounds are converted into synthetic gas and inorganic compounds (such as metals) are melted in the reactor with residual inert, non-toxic granite-like output which can be safely used i.e. as aggregate for construction works. Dangerous dioxins and particulates are removed in the process, unlike incineration.

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51 http://www.wtert.eu/default.asp?Menue=13
52 http://www.ecomed.org.uk/content/IncineratorReport_v3.pdf
53 http://www.ecomed.org.uk/content/IncineratorReport_v3.pdf
54 http://www.scmp.com/comment/insight-opinion/article/1305807/delay-disclosing-toxic-run-makes-landfill-expansion-harder

4.6 Plasma gas technology has already been used in the commercial industries for at least 30 years with demonstration plants operating at volume throughout the globe.[55] The technology is already successfully[56] used in China, Japan, the US and the UK to neutralize toxic byproducts of incinerators.

4.7 The government preys on the fact that the '... only commercial size plant operated to treat mixed MSW was the Eco Valley facility at Utashinai, Japan, which commenced operation in 2003 to treat 165 tpd of a 50/50 mixture of MSW'[57], which consequently ceased operation in December 2012. Whilst there were initial teething problems with the technology, this was soon resolved. The reason why operations were ultimately halted was because of the lack of source of specific feedstock required.[58] This alone encompasses the notion of waste separation and best use of resources; the same cannot be said about incineration which will seek to burn unsorted waste- a fact which government champions, against its own goals of the Three Rs. 'Burning waste can seem easier and less expensive than sorting, diverting and recycling it. But once it's burned, it can never be used for anything else – it's gone!'.[59]

4.8 The UK government has agreements in place with Air Products who estimates that TV1 will be operational as of 2014 for the processing of up to 1,000 tonnes of waste a day, producing up to 50MW (gross) of renewable electricity generation and electricity for up to 50,000 homes in each year and will have industry investment

[55] Such as Westinghouse Plasma Corp., Advanced Plasma Power, Tetronics, Solena Fuels, Air Products and New Earth Advanced Thermal to name but a few

[56] http://www.airproducts.co.uk/teesvalley/technology.htm

[57] Letter to NT Concern Group dated 19th August 2013 and signed by the Director of Environmental Protection Department, P.H. Lui.

[58] Independent Waste Technology Report of The Alter NRG/ Westinghouse Plasma Gasification Process published in 2008 by Juniper Consultancy, p.40.

[59] http://www.davidsuzuki.org/blogs/science-matters/2013/09/incinerating-trash-is-a-waste-of-resources/

in the area for at least 20 years. The UK government is so confident in the technology, which meets and surpasses strict UK and EU environmental standards, that it has signed another agreement for the installation of TV2.

4.9 The government dismisses plasma gas technology by saying any working scale at present can only process 300 tpd. The EPD also fails to acknowledge that plasma gas technology is modular, which essentially means that the plant capacity can be expanded by installing additional units in series with relatively little difficulty by comparison to landfills and incinerators.

4.10 It would be unfair and wholly unjust that facts from the 2009 paper are cherry-picked in favor of incineration by the government and to the disadvantage of plasma gas when the current technological advances of the latter have improved immensely yet are ignored to this date in 2013. The plasma gas technology has been endorsed by at least 6 different independent industry experts such as: R.W. Beck, ENSR|AECOM, AMEC, Golder Associates, Shimadzu Techno Research and Juniper Consultancy.[60] In addition, Fichtner Consultancy has also endorsed the technology.[61]

4.11 A 150,000 tpy pilot plasma gas plant, occupying up to 10 acres, could potentially be on-stream as early as 2017, at no monetary cost to the government (subject to agreements entered) to demonstrate its technological merits and capacity for loads of 400 tpd or more. What are the downsides for the government facilitating one or more such pilot plants? Two full-scale plants

[60] http://www.westinghouse-plasma.com/wp-content/uploads/2013/04/WPC-SoQ-March-2013-NDA-Not-Required-Final.pdf
[61] http://www.advancedplasmapower.com/solutions/proven-technology/

processing 700,000 tpy (2,000 tpd) would potentially take around 30 months to build, at a saving to government of about 4 years and at least HK$0.6 billion.

4.12 The government is not offering a pilot incineration plant, notwithstanding the EPD concedes that 18% of particulates emitted from incinerators were highly toxic. [62] Instead, the government puts forward this costly mega-incinerator, in terms of time and money, as the 'pilot plant'. The government is therefore taking a huge risk and gambling with the taxpayers' money and confidence.

[62] http://www.epd.gov.hk/epd/english/resources_pub/policy/files/White_Paper-A_time_to_act.pdf

5 Local community

5.1 Local communities in Tuen Mun, Cheung Chau and Lantau, potentially affected by the prospective siting of an incinerator in their vicinity have protested vigorously. A Cheung Chau resident is the lead applicant for the judicial review currently on appeal through the courts. These local voices have been joined by NGOs concerned about the ecological and health impacts of the proposed incinerators which they say will affect the entire territory of Hong Kong and have potentially yet broader negative impacts.

5.2 In addition, with the Eco-Park and a landfill site currently situated in Tuen Mun, it could potentially be a candidate district to house an operational pilot plant or full-scale plant. With this innovative technology in Tuen Mun's back garden, a trend of being a technologically advanced district could be set, whilst providing employment to the local residents and stimulating the local economy. If this district municipality recognizes all the advantages of this wonderful waste management system and knows that it will be turned into a green city, of what then is central government so afraid? The site is ready, the technology is ready and feedstock will be readily available. A pilot plant will evidence the efficiencies, cost-effectiveness and merits within a small area and could easily be expanded as the technology is modular in nature.

6 Recommendations and conclusion

6.1 From the research undertaken and from the fact-finding mission to Europe, the government should implement the Three Rs head on without further delay and educate Hong Kong's population as it goes. We believe the policy will be the more palatable if appropriate rewards are included to make it the Four Rs policy.

6.2 Whether incineration or plasma gas technology is adopted, these in themselves provide no encouragement to Hong Kong's population to separate and reduce waste. The population's concept of creating waste will be just as great as it currently is. The population could be motivated to do so via a waste-disposal charge which will see the reduction of waste build-up.[63] This is the stick approach. A carrot approach of incentivizing waste reduction and recycling through appropriate rewards is desirable as a complimentary method. To implement the requisite infrastructure will provide employment for those who currently most need it - the relatively unskilled and impoverished groups within Hong Kong's current community.

6.3 The delegation concludes that Plasma Gasification technology is a much cleaner alternative which encourages waste separation from the outset and therefore encourages second chance recycling. It is likely to incentivize the population to reduce waste by the fair imposition of waste-disposal charges and there is no continued contribution to the dumping of landfills as there is no ash, toxic or otherwise, produced. As well as the production of cleaner energy there are no dioxins produced and the by-product, inert slag is successfully used in the likes of construction work with no harm caused to the environment.

[63] http://www.scmp.com/news/hong-kong/article/1317862/families-could-pay-hk74-month-dump-waste-says-consultation-paper

6.4 The plasma gas technology is 1/6 cheaper than the proposed IWMF and is no longer in its infancy. It has been used for many years and will provide a strong workforce from the local community. Adopting plasma gas technology will allow for the sell back of energy, production of clean fuel, encourage landfill mining and ultimately land reclamation.

6.5 In assisting the government by suggesting an alternative, Tuen Mun's Eco-Park should be considered for the housing of the plasma gas pilot plant which will be affordable, operate in a feasible time-frame and will not delay in addressing Hong Kong's waste issue. As a pilot, it would only make a small dent in the reduction of MSW but it will serve as working proof that the technology is successful and will avoid the requirement of landfill extensions and allow for the eventuality of reverse landmining, after all, seeing is believing. Not only will this address the issue of location, but it will also make Tuen Mun a functional, innovative and modern green district. This will create a positive synergy involving the government, the private sector, NGOs and the community.

6.6 In addition, Green Tuen Mun, a status which the district should already have but is currently lacking, should be treated accordingly - a district where the green environment is heavily promoted and the technology developed. The government should cease using Tuen Mun as a "convenient" dumping ground for waste it does not want in its back garden. The government should be incentivizing the development of alternative waste management technologies which will eventually address the landfill problem and subsequently be meeting waste reduction targets as set out in its Blueprint.

6.7 It perhaps appears that the government is motivated to build this mammoth sized incinerator at Shek Kwu Chau to solely deal with the enormous amounts of MSW produced by its population and not for actual waste management reasons- forgetting its objectives as set out in the Blueprint and potentially missing its earlier goals which were also missed in 2005. It does not directly deal with the issue of using resources optimally.

6.8 As government is convinced that incineration is the way forward, it should keep to its own time-frames whilst considering and implementing other feasible technology such as plasma gas. Tsang Tsui has been identified as a potential site with an EIA already completed, government's actions are costly in time, money, health and to the environment. Instead, this huge area of about 200 hectares could be used to test plasma gas and alternative technology and potentially expand the units since it is modular in nature. Transparency is required and fair consideration of alternative waste management systems is respectfully requested. Government has maintained continual dialogue with experts in the incineration field; experts from the plasma gasification and pyrolysis coupled with gasification industry should also be afforded the equal opportunity to be extensively interviewed by the administration and have their technologies seriously considered.

6.9 Based upon the above data retrieved from NT Concern Group's investigation to Europe and from their understanding of other literature and sources, the recommendations are as follows:-

6.9.1 the Blueprint is not a concept with which we disagree with in principle, be that as it may by imposing levies and providing a reward scheme to encourage, incentivize and motivate the people of Hong Kong to practice waste separation in line with the Three Rs of Reduce, Reuse and Recycle;

6.9.2 we disagree with shutting out alternative technology. Is incineration the best and only available technology for Hong Kong? No. Plasma gasification technology and other advanced thermal technologies should be given a chance. A pilot plant or plants could be operational by 2017 and should be housed in Tuen Mun as the site is ready (Tsang Tsui), the technology which is modular is ready and the logistics of being next to the landfill means there is a readily available supply of around 6,000 tpd of MSW;

6.9.3 the landfills should not be expanded but instead, technology should be employed to recuperate the land by back-mining the waste, a process which plasma gasification can carry out, allowing for better and greater utilization of a premium and lack of resource to Hong Kong;

6.9.4 Tuen Mun should not be seen to be like the sacrificial kamikaze by conveniently dumping waste in its backyard but instead should be turned into a useful, functioning, green city which can process the waste produced and latterly back mine; and

6.9.5 Hong Kong should take the lead in advancing this technology in the Pearl River Delta region. In adopting this approach, the acutely problematic pollution and harm to the environment could be lessened. Hong Kong should take back the initiative and influence others on the merits of plasma gasification.

6.10 On a final note, failure to manage rubbish and people well will lead to a catastrophe and result in a waste of talent and opportunity.

Give Hong Kong a chance. Give ourselves a chance. Give our future generations a chance

NT Concern Group

23rd November 2013

7 Annexures

Annexure 7.1 - Incineration vs. Plasma Gasification

INCINERATION	PLASMA GASIFICATION
Total cost: 42 billion*	7.2 billion#
3,000 to 4,000 MSW processed (tpd)	2,000 MSW processed (tpd)
Fly Ash and Bottom Ash as by-product	Slag as by-product
Does not support reverse land mining, as the ash requires to be dumped into landfills	Supports reverse land mining, as any ash produced is vitrified and turned into inert slag. Nothing is dumped into landfills
Reduces waste to heat and ash	Converts waste to synthesis gas and inert slag
Operates between 700°C and 1,000°C	Operates between 1,200°C and 10,000+°C
Requires hydrocarbon fuel or fuel gas to start burning of waste	Requires initial input of electricity but becomes self-sufficient when the plant produces electricity itself
Air is required for complete combustion	Little to no oxygen is required therefore no combustion
Any potential energy is converted to heat	Gases are collected and used to produced a variety of energy forms such as heat, hydrogen, synthetic gas and jet fuels
As much as 30% of waste becomes ash which requires careful disposal	As much as 15% of waste becomes inert slag which can be safely used and reduce the requirement to import aggregate
Greater emissions of greenhouse gases, pollutants and toxic ash	Lower emissions

* Based on the government's IWMF funds sought for use in 2013 (does not include cost for reclamation). Will likely increase by the time the final judicial review appeal decision is made (possibly end of 2014 or later) with costs estimated to have jumped to around HK$18 billion. The total amount of government's incinerator includes the direct construction cost of incinerator at 15 billion and reclamation at 10 billion. It also encompasses the cost of the required landfill extension of Tuen Mun at 9 billion and Ta Kwu Ling and Tseung Kwan O at 8 billion.

Based on capital investment used for TV1 and to be used for TV2 (cost not including land reclamation as the land was already reclaimed by the time Air Products begun construction- the figure for land reclamation was not made available).

Annexure 7.2- Three R's

Reduce, Reuse and Recycle

STAGE 1

Blue Bin (Paper)

Yellow Bin (Metals)

Brown Bin (Plastic)

Residential Waste

+$ for recycling

-$ Levy for mixed waste disposal

STAGE 2

+$ from collection & recycling

Encouragement for 2nd chance recycling due to -$ tipping fee

Metals

Paper & Plastics

Solid waste

STAGE 3

Incineration

Gasification

Plasma Gasification

Landfill

STAGE 4

(1W) Advantages:

-Heat for steam energy to power= REVENUE

(3L) Disadvantages:

-Environment: Toxic emissions such as dioxins, toxic fly ash discharge of CO2, bottom ash to be dumped in landfill

-Government: Costly technology

-Community: Resentment

(3W) Advantages:

-EfW: Synthetic gas to biofuels, hydrogen and power, slag= REVENUE

-Environment: non-toxic emissions, no outputs required to be dumped in landfills, reverse land mining

-Community and commercial: distribution of energy to locals

Advantages:

-Methane gas (if captured)

-Potential for reclamation of land for recreational use

Disadvantages:

-Leeching

-Vermin

-Rotten smell

-A waste of land

Annexure 7.3 - Data

	Size (acres)	Input	Output	Waste processed (tpy), Discharge (tpy) and Environmental Standards	Construction time	Modular?	Workforce	Initial Costs and Operational costs	Internal Rate of Return	Future development?
RAV Water Treatment (Rotterdam)	TBC	60MW for entire site including incinerator, biomass and water treatment	41.5MW from incineration	-1.3k tonnes incineration -2% fly ash and 20-22% bottom ash -EU 0.1ng TEQ/m^3	1 year	No	270	TBC	TBC	TBC
WSS (Amsterdam)	660 litre containers x 10,000+ units	Solar power	TBC	-14% incinerated -2% landfilled 84% processed/ recycled	1 to 2 hours per 660 litre container	Yes	3 per 500- 1,000 containers of 660 litres	TBC	TBC	2nd chance recycling
Advanced Plasma Power (Swindon)	10	4MW	16-20MW	-150,000 per line -12,000 Plasmarok (slag)	2 years	Yes	50	TBC	TBC	2nd chance recycling and Reverse Land Mining
New Earth (Avonmouth)	11 for entire site of which energy plant sits on 2	120kt RDF	13MWe	-120 kt -12% ash	18 months	Yes	7 in Operations at energy recovery plant per shift and over 120 for New Earth/ NEAT Group	TBC	Estimated to be 20% in an unlevered project	Gas to engine technology
Air Products (Teesside)	30 (can be reduced)	13MW	Gross output 50MW	-TV1 350,000 and TV2 350,000 -87,500 slag	27 to 30 months	Some components	50 700 during construction	GBP 300 million	TBC	2nd chance recycling and Reverse Land Mining

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