Example 4

Paul Warwick, Waste2Tricity

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Unrecyclable Plastic To Distributed Hydrogen

Waste2Tricity Guest Speaker Paul Warwick

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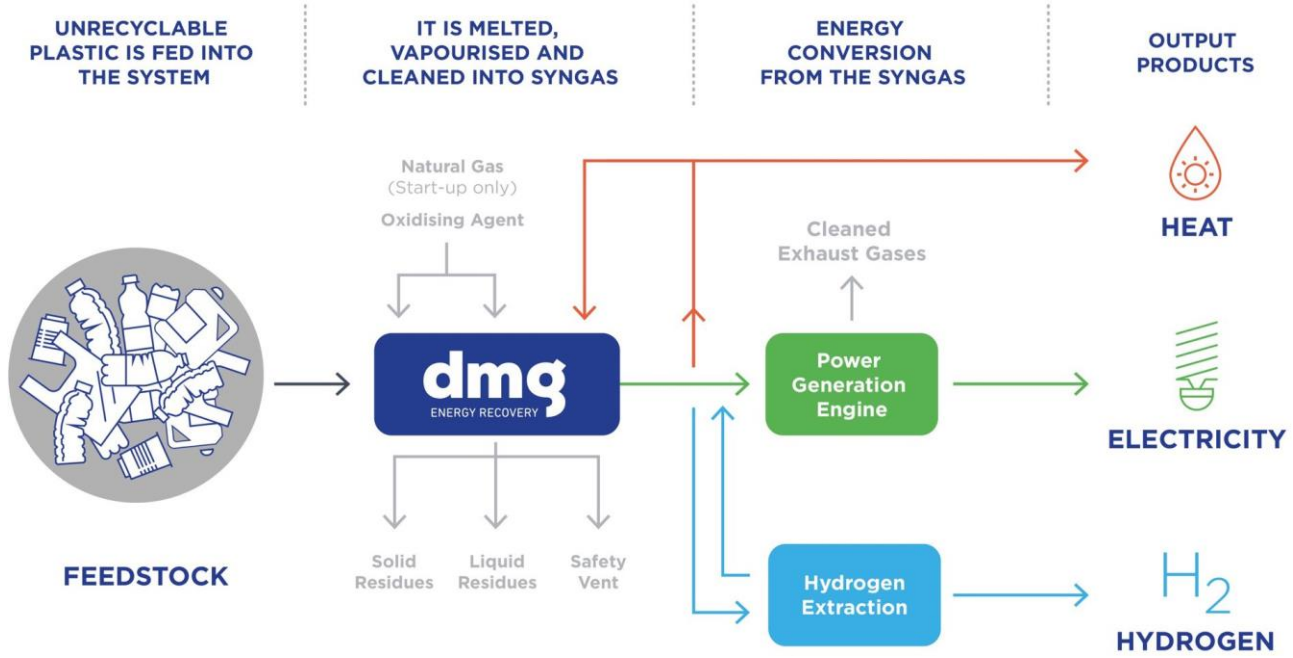
DMG® Technology

- Equipment is modular, already used in similar service. Operating parameters for hydrogen or power.
- Typical licensed application to authorities recyclers and waste companies. .



Process Ready

- Process controlled for either power generation or Power and hydrogen generation.
- Technology design now complete.
- Gas at similar energy to natural gas.
- Cleaned emissions fully compliant to IED.
- Design subject to successful DNV-GL Technology Assessment.

DNV·GL

STATEMENT OF FEASIBILITY

This is to state that the technology designated

Distributed Modular Gasification (DMG) Waste-to-Energy System

as detailed in /1/ has been assessed with basis in DNV-RP-A203 /2/ for its designated use. DNV GL considers the technology feasible as defined in /2/ and therefore suited for further development and qualification.

Owner: **PowerHouse Energy Group plc**
TEC 109, The Energy Centre, Thornton, Chester, CH2 4NU, United Kingdom

Description: The PowerHouse Energy Group plc DMG Waste-to-Energy technology can convert 25 tonnes per day of feedstock comprising of high calorific value waste materials, via a gasification process, into a synthetic gas ('syngas'). The produced energy-rich syngas can be combusted to produce power for distributed electrical generation. The DMG technology allows for integrating a process for the co-production of high purity hydrogen (1 tonne per day) from a proportion of the syngas in addition to generating power.

Benefits include:

- Waste elimination with high levels of energy recovery
- Production of electrical power for distribution
- Ability to co-produce high purity hydrogen with electrical power
- Modular

as further detailed in /1/.

Designated use: Distributed energy recovery from waste, producing syngas, electrical power and hydrogen fuel. Subject to local and regulatory requirements, as detailed in /1/.

Main uncertainties: Subsequent qualification activities should address the issues as detailed in /1/ which includes: Site application specific feedstock variability and feed system; Heat and mass balance validation and testing of gases produced for design and sizing, including utilities requirements, emissions and waste streams handling, and relief and blowdown; Methodology for dealing with and removing blockages; Operational and functional control philosophies; HAZID requirement.

Involvement: DNV GL has been involved in the qualification process in accordance with /2/ and has facilitated and documented the technology qualification process as explained in /3/.

Qualification and verification: Technology qualification can proceed with a threat assessment to identify the causes and mechanisms of failure to be considered. Following a complete technology qualification in accordance with /2/, products can be verified per validated requirements arising from the technology qualification and /1/.

Reference documents:
/1/ DNVGL Report - Technology Qualification Basis and Technology Assessment for Distributed Modular Gasification Waste-to-Energy System, Report 11BGTBNF, October 2018
/2/ DNV-RP-A203, Technology Qualification, June 2017
/3/ DNVGL-SE-0160, Technology Qualification Management and Verification Edition December 2015, Amended February 2018

The technology qualification is in progress and new sources of uncertainty might be discovered as qualification progresses. Attention is drawn to the iterative nature of the technology qualification process /2/.

UK, 15.10.2018
for DNV GL Oil & Gas,

Dr Chris O'Connor
Principal Consultant, TQ Lead
Advisory, Gas Technology

Michael Pritchard
Head of Section
Advisory, Gas Technology

First Application

- Protos strategic energy hub at the core of the Northern Powerhouse Licensing Model for monetization.
- HOTs for power and feedstock.
- Planning submitted.
- Waste2Tricity is working to fund project.

- At 35tpd of plastic and producing 2tpd of H2 the export of electricity is 52.8MWpd or 2.2MW standing.

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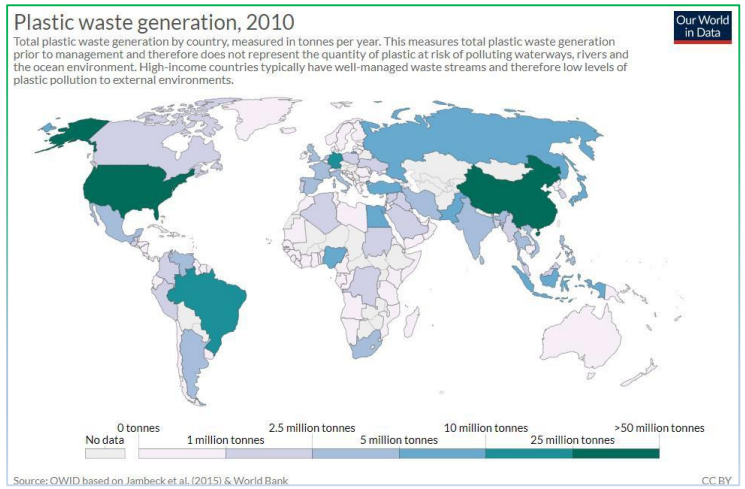
The Plastic reality

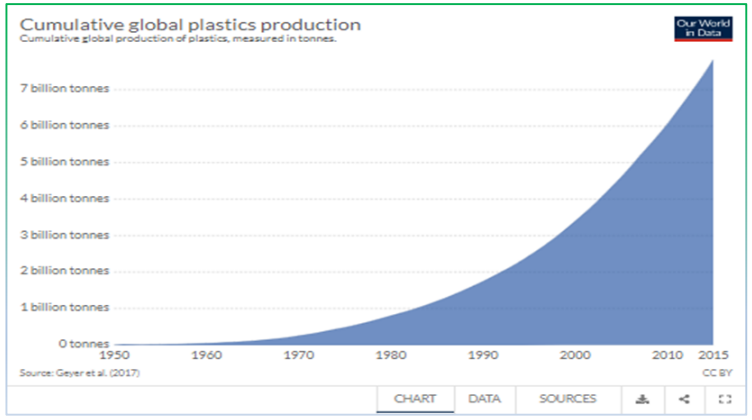
- An estimated global plastic annual production of 393 million metric tones (MT) for 2016 including resin used in spinning textile fibers (Plastics Europe, 2017 & Lenzing Group, 2016).

- By 2040 global plastic annual production is expected to be 800 million metric tons (MT) with an estimated 12,000 million metric tones (MT) of plastic in landfill sites or the natural environment by 2050.

- China is by far the largest producer of plastic in the world generating 60 million tones of plastic each year, in contrast with countries in the West such as the U.K. that produces 1.7 million tones each year.

- The growth of plastics in the world/ASEAN countries production in the past 65 years has substantially outpaced any other manufactured material. The same properties that make plastics so versatile in innumerable applications— durability and resistance to degradation—make these materials difficult or impossible for nature to assimilate . Without a coherent management strategy for end-of-life plastics, we are conducting an uncontrolled experiment on a global scale, in which billions of metric tons of plastic will accumulate across all major terrestrial and aquatic ecosystems on the planet.





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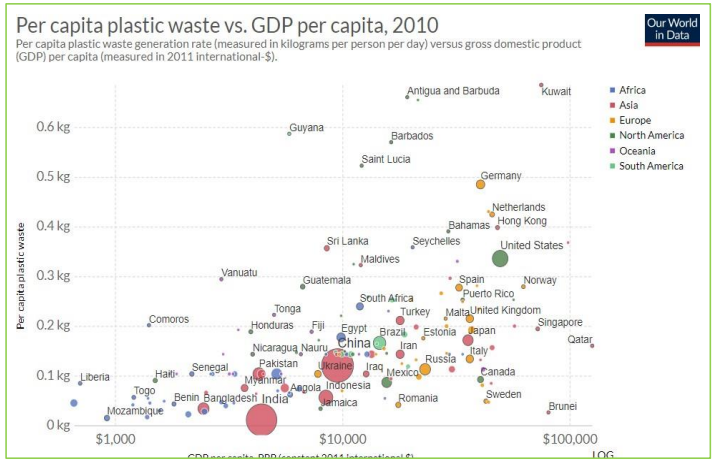
The Plastic reality cont…

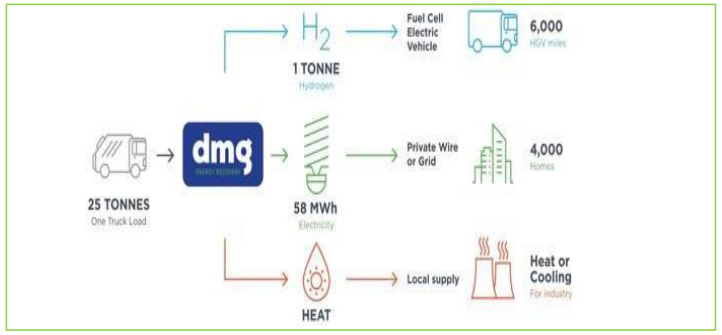
- In the chart at the right of this page it shows the plastic waste generate rate per person versus gross domestic product (GDP) per capita. In general — although there is significant variation across countries at all levels of development — plastic waste generation tends to increase as we get richer. Per capita plastic waste at low incomes tends to be notably smaller.



- As the ASEAN countries economies are growing and so it is their plastic production. And so is everyone else's in the world despite well merited efforts by the Western Governments to reduce the plastic production. The question still remains what happens to the plastic that has already been produced, let alone the plastic the we are producing and we will be producing in the future.

The Solution – Powered by Waste 2 Tr i c i ty

- PowerHouse Energy powered by Waste2Tricity has come up with a unique innovative solution that can convert plastic into Hydrogen and Electricity with almost zero release of CO2 into the atmosphere.
- Waste-to-energy schemes such as ours are a core solution for end-of-life and hard-to-recycle plastics with a vital and unavoidable role in any integrated waste management system that might include dematerialization, substitution, reuse, and material recycling.



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Waste Plastic

- DMG® offers potential reduced waste sorting and cleaning costs vs other EfW processes.
- Can take any mix of polymers.
- Feedstock can be wet, with organics.
- The CV range is less significant to DMG® operation and efficiency than to other EfW processes.
- DMG process is not dependant on specific waste.
- We offer testing and analytical and trialling services to potential customers.

Typical Feedstock

Plastic	% W/W
PET	32%
PE	33%
PP	18%
PVC	4%
POM	3%
PEEK	3%
PBT	2%
PC	2%
PS	2%
SAN/ABS	1%
PLA	1%

Tyre shred

Cable shred

Tested Feedstocks

We have successfully tested

- Automotive shred (pictured right & data)
- SRF
- Shredded tyres (pictured left)
- Shredded cables (pictured left)
- shredded labels and mixed plastics
- shredded beach waste
- Biomass

Analytical Report No: BI19-00168.001

Automotive shred

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DMG® Plastics Regeneration

- Powerhouse DMG® process regenerates non-recyclable mixed & contaminated plastics with minimum land take, simple permitting.
- Technology at an exciting stage, In UK partnering and co-located with existing waste management services and industrial land developers active.
- Actively seeking engagement of council partners in roll out.
- Negative CO2 emissions when on hydrogen operation.
- Enabling easily executed, lower cost waste plastic processing.
- Savings for Councils of £1,000,000 per annum reducing power, gas and diesel bills significantly.

What can we do

- Destroy unrecyclable plastic cleanly and efficiently.
- Produce road fuel hydrogen.
- Export electricity and heat.
- Make hydrogen near point of use reducing costs and vehicle movements.
- Drive the hydrogen infrastructure whilst disposing of plastics.

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UKHFCA

plastiphobia

[plas-ti-foh-bee-uh]

noun: the vilification of plastic as a material (when correctly collected, managed and recycled, plastic need not be something to fear). *Term coined at RECOUP Conference 2019.*

THANK YOU

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