Driving energy and resource efficiency through chemical engineering

Promoting a Circular Economy with Clean Fuels and Chemicals made from Municipal Waste

Introduction

As part of the EU's circular economy policy it has produced a new set of rules to make waste legislation fit for the future. These include new recycling targets for municipal waste whereby 55% will be recycled by 2025, 60% by 2030 and 65% by 2035. Eurostat data shows that in 2016 the EU 28 recycled 29% of its municipal waste with 24% going to landfill, 27% incinerated and 16% composted[1]. There is a clear need to improve the sustainability and efficiently of waste treatment. Waste hierarchy principles argue for waste prevention and minimisation as the most preferred option, but recycling and recovery reduce reliance on the worst action: disposal.

In the case of municipal waste, meeting accepted waste hierarchy principles requires efficient collection and sorting systems to first separate streams which can be recycled. These include plastics and material suitable for composting. The remaining stream can pass to other recovery routes such as incineration ideally with energy recovery or via chemical reprocessing to potentially valuable products such as fuels. The final residue typically goes to landfill.

In the UK local authorities have developed their own systems for collection, sorting and further treatment. Consequently, there is significant disparity in recycling levels and performance across regions. The data is made more difficult to interpret because it is heavily skewed by the overseas export of material. (Although China has recently banned the import of most recyclable waste, other countries in South East Asia have increased their imports to compensate.) Though this waste is classified as recycled, there is no information on how materials are actually handled. Government intervention is required to rationalise collection and sorting systems to ensure as much waste is diverted from landfill, as landfill waste is a generator of potent greenhouse gases.

New recycling targets for municipal waste:

55% to be recycled by **2025** → **60%** by **2030** → **65%** by **2035**

Eurostat data shows that in **2016** the EU 28 recycled **29%** of its municipal waste with **24%** going to landfill, **27%** incinerated and **16%** composted.

[1] *Eurostat, Municipal waste statistics,* ***http://bit.ly/2CNGYJ2****, accessed 18/01/2019*

IChemE Energy Centre

IChemE ADVANCING CHEMICAL ENGINEERING WORLDWIDE

A Solution

At the forefront of waste management strategy is a facility in Alberta, Canada. Here the city have constructed the Edmonton Waste Management Centre (EWMC) at a cost of C$400 million. This one centre combines a variety of waste processing and research facilities. Owned and operated by the city, the EWMC has increased diversion from landfill, due in part to the world's first commercial scale waste-to-biofuels and chemicals facility which is developed, owned and operated by Enerkem Alberta Biofuels.

This technology takes otherwise unrecoverable (ie non-recyclable and non-compostable) dry solid waste for conversion to methanol and ethanol in a process resilient to variations in feedstock composition. Utilising waste streams for production in this way comes with several advantages over other biofuel feedstocks:

- no competition with food supply;
- no additional land use;
- utilises existing collection, processing and distribution infrastructure.

When operating at full capacity in 2020, the facility is expected to significantly contribute to the city government's goal of increasing their diversion rate from 50% to 90% by 2022[2]. This offers environmental benefit not only by preventing methane release from landfills, but also by displacing sources of ethanol and methanol which have higher CO_2 emissions across their production chain. In 2017, 97% of methanol production was derived from natural gas (80%) and coal (17%). The waste-to-methanol process produces the chemical with a 40% reduction in greenhouse gas emissions compared to fossil fuels, and 30-35% reduction compared to methanol derived from bio-resources[3].

*Figure 1. The Circular Economy (courtesy of **Enerkem**)*

Access to growth capital is, typically, the biggest barrier to the development of novel technology. This is particularly the case in the clean technology area where project payback periods might be longer than typical corporate behaviour. For waste-to-methanol processes, the payback time has been estimated at about four years, a return of investment of ~29%[3].

This waste-to-biofuels and chemicals technology has been developed over a ten-year period with the support of the Canadian government. It benefits from co-location with the larger Edmonton Waste Management Centre, which has an Integrated Processing and Transfer Facility to sort and treat the refuse before it is distributed between the Centre's facilities such as for composting, anaerobic digestion, material recovery, and electronic waste recycling.

*Figure 2. The Enerkem Alberta Biofuels facility (courtesy of **Enerkem**)*

The Enerkem Alberta Biofuels facility was certified in 2016 under the International Sustainability and Carbon Certification (ISCC) scheme. In 2017 the carbon intensity of the ethanol biofuel produced was rated at -55 gCO_2e/MJ, compared to a +88gCO_2e/MJ rating for gasoline by the same authority (British Columbia Renewable and Low Carbon Fuel Requirements Regulation). This makes Enerkem's waste-based biofuel the lowest carbon-based transportation fuel ever approved under the scheme. The plant was also the first of its kind to sell the ethanol under the US Renewable Fuel Standard after receiving the Environmental Protection Agency's approval in 2017.

In advance of the Alberta plant starting to operate at full capacity, Enerkem have signed on with a consortium of companies to develop an advanced waste-to-chemistry facility in Rotterdam[4], and signed an agreement with Sinobioway Group which may lead to the construction of over 100 facilities in China.

> **"In 2017,** the carbon intensity of the ethanol biofuel produced was rated at -55 gCO_2e/MJ, compared to a +88gCO_2e/MJ rating for gasoline.**"**

The Technology

The four-step thermochemical process consists of:

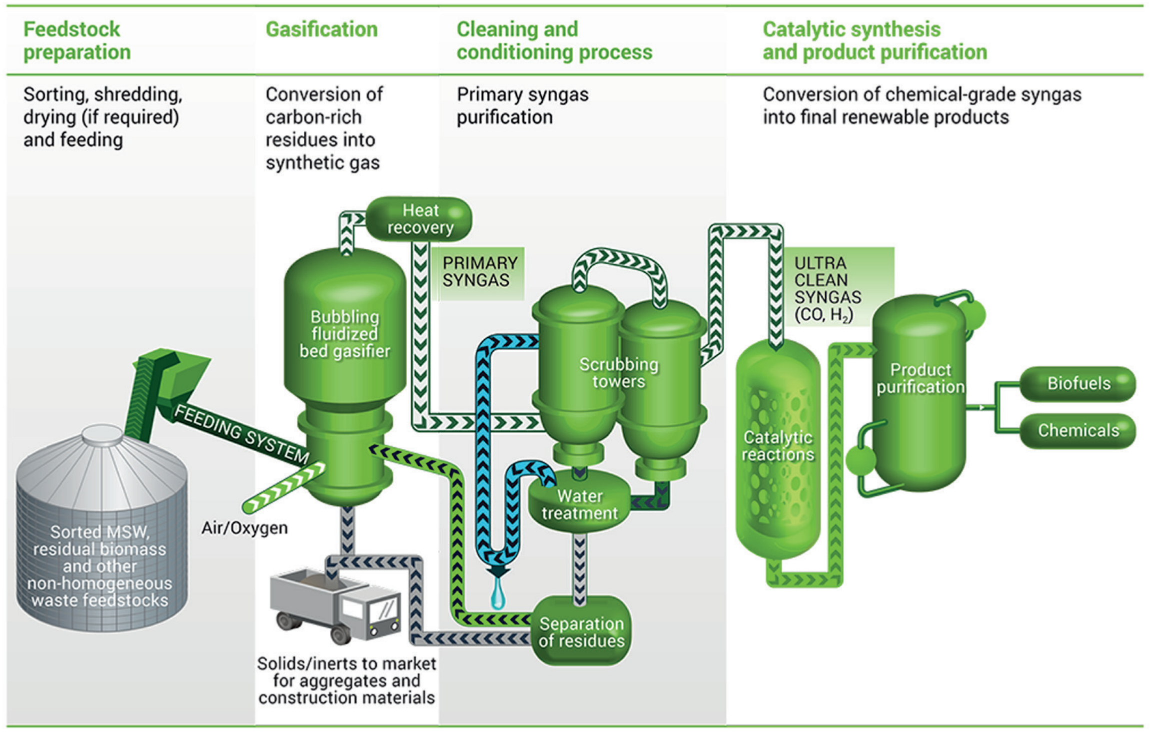
1. Feedstock preparation – sorting and shredding
2. Partial oxidation gasification
3. Cleaning and conditioning of syngas – recycled water wash
4. Catalytic synthesis

The proprietary gasification stage is said to be at relatively low temperature and pressure whilst the catalytic synthesis step uses conventional catalysts. Around 90% of the feedstock carbon is converted to syngas by this process.

[2] *Waste Services Business Plan, City of Edmonton,* ***http://bit.ly/2TZTE4G***

[3] *Waste-to-methanol: Process and economics assessment,* ***doi.org/10.1016/j.biortech.2017.06.172***

[4] *The Chemical Engineer, 2018,* ***http://bit.ly/2NhN32G***



** Municipal solid waste*

*Figure 3. Flow diagram of the Enerkem Alberta Biofuels Plant (courtesy of **Enerkem**)*

Conclusions

In the drive towards a circular economy chemical engineers should consistently think of ways to extract value from unavoidable waste streams. In this case solid municipal waste streams, from which recyclable and compostable material has been separated, are a potential source of carbon. When this is converted into fuels, it can displace those fuels derived from fossil sources. Where the alternative disposal scheme is landfill, this carbon would be converted into methane which as a greenhouse gas is 24 times more potent than carbon dioxide.

The economics of this process are not solely dependent on the production cost of the biofuels. Other factors to be taken into account are the savings made on landfill tax and the value placed on GHG emission reductions against the alternative fossil based fuels and the reduction in landfill gas release.

This case study also illustrates the potential complexity of evaluating the optimum choice for implementation since incineration with energy recovery might be an attractive alternative disposal route for this solid municipal waste stream in different circumstances.

In seeking to drive progress to a circular economy **chemical engineers** should be consistently **thinking of ways to extract value from unavoidable waste streams.**

Led by members, supporting members, serving society

Contact us for further information

UK
t: +44 (0)1788 578214
e: membersupport@icheme.org

Australia
t: +61 (0)3 9642 4494
e: austmembers@icheme.org

Malaysia
t: +603 2283 1381
e: malaysianmembers@icheme.org

New Zealand
t: +64 (4)473 4398
e: nzmembers@icheme.org

Singapore
t: +65 6250 0385
e: singaporemembers@icheme.org

www.icheme.org

Incorporated by Royal Charter 1957. The Institution of Chemical Engineers (trading as IChemE) is a registered charity in England and Wales (214379) and Scotland (SC039661). The Institution also has associated entities in Australia, Malaysia, New Zealand and Singapore.

LC0108_18