Techno-economic analysis of municipal solid waste gasification to methanol

MOTIVATION

- Annual municipal solid waste production in US in 2018 - 265 MMT
- Carbon-rich waste stream that could be used for generation of valuable chemicals
- Gasification refers to conversion of any carbon-based source to syngas (CO+H₂)
- Global syngas market projected to grow at 6% and reach $67 bn by 2027
- Techno-economic analysis performed, and minimum selling price (MSP) estimated for methanol produced by MSW gasification pathway

PROCESS DESIGN

- Feed ultimate composition: C-44%, H-7%, O-29%, Ash-18%
- Direct gasification carried out with steam and oxygen, Steam/MSW=0.44, Oxygen/MSW=0.21
- Sulfur removal involves LOCAT-S system and ZnO catalyst beds
- Tar reforming and steam reforming carried out in two separate steps to increase syngas yield by reforming hydrocarbons
- CO₂ removed prior to methanol synthesis to reduce CO₂ mole fraction at reactor inlet to 7.5%
- Final product yield from simulation = 0.48 kg methanol/kg MSW

CONCLUSIONS

- MSP for methanol from MSW gasification is $0.55/kg (compared to 5-yr avg. price of $0.30/kg for fossil fuel-based methanol), feedstock in RDF form assumed to be zero cost
- Major contribution to MSP is from capital cost recovery and fixed operating costs

Sensitivity Analysis

- Plant capacity has a major impact on process economics
- Steam/Carbon in SMR has a major impact as CO₂ is removed prior to methanol synthesis leading to loss of yield
- MSP is lowered with the tipping fee credit, but MSP is still high ($0.47/kg) for US avg. tipping fee of $59/MT

Supply Chain GHG Emissions

- GHG emissions estimated using NREL’s Materials Flows through Industry (MFI) tool
- Overall emissions are higher than fossil fuel-based methanol, mainly attributed to loss of carbon yield due to conversion to CO₂
- If credit is taken for avoiding landfill emissions (-1.61 kg CO₂/kg MSW), overall emissions are -0.9 kg CO₂/kg methanol

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