Feedstock Recycling of Waste

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Institute for Technical Chemistry (ITC)

IEA Bioenergy

Task 36

Integrating Energy Recovery into Solid Waste Management Systems
Implementation of a Circular Economy for Carbon Containing Materials

- Replacement of fossil carbon feedstocks by recycled materials
- A variety of recycling processes have been developed in the past for:
  - Mechanical/material recycling
  - Feedstock recycling of waste
  - Waste to energy
- Carbon CE Drivers:
  - (Temporarily) high oil prices
  - Advanced environmental legislation
- Carbon CE Barriers:
  - Low fossil feedstock prices
  - High capital demand of new process chains
- Material recycling in place for:
  - Pure manufacturing residues
  - Some fractions from sorting systems
Carbon Cycle

$\text{CO}_2$
Defossilization of the Anthropogenic Carbon Cycle

- Chemicals and RE-fuels from
  - Biomass
  - Waste recycling
  - CO$_2$-capture
Residual Biomass Potential

Theoretical potential of biomass residues in Germany. Fachagentur Nachwachsende Rohstoffe e.V. (FNR) 2015, Biomassepotentiale von Rest- und Abfallstoffen: Status quo in Deutschland, Schriftenreihe Nachwachsende Rohstoffe 36

Sustainable supply of 10% of Germany’s primary energy demand, approx. 1000 PJ (278 TWh)
Energy Demand of the Industrial Sector

Total primary energy demand German industry 2013: 1.081 TWh

Carbon Material Sources & Demand in Germany Today

- Biomass, 150 mn t/a: 1,000 PJ
- MSW, 50 mn t/a: ca. 250 PJ
- Material utilization of fossil sources (w/o coke): 975 PJ
- Fuels for mobility: 3,330 PJ
- Total primary energy consumption: 10,000 PJ
MSW Thermal Treatment Status 2012

* incl. 115,000 Mg sewadge sludge (dry)
** incl. 284,000 Mg sewadge sludge (dry)

Incineration: 20.0 Mil. Mg/a
SRF-plants: 5.1 Mil. Mg/a
Cement: 2.8* Mil. Mg/a
Co-Combustion: 1.8** Mil. Mg/a
Incineration Technology

- Standard technology
- Alternative technologies
- Special thermal treatment emission issues
Thermal Waste Treatment in Germany

Mio t of Waste Treatment
Σ 24,2 (2012)

- Thermal Waste Treatment Plant: 20,2
- Sewage Sludge Incineration: 2,0
- Hazardous Waste Incineration: 1,3
- Other Thermal Plants (e.g. Pyrolysis): 0,6

(not including dedicated SRF-plants)

destatis, article no: 2190100137005, © Statistisches Bundesamt, Wiesbaden 2015
Incineration Technology

Reverse acting grate with dry bottom ash discharge

Option: Metal recovery from bottom ashes
Is large-scale gasification viable?

It’s green, flexible, and readily available. So why is large-scale thermal gasification slow to take off? Tom Goulding reports.

On an industrial site in North East England, work has been underway on a single project with two of the largest waste gasification plants ever conceived for the UK. With a combined throughput capacity of 700,000 tonnes, Tees Valley 1 and 2 have been several years in the making – two identical sites contracted to convert virtually all of the municipal refuse produced in the City of Hull into synthetic gas. But last month with just weeks to go, construction suddenly ground to a halt on TV2 and 700 workers were laid off.

Air Products to halt UK Tees Site EfW plasma gasification project

MSW Pyrolysis Plant at Burgau, Germany

- Started up in 1983
- Final capacity: 26 kt/a
- Shut down in Dec. 2015
Burgau: Pretreatment of waste

Figure 3.20: Raw waste, shredded waste, separated upholstery at MPA Burgau

Disassembled feeding system:
100 MW (ca. 25 Mg/h) CFB-gasifier at the CEMEX Rüdersdorf cement plant running on SRF for approx. 20 years (Energetic syngas utilization)

Figure 3.71: Integration of the ZWS-gasfier into the production of cement at Rüdersdorf site [Cemex 2013].

Special Thermal Treatment Emission Issues

- Composites
- Persistent Organic Pollutants
- Carbon Fibers

PMMA-NC (10 Gew-% TiO₂)

https://de.wikipedia.org/wiki/Hexabromcyclododecan

Rheinisch-Westfälische Technische Hochschule Aachen (RWTH)
Lehr- und Forschungsgebiet
Technologie der Energierohstoffe (TEER)
Development of the Recovery of Plastics

Quelle: Umweltbundesamt 2015, eigene Zusammenstellung mit Daten der CONSULTIC GmbH - Produktion, Verarbeitung und Verwertung von Kunststoffen in Deutschland 2013 (Stand: 09/2014)
Entrance Opportunities

Thermochemical Processes for Feedstock Recycling of Carbon Containing Waste - Challenges

- Feedstock flexible processes allowing for economies of scale
- Mixed waste feedstock
- Waste to Chemicals-process chains to be applied in Chemical, Metallurgical or Minerals / Building materials industries
- Main products depending on process are syngas, synthetic crude oil (petrochemical liquid feed), reducing agents
- Byproducts are physical energy and mineral products (P,…)
- Deposit for critical components (Cl,S,…)

Pretreatment - Conversion - Upgrading
Thermochemical Conversion Technologies for Solid Feed to Secondary Chemical Feedstocks (Major reaction step)

- **Pyrolysis**
  - Rotary-Kiln, Multiphase-Flowreactor, …
  - Catalytic / Hydrogenating Liquifaction, …

- **Gasification**
  - Fixed bed, Fluidized bed, Entrained Flow
  - Special type (Plasma, …)
  - Co-Gasification (Shaft Furnace in Metallurgical / Mineral processing)

- **Others**
  - Thermolysis
  - Hydrothermal treatment