Thermo-catalytic reforming: Sustainable efficient energy from bio and plastics waste

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Thorsten Hornung
Global sustainability challenges require efficient solutions

Global municipal solid waste growing to 2.6 bn. tons per year by 2025?

+5°C global warming by 2100 without turnaround on greenhouse gas emissions?
A flexible, integrated waste-to-energy solution ...

- Agricultural residue
- Municipal biowaste
- Industrial biowaste
- Plastics waste
  ... or animal grease, glycerol, other fats, oils and waxes

Thermo-Catalytic Reforming (TCR®)

- Syngas
- Oil
- Biochar

Bio-Activated Fuel option (BAF)

Power
Heat
Fuels
Fertilizer
Chemical precursors
Thermo-Catalytic Reforming (TCR®) of waste biomass
Thermo-Catalytic Reforming (TCR®) – process overview

1. Thermal Drying
2. Thermal Decomposition
3. Catalytic Reforming
4. Product Treatment
Further extending the feedstock range – BAF reactor option for plastics waste, oils & fats
High feedstock flexibility

- Animal manure
- Oil & fruit pomace
- Plantation residues
- Straw, husk
- Wood residue

Suitable for most solid biomass
- Food waste
- Organic waste
- Municipal solid waste
- Roadside & park clippings
- Sewage sludge

Up to 10% plastics in biomass
- Bagasse
- Biogas digestate
- Paper sludge
- Bioethanol residual

Mixed feedstock
- Over 50% moisture content
- Agricultural residue
- Municipal biowaste
- Industrial biowaste

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Superior product quality – many applications

**Oil**

- No tar or wax
- High heating value (33-36 MJ/kg)**
- Low acidity (TAN 2 - 5 mg KOH/g)**
- Blending with regular fuels
- Suitable for motor applications

**Engine quality oil**

**Syngas**

- Tar and dust free
- Free of aromatics
- Up to 50% hydrogen content
- Suitable for motor applications
- Suitable for synthesis processes

**Engine quality syngas**

**Biochar**

- Dry, storable and transportable
- Fixed carbon content at hard coal level
- Increased ash concentration
- Suitable as solid bio fuel
- Suitable for soil improvement applications

**Biochar in hard coal quality**

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Folie 8

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**Illustrative Scenario – Value from oil press residue**

- **2.250 t/year** 14% humidity

- **Straw**

- **TCR® Reactor**

- **Approx. 180 t/year** For plant heating

- **928 t/year**

- **164 t/year**

- **522 t/year**

- **Chemical Upgrading Plant**

- **300 kW electric** (peak)

- **Biooil**

- **Biochar**

- **Syngas**

*Biooil is blended with 10-20% of vegetable oil, biodiesel or regular diesel*

**Plant incl. dryer is heated using heat from CHP plant and combustion of biochar or external fuel**

***In addition process water is produced (approx. 20% of the feedstock)***
Illustrative Scenario – Processing plastics & biomass waste

7600 t/year
Digestate
75% humidity

3400 t/year
Plastics waste

TCR® Plant

Syngas
1600 t/year

CHP Plant
1800 kW electric (effective)

Aliphatic fuel
2800 t/year

Biochar
430 t/year

Approx. 250 t/year
For plant heating

* Biooil is blended with 10-20% of vegetable oil, biodiesel or regular diesel
** Plant incl. dryer is heated using heat from CHP plant and combustion of biochar or external fuel
*** In addition process water is produced (approx. 20% of the feedstock)
Our technologies are ready for application …

Pilot plants at Fraunhofer UMSICHT …

... and commercial plants at design stage.
Key advantages of TCR® technology

<table>
<thead>
<tr>
<th>Other waste-to-energy technology</th>
<th>TCR® technology</th>
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</thead>
<tbody>
<tr>
<td>Limited feedstock flexibility</td>
<td>High feedstock flexibility</td>
</tr>
<tr>
<td>Limited to niche markets</td>
<td>Product diversification</td>
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<td>Complex product treatment</td>
<td>Superior product quality – simple design</td>
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<td>Variable energy yields</td>
<td>Unlocks &gt; 70% of feedstock energy</td>
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<tr>
<td>Large capital requirements</td>
<td>Economic solution at small scale</td>
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<td>Major development potential</td>
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Fraunhofer UMSICHT spin-off to commercialize TCR® technology

- Company offering TCR® technology equipment
- Collaborating with Fraunhofer UMSICHT and other partners on demonstration projects

Energy and fuels from biomass and plastics waste through sustainable and efficient thermo-chemical conversion solutions
Interested?
Please contact us.

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**Illustrative Scenario – Value from oil press residue**

- **Oil press residue**

  - 2.250 t/year
  - 10% humidity

- **Olive pomace**

  - 300 kg/h
  - TCR® Reactor

- **Syngas**
  - 630 t/year
  - (15 MJ/kg)

- **Biochar**
  - 410 t/year
  - (36 MJ/kg)

- **Biooil***
  - 630 t/year
  - (26 MJ/kg)

- **Approx. 180 t/year**
  - For plant heating

- **Plant incl. dryer**
  - Heated using heat from CHP plant and combustion of biochar or external fuel

- **TCR® Reactor**
  - CHP Plant
  - 280 kW electric (effective)

- **Biooil** is blended with 10-20% of vegetable oil, biodiesel or regular diesel

- **Plant incl. dryer** is heated using heat from CHP plant and combustion of biochar or external fuel

- **In addition process water is produced (approx. 20% of the feedstock)**
## Illustrative Application Scenario – Business Case

### TCR® Plant

<table>
<thead>
<tr>
<th>Expense</th>
<th>mn. INR/a</th>
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<tbody>
<tr>
<td>Feedstock</td>
<td>1.78</td>
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<tr>
<td>Biodiesel</td>
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<td>Labor</td>
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<td>Maintenance</td>
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<td>Other</td>
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<td><strong>Total</strong></td>
<td><strong>10.4</strong></td>
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### Revenue

<table>
<thead>
<tr>
<th>Revenue</th>
<th>mn. INR/a</th>
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<tbody>
<tr>
<td>Power sales</td>
<td>24.3</td>
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<tr>
<td>Heat</td>
<td>3.57</td>
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<tr>
<td>Biochar</td>
<td>2.09</td>
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<td><strong>Total</strong></td>
<td><strong>30.0</strong></td>
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### Result

<table>
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<tr>
<th>Result</th>
<th>1.000 EUR/a</th>
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<tr>
<td>EBITDA</td>
<td>19.6</td>
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<tr>
<td>Depreciation</td>
<td>3.26</td>
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<td>EBIT</td>
<td>16.3</td>
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<td>IRR</td>
<td>29%</td>
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- Illustrative business case based on experimental data and estimates
- Annual averages over 20 years project duration
- Loan financing not considered

- Power price: 9300 INR/MWh
- Heat price: 2300 INR/MWh (50% utilization)
- Biochar price: 7800 INR/t
Illustrative Scenario – Value from biogas digestate

7600 t/year
75% humidity

Digestate

700 kW thermal
500 kW imported from biogas plant

Biomass Dryer

2.250 t/year
15% humidity

Digestate, dry

300 kg/h

TCR® Reactor

Approx. 250 t/year
For plant heating

880 t/year

Syngas

180 kW electric
(effective)

170 t/year

Biooil*

Biochar

430 t/year

* Biooil is blended with 10-20% of vegetable oil, biodiesel or regular diesel
** Plant incl. dryer is heated using heat from CHP plant and combustion of biochar or external fuel
*** In addition process water is produced (approx. 20% of the feedstock)