Advanced CtL/CtG Technologies for Lignite

Innovative Coal Value Chains

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RWE Generation SE
1 Chances and potentials of lignite to chemicals
2 Lowering of capital costs
3 Team up with renewable energies
4 Conclusions
Lignite can provide a significant contribution to security of supply in the future

In power production already today:

- Lignite power plants are already highly flexible to secure residual load. They are ideal partners for renewable energies.
- Refinement products from lignite are attractive for industry.
- Domestic raw material resource reduces import dependency.

Additionally as carbon supplier in the future:

- Raw material supply of chemical industry is based today mainly on crude oil and natural gas.
- Crude oil reserves decline; oil quality decreases
- Chemical industry can diversify its raw material base in the long run with stable prices.
A committee of inquiry* confirms relevance of lignite for the German energy system and raw material supply

- Cross party agreement of all political parties in NRW parliament

**Main messages:**

- Potential of lignite for production of chemicals
- Domestic resource lowers German dependence on geopolitical situations and world-market prices
- Lignite vicinity to chemical industry supports economic viability of CtL/CtG

**Recommended action:**
- establish scientific chairs in NRW, subsidies for demo plants

- RWE appreciates the outcome of the committee and will support development of CtL/CtG.

* „Enquetekommission zur Zukunft der chemischen Industrie in Nordrhein-Westfalen“
RWE’s approved lignite reserves contribute to a long term supply of energy carriers and raw material

<table>
<thead>
<tr>
<th>Mine</th>
<th>Exploitation</th>
<th>Reserves</th>
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<tbody>
<tr>
<td>Garzweiler</td>
<td>35 – 40 Mt/a</td>
<td>1.2 bn t</td>
</tr>
<tr>
<td>Hambach</td>
<td>35 – 45 Mt/a</td>
<td>1.4 bn t</td>
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<tr>
<td>Inden</td>
<td>20 – 25 Mt/a</td>
<td>0.3 bn t</td>
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System lignite
- Exploitation: ~ 90 - 100 Mt/a
- Power production: ~ 70 - 75 TWh/a (40 % NRW / 13 % D)
- ~ 10,000 employees

* Status 01.01.2014, ** without gas turbines
Gasification most promising for high product yield and quality

Key technologies

Drying → Gasification → Gas-treatment → Synthesis

Alternative routes

Synthesis gas → Synthetic natural gas → Basic chemicals* → Fuels → Waxes

* Naphtha, hydrogen, acetic acid, formic acid, methanol, ammonia, …
Vision: Commercialization of CtL/CtG for Rhenish Lignite until mid ‘20ies

Special challenge: economic integration of new plant technologies into existing infrastructures at lignite and chemical sites

- Technologies used for CtL/CtG-plants are in general commercially available.
- Adaption and proving with regard to Rhenish Lignite and German provisions.

*Themal gasification capacity as benchmark for whole plant
Challenges and chances for CtL in Germany

**Economy**
- Lignite is economically available
- Equipment for CtL is extensive and capital intense
- Cost-benchmark für CtL products is crude oil price

→ **Approach 1: Lower the capital costs**

**Security of supply**
- Domestic resource is price stable and regionally available
- Added value remains inside the country

**Environment**
- CtL process emits more CO2 than products from gas or oil
- Combination with H2 from renewable energy allows carbon containing products from CO2 free process
- Potential of CO2 use via renewable energy

→ **Approach 2: Combine with renewables**
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Capital costs: Annex-Principle as a low-cost approach

**Annex-Principle** = Integration of a CtL/CtG-plant into existing site infrastructure

- Reduces investment
- Offers new utilization- / operation-options for existing infrastructure

**Diagram:**
- **Raw lignite** → **Lignite power plant** → **Dry lignite** → **Lignite gasification plant** → **Synthesis** → **Lignite to chemicals**
- **Industrial site** → **Solid residues** → **Process gases** → **Water** → **Steam** → **Power production**

- **Existing plants**
- **New plant**

- **Power plant** and **industrial sites** offer potentials for annex-plants
**Approach capital costs: Alternative gas scrubbing**

**Gasscrubbing has high capital and operational costs**
The widely used scrubbing technology for CtL (Rectisol – physical scrubbing with cold methanol) requires 20% of CtL capital costs.

<table>
<thead>
<tr>
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<th>Rectisol scrubber</th>
<th>Alternative scrubber</th>
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</thead>
<tbody>
<tr>
<td>Purity of synthesis gas</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Operational costs</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Flexibility (Aromats, higher HC)</td>
<td>+</td>
<td>-1)</td>
</tr>
<tr>
<td>Technical maturity</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Capital costs</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

→ **Approach for a chemical scrubbing system with high product purity**
- reduce the amount of necessary equipment
- avoid cryogenic system

1) add. . Benzol scrubbing necessary in case of higher HC in raw syngas
New gas scrubbing concept with potential to lower capital costs

Amin scrubber

Desorber

NaOH-scrubber

H2O + Na2SO4

H2O + Na2S

CO2

H2S + CO2

H2O2-scrubber

Sulphur

clean synthesis gas

Raw syngas

H2O + Na2S-treatment

Steam + air

H2O2-scrubber

Na2S-treatment
Measures to lower capital costs
Alternative scrubbing concept offers capital saving potential

- No capital and energy intense kryogenic methanol system,
  Cost reduction of scrubbing by about 50% via:
  - Only half amount of equipment
  - Only a third of compression power

- Components are known and tested in other processes:
  - Amin scrubbing: *(reformed gas cleaning and Carbon Capture)*
  - NaOH scrubbing: *(reformed gas cleaning)*
  - NaSO₂ treatment: *(tested)*
  - H₂O₂-scrubbing: *(used in waste water treatment)*

Reduction of estimated scrubbing investment by about 50%,
i.e. reduction of total investment by about 10%
Transformation of carbon containing substances

Challenge for lignite:
- Conversion solid fuels to liquid or gas
  \( \triangleq \) modification of H:C:O-ratio
- Solid fuels contain “too much” Oxygen („O“) and carbon („C“) and “not enough“ hydrogen („H“)
  \( \rightarrow \) change of ratios by shift reaction
  \( \rightarrow \) addition of e.g. renewable H\(_2\) also possible

Chance:
- Production of carbon containing goods from lignite lowers CO\(_2\) emissions compared to pure power production

Example Methanol production:
\[
\text{Gasification: } 2\text{CO} + 4\text{H}_2 \xrightarrow{\text{Synthesis}} 2\text{CH}_3\text{OH} + 3\text{CO}_2
\]
\( \Rightarrow \) at least 40 % carbon bonding
Use of renewable power to enhance product yield and reduce CO$_2$-emissions at an early process step

Flexible process heating by surplus electricity from renewables

Combined potentials of regenerative heating:

- lowering CO$_2$ emissions by up to 20%
- lowering O$_2$ demand by up to 30%
- increasing product yield by up to 20%
Exploring cost-cutting potential, CO$_2$ reduction, grid balancing

Development concluded with WTA-prototype in Niederaußem

Development ongoing regarding Rhenisch lignite e.g. within Fabiene project until 2020

Rectisol process to be replaced by amine scrubbing combination with NaOH and H$_2$O$_2$ scrubber
Development: 2017 – 2020

Development ongoing regarding customer specific products e.g. within Fabiene project
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- Domestic lignite has potential as a chemical feedstock resource.
- Combination with renewable energies can contribute to efficient use of renewables.
- For economic optimisation capital costs and CO₂ reduction are key.
- There is potential to reduce capital costs via alternative gas scrubbing.
- Higher product yields and CO₂ avoidance via combination with surplus power.
- CtL/CtG are enablers for use of CO₂.
Thank you!