Power-to-Gas: New Solutions for Power, Bio-Energy and Mobility

Gregor Waldstein, April 15th, Hannover Fair
Content

1. About ETOGAS
2. Example of a successful Power-to-Gas project
3. What does Power-to-Gas mean for mobility?
4. How can Power-to-Gas contribute to integrate volatile renewable energy?
5. Outlook
Power-to-Gas stores renewable energy in the natural gas grid. Energy can then be consumed anywhere at anytime.

**Schematic view of energy utilization paths**

- **Power sector**
  - Feed-in from renewable sources
  - Electrolysis
  - Methanation
  - CO₂

- **Gas sector**
  - Green H₂
  - Gas-to-Power (gas turbine, CHP, …)
  - Gas storage

**Renewable gas**
- ... for renewable fuel
- ... for renewable heat
- ... for green products
- ... for backup power

*Source: ETOGAS; * SNG: Synthetic Natural Gas - can be directly fed into the natural gas grid
ETOGAS supplies optimized Power-to-Gas (Hydrogen or Methane) turnkey hardware and related services using proprietary technology

**ETOGAS services cover all phases of a turnkey Power-to-Gas project**

### PRODUCTS AND SERVICES

**Power-to-Gas turn-key systems**
- Power-to-Hydrogen (PtH2)
- Power-to-SNG (PtSNG)
- Hydrogen-to-SNG (H2tSNG)

**Consulting/Services**
- Feasibility Studies & Power-to-Gas Business Model Design
- Basic Engineering
- Site Engineering

---

Source: ETOGAS
## Content

1. About ETOGAS
2. Example of a successful Power-to-Gas project
3. What does Power-to-Gas mean for mobility?
4. How can Power-to-Gas contribute to integrate volatile renewable energy?
5. Outlook
ETOGAS acted as turnkey supplier in charge of design, installation and ramp-up of the world’s largest industrial Power-to-SNG project – the 6.3 MW$_{el}$ Audi e-gas plant in Werlte, Germany

Werlte, Emsland
The ETOGAS 6.3MW beta plant is situated next to a waste biogas plant of EWE AG

EWE BGA Werlte before project start

Source: Google maps
The ETOGAS 6.3MW beta plant combines electrolysis and methanation using CO₂ from a biogas upgrading plant – it delivers SNG to the local natural gas network.

**Audi e-gas plant - overview**

**Source:** Audi, ETOGAS
The ETOGAS 6.3MW beta plant was completed in time and in budget

**Impressions from the opening ceremony, June 2013**

Mr. Hollerweger (Audi AG) and Mr. Flasbarth (Federal Environment Agency) at the opening ceremony

Source: ETOGAS, Audi
The Audi e-gas plant is in operation since end of 2013

Impressions from the plant in Werlte, Germany (near Bremen)

Electrolyzer hall
One of three 2MW\text{el} electrolyzers
Methanation reactor

Source: ETOGAS, Audi
Since early 2014, the Audi e-gas plant is running in the intended operation mode producing Methane from excess power

**Impressions from the beta plant in Werlте, Germany**
Since early 2014, the Audi e-gas plant is running in the intended operation mode producing Methane from excess power

Impressions from the beta plant in Werlte, Germany
The Audi e-gas follows electric input requirements without limitation
Quick response – no time limitation – reliable feed in gas quality

Measured data: Dynamic operation of the 6.3 MW PtG plant in Werlte
Content

1 About ETOGAS
2 Example of a successful Power-to-Gas project
3 What does Power-to-Gas mean for mobility?
4 How can Power-to-Gas contribute to integrate volatile renewable energy?
5 Outlook
In 2014 Audi introduced the new CNG car A3 g-tron and e-gas as a 100% carbon neutral Option

• g-tron customers can refuel their vehicle with natural gas at 950 CNG stations in Germany.
• Audi feeds the same amount of climate-friendly e-gas into the gas grid.

Source: Audi
CNG refuelling stations are available -
The mobile app shows the nearest CNG filling station

CNG-Finder App

Source: CNG Finder, 4.7.2014
Driving with e-gas shows outstandingly low cradle-to-grave emissions (LCA)

Cradle-to-Grave GHG emissions for a middle-class vehicle, 200,000 km operation

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>CO₂ equivalent [g/km]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil fuel (Gasoline)</td>
<td>168</td>
</tr>
<tr>
<td>Fossil fuel (CNG)</td>
<td>146</td>
</tr>
<tr>
<td>Biogas (Maize)</td>
<td>138</td>
</tr>
<tr>
<td>e-gas Werlte</td>
<td>113</td>
</tr>
<tr>
<td>e-gas Werlte (Wind power)</td>
<td>54-75</td>
</tr>
<tr>
<td>BEV (EU mix)</td>
<td>50</td>
</tr>
<tr>
<td>BEV (Wind power)</td>
<td>33</td>
</tr>
</tbody>
</table>

Source: Audi AG; VW AG; Basis LCA model and database GABI
An e-gas vehicle is economic, even if a substantial price premium is paid for the renewable fuel.

**Monthly total total cost of ownership for compact car with 200,000 km total mileage [TCO €/month]**

<table>
<thead>
<tr>
<th>Model</th>
<th>Leasing</th>
<th>Fuel</th>
<th>e-gas surcharge @ cost parity w/ fossil gasoline</th>
<th>Insurance</th>
<th>Maintenance and taxes</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audi A3 1.4 TFSI</td>
<td>226</td>
<td>142</td>
<td>56</td>
<td>60</td>
<td>484</td>
<td></td>
</tr>
<tr>
<td>Gasoline (fossil)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>484</td>
</tr>
<tr>
<td>Audi A3 g-tron</td>
<td>235</td>
<td>63</td>
<td>73</td>
<td>52</td>
<td>61</td>
<td>484</td>
</tr>
<tr>
<td>e-gas (renewable)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audi A3 g-tron</td>
<td>235</td>
<td>63</td>
<td>52</td>
<td>61</td>
<td>411</td>
<td></td>
</tr>
<tr>
<td>CNG (fossil)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>411</td>
</tr>
</tbody>
</table>

Source: Audi
Assumptions: Private leasing, 20 percent deposit, list price; Fuel, insurance, maintenance based on ADAC data
Mobility with e-gas is the only concept today which provides both – superior carbon saving and cost saving

2015 – Cost savings vs. CO₂ savings for different mobility concepts

Source: AUDI, own representation
* Reference is conventional Audi A3 1,4 TFSI with 168 [g CO₂/km] and TCO of 484 [€/month]
Content

1. About ETOGAS
2. Example of a successful Power-to-Gas project
3. What does Power-to-Gas mean for mobility?
4. How can Power-to-Gas contribute to integrate volatile renewable energy?
5. Outlook
Renewable energy is volatile and weather-driven – what is the problem?

Power generation and load in Germany, Fraunhofer IWES scenario „80% renewable electricity“

“someone“ needs to react to match supply and demand:

• Power stations
• Storage operators
• Market
• End consumers

„renewables produce and forget“ - does this affect the power market?

Source: ETOGAS
The spot market reacts severely to volatile generation

Hourly output of volatile renewables and EEX spot market prices (Germany March 2014)

Volatile power generation (Wind, PV) and power prices

On a sunny and windy Sunday, nobody (!) is able to sell electricity on the spot market at a positive price!

Source: ETOGAS based on EEX data
Spot prices are low whenever volatile production is high - in expectation of this effect forward prices are at a non-sustainable level.

Correlation of power price with PV & wind feed in (2014) and average power prices EPEX SPOT (2012-2014)

Source: ETOGAS

1 public EPEX SPOT and EEX Transparency data
Wholesale power prices are falling – consumer prices are rising – subsidies are exploding

Average industry power prices in Germany and Great Britain [ct/kWh]

Can we continue to expand renewables without solving the revenue problem?

Source: ETOGAS, EY, VEA, DIHK
Can we provide demand conforming power and clean mobility at affordable prices by combining volatile and adaptive assets?

Schematic overview

Renewable Energy System

- Volatile
- Adaptive

Secured renewable power supply according to demand profile

Utilization of biomass

Gas storage

Secured gas supply anywhere anytime

Constant heat supply

Legend:
- Power
- Methane
- CO2
- Heat

Source: ETOGAS
Volatile renewables combined with adaptive infrastructures including Power-to-Gas provide secured power for economic green energy systems

Example: Adaptive portfolio with biogas plant, CHP and PtG in Situation no wind

Secured renewable power supply according to demand profile

Utilization of biomass

Constant heat supply

Gas storage

Secured gas supply anywhere anytime

Long-term forward contractable

Source: ETOGAS
Volatile renewables combined with adaptive infrastructures including Power-to-Gas provide secured power for economic green energy systems

Example: Adaptive portfolio with biogas plant, CHP and PtG in Situation high wind

Source: ETOGAS
Content

1. About ETOGAS
2. Example of a successful Power-to-Gas project
3. What does Power-to-Gas mean for mobility?
4. How can Power-to-Gas contribute to integrate volatile renewable energy?
5. Outlook
Fraunhofer ISE study answers the question: Which infrastructure is required for cost minimal 80% CO₂ reduction?

Complex Simulation Model shows required Assets for cost minimization
Fraunhofer ISE study shows that 80% CO₂ reduction targets can be met economically. Power to Gas plays an important role.

### Key results ISE Study for German Energy System @ 80% CO₂ reduction

#### Results

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volatile power</strong></td>
<td>• Wind- and PV are installed as high as possible</td>
</tr>
<tr>
<td></td>
<td>Limiting factor is availability of sites not power integration or volatility</td>
</tr>
<tr>
<td></td>
<td>• Most power demand is covered directly from volatiles maximizing efficiency</td>
</tr>
<tr>
<td><strong>Biomass</strong></td>
<td>• Potential is fully exploited</td>
</tr>
<tr>
<td><strong>Power-to-Gas</strong></td>
<td>• Investment in Power to Gas equals approx. 30% of investment in Wind</td>
</tr>
<tr>
<td></td>
<td>• PtG utilizes most of the excess power</td>
</tr>
<tr>
<td><strong>Gas grid</strong></td>
<td>• Gas grid carries 35% e-gas, 10% Biomethane and 55% fossil gas</td>
</tr>
<tr>
<td></td>
<td>• Most gas is used in the mobility sector</td>
</tr>
<tr>
<td></td>
<td>o Gas vehicles have a major share of the private car market,</td>
</tr>
<tr>
<td></td>
<td>o other technologies like BEV and FCEV will follow later</td>
</tr>
<tr>
<td><strong>Total system cost</strong></td>
<td>• A system with Power-to-Gas saves 50-90 billion € annually compared to</td>
</tr>
<tr>
<td></td>
<td>a system without PtG</td>
</tr>
</tbody>
</table>

Source: Fraunhofer ISE, The role of Power-to-Gas in achieving Germany’s climate policy targets, 2015
Why don’t we deploy the required assets today?
Regulation is key to attract private investment in cost minimizing infrastructure

**Regulatory requirements**

**Regulation drives deployment of renewable technologies**

- **Advanced Biofuels**
  - Promote advanced biofuels on EU and national level to create attractive sales opportunities for low GHG emission fuels like Hydrogen or Methane
    - EU: RED FQD to be finalized 2015, national action to follow within 18 months

- **Market Design for Renewables**
  - Support demand conforming delivery from renewable asset portfolios
  - Demand conforming output is important NOT extra support for backup power or storage
  - Allow exploiting revenue potential outside the power sector
    - Germany: green/white book market design in discussion now

Source: ETOGAS
ETO GAS
smart energy conversion