PREIS DER DEUTSCHEN GASWIRTSCHAFT FÜR INNOVATION UND KLIMASCHUTZ

Deutschland Land der Ideen

MIT Technology Review 50 DISRUPTIVE COMPANIES 2013

ENERGY AWARDS

Preisträger Technology Fast 50 Award 2014 Powerful Connections Deloitte.

2014 Global Cleantech 100 One to Watch

ETOGAS

smart energy conversion

World's largest Power-to-SNG plant with 6.3MW$_{el}$ – built by ETOGAS for Audi AG

Power-to-Gas projects
business models and related regulatory aspects

Gregor Waldstein, June 24th, HIPS-NET Workshop

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

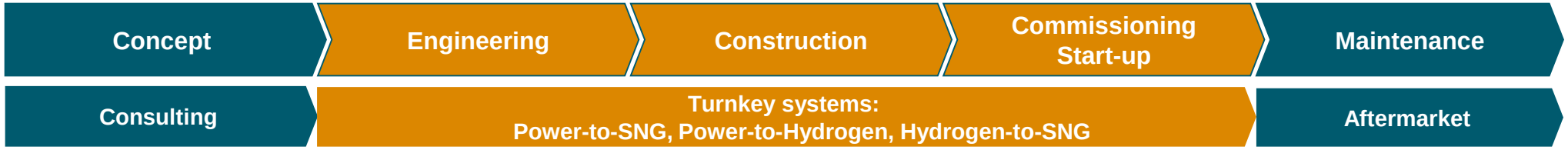
PRODUCTS AND SERVICES

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

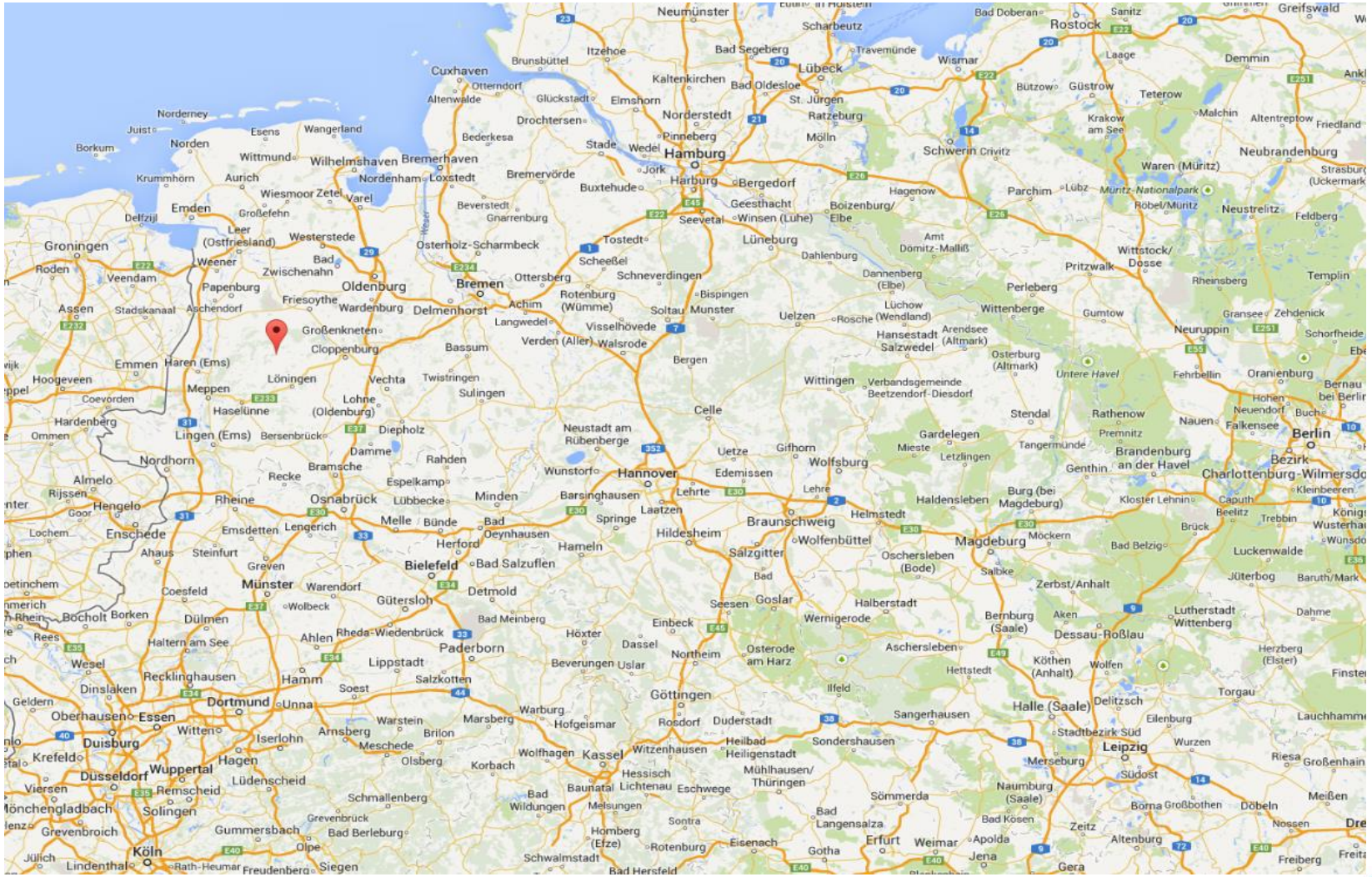


Source: ETOGAS

Content

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



Source: Google maps

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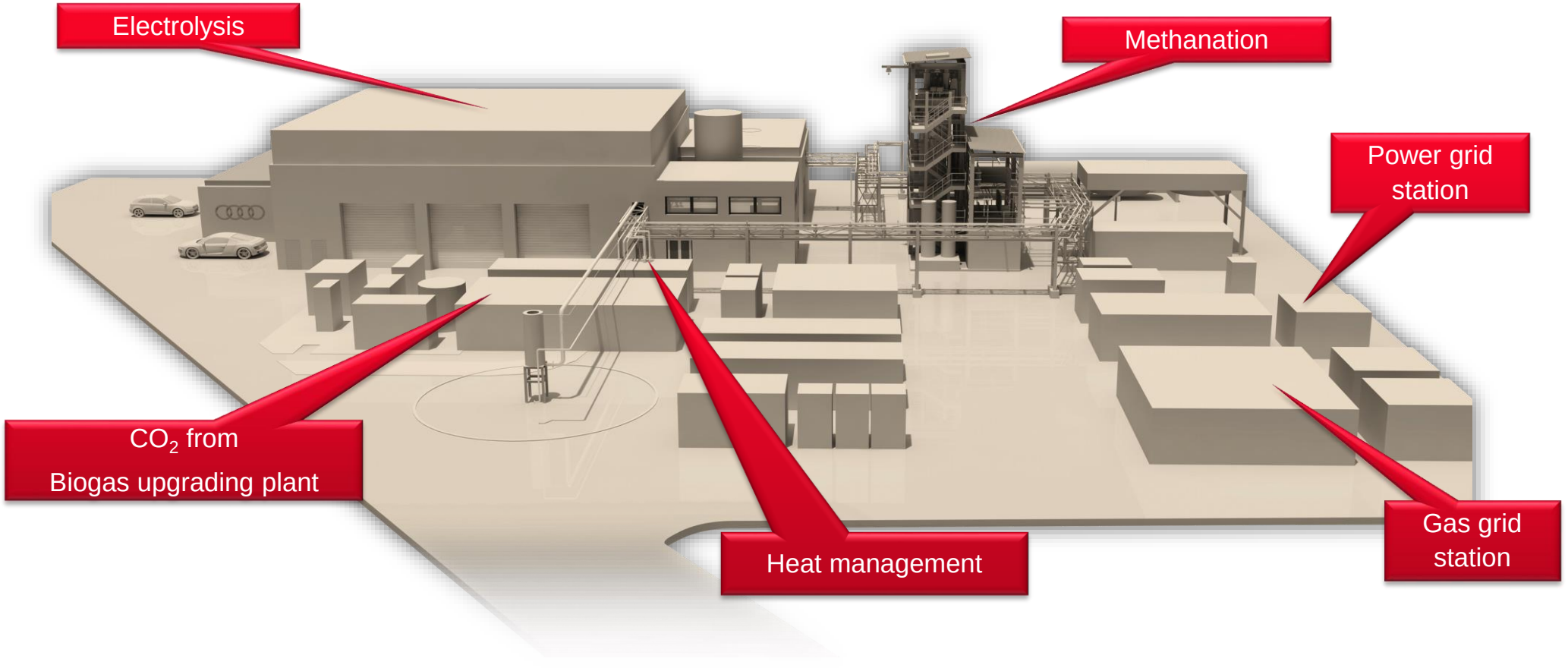
The ETOGAS 6.3MW beta plant is situated next to a waste biogas plant of EWE AG

EWE BGA Werlte before project start

Source: Google maps

The ETOGAS 6.3MW beta plant combines electrolysis and methanation using CO_2 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$_{el}$ electrolyzers

Methanation reactor

Source: ETOGAS, Audi

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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

Source: ETOGAS, Audi

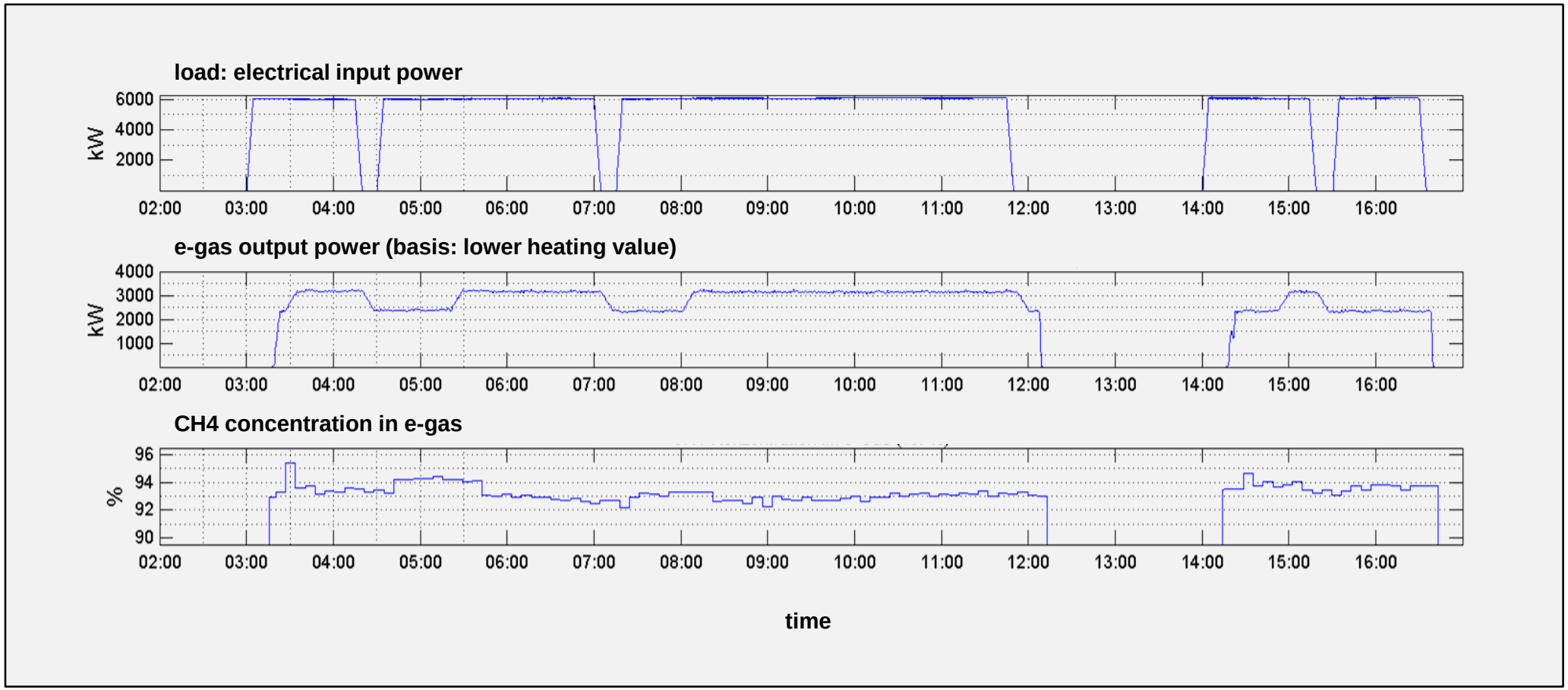
Since early 2014, the Audi e-gas plant is running in the intended operation mode producing Methane from excess power

Impressions from the beta plant in Werlte, Germany

Source: ETOGAS, Audi

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



Source: ETOGAS

Content

In 2014 Audi introduced the new CNG car A3 g-tron and e-gas as a 100% carbon neutral Option

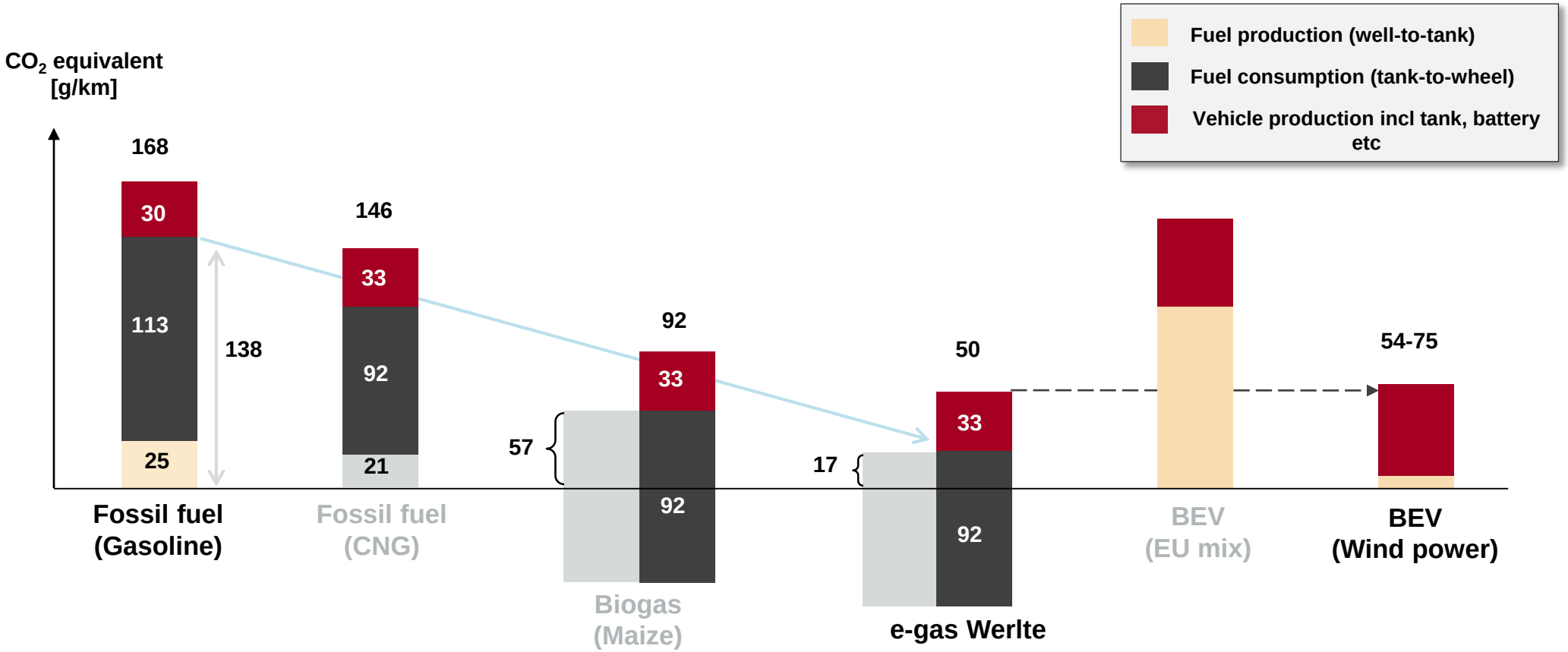
Rupert Stadler presenting the A3 g-tron and e-gas option in Geneva, March 2014

- **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

Driving with e-gas shows outstandingly low cradle-to-grave emissions (LCA)

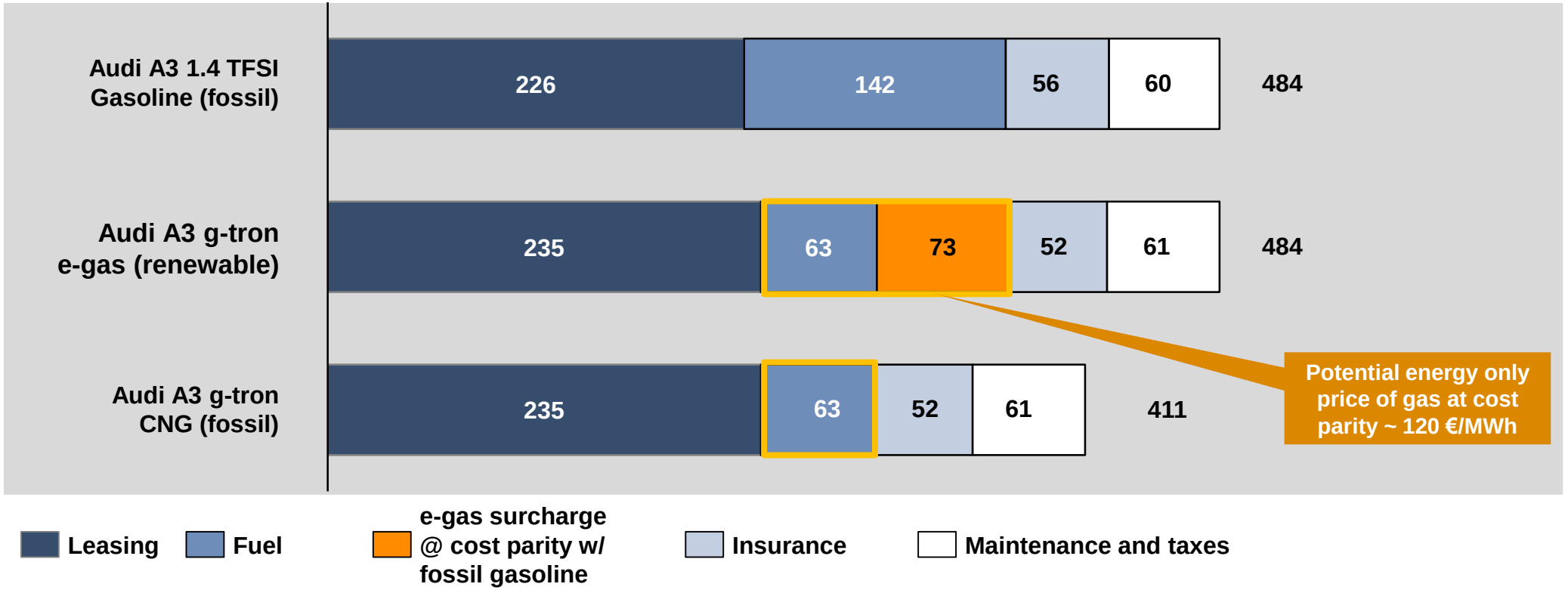
Cradle-to-Grave GHG emissions for a middle-class vehicle, 200.000 km operation



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

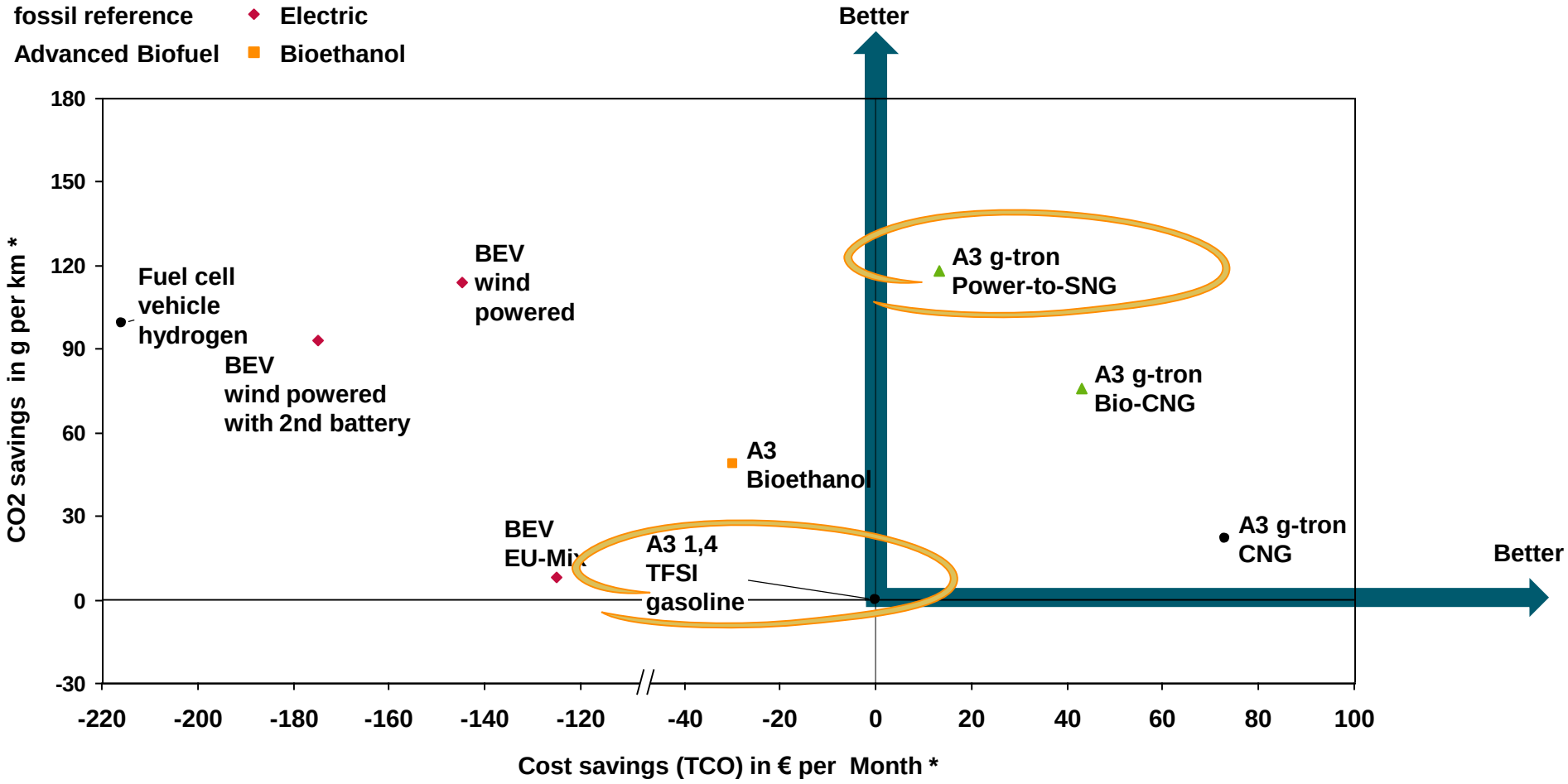
Monthly total total cost of ownership for compact car with 200.000 km total mileage [TCO € /month]



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. CO_2 savings for different mobility concepts

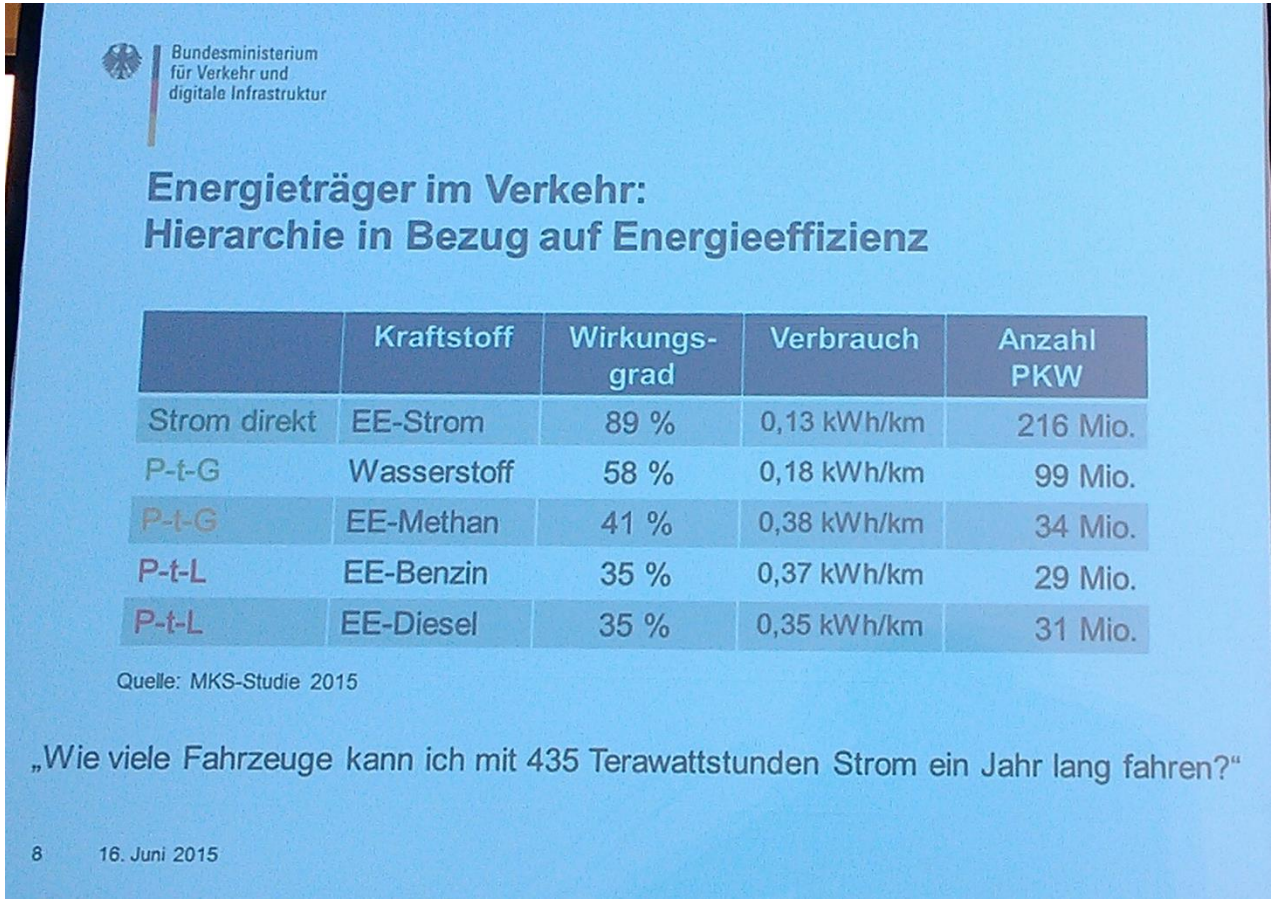


Source: AUDI, own representation

* Reference is conventional Audi A3 1,4 TFSI with 168 [g CO_2/km] and TCO of 484 [€/month]

Efficiency of Power-to-Gas is often criticised…

Example of misleading comparison



Bundesministerium für Verkehr und digitale Infrastruktur

Energieträger im Verkehr: Hierarchie in Bezug auf Energieeffizienz

	Kraftstoff	Wirkungs-grad	Verbrauch	Anzahl PKW
Strom direkt	EE-Strom	89 %	0,13 kWh/km	216 Mio.
P-t-G	Wasserstoff	58 %	0,18 kWh/km	99 Mio.
P-t-G	EE-Methan	41 %	0,38 kWh/km	34 Mio.
P-t-L	EE-Benzin	35 %	0,37 kWh/km	29 Mio.
P-t-L	EE-Diesel	35 %	0,35 kWh/km	31 Mio.

Quelle: MKS-Studie 2015

„Wie viele Fahrzeuge kann ich mit 435 Terawattstunden Strom ein Jahr lang fahren?"

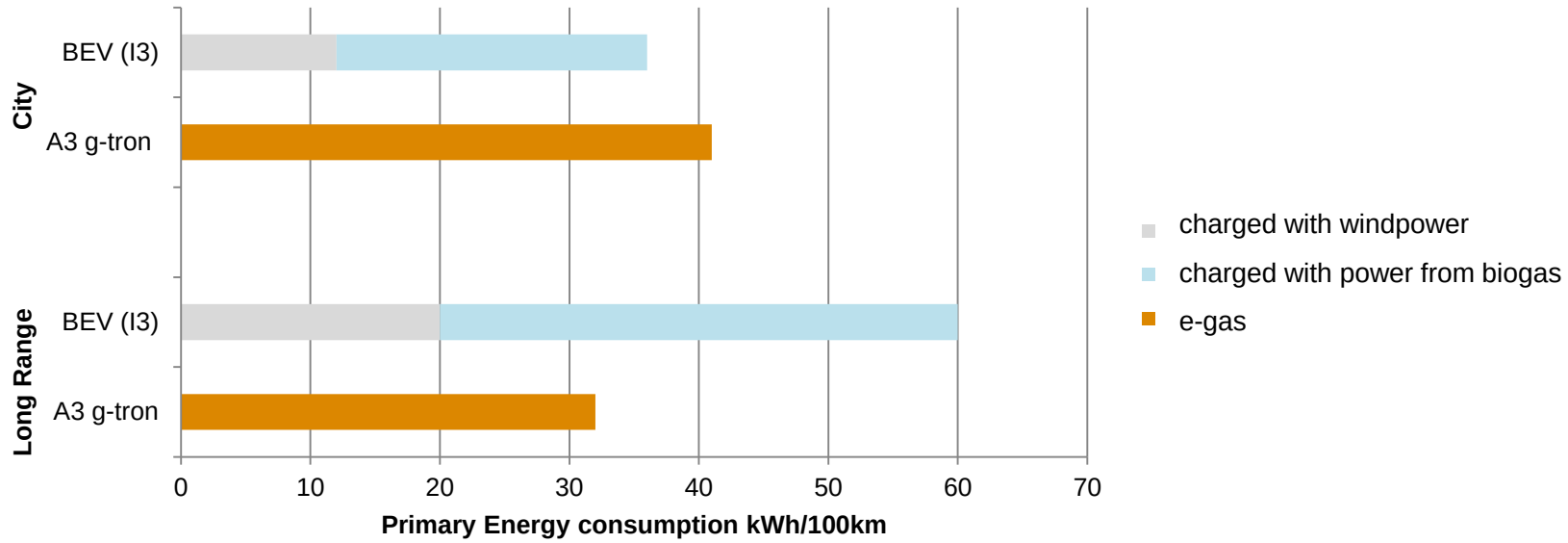
8 16. Juni 2015

Where is the mistake?

Source: dena conference 2015, Veit Steinle, Ministary of Transport, Germany

The Efficiency of driving with e-gas:
depends on the Type of use and on the Type of primary Energy consumed

Comparison of primary Energy consuption per Vehicle-Kilometer



A more differentiated Evaluation is required to avoid wrong Conclusions

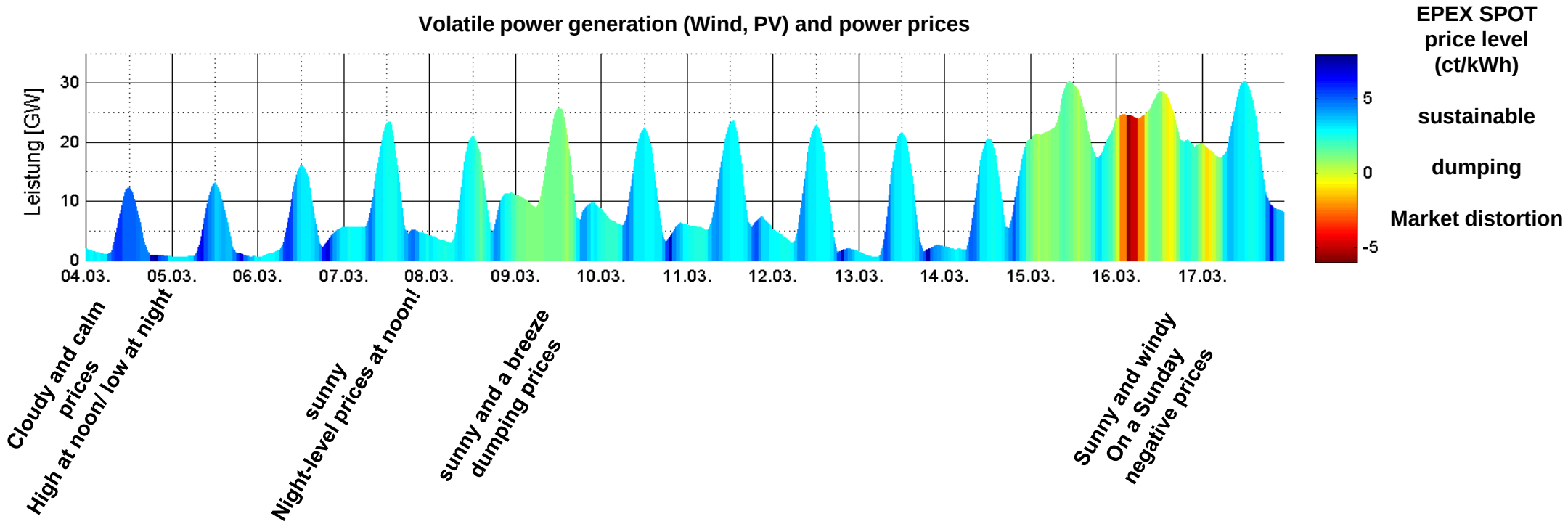
Quelle: ETOGAS

Content

Produce and forget?

The spot market reacts severely to volatile generation

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



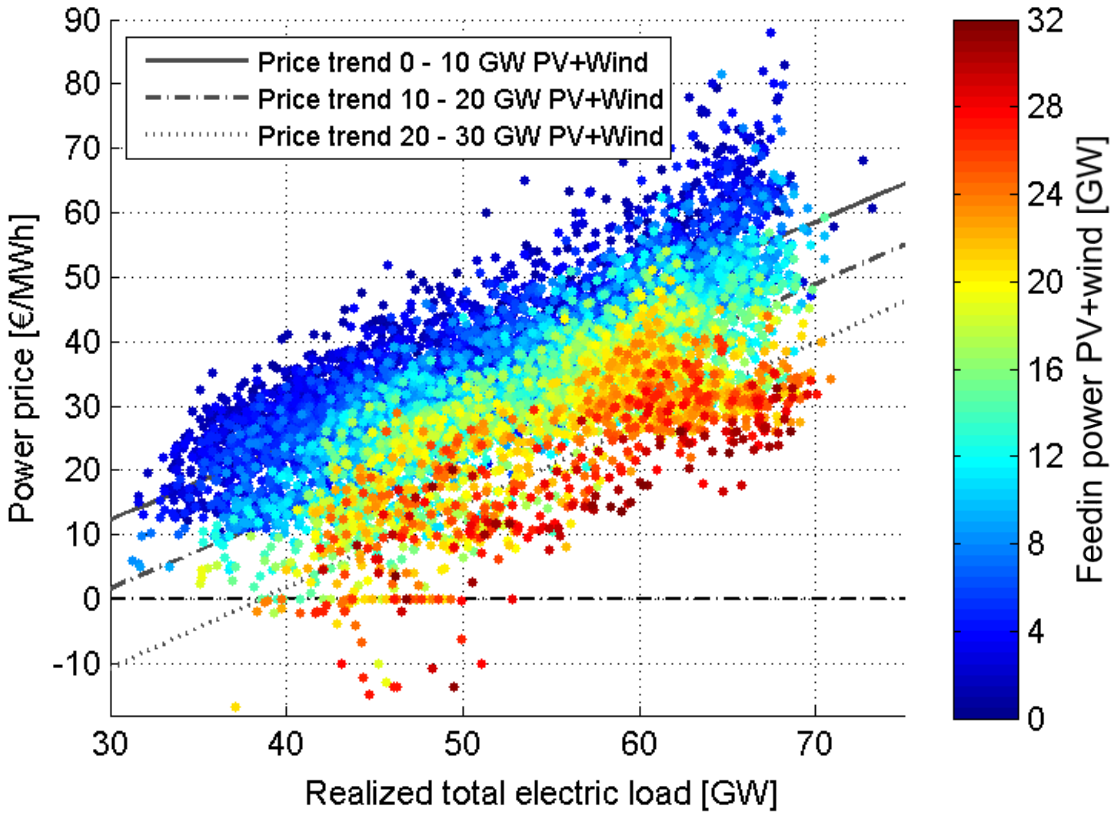
On a sunny and windy Sunday,
nobody (!) is able to sell electricity on the spot market at a positive price!

Source: ETOGAS based on EEX data

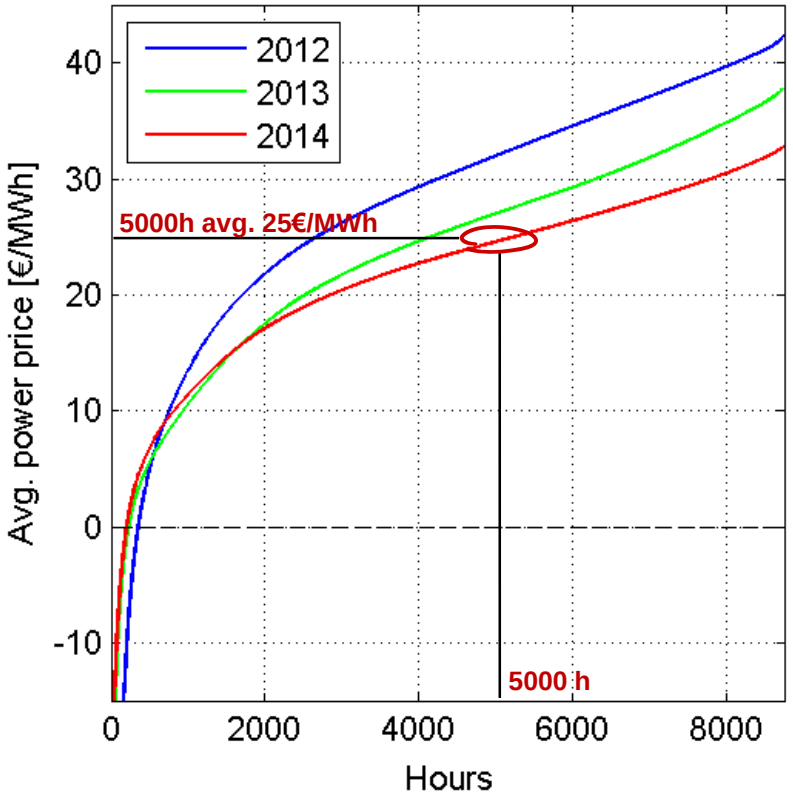
Spot prices are low whenever volatile production is high - in expectation of this effect forward prices are at a non-sustainable level

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

Time-based correlation of EPEX SPOT power price with PV & wind feed in (2014) [1]



Average power prices EPEX SPOT for the hours per year with lowest prices (2012-2014)[1]



Source: ETOGAS

[1] public EPEX SPOT and EEX Transparency data

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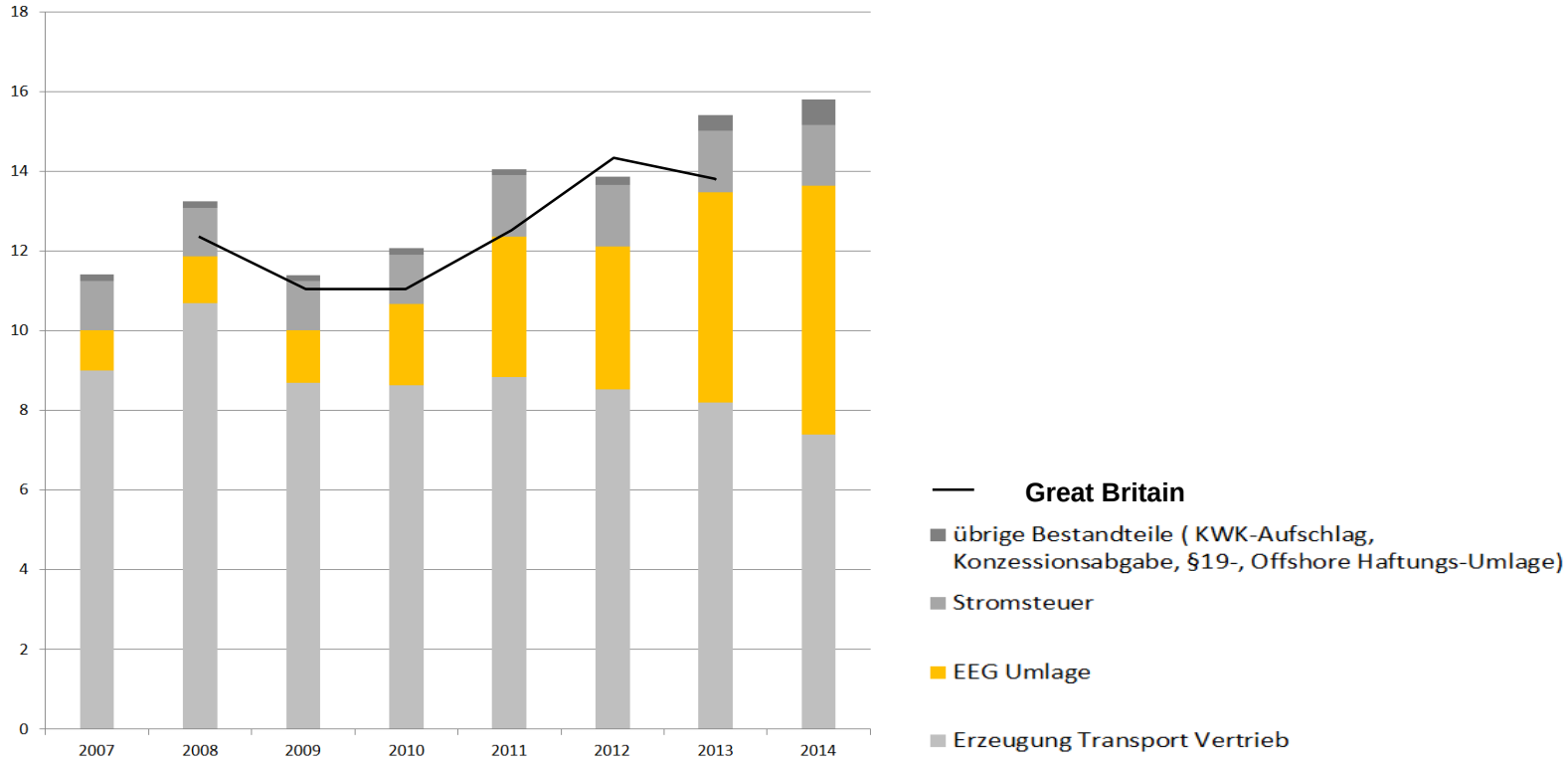
Wholesale power prices are falling – consumer prices are rising – subsidies are exploding

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

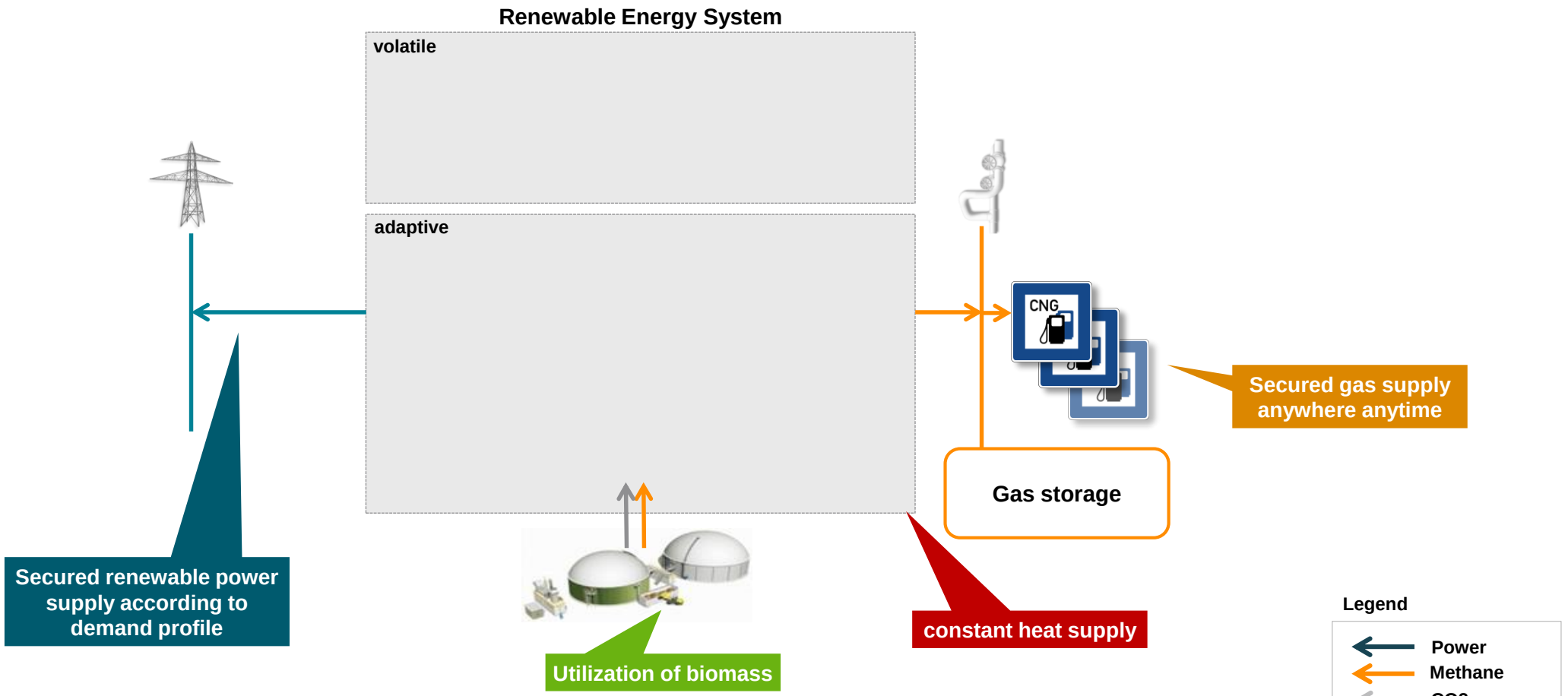


Can we continue to expand renewables without solving the revenue problem?

Source: ETOGAS, EY, VEA, DIHK

Can we sell demand conforming power and clean fuels for mobility at affordable prices by combining?

Schematic overview



Source: ETOGAS

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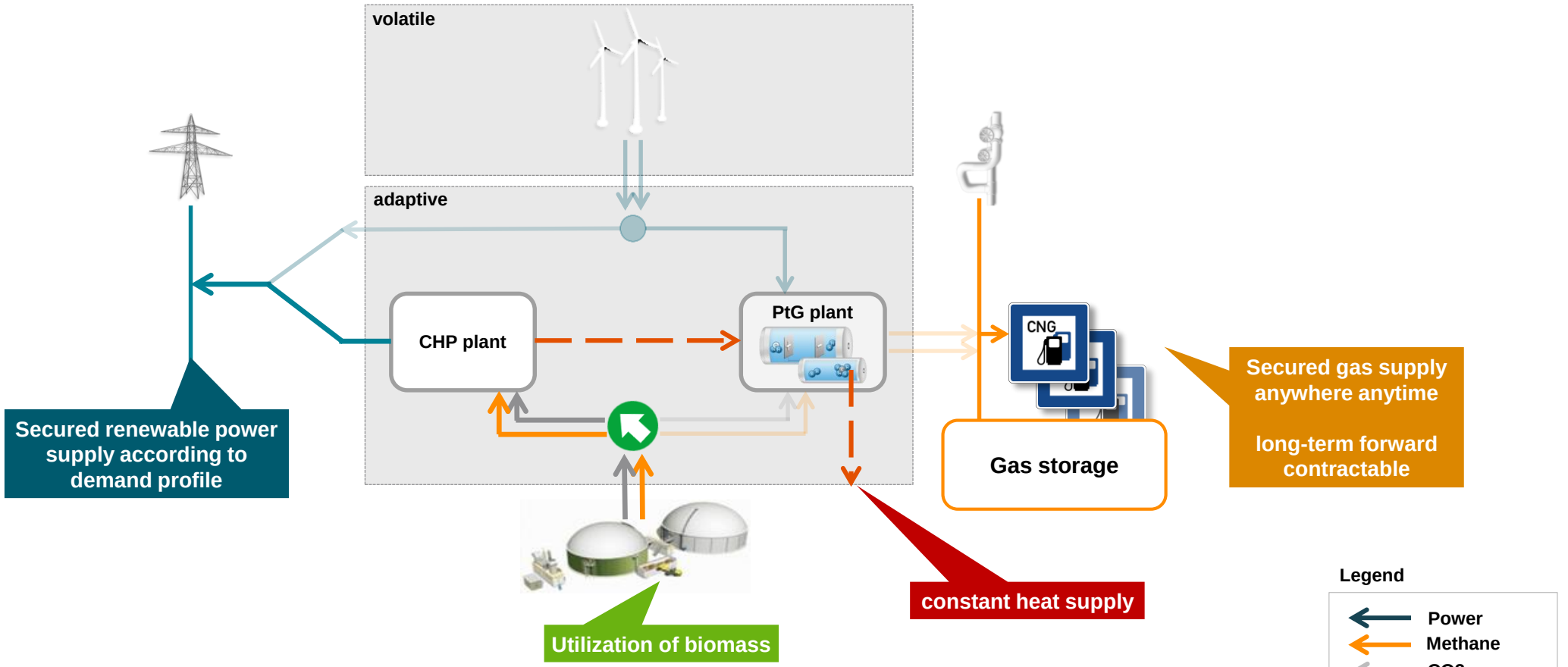
Volatile renewables combined with adaptive infrastructures including Power-to-Gas provide secured power for economic green energy systems

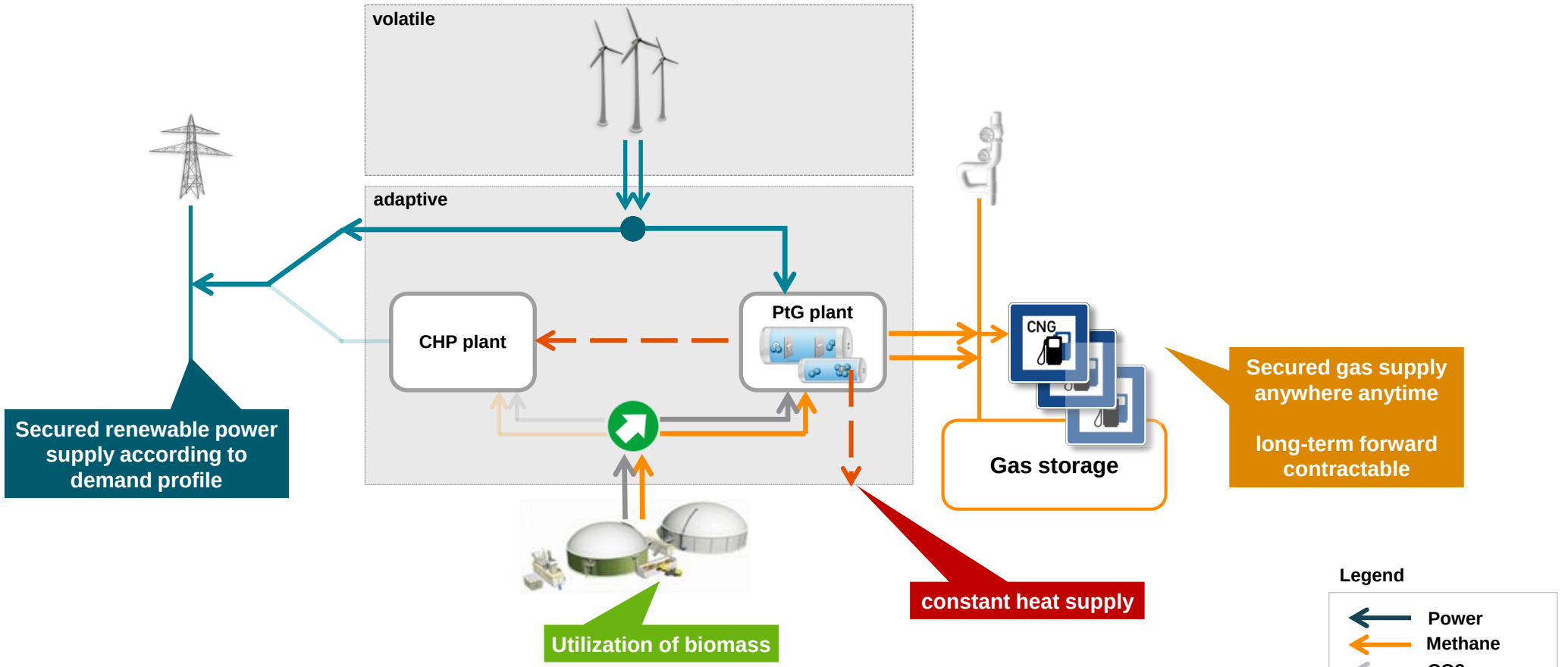
Example: Adaptive portfolio with biogas plant, CHP and PtG in Situation no wind



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

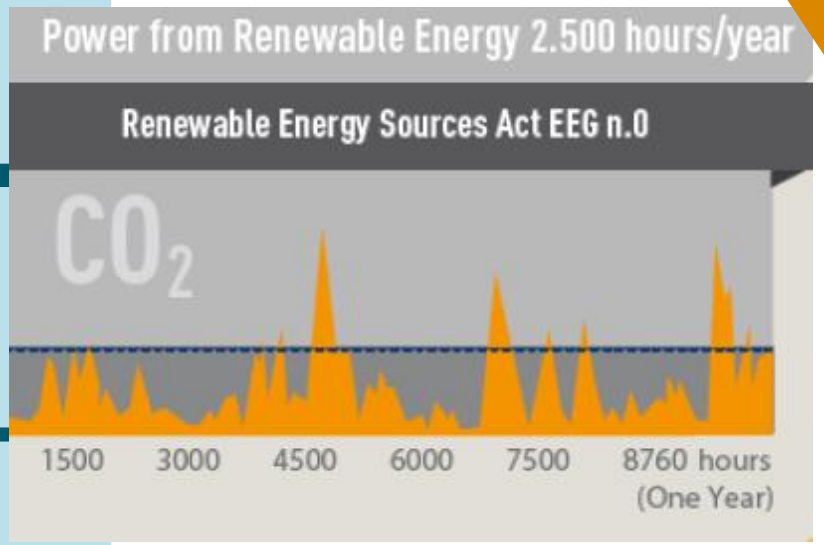
ETOGAS smart energy conversion

Using Power-to-Gas in the right way makes renewables efficient, reliable and affordable

Advantages of deploying Power-to-Gas from the electricity perspective

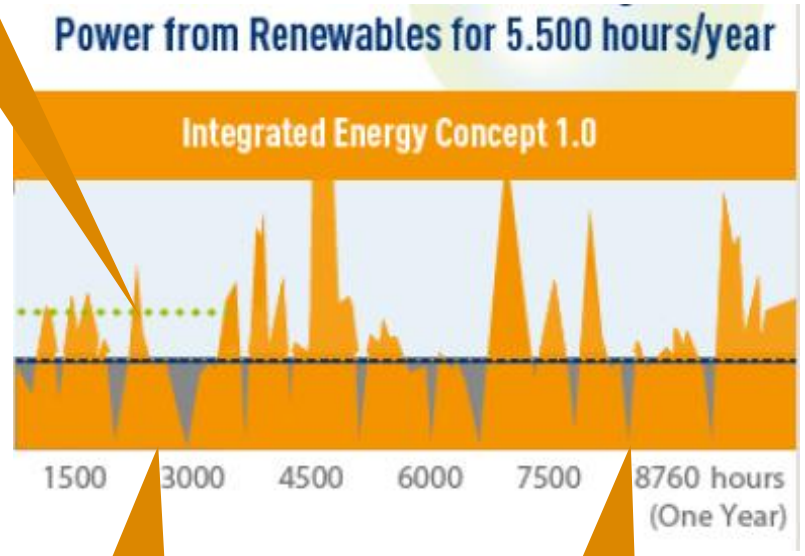
Renewable energy systems using Power-to Gas are

- **efficient**
- **affordable**
- **reliable**



Affordable:
Mobility customers contribute to cost of generation

Reliable:
Fast response adaptive portfolio provides grid stability



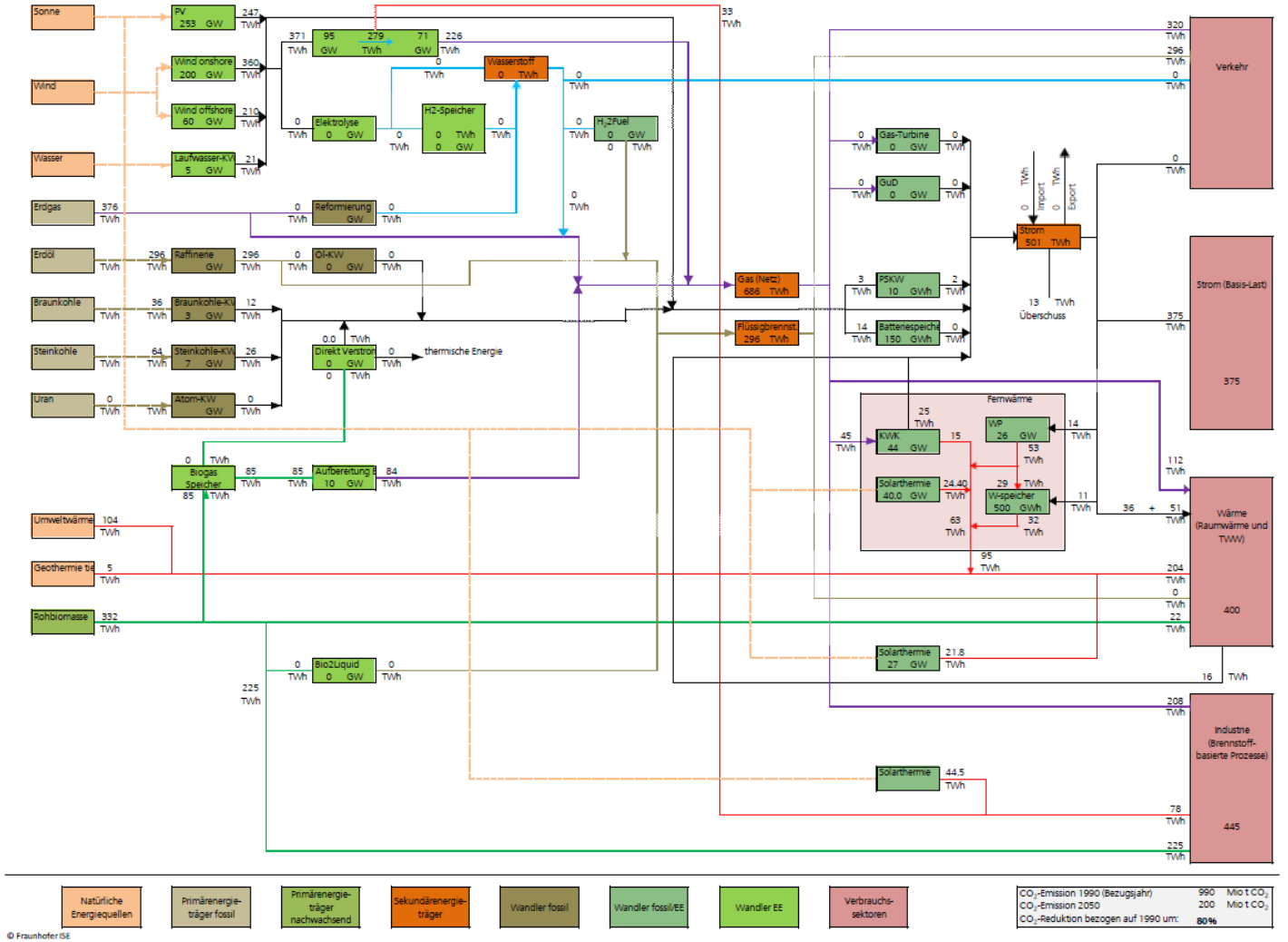
Efficient:
Direct use of renewables maximized (5.500h)

Affordable:
Expensive electricity from storage minimized (3.260h)

Quelle: ETOGAS; Presentation W. Diwald

Fraunhofer ISE study answers the question: Which infrastructure is required for cost minimal 80% CO_2 reduction?

Complex Simulation Model shows required Assets for cost minimization



Fraunhofer ISE

FRAUNHOFER-INSTITUT FÜR SOLARE ENERGIESYSTEME ISE

THE ROLE OF POWER-TO-GAS IN ACHIEVING GERMANY'S CLIMATE POLICY TARGETS WITH A SPECIAL FOCUS ON CONCEPTS FOR ROAD BASED MOBILITY

Content

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	• **Implement advanced biofuels regulations on national level to create attractive sales opportunities for low GHG emission fuels like Hydrogen or Methane** ○ EU guideline: RED FQD 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** ○ Eliminate grid tarifs, levies for grid level energy conversion in the context of supplying demand conforming electricity supply

Source: ETOGAS

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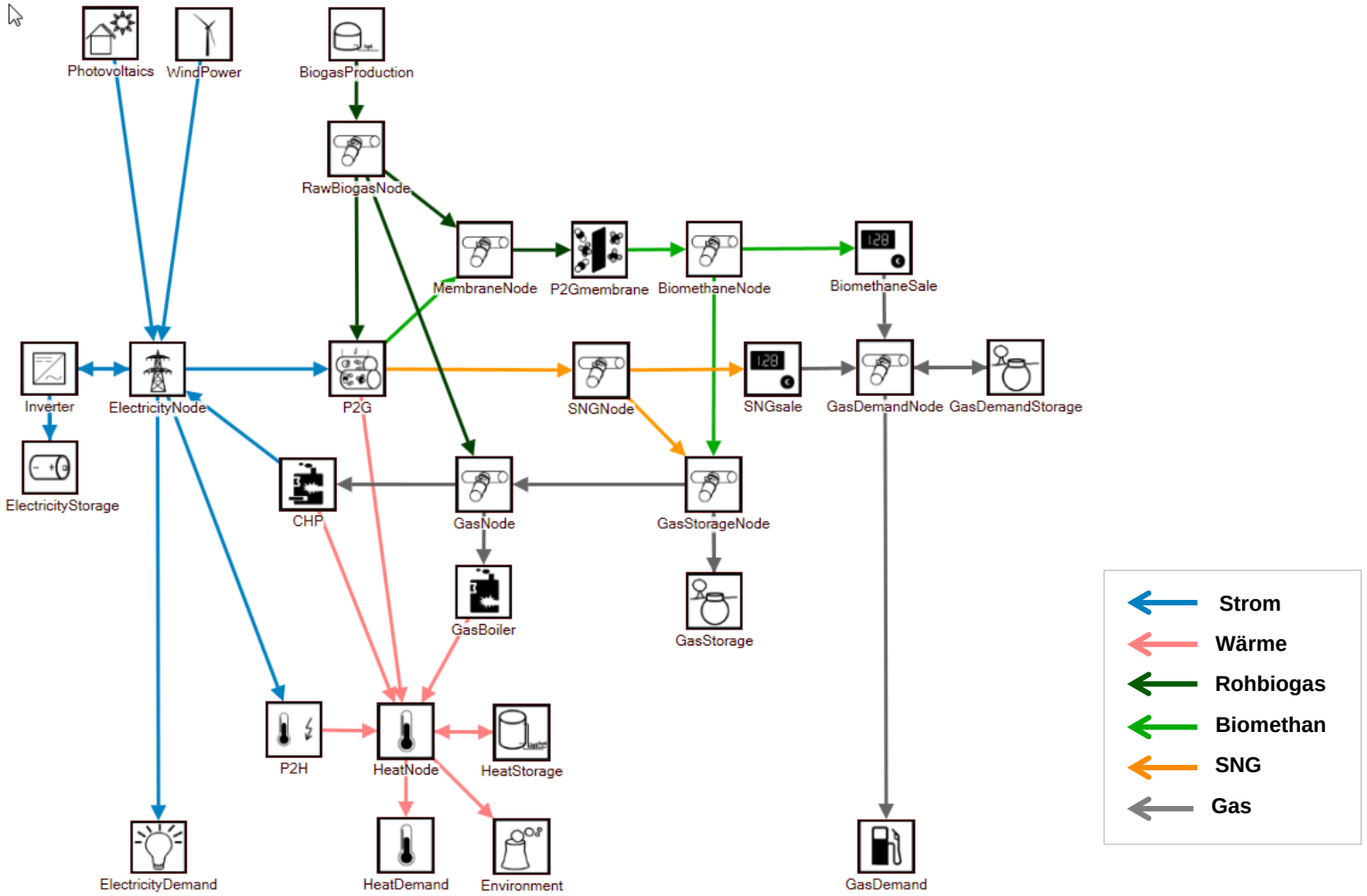
2014 One to Watch

Eine dynamische Simulation zeigt detailliert, wie volatile erneuerbare Quellen mit adaptiver Infrastruktur zu kombinieren sind, um den Strom-, Wärme- und Gasbedarf kostenminimal erneuerbar zu decken

Netzwerk der Energiesystemkomponenten



Quelle: ETOGAS

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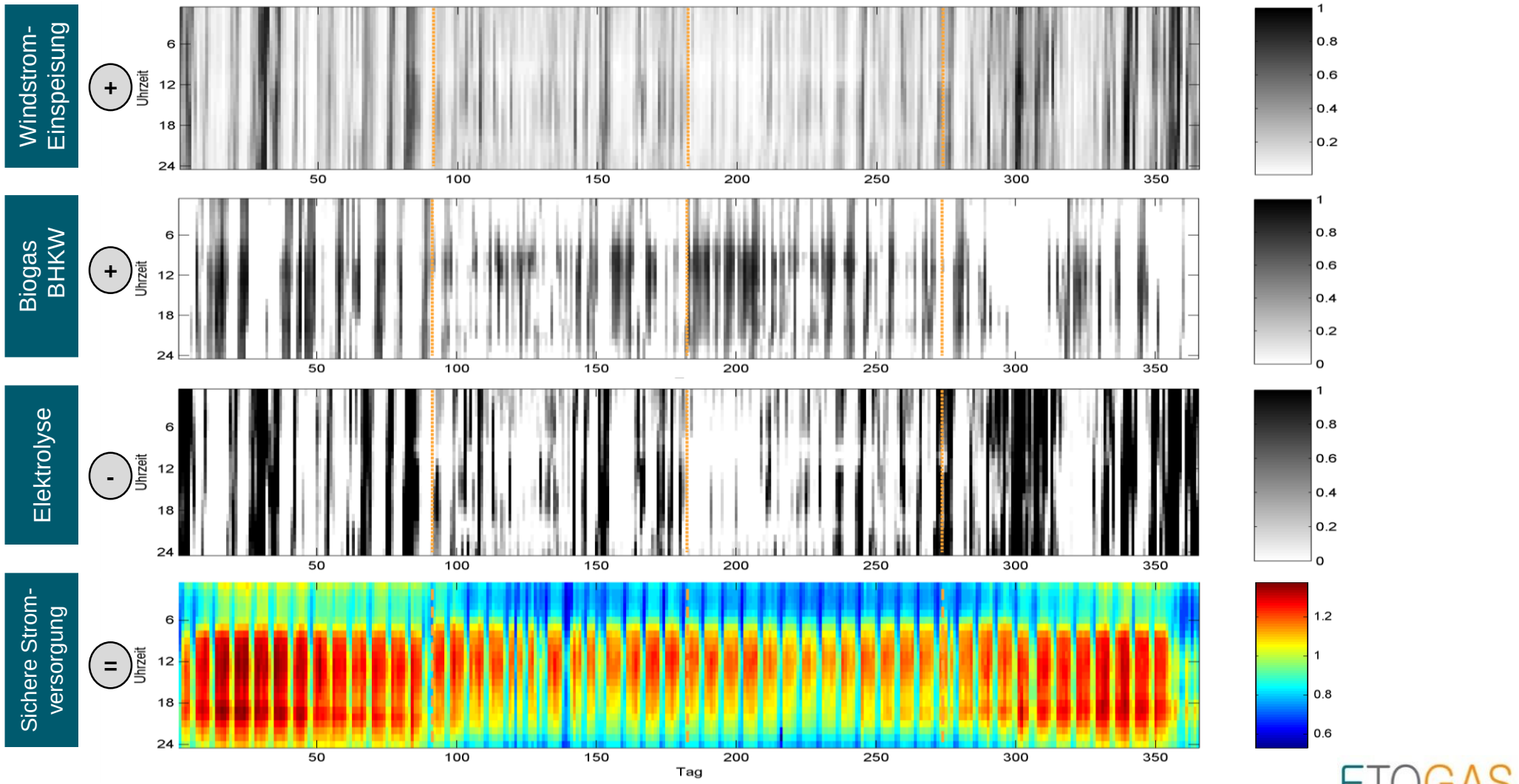
Volatile erneuerbare Quellen und adaptive Infrastruktur liefern bedarfsgerecht Strom…

Exemplarische Jahresgang-Darstellungen eines optimierten Systems (normiert)



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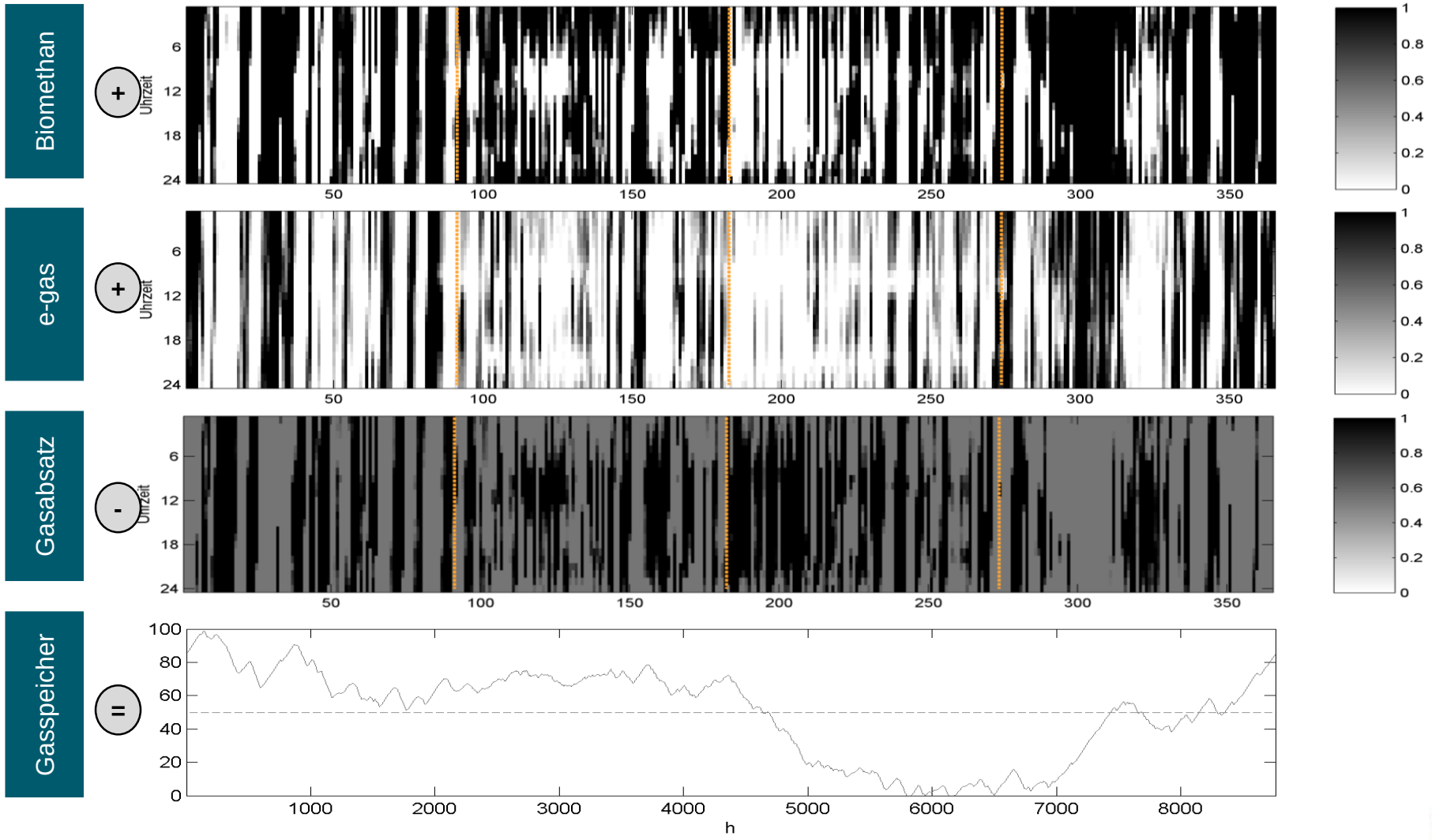
Verlauf Einspeisung, Ausspeisung Speicherfüllstand Gas…

Jahresgang-Darstellungen eines optimierten Systems (normiert)



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