



Power-to-Gas technology – the missing link in renewable energy systems

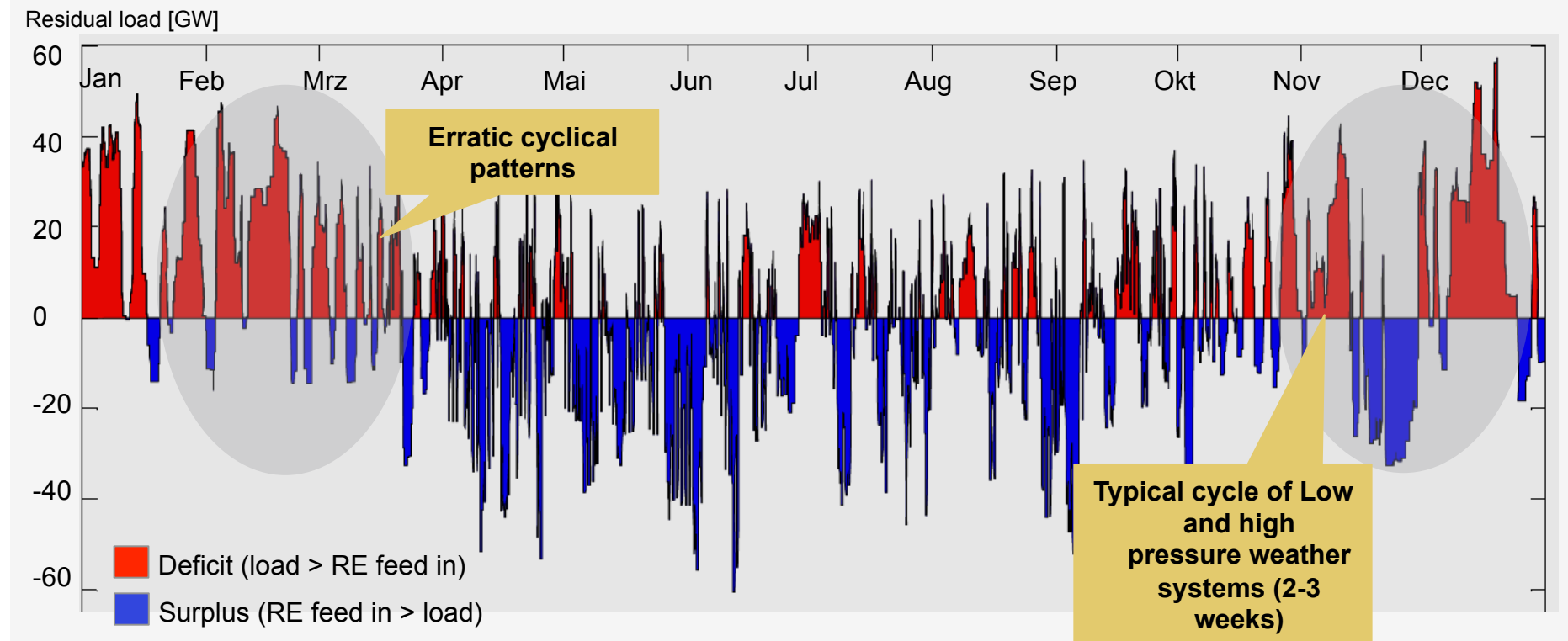
SolarFuel GmbH, Stephan Rieke

Ecosummit, Berlin
23.03.2012

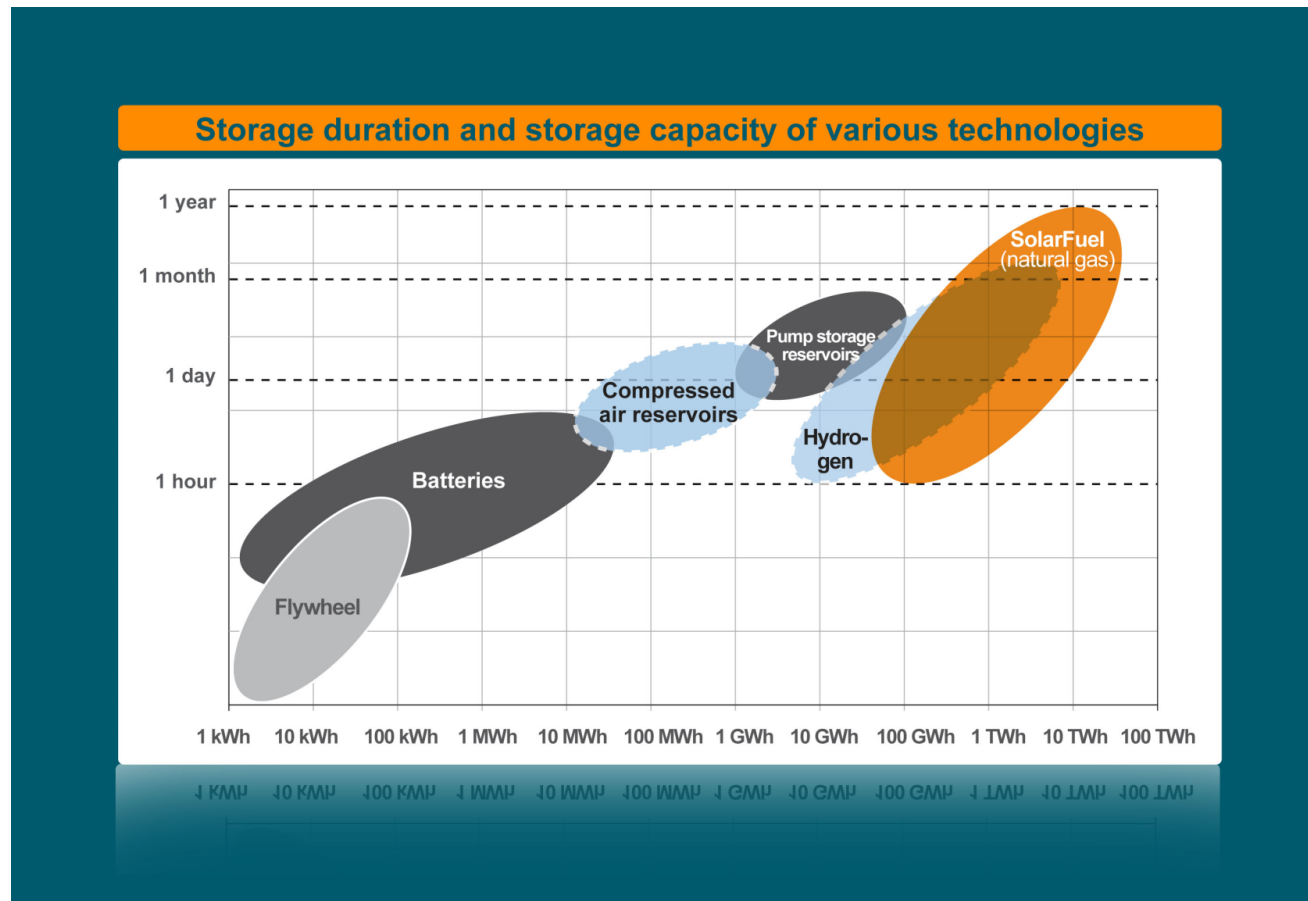
In systems with close to 100% renewable energy in the electricity system, a key challenge will be the utilization of energy surplus to provide power in times of deficit

Residual load [GW], deficit in red, surplus in blue, simulation for a 100% scenario in the year 2050

Residual load in Germany 2050; all available options of load management and pumped hydro taken into account



Comparison of storage capacity and duration of different energy storage technologies

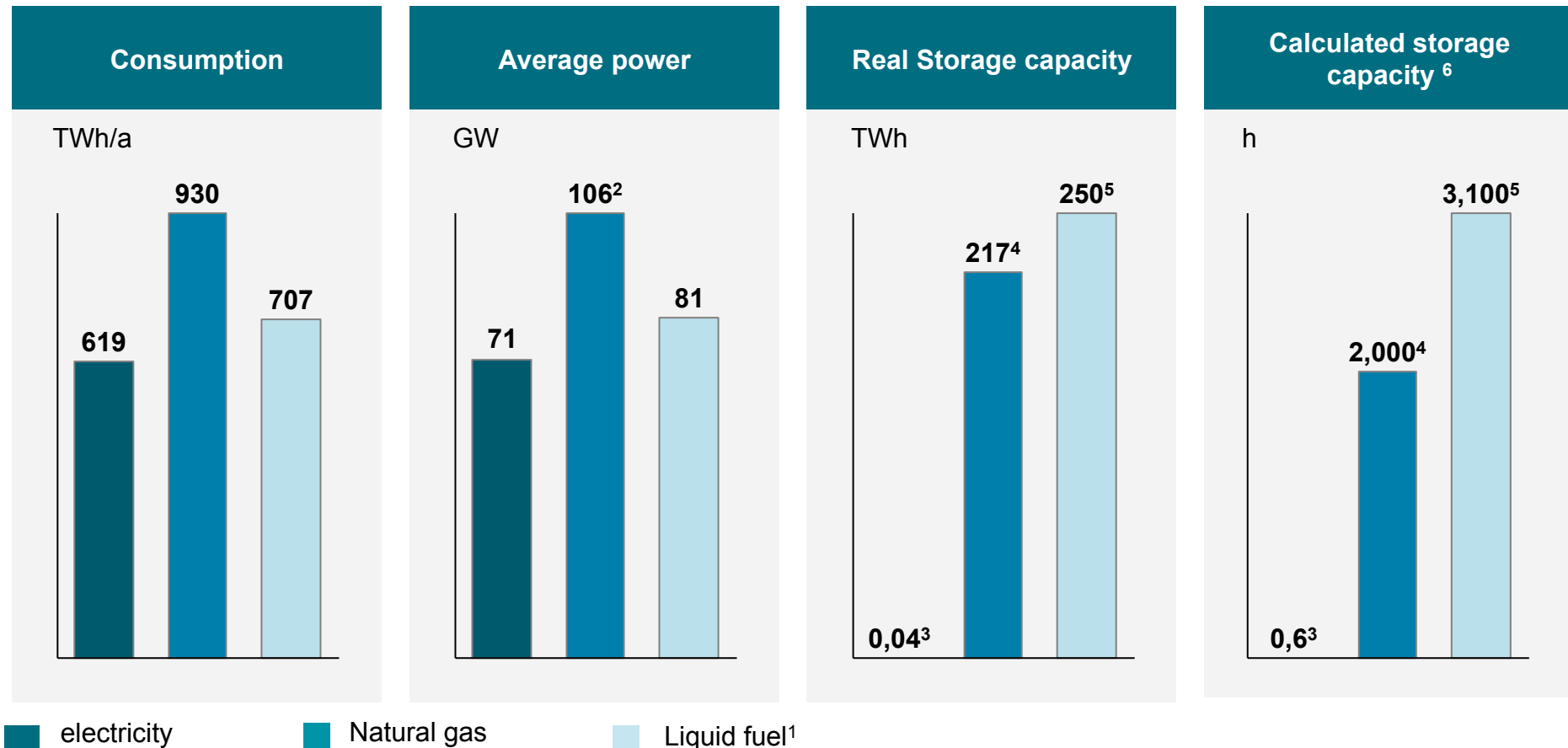


The advantages of chemical storage mediums for solving the electricity storage problem in a 30-100 % vision of renewable energy system of the near future 2020-2050.

Chemical storage of methane could be interesting due to time, cost, capacity, existing infrastructure.

Storage capacity of the natural gas grid in Germany last for 2000 h, storage capacity of the electricity grid last for only 0,6 h

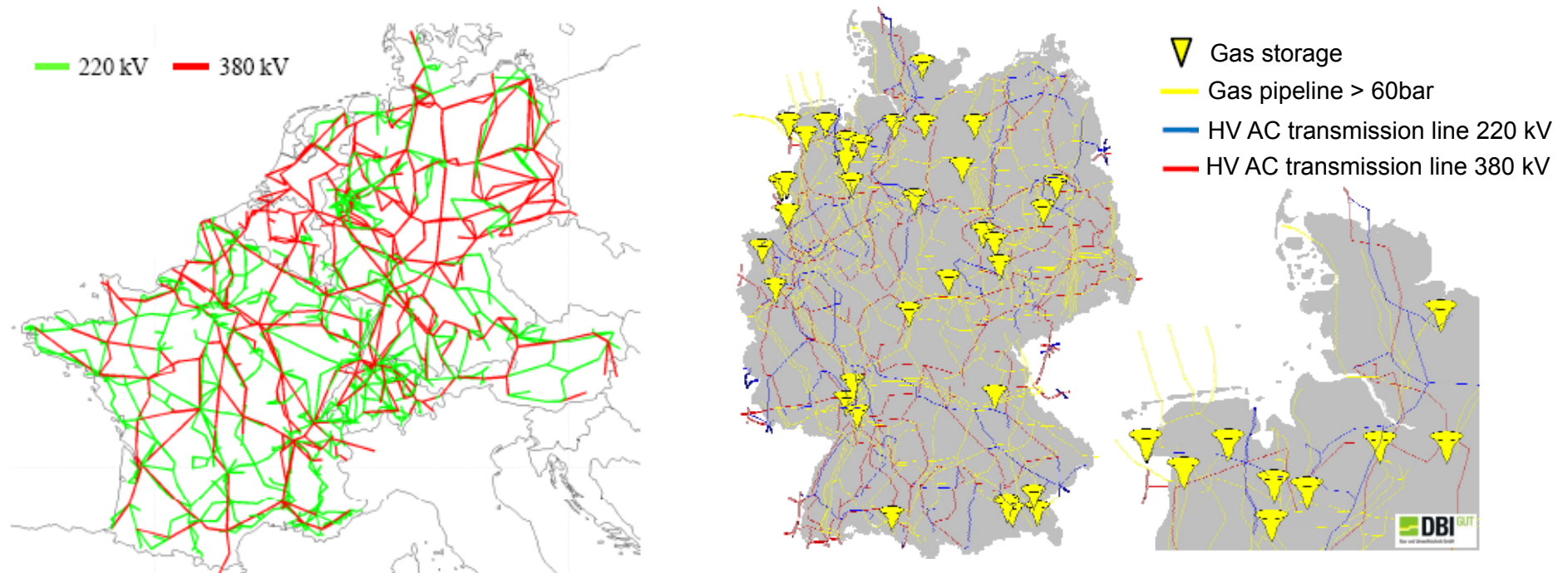
Energy consumption and storage capacity in Germany, 2008



1) fuel, diesel, kerosine 2) high differences from season to season 3) pump accumulator power plants 4) 46 underground gas storage / plus 72 TWh in construction / planning 5.) stockage of fuel, diesel, kerosine and fuel oil EL 6.) related to average capacity
source: ZSW



Linking Gas – Electricity network: An approach for transporting high energy fluxes



IAEW RWTH Aachen: Breuer, Echternach, Lindemann, Prof. Moser et. al.

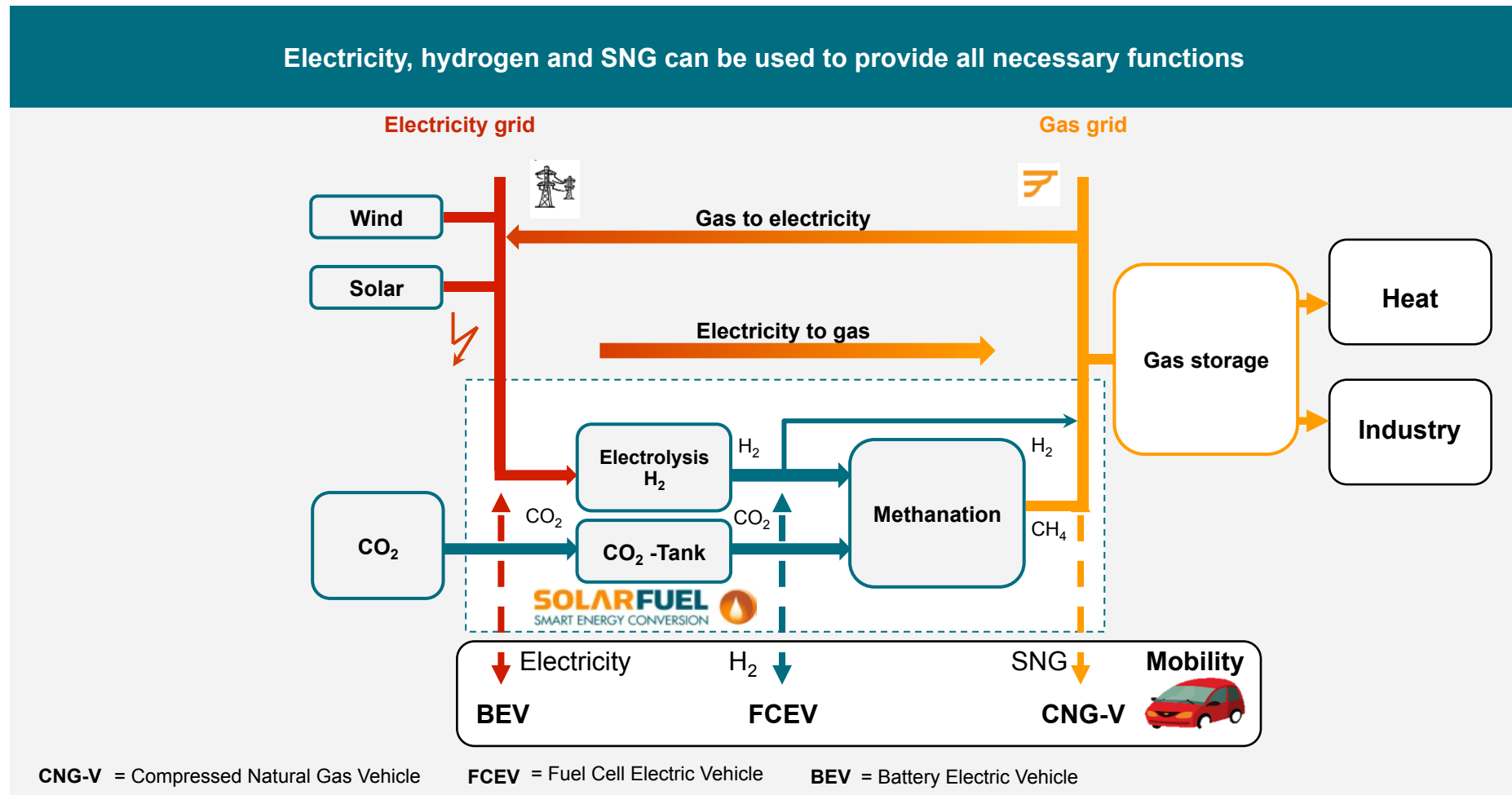
**Gas transportation and storage system in Germany (HP: >100.000 km, MP: > 140.000 km
Storage capacity: ca. 220 TWhgas 2011, target : 300 TWhgas)**

Electricity grid (36.000 km, >220 kV, 75.000 km, 110 kV)

Study of integration gas grid with electricity network, storage systems and CO2 potential under way by SolarFuel

...and long-range renewable mobility and 100% RE become possible

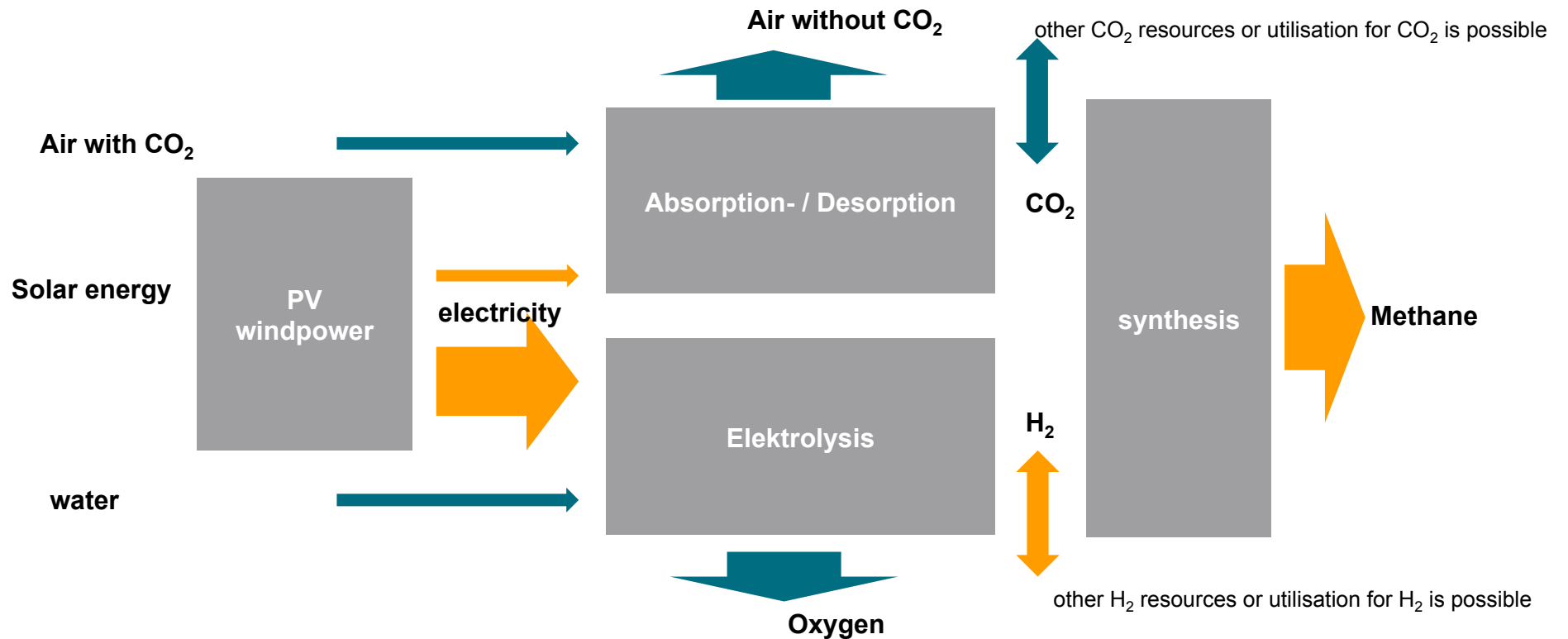
PtG as systems integrator



Quelle: Specht, Sterner et al.

Renewable methane (RM): Prototype 2009 SolarFuel, Absorption/electrochemical desorption of CO_2 , reduction of H_2O to H_2 and followed reduction of CO_2 by hydration will function

Basic plant concept of CO_2 absorption by air inlet



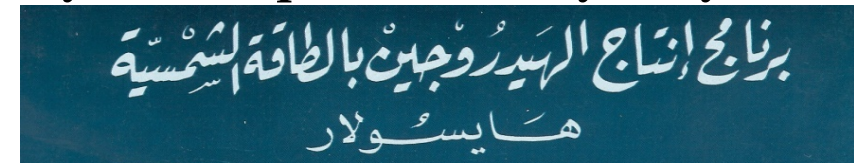
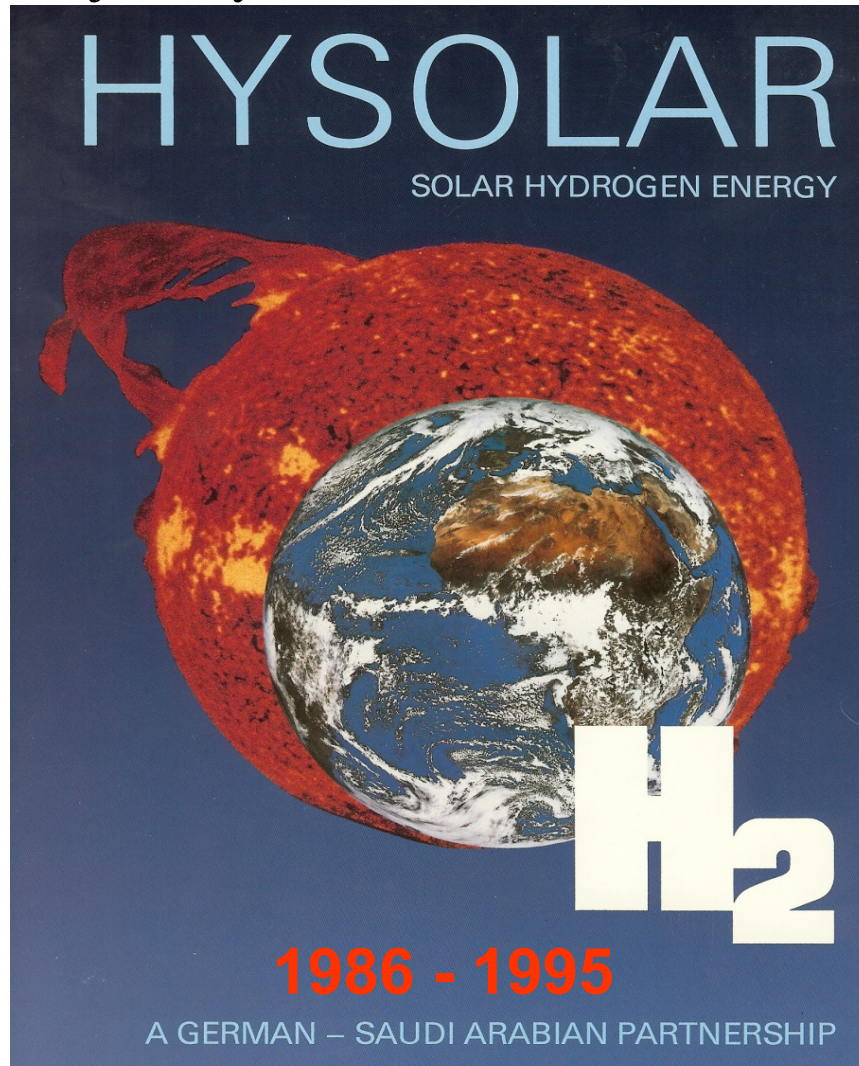
Detailed analysis of process shows optimal process realisation

source: SolarFuel

■ stuff ■ energy



Project Hysolar: Use of the Knowledge of dynamic operation of hydrolyzer



SOLAR HYDROGEN PRODUCTION AND UTILIZATION
A COOPERATION IN RESEARCH, TECHNOLOGY AND EDUCATION

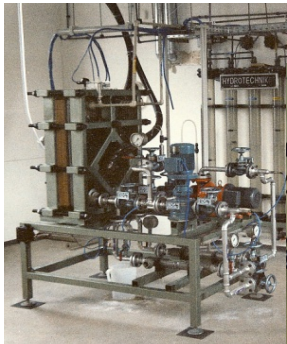


Quelle: ZSW, Brinner

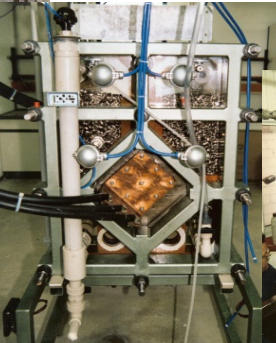


Hysolar Project: Alkaline Elektrolyzer units of the project (ZSW)

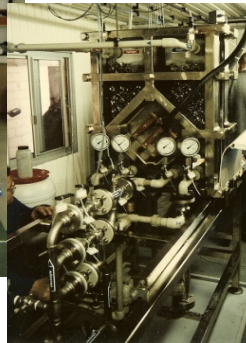
$P = 2 - 350/500\text{kW}$, $p = 1 - 10\text{bar}_{\text{abs}}$, $T = 40 - 95^\circ\text{C}$



HT



HT/DLR

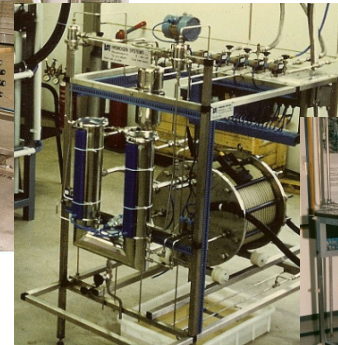


HT/
DLR

Powerrange: 2- 10 kW



HS

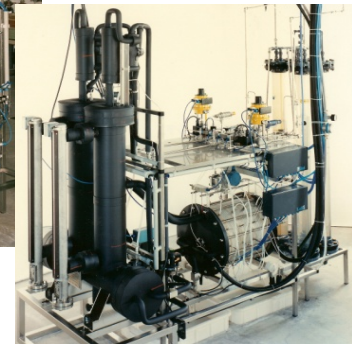


HS/DLR

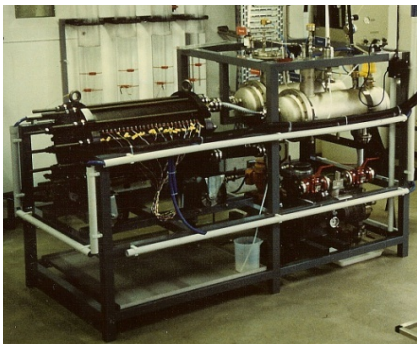
Powerrange: 10 – 15 kW



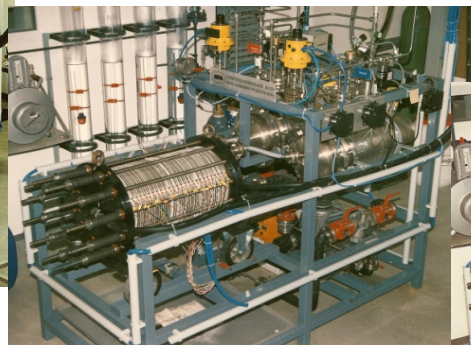
MA



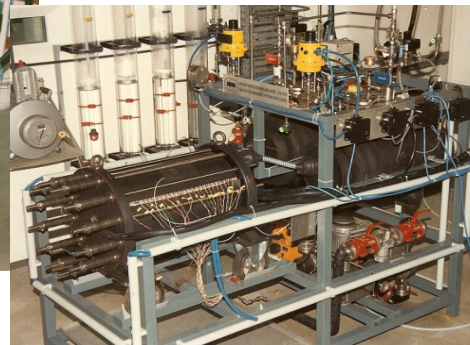
MA/DLR



FZJ



FZJ/DLR



FZJ/DLR

Powerrange: 10 – 15 kW

Quelle: ZSW, Brinner

R&D member

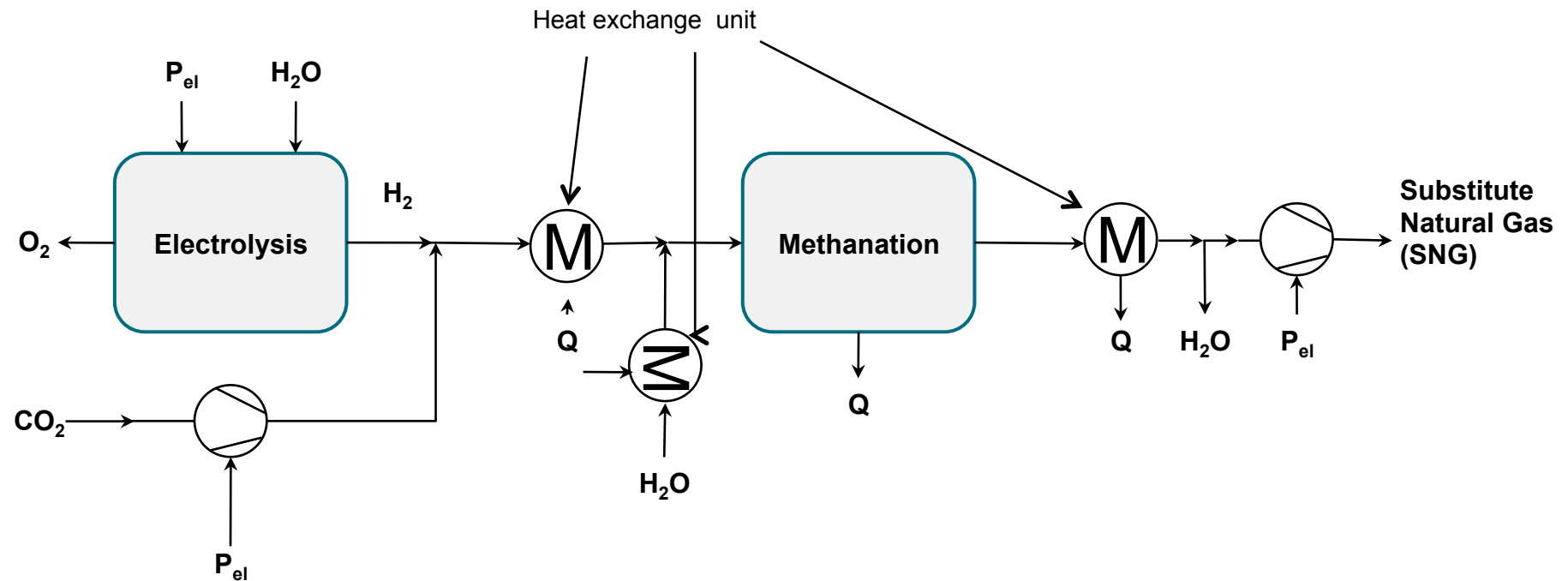
FZJ: Forschungszentrum Jülich

HS: Hydrogen Systems

MA: Metkon Alyzer

SolarFuel pilot plant converts surplus electricity from wind or pv power into renewable methane/SNG (substitute natural gas)

Flow chart SolarFuel plant: combination of industrial available technologies in a new system

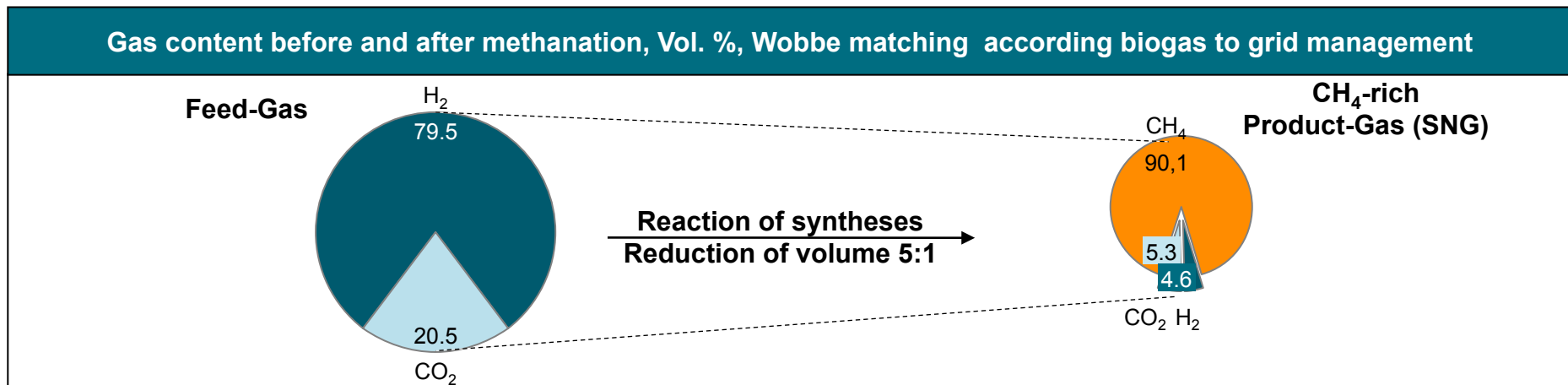
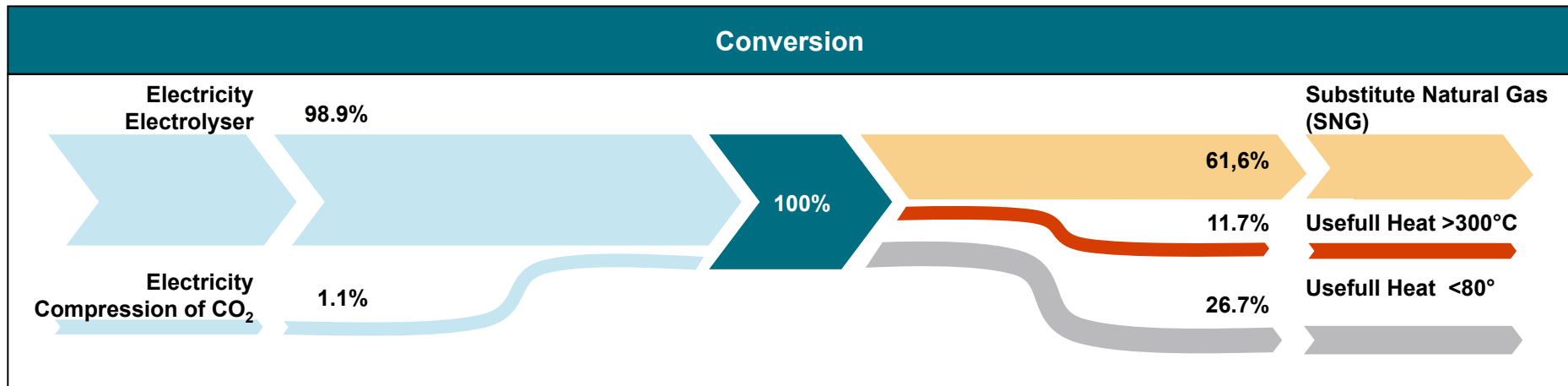


Feed gas stoichiometry adapted for optimized methanation operation conditions.
Addition of steam to avoid carbon depositions/catalyst deactivation.
Methanation heat utilization at $T > 200\text{ }^{\circ}\text{C}$ possible

source: ZSW/SolarFuel

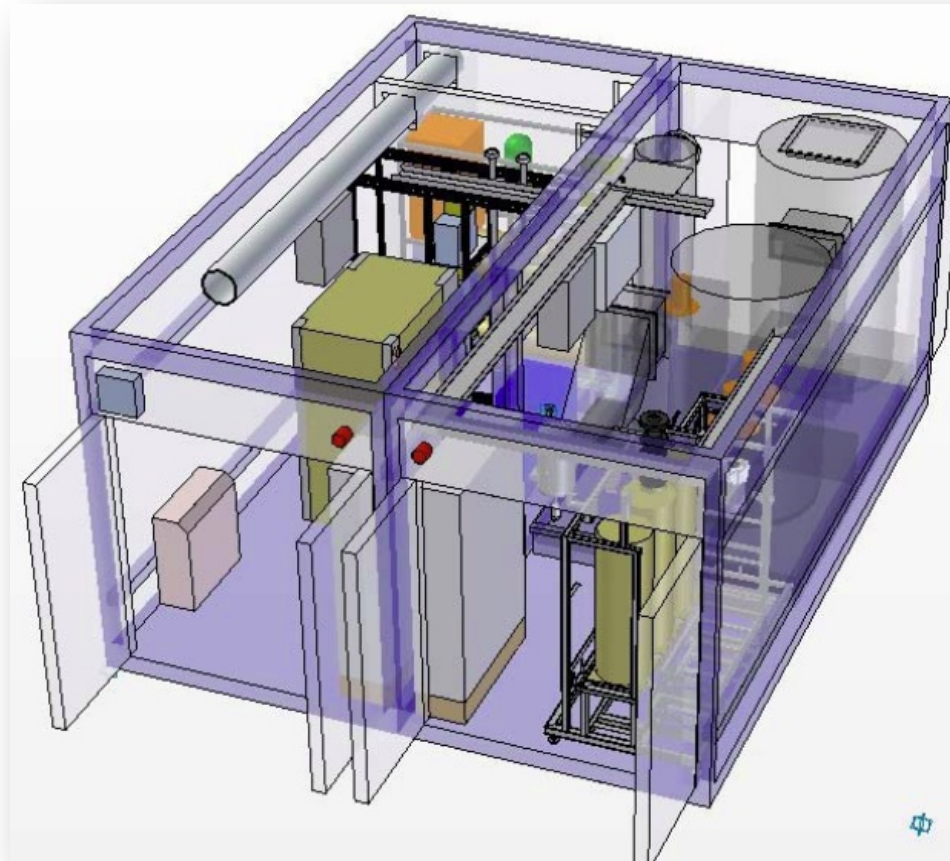
Conversion efficiency will exceed over 60%, SNG will be feed directly into the natural gas network, total efficiency >80% (gas + heat utilization)

Vol. %, G262, DIN 51624 according



The SolarFuel demonstration plant in Stuttgart uses CO_2 from air for off grid/remote area application or not concentrated CO_2 resource

X ray image of the plant, 2009

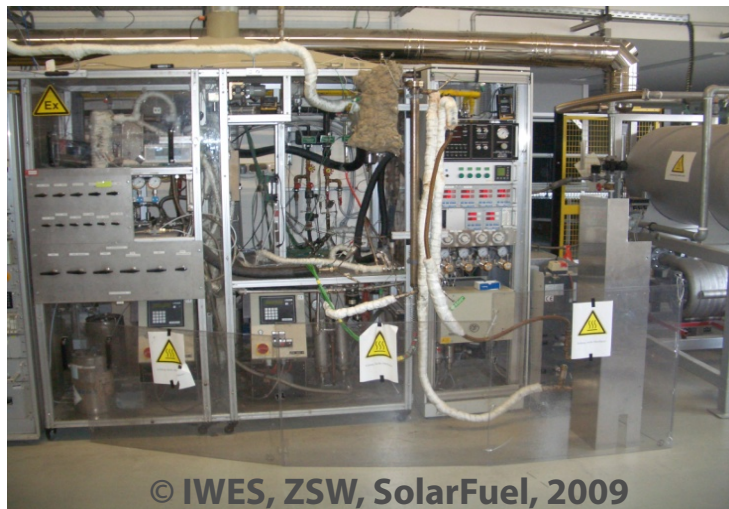
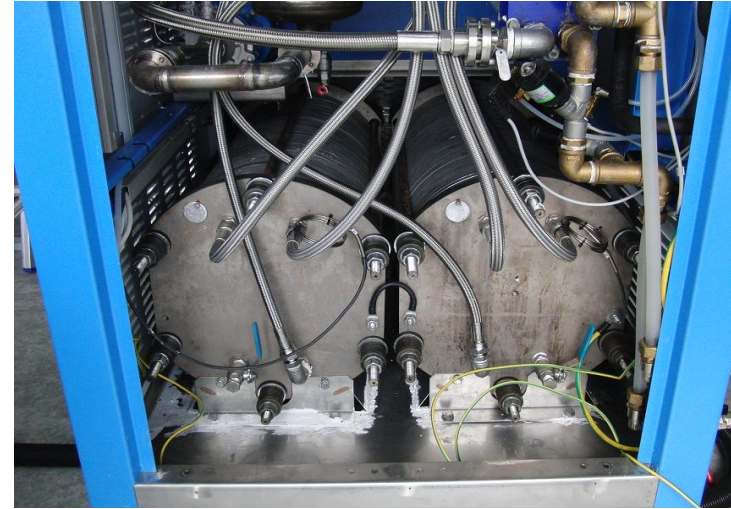


Option: CO_2 from biogas plants (>7000 plants, $2,7 \text{ GW}_{\text{el}}$, 2011), potential of approx. 50 TWh SNG 2011, other CO_2 resources are bioethanol, brewery, sewage treatment or industry (lime stone, chemical processes).

source: SolarFuel



From idea to reality (1): SolarFuel's first pilot plant, built by ZSW Stuttgart (Research Center for Solar Energy and Hydrogen)

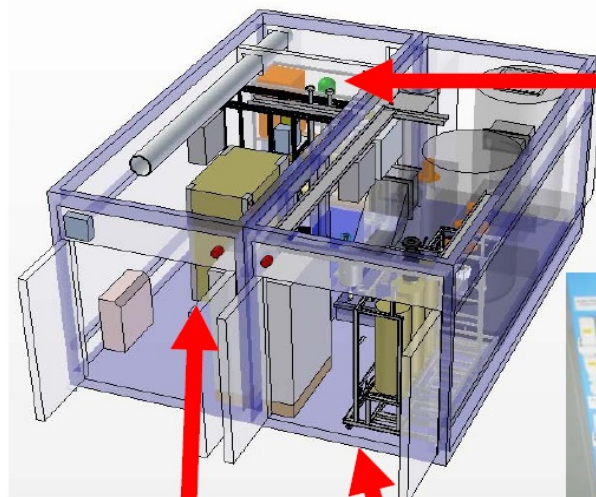


Source: Specht et al., 2009





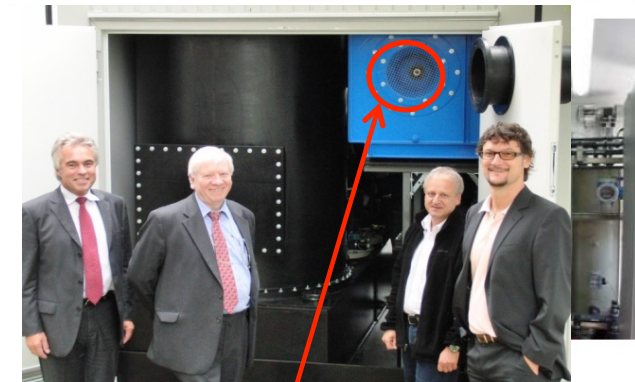
From idea to reality (2): SolarFuel's first pilot plant, built by ZSW Stuttgart (Research Center for Solar Energy and Hydrogen)



CH₄-Filling station
ca. 15 kg, 200 bar

CO₂-
Recovery

Electrolyser

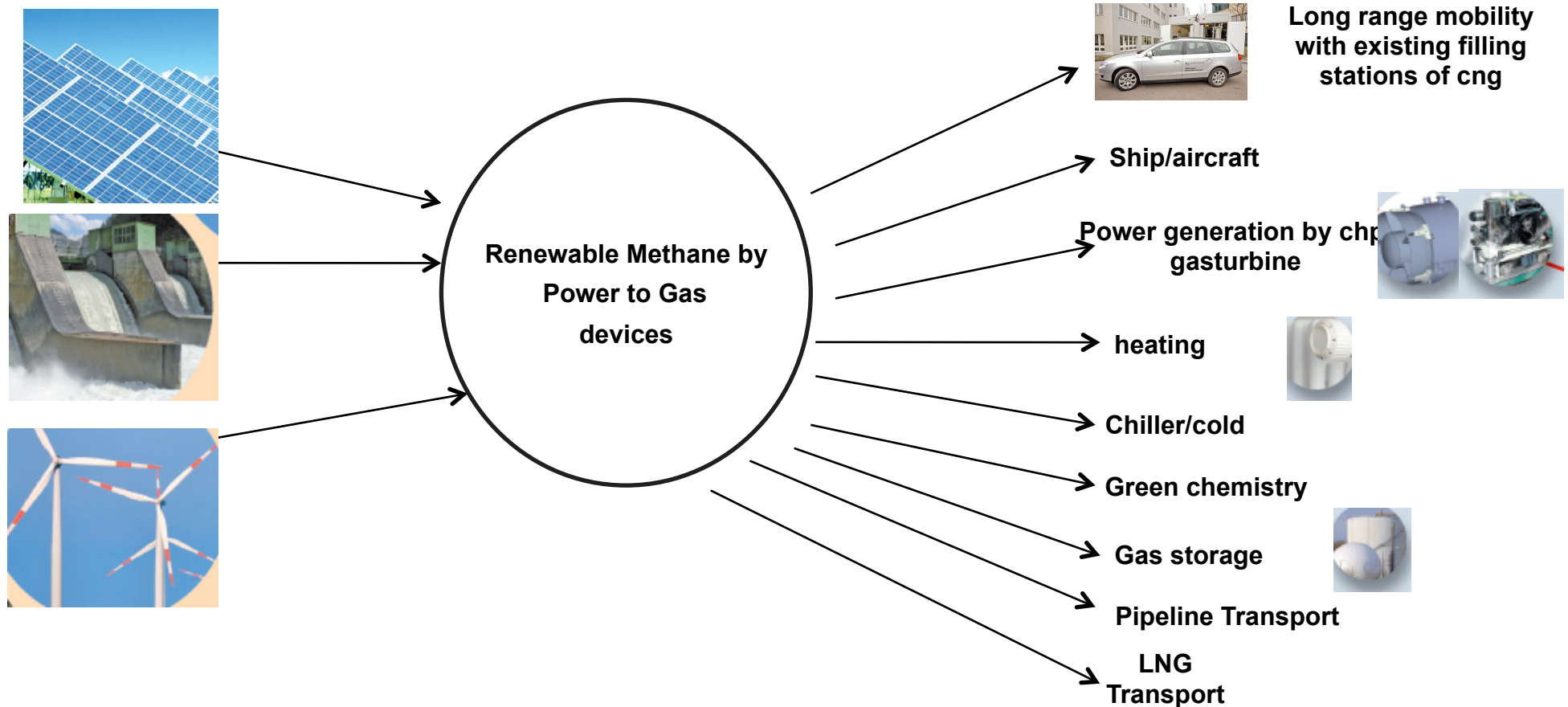


CO₂ Absorption = 1,5 hectares corn / a

Quelle: Specht et al., 2009

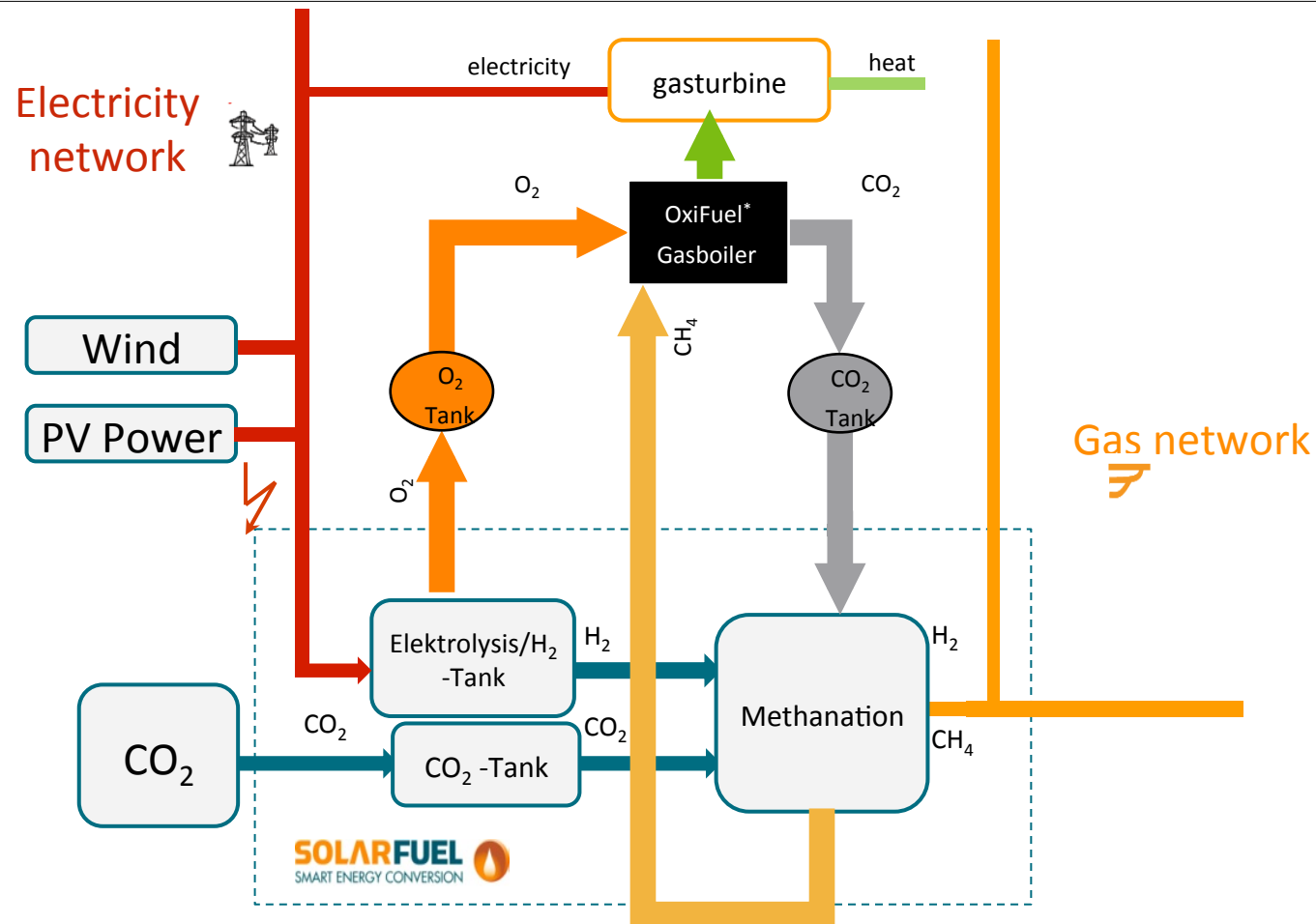


RM in different energy markets is now possible with existing gas infrastructure for supplying an assured, planable supply of energy



Multi dimensional value of RM in the system platform gas network according market efforts/demands (peak power versus fuel f.e.)

Integrated Storage-power device based on renewable methane by using existing gas network/power turbine infrastructure and fuel transformation of natural gas to renewable methane



source: SolarFuel et al.

Audi is SolarFuel's key customer in the mobility market – „e-gas“ is part of Audi's sustainability strategy „balanced mobility“

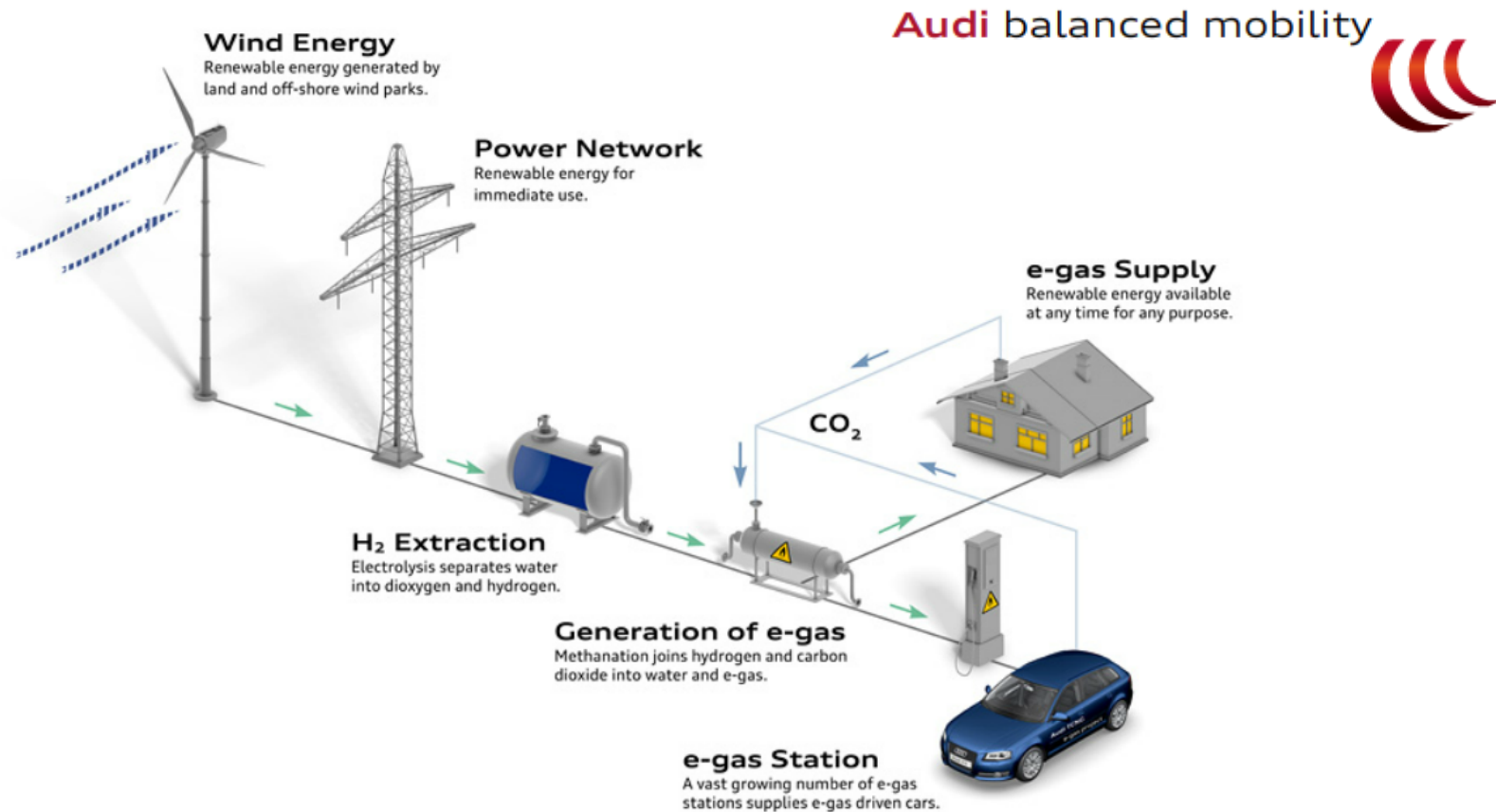
Vorsprung durch Technik



Quelle: www.audi-balanced-mobility.de

Audi demonstrates the complete process of renewable long-range mobility from wind energy to gas vehicle

Process chain of Audi's „e-gas-project“ together with SolarFuel



Quelle: www.audi-balanced-mobility.de

The new A3 TCNG will be launched in 2013; in the same year, the PtG-plant will start to produce the yearly demand of renewable SNG for 1500 vehicles

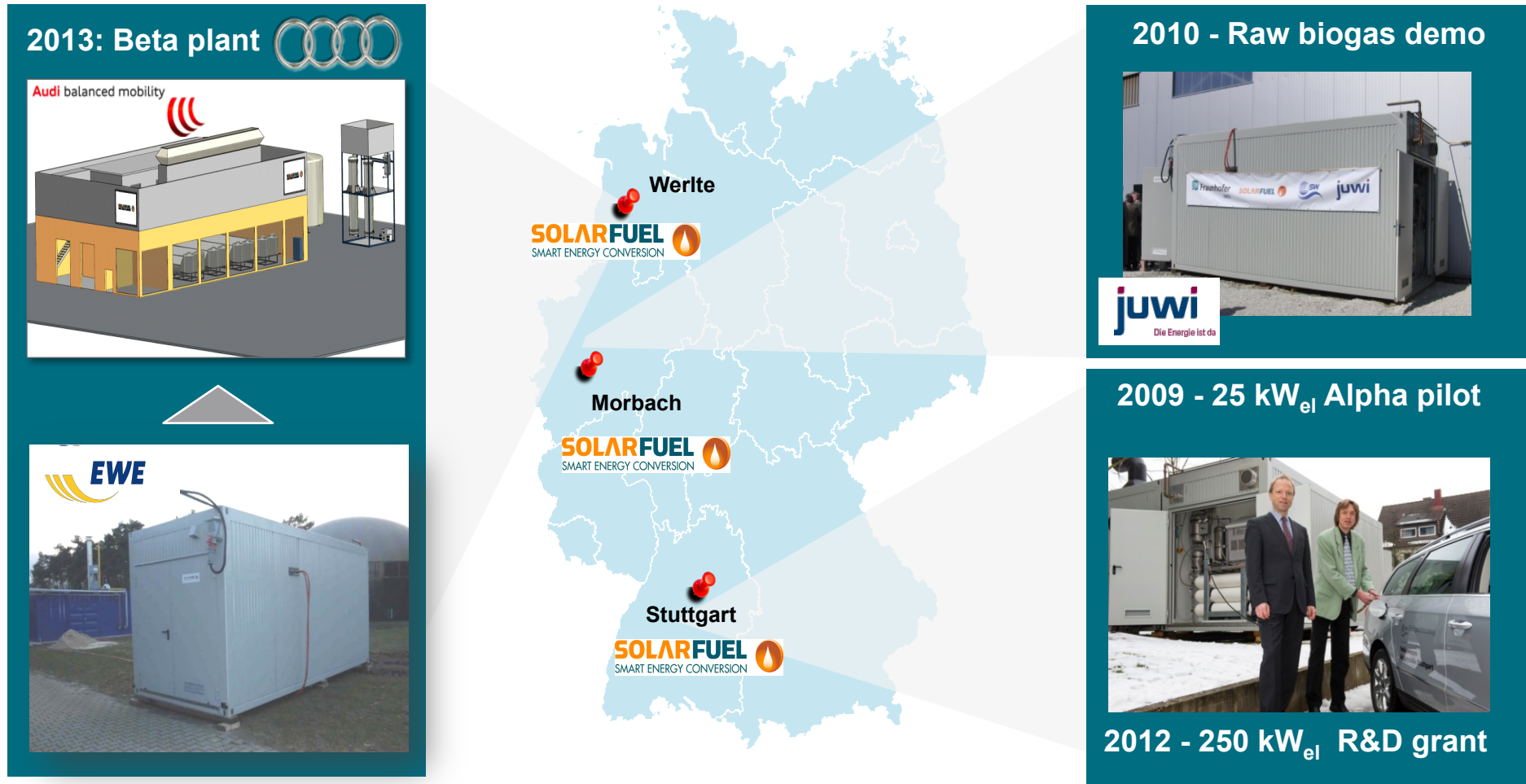
Audi's new A3 TCNG



Quelle: www.audi-balanced-mobility.de

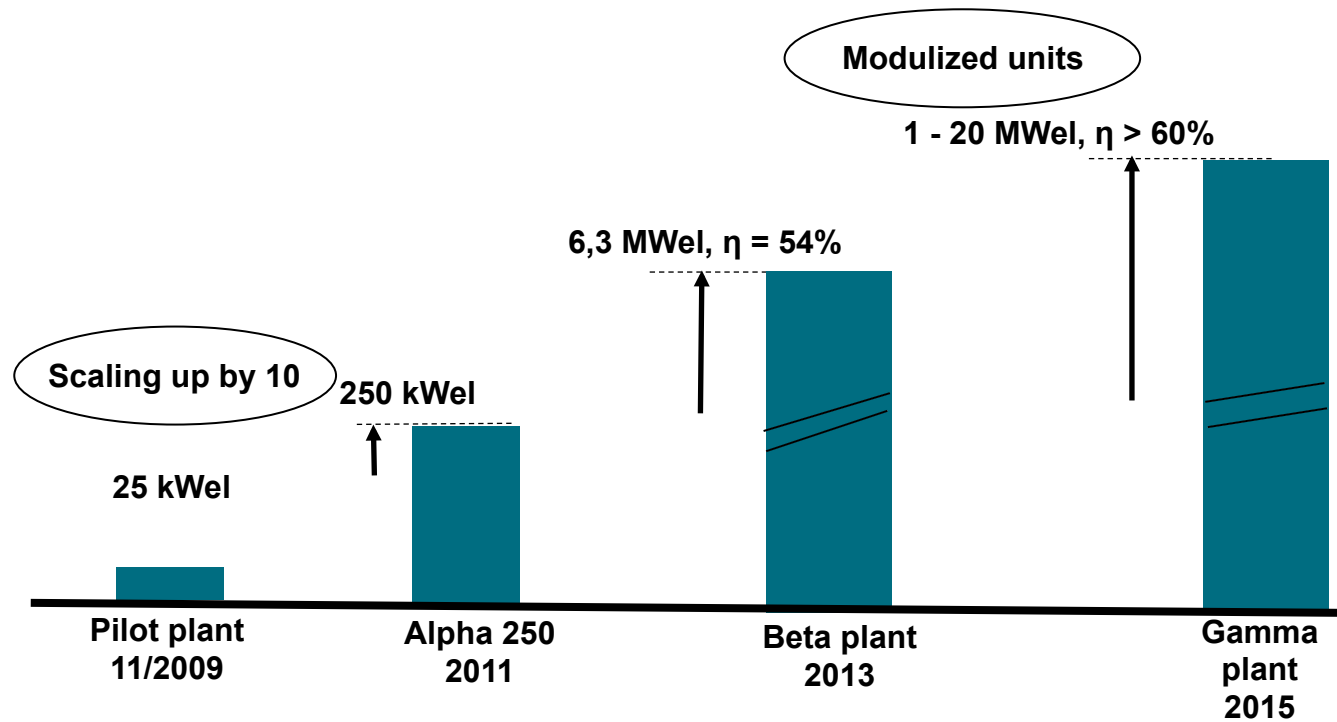
SolarFuel systematically ramps up the technology from pilot to industrial scale with leading industrial firms

Steps of technology ramp up



Quelle: SolarFuel

Plan for Roll-out of the commercial product of SolarFuel plants



Commercial plants of SolarFuel will be available since 2015 with a power range up to 20 MW , total efficiency of > 80% (gas + waste heat)

SOLARFUEL

SMART ENERGY CONVERSION



www.solar-fuel.net