Gas- und Wärme-
Institut Essen e.V.

The influence of power-to-gas on natural gas quality and application

Dr. Johannes Schaffert

IGRC | Copenhagen| September 2014

The Gas- und Waerme-Institut Essen e.V. (GWI)

GWI is a research institute dedicated to applied technology
In the fields of natural gas and heat

- Non-profit association
- Founded 1937 by the gas industry
- 61 members: Gas utilities, equipment manufacturers, associations, public utilities
- 63 staff

The GWI as a full-service provider

A close interaction between the departments

- R & D
  - Fuel and Appliance Technology
  - Industrial Combustion Technology
- Testing Laboratories
- Academy

creates synergy effects for our members and clients.

Our members


AVU... Netz GmbH
bayerngas Energiepartnerschaft mit Zukunft
Buderus
JUNKERS Bosch Gruppe
BRINKMANN since 1885
BRÖTJE HEIZUNG
CERAMIC FUEL CELLS
DECHEMA
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ELE
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ERDGAS MÜNSTER Partner für Deutsches Erdgas
ESB IDEEN. INNOVATIONEN. ENERGIE.
FairEnergie
figawa
gas union
GASAG BERLINER GASWERKE AKTIENGESELLSCHAFT
Gasversorgung Ihr Nachbar. Ihr Partner. Westerwald
GELSENWASSER GAS. STROM. NATÜRLICH WASSER.
GoGaS
GWN
HKI
catalysis Leibniz-Institut für Katalyse e.V.
mainova
Enervie Gruppe mark E
M&G Muelink & Grol
N-ERGIE AKTIENGESELLSCHAFT
PFALZ GAS Wärme aus der Nachbarschaft
Regenis BIOENERGIE TECHNOLOGIE
REGIONALGAS EUSKIRCHEN
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rhenag EnergieBündel. Seit 1872.
RMG by Honeywell
VORWEG GEHEN
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sanitär heizung klima
STAWAG
Stadtwerke Bochum GmbH
Stadtwerke Düsseldorf
Stadtwerkessen Wir sind Zuhause.
stwh STADTWERKE HERNE
STADTWERKE MAINZ AG
swn meine stadtwerke
Stadtwerke Velbert
SVB erdgas wasser wärme
swb
thüga DIE ENERGIEGRUPPE
Vaillant
UMSICHT FÖRDERVEREIN
VIESMANN climate of innovation
Verbundnetz Gas AG
WINGAS
WOLF Energiesparen und Klimaschutz serienmäßig
WS
WSW

Agenda

- Introduction: Power-to-Gas as a stepping stone to a regenerative gas supply
- Feed-In potential of H2 into the German natural gas grids
- Laboratory experiments on the H_2 tolerability of household boilers
- Foundation of a Virtual Power-to-Gas Institute

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Power-to-Gas offers enormous long-term storage capacities

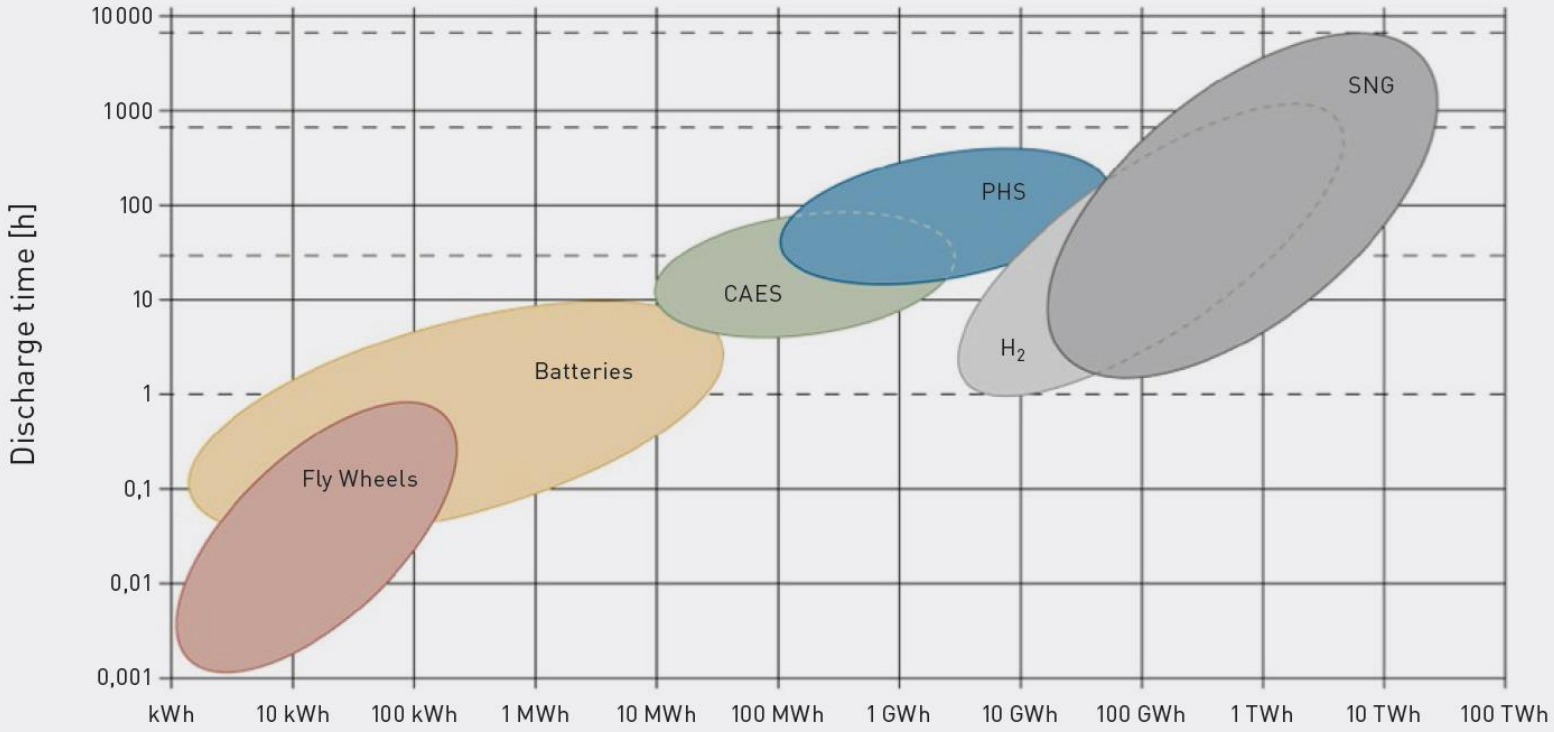


Figure 1. Discharge times and storage capacities. CAES: Compressed Air Energy Storage, PHS: Pumped Hydro Storage, H_2, SNG: Hydrogen, Synthetic Natural Gas.

Source: Research Center Jülich

Power-to-Gas

‚PtG both enables and benefits from the energy transformation to a future based on an increasing renewable content in our energy‘ [1].

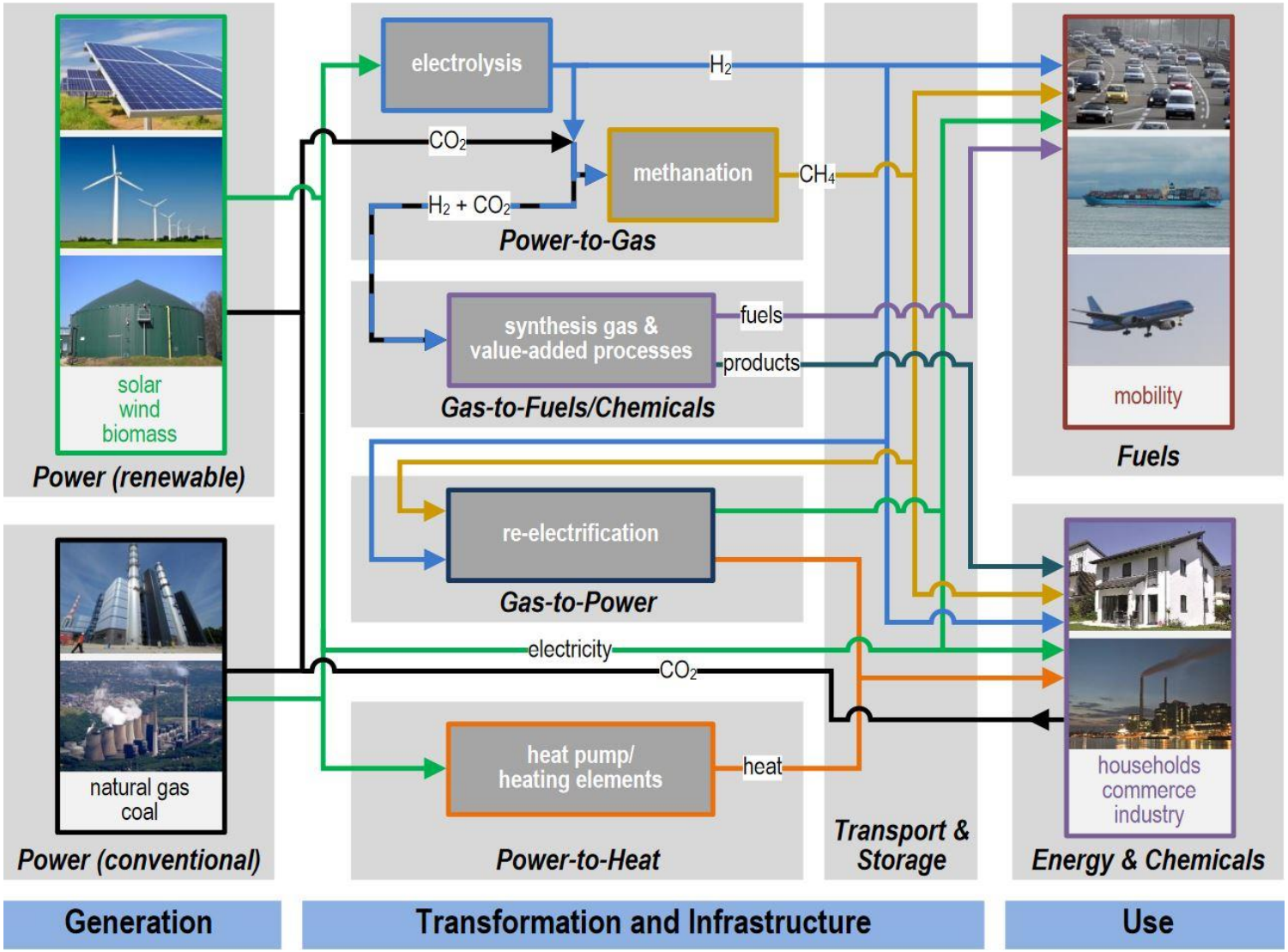
The variety of technical questions are beeing addressed right now in several R&D projects, with generally positive results concerning fundamental questions such as hydrogen tolerances of infrastructure and appliances [1-3].

One pivotal challenge is to identify paths for the integration of PtG and related techniques and their output energy and mass fluxes into our existing energy systems.

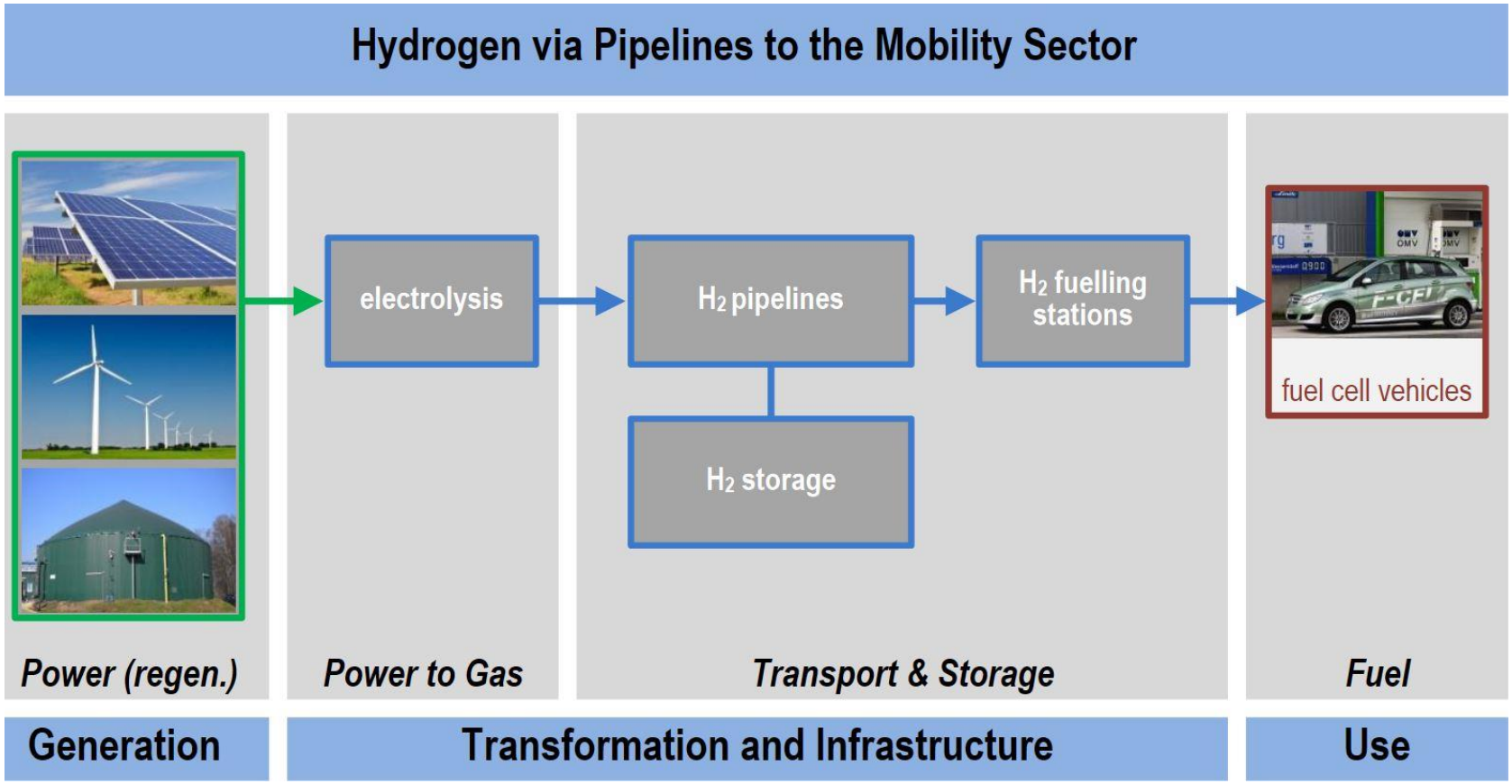
The GWI addresses these issues within the framework of a new collaborative PtG Institute.

[1] Robert Judd and Dave Pinchbeck, current and former Secretary Generals of GERG, in: *gas for energy* 2/2013.
[2] Gerd Müller-Syring and Marco Henel, DBI, Final Report: DVGW project, Wasserstofftoleranz der Erdgasinfrastruktur und aller assoziierter Anlagen‘.
[3] DVGW Gas Innovation Campaign, english brochure: Mastering future challenges with gas innovations - intelligent technologies for the energy transition

Integration of Renewables into the Energy System



5 System Paths



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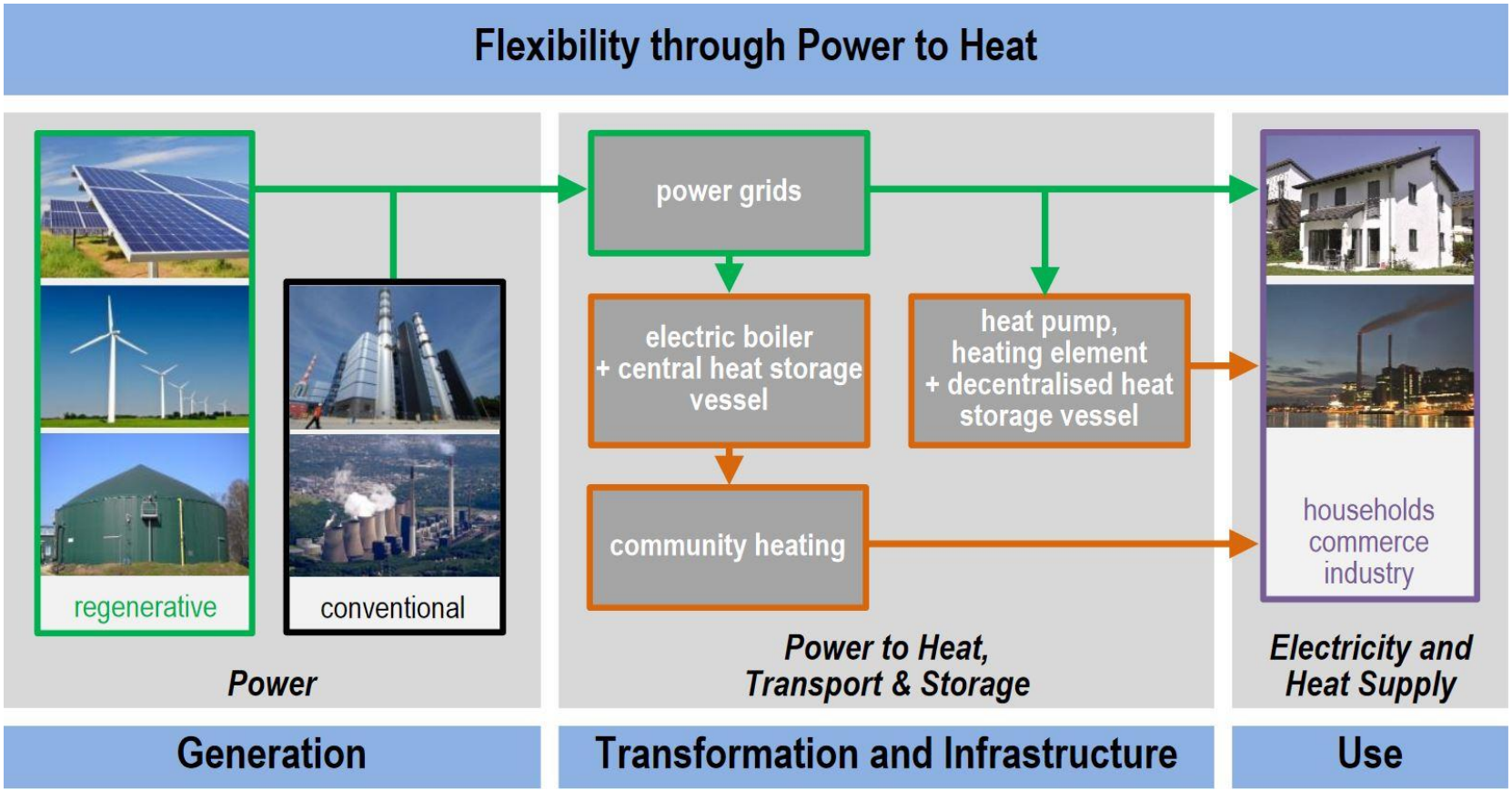

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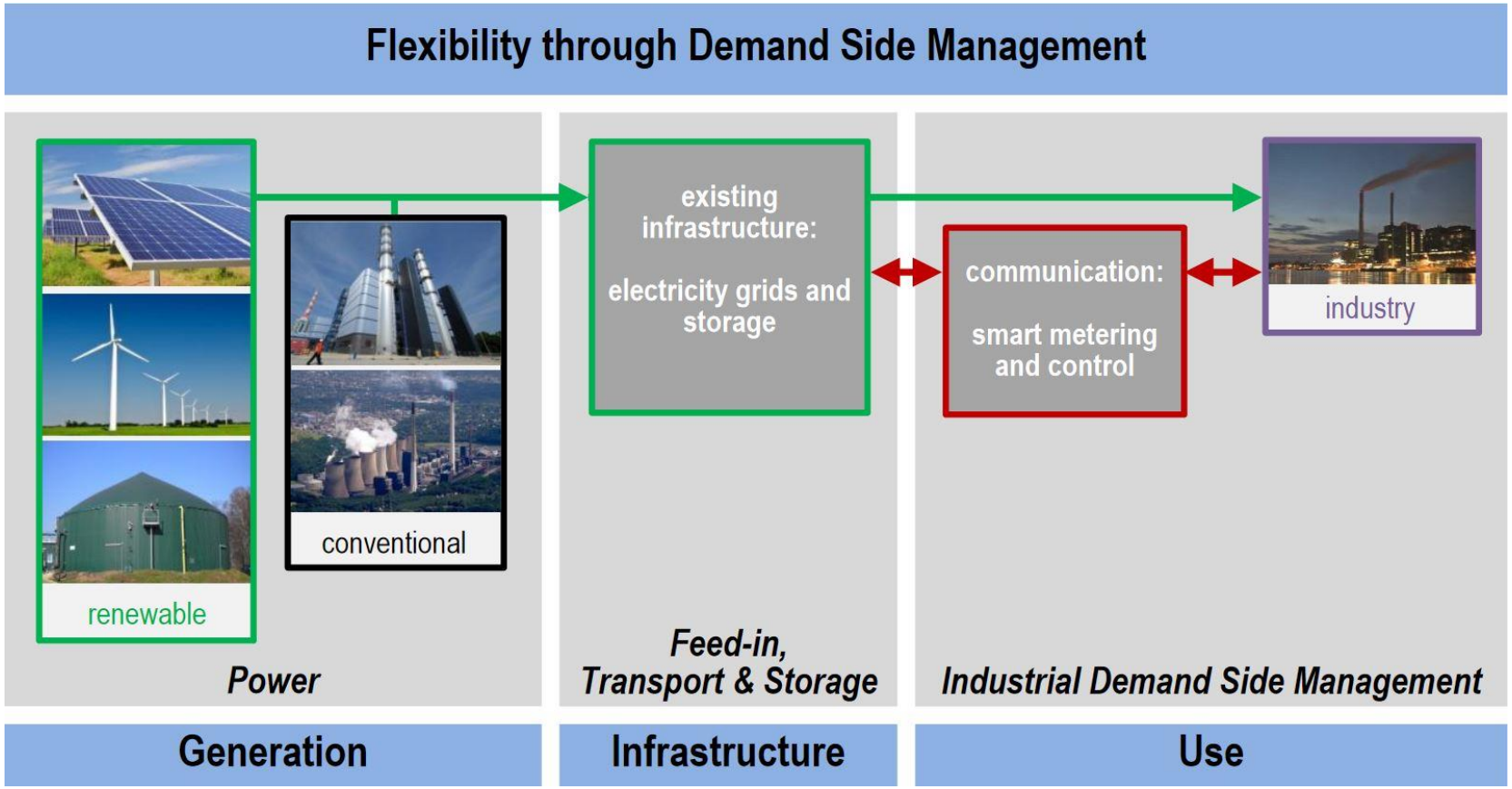

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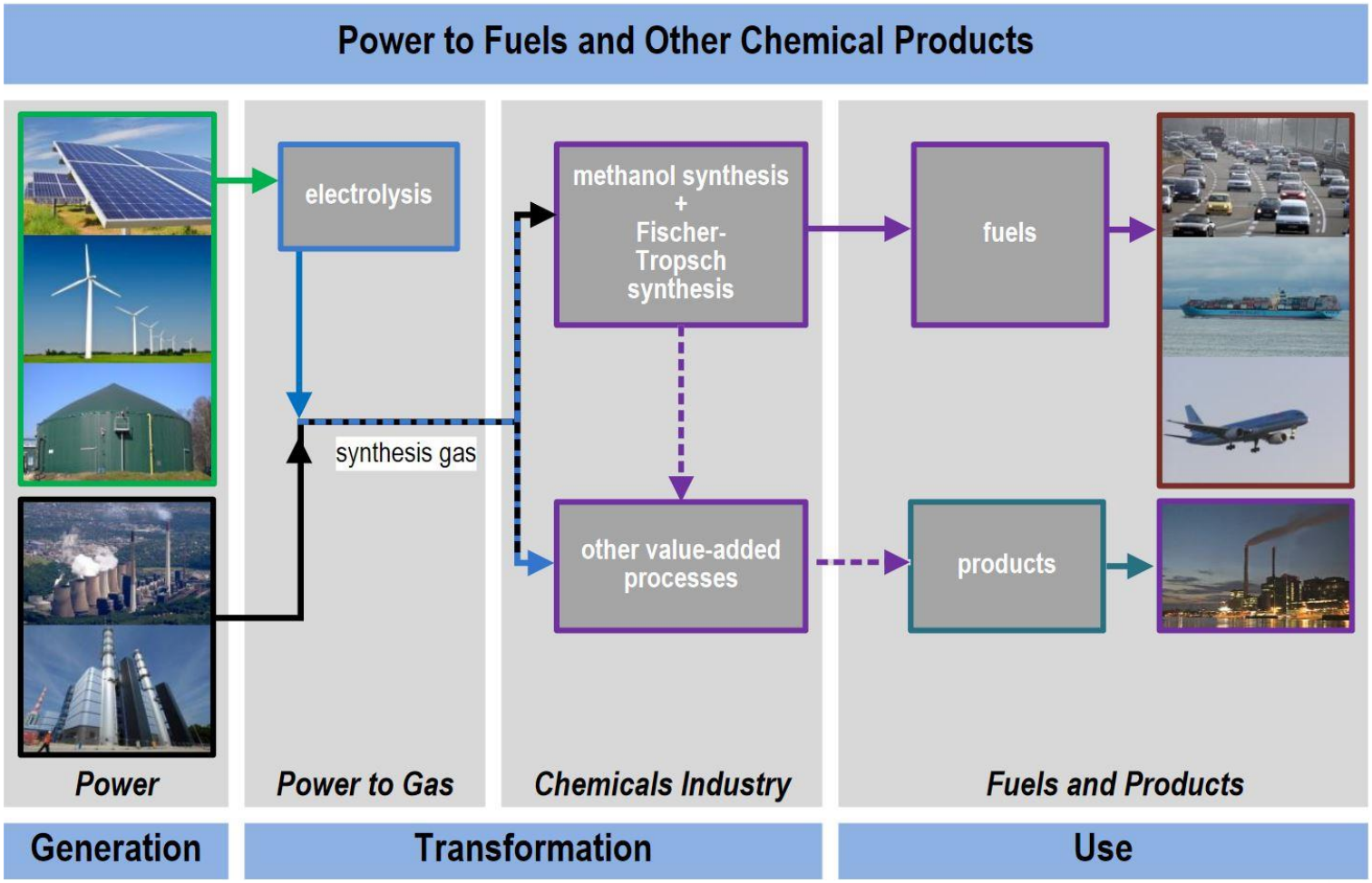

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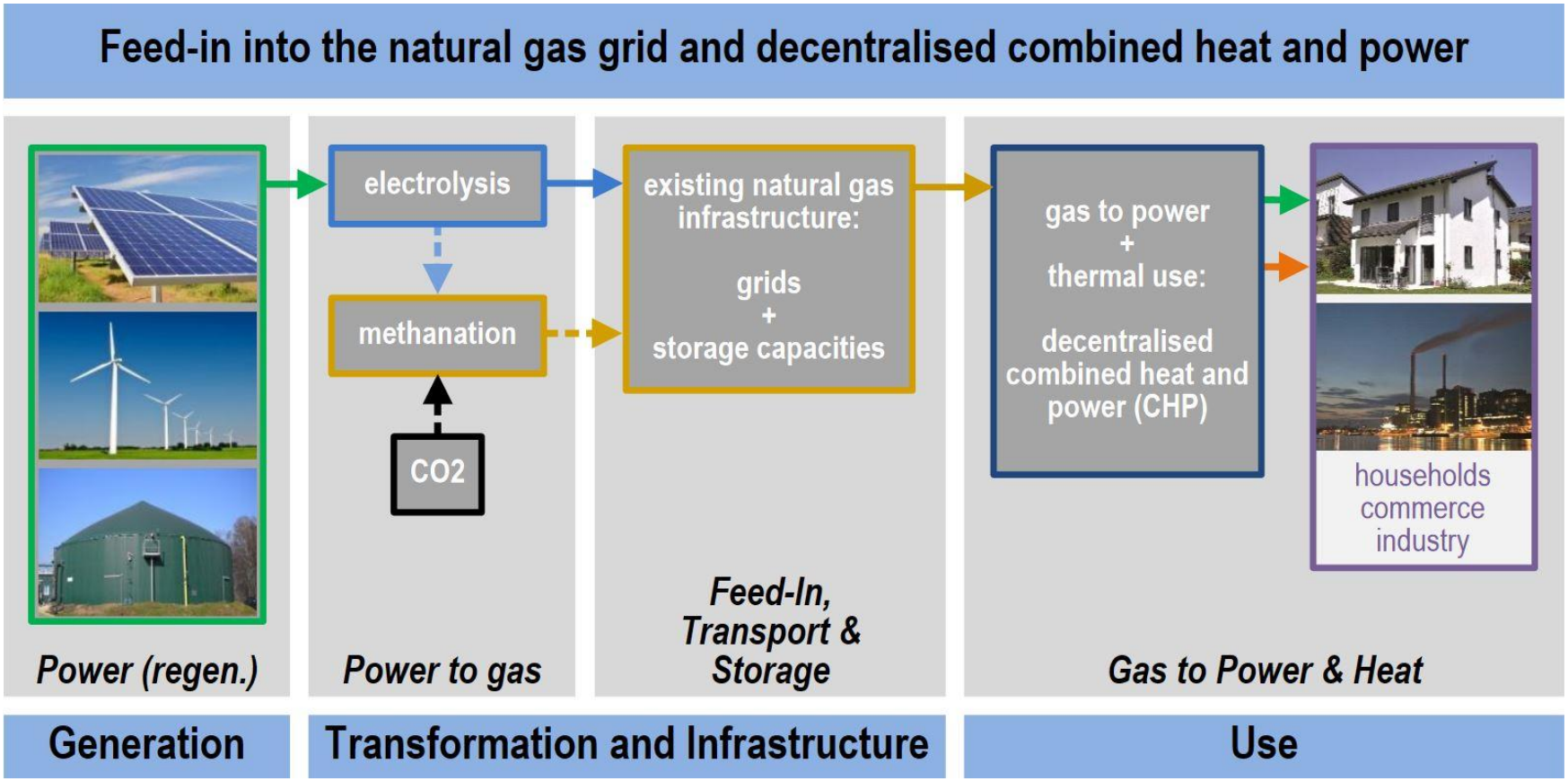

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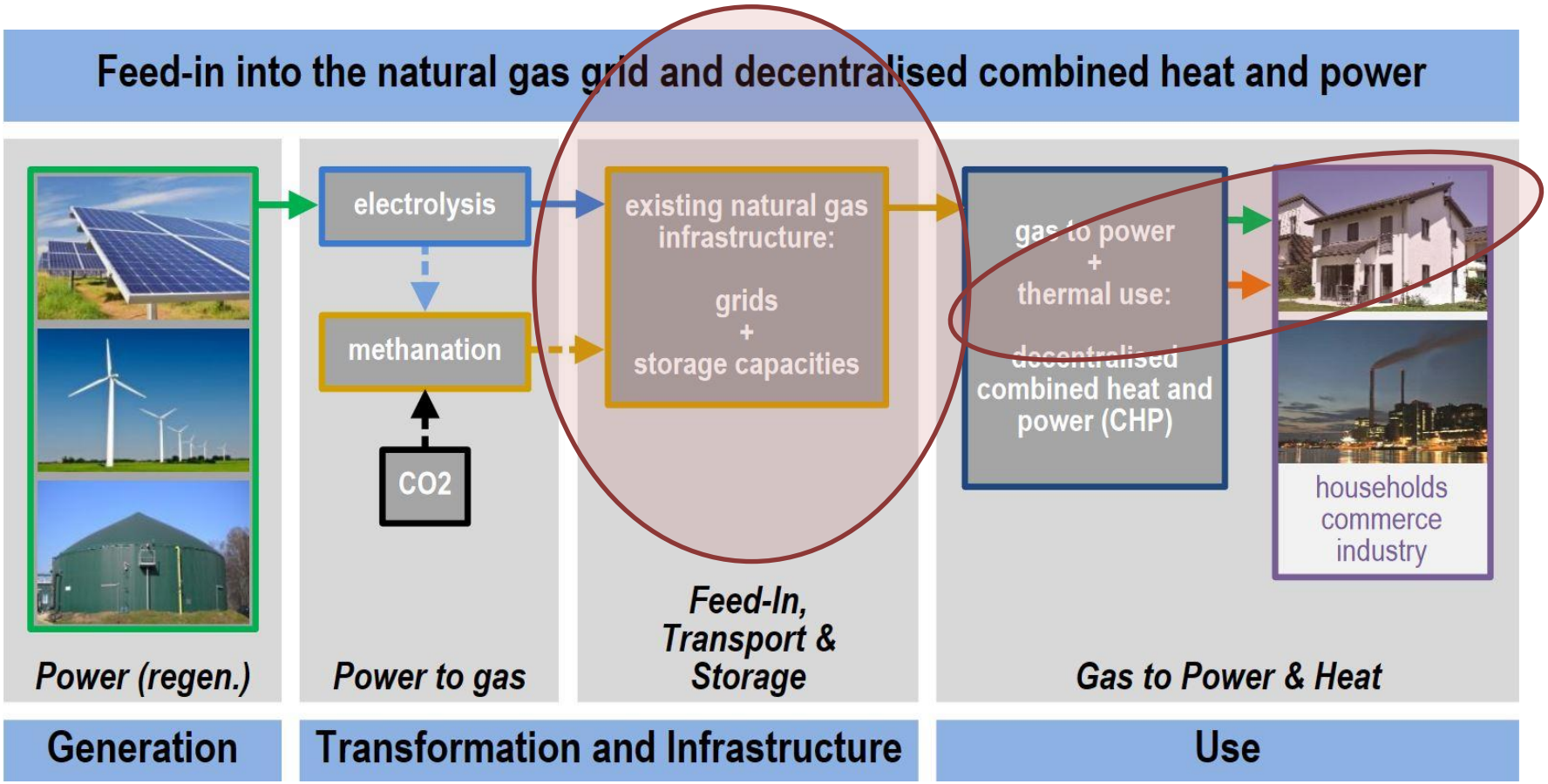
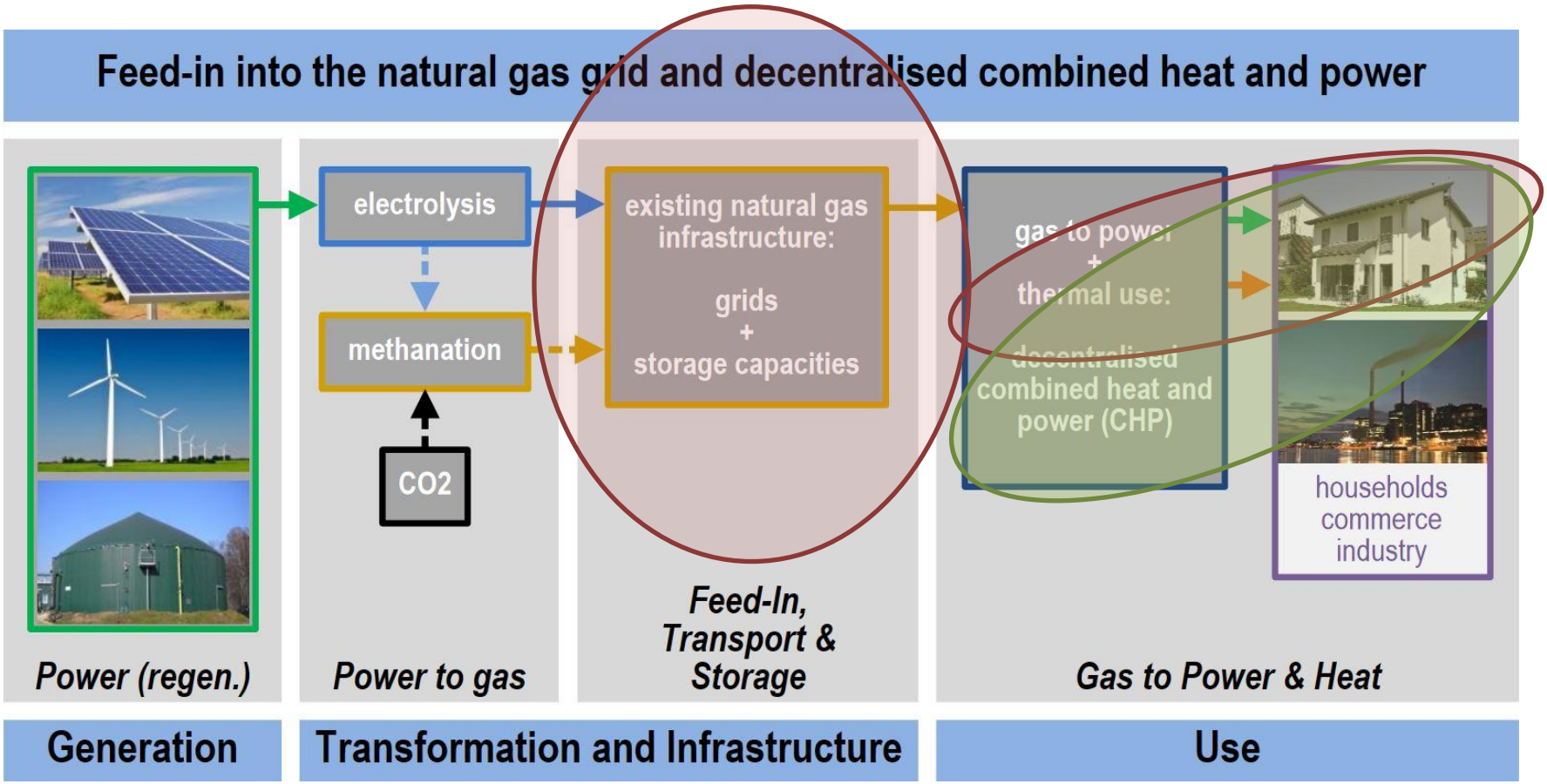


Topics of this talk

5 System Paths



Talk TW1-2 (109): Today, 16:40, Congress (Ground Floor)

"Scientifically supported operation of 100 micro-CHP systems in a representative district of the German agglomeration „Ruhrgebiet": experiences, issues and results"

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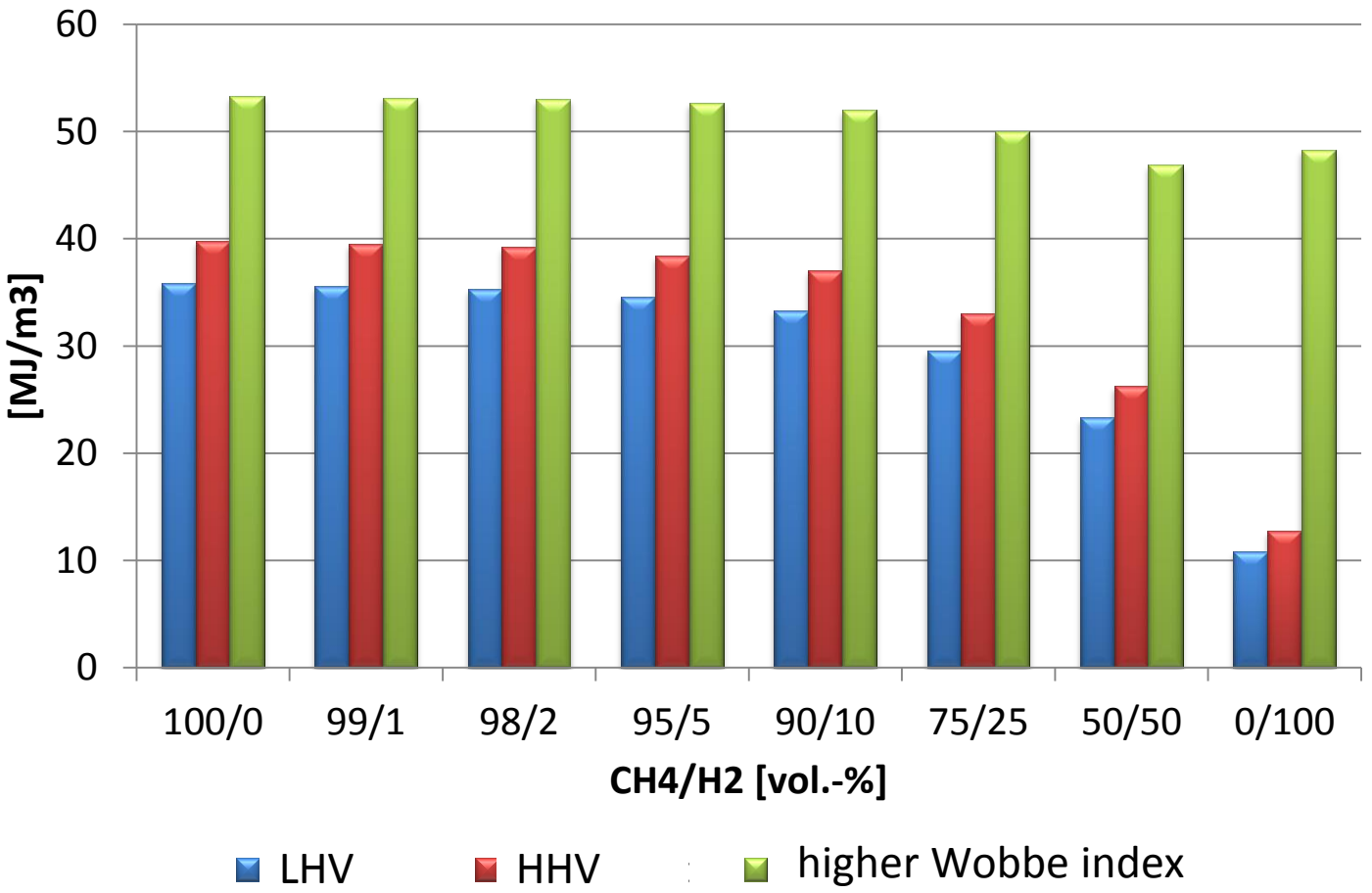
Properties of Hydrogen enriched Methane Test Gas



Volumes relate to T = 0°C = 273.15 K and atmospheric pressure p = 1013.25 mbar = 101325 Pa.

Properties of Hydrogen,Methane, and the Gas Mixture

Fuel Gas Properties	Natural gas H	G20 (100% CH_4)	Hydrogen enriched G20 (30% H_2)
Higher heat value [kWh/m³]	11.55	11.06	8.80
Lower heat value [kWh/m³]	10.44	9.97	7.87
Density [kg/m³]	0.8004	0.7175	0.5292
Limit of flammability [vol.-%]	4.71 – 14.38	5-15	4.7 – 32.8
Air requirement L_{min} [m^3_{air} / m^3_{fuel}]	9.99	9.57	7.40
Adiabatic flame temperature [K]	2223	2240	2265
Lower Wobbe index [kWh/m³]	13.269	13.383	12.313
$CO_{2,max}$ [vol.-%]	12.11	11.73	10.48

Volumes relate to T = 0°C = 273.15 K and atmospheric pressure p = 1013.25 mbar = 101325 Pa.

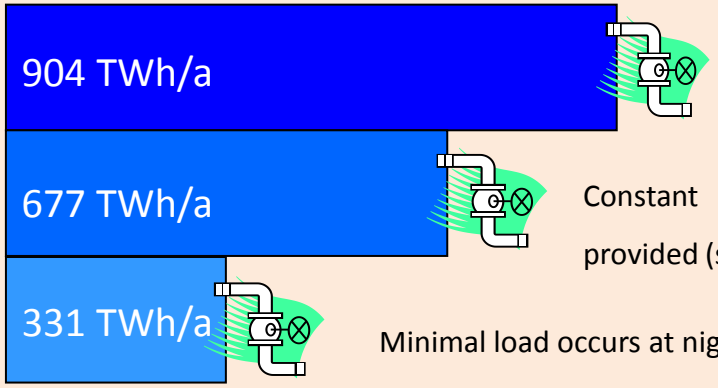
Minimum Feed-In Potentials of Additive Gases and Replacement Gases in Germany

Total natural gas sales

Local distribution

Summer load

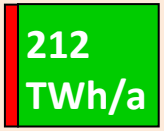
Minimal night load



Direct delivery to power plants and industry

Constant mass flow needs to be provided (summer load)

Minimal load occurs at night



Biogas:
Potential for additive raw gas (6 TWh/a)
and conditioned replacement gases

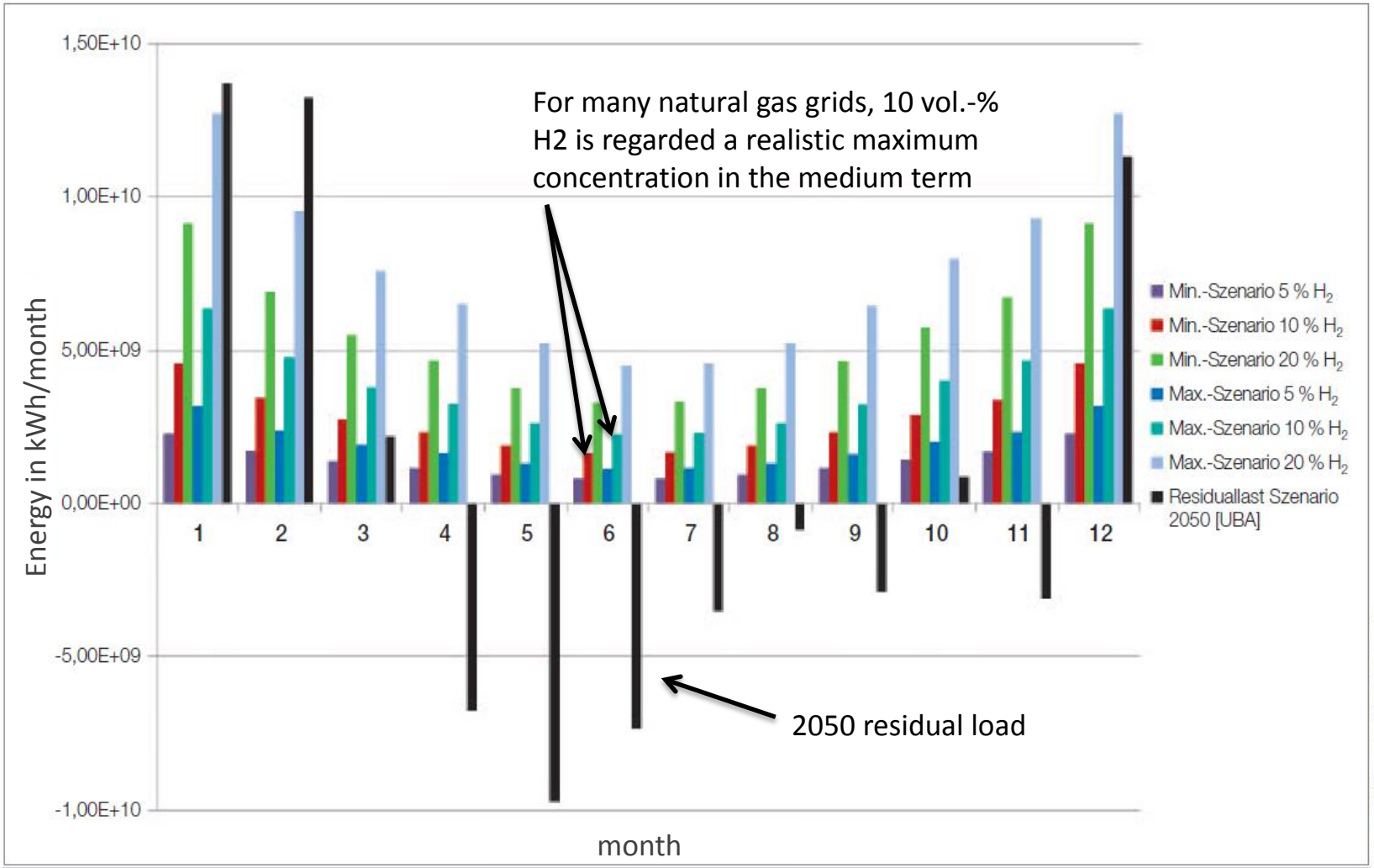
Hydrogen:
Potential for 10 vol.-% additive gas*: 21.6 – 30.0 TWh/a (LHV)
corresp. electric energy input = 33.2 – 46.2 TWh/a**

Maximum feed-in rate equals the current consumption within the same grid

➔ **The minimal load is the crucial factor**

[4] Burmeister *et al.* energie wasser praxis, gat-Spezial 06/2012

Results



Quelle: Gas- und Wärme-Institut Essen e. V.

Seasonal variations of potential feed-in amounts of renewable energy into the natural gas grids via electrolysis as a function of hydrogen concentration. Black columns indicate the 2050 residual load [4].

[5] Residual load scenario for 100% renewable electrical power supply, German Federal Office for Environment UBA

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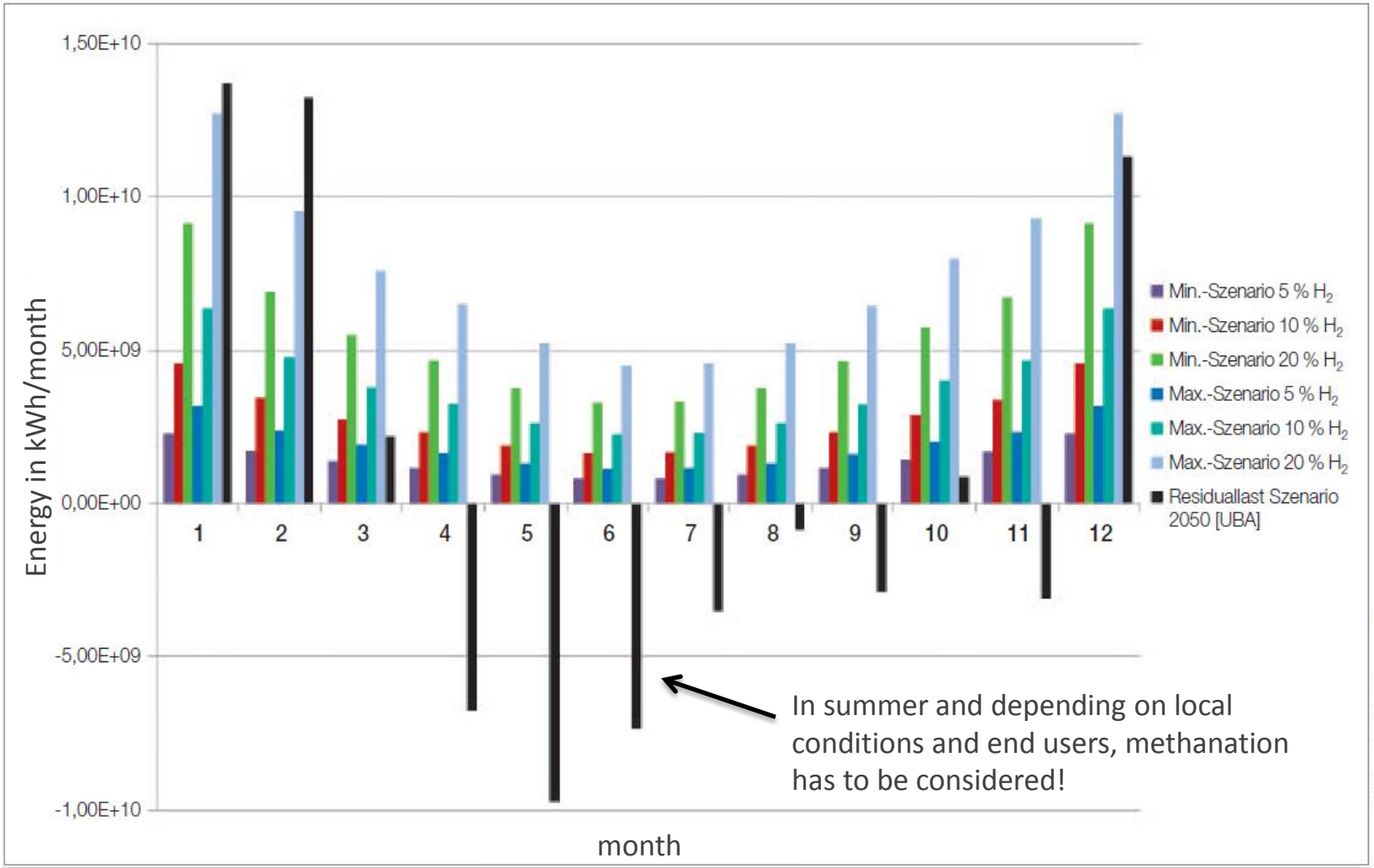

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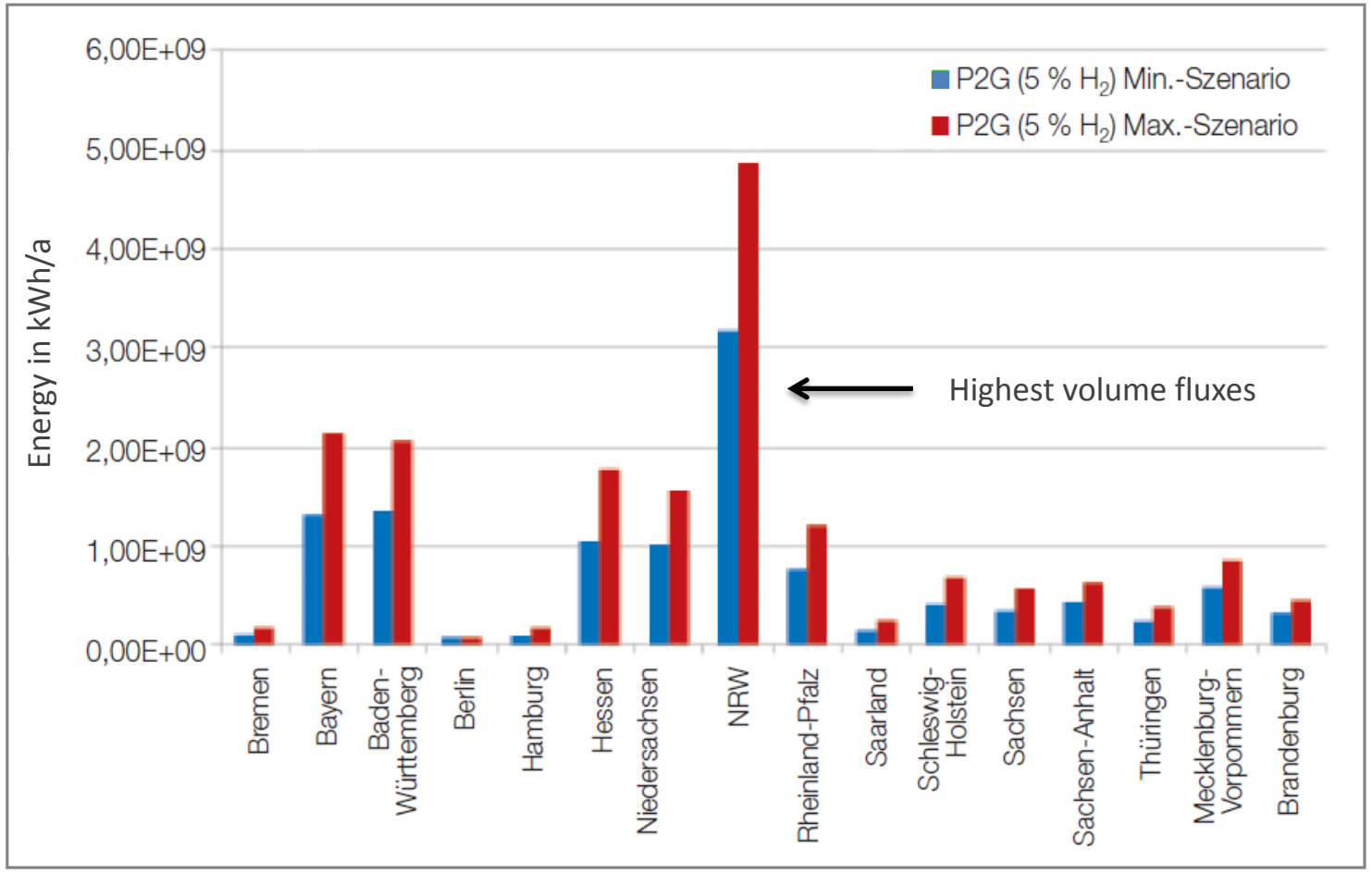

Regional variations of potential feed-in amounts of hydrogen into the natural gas grids.

[4] Burmeister *et al.* energie wasser praxis, gat-Spezial 06/2012

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Choice of devices

Device no.	Power	Device type
1	Q_{max} = 25 kW	Controlled gas-fired condensing boiler (ionization current measurement)
2	Q_{max} = 20 kW	Controlled gas-fired condensing boiler (ionization current measurement)
3	Q_{max} = 13 kW	Gas-fired condensing boiler (CO sensor)
4	Q_{max} = 40 kW	Wall-mounted gas-fired condensing boiler
5	Q_{max} = 22 kW	Floor-standing gas-fired condensing boiler
6	Q_{max} = 20 kW	Wall-mounted gas-fired condensing boiler (closed combustion chamber, ambient-air or room-sealed)
7	Q_{max} = 22 kW	Floor-standing low-temperature non-condensing boiler (ambient-air premix burner)
8	Q_{max} = 20 kW	Compact non-condensing wall-mounted boiler (ambient-air dependent)
9	Q_{max} = 22 kW	Low-temperature non-condensing boiler (ambient-air dependent, premixing, single-stage)
10	Q_{max} = 20 kW	Compact non-condensing wall-mounted boiler (room-sealed, atmospheric burner)

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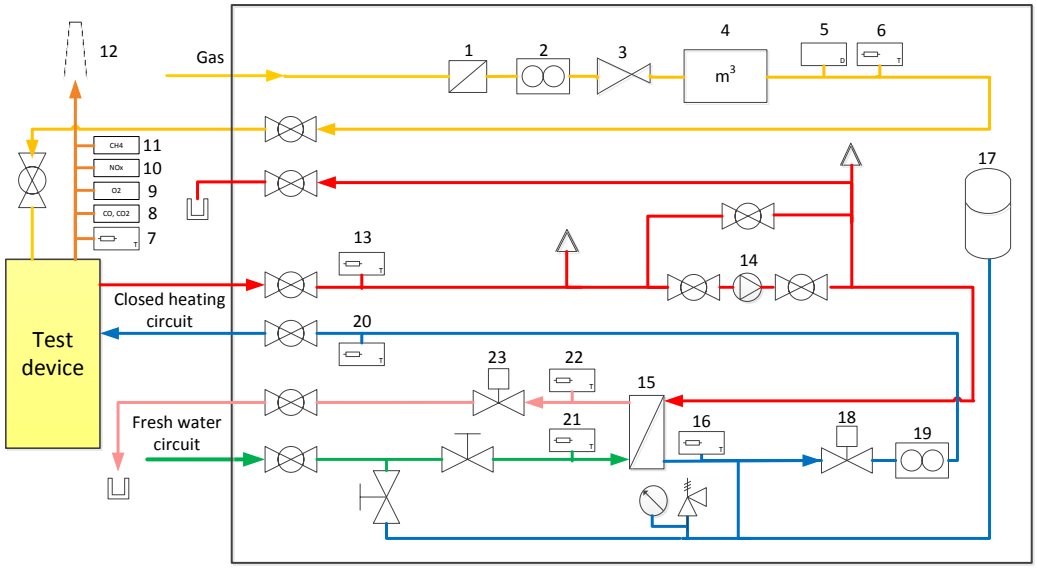
Experimental setup

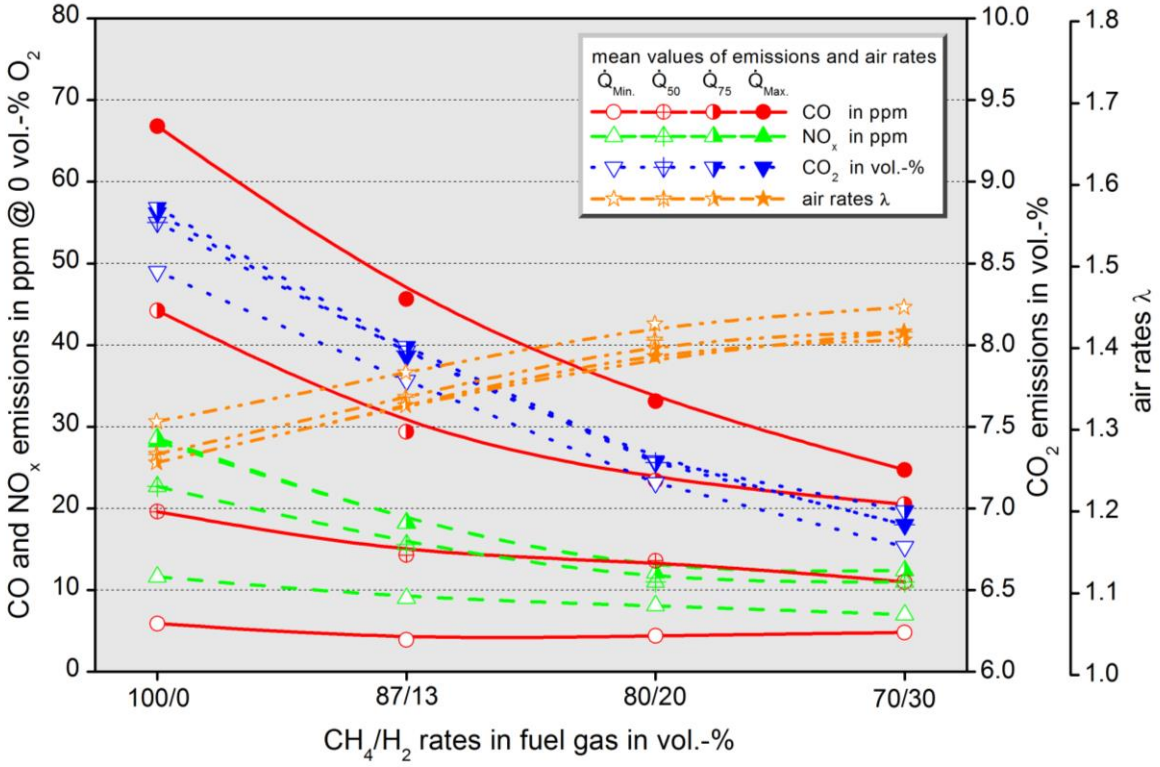
Hydrogen tolerance test rig:



Procedure:

- Test Gas G20 (=methane) enriched with 30 vol.-% hydrogen (20 vol.-%, 13 vol.-%)
- Boilers tested at full load, as well as 75%, 50%, 25% part load at fixed thermal spread
- Cold start experiments at -15°C ambient air temperature
- Monitoring CO, CO_2, NO_x, air ratios, water and gas fluxes and temperatures

Results: Exemplary boiler



- Device tolerates hydrogen well – ignition and operation without problems at all part load set-points
- Cold starts without problems
- Air ratio increases upon hydrogen addition
- Emissions decrease upon hydrogen addition

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Virtual Institute

Intelligent and Flexible Energy supply for North Rhine-Westphalia (IFES.NRW)

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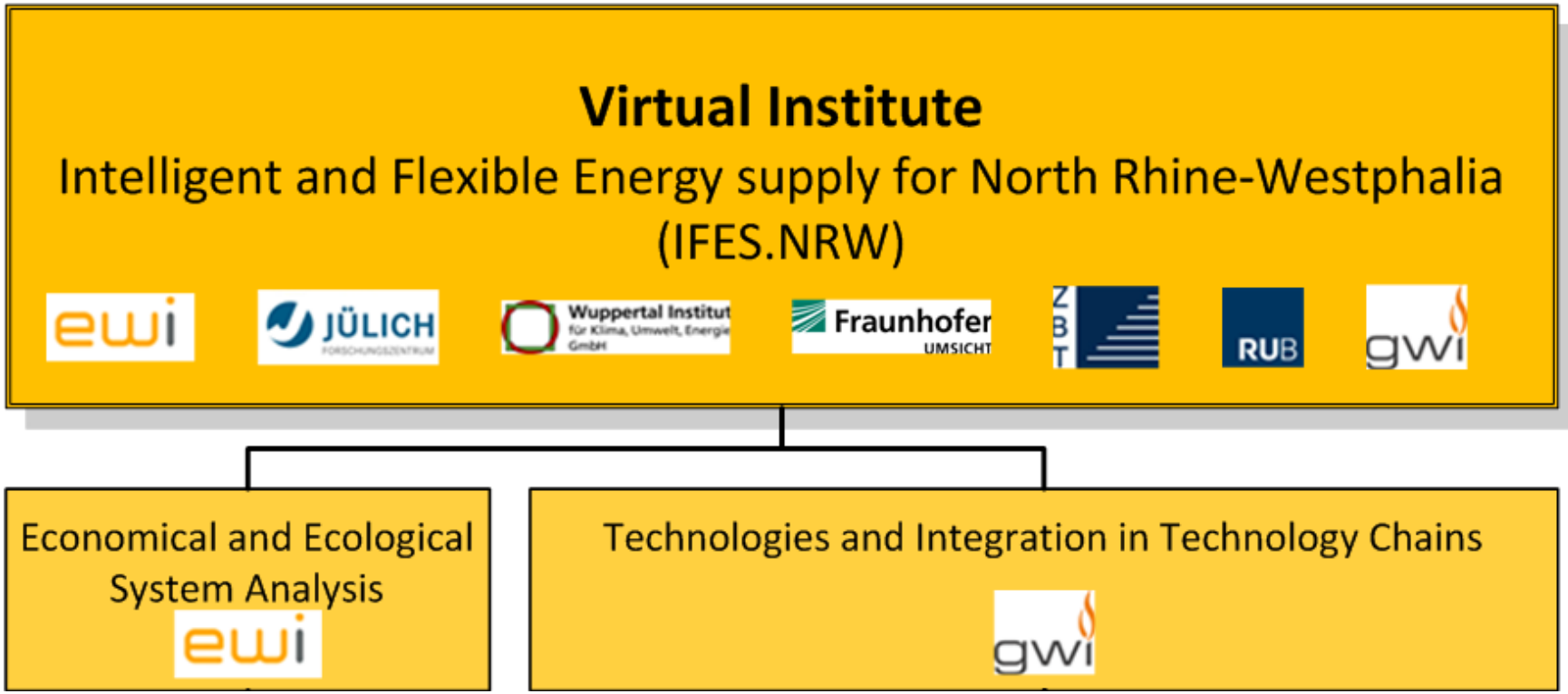
Intelligent and Flexible Energy supply for North Rhine-Westphalia (IFES.NRW)

ewi | JÜLICH Forschungszentrum | Wuppertal Institut für Klima, Umwelt, Energie GmbH | Fraunhofer UMSICHT | ZBT | RUB | gwi

Economical and Ecological System Analysis

ewi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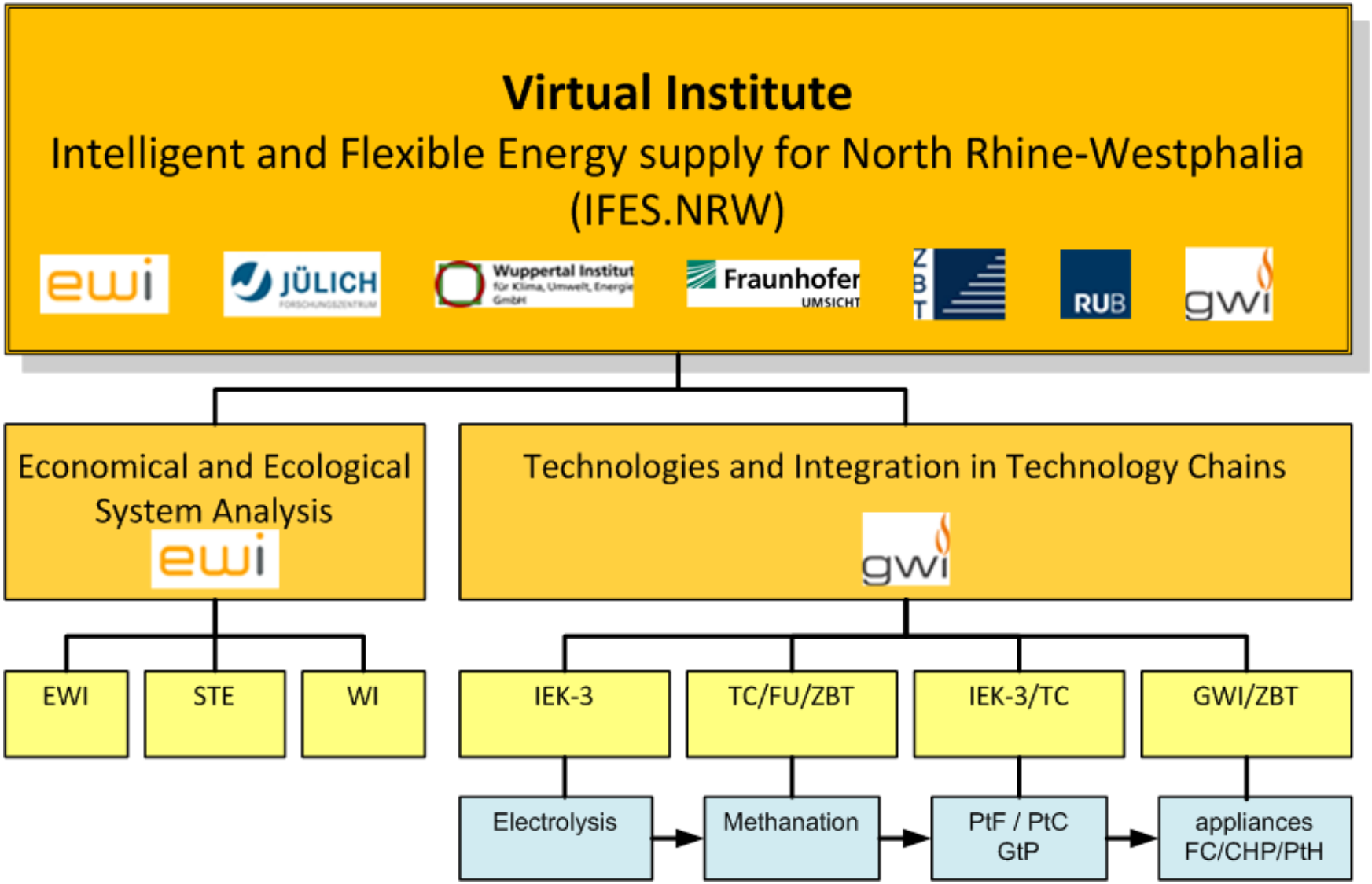
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IEK-3
TC/FU/ZBT
IEK-3/TC
GWI/ZBT
Electrolysis
Methanation
PtF / PtC GtP
appliances FC/CHP/PtH

Virtual Institute iFES.NRW

1 year pre-study:

- Development of a Research agenda against the background of the specific requirements and challenges of North Rhine-Westpalia
- Generation of a joint information pool: technology characterisation, literature research, review of existing computational methods
- Establishing a project group that covers the identified demands

We are open to your ideas!

https://broschueren.nordrheinwestfalendirekt.de/broschuerenservice/energieagentur/virtuelles-institut-strom-zu-gas-und-waerme-flexibilitaetsoptionen-im-integrierten-strom-gas-und-waermesystem/1792

Thank you for the kind attention!

gwi Gas- und Wärme-Institut Essen e.V.

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