

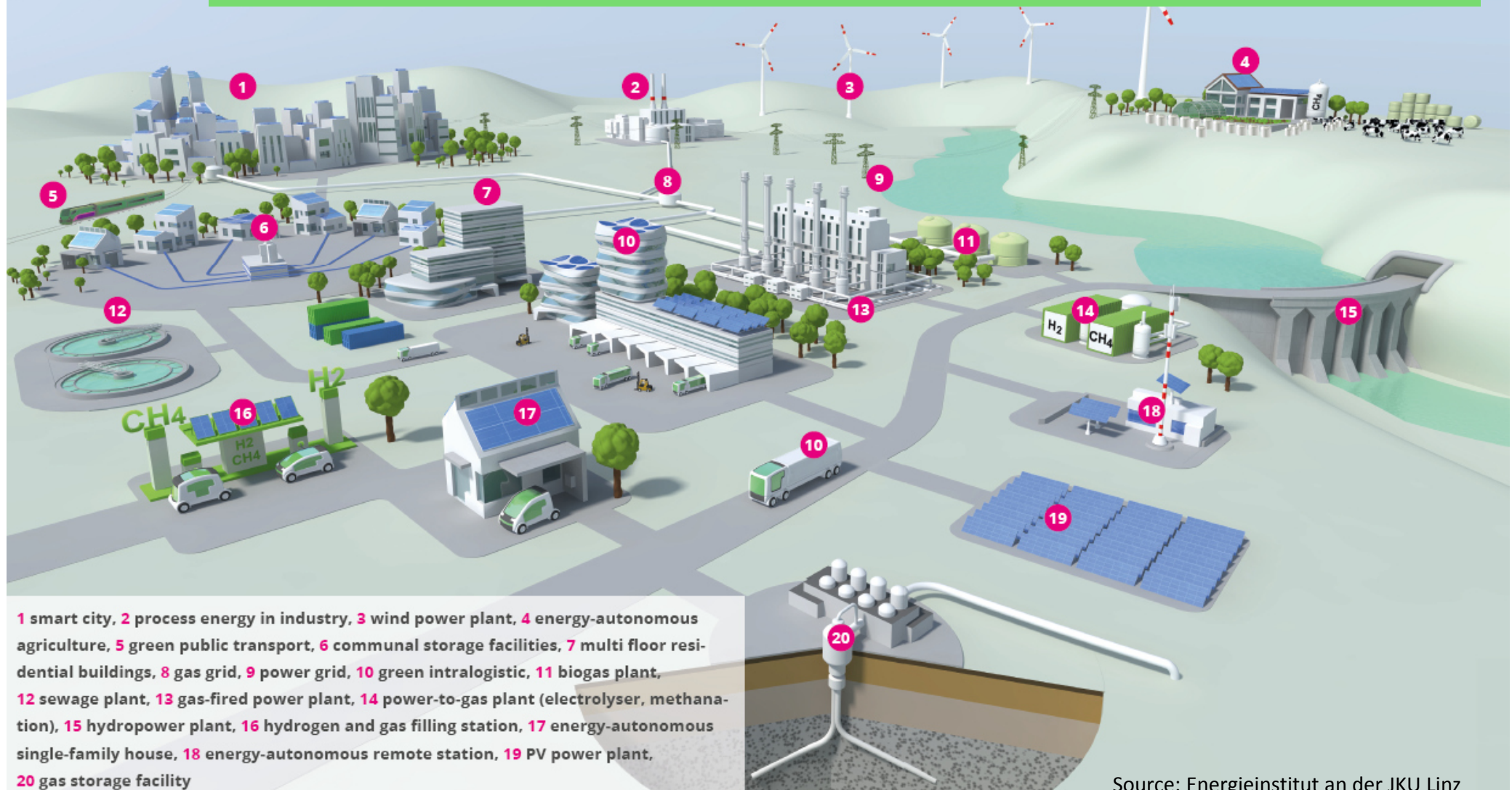


Research on Power-to-X-Concepts

RLS Energy Network, Québec 17.05.2017

Dr. Robert Tichler
Energieinstitut an der JKU Linz

Long-run vision of power-to-x: green gases / green hydrocarbons are an important cornerstone of the future energy system



Source: Energieinstitut an der JKU Linz

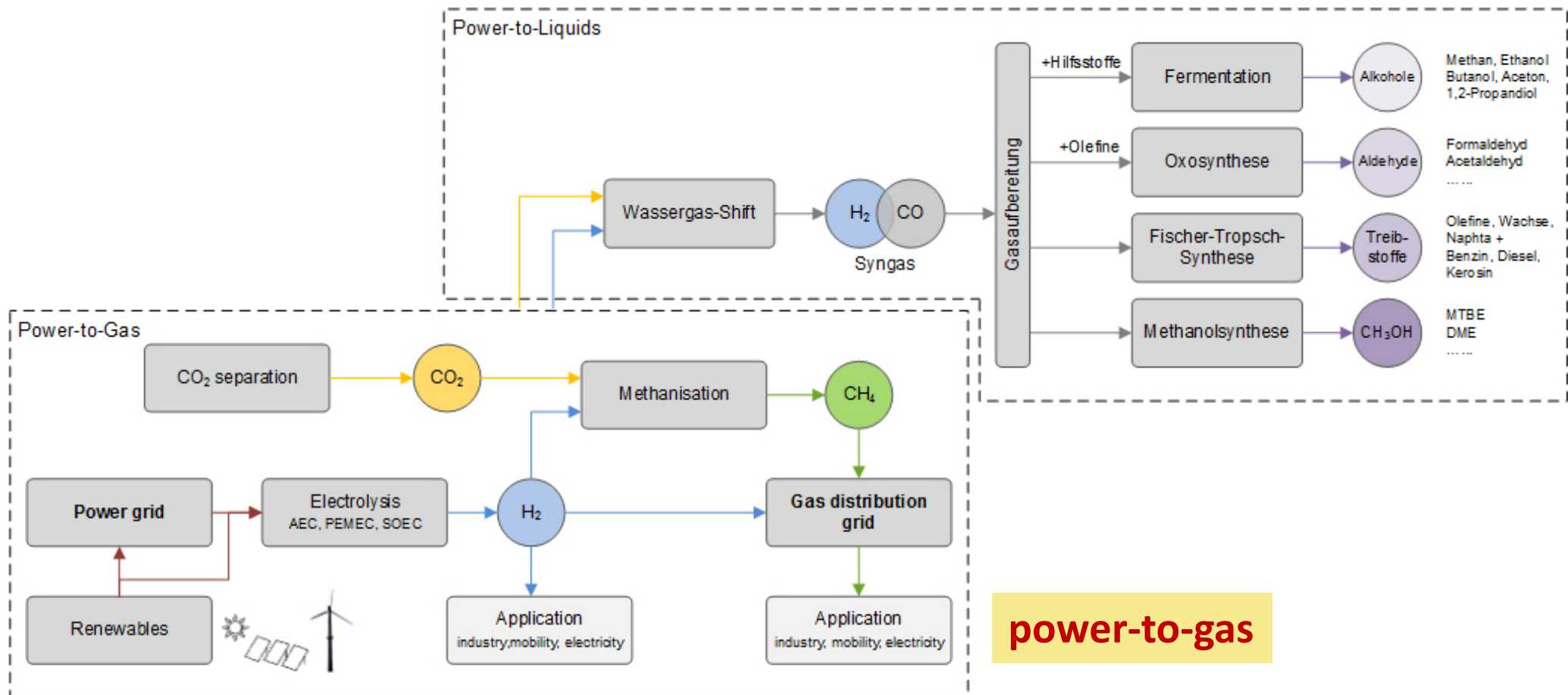
- Systemic reasons for the necessity of power-to-x
(Macroeconomic / socioeconomic / technoeconomic contribution of power-to-x systems for economy, society and ecology)
- Research items of *Energieinstitut an der JKU Linz*
- Examples of (Upper-)Austrian R&D on power-to-gas
- Upper Austria as possible role model for power-to-x systems



Source: www.storeandgo.info

power-to-x-systems

power-to-liquids / power-to-chemistry



power-to-gas

Quelle: Energieinstitut an der JKU Linz

R&D of Energieinstitut an der JKU Linz within power-to-x

- Multi- and transdisciplinary team – working on power-to-gas since 2007
- Three departments involved: Energy Economics, Energy Law, Energy Technologies
- Approx. 30 finished and currently running projects in this context; 15 in concrete planning
- Author of official Austrian R&D roadmap for Power-to-Gas
- Coordinator of Austrian PtG-platform and Austrian hydrogen initiative

Methodology

- Systemic research – (macro)economic analysis
- Regulatory approaches; Legal analysis
- Technoeconomic analysis – learning curves, benchmarking
- Behavioral Economics – social and public acceptance and willingness to pay
- Roadmapping, project management

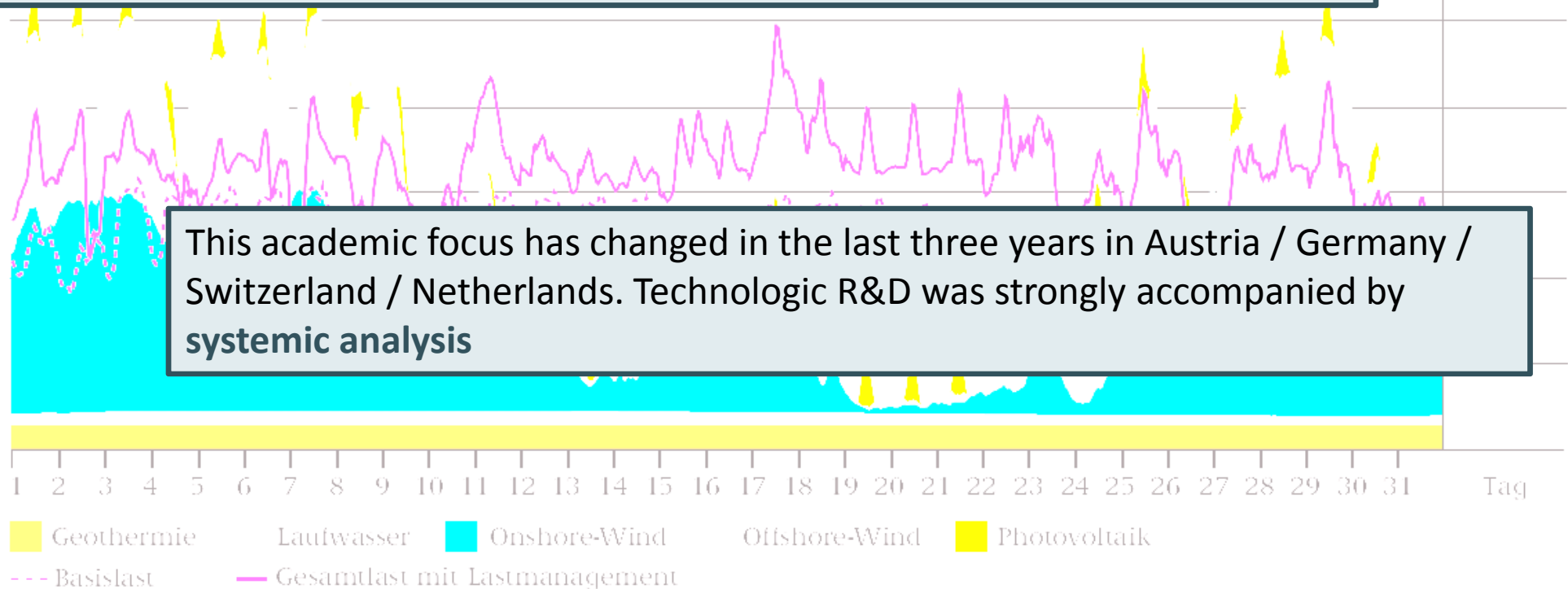
power-to-x paradox

- The importance of power-to-x systems for the future energy system suffers from one dominant fact – the **broad spectrum of positive effects**.
- This generates a **complexity pitfall** – it takes more time and capacity for explaining / teaching / developing than for other - singular applicable – technologies.
- This can be described even with the (own) **historic development of systemic research** on power-to-gas.



Middle-European development:

Discussion about power-to-X in the years 2008-2015 was driven by the ability of positive system service functions of (esp.) power-to-gas for the electricity market – long run storage of volatile green electricity production (of huge amounts)



Main applications of power-to-gas / power-to-x-systems for the central European energy markets *(the specific order is desired) [part 1]*

1. Power-to-gas enables the transition of the energy system to a **complete green system** by a **significant usage of existing** (transmission, distribution, storage) **gas-infrastructure**
2. The transition of **specific industrial processes** is only possible via green hydrogen (e.g. steel production – see therefore Upper Austrian project H2future – www.h2future-project.eu)
3. Difficult sectors for **decarbonisation** like **mobility** and **industry** gain new green energy paths/products - a **diversification** is accomplished / alternative to a full electrification



Source: www.storeandgo.info

Main benefits of power-to-gas / power-to-x-systems for the central European energy markets *(the specific order is desired) [part 2]*

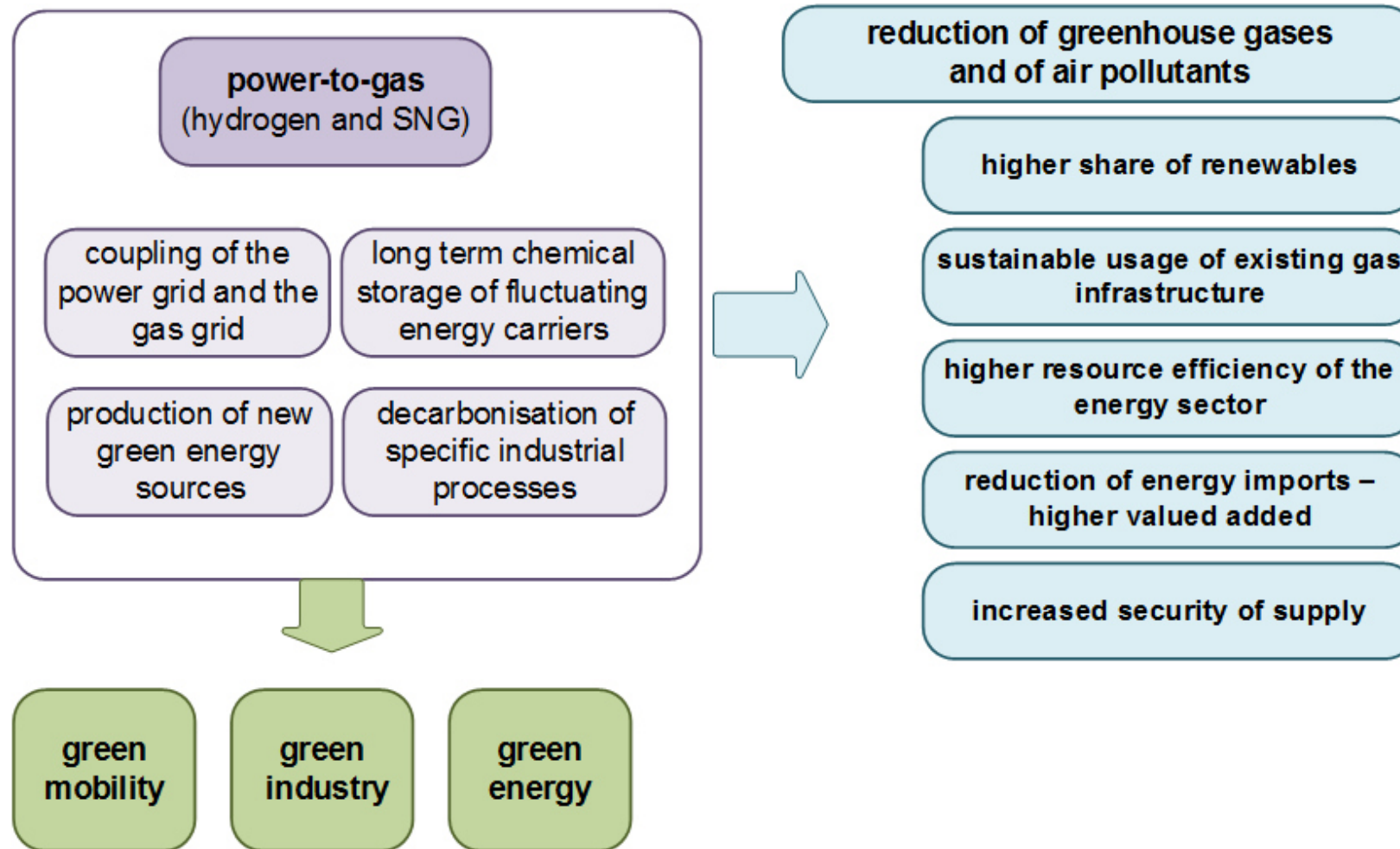
4. **Sector coupling**: capacity management and **long run storage** of volatile produced green electricity
5. Substitution of energy transport via electricity grid to **transportation via gas grids** – avoidance of socioeconomic challenges (e.g. NIMBY)
6. **Carbon Capture and Utilization** – important step to carbon cycle economy
7. Generation of **full autarkic energy systems**, also for back-up options

“greening of the molecules”



Source: www.underground-sun-conversion.at

Benefits of a green-hydrogen-based energy system



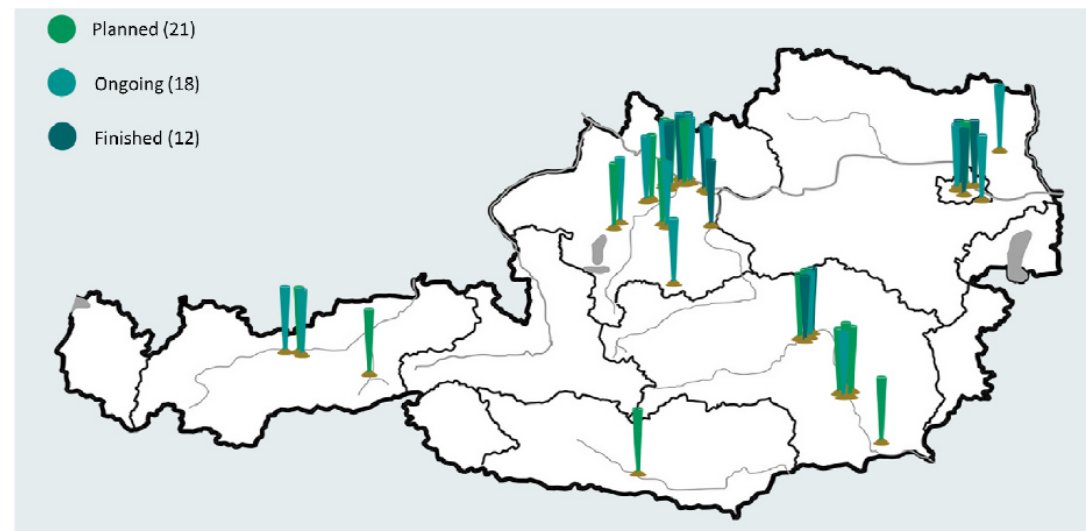
Source: Energieinstitut an der JKU Linz

Selection of power-to-x concepts and projects

(Energieinstitut involved)



- Austrian energy model region – hydrogen and power-to-gas (funded by the Austrian „Klima- und Energiefonds“)
- Austria is perfectly suited to realize the energy model region WIVA P&G, which illustrates the conversion of the energy system to green hydrogen
- 9 concrete and proposed projects; 11 additional projects in concrete planning
- 6 of 13 major partners are from Upper Austria
 - *Energieinstitut*
 - *Fronius International*
 - *RAG Austria*
 - *Energie AG OÖ*
 - *Voestalpine Stahl*
 - *K1 MET*



- Sectorally integrated projects using green electricity will boost the transition to sustainable energy system.
- WIVA P&G subsumes the experiences of more than **30 completed and ongoing projects** and is going to implement 25 sub-projects within the energy model region.
- The **founded research association** WIVA P&G coordinates and implements the model region with the structure of an Austria-wide and therefore transregional, thematically focused and internationally visible cluster project.
- It has a **multidisciplinary innovation structure**, demonstrates and tests intelligent system solutions in practice, and provides applicable systems for users.
- There is no geographical restriction within Austria, so that WIVA P&G has a significant **international visibility** with its outstanding research projects.

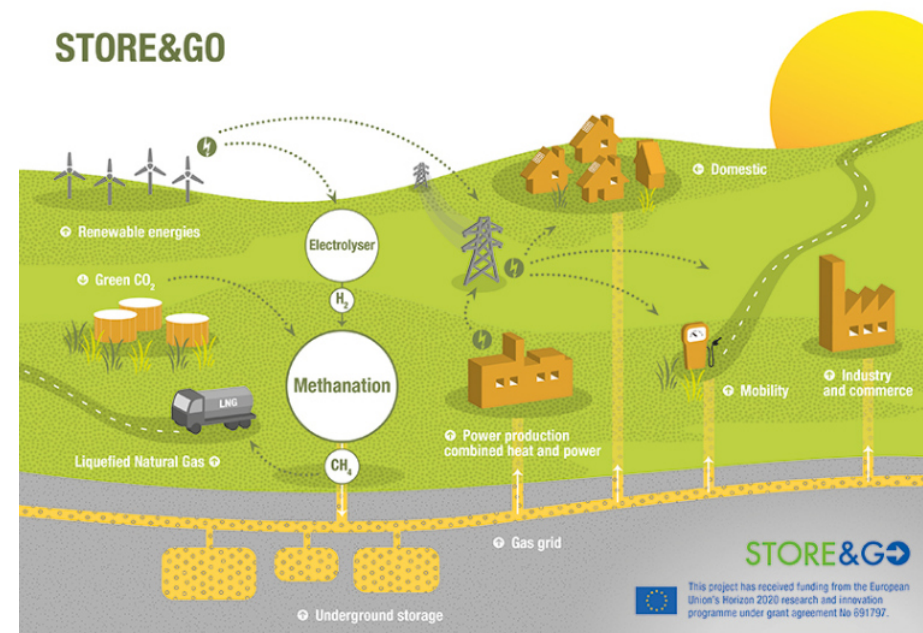
STORE&GO



HORIZON 2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691797.

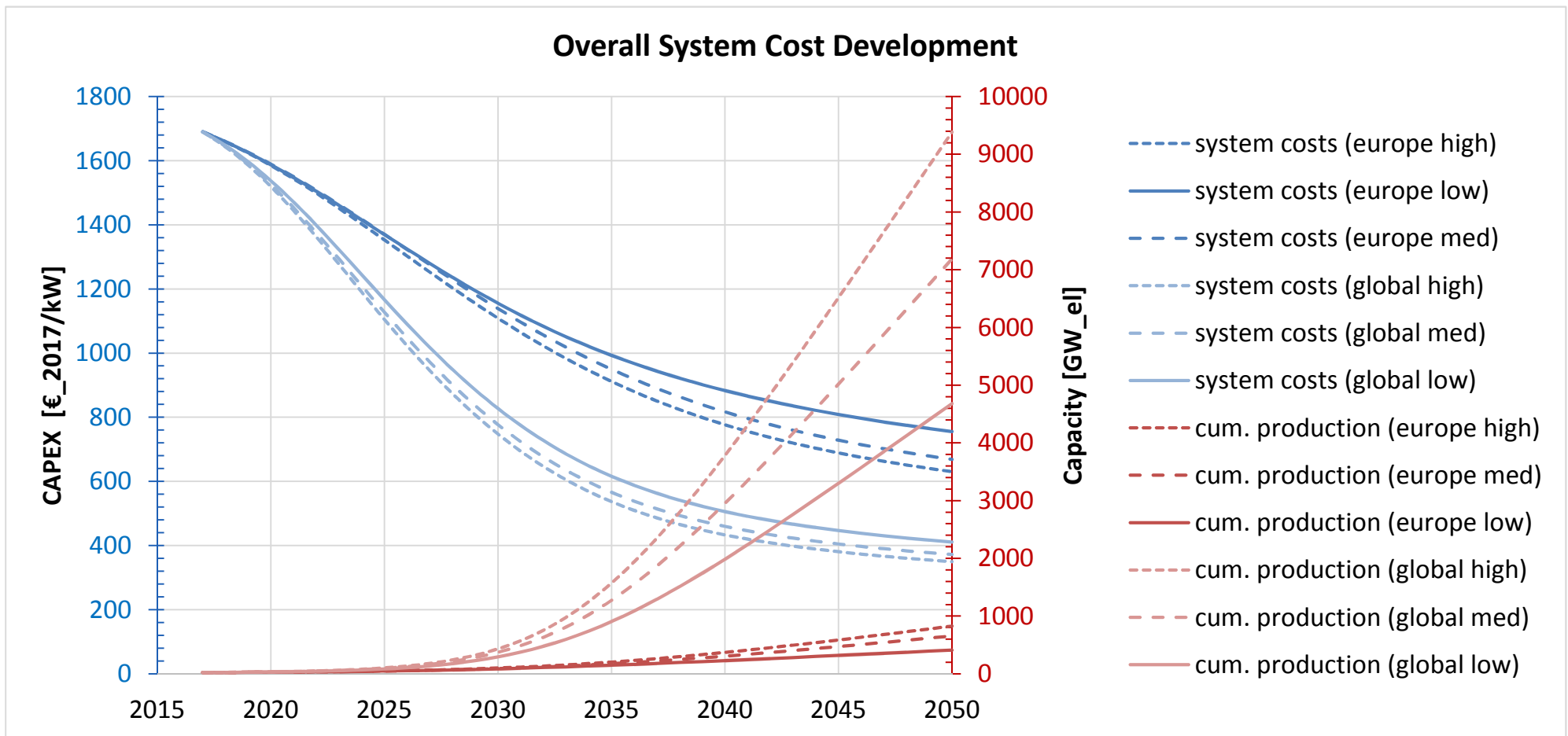
- *“Innovative large-scale energy STOragE technologies AND Power-to-Gas concepts after Optimisation”* [funded by Horizon2020]
- Focus of R&D: further development and demonstration of 3 specific methanation technologies
- 28 project partners (lead: DVGW-EBI-KIT)
- Content (selection):
 - chemical-catalytic methanation
 - biologic methanation
 - Direct CO₂-air-Capture
 - PEM/AEC electrolyzers
 - Production of green SNG and green LNG
 - Power-to-gas roadmap
- <https://www.storeandgo.info/>



Source: www.storeandgo.info

STORE&G

Learning curves: Development of specific investment costs for **electrolysers** according to different power-to-gas-potentials on a European and global level
(calculation was performed with the **tool CoLLeCT by Energieinstitut**)



UNDERGROUND SUN.CONVERSION



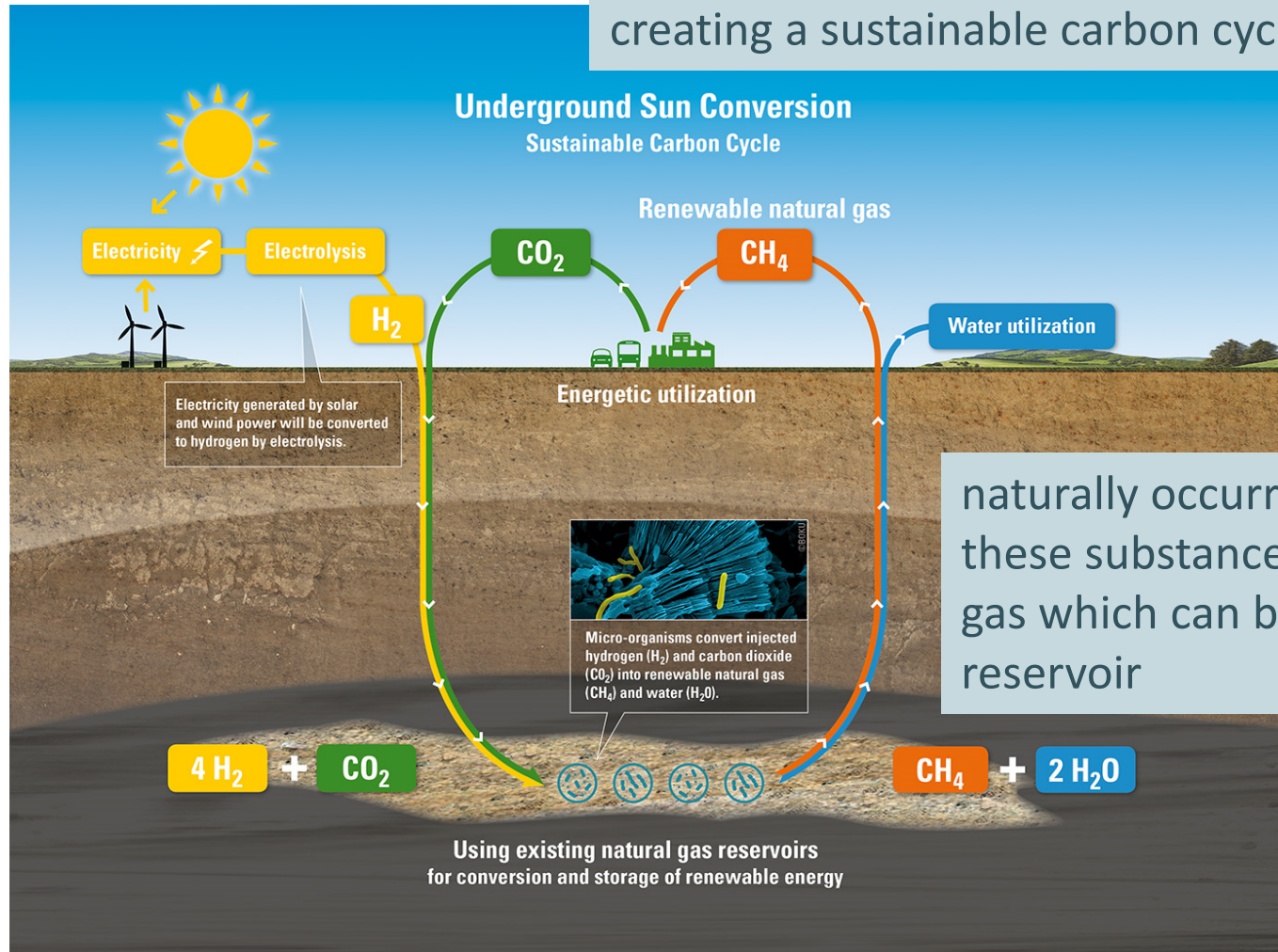
- “Renewable Energy Storage and Conversion by in- situ biological Methanation in porous Underground Gas Reservoirs” – Underground Sun.Conversion
- For the first time this project will enable **production of natural gas directly within a gas reservoir using a microbiological process** initiated specifically for this purpose, and to store it in the same reservoir.
- This innovative method is **unique worldwide**, and recreates the natural process by which gas originates, but **shortens it by millions of years**
- www.underground-sun-conversion.at/

Projektpartner:



UNDERGROUND SUN.CONVERSION

hydrogen from solar or wind energy gets injected into an existing gas (pore) reservoir, together with carbon dioxide – creating a sustainable carbon cycle.



naturally occurring microorganisms convert these substances into renewable natural gas which can be stored in the same reservoir

Source: RAG Austria

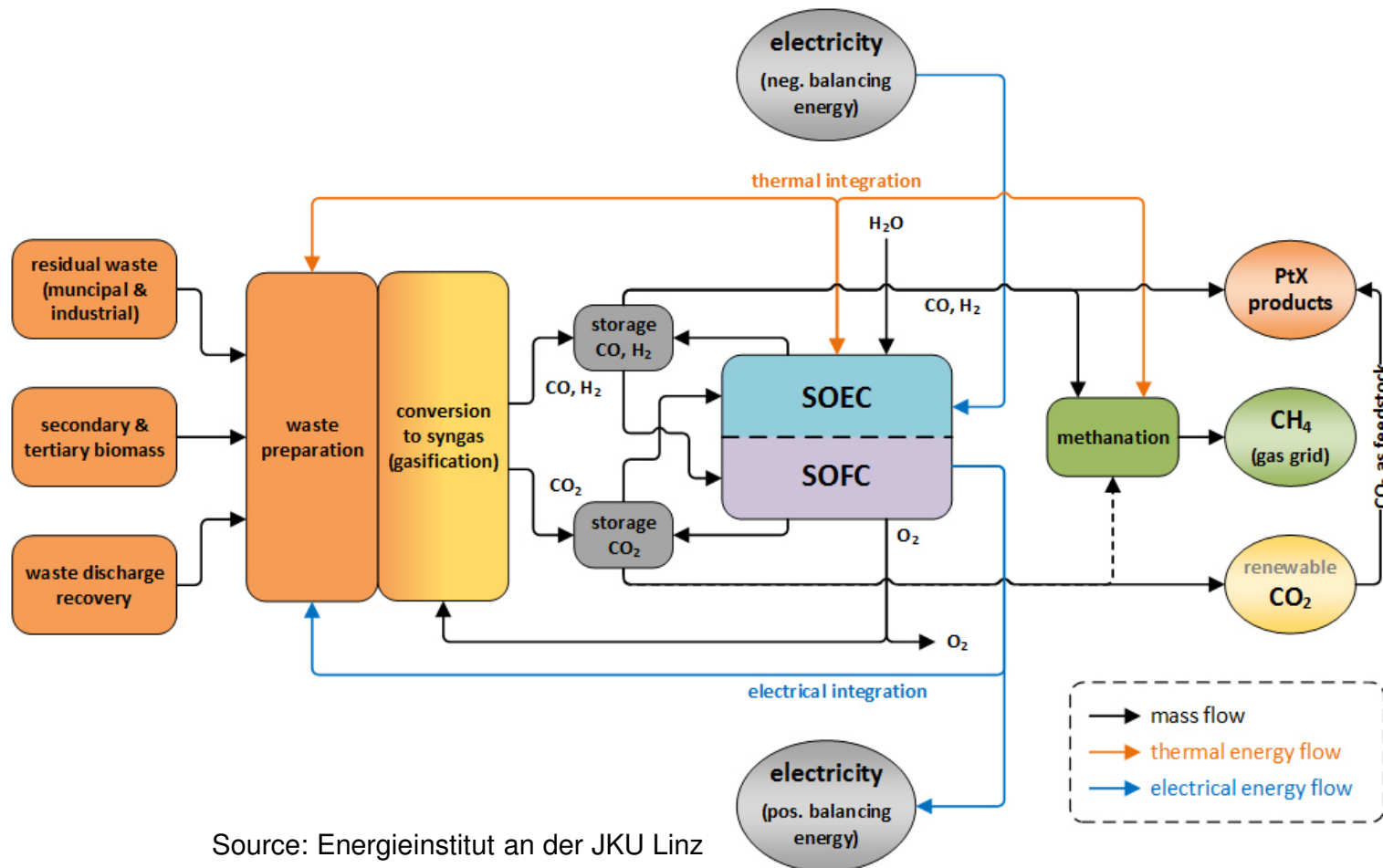
Proposal: Flexible, efficient reversible SOC plants for waste-stream usage, providing balancing power and power-to-x-production – X-FACTORY

- Common project proposal for Horizon2020 of [Energieinstitut an der JKU Linz](#) and [Friedrich-Alexander Universität Erlangen-Nürnberg](#) (and 5 other partners)
- Elaboration of concepts of power balancing plants based on the thermal integration of various gasification processes for low-grade waste streams in combination with [reversible solid oxide cells](#) (rSOC) [fuel cell and electrolyser]
- By using low-grade [waste materials](#) as long-term available energy source together with storage options based on yet existing infrastructure, the economic viability is increased at early stage – “[systemic feasibility study](#)”

RLS-network output – energy R&D collaboration of Upper Austria and Bavaria

Proposal: X-FACTORYy (II)

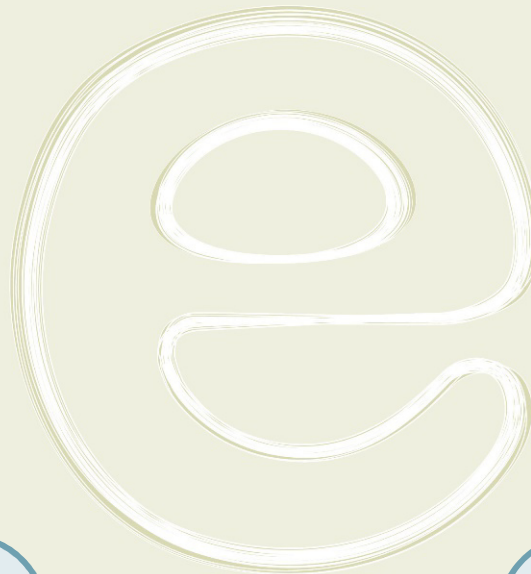
The overall objective is to **pave the way for the large scale deployment** of rSOC based balancing power plants by removing knowledge gaps and **technical and non-technical barriers**



Upper Austria as role model for power-to-x systems

Upper Austria ...

- ... accommodates innovative power-to-x **projects**
- ... possesses an optimal **gas infrastructure**
- ... provides significant **CO₂ sources** both green and grey
- ... offers **innovative industry** and technology providers
- ... is a **key energy crosspoint** and therefore predestinated for sector coupling
- ... wants to **connect** and therefore strengthen R&D activities e.g. in power-to-x **with other regions** (in a bidirectional way)



- ❖ **Many thanks for listing!**
- ❖ **We are looking forward to cooperation / common R&D.**
- ❖ **We are thankful for your questions / hints / discussions.**

Dr. Robert Tichler

**Energieinstitut an der Johannes
Kepler Universität Linz**

Altenberger Strasse 69

4040 Linz, AUSTRIA

Tel: +43 723 2468 5656

Fax: + 43 723 2468 5651

e-mail: tichler@energieinstitut-linz.at