

PATHFINDER project



ETH zürich



HOCHSCHULE
LUZERN



UNIVERSITÉ
DE GENÈVE

EPFL



Human power systems

100m / 9.80s!
→ 42.2km / 1h 9min?



High power –
Relies basically on glucose only.

Erik van Leeuwen (bron: Wikipedia)

- **Energy storage**
- **Energy conversion**
 - Metabolism
 - Access of energy
- **Conditioning**

42.2km / 2h 1min 39s!
100m / 17.3s!

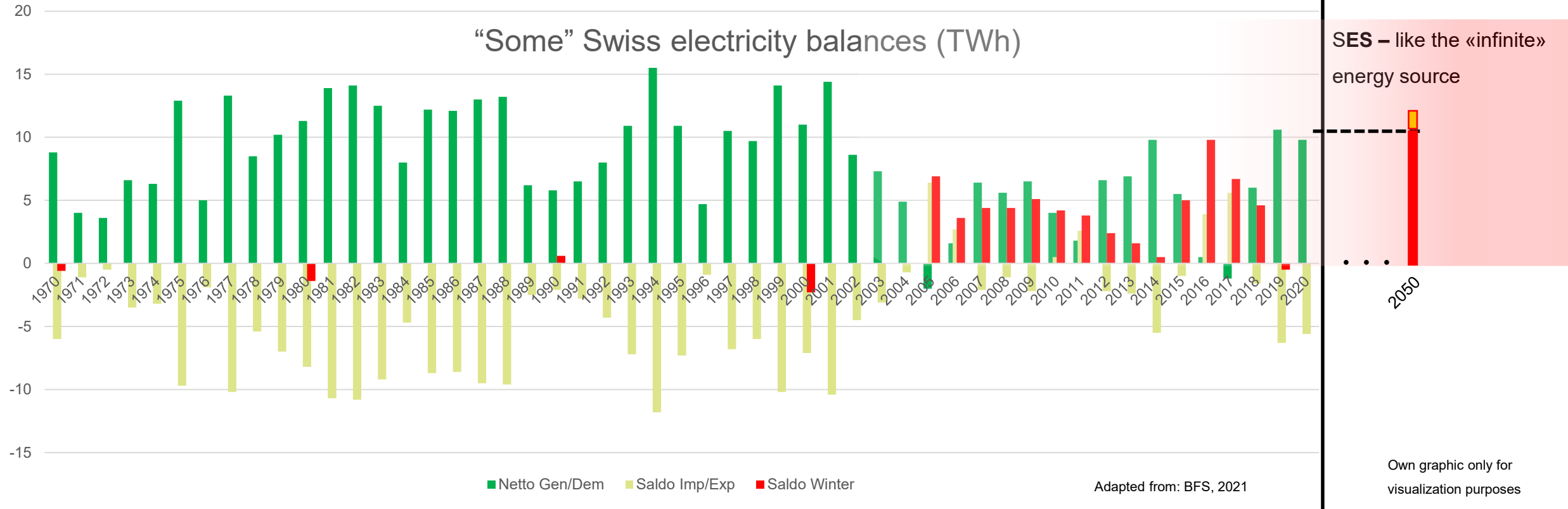


Sustainable power – Relies on
glucose and fat, which serves as
additional energy (storage) source.

Avda / avda-foto.de

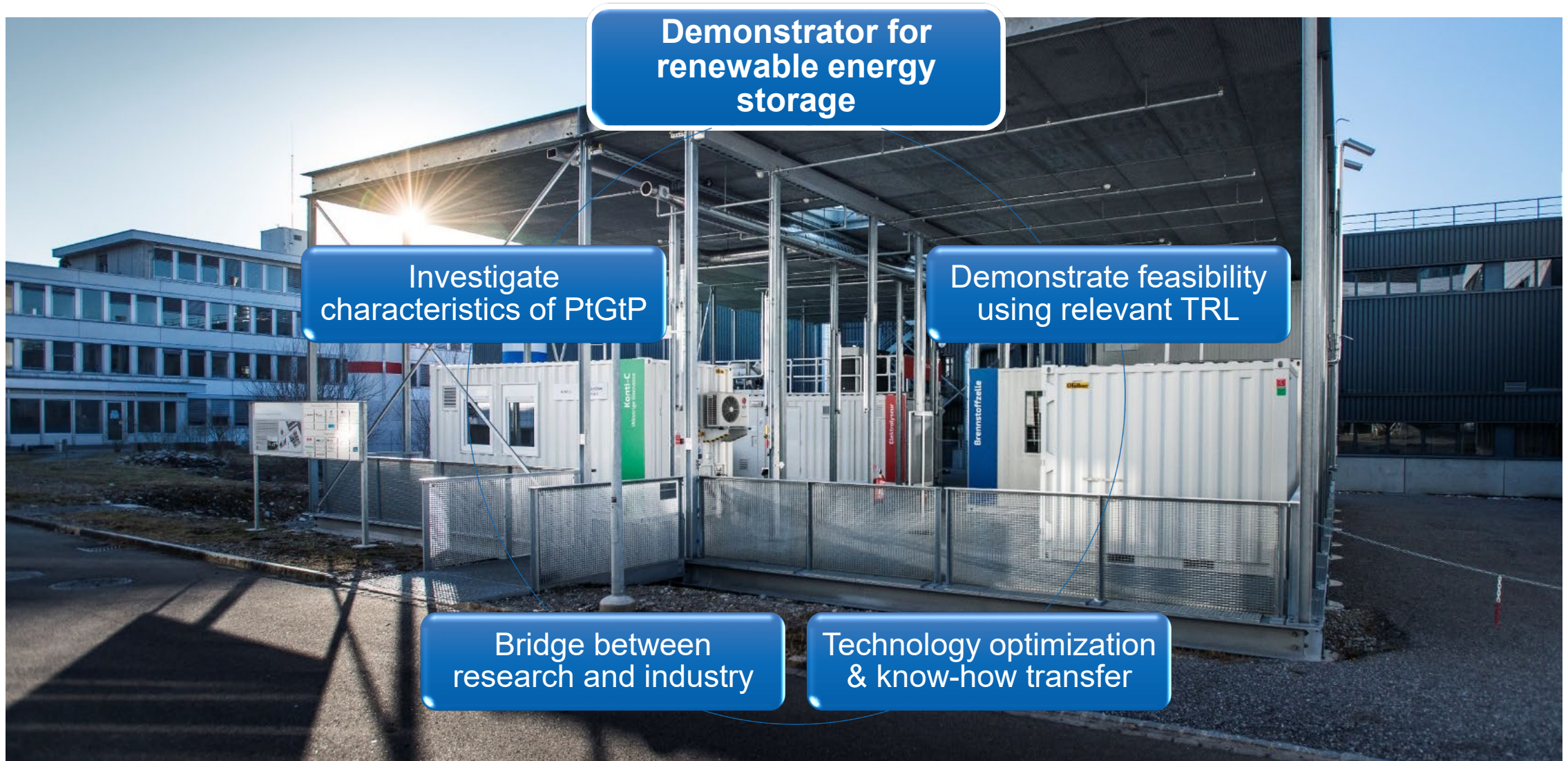
Electrical power system

“Some” Swiss electricity balances (TWh)



- Electrification of mobility
- Heat pumps
- Phase out of nuclear power gen.
- Increase in population
- Swiss / European NTC
- Political development / agreements
- Dark lull (Dunkelflaute)

Purpose of Energy System Integration Platform (ESI)



Outline of talk



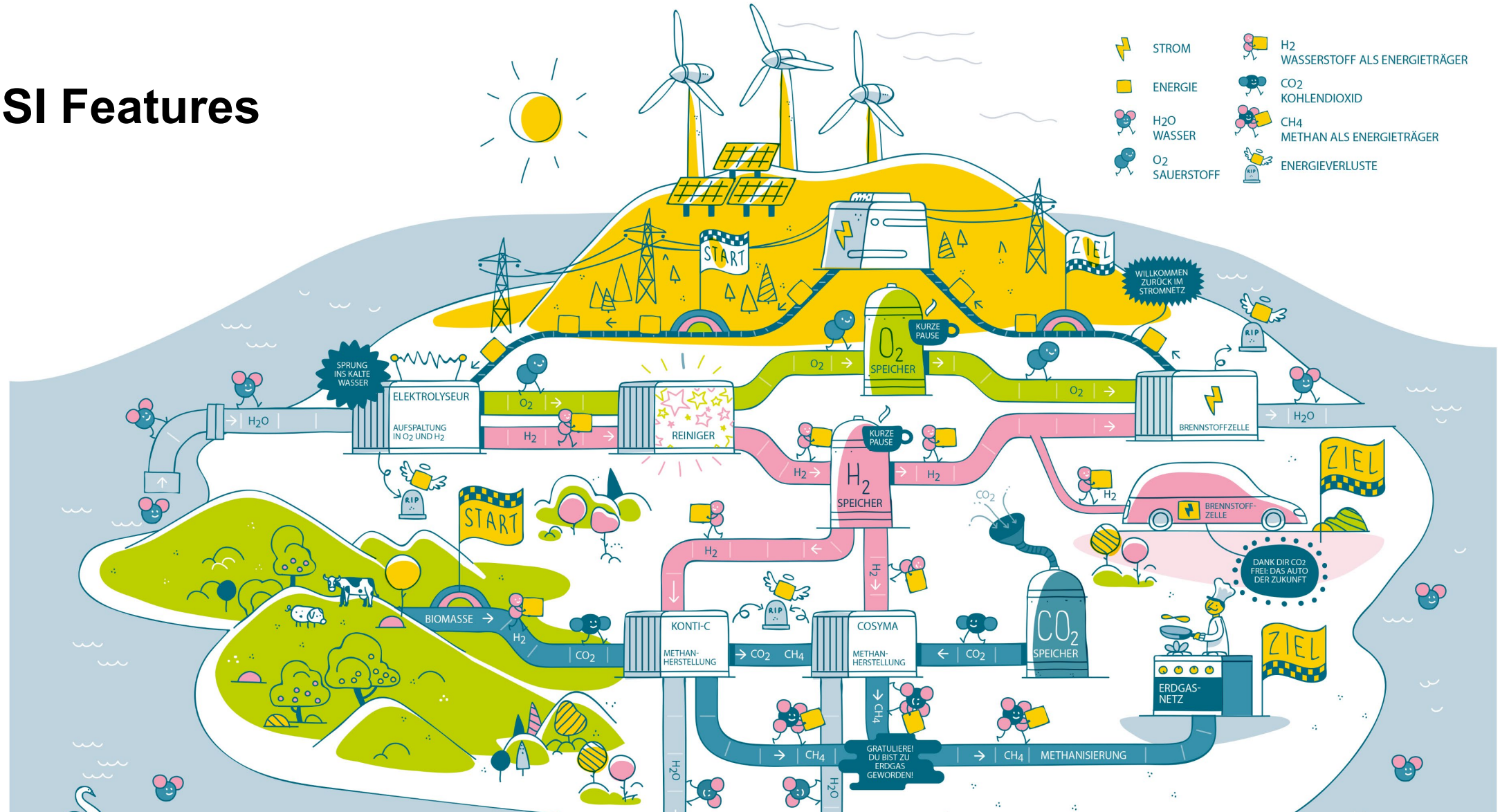
Purpose

Features

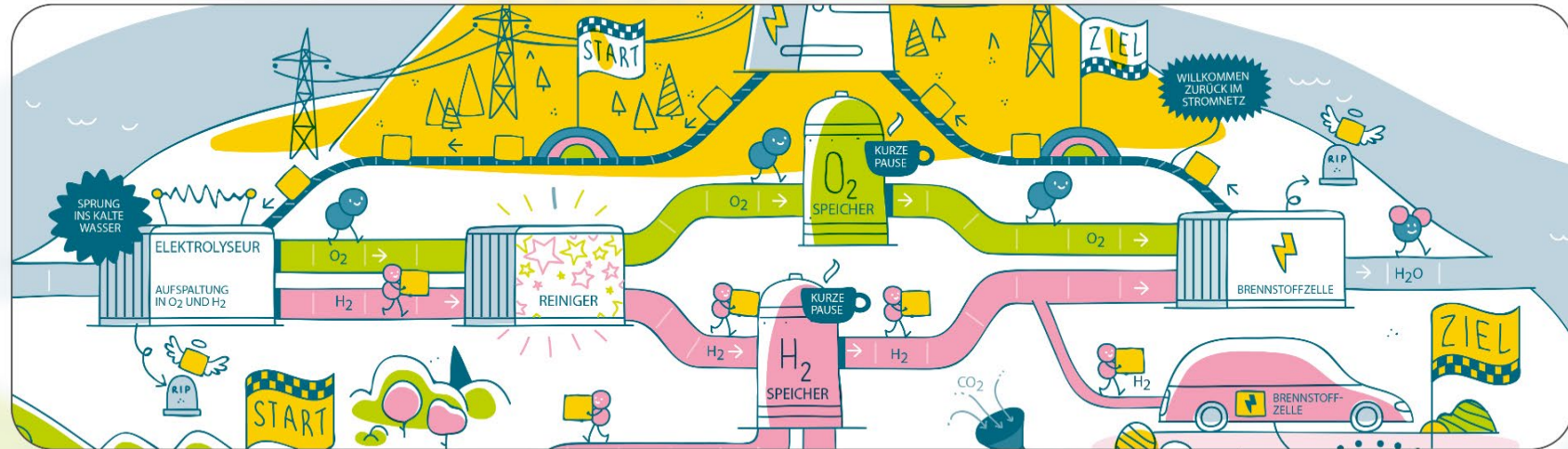
Case studies

Application in
PATHFNDR

ESI Features



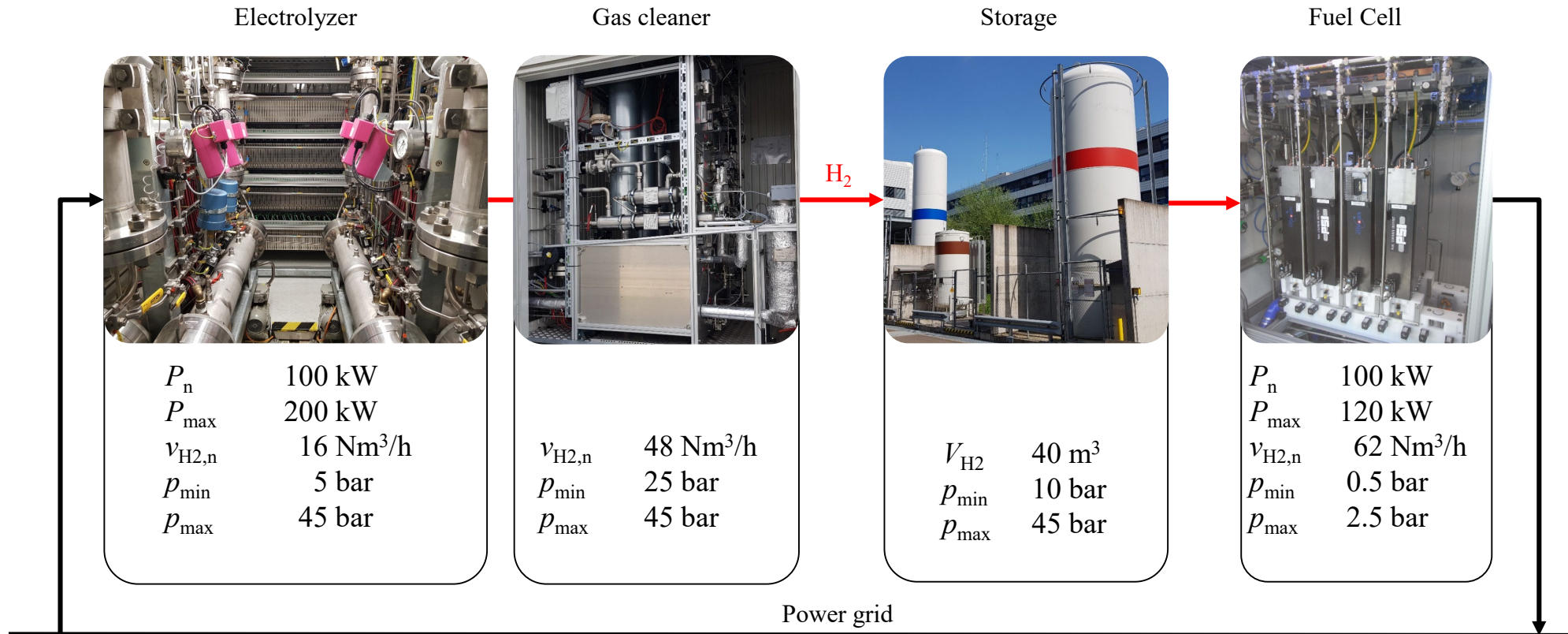
ESI Features



H₂-Path

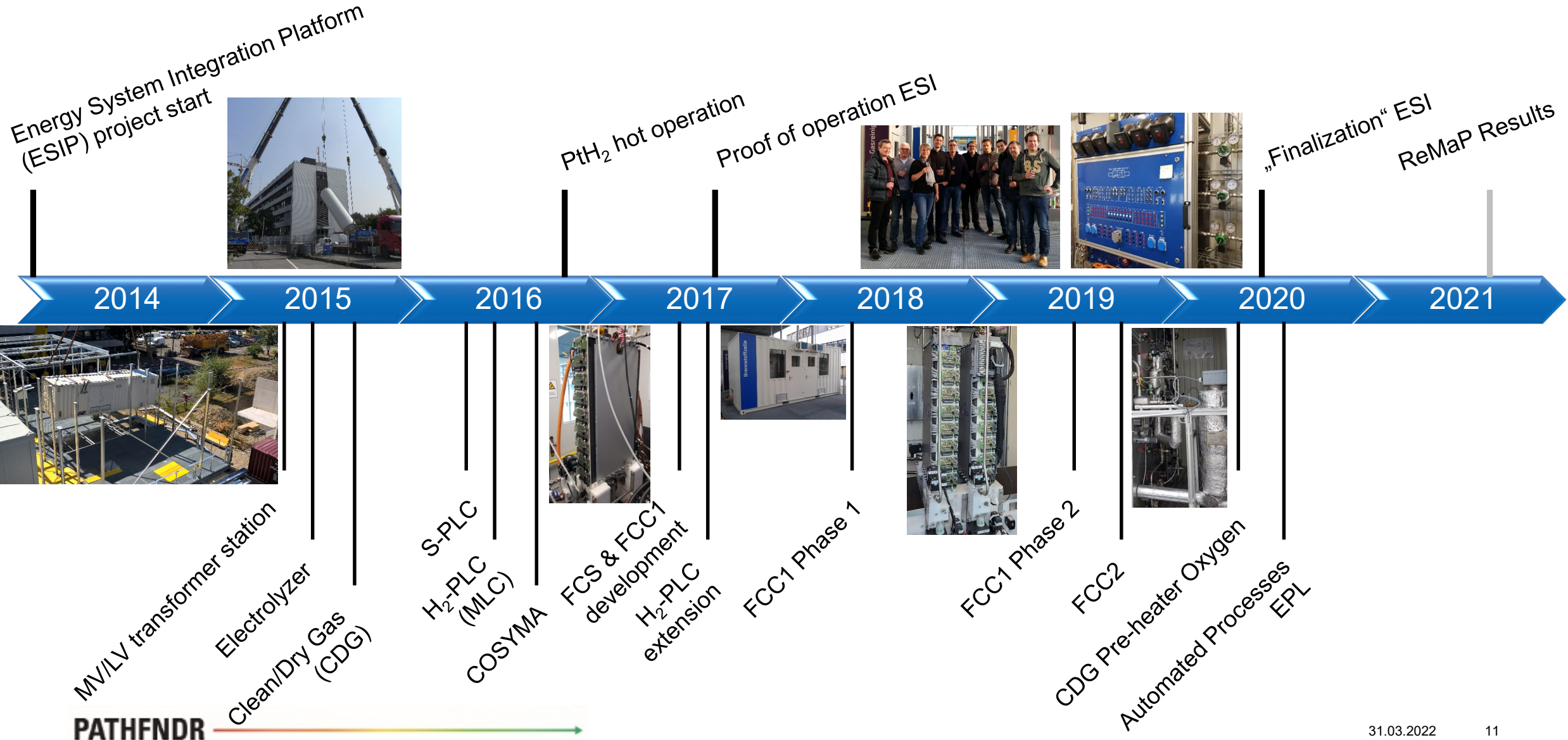
ESI Features

Overview on ESI's hydrogen technologies, the demonstrator's backbone:



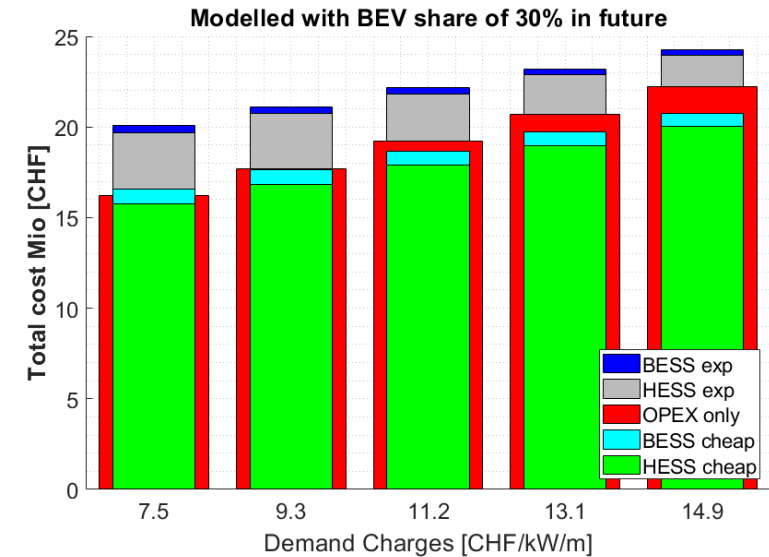
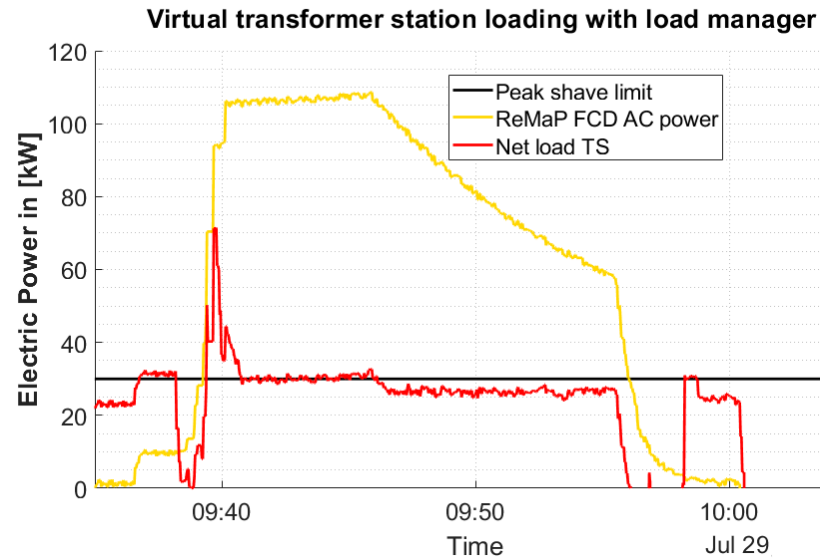
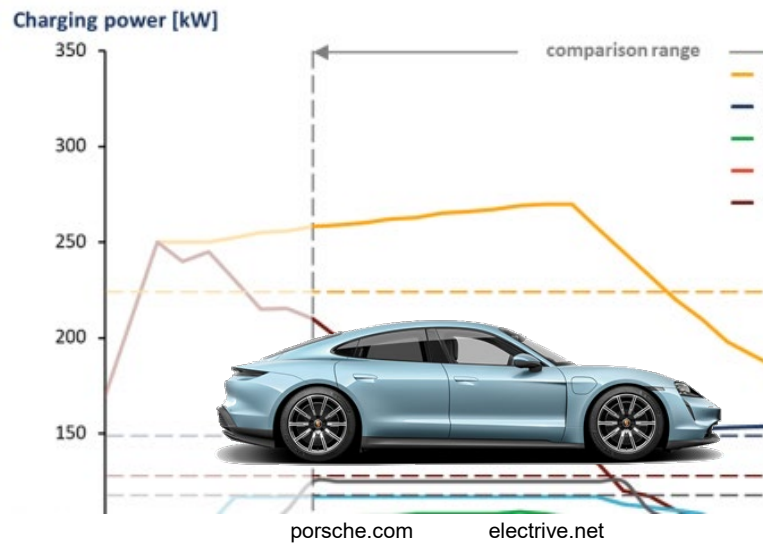
- PEM based
- Pure O₂ based
- Gas quality 4.5
- Interm. operation
- Low voltage grid
- Fully automated
- ReMaP access
- Data acquisition
- Process historian
- T_s of 5 sec.

Timeline – developing the technology oriented demonstrator



Case study: Electrochemical Energy Storage (ReMaP T3.10)

ReMaP T3.10 - Case study there: Peak shaving the fast charging demand at a highway rest stop

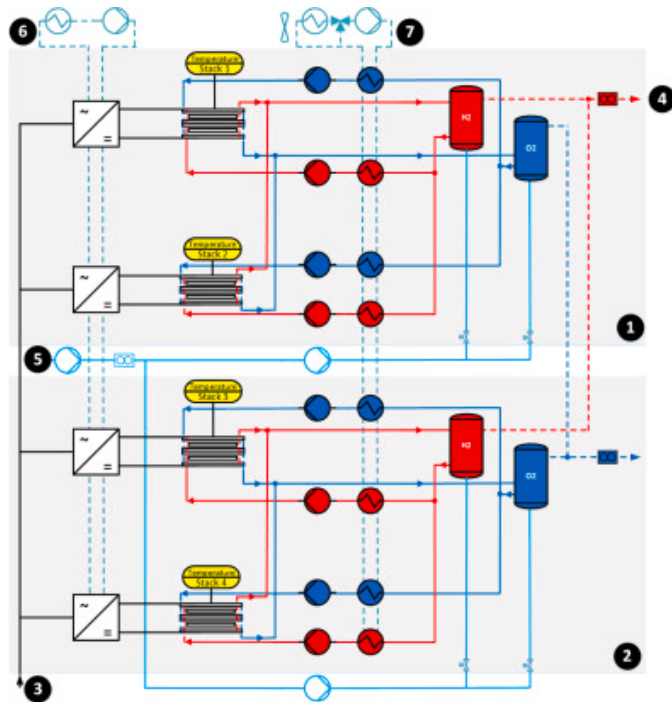


- Feasible with HESS
- Demonstrated ESI's remote control capability
- Simulation environment

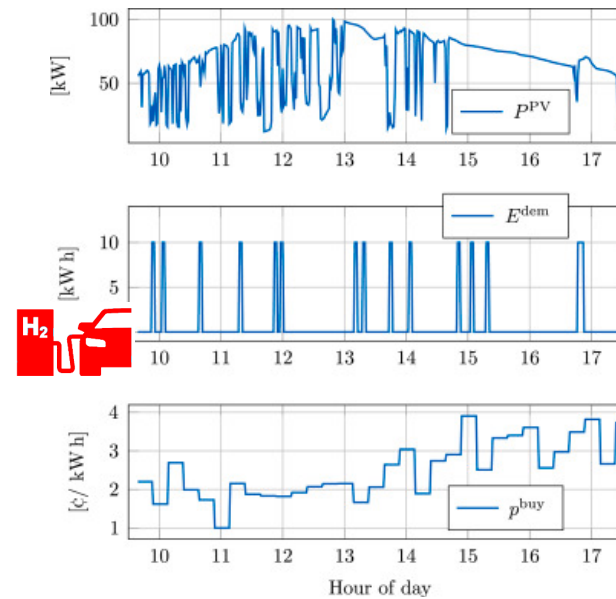
Case study: Advanced control algorithms for future energy system

ReMaP T3.9: Electrolyzer modeling and real-time control for optimized production of hydrogen gas

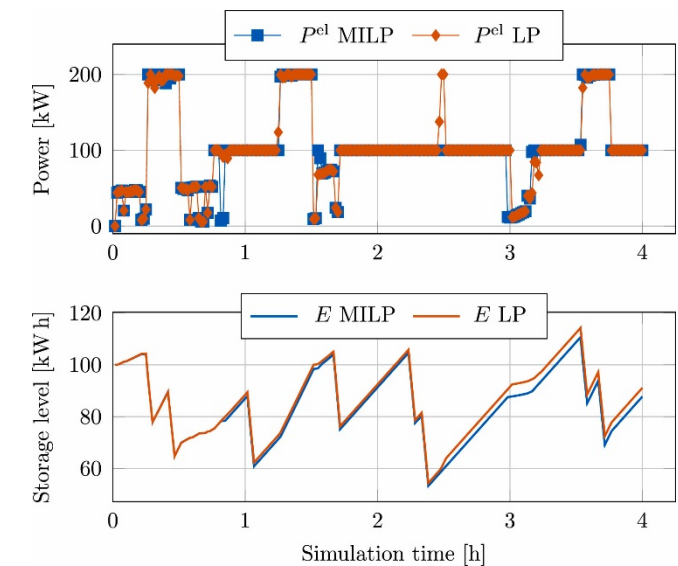
Silyzer 100 representation:



Boundary conditions:



Performance MPC ESI HIL:

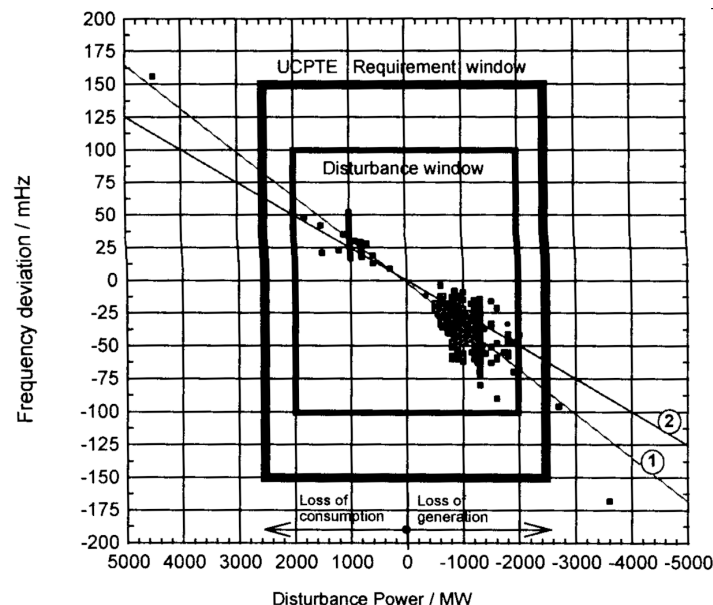


B. Flamm et al., Applied Energy, 281, 116031 (2021).

- Sys. ID tool
- PEM ELY model
- MILP for MPC
- Validation platform

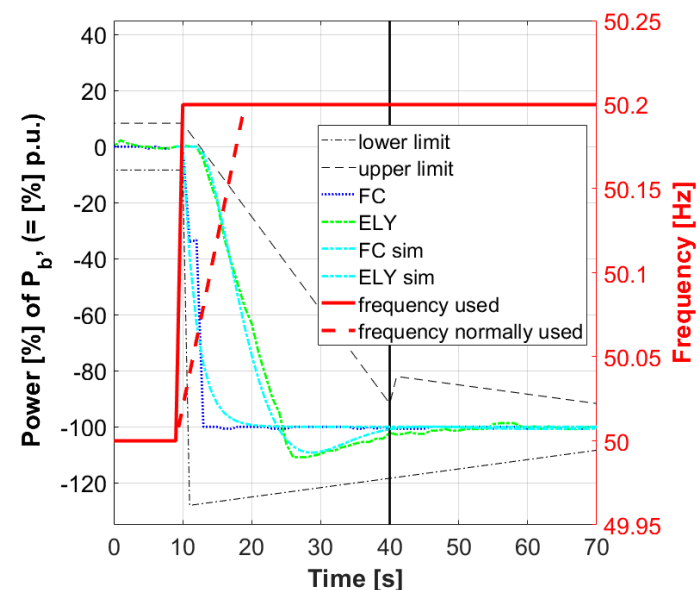
Case study: PEM Technologies in Power System Frequency Control

Grid disturbance events:

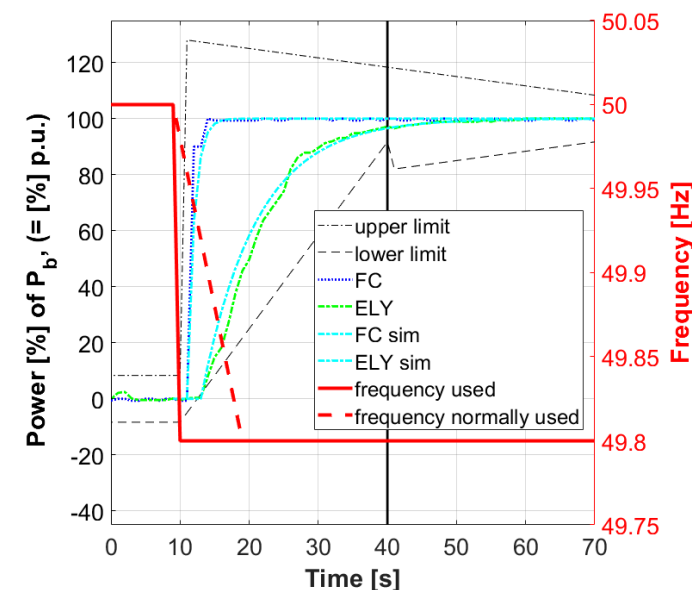


H.W. Weber et al., ETG '97, summer meeting, 395-405 (1997).

Primary frequency control test results:



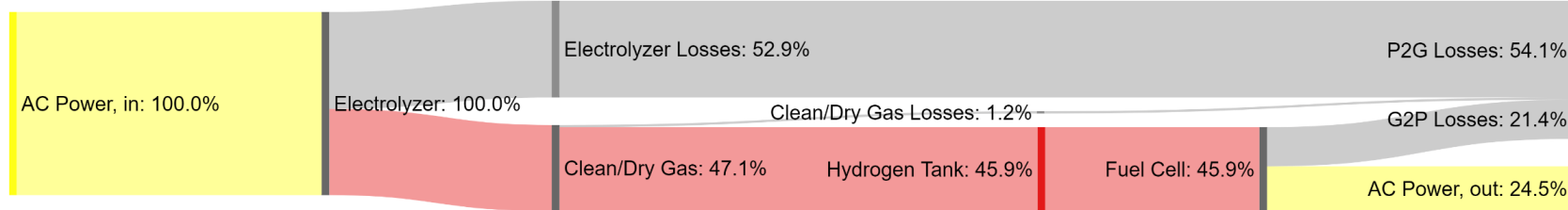
C.Peter et al., IJEPES, 141, 108121 (2022).



- Successful frequency control reserve test results
- Dynamics & efficiencies determined using H_2/O_2
- Feasibility demonstrated
- Collaboration with Swissgrid using relevant technology level

Case study continued - Efficiencies of PEM Technologies

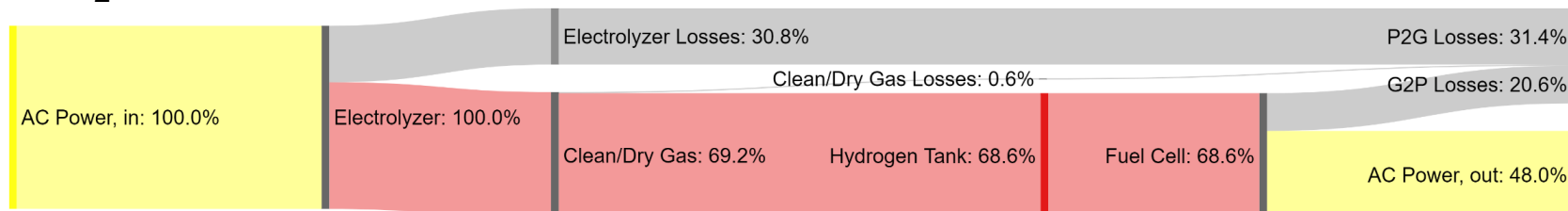
ESI with TRL 5-7 in 2019, measured:



Category	Losses in % of system feed entity:					
	PtG			GtP		
	2011	2040	Δ	2017	2040	Δ
BoP	5.8	3	2.8	5.6	1.2	4.4
Converter	8.0	0.5	7.5	4.0	1.4	2.5
EC	38.5	26.8	11.7	33.5	27.2	6.3
GC	0.5	0.5	0	—	—	—
GUL	—	—	—	3.6	0.24	3.4
Tot. EL	52.9	30.8	22.1	—	—	—
CDG	1.2	0.6	0.6	—	—	—
Total	54.1	31.4	22.7	46.7	30.1	16.6

- Fundamental efficiencies determined
- Basic scale-up data
- Base for techno-economic analysis
- **PtH₂tP using pure oxygen**

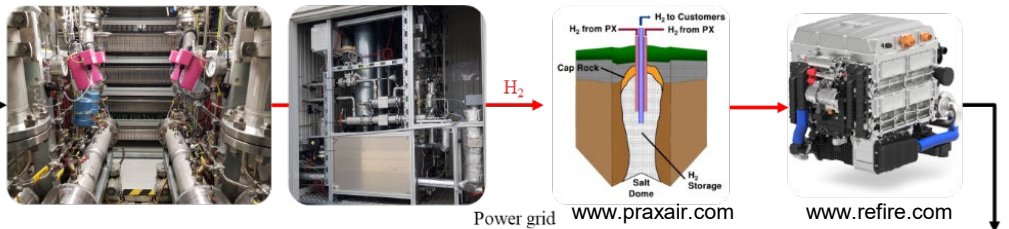
PtH₂tP in 2040, estimat-ed.



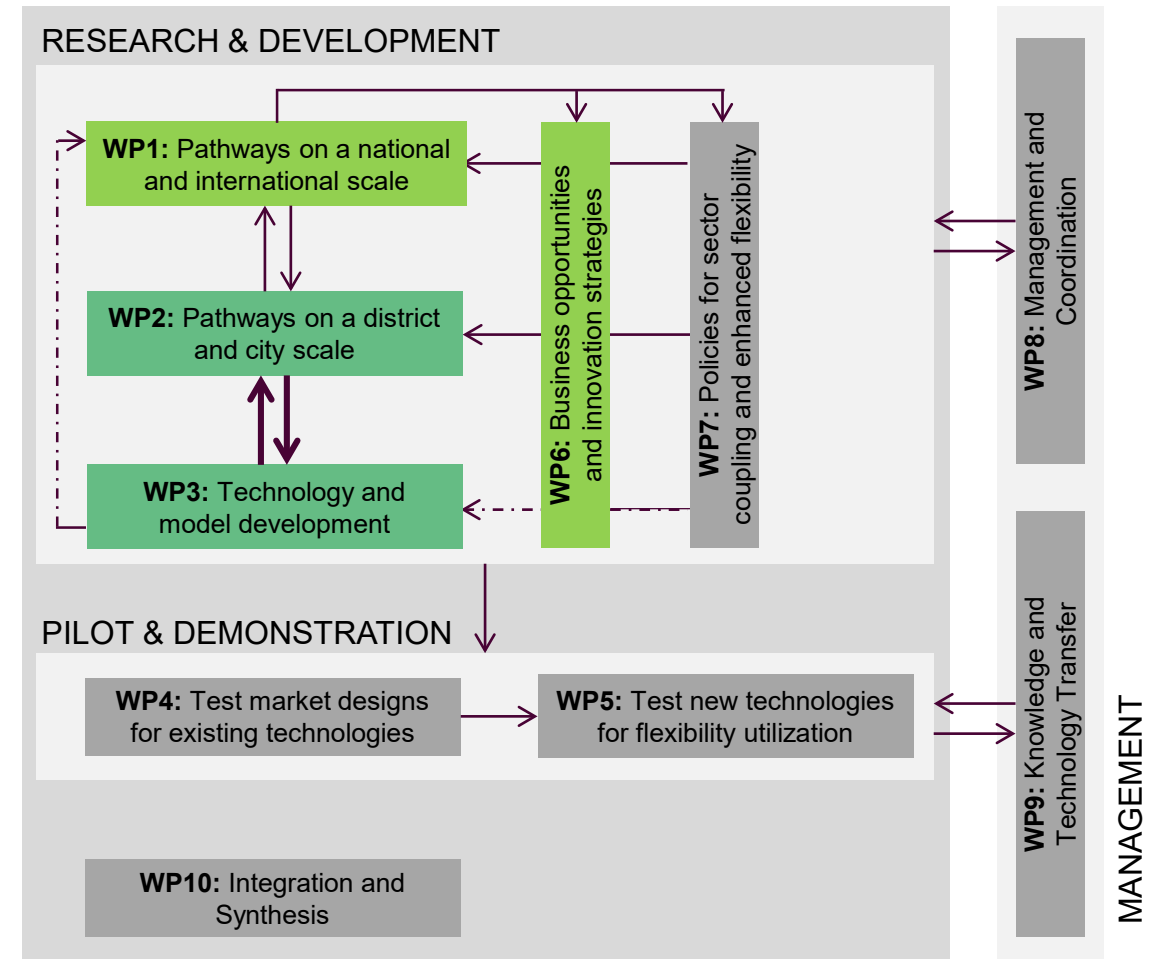
C.Peter et al., IJEPES, 141, 108121 (2022).

Application under the PATHFNDR project

- PtGtP PEM technologies - H_2 /Air vs H_2 / O_2
- Dynamics and efficiencies data
- Degradation data
- **Control-oriented and high fidelity models**
- Scale-up data
- Geologic hydrogen energy storage

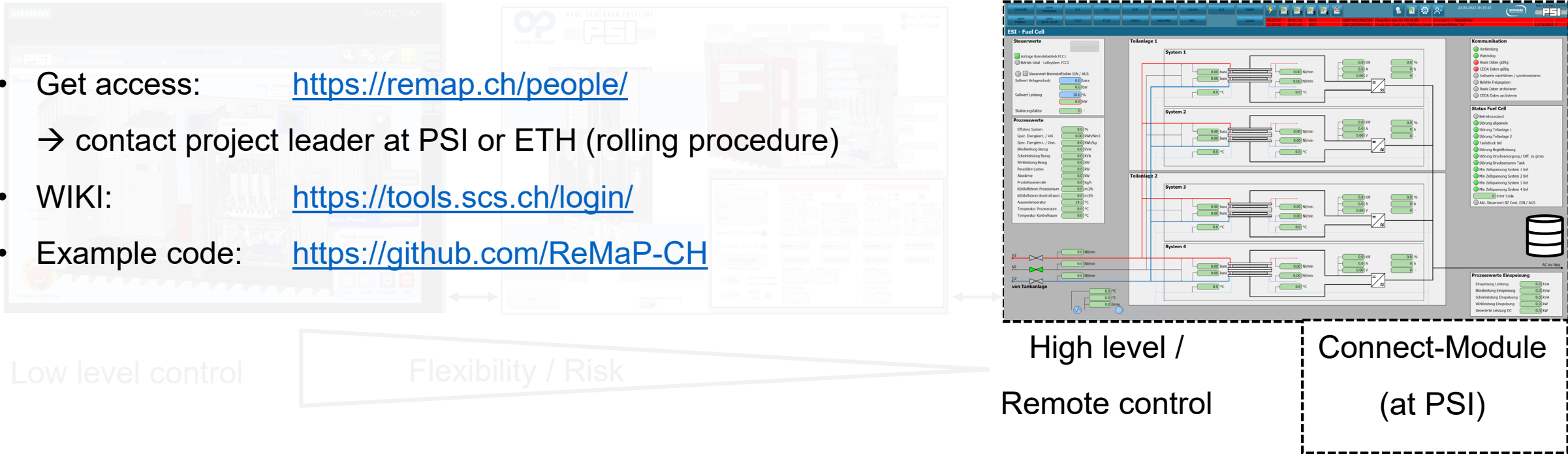


- ReMaP access
- Fully automated – still flexible
- E.g. case studies on heat coupled HESS



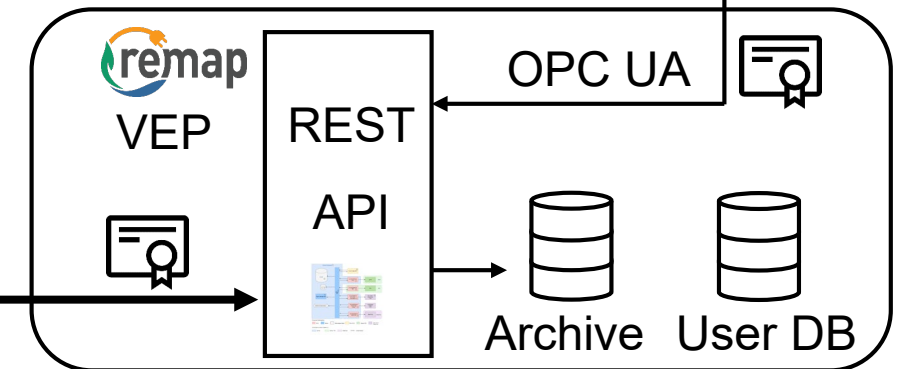
User interface

- Get access: <https://remap.ch/people/>
→ contact project leader at PSI or ETH (rolling procedure)
- WIKI: <https://tools.scs.ch/login/>
- Example code: <https://github.com/ReMaP-CH>



Client's use case / control scheme with:

- Python → .py source
- Matlab → .m source
- Labview → .vi source



Limitations

- No simulation environment
- No battery
- No standalone / smart grid (yet)

Users

Typical / potential users:

- Researchers:
 - Controls
 - System analysis
- Industry partners
 - Component / system development
- Distributions system operators
- Electric utility companies
- Heavy duty / car manufacturers
- Aerospace companies

Contributors

Umsetzungsplattform für

Förderinstitutionen



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PATHFNDR: <https://sweet-pathfndr.ch>
ESI: <https://www.psi.ch/de/media/ueberblick-esi-plattform>

