sweet swiss energy research for the energy transition

PATHFNDR

Alternative fuels

# The $H_2$ districts P+D project: roadmap and preliminary results

**Work package 5**


Gabriele Humbert [1], Matthias Brandes[1], Thomas Walter[2], Kevin Wister[3], Philipp Heer [1]

[1] Urban Energy Systems Laboratory, Empa, Dübendorf, Switzerland
[2] H2Energy AG, Zürich, Switzerland
[3] Hälg AG, St. Gallen, Switzerland


## 1 INTRODUCTION AND MOTIVATIONS

- The H2districts project deals with the design and operation of proton exchange membrane (PEM) fuel cells used as combined heat and power (CHP) systems in districts.
- We assess the potential to address peak energy demand during winter and decarbonize the heating sector.
- The expected benefits area reduction of grid reinforcement needs, an increase in local self-sufficiency, and support in energy system resilience and decarbonization through green hydrogen.

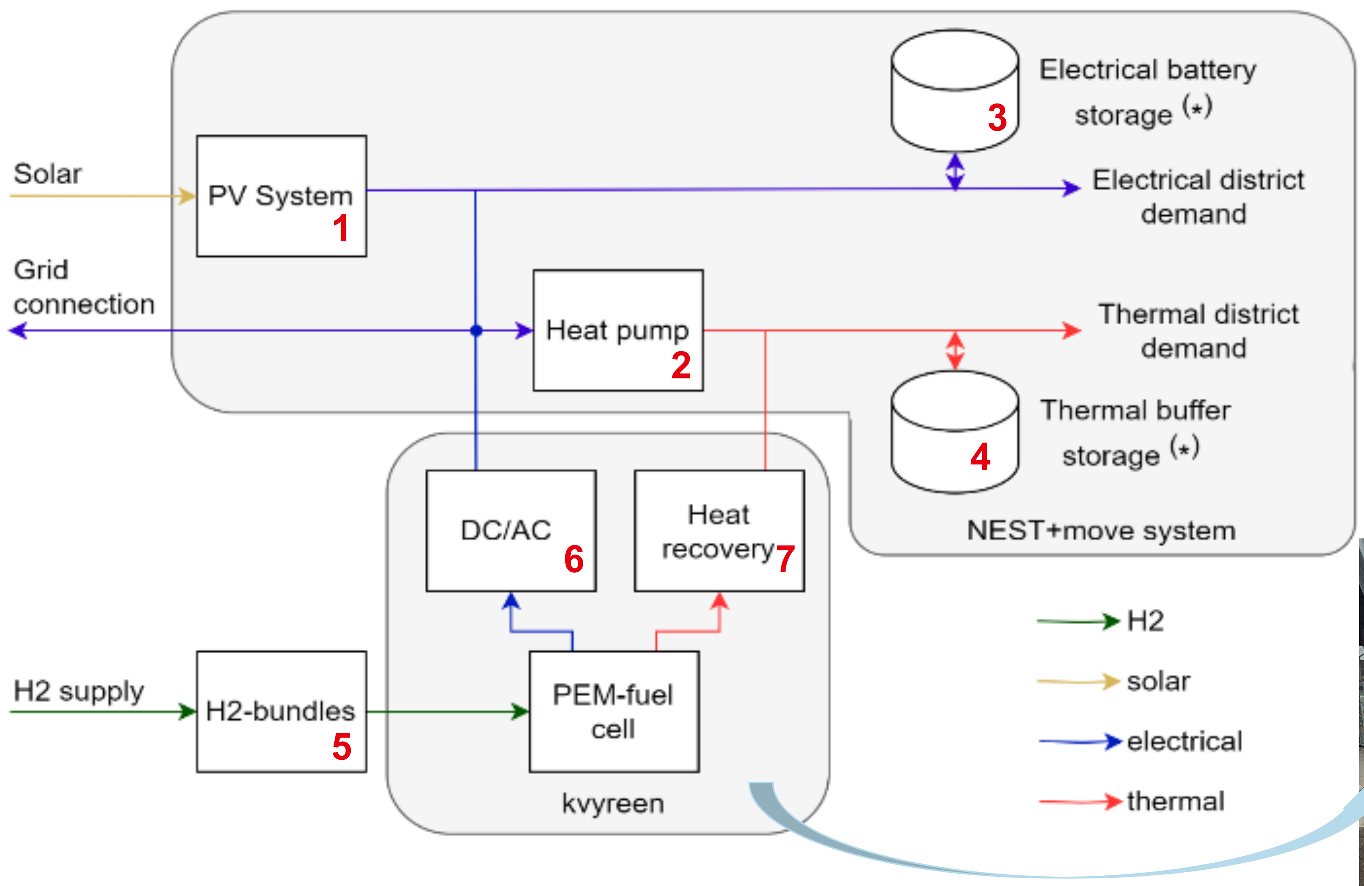

## 2 RESEARCH QUESTIONS

- How and to what extent can the flexibility provided by hydrogen fuel cells in district energy systems be maximized, and how much grid reinforcement cost can be deferred or saved? **WP2**
- How does aging affect the fuel cell performance and lifetime during stationary applications? **WP3**
- What district settings are most suited for such systems? **WP4**

| # | Name | WP Lead | Support | '23 Q3 | '23 Q4 | '24 Q1 | '24 Q2 | '24 Q3 | '24 Q4 | '25 Q1 | '25 Q2 | '25 Q3 | '25 Q4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WP1 | kvyreen integration | Hälg | Empa, Osterwalder, H2Energy | | | | | | MS1 | | | | |
| WP2 | Development of grid-supporting operating strategies | Empa | Hälg, H2Energy | | | | | | | MS2 | | | |
| WP3 | Aging considerations | Empa | Osterwalder, H2Energy | | | | | | | | MS3 | | |
| WP4 | Techno-economic analysis | Empa | Hälg, Osterwalder, H2Energy | | | | | MS4 | | | | | MS5 |
| WP5 | Project Management | Hälg | | | | | | | | | | | |

## 3 INSTALLATION AND COMMISSIONING

- A 60 $kW_{el}$ and 60 $kW_{th}$ PEM fuel cell was installed at the NEST+move demonstrators at Empa [1,2].
- After securing permits, the system was integrated electrically and thermally. Commissioning tests verified power generation, H2 supply, and heat transfer.
- The data connection will be finalized by December 2024, such that the experimental campaign can begin.
- The system is connected to the medium-temperature district heating network (28 to 38 °C) of the Empa campus.
- The project will consider the demand from the NEST building, which hosts office spaces, apartments and a gym, and other office buildings on the Empa campus.
- **Key Learnings**: The process of acquiring permits required multiple iterations with authorities, which caused delays.



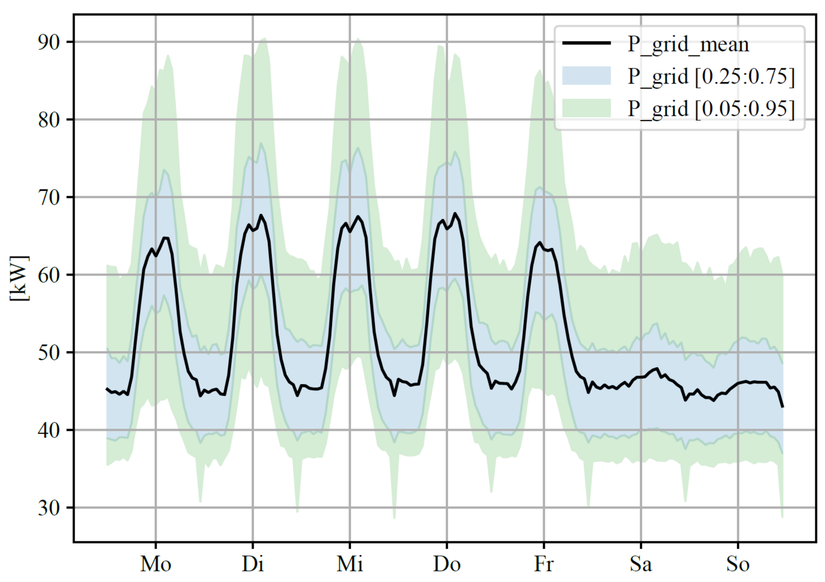

***Sizes of Empa demonstrator***

1 ~100 $kW_p$
2 100 $kW_{th}$; 24 $kW_{el}$
3 96 kWh battery storage
4 4400 l thermal storage
5 H2-bundles by Osterwalder/Empa
6 10-60 $kW_{el}$
7 10-60 $kW_{th}$

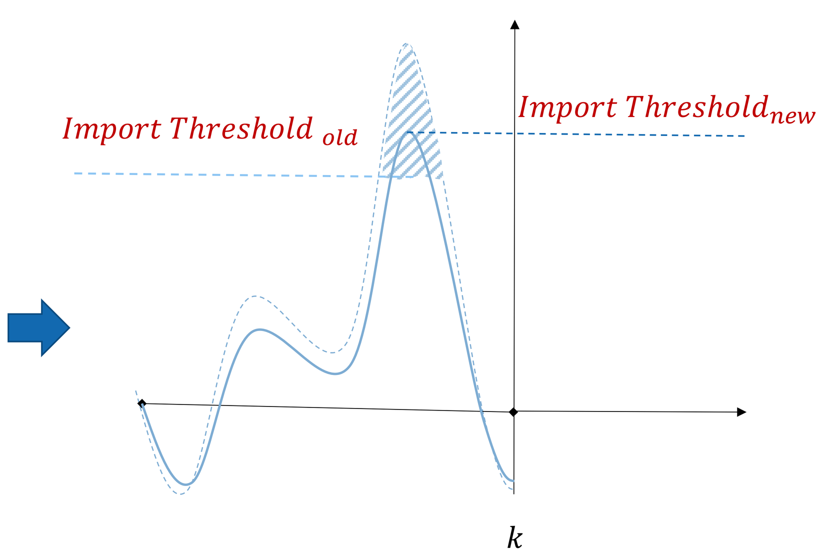
*Fuel cell system (Kvyreen) installed at Empa.*

## 4 OPERATION STRATEGIES (WP2)

- The objective is to develop control strategies to (i) reduce grid loads, (ii) reduce emissions and (iii) save costs for the user.
- Predictive control methods will be implemented to leverage the potential of the fuel cell, as well as PV availability, heat pumps and storage solutions.
- One of the targets is the reduction of peaks in electricity demand on a 15-minute.
- Accurate forecast for demand peaks over short periods remains a challenge [3]. The proposed solution is the definition of upper bounds for the imported electricity as soft-constraint in short-term optimal control.



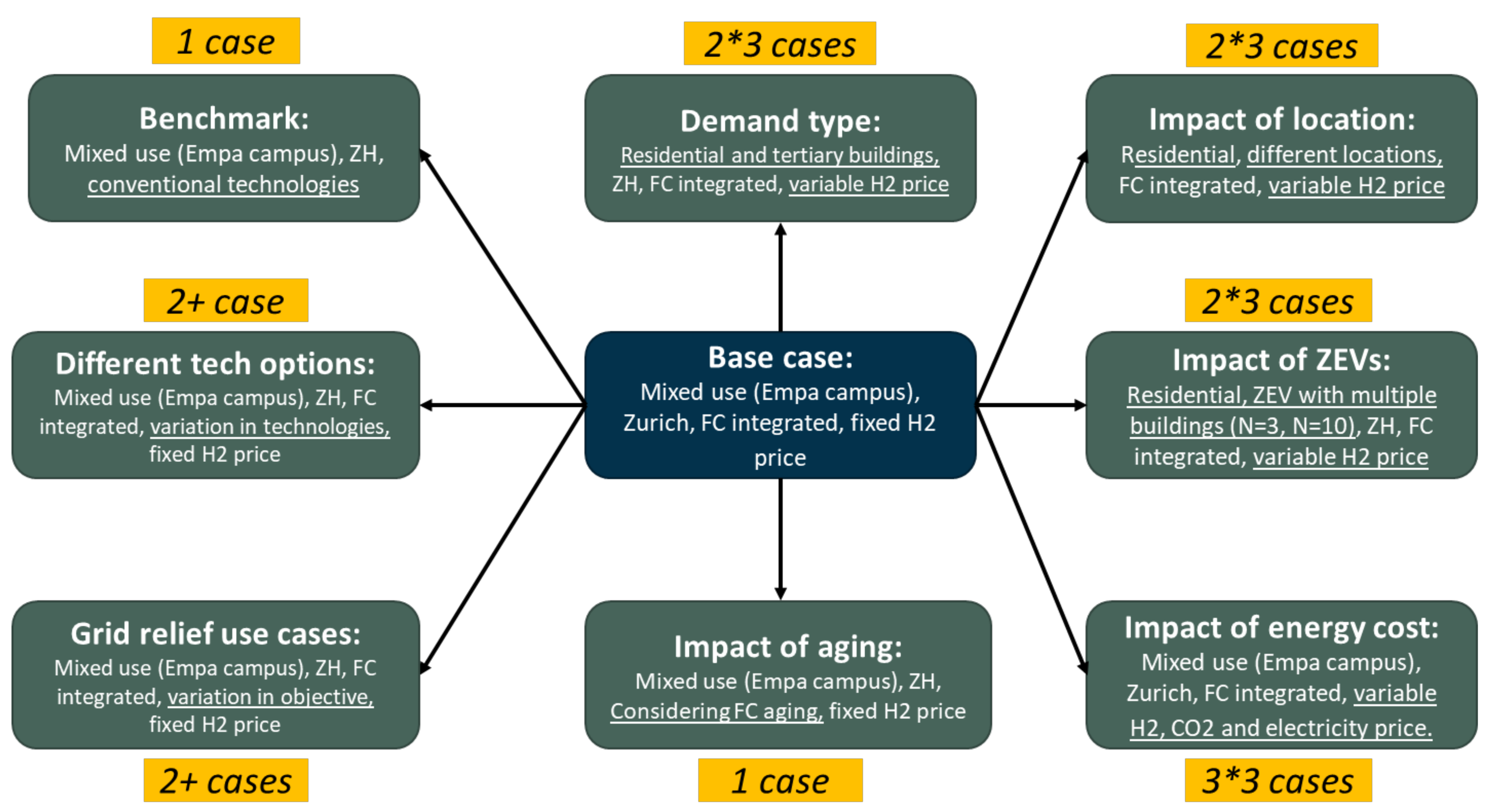

*Challenges in peak power forecast*




*Threshold definition*

## 5 TECHO-ECONOMIC ANALYSIS (WP3 and WP4)

- Multiple scenarios will be investigated by means of the EhubX tool [4] to identify the most attractive design cases for the system under analysis.




| | Current price (2024) | Future (2030) – high | Future (2030) - low |
|---|---|---|---|
| **H2 price** | 10 CHF/kg | 6 CHF/kg | 2 CHF/kg |

## REFERENCES


*[1] NEST – buildings of the future https://www.empa.ch/web/nest/*
*[2] MOVE – mobility of the future, https://www.empa.ch/web/move*
*[3] Pierre et al., Peak Electrical Energy Consumption Prediction by ARIMA, LSTM, GRU, ARIMA-LSTM and ARIMA-GRU Approaches, 2022;*
*[4] Bollinger et al., The Ehub Modeling Tool: A flexible software package for district energy system optimization, 2017.*


## CONTACT


Gabriele Humbert
Empa
Urban Energy System Laboratory
Gabriele.humbert@empa.ch
www.sweet-pathfndr.ch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