

PATHFNDR project

EXPANSE

(University of Geneva)

sweet swiss energy research
for the energy transition

PATHFNDR

ETH zürich

 Empa

PAUL SCHERRER INSTITUT
PSI

zhaw

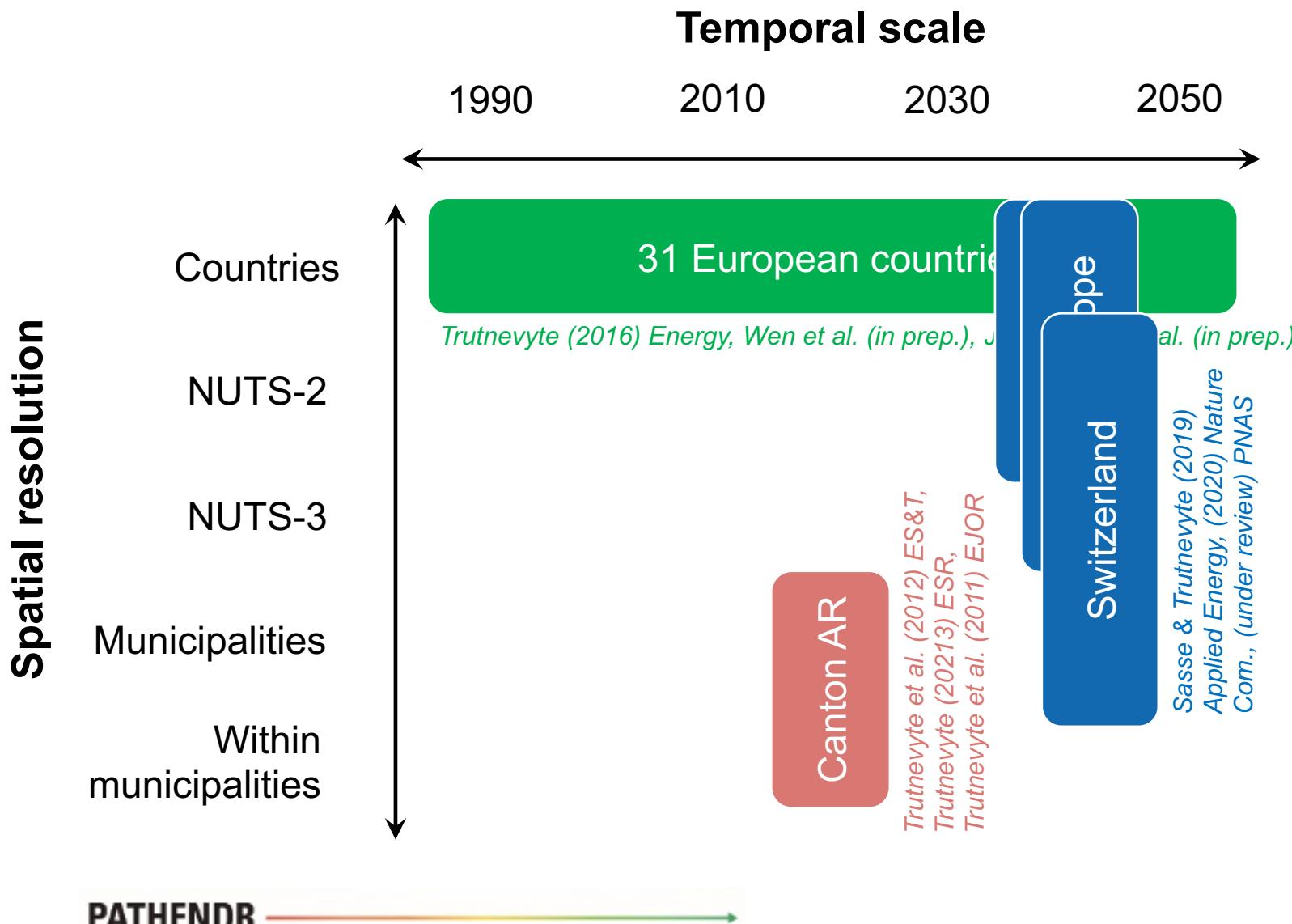
HOCHSCHULE
LUZERN



UNIVERSITÉ
DE GENÈVE

EPFL

EXPANSE modeling framework (1)

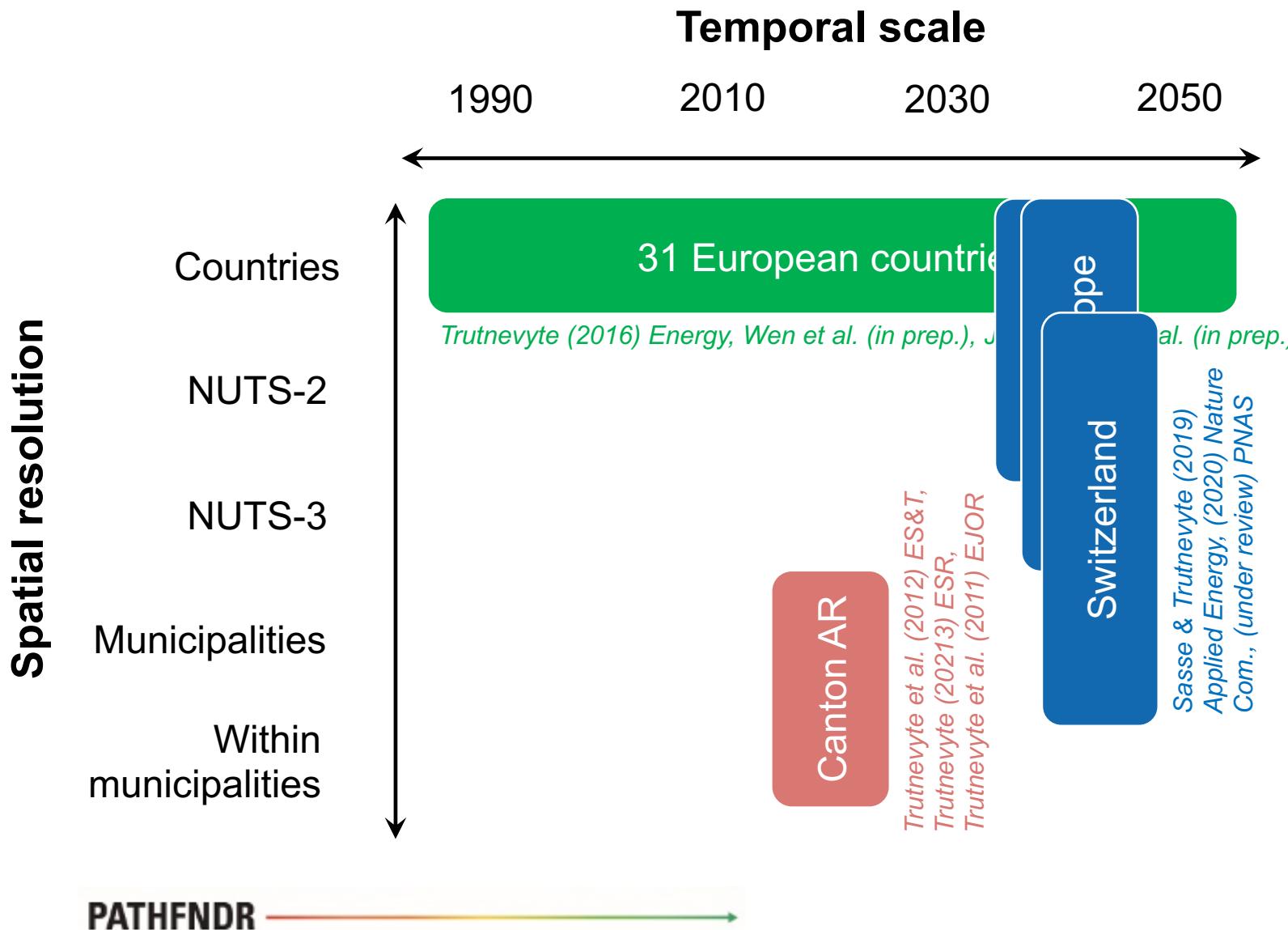


Basis: bottom-up technology-rich cost-optimization model

Coverage:

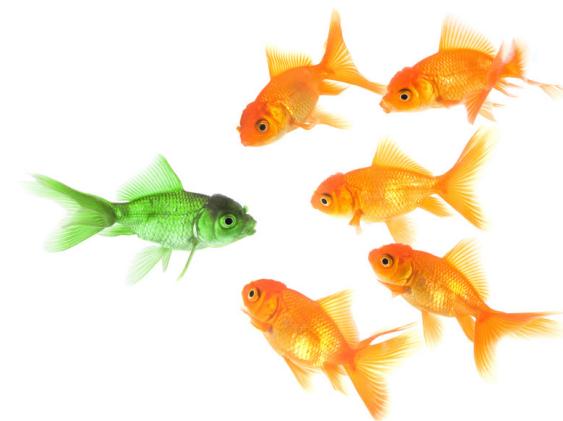
- electricity (Switzerland, Europe)
- whole system (under development for all European countries, including Switzerland)
- electricity and heat (local)

EXPANSE modeling framework (2)



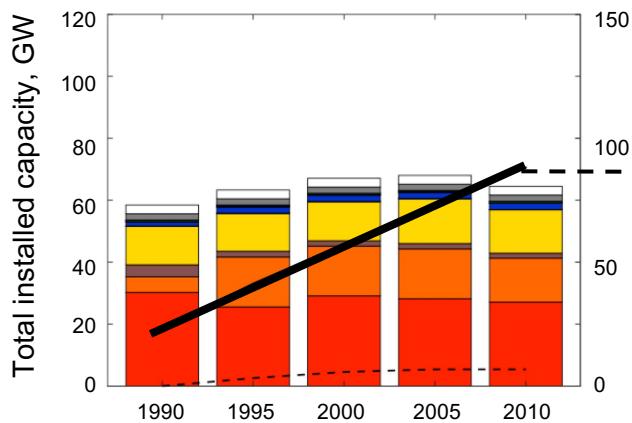
Innovative features:

- Closing the gap between the model and real-world transition
- Extensive uncertainty analysis



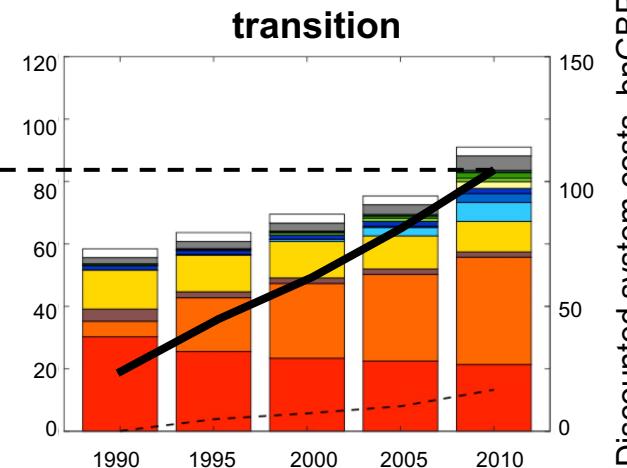
Cost optimization is fiction!

Typical cost-optimization model with nearly eliminated parametric uncertainty



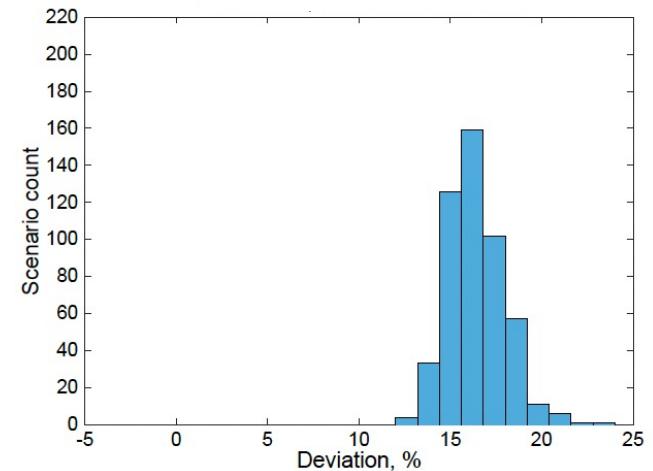
16% higher total system costs in reality

Real-world transition



Discounted system costs, bnGBP

Deviation from cost optimality in 500 Monte Carlo runs



- [Yellow square] Nuclear
- [Dark brown square] Oil & other
- [Orange square] Gas CCGT
- [Red square] Coal
- [White square] Hydro storage
- [Grey square] Import
- [Blue square] Hydro
- [Black line] Cumulative total costs
- [Dashed line] Cumulative investment costs

Underestimated technologies:

- [Blue square] Wind offshore
- [Light blue square] Wind onshore
- [Yellow square] Solar PV
- [Green square] Biomass
- [Dark green square] Waste
- [Orange square] Gas CCGT
- [Light green square] Landfill

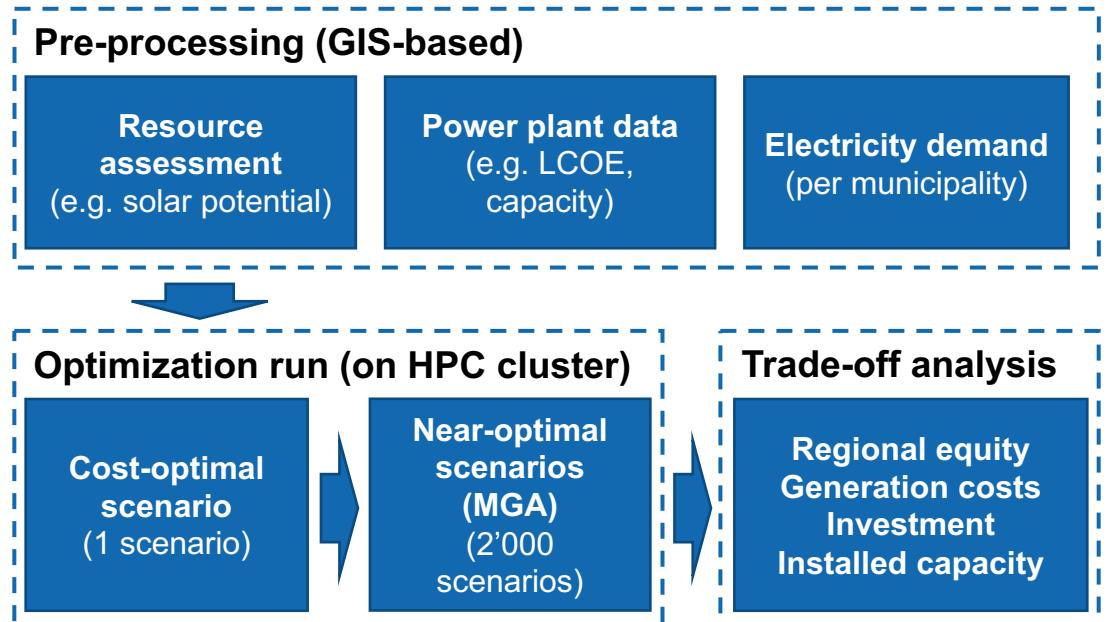
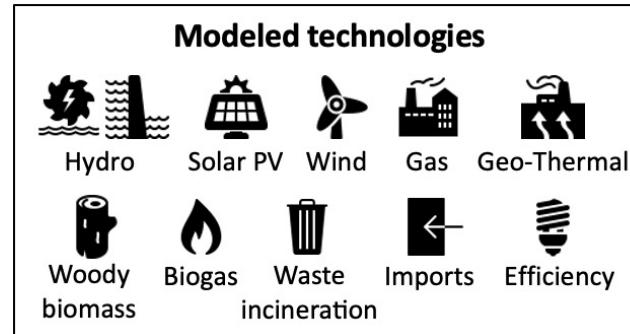
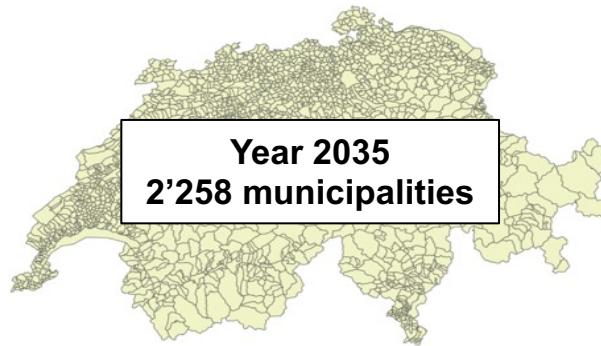
Closing the gap between the model and real-world transition

- **Retrospective modeling** to reduce model error and improve uncertainty representation
- Coupling **statistical and optimization-based** modeling
- Integrating insights from **socio-technical transitions analysis** into modeling

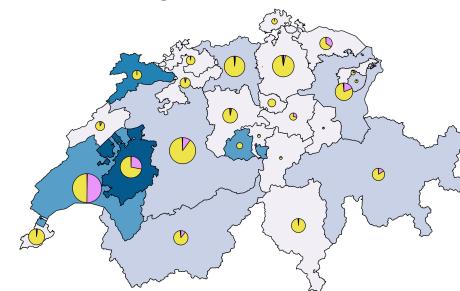
Extensive uncertainty analysis

- **Modeling to Generate Alternatives** (MGA) to:
 - Identify alternative scenarios within acceptable costs
 - Identify scenario ranges within history-informed deviation from cost optimality
- Combining **stochastic methods**, **MGA** and **methods to analyze large scenario ensembles** for more complete analysis of uncertainty

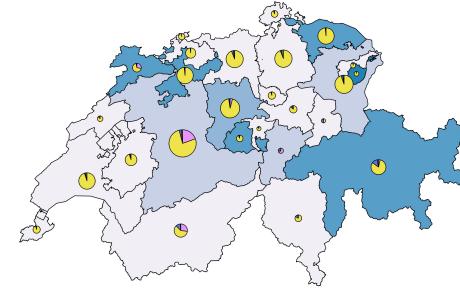
Case study: regional equity in Switzerland (1)



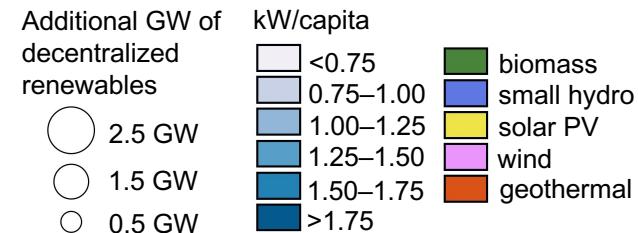
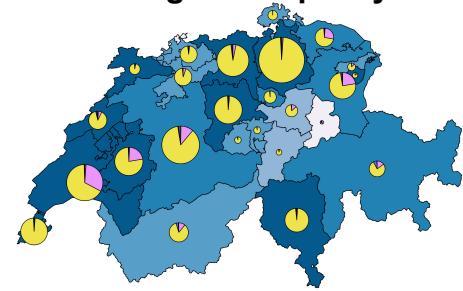
Cost-optimal scenario 2035



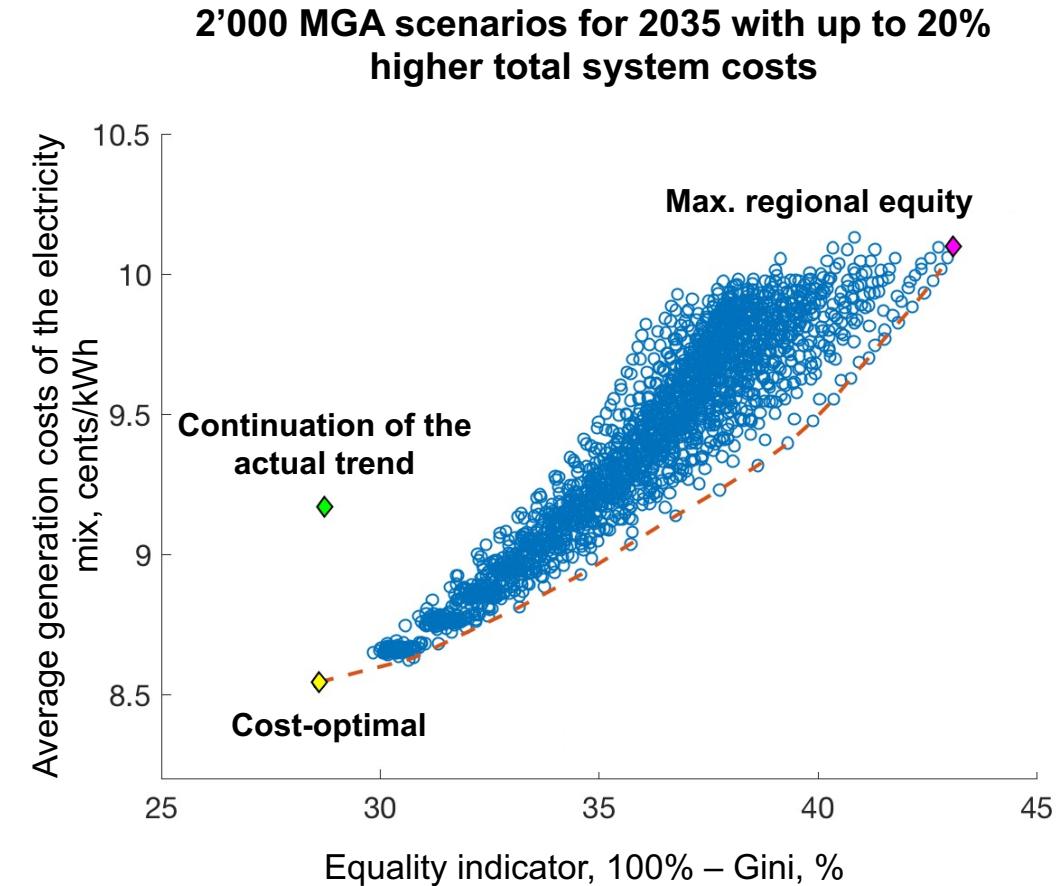
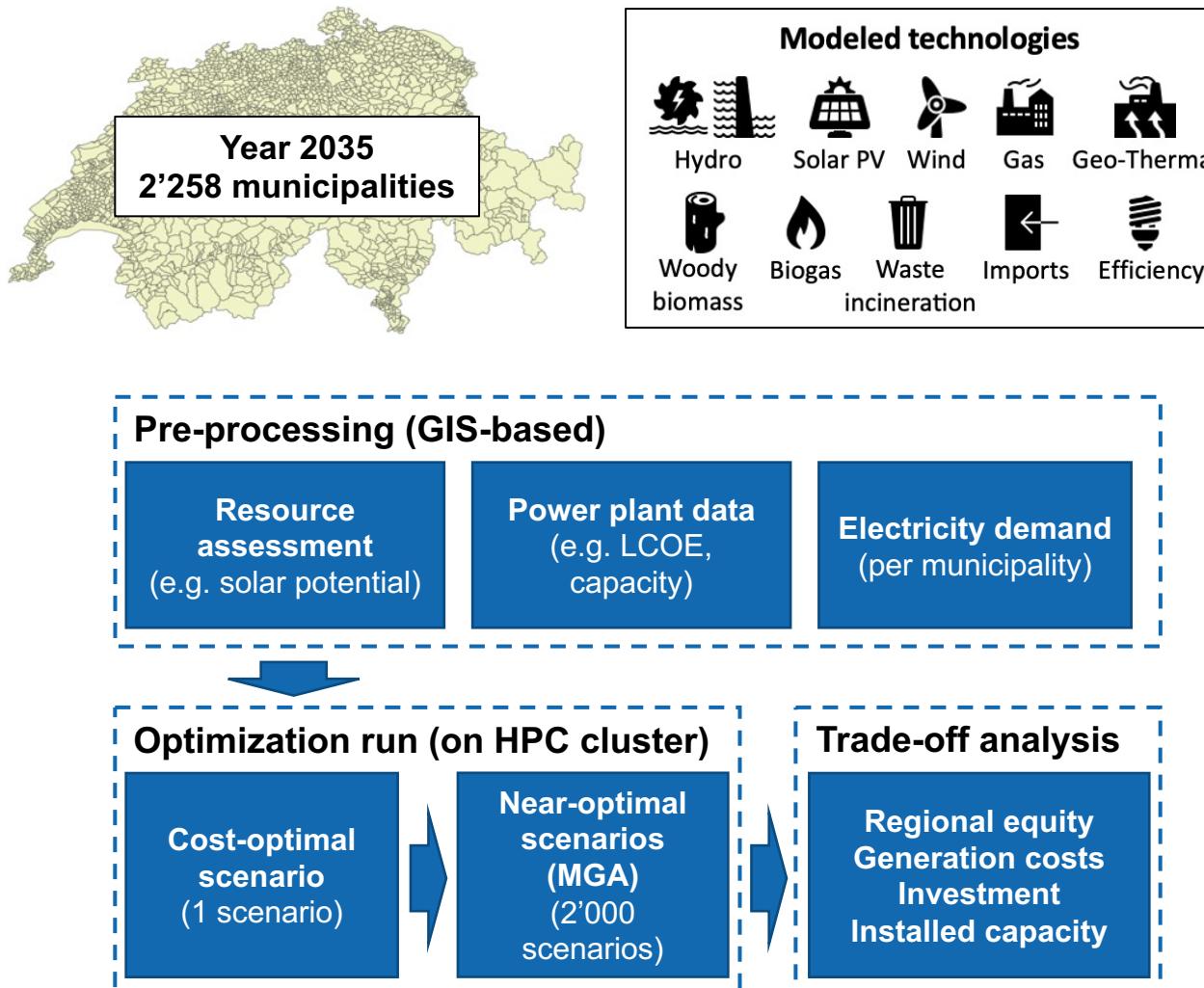
Continuation of the actual trend until 2035



Max. regional equality 2035

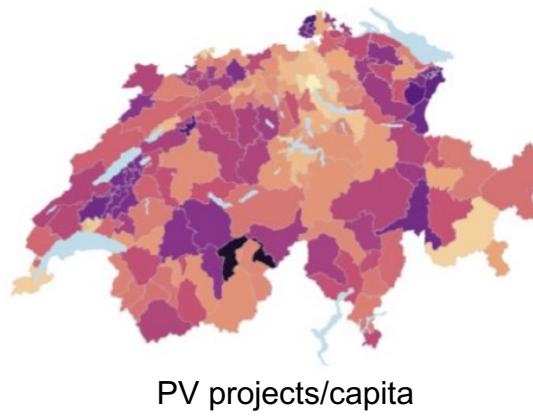


Case study: regional equity in Switzerland (2)



Case study: closing the gap with the real-world transition

> 68'000 solar PV projects in 2017



0.00 0.01 0.02 0.03 Net personal income

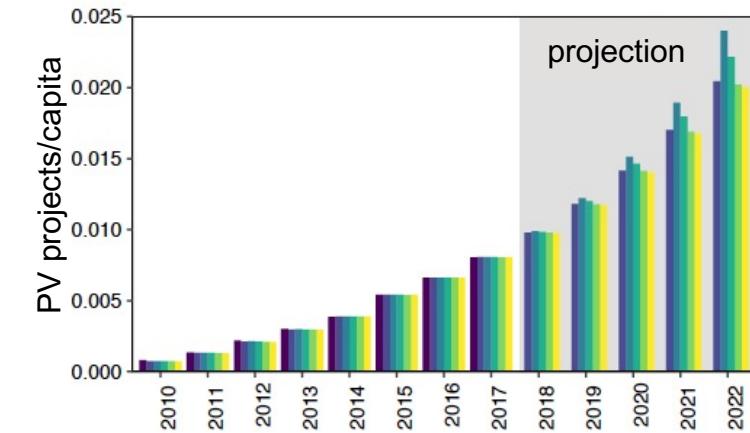
Unproductive area

Intercept

Adj. R²

*** p ≤ 0.001
* p ≤ 0.05

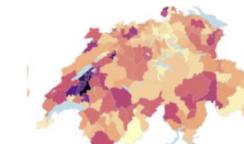
| N=143 districts | Multiple linear regression (MLR) | Simultaneous autoregressive model (SAR), radial distance weights |
|---------------------------|----------------------------------|--|
| Exploitable PV potential | 0.29*** | 0.27*** |
| Household size | 0.24*** | 0.25*** |
| Age coefficient | 0.14*** | 0.15*** |
| Electricity price | 0.09** | 0.05 |
| Return on investment | 0.05 | 0.03 |
| Energiestadt label | 0.05 | 0.03 |
| Green voters | 0.01 | 0.01 |
| Electricity demand | -0.02 | -0.02* |
| Net personal income | -0.07* | -0.03 |
| Unproductive area | -0.14*** | -0.13*** |
| Intercept | -4.68*** | -2.62*** |
| Adj. R² | 0.71 | 0.81 |



- Observed
- Multiple linear regression (MLR)
- Simultaneous autoregressive model (SAR), rook contiguity
- Simultaneous autoregressive model (SAR), radial distance

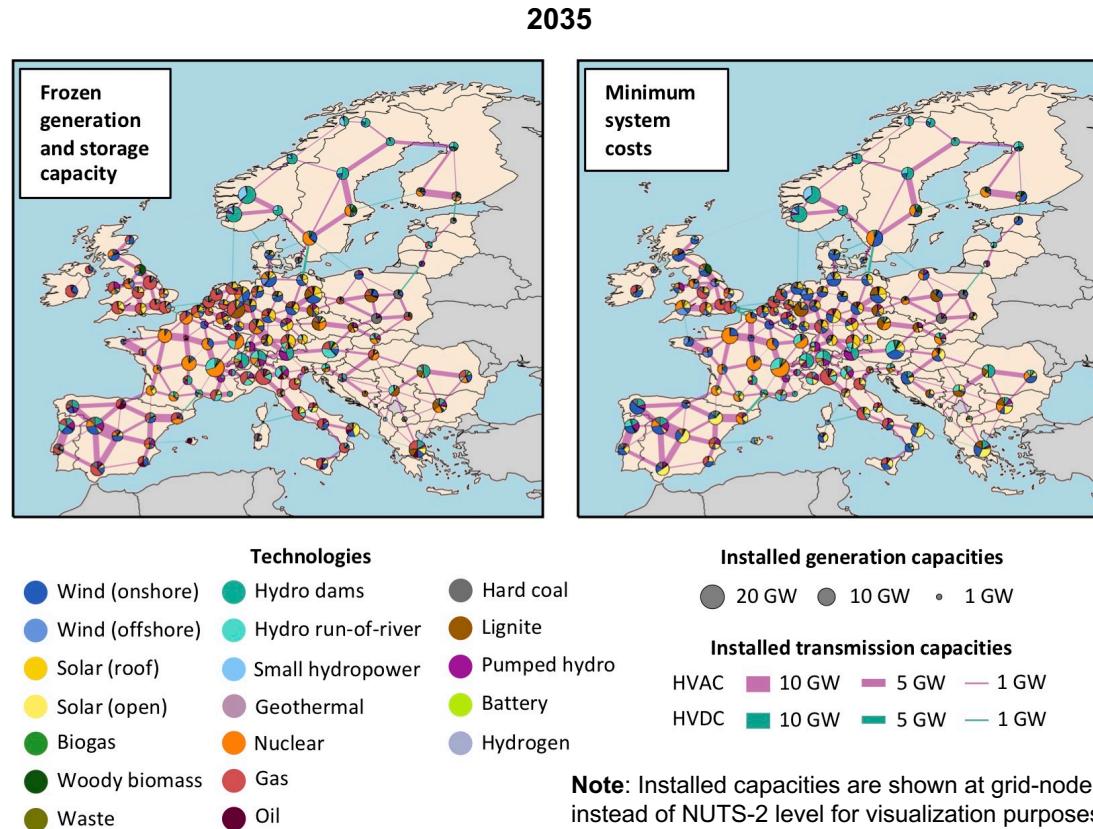
Best retrospective accuracy performance (not shown here)

- Spatial error model (SEM), rook contiguity
- Spatial error model (SEM), radial distance



0.00 0.03 0.06 0.09
PV projects/capita

Case study: benefits and vulnerabilities in Europe **RES**



Unpublished
work has been
excluded

Source: Sasse & Trutnevyyte (2021)

Case study: closing the gap with the real-world transition

Unpublished
work has been
excluded



Improving the models to minimize subjectivity:

- Retrospective modeling and evaluation
- Testing various model configurations
- Testing various uncertainty methods
- And more!

Case study: Integration of stakeholder preferences **RES**

www.riskmeter.ch

RISKMETER User instructions Technologies References Feedback Login EN DE FR

Select your electricity supply for 2035

Your chosen electricity portfolio

Demand is not yet covered

Target demand: 70.0 TWh/year

Electricity saving and efficiency: -3.5 TWh/year

Total supply: 50.9 TWh/year

Net import: 0.0 TWh/year

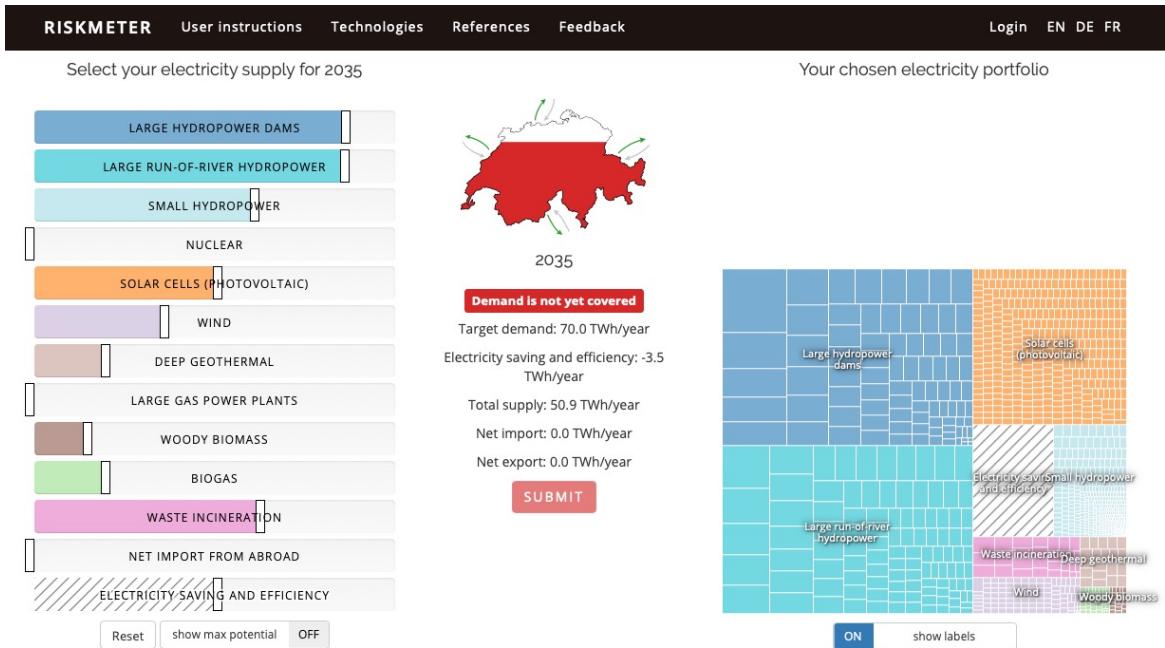
Net export: 0.0 TWh/year

2035

Large hydropower dams
Large run-of-river hydropower
Small hydropower
Nuclear
Solar cells (photovoltaic)
Wind
Deep geothermal
Large gas power plants
Woody biomass
Biogas
Waste incineration
Net import from abroad
Electricity saving and efficiency

ON show labels SUBMIT

Reset show max potential OFF

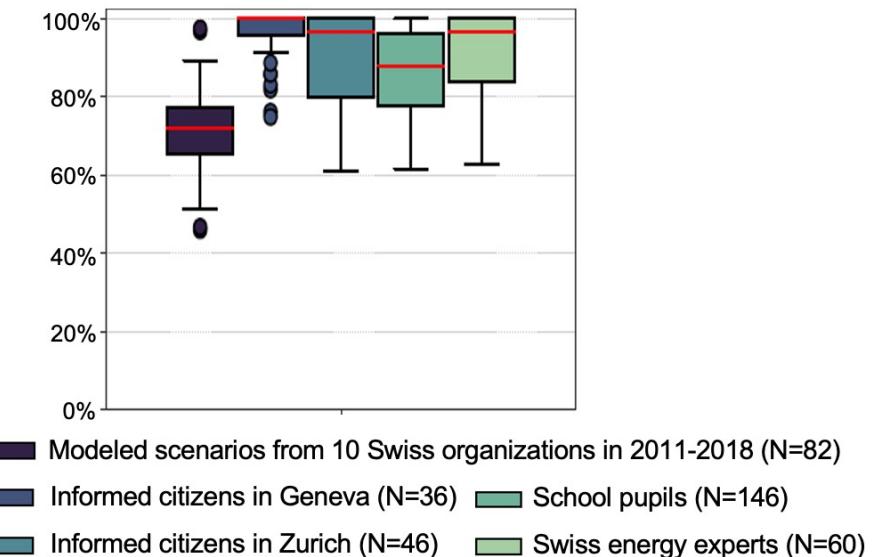


- Riskmeter for Switzerland
 - In French, German, and English
 - For citizens and for schools
 - With and without impacts
- Riskmeter for France, Germany, Poland, and the EU

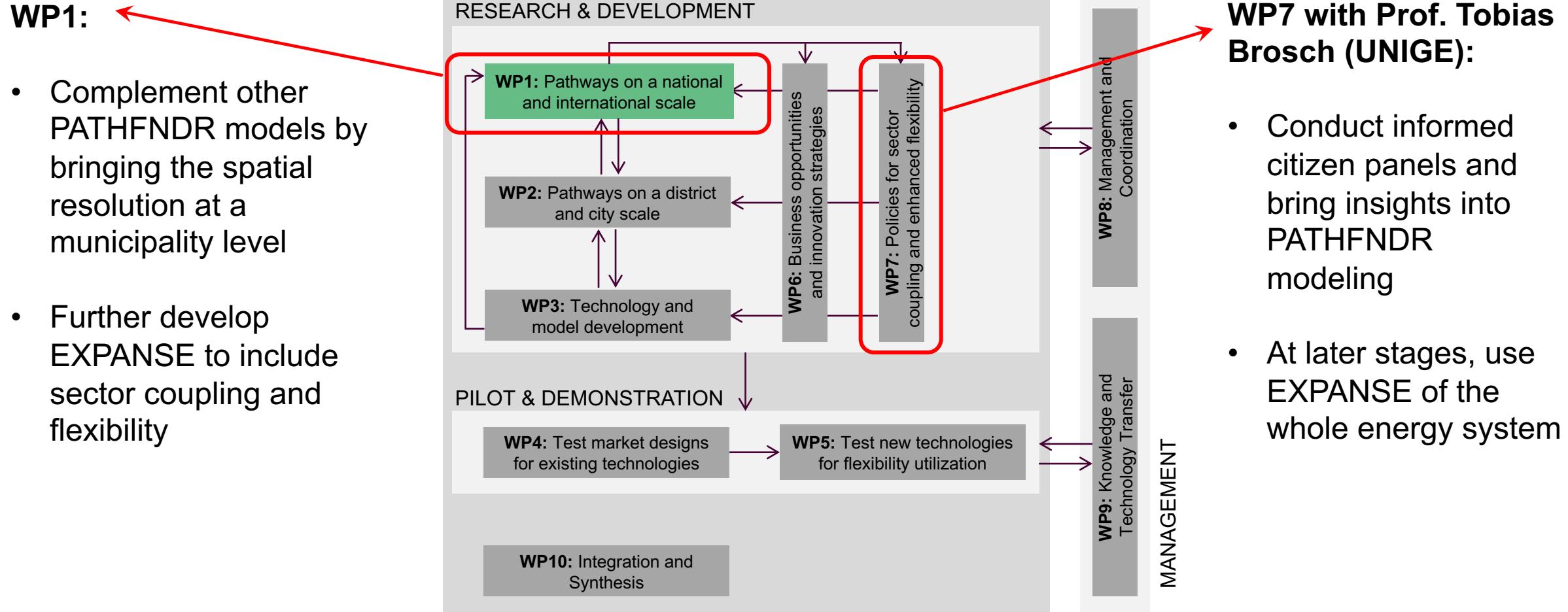
Workshops and surveys for usability testing and elicitation of preferences



Share of domestic renewable generation in 2035



Future development under the PATHFNDR project





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www.unige.ch/res
<https://sweet-pathfndr.ch/toolbox/>

