HSLU Lucerne University of Applied Sciences and Arts

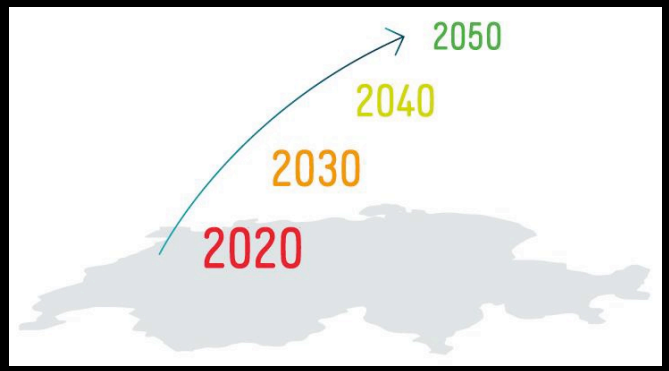
From Data to Decisions

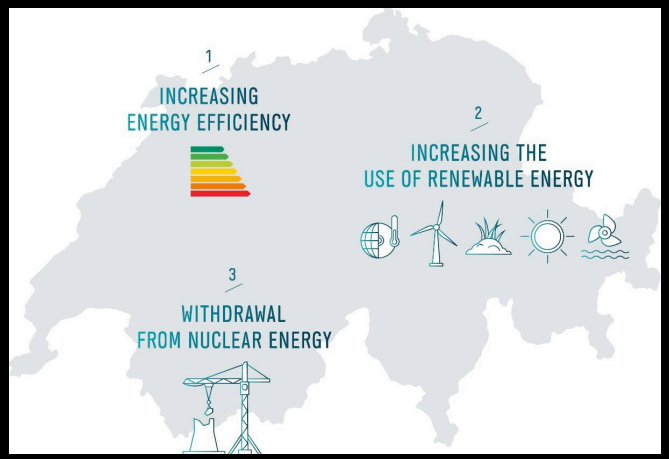
A Recommender Tool for Communal Energy Planning in Switzerland

Energieforschungsgespräche Disentis 2025

Ueli Schilt

January 31, 2025



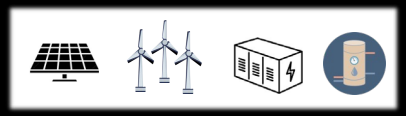


?

$$$ Cost

CO2 Emissions


Demand


Technologies


Operation

$$$

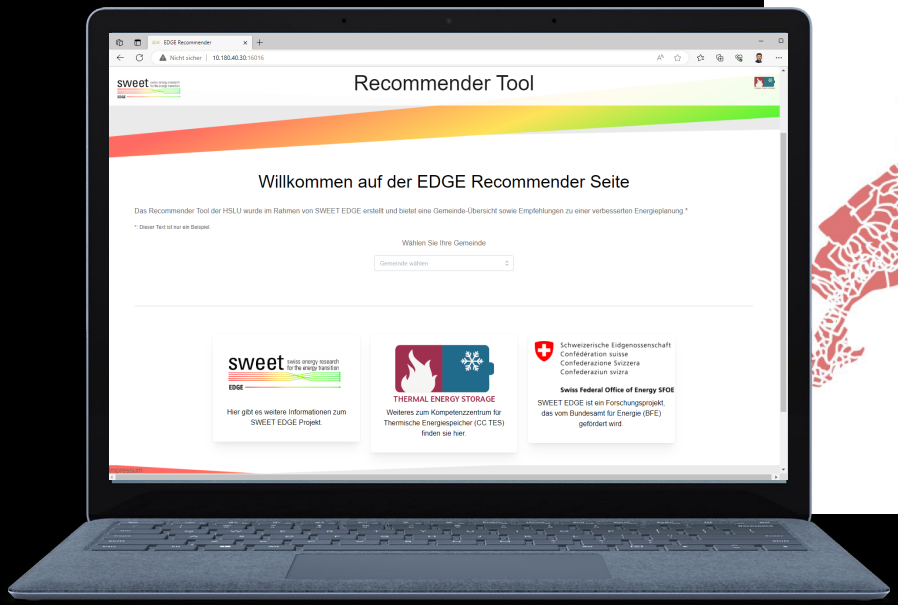
vs.

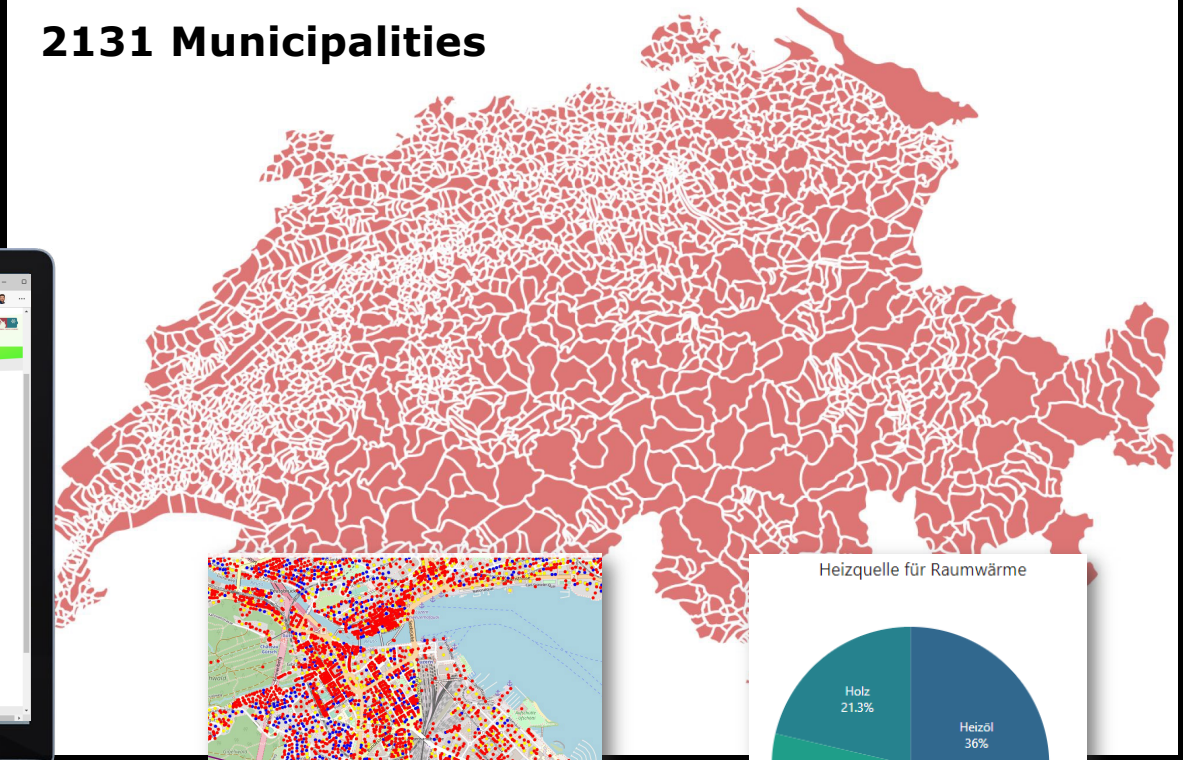
$

How can communal energy planning be supported with an online tool?

sweet swiss energy research for the energy transition

EDGE (1)





(1) www.sweet-edge.ch

Model input

District Energy Model (DEM)

```
scen_techs = {'heat_pump':{'deployment':True,
                           'hW_th_max':10e10,
                           'cop':3.0},

              'electric_heater':{'deployment':True,
                                 'hW_max':10e10},

              'oil_boiler':{'deployment':True,
                            'hW_th_max':10e10,
                            'hv_oil_MJpkg':45.0,
                            'eta':0.90,
                            'replacement_factor':fhrp/100},

              'gas_boiler':{'deployment':True,
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              'wood_boiler':{'deployment':True,
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```
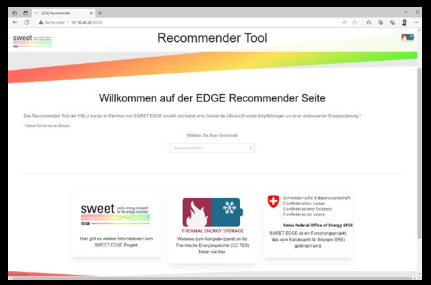

User input

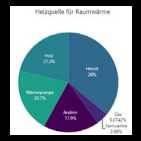
Output

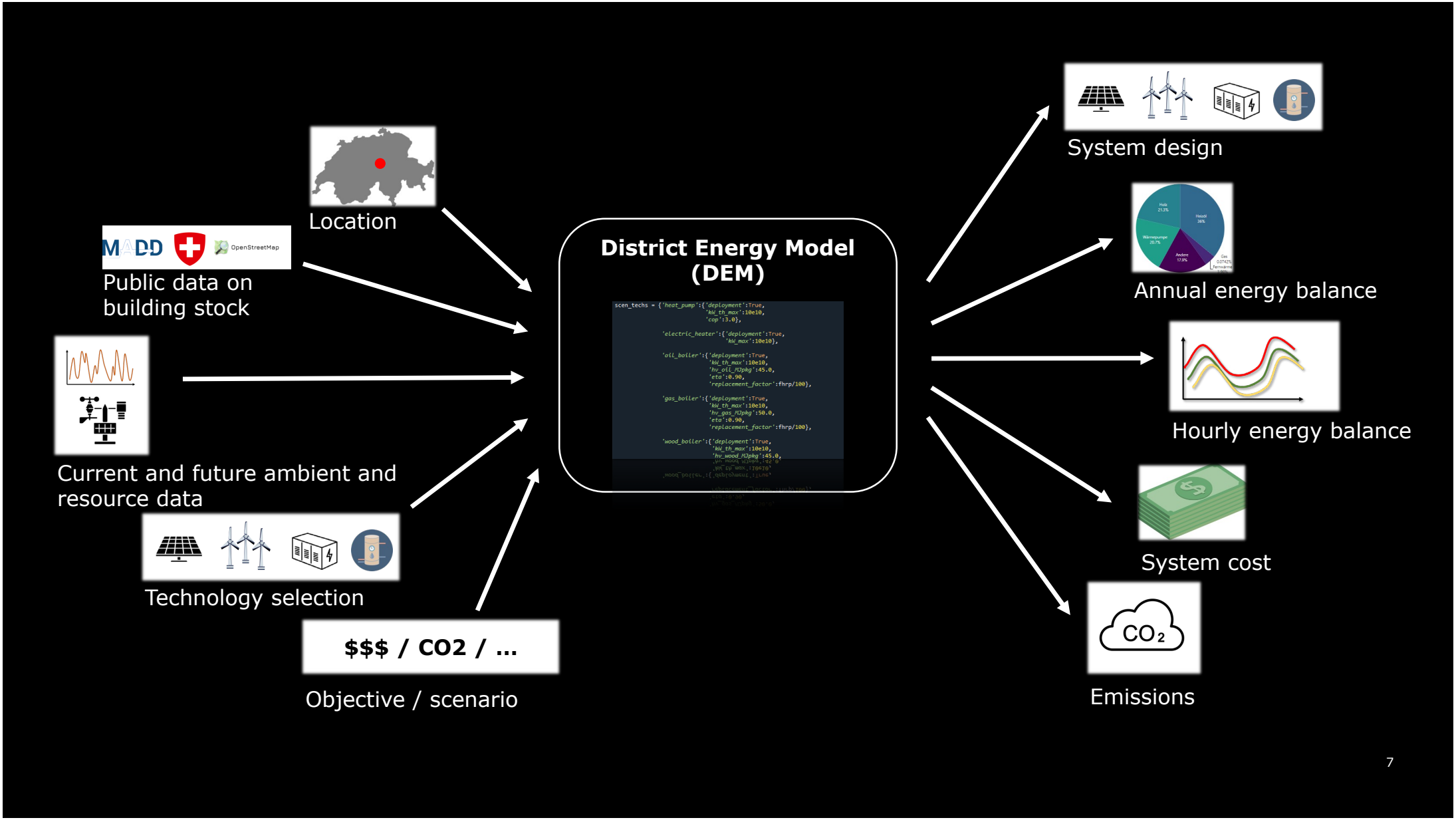
User input

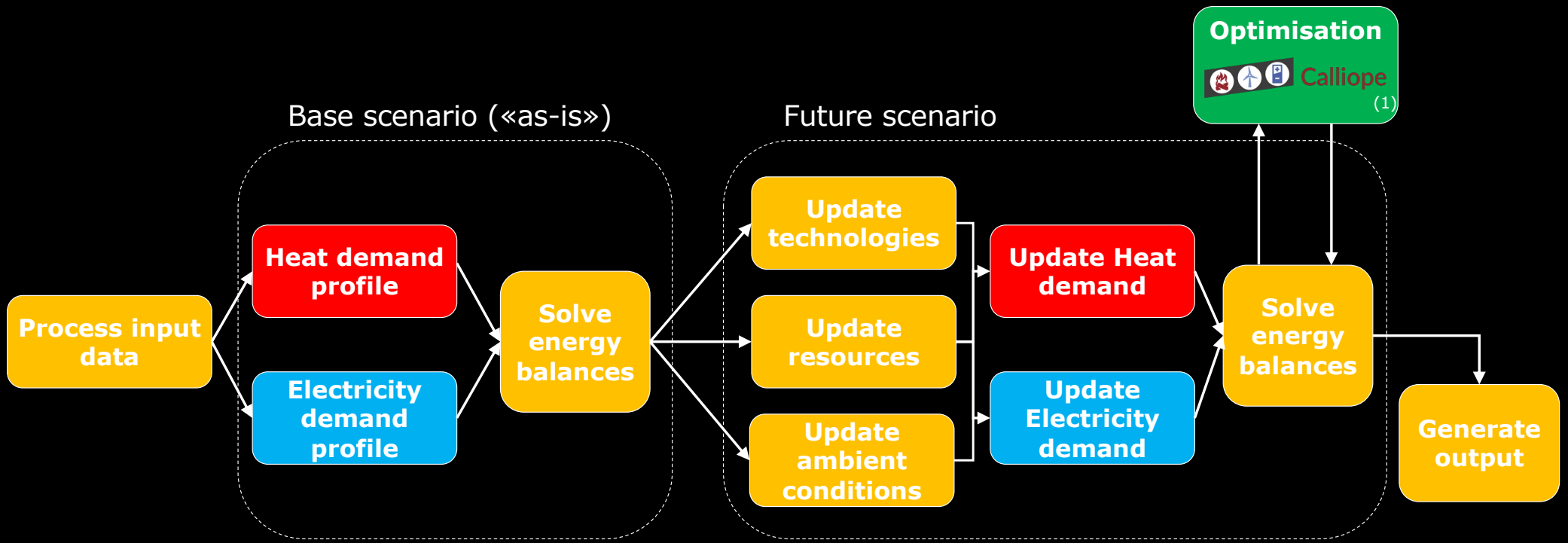
Recommender Tool



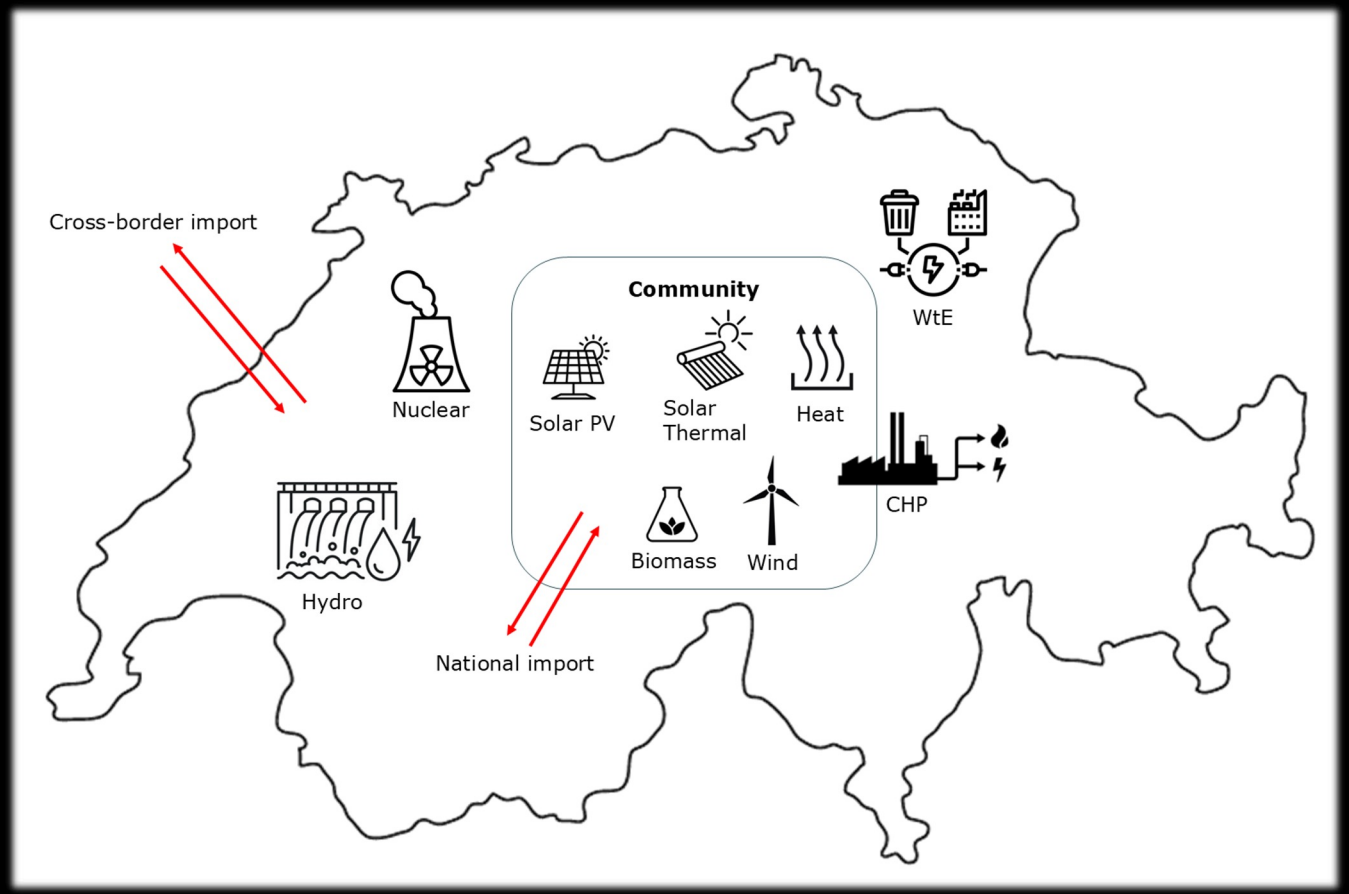
Output

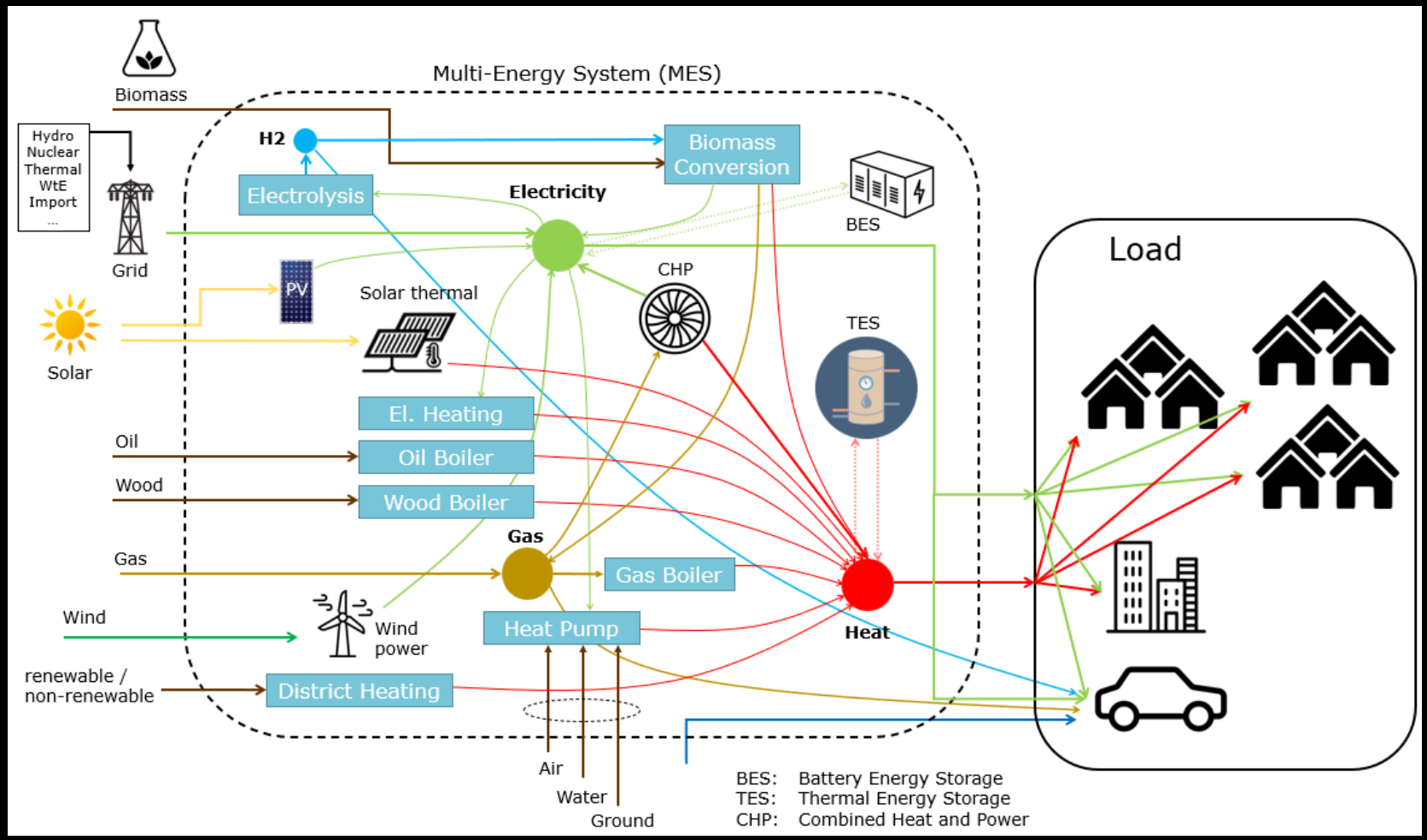



Location
Public data on building stock
Current and future ambient and resource data
Technology selection
$$$ / CO2 / ...
Objective / scenario
District Energy Model (DEM)
System design
Annual energy balance
Hourly energy balance
System cost
Emissions



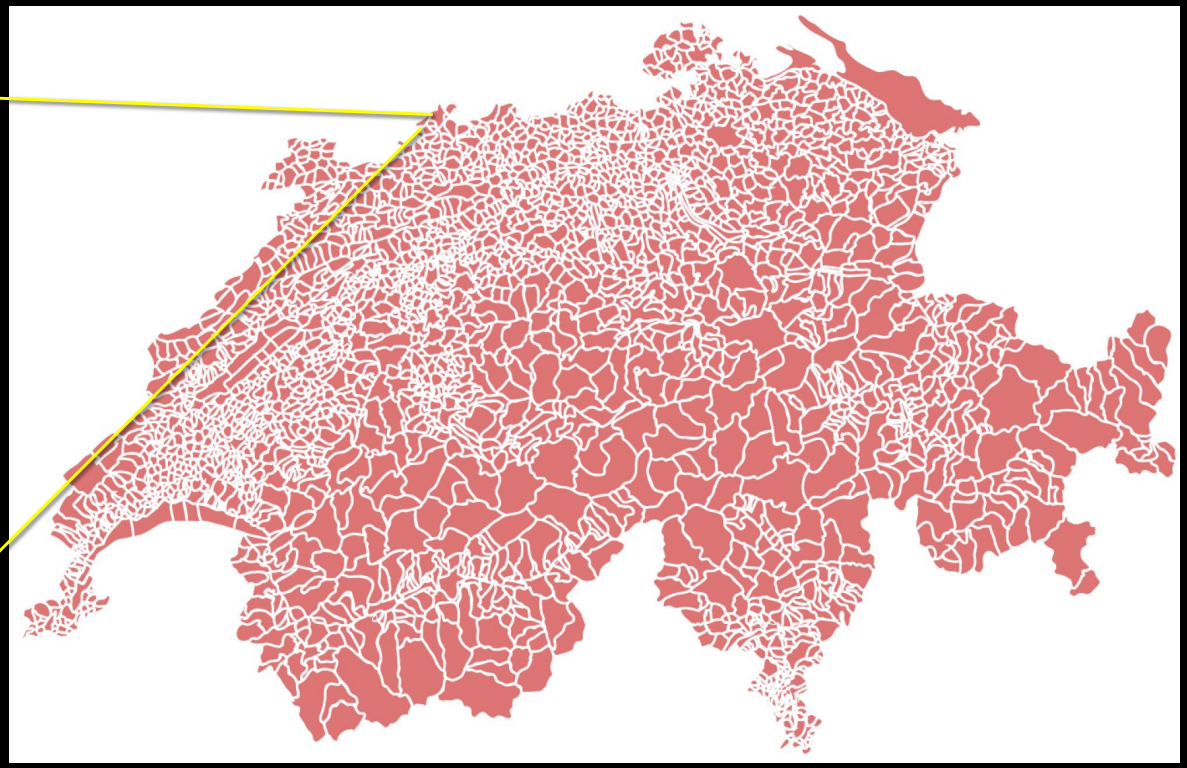
(1) Pfenninger and Pickering (2018)


Cross-border import
Nuclear
Community
Solar PV
Solar Thermal
Heat
WtE
CHP
Biomass
Wind
Hydro
National import


Multi-Energy System (MES)
Biomass
Hydro
Nuclear
Thermal
WtE
Import
...
Grid
H2
Electrolysis
Biomass Conversion
Electricity
BES
Load
PV
Solar thermal
CHP
Solar
TES
El. Heating
Oil
Oil Boiler
Wood
Wood Boiler
Gas
Gas
Gas Boiler
Wind
Wind power
Heat Pump
Heat
renewable /
non-renewable
District Heating
Air
Water
Ground
BES: Battery Energy Storage
TES: Thermal Energy Storage
CHP: Combined Heat and Power

District Energy Model – Case Study

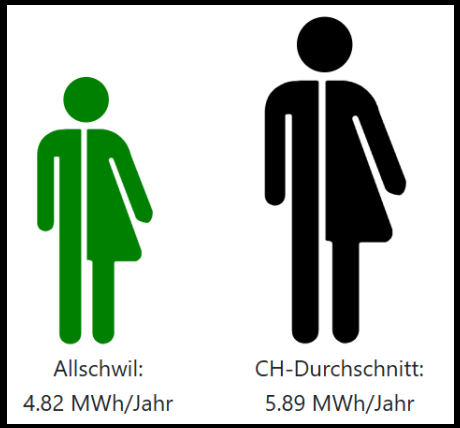
Example: Allschwil (BL)

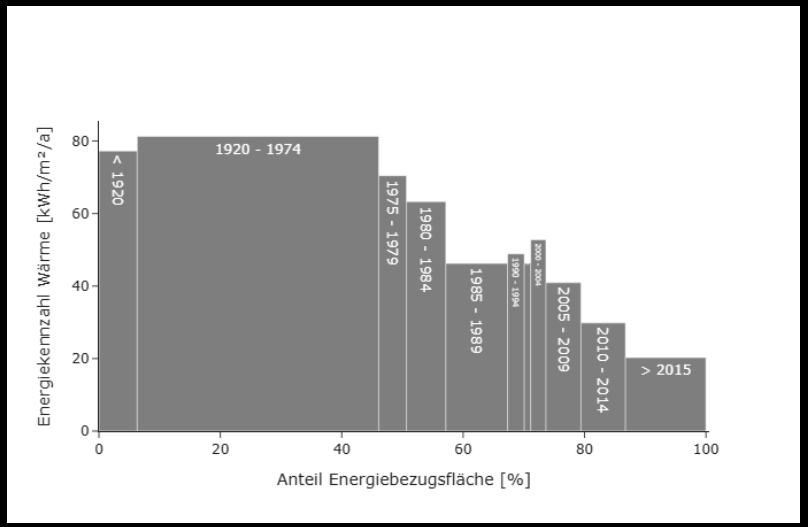


District Energy Model – Case Study

Example: Allschwil (BL)

- Population: 21’000
- Area: 9 km^2

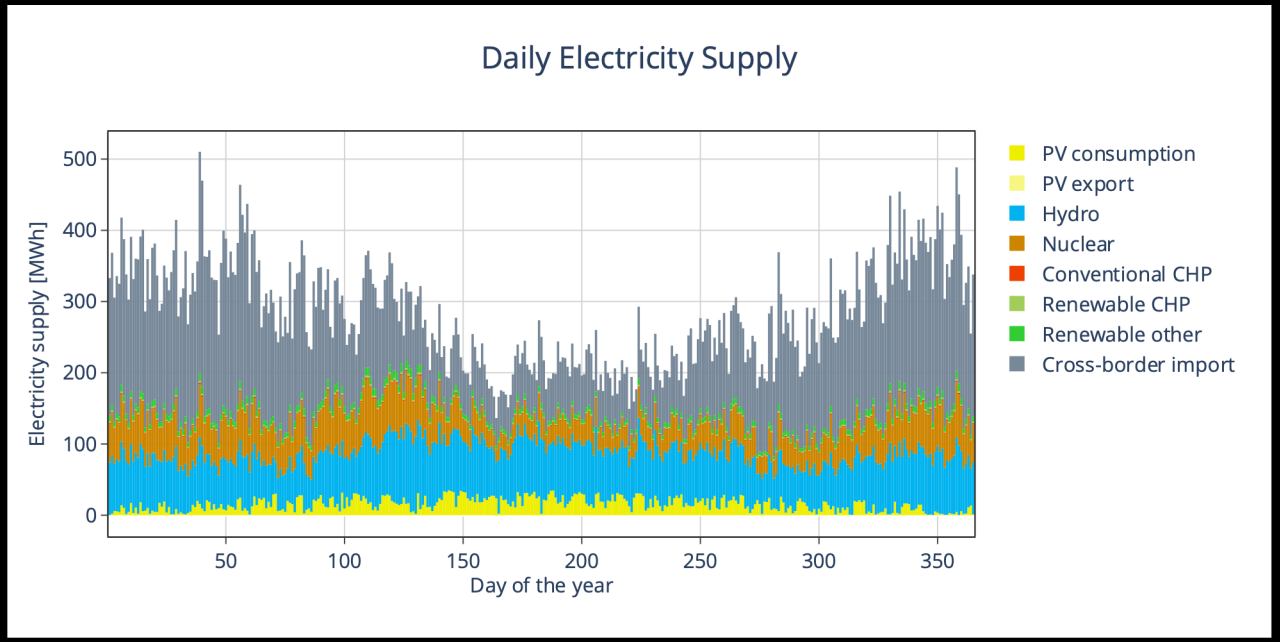




District Energy Model – Case Study

Example: Allschwil (BL)

Scenario: «as-is»



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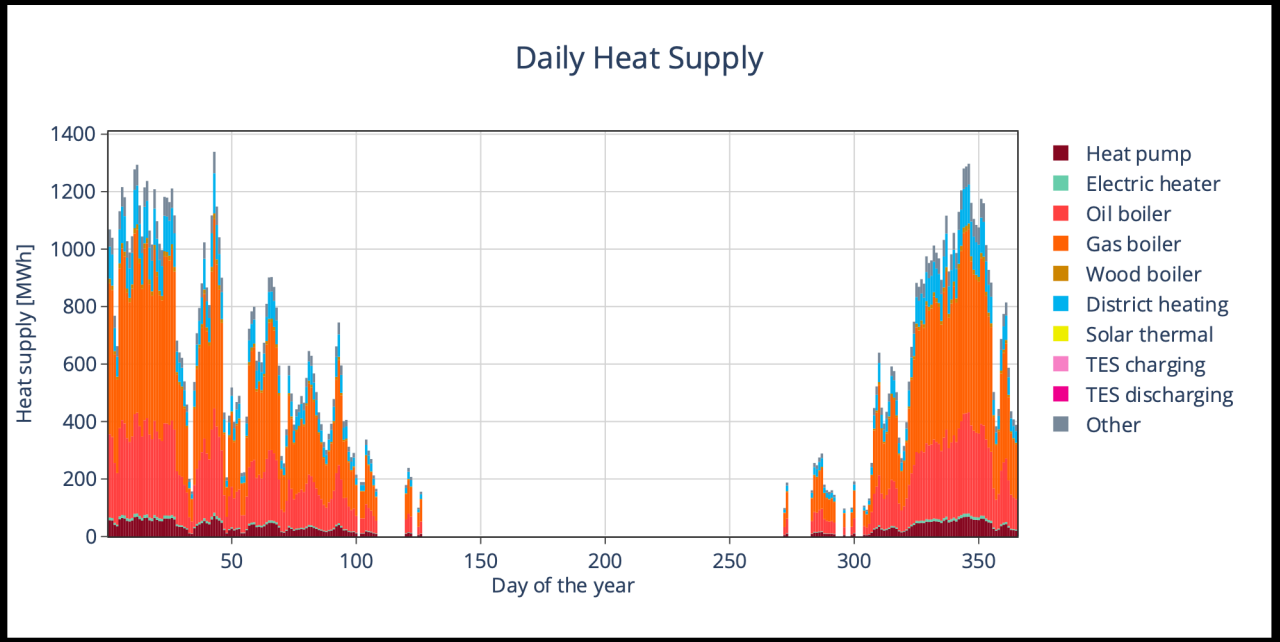
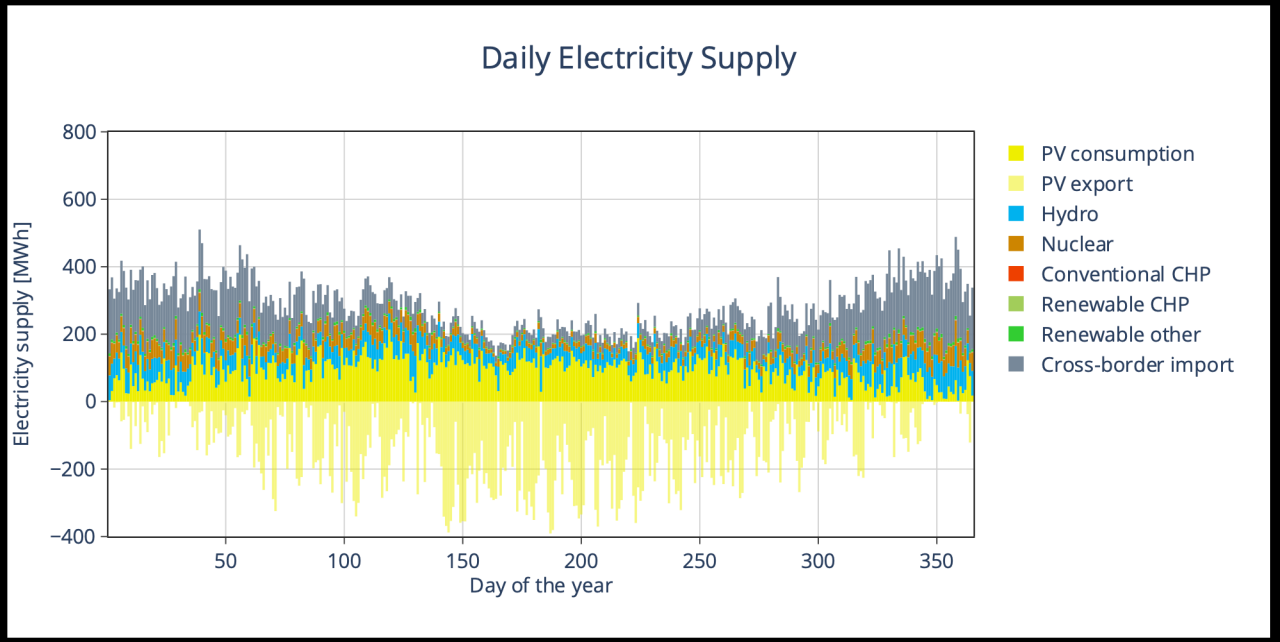


District Energy Model – Case Study

Example: Allschwil (BL)

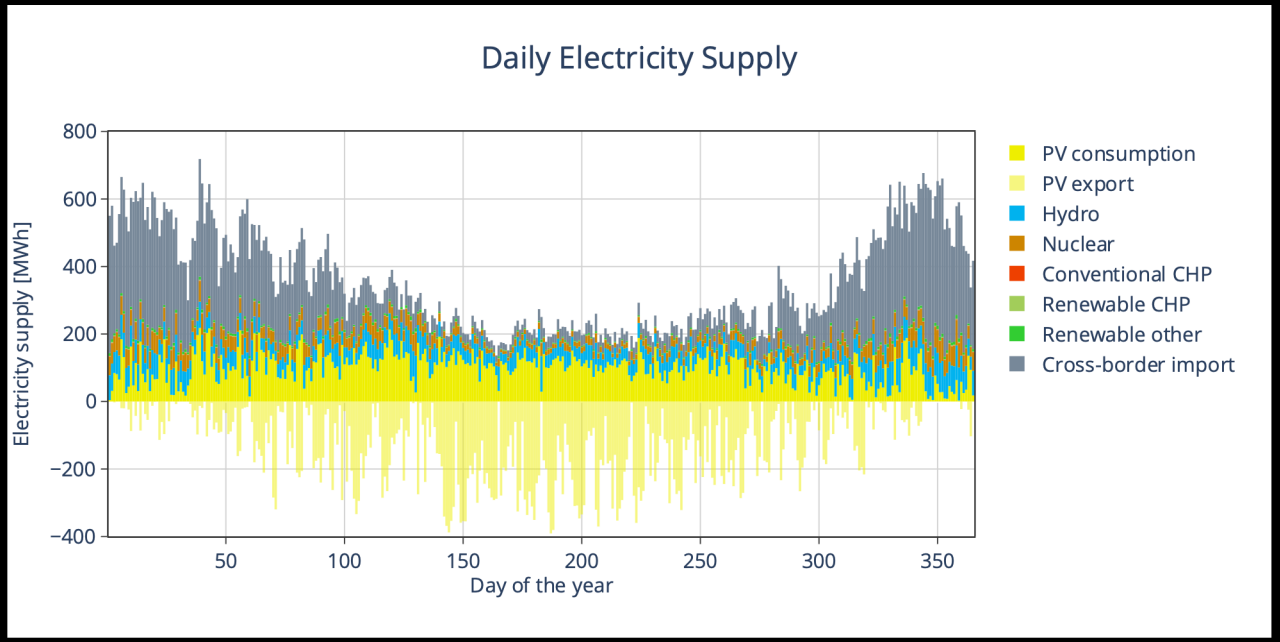
Scenario: 80% PV integration



District Energy Model – Case Study

Example: Allschwil (BL)

Scenario: 80% PV integration, 80% heating system replacement



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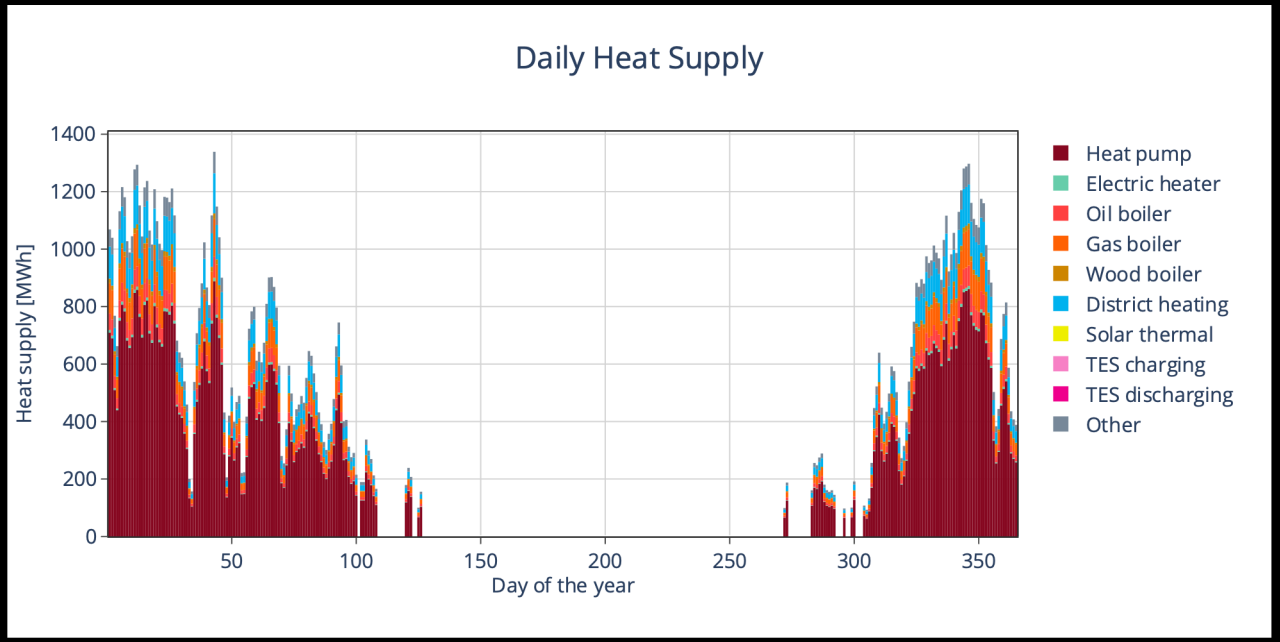
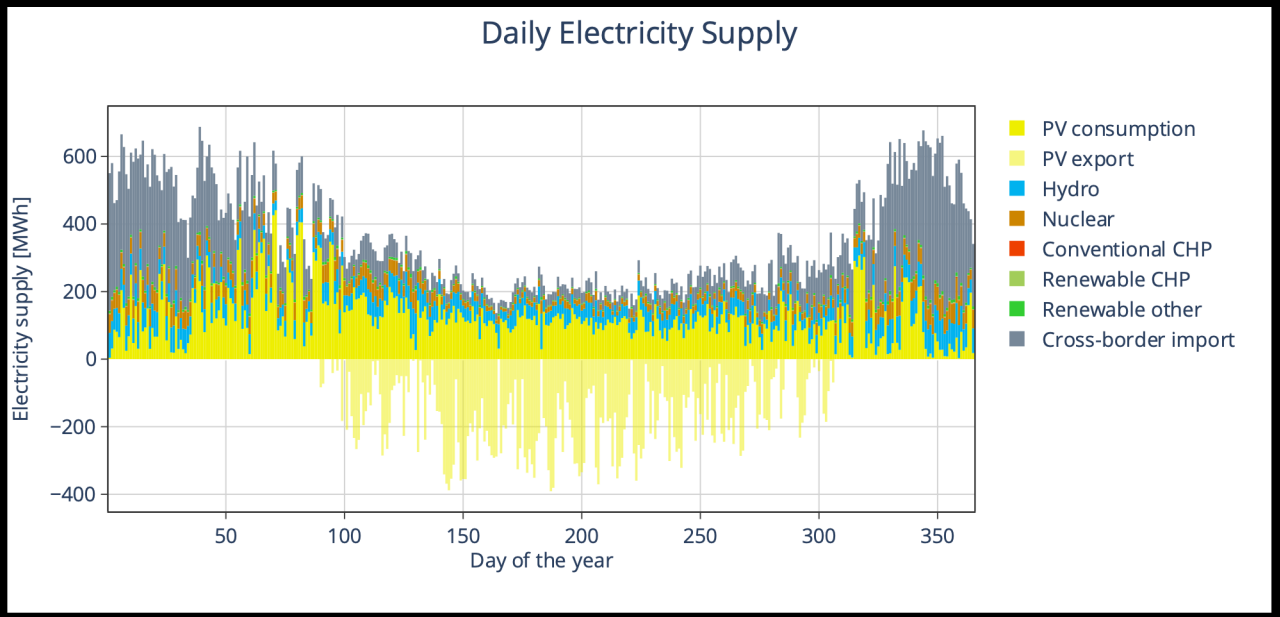


District Energy Model – Case Study

Example: Allschwil (BL)

Scenario: 80% PV integration, 80% heating system replacement, 2GWh Thermal Energy Storage



District Energy Model – Case Study

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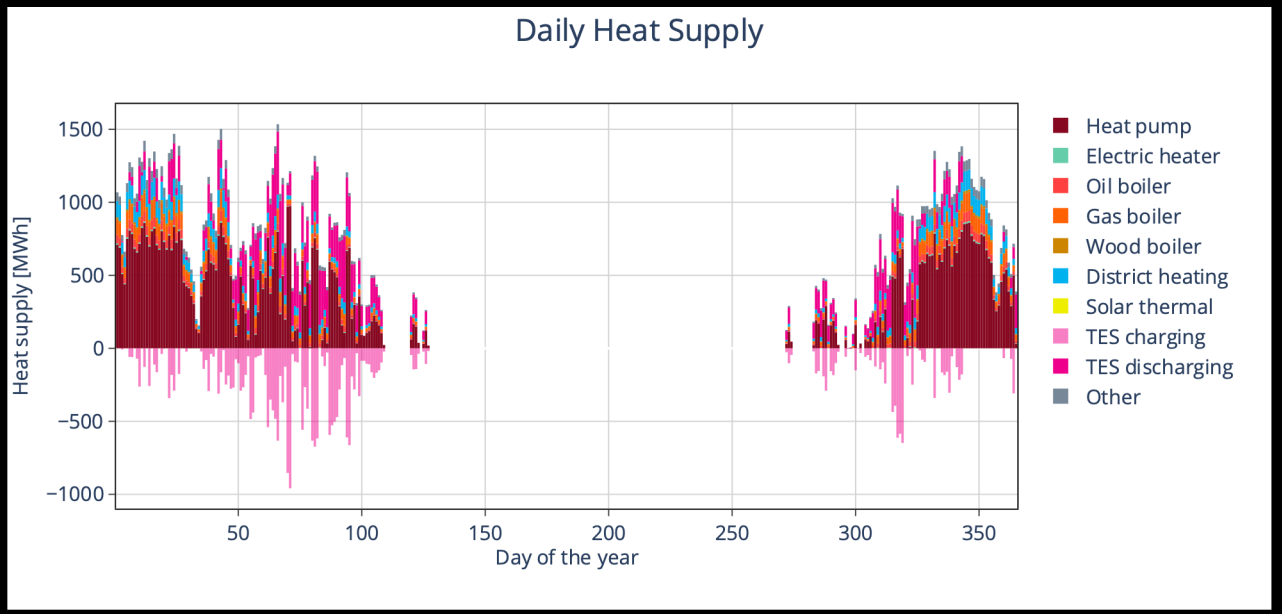

District Energy Model – Case Study

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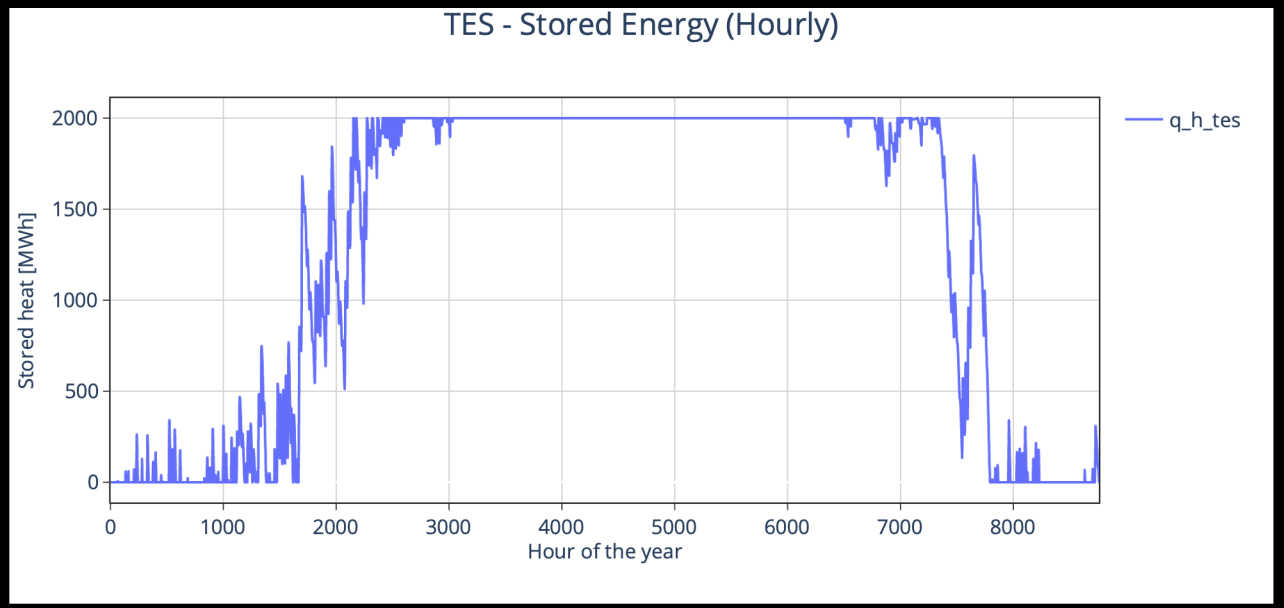
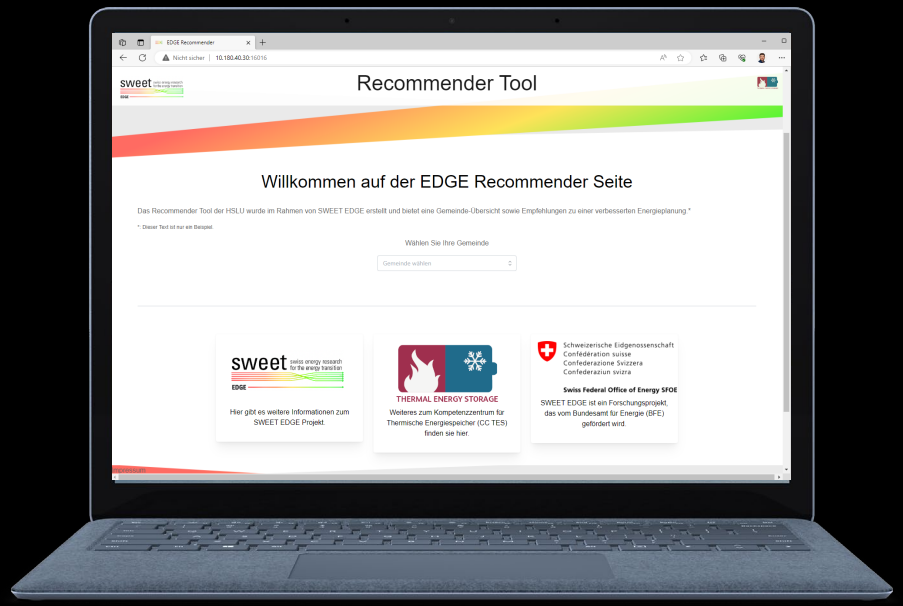


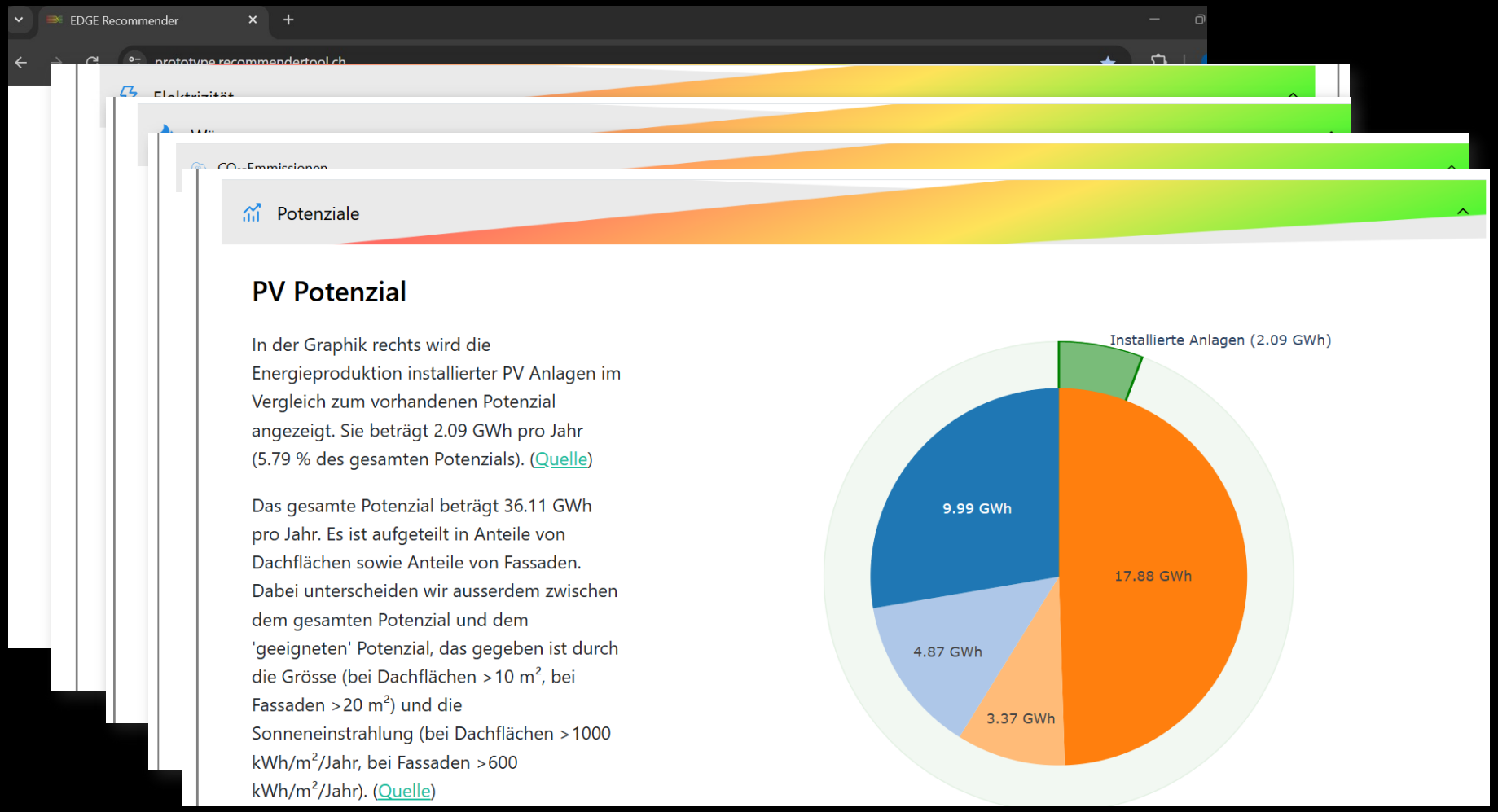
www.prototype.recommendertool.ch



Caveats:

- Language: German
- Prototype
- Designed exclusively for computer screens

www.prototype.recommendertool.ch



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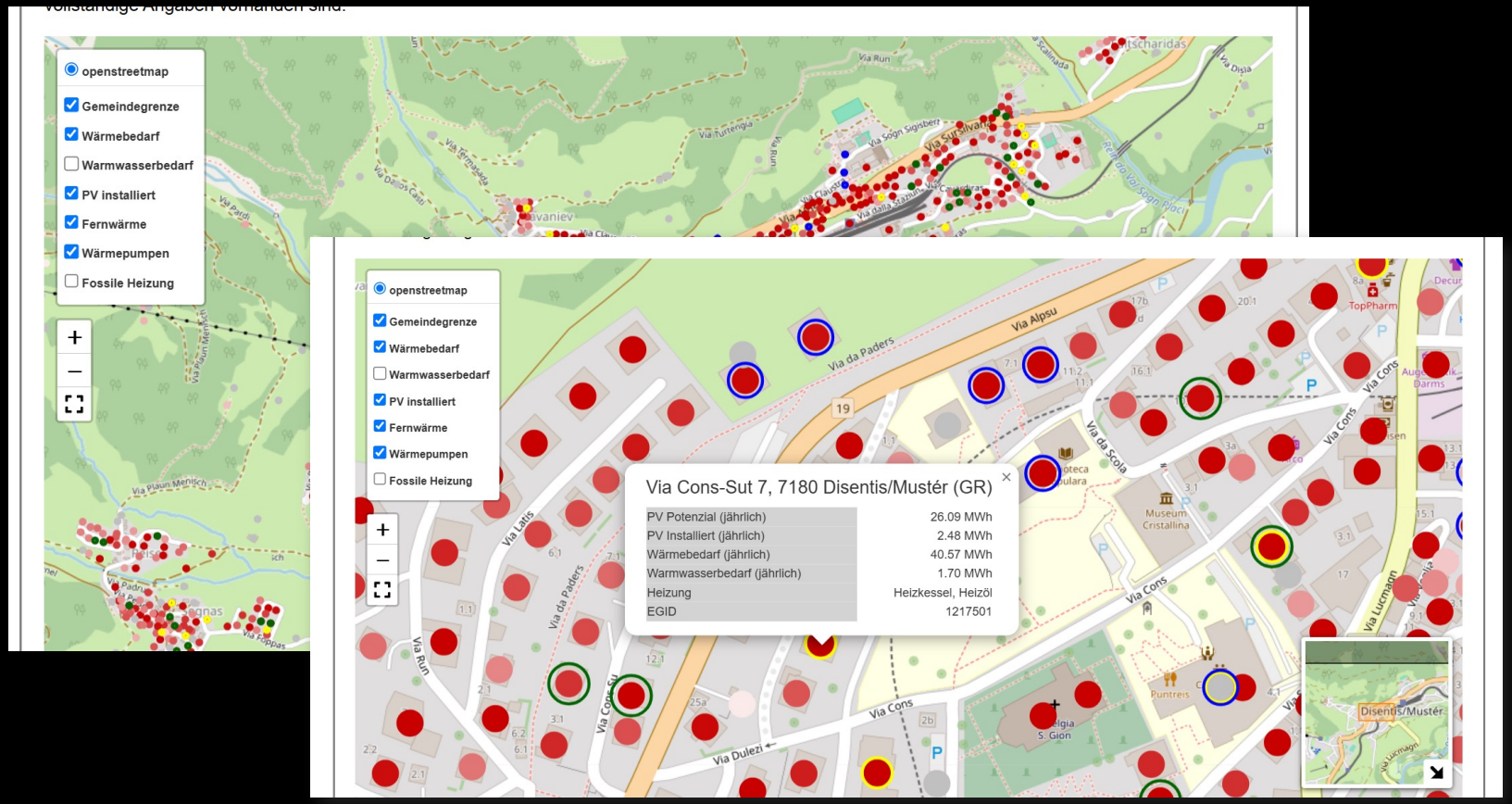


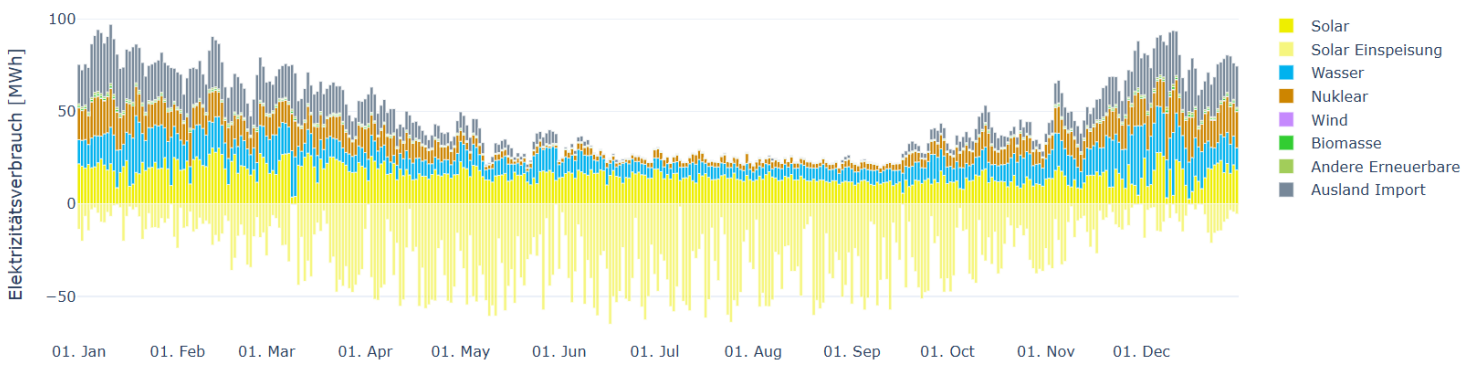
www.prototype.recommendertool.ch

Vergleich Elektrizitätsverbrauch

Hier sind die Zusammensetzungen des Elektrizitätsverbrauchs im Ist-Zustand (Status Quo) und im gewählten Szenario gegenübergestellt. Darunter können die beiden Jahresprofile verglichen werden. Negative Werte kennzeichnen den überschüssigen Strom, der in der Gemeinde nicht verwertet werden kann und somit ins regionale resp. nationale Netz eingespeist wird.

Status Quo | Gewähltes Szenario

Täglicher Elektrizitätsverbrauch | Wöchentlicher Elektrizitätsverbrauch



However . . .

- A model is only as good as the provided data
- Relying on many assumptions

→ **More accurate data can improve the results**

→ **Feedback is welcome!**

Looking forward to your questions!

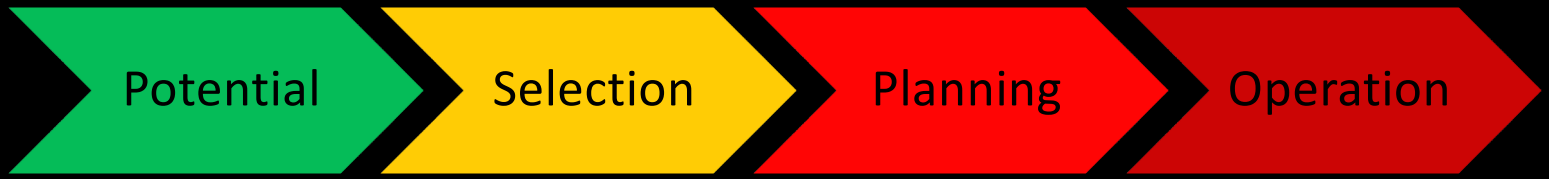
Lucerne School of Engineering and Architecture
Institute of Mechanical Engineering and Energy Technology IME

Ueli Schilt
Research Associate Doctoral Student

ueli.schilt@hslu.ch

Why is energy planning difficult?

Project phases

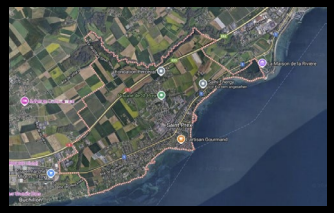


Which options? | Which option is best? | How to build it? | How to get it work?

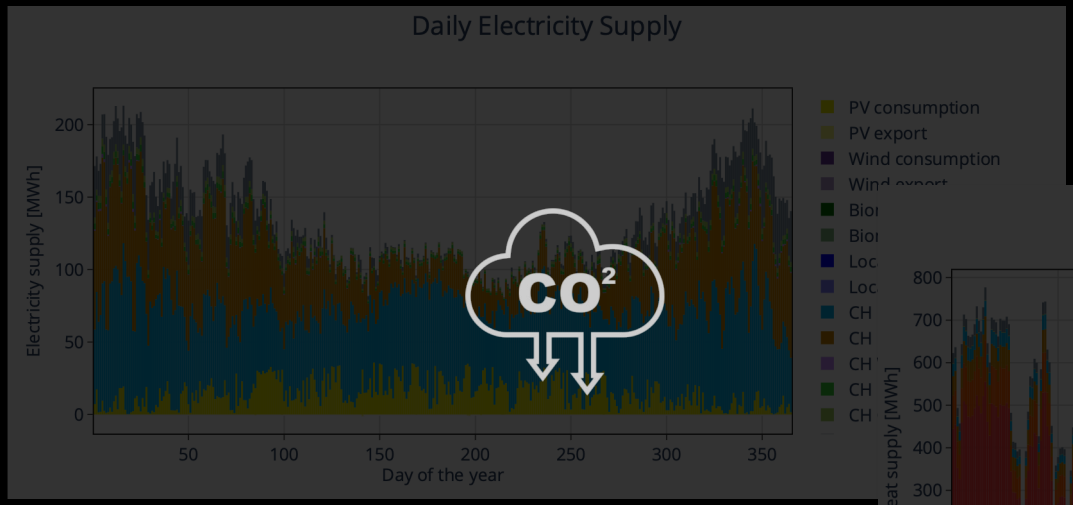
Single buildings

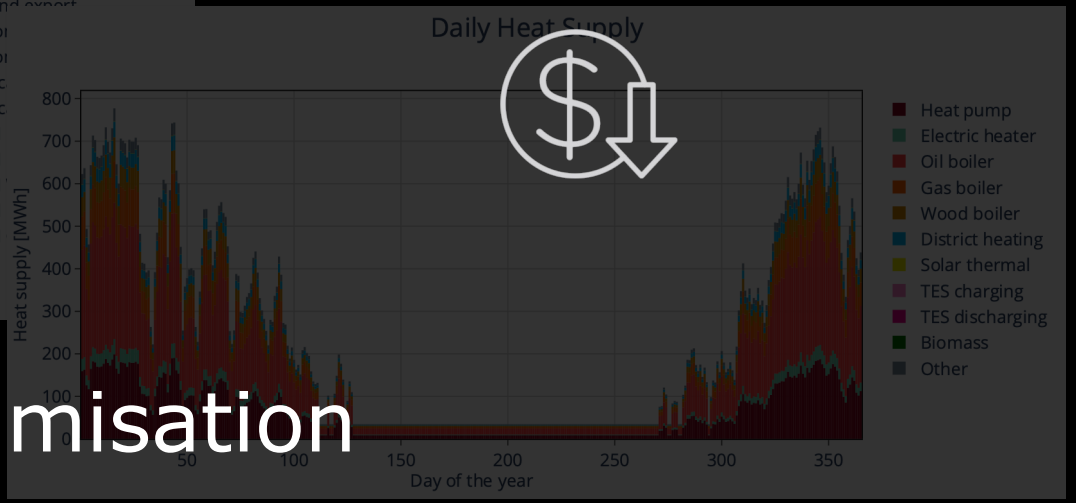
Districts

Community

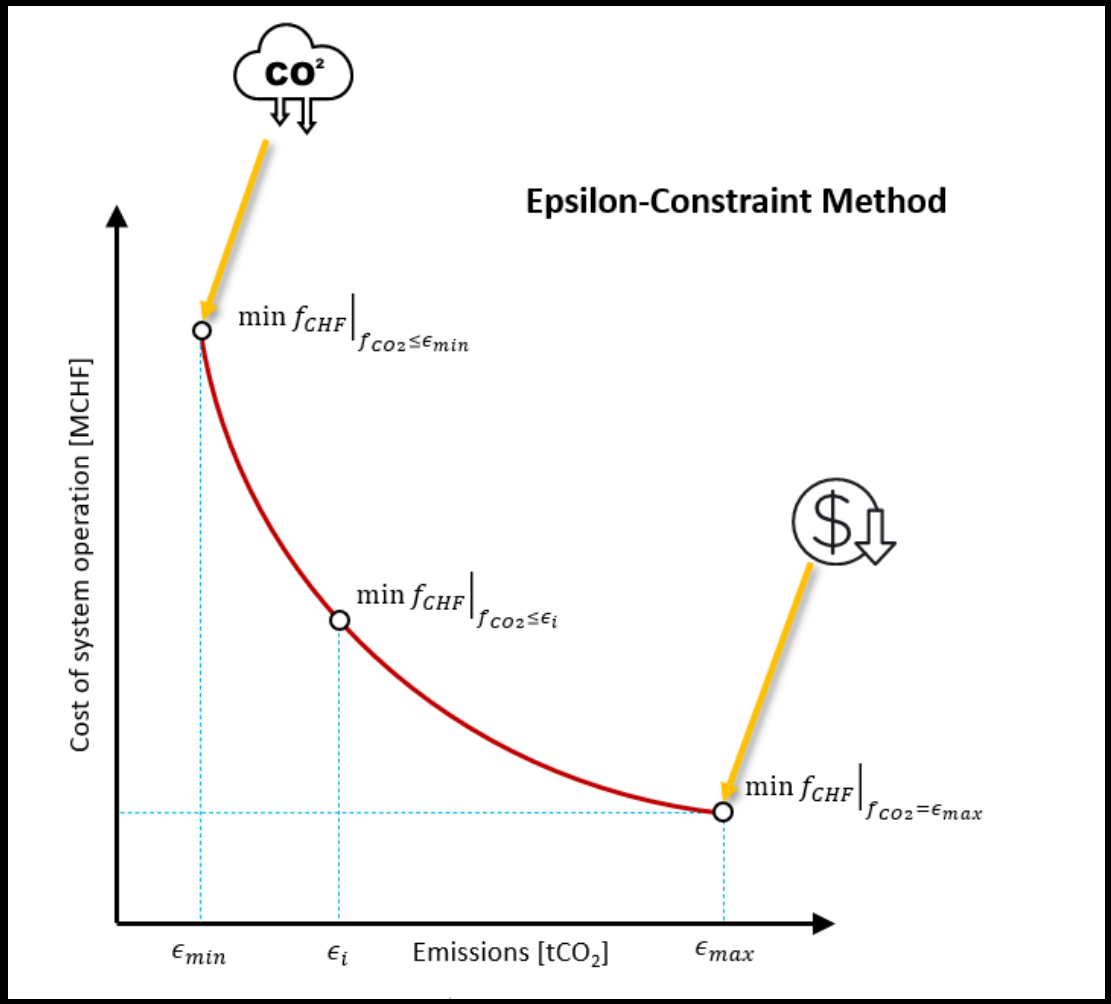


What is the optimal solution?

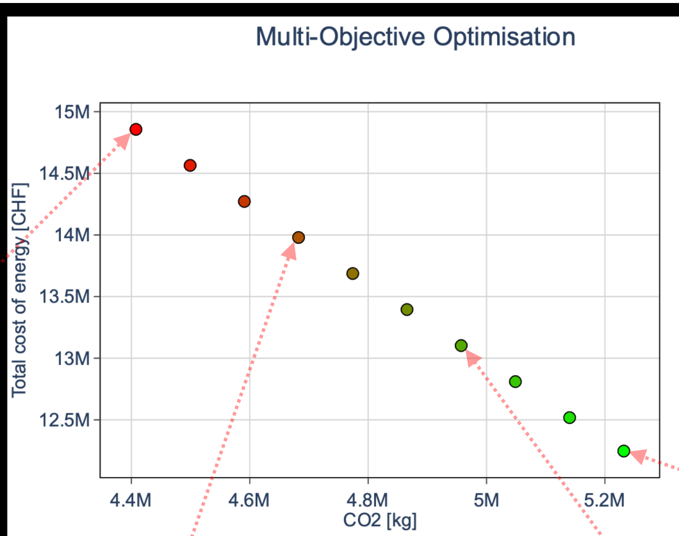




Optimisation


Epsilon-Constraint Method
$\min f_{CHF}\big|_{f_{CO_2} \leq \epsilon_{min}}$
$\min f_{CHF}\big|_{f_{CO_2} \leq \epsilon_i}$
$\min f_{CHF}\big|_{f_{CO_2} = \epsilon_{max}}$
Cost of system operation [MCHF]
ϵ_{min}
ϵ_i
Emissions [tCO$_2$]
ϵ_{max}

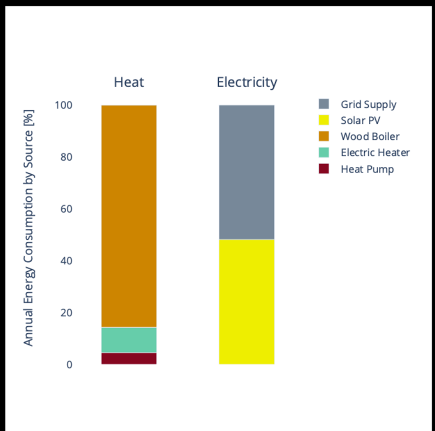
Sirnach (TG)

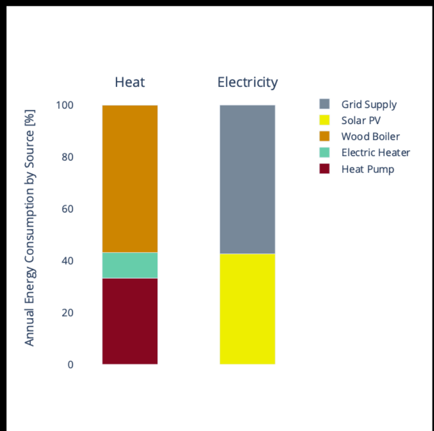


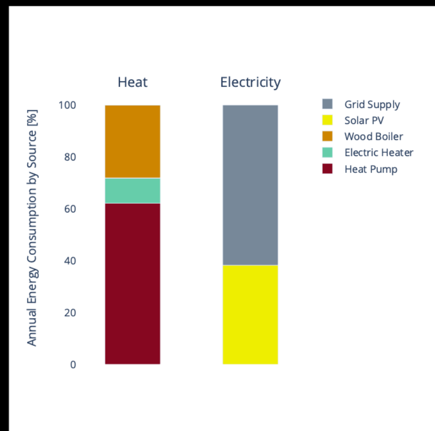
Without Thermal Energy Storage

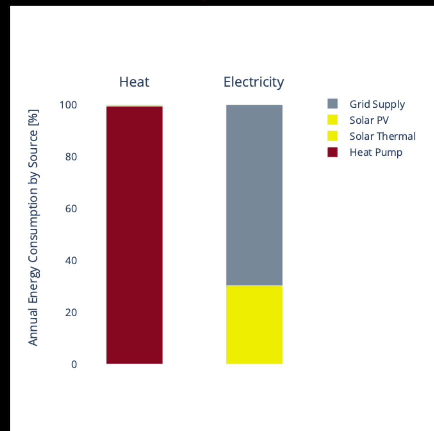
Not considered:

- *Wind*
- *Biomass*

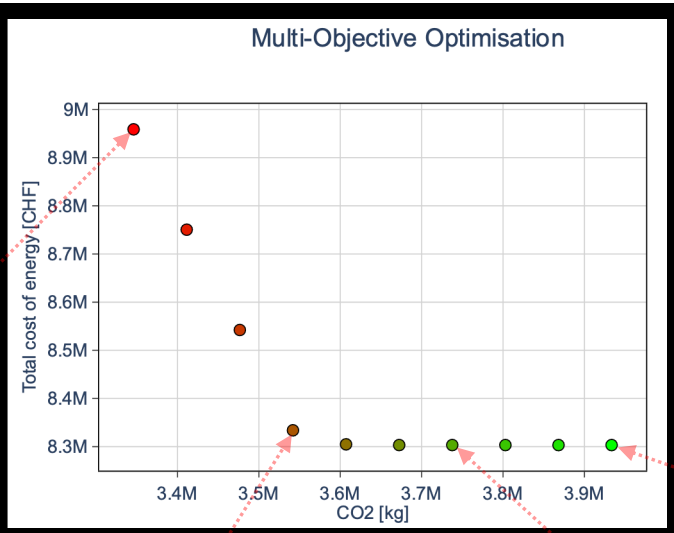








Sirnach (TG)



With Thermal Energy Storage

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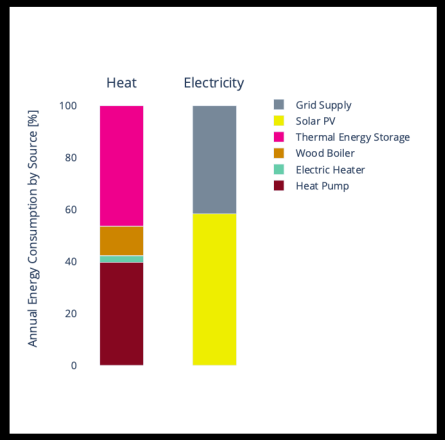
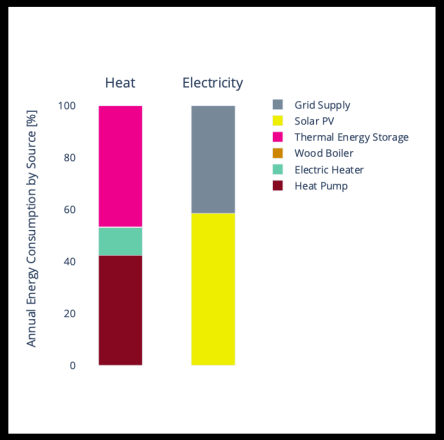
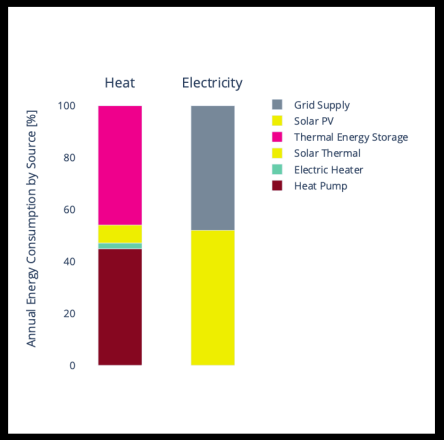
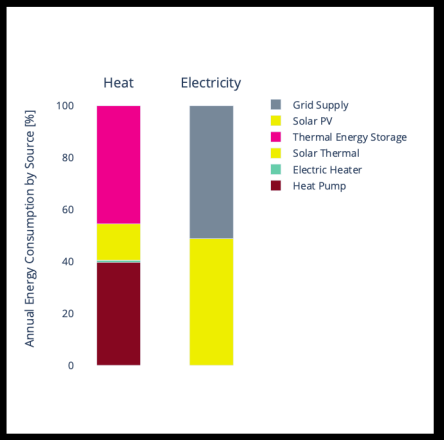
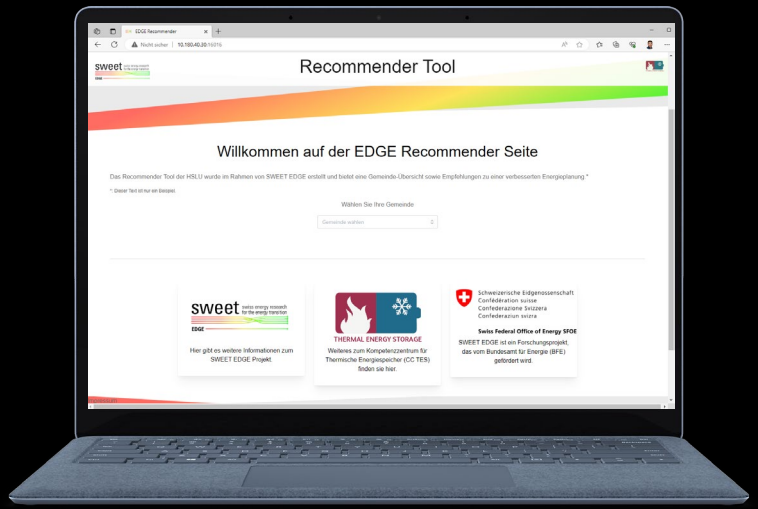
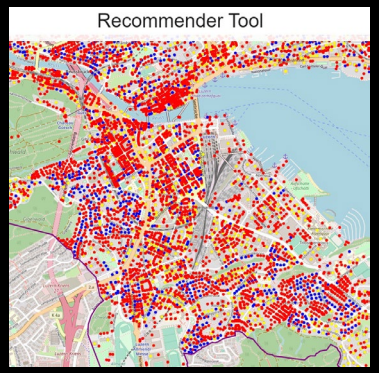


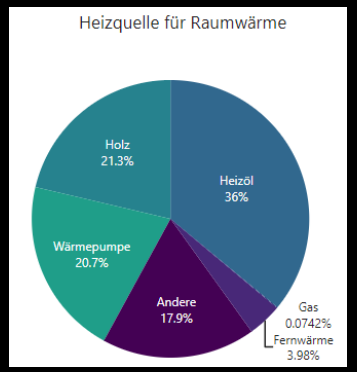


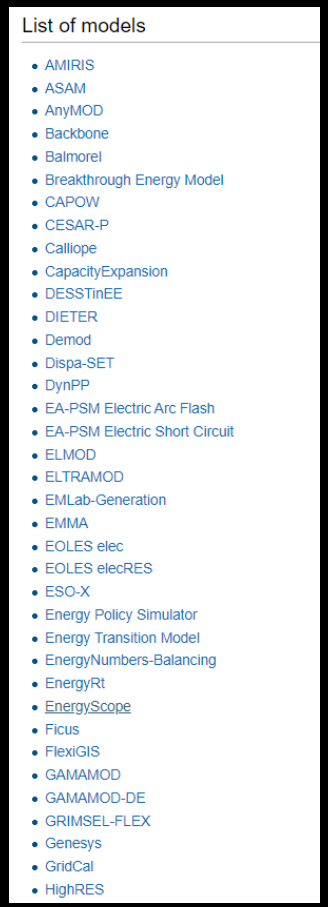





Recommender Tool
Willkommen auf der EDGE Recommender Seite
Das Recommender Tool der HSLU wurde im Rahmen von SWEET EDGE erstellt und bietet eine Gemeinde-Übersicht sowie Empfehlungen zu einer verbesserten Energieplanung.*
* Dieser Text ist nur ein Beispiel.
Wählen Sie Ihre Gemeinde
Gemeinde wählen
sweet
EDGE
Hier gibt es weitere Informationen zum SWEET EDGE Projekt.
THERMAL ENERGY STORAGE
Weiteres zum Kompetenzzentrum für Thermische Energiespeicher (CC TES) finden sie hier.
Swiss Federal Office of Energy SFOE
SWEET EDGE ist ein Forschungsprojekt, das vom Bundesamt für Energie (BFE) getördert wird.


Recommender Tool


Heizquelle für Raumwärme
Holz
21.3%
Heizöl
36%
Wärmepumpe
20.7%
Andere
17.9%
Gas
0.0742%
Fernwärme
3.98%



(1)

Many models exist, but...

- Not open-source
- Not multi-sectoral
- No optimisation (only simulation)
- Lack of modelling detail (e.g. modelling of storage)
- Only applicable to specific community (→ lack of comparison)

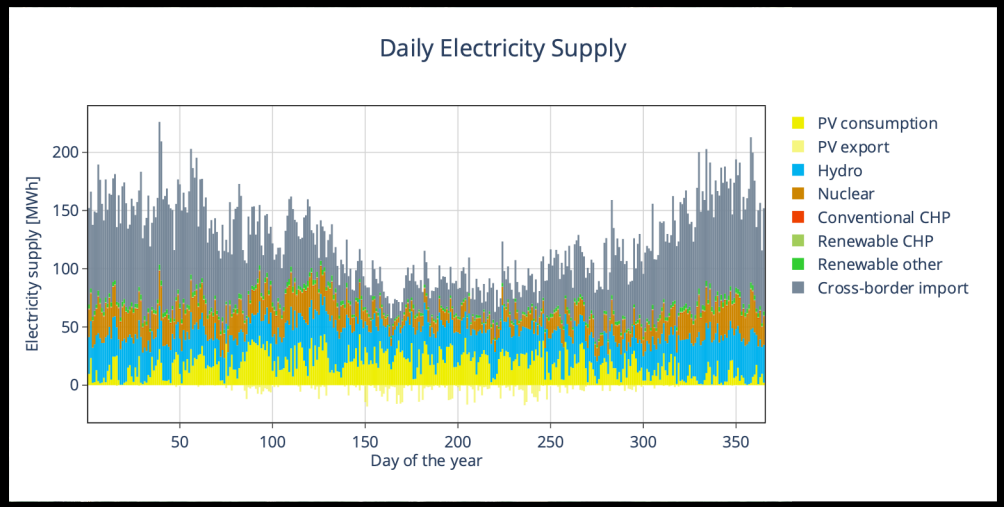
(1) https://wiki.openmod-initiative.org/wiki/Open_Models

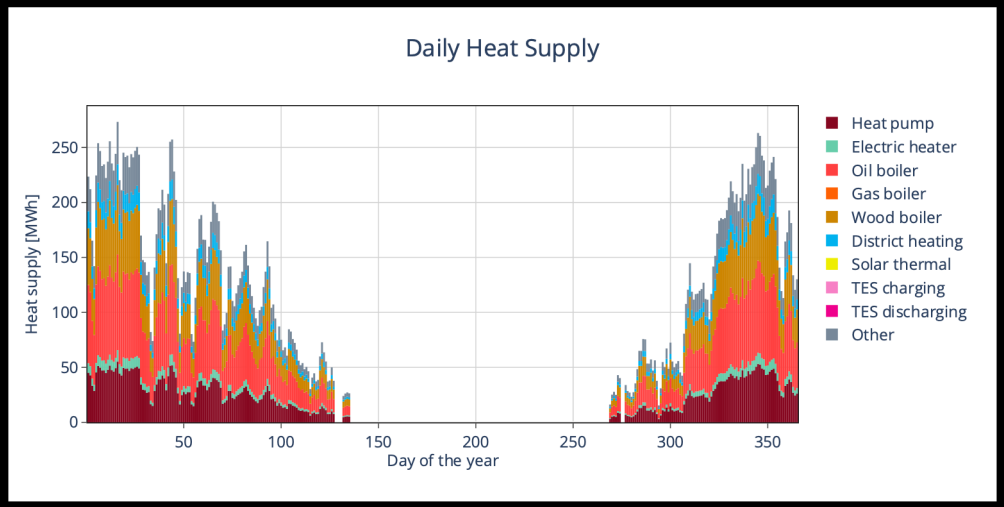
Research gaps:

- Impact of temporal resolution on MES with high shares of renewable energy[1]
- Low time-resolutions leading to underestimation of system flexibility in systems with high shares of decentralised sources[1,2]
- Building thermal dynamics modelling mostly based on simulation data or controlled test-dwellings[3]

(1) Heendeniya et al. (2020), (2) Ma et al. (2013), (3) Leprince et al. (2022)

Example: Buttisholz «as-is»





Example: Buttisholz **50%** PV integration, **50%** heating replacement, **2 GWh** TES