Der nächste intelligente Schritt im Gebäudebereich

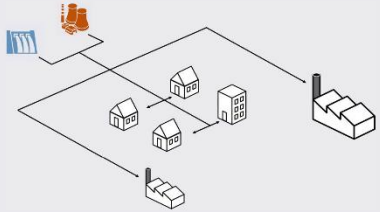
29. Energie-Lunch: Künstliche Intelligenz im Gebäude, 22. April 2021

Philipp Heer
Deputy Head Urban Energy Systems Laboratory, Empa

Motivation

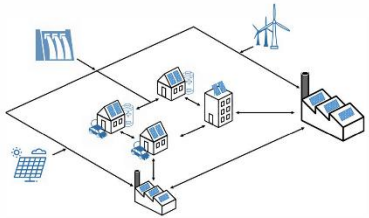
STATUS QUO

CENTRAL GENERATION



2050

DECENTRAL GENERATION

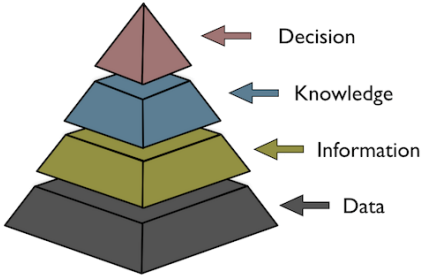


STATUS QUO

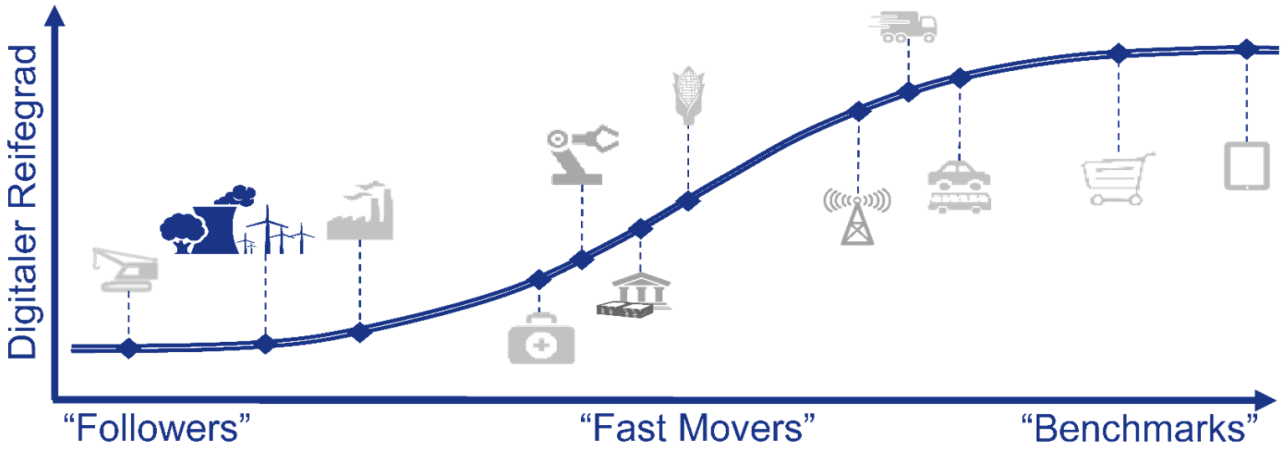
DOMINATING FOSSILE ENERGY CARRIERS

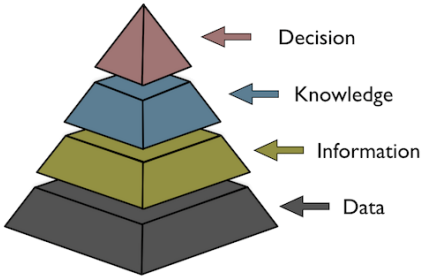
2050

DOMINATING ELECTRICITY AS ENERGY CARRIER



Digital Maturity Assessment

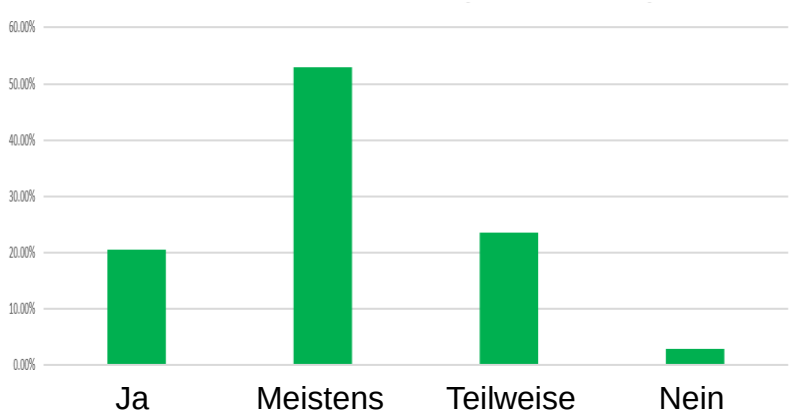




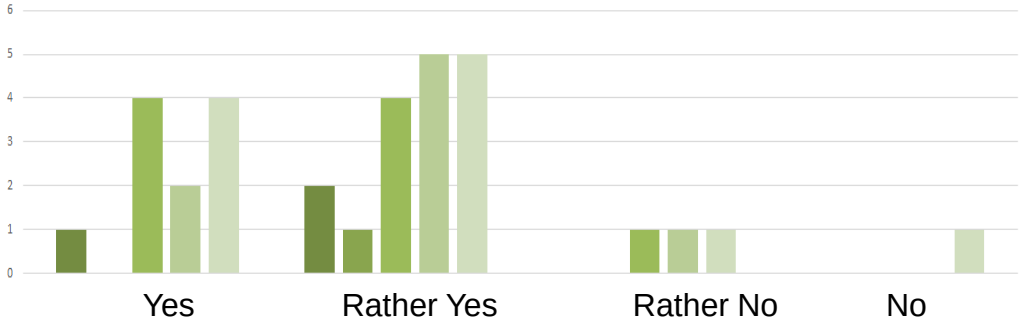
Source: Digital Maturity Assessment; TM Forum 2018

Umfrage bei Gebäudeeigentümern (~9’500 Gebäude)

Funktionieren ihre technischen Installationen gemäss ihren Erwartungen?



Denken sie ihre Messdaten könnten besser genutzt werden?



Full interconnectivity.	Predictive control. EE Class A+
Interconnected fields.	Premium room automation. EE Class A
Partially interconnected fields.	Basic room automation. EE Class B
Individual fields.	Basic room automation. EE Class C
Individual fields.	No Room automation. EE Class D

https://www.energie-cluster.ch/de/wissenstransfer/innovationsgruppen-(ig)/konnektivitaet-im-gebaeude-(ig-kig)/projekt-konnektivitaet-im-gebaeude-(kig)-6059.html

Was sind Smarte Gebäude?

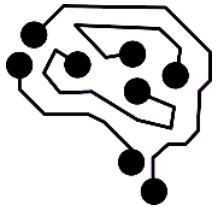
Klassischer Ansatz: Gebäudeautomation bedient drei Kategorien:

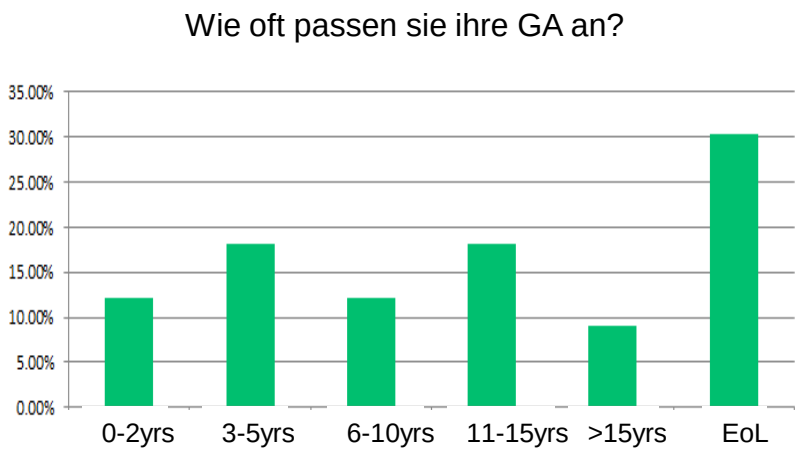
- Sicherheit
- Komfort
- (Energie) Effizienz

Smarter Ansatz: Gebäudeautomation ist eine **Plattform** die in einem grösseren Kontext, voll integriert, **Use cases** mehrerer Stakeholder bedient.

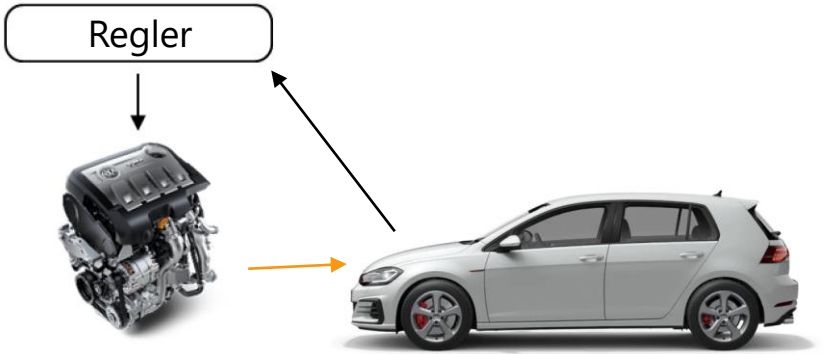
e.g. 49 Use cases in
«Navigating_SmartBuildings_Whitepaper»
https://crem.locatee.com/use-case-navigator

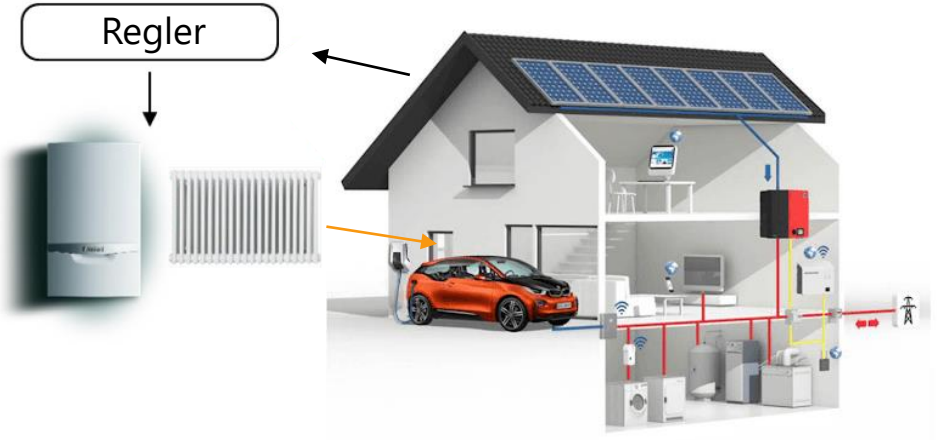
Gebäudeautomation im Wandel?



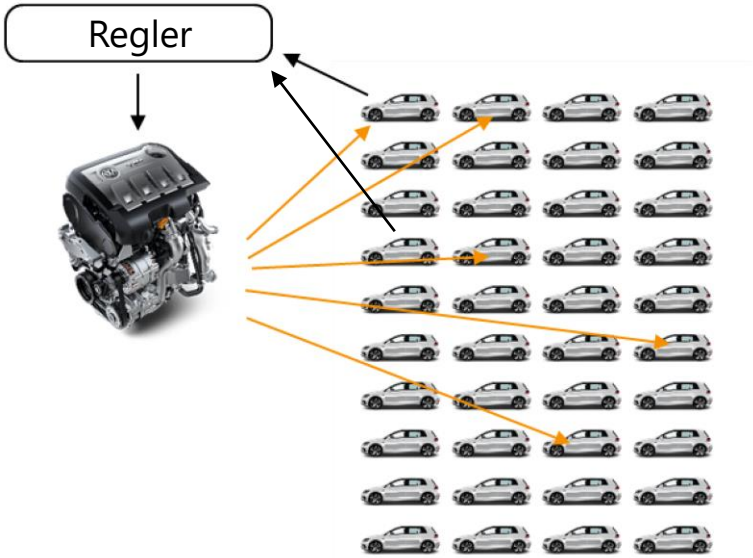


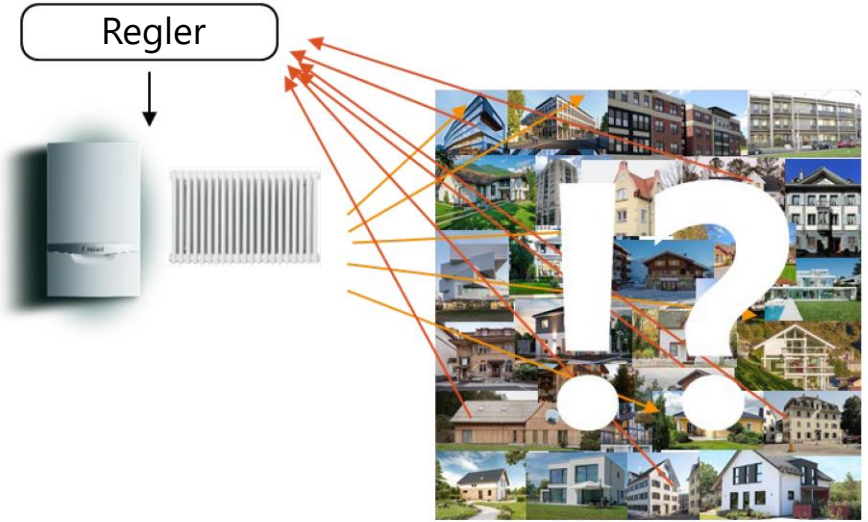
Regler in verschiedenen Branchen





Regler in verschiedenen Branchen





Adaptive Regler, lernende Regler

Regler

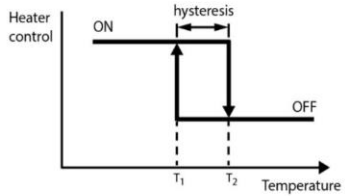
Reglertyp

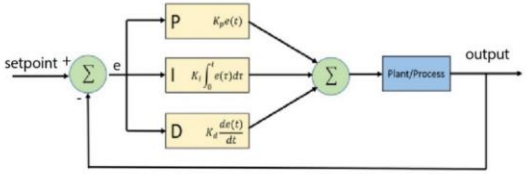
Zweck

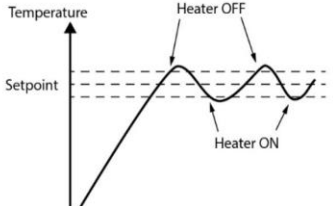
Konstante Raumtemperatur

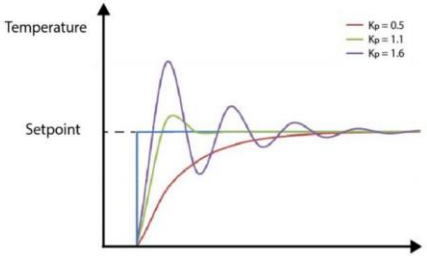
Modell/Parameter

Regelbasiert





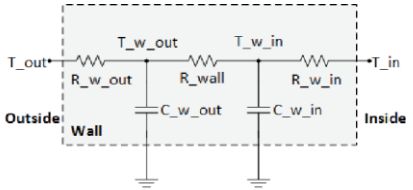




Hysterese

PID

Modell basiert

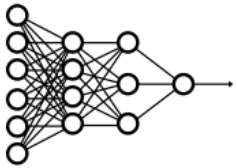


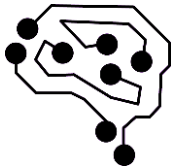
$$\underset{x,\ u}{\text{minimize}} \quad \sum_{j=0}^{N-1} J(x_{k+j+1},\ u_{k+j})$$

$$\text{subject to} \quad x_{k+j+1} = f(x_{k+j}, u_{k+j}, d_{k+j})$$
$$(x_{k+j+1},\ u_{k+j}) \in (\mathcal{X},\ \mathcal{U})$$
$$\forall j \in [0,\ \ldots,\ N-1]$$

MPC

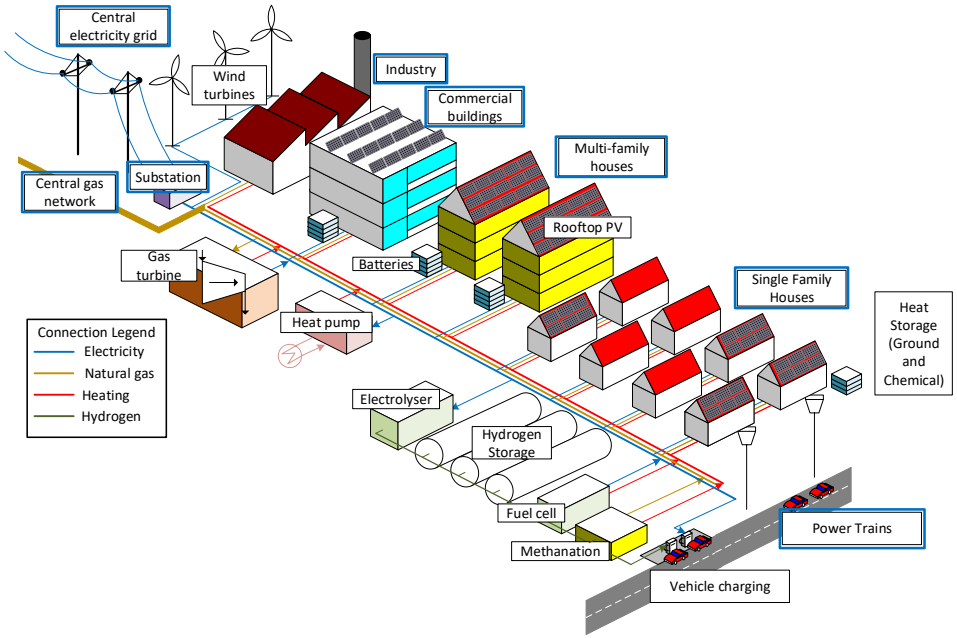
Lernende Regler

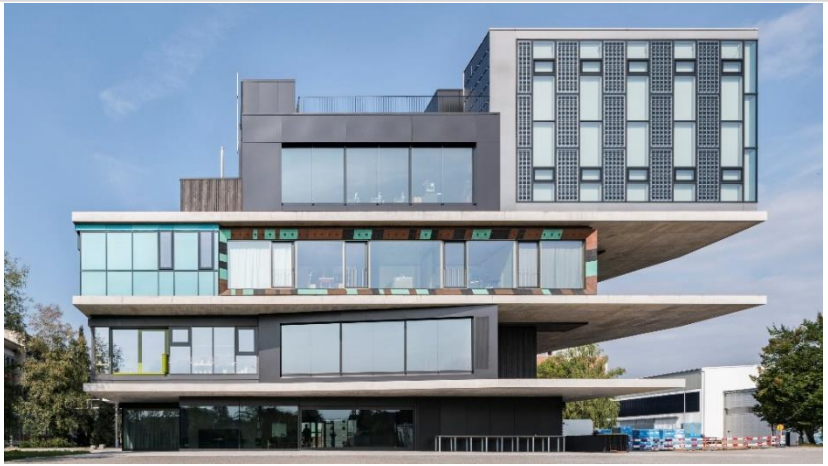




DPC

Der ehub demonstrator der Empa



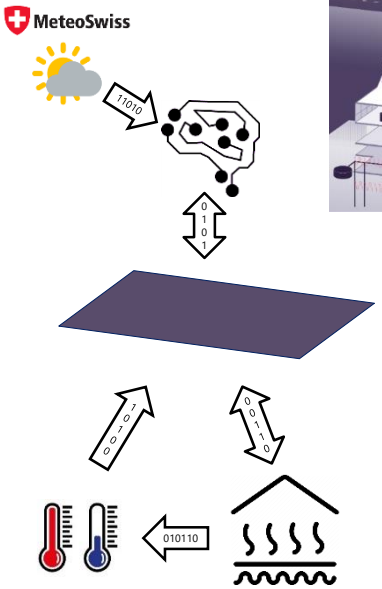


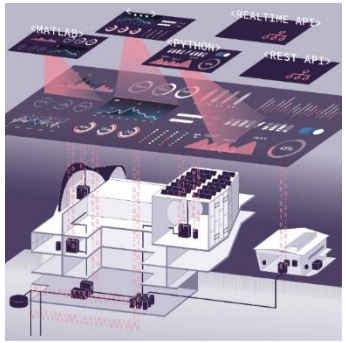
6 Heat pumps
3 Thermal buffers
1 Ice storage unit
⋮
2 Batteries
7 PV and thermal collectors
1 EV charging station
⋮
4 Thermal networks
4 Electrical networks

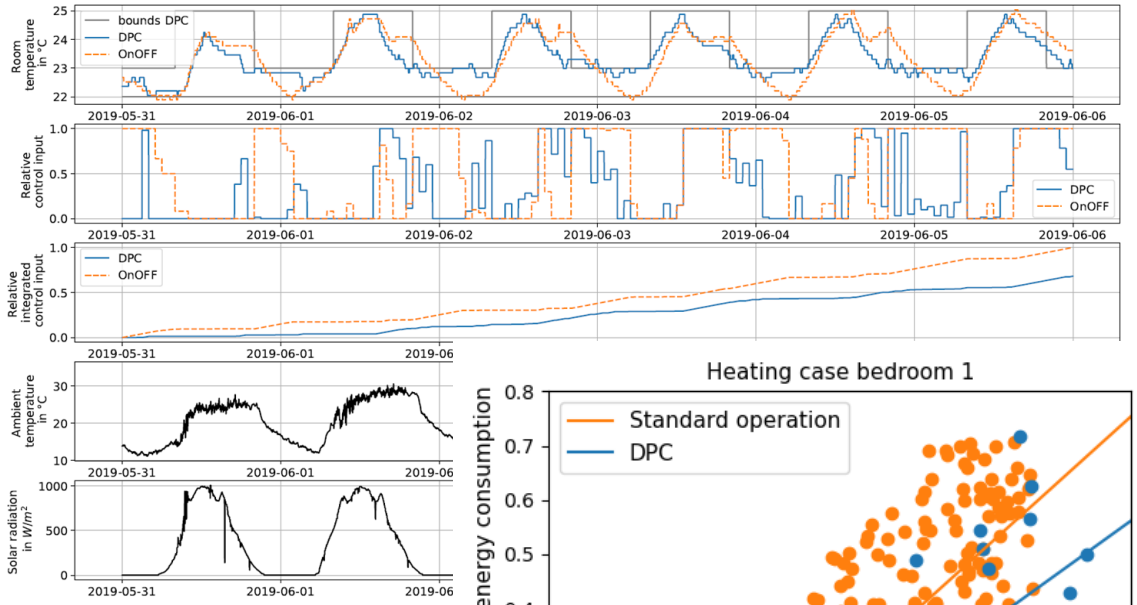
500+ Actors
1100+ Sensors
8000+ Datapoints

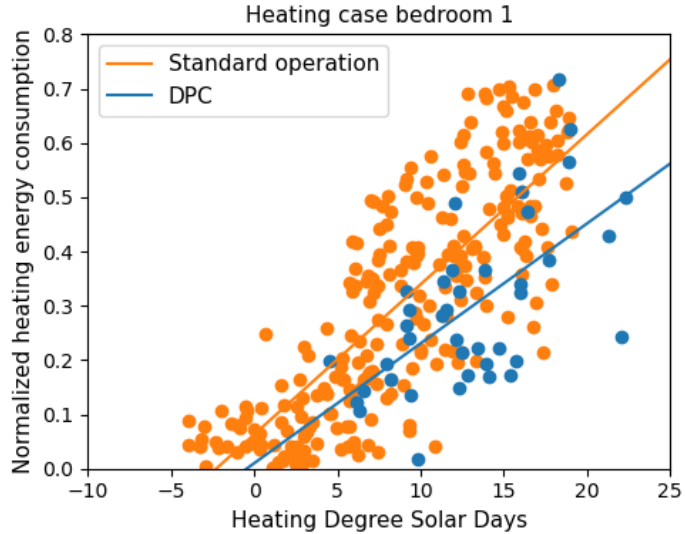
multi energy system

Project: Data Predictive Control – heizen und kühlen mit KI



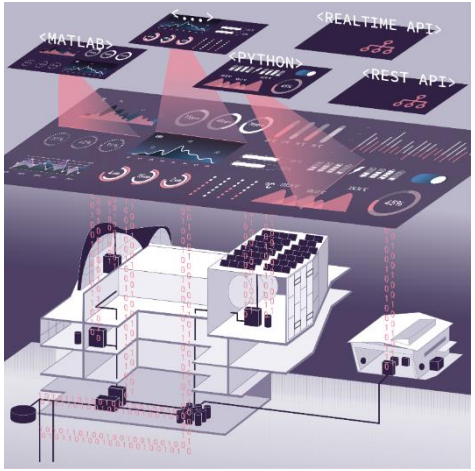


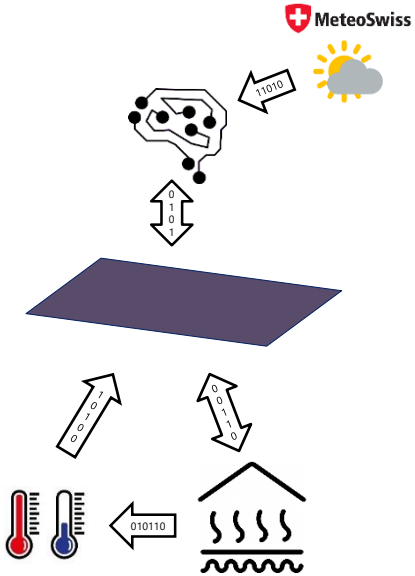




Bünning, F., Huber, B., Heer, P., Aboudonia, A., & Lygeros, J. (2020). Experimental demonstration of data predictive control for energy optimization and thermal comfort in buildings. Energy and Buildings, 211, 109792 (8 pp.). https://doi.org/10.1016/j.enbuild.2020.109792

Project: Data Predictive Control – heizen und kühlen mit KI





25% of heating and cooling energy can be saved with a predictive controller.

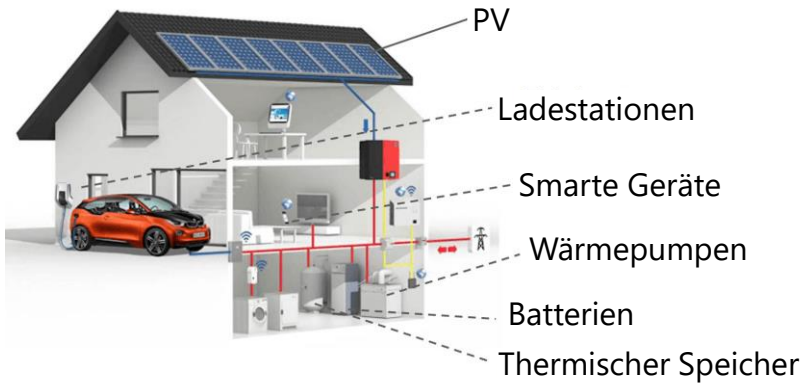
It is possible to achieve both objectives at the same time:

reducing energy cost

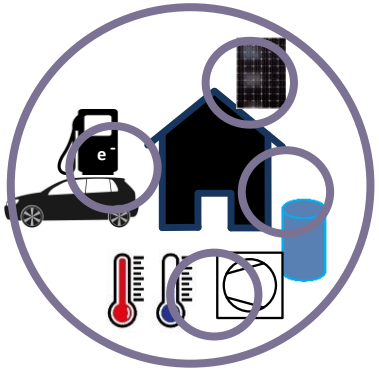
increasing comfort

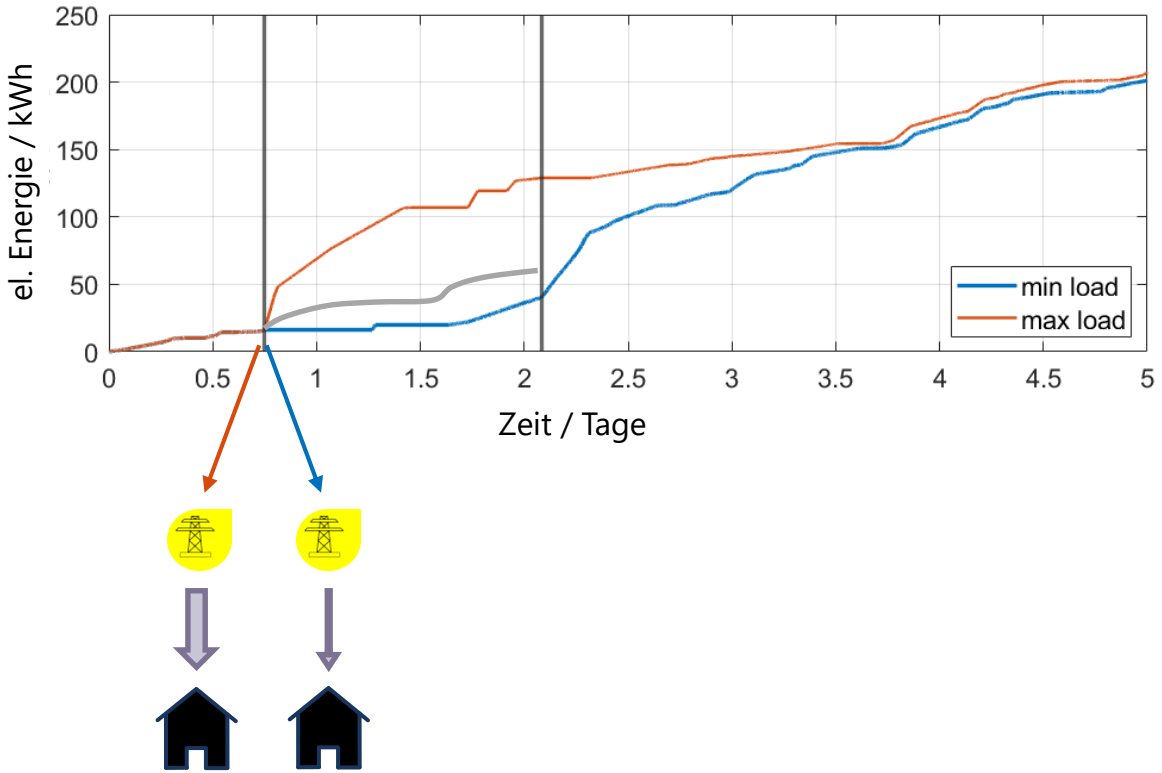
Bünning, F., Huber, B., Heer, P., Aboudonia, A., & Lygeros, J. (2020). Experimental demonstration of data predictive control for energy optimization and thermal comfort in buildings. Energy and Buildings, 211, 109792 (8 pp.). https://doi.org/10.1016/j.enbuild.2020.109792

Von Gebäuden zu Quartieren und Städten

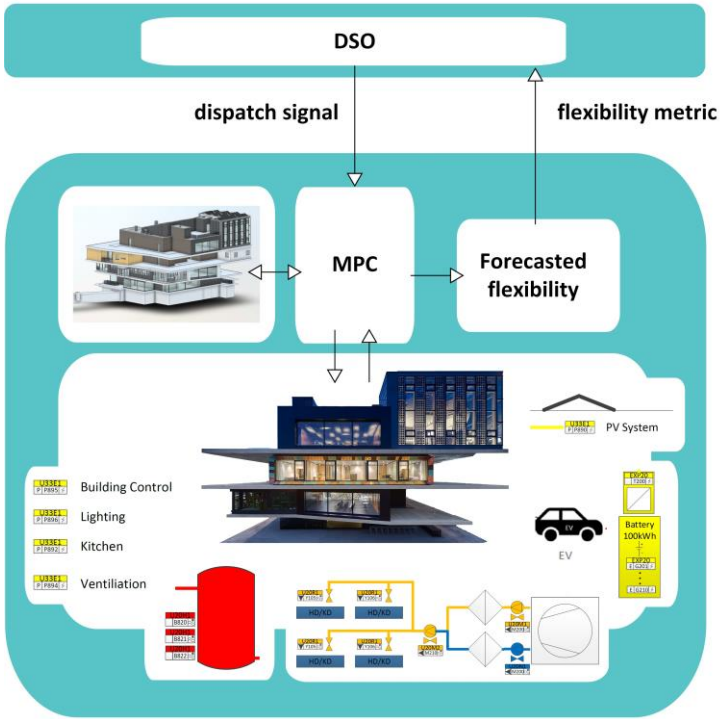


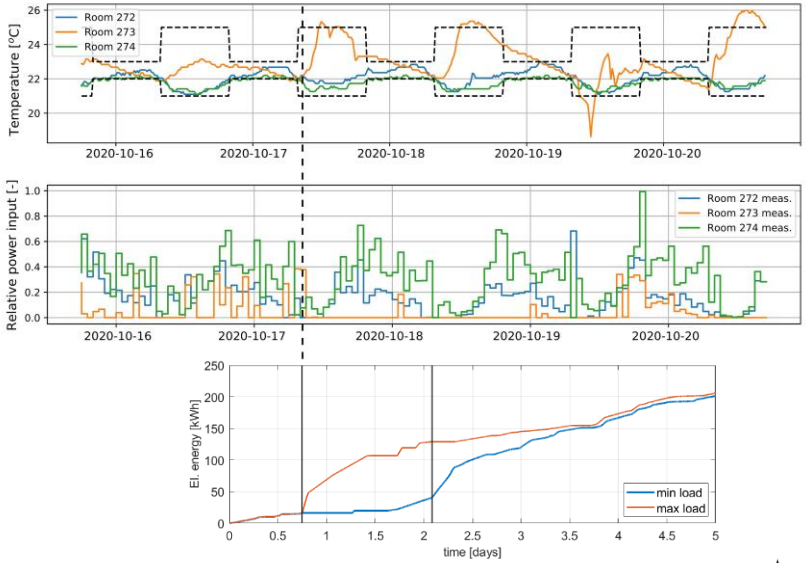
Von Gebäuden zu Quartieren und Städten

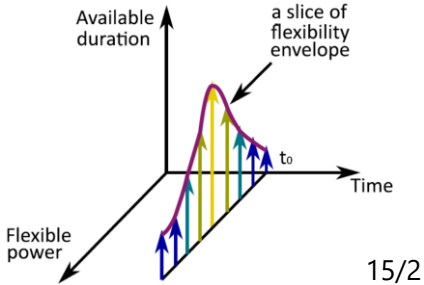




Project: Benefits in districts – quntify and predict energetic flexibility

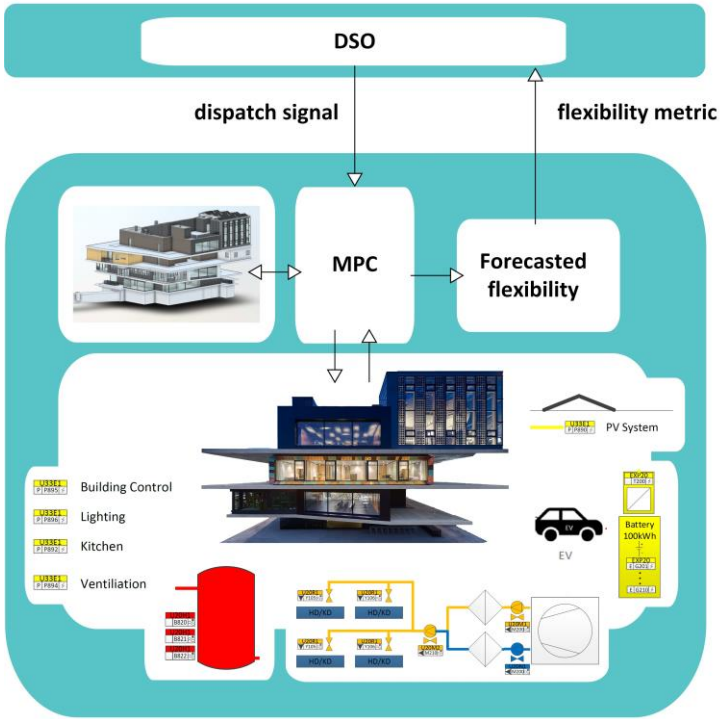


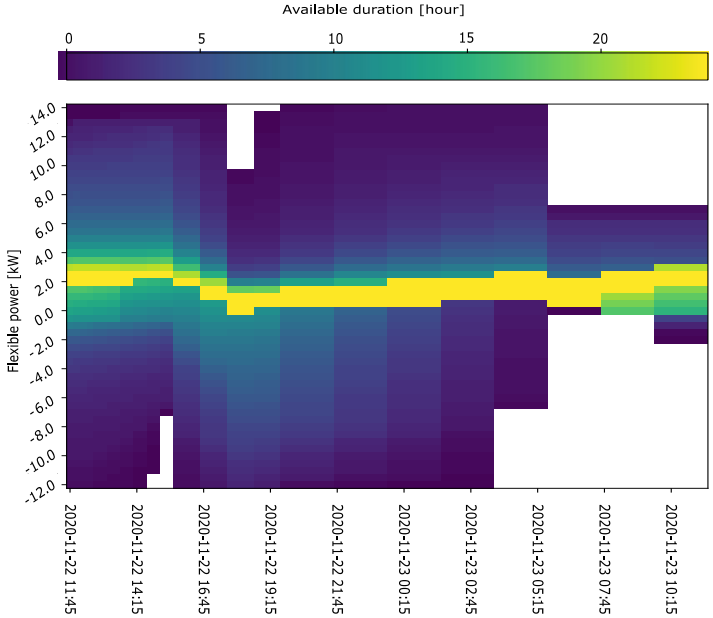


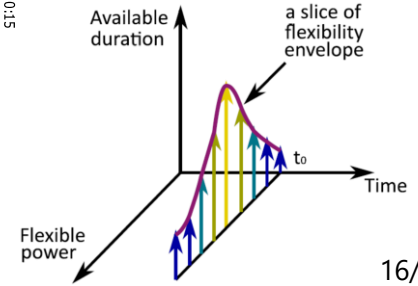


Gasser, J., Cai, H., Karagiannopoulos, S., Heer, P., & Hug, G. (2021). Predictive energy management of residential buildings while self-reporting flexibility envelope. *Applied Energy*, *288*, 116653 (14 pp.). https://doi.org/10.1016/j.apenergy.2021.116653

Project: Benefits in districts – quantify and predict energetic flexibility







Gasser, J., Cai, H., Karagiannopoulos, S., Heer, P., & Hug, G. (2021). Predictive energy management of residential buildings while self-reporting flexibility envelope. *Applied Energy*, *288*, 116653 (14 pp.). https://doi.org/10.1016/j.apenergy.2021.116653

V2x – (V2H, V2V, V2B, V2G)

Schweizer Haushalt: 4’500kWh/a -> ø 12.33kWh/d

17kW Sicherung (GLZ 0.6)

Tesla Model 3*): 50kWh

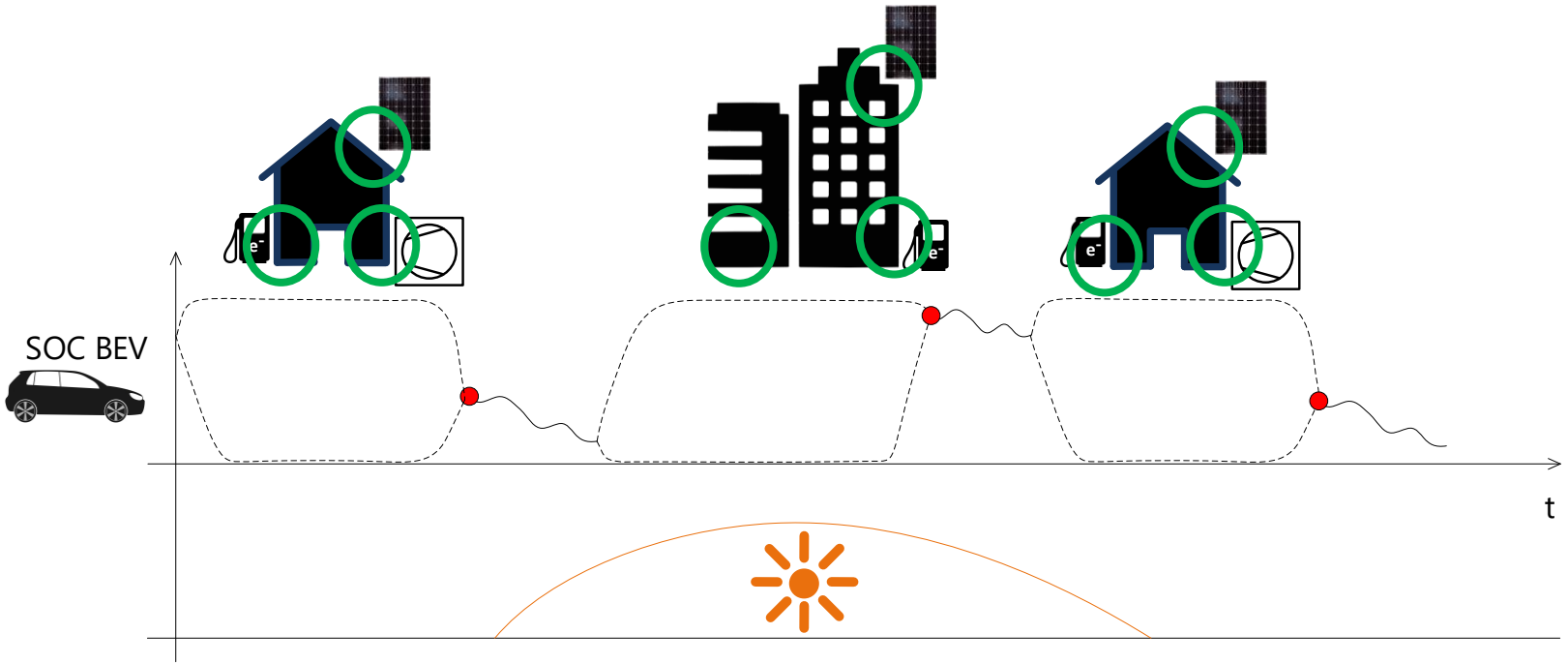
14,1 kWh/100km

3, 11, 22 kW

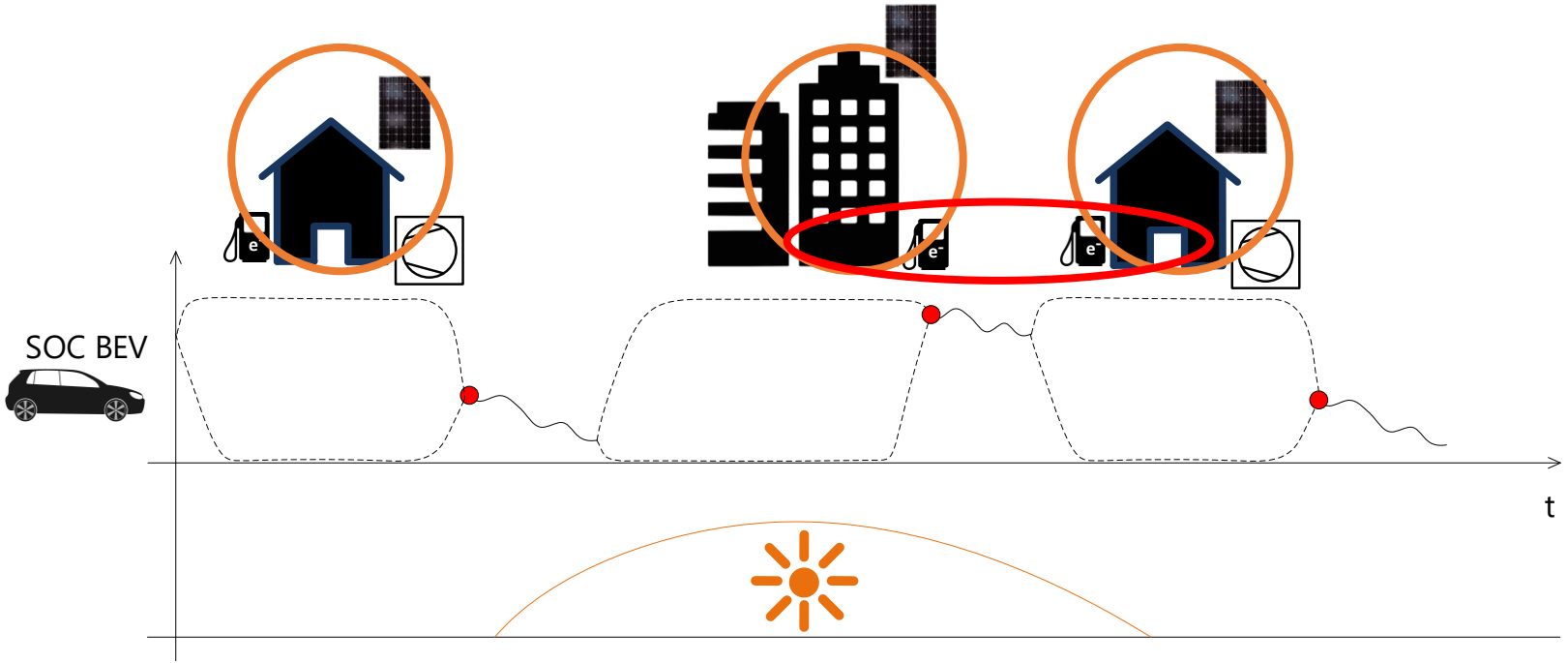
Unterschiedliche Lastprofile + nicht 100% Auslastung -> Potential für Flexibilität

*) Meist verkauftes BEV 2019 in CH

Mobilität für das Energiesystem



Mobilität für das Energiesystem



RDF – accessible and understandable data

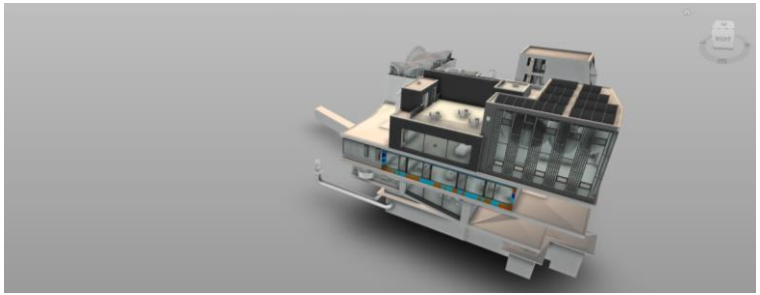
?

https://visualizer.nestcollaboration.ch/Realtime/data/42110038

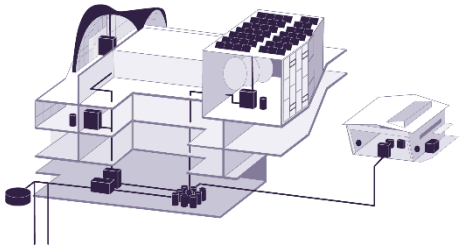
https://visualizer.nestcollaboration.ch/Realtime/data/3200008

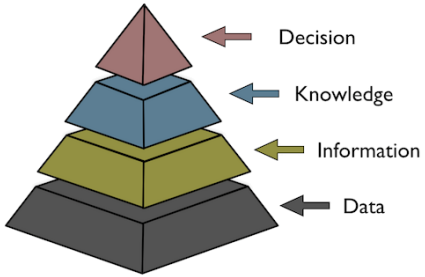
https://visualizer.nestcollaboration.ch/Realtime/data/3200000

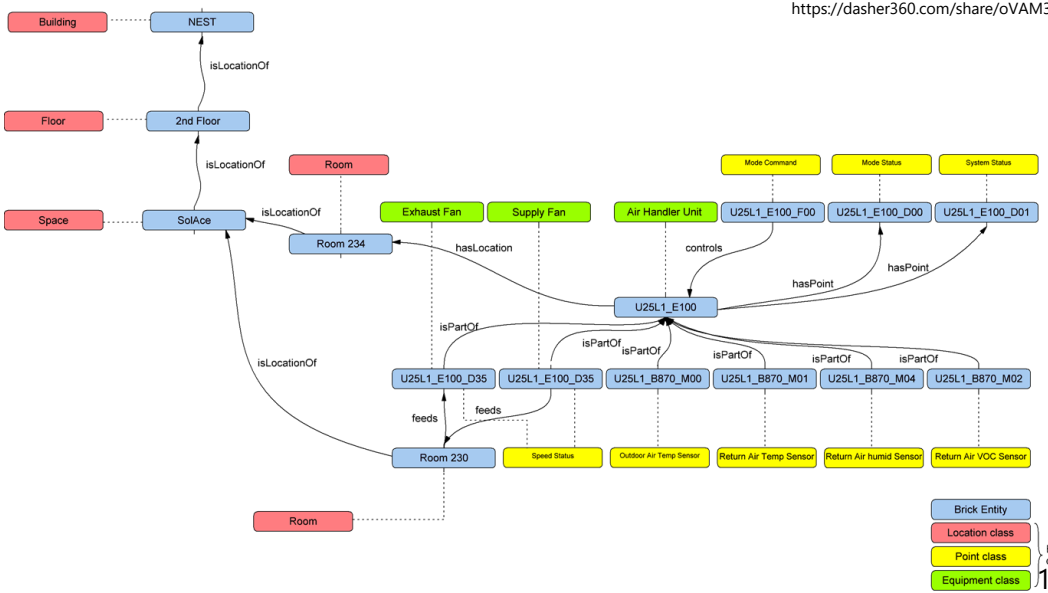

```
[
  {
    timestamp: "2020-06-02T15:16:03.8576803Z",
    value: 0.0401102342,
    numericId: "40110138"
  }
]

[
  {
    timestamp: "2021-03-12T08:01:06.005Z",
    value: "-3.20",
    numericId: 42110038,
    unit: "kW",
    datapoint_InOrOut: "feedback"
  }
]
```

https://dasher360.com/share/oVAM3dF7M







Key Take aways

- Dezentralisierung, Elektrifizierung, und Digitalisierung **verändern das Energiesystem** drastisch.
- Digitalisierung erlaubt eine **flexiblere Nutzung** von Technologie!
- **Gemessene Daten** können genutzt werden um das Verhalten von Systemen zu verbessern und anzupassen.
- **Lernende Systeme** können die Verbreitung Smarter Systeme stark beschleunigen und helfen die Ziele der Energiestrategie zu erreichen.
- Es braucht vereinheitlichte Beschreibungen von Daten damit digitalisierte Lösungen schneller **in den Markt** kommen.

Empa
Materials Science and Technology

Vielen Dank für ihre Aufmerksamkeit!

Philipp Heer
Deputy Head Urban Energy Systems Lab

philipp.heer@empa.ch
ehub.empa.ch
empa.ch/web/s313