ARCHITECTURES & USE CASES

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Wuppertal Institut für Klima, Umwelt, Energie GmbH

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Smart Appliances?

- Focal point study is **Demand Response**
- Smart Appliance = appliance that offers the flexibility in its electricity profile as a service
- What are the interactions with the outside world, **from the point of view of the appliance**

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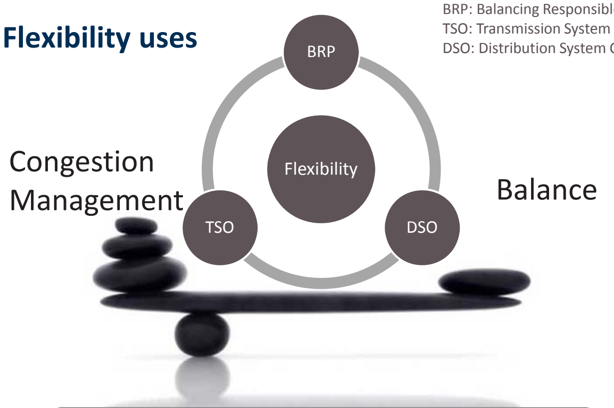
Flexibility uses

BRP: Balancing Responsible Party
TSO: Transmission System Operator
DSO: Distribution System Operator



Target is always balancing and/or grid congestion management, flex buyers are always TSO, BRP or DSO

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But this translates to a high number of technical objectives

- Frequency containment, automatic frequency restoration, manual frequency restoration, grid congestion management, wholesale market, intra-day balancing, day ahead portfolio optimization, reactive power ancillary services, PV grid injection minimization, etc.
- What is today's highest value application of residential flexibility?
- What is tomorrow's highest value application of residential flexibility?
- **Smart appliances should support as many as possible**

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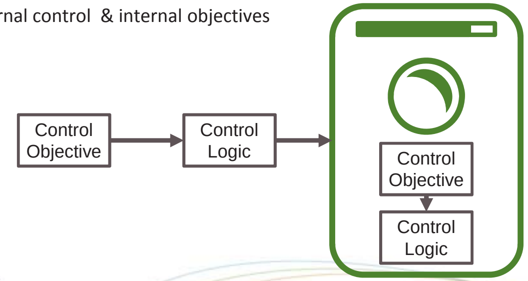
Control architecture

- 3 approaches: (≈ generalized use cases)
  - External control & external objectives
  - Internal control & external objectives
  - Internal control & internal objectives



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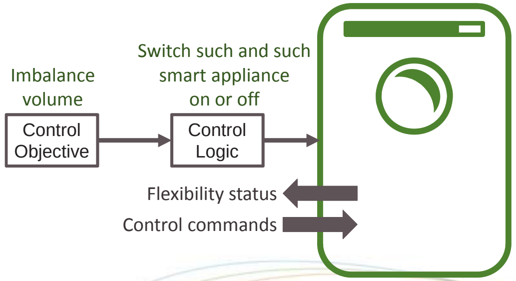
External control & external objectives

- Use case example: use the flexibility of smart appliances to maintain the intraday balance between electricity production and consumption
- New/altered BC (Business Case) ➔ no impact on appliances



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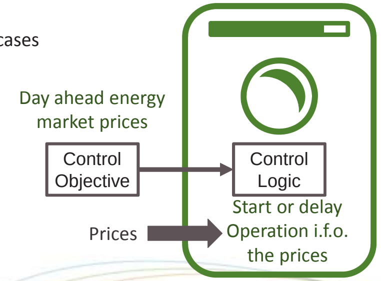
Internal control & external objectives

- Use case example: smart appliances respond directly to day ahead energy market prices
- Control logic required in appliance for all supported BC's
- Mainly open loop control cases
- New/altered BC
  - ➔Impact on appliances
  - ➔Impact on interfaces



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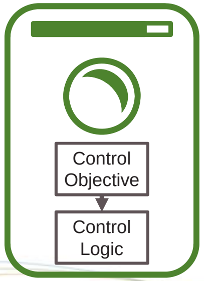
Internal control & internal objectives

- Use case example: automated frequency restoration based on local frequency measurements
- No communications required
- Control logic required in appliance for all supported BC's
- Only open loop control, but very fast
- New/altered BC
  - ➔ Impact on appliances
  - ➔ Potentially hardware impact

frequency measured

Increase/decrease power i.f.o. frequency



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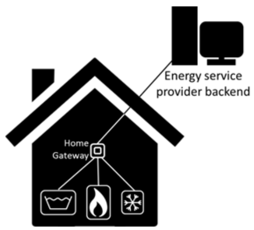
In house communications are difficult

- No plug&play solution that works for the majority of the households
- No dominant technology

  (power line, wireless P2P, wireless meshed, wired, …)

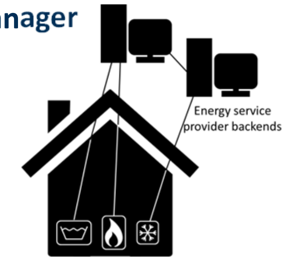
- **No technology may be excluded**

Cloud vs. Central Energy Manager



Central Energy Manager

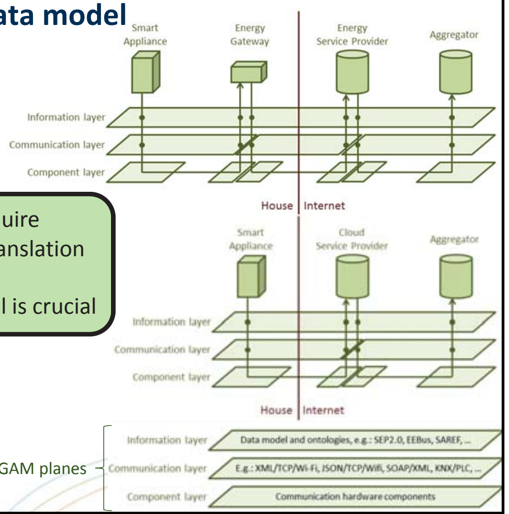
- Easier to manage/guarantee security and privacy
- Open and interoperable interfaces required on the appliance



Cloud

- No extra hardware
- Each appliance must be able to establish extra-house communication
- Open and interoperable interfaces required at the servers

A common data model



All models require continuous data translation
↓
A shared data model is crucial

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Conclusion

- **Control architectures**
  - 3 models, none dominant
  - Large impact on smart appliance functionality and data model
  - Can/should this be limited?
  - Today's initiatives often partly support both internal and external control
- **Communication architectures**
  - 2 models, none dominant
  - Can co-exist and impact on appliance can be limited
  - Provided a common data model is used
- **Many data model/ontology initiatives:**
  SAREF, EEBus, SEP2, OpenADR 2.0, CIM, ...

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MARKET/BUSINESS MODELS

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End consumer business models

- A **wide variety of business models** for the end consumer are possible
  - Variable pricing
  - Capacity/activation fee
  - PV injection minimization
  - Energy services bundle offer
  - Rebate or subsidy scheme at purchase
  - Obligatory

- Smart appliances should accommodate as many as possible
- Limited public available information

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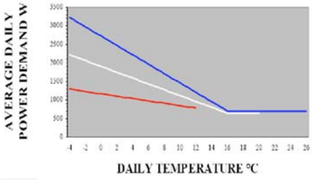
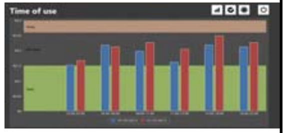
Variable pricing

- Vattenfall/Sweden
  - Retail contracts with Nordic power exchange based hourly prices
- France Option Tempo
  - Blue, white and red days
- Eneco SlimLaden
  - Smart charging of Tesla's based on energy market prices



Variable pricing – research project experience



- Linear:
  - 6 fixed time blocks per day with variable prices set per day
  - Variable pricing with automated control works well, but non-controlled (peak) loads represent financial risk
  - Too complex for manual demand response (response fatigue)
- PowerMatching city Hoogkerk
  - Automated control preferred over manual control
  - No response fatigue for manual control, as fixed price patterns render price consultation redundant

Capacity/activation fee

- Traditionally used for balancing reserves
- Typically used for industrial demand response based reserves
  - R3-DP and SDR products of Elia in Belgium
  - FCDM and STOR of National Grid in the UK.
  - …
- Load management program for airco's in the US (FPL, BGE, …)
- Research project experience: Linear
  - Capacity fee was well received by users: simple, no financial risk

Other examples

- PV injection minimization
  - Feed in tariffs for PV production in Germany and Belgium
- Free thermostat or thermostat rebate in exchange for airco control
  (Austin Energy and CPS Energy in Texas, US)

Call for information

- Important that no revenue model is excluded
- Limited pubic information

- What are your experiences on business and remuneration models for smart appliances?

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