SEVENTH FRAMEWORK PROGRAMME

ENERGY DEMAND-AWARE OPEN SERVICES FOR SMART GRID INTELLIGENT AUTOMATION

SmartHG

SmartHG Project: Energy Demand Aware Open Services for Smart Grid Intelligent Automation

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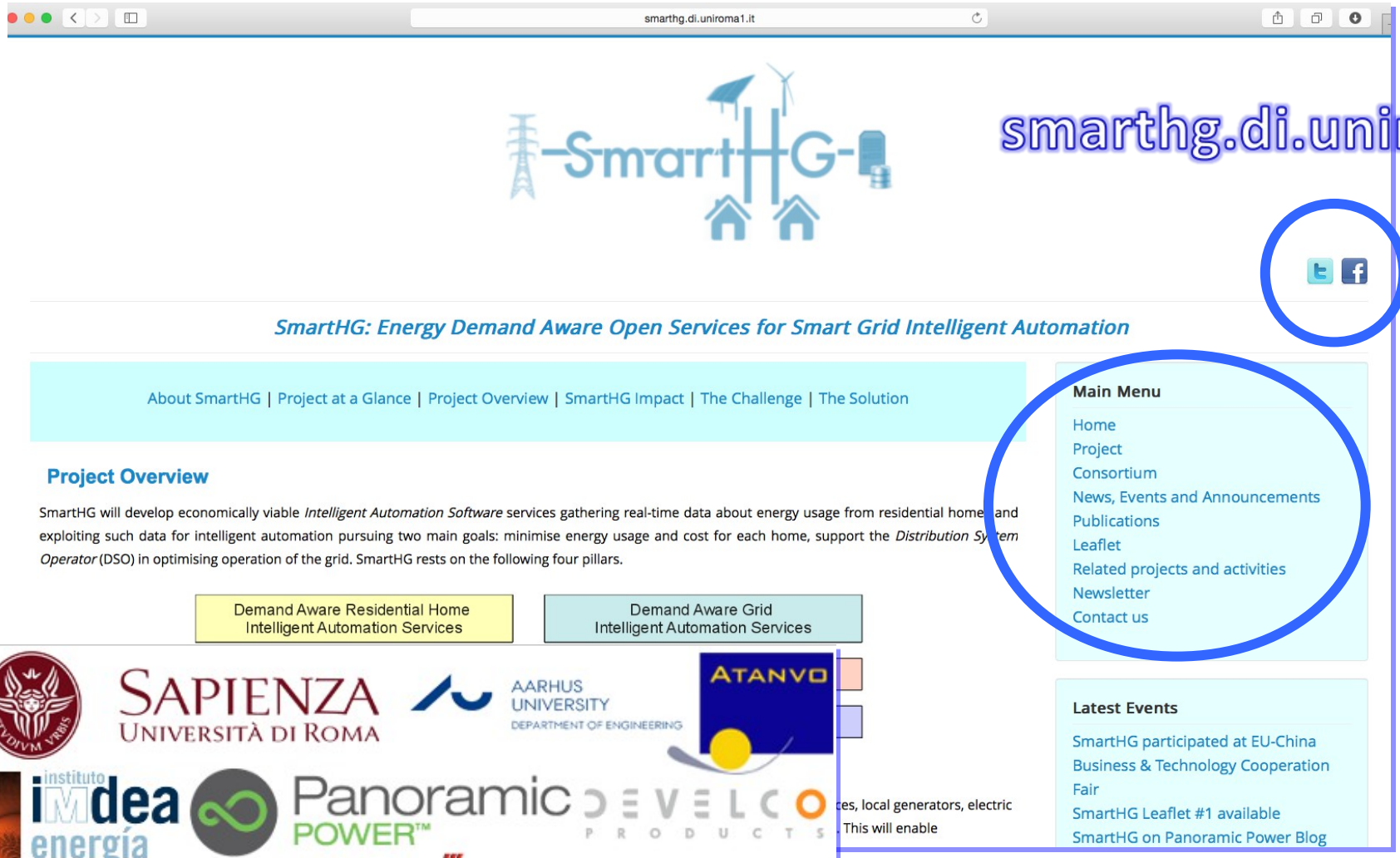
SmartHG Online



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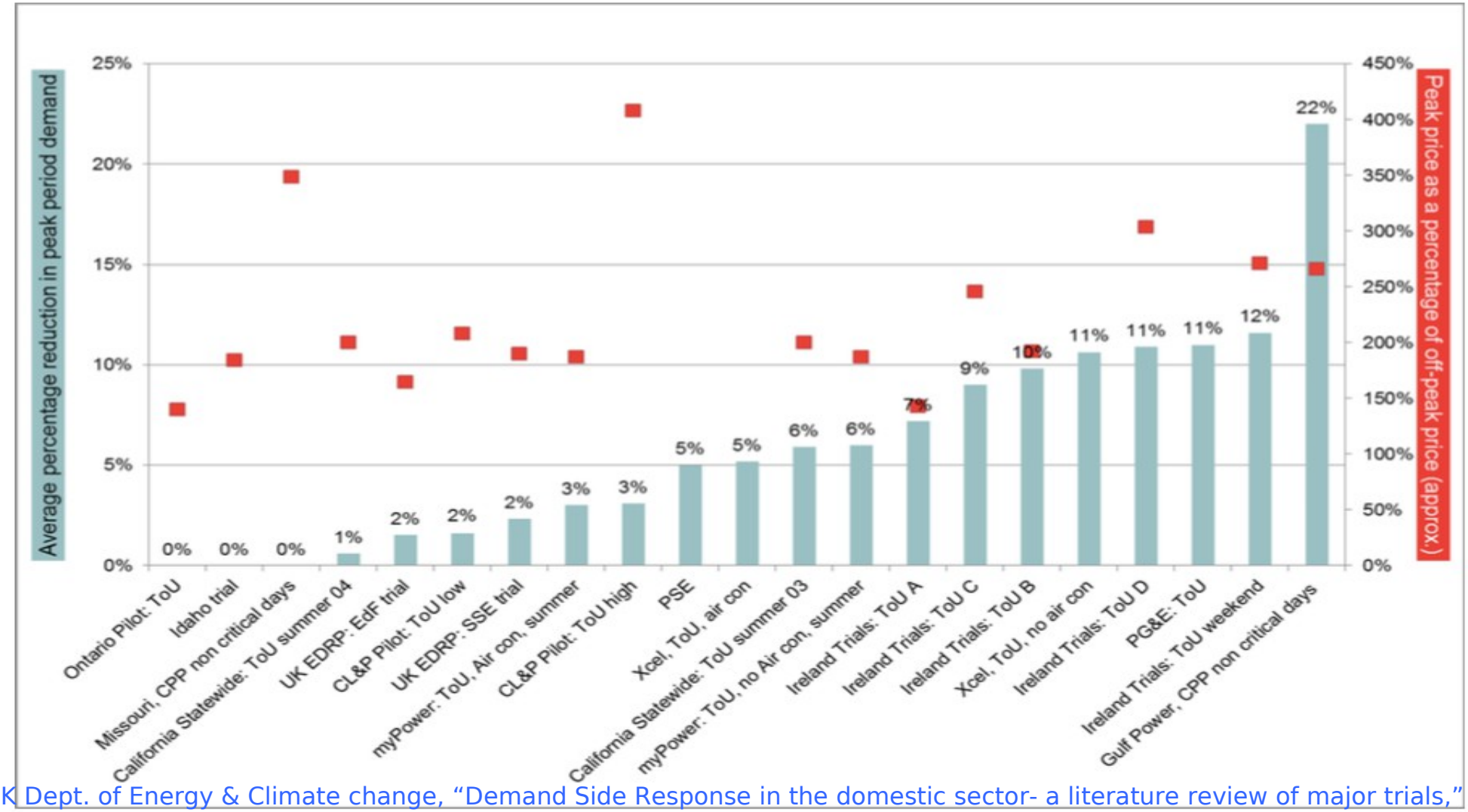
SEVENTH FRAMEWORK PROGRAMME

Autonomous Demand Response

Peak period demand reductions and peak to off-peak price differentials under ToU tariffs



UK Dept. of Energy & Climate change, "Demand Side Response in the domestic sector- a literature review of major trials," 2012

Little evidence on the impact of ADR incentives on customers

➔ ADR moderately effective

SEAS-NVE ADR Pilot

SEAS-NV pilot study *Vind med nye elvaner* (Win with new electrical habits).

About 300 customers without electrical heating.

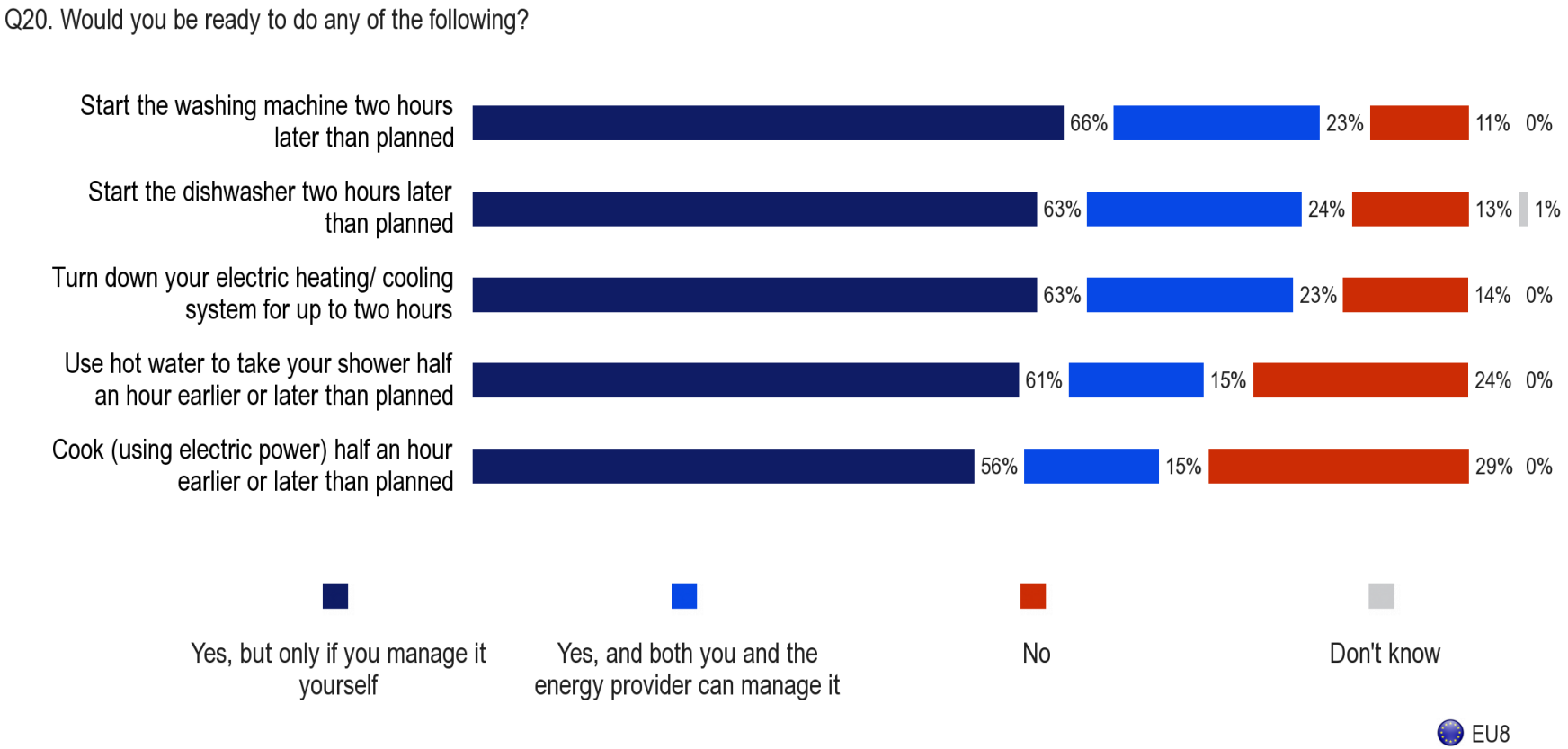
Pilot runs from Oct. 2013 to Oct 2014.

Pilot proposes to participants aTime of Usage (ToU) tariff:

Day (6am - 5pm) = 0.20 Eur/KWh.
Peak (5pm - 8pm) = 1.07 Eur/KWh.
Night (8pm - 6am) = 0.0 Eur/KWh (electricity **free** at night!).

Nevertheless ... **only about 25% of electricity** consumption has moved from peak hours to night accordingly to the data gathered so far.

Citizens are ready for active demand BUT only if they manage it themselves



➔ DLC raises privacy and security issues

Business Issue

- We may deploy high-tech devices in each home to monitor and control energy usage
- Technically feasible
  BUT
  economically uninteresting

Saving: $

➔ Energy saving from a single residential home too small to provide an interesting business opportunity.

Sensors/Actuators/Control cost: $$$

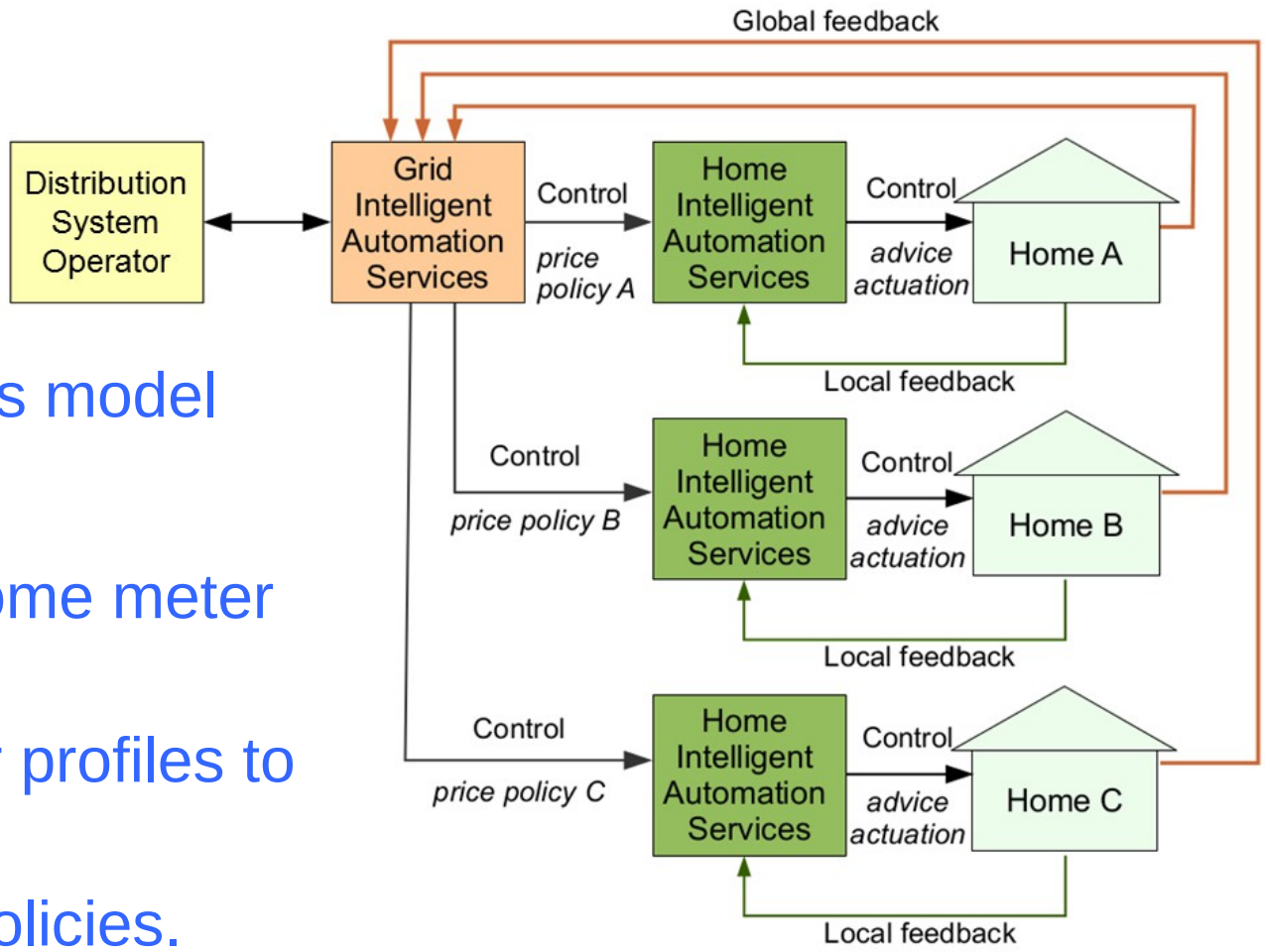
SmartHG Approach (1)

SmartHG approach

- Demand Aware
- Combines ADR and DLC benefits
- Provides a viable business model

HOW

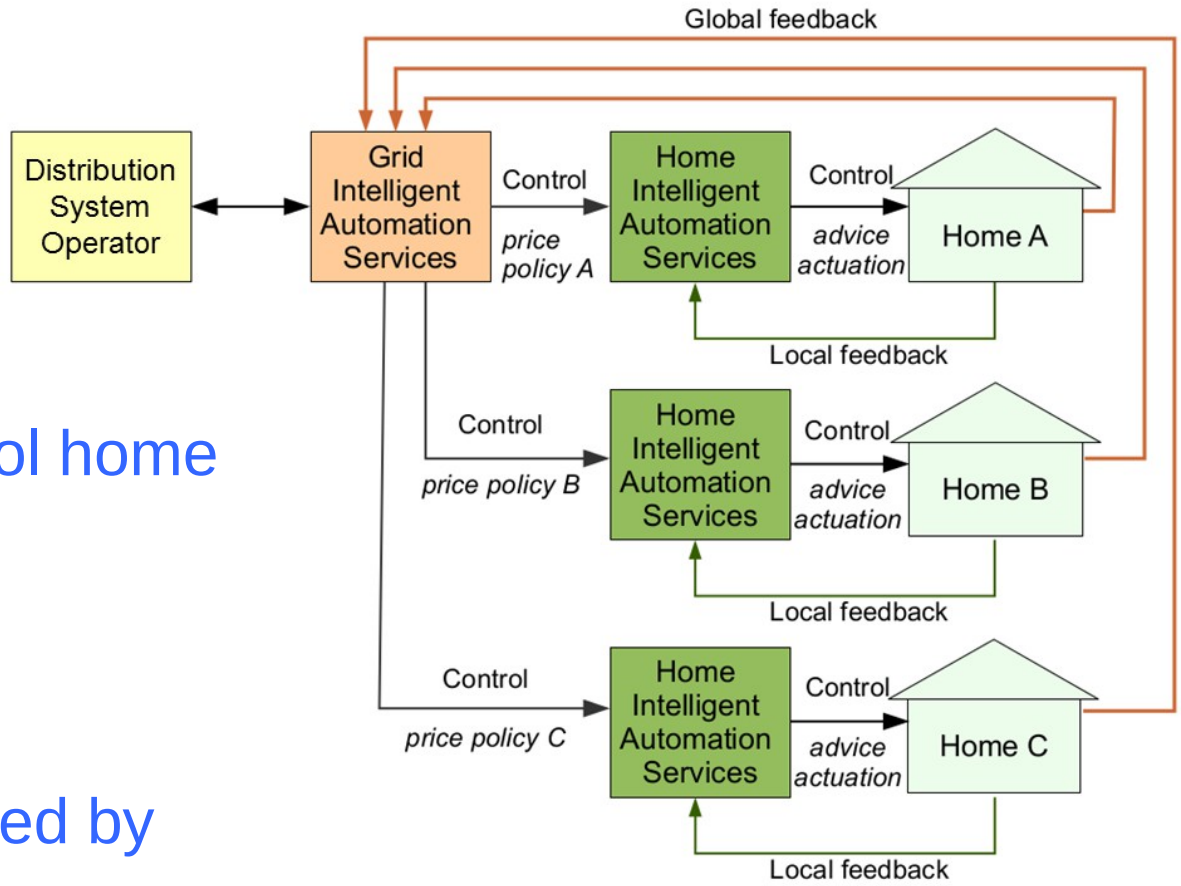
- Using energy demand (home meter level ... no privacy issues)
- DSO computes fair power profiles to be followed by users
- DSO Enforces via price policies.
- Users follow proposed power profile using home hub to automatically manage home appliances



SmartHG Approach (2)

Advantages

- No home device data need to be transferred to the DSO (as ADR)
  - ➔ Security issues avoided
- DSO does not directly control home devices (as ADR)
  - ➔ Safety issues avoided
- Home energy profile proposed by DSO (*soft DLC*)
- Home appliances automatically managed by home hub (*soft DLC*)



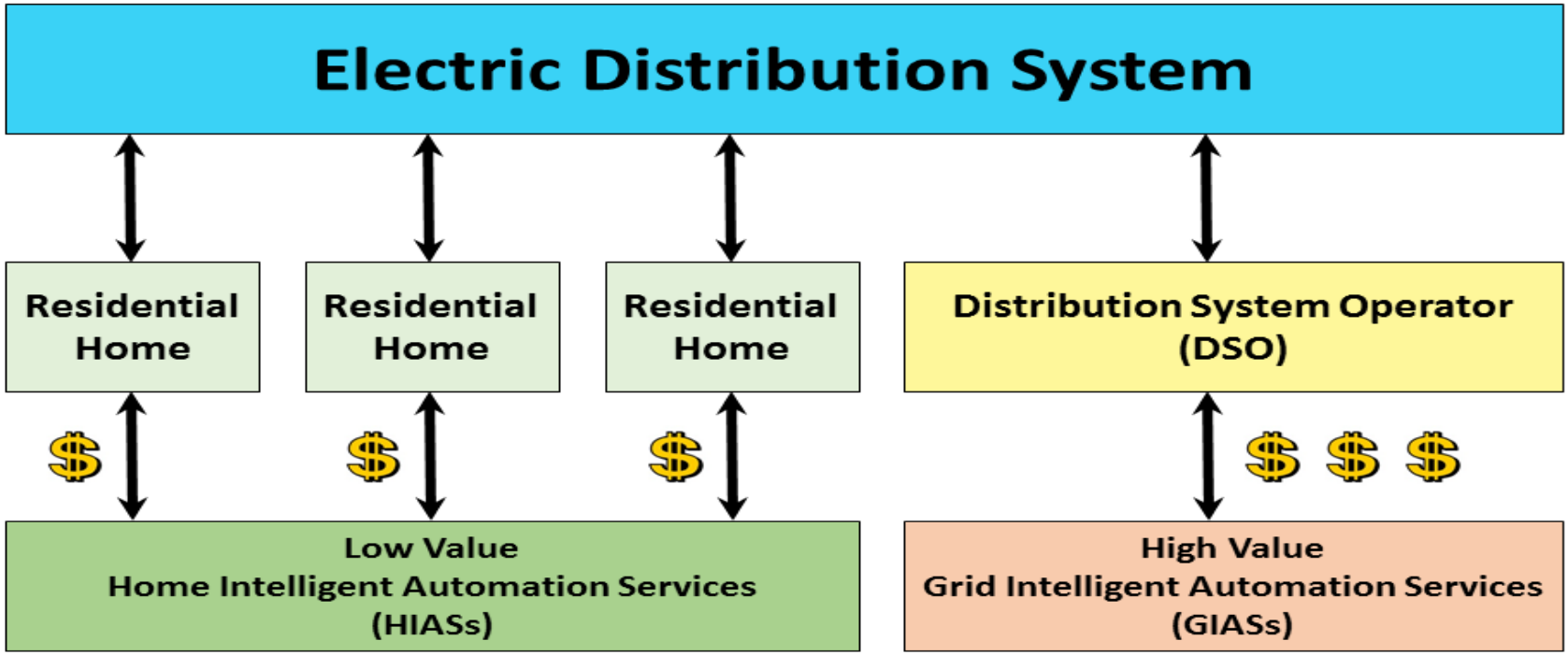
SmartHG Business Model

DSO customer for services computing power profiles for each home

➔ Benefits: DSO saves money by controlling the aggregated demand at substation level

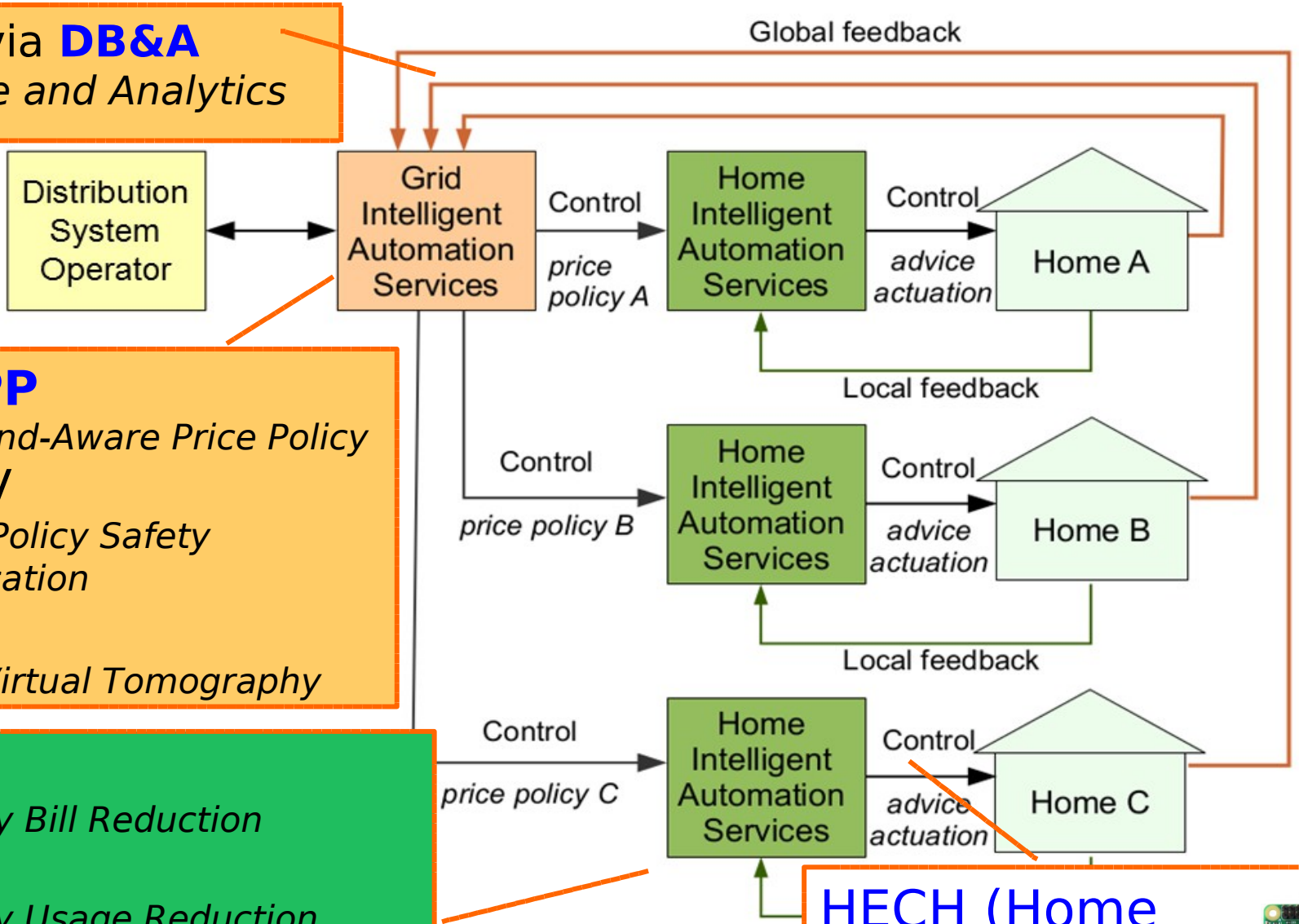
Users customer for lightweight devices following DSO suggested power profile

➔ Benefits: Users save money on electric bill



SmartHG Architecture

Comm via **DB&A**
Database and Analytics



- **DAPP**
  Demand-Aware Price Policy
- PPSV
  Price Policy Safety Verification
- EVT
  EDN Virtual Tomography

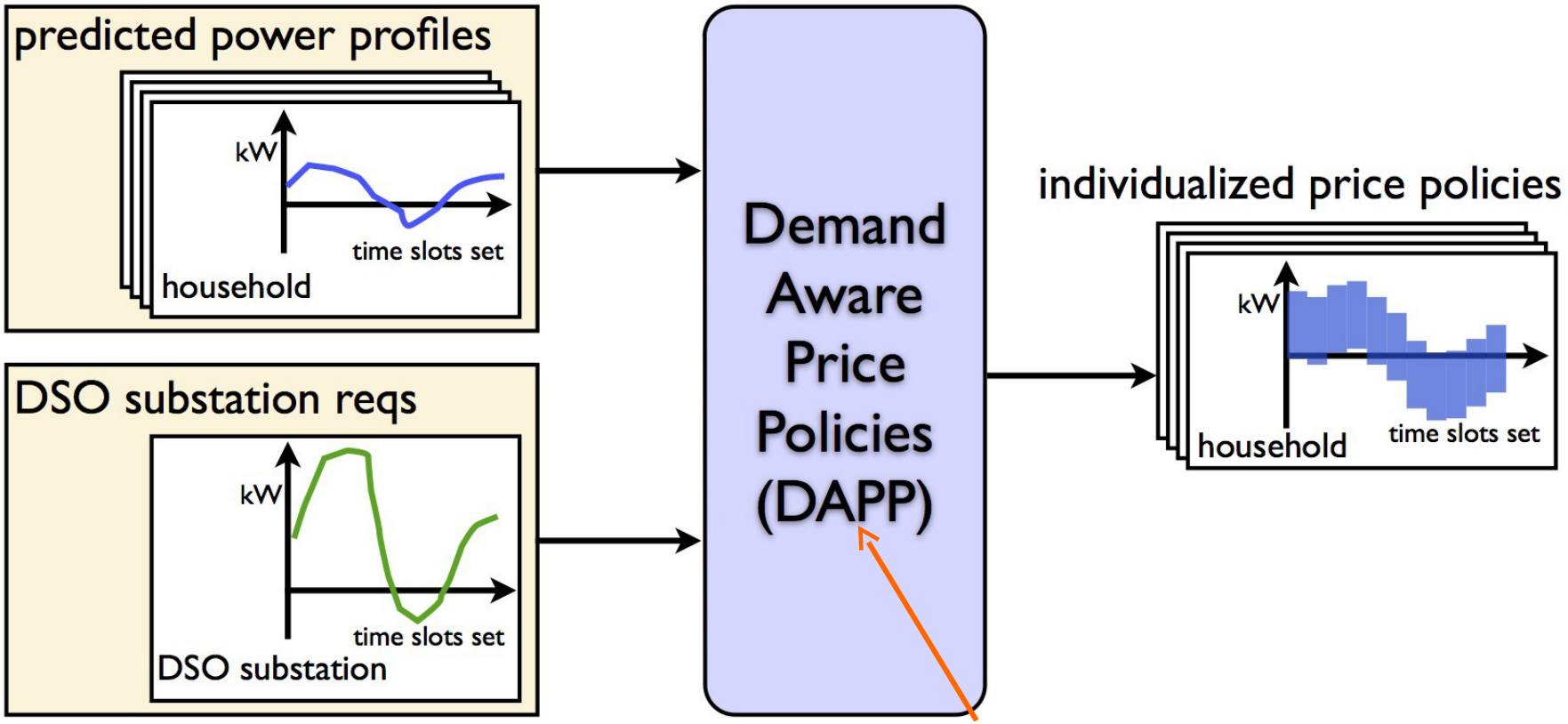
- **EBR**
  Energy Bill Reduction
- EUR
  Energy Usage Reduction
- EUMF
  Energy Usage Model Forecasting

HECH (Home Energy Controlling Hub)

DAPP

Goal Proposing to customers *individual*, yet *fair*, price policies in order to steer the aggregated energy demand

I/O

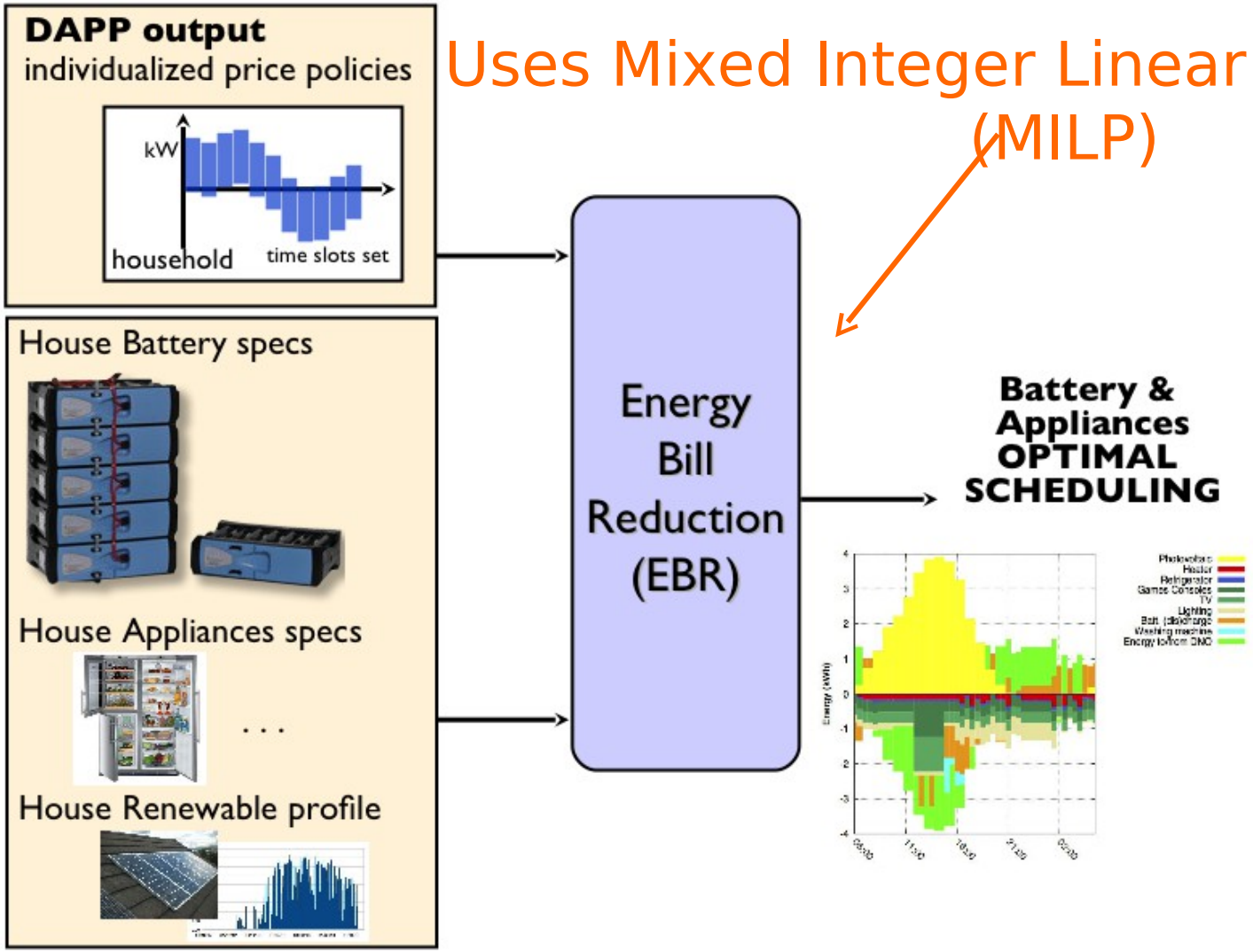


Uses Mixed Integer Linear Programming (MILP)

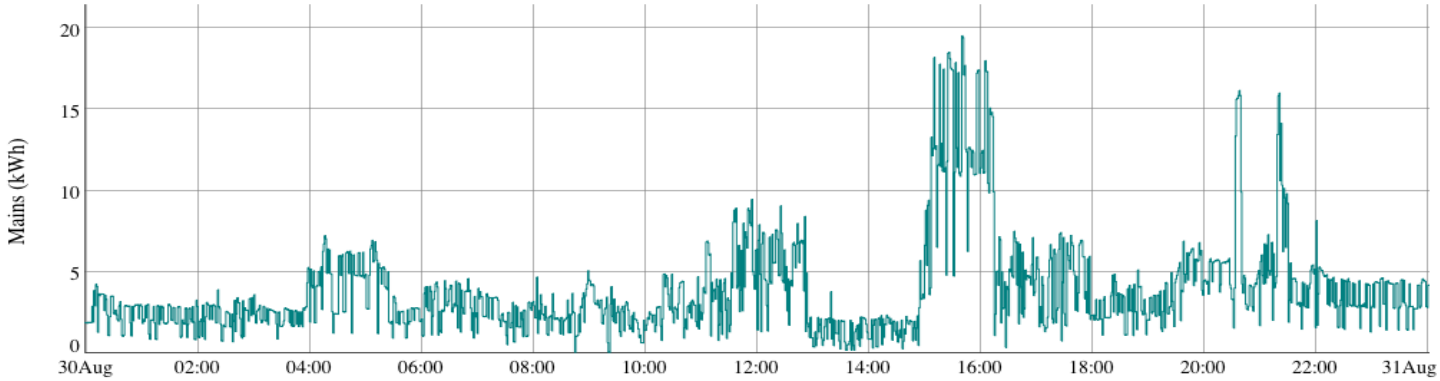
EBR

Goal Optimise home energy usage and local generation with respect to cost

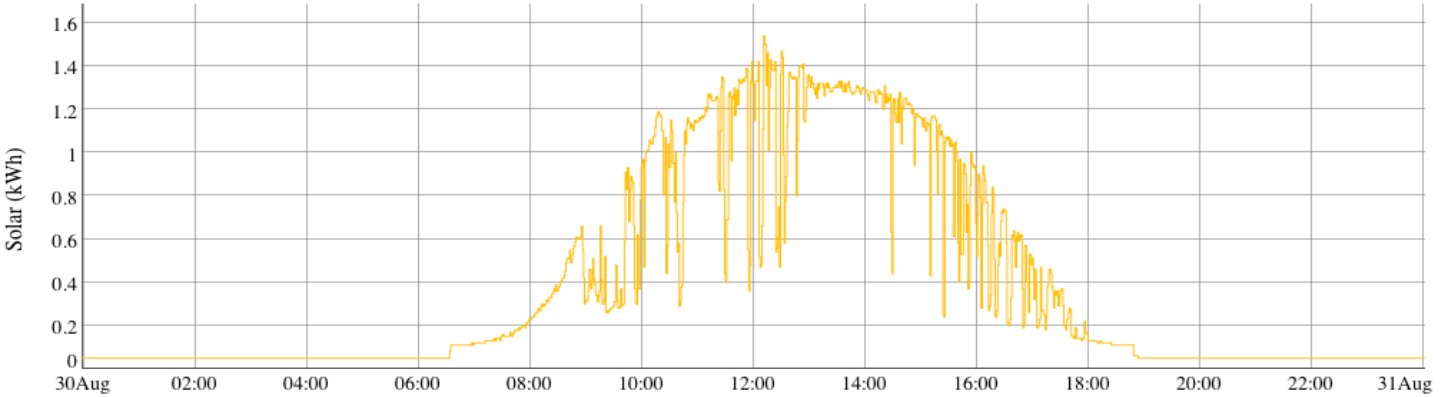
I/O



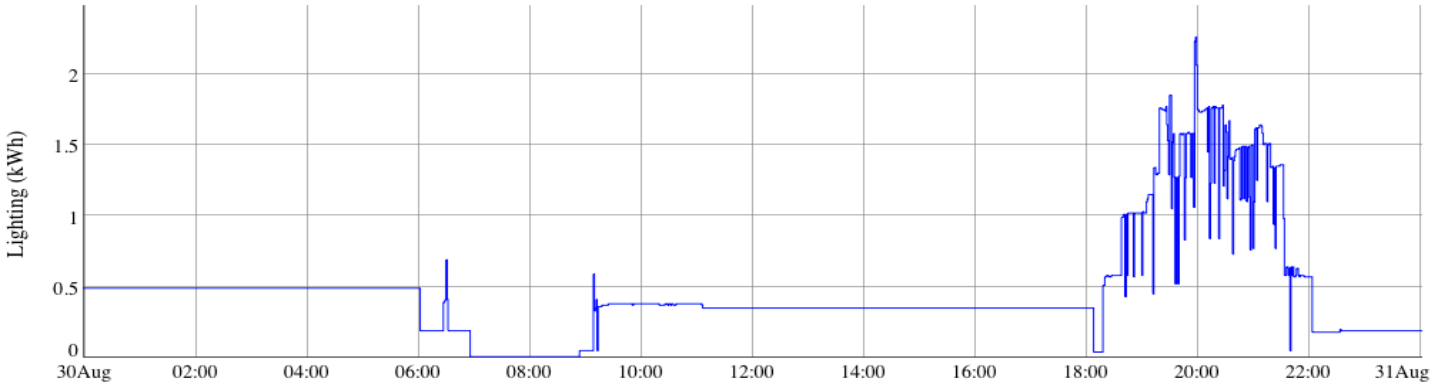
EBR – Input (1)



Mains

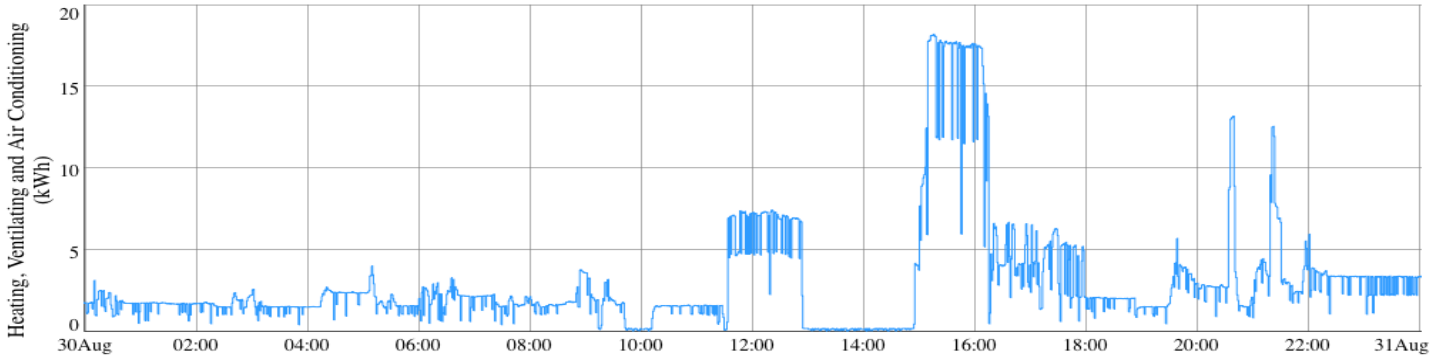


Photovoltaic

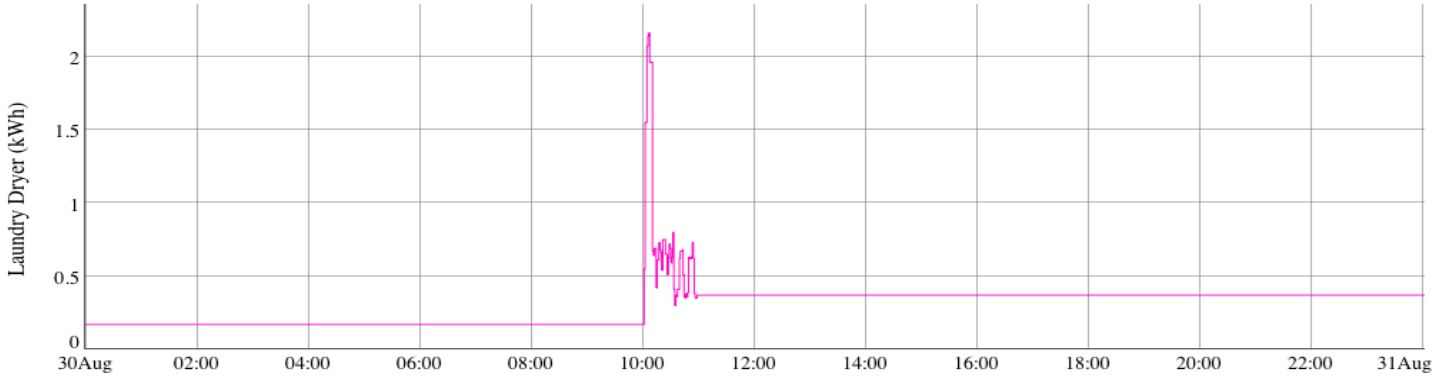


Lighting

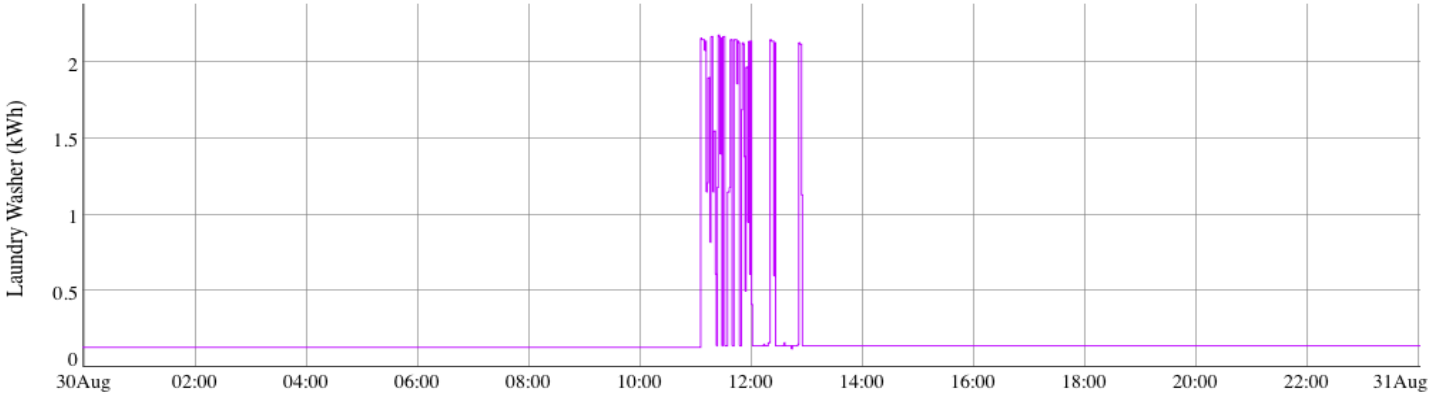
EBR – Input (2)



HVAC



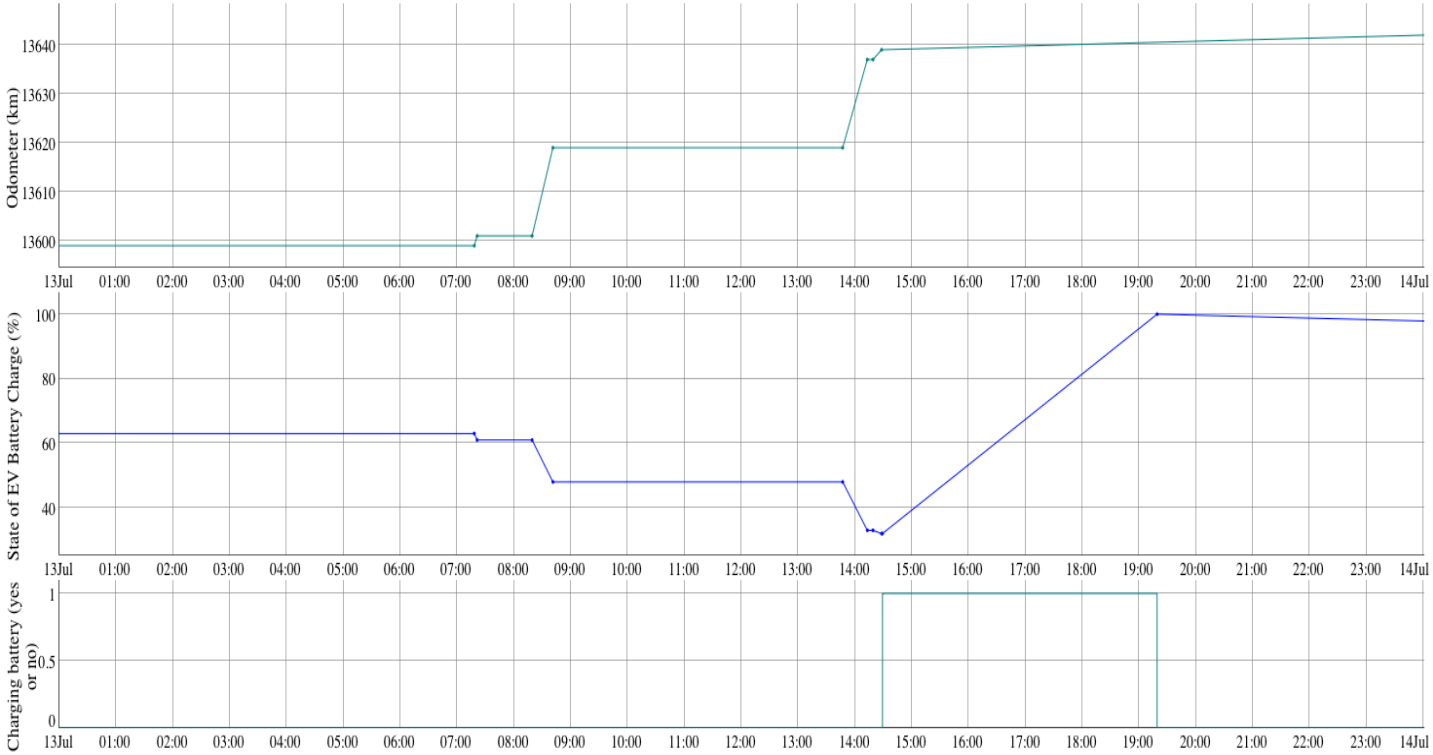
Laundry dryer



Laundry washer

EBR – Input (2)

Plug-in Hybrid Electrical Vehicle (PHEV)



Odometer

State of Charge

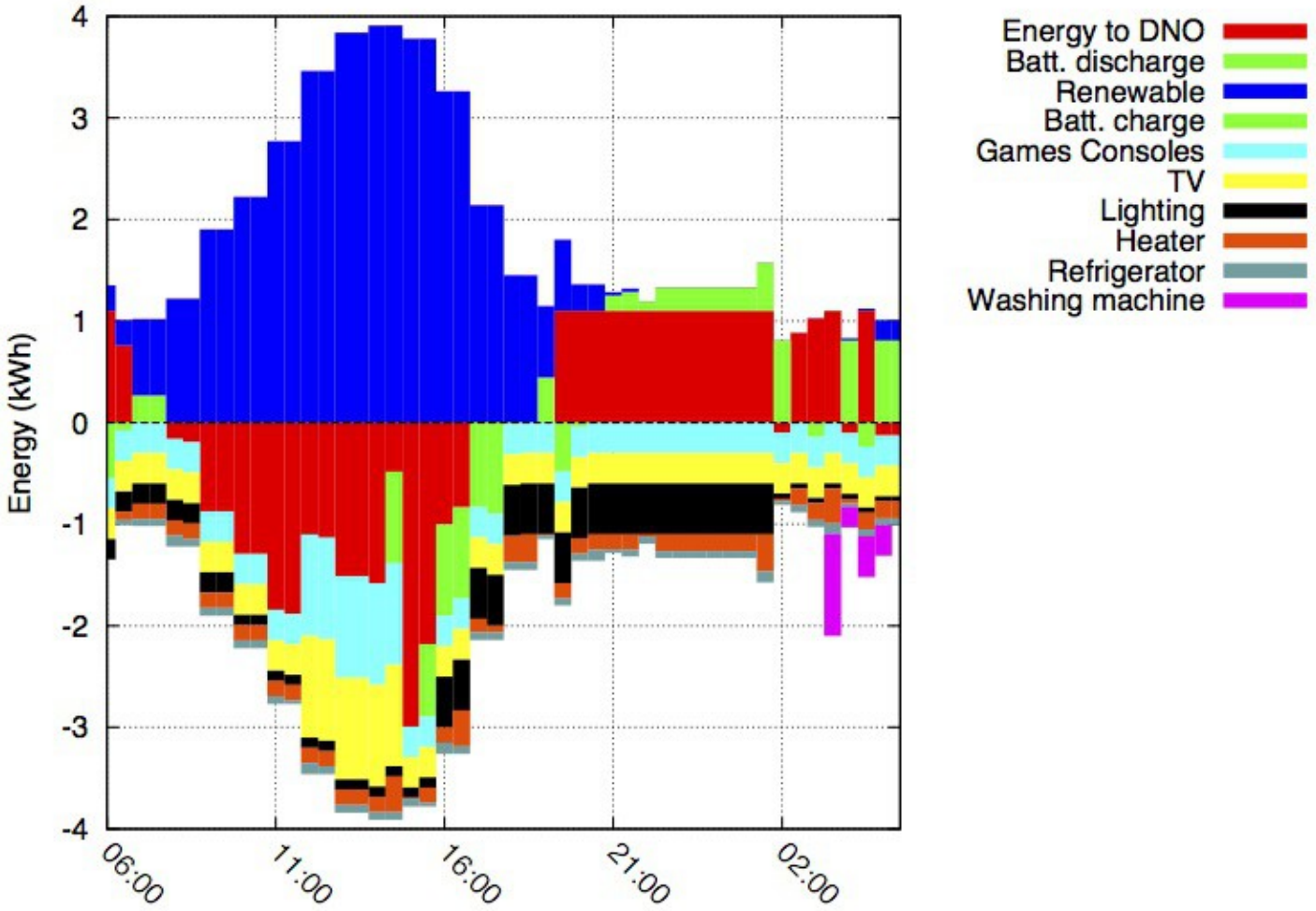
Charging

User desiderata, for example:

Laundry washing must take place between 6pm and 11pm.

EBR – Output

Optimal Scheduling of home appliances



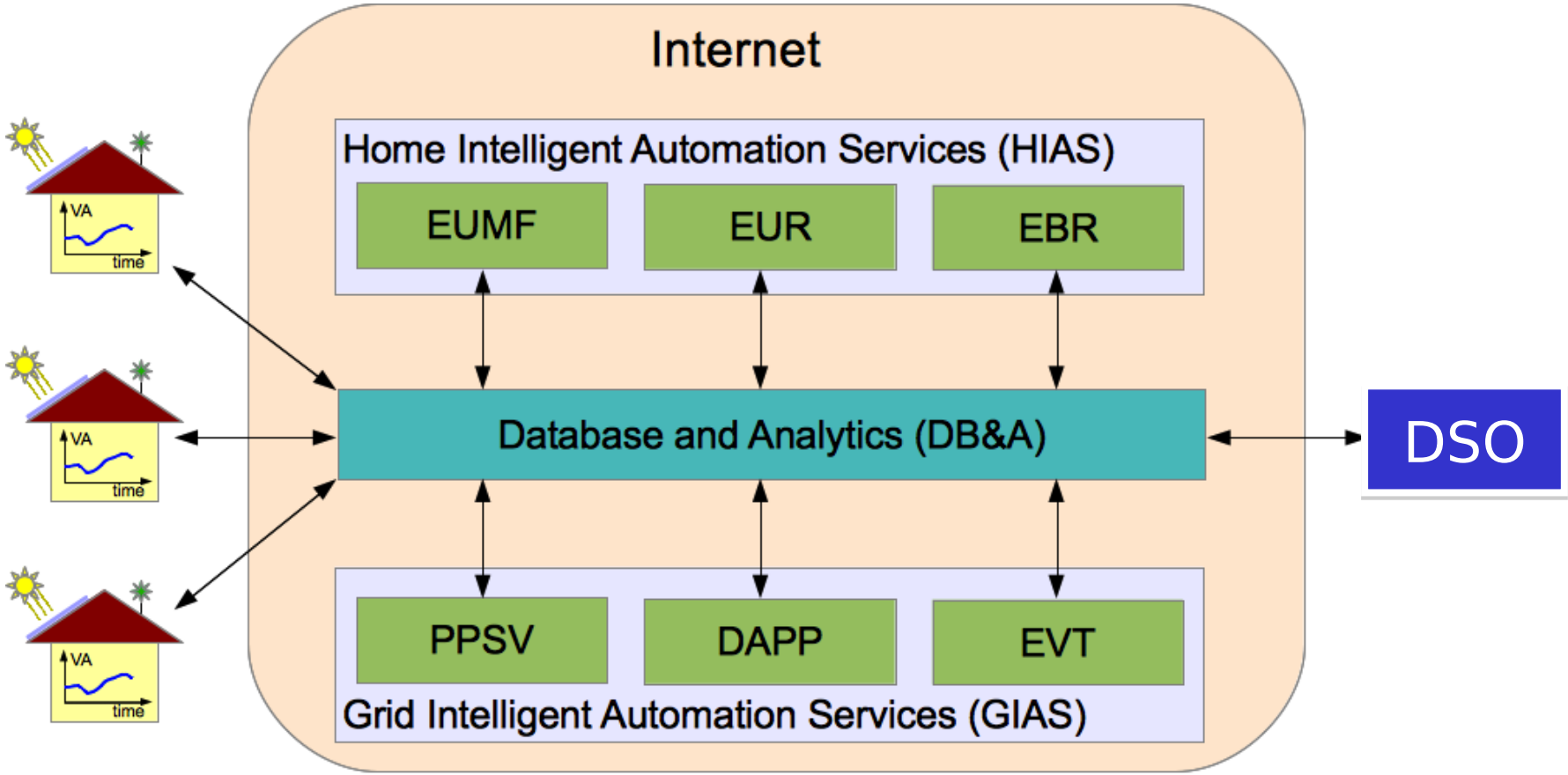
DB&A

Goal

- Store measures to monitor the status of the EDN
- Collect data about energy consumption and generation profiles

I/O

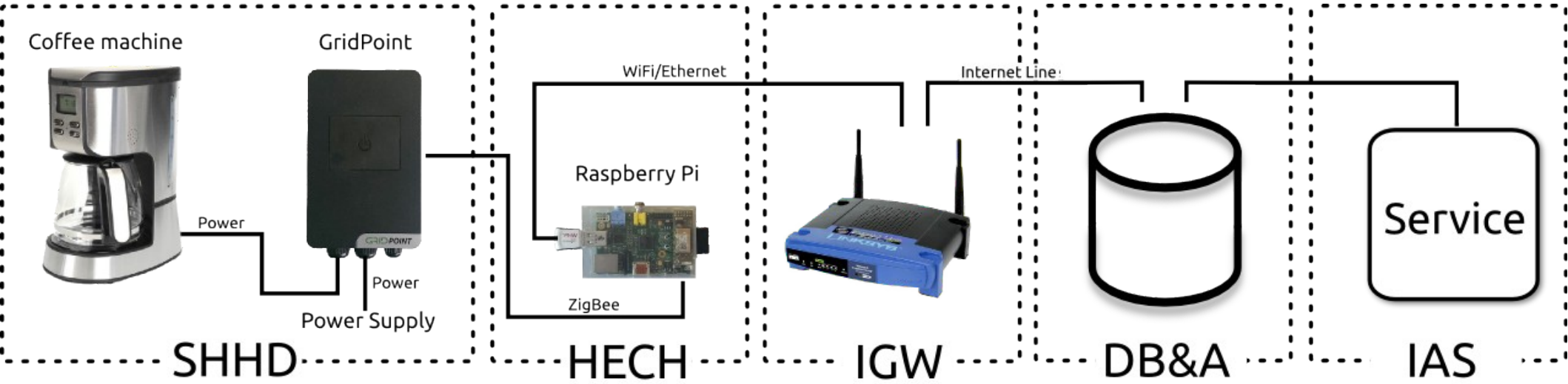
- Enable collected data aggregation



HECH

Raspberry Pi

- Contains software ensuring interoperability
- Between SHHDs and IASs
- Ensures security and privacy



Smart Home Hardware Devices

Sensors

- Two case studies
  - Kalundborg, Denmark
  - Minks, Belarus
- Deployed sensors from Panoramic Power and Develco Products

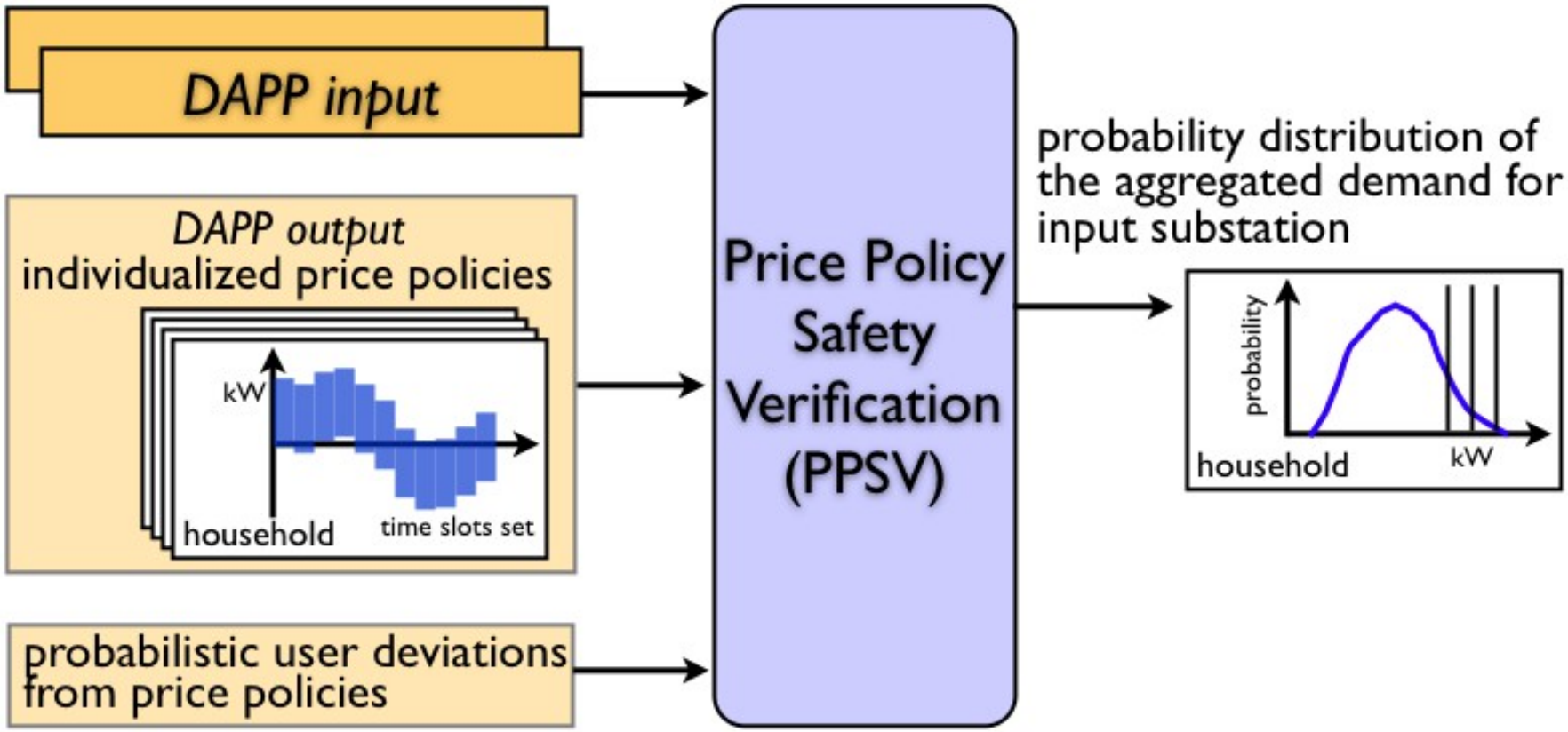
Second Year Deployment

Safety Issues: PPSV

Goal

Verify robustness of DAPP policies w.r.t. grid safety

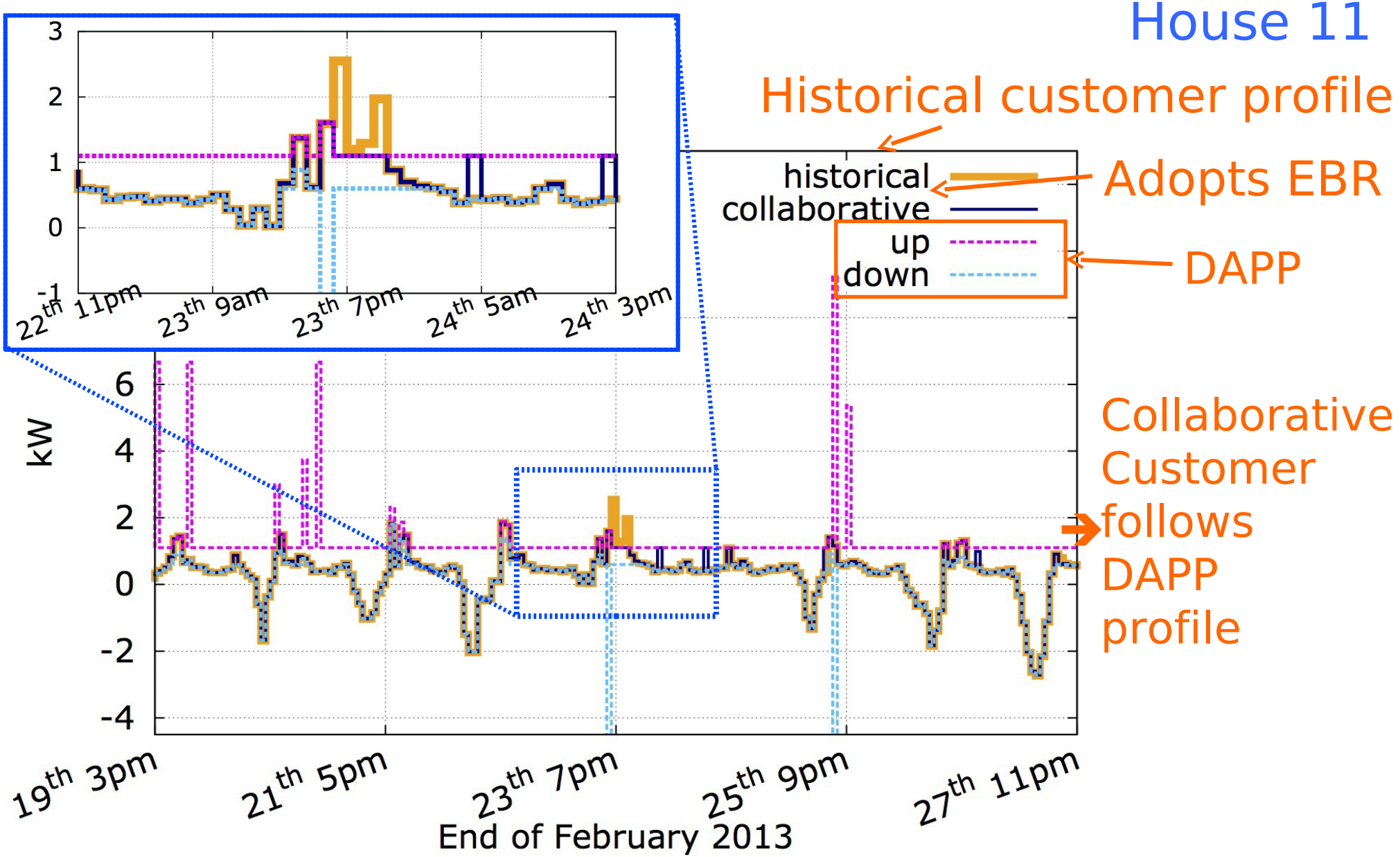
I/O



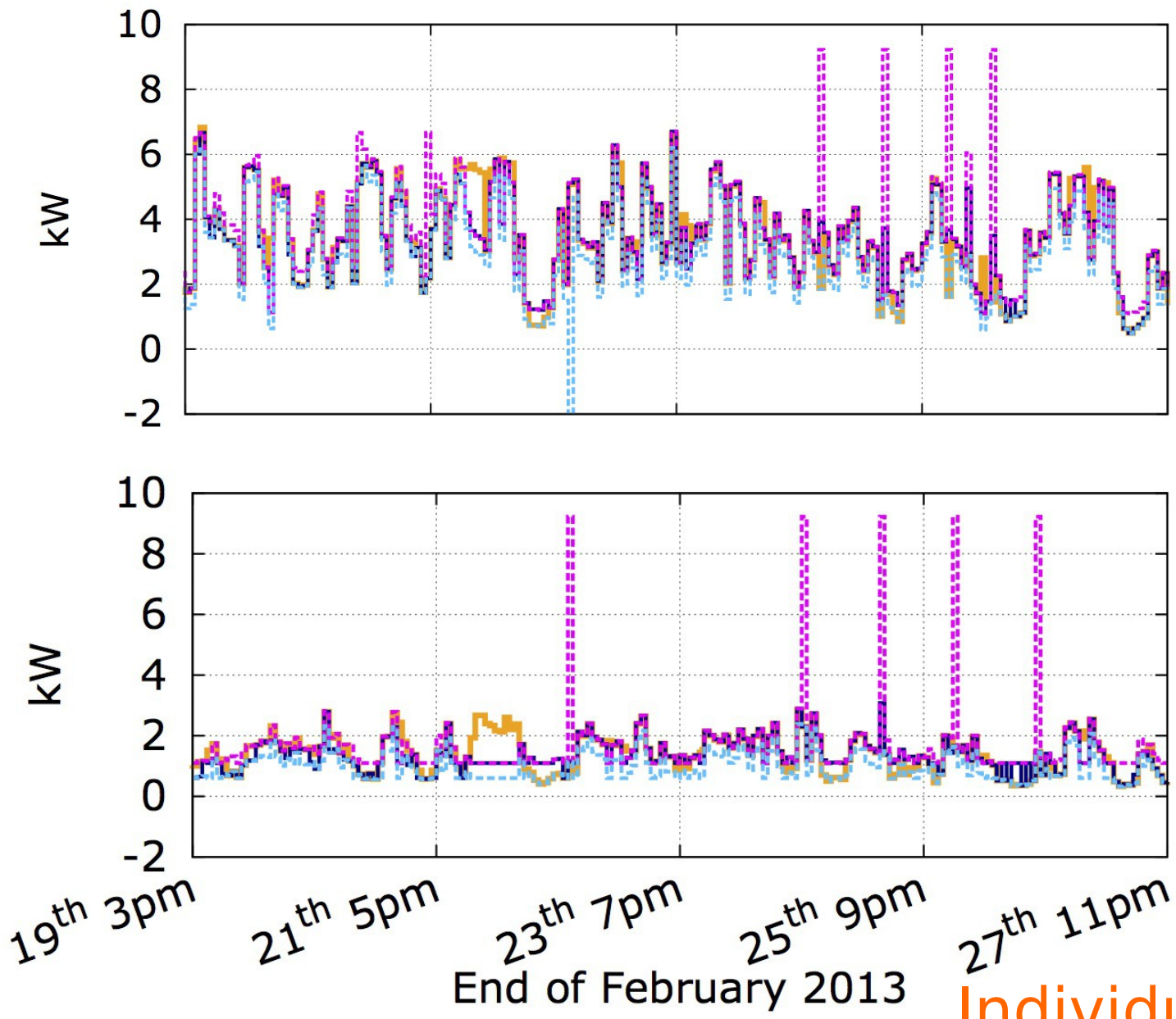
Experimental Results – Settings

- Feeder nominal power is 400 KVA
- DSO requirements: user aggregated demand always less than 80% of nominal power (320 KVA)
- 130 homes for 1 year (Oct. 2012–Oct. 2013)
- About 40 minutes are needed to acquire input from DB&A and compute the DAPP suggested one-month power profile for each home
- 95% of such a time is to exchange data w/ DB&A
- MILP solving requires about 1GB RAM

Experimental Results (1)



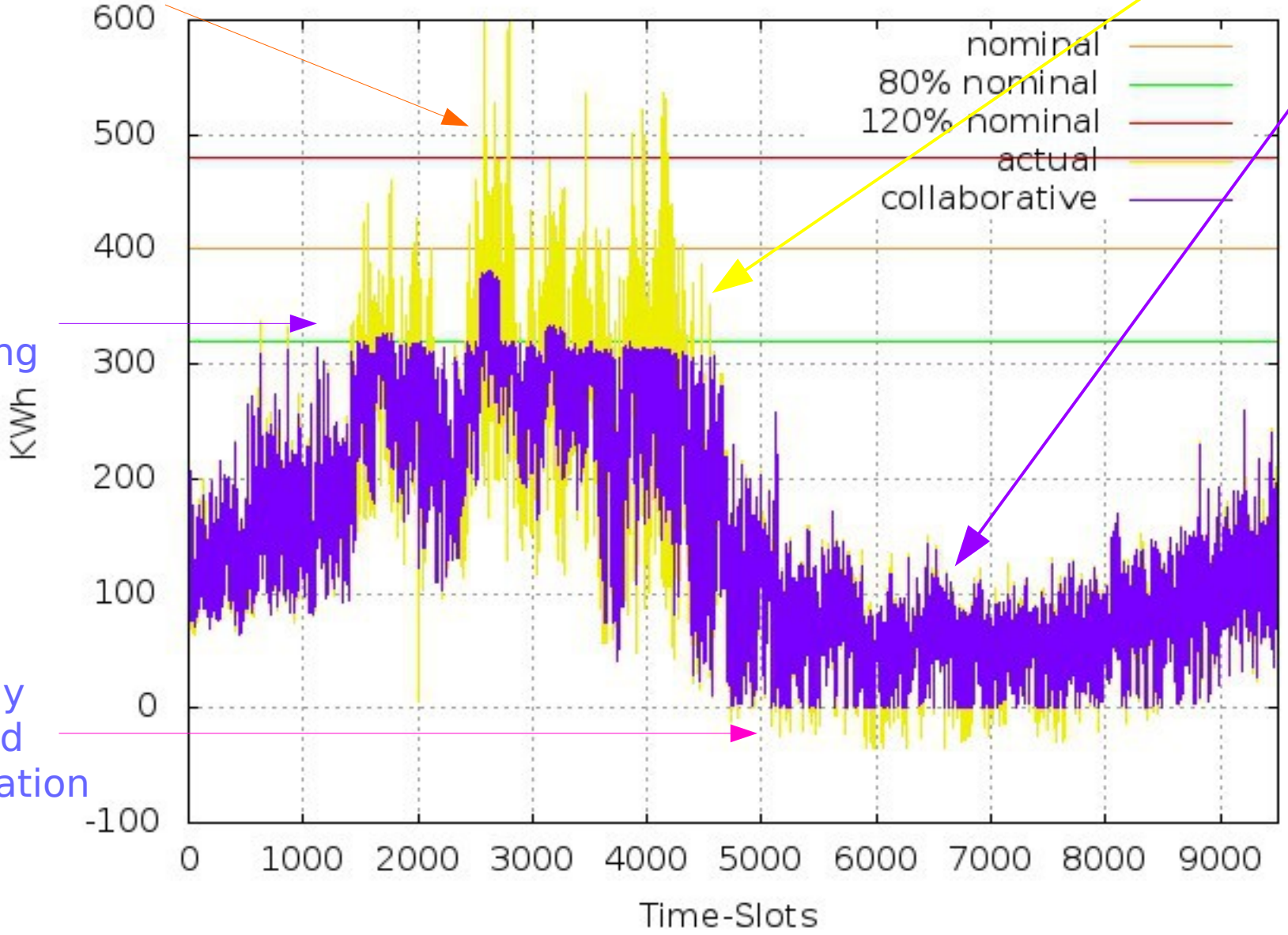
Experimental Results (2)



Individualized profiles

Experimental Results (3)

Data from Oct 2012 to Oct 2013. Aggregated demand (130 homes) without and with DAPP: No peaks beyond nominal value; No energy flows from homes to substation.



Peak shaving

Energy toward substation

Conclusions

SmartHG overcomes the limitations of ADR and solves the security/privacy and safety issues of DLC by proposing an economically viable hierarchical control schema for electrical energy demand from residential homes.

The high level (DSO) control law is designed on the base of the user main meter energy demand.

The low level (Home) control law tries to comply by suitably managing home devices.

Thanks

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