Demand Response Services
Integrating Renewables and enabling Flexibility of Households and Buildings

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International DSM Day

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Contents

- Challenges and Opportunities
- DR Resources and Potentials
- Market integration of Demand Flexibility
- Pilot projects, demonstration and case studies
- Conclusion and Outlook

CHALLENGES AND OPPORTUNITIES

Definitions

- **Demand Side Management**
  - " … encourages consumers to modify patterns of energy usage, including the timing and level of electricity demand. Demand side management includes demand response and demand reduction." [SGTF-EG3]

- **Demand Reponse**
  - "DR can be defined as a change in the consumption pattern of electricity consumers in response to a signal (e.g. changes of electricity price) or due to incentives for increase of energy efficiency or fulfilling certain objectives (e.g. reliability of supply)" [EC, DoE]

- **Flexibility**
  - "Flexibility is intrinsically linked to a number of key terms or concepts and encompasses, Demand Side Response, Demand Management, Flexible Generation and Energy Storage on the supply and demand side." [SGTF-EG3]

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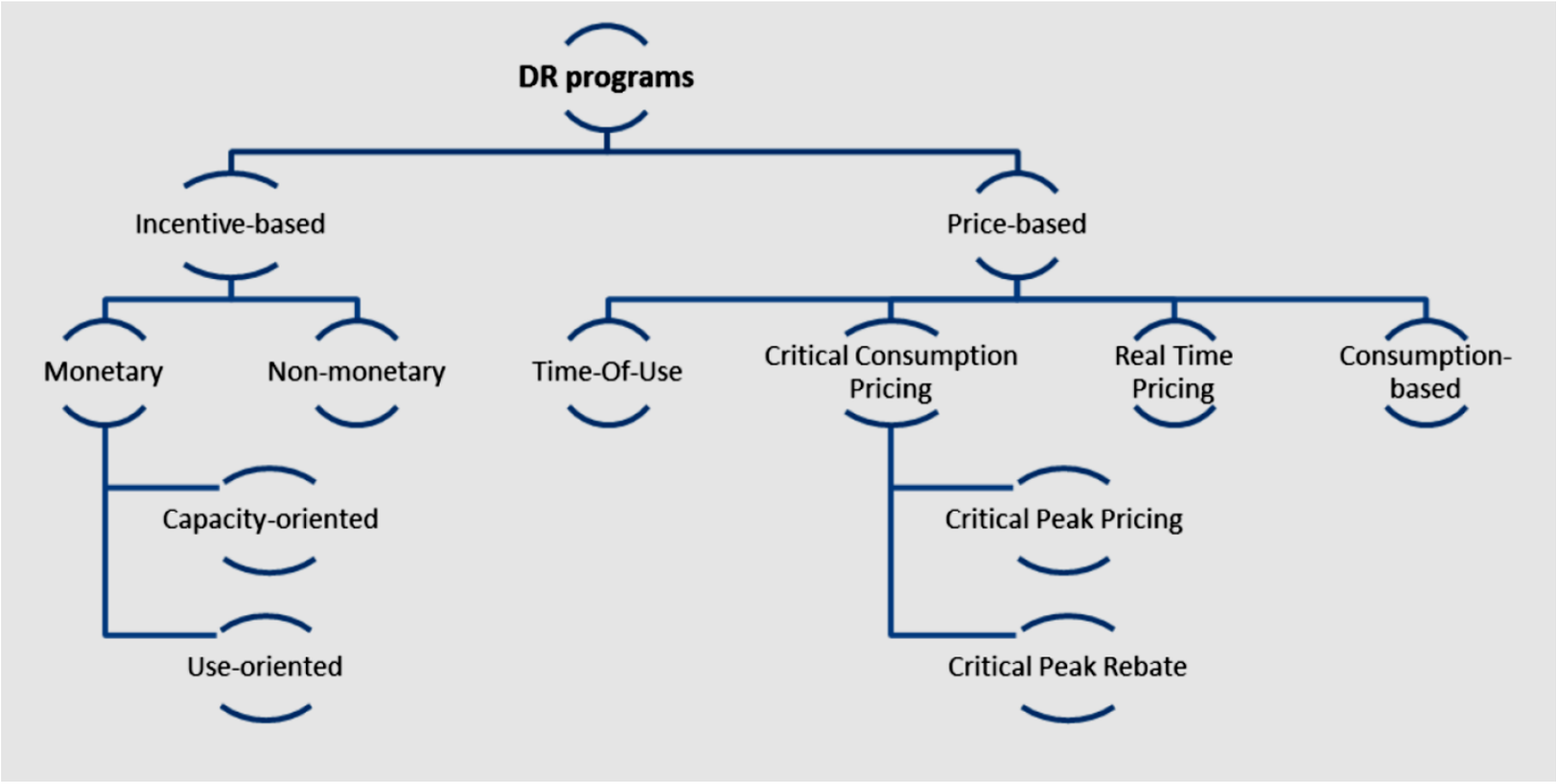
Categorization of Demand Response

Categorizations

- Incentive based
- Price based
- Commercial & Industry
- Residential



Source: S3C - Report on state-of-the-art and theoretical framework for end-user behaviour and market roles

Challenges and Opportunities

- **Electrification** of energy delivery → higher demand peaks
  - Electrical vehicles, HVAC (Air Conditioner, Heat Pump)
- **Distributed generation** → higher dynamic in the network
  - wind turbines, combined heat and power (CHP), photovoltaic systems (PV)
- **Heterogeneous**: hotspots → local congestions
  - No: one-size fits all and fit-and-forget principles anymore
- **Legislation** and **regulation** → solve problem where it arises
  - Optimized for operation and transactions from large generators and averaged, profiled demands

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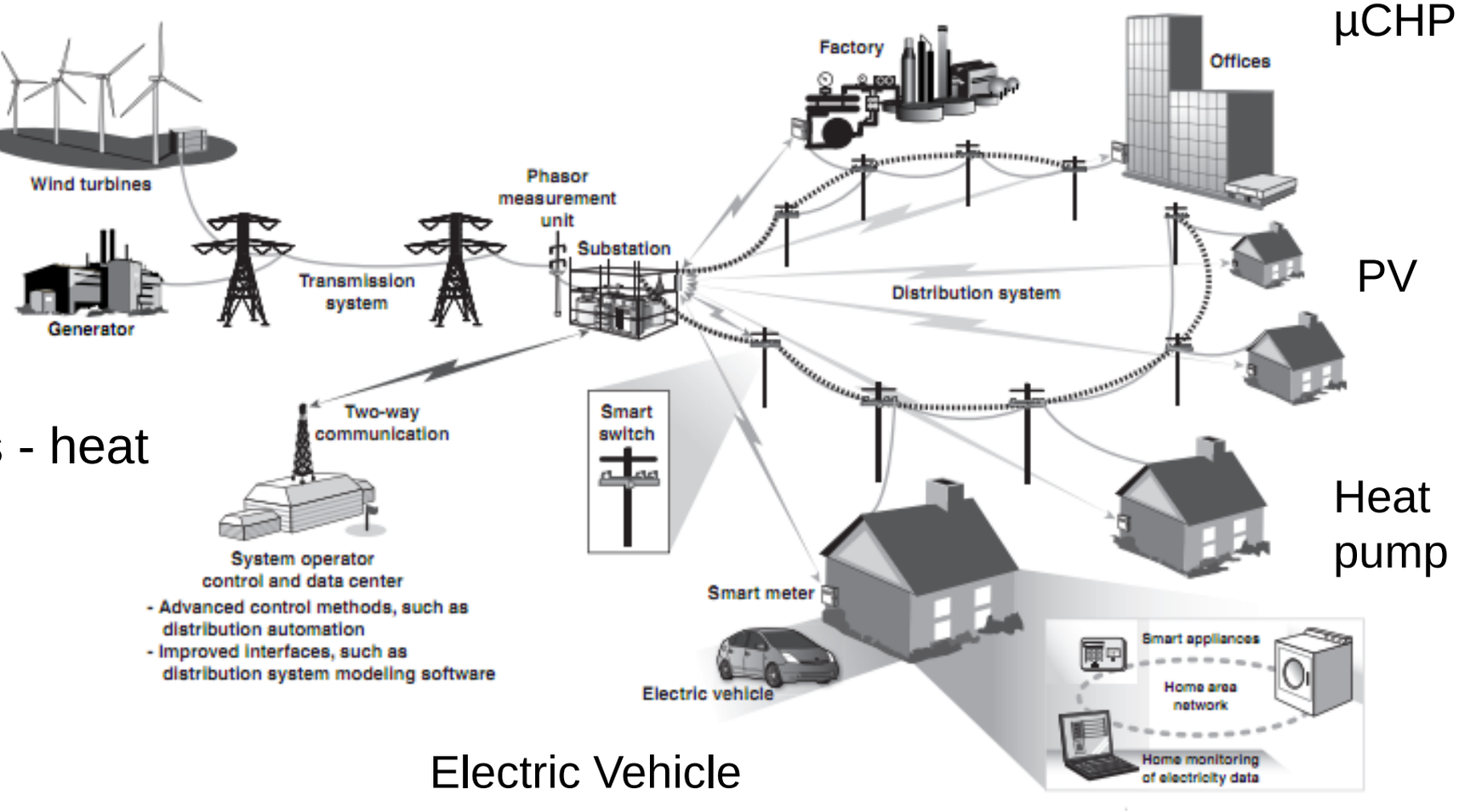
Power flows in electricity grids

central → **distributed generation**

unidirectional → **bidirectional power flow**

- **Synergies**
  - electricity - gas - heat
- **Electrification**
  - EV, HP, HVAC



µCHP

PV

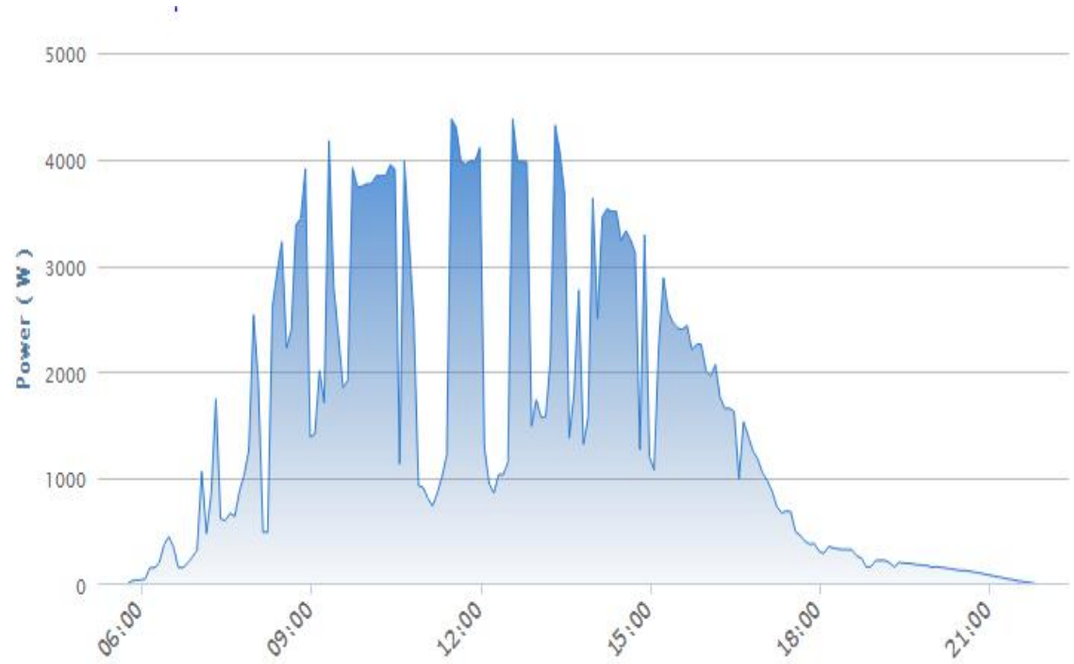
Heat pump

Electric Vehicle

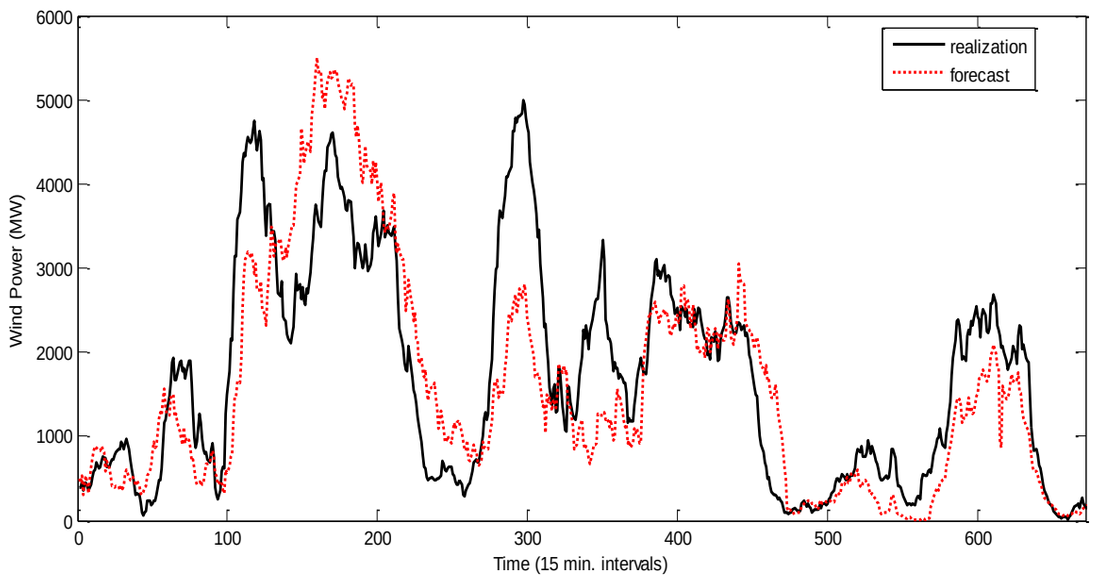
Source: Leonardo ENERGY - Smart grid: A grid suitable for renewable energy

Increase of Volatility and need for Balancing

- PV generation on a cloudy day



- Wind generation and deviation from forecast



→ need for balancing

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Increase in Demand: EV Opportunity Charging

Scenario	Number of EVs
5%	574
10%	1149
25%	2873

Charging power:
11 kW

3.500 kW
3.000 kW
2.500 kW
2.000 kW
1.500 kW
1.000 kW
500 kW
0 kW

00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00

5%-11kW 10%-11kW 25%-11kW

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Increase in Demand: EV Opportunity Charging

Scenario	Number of EVs
5%	574
10%	1149
25%	2873

Charging power:
11 kW
43 kW

3.500 kW
3.000 kW
2.500 kW
2.000 kW
1.500 kW
1.000 kW
500 kW
0 kW

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5%-11kW 10%-11kW 25%-11kW 5%-43kW 10%-43kW 25%-43kW

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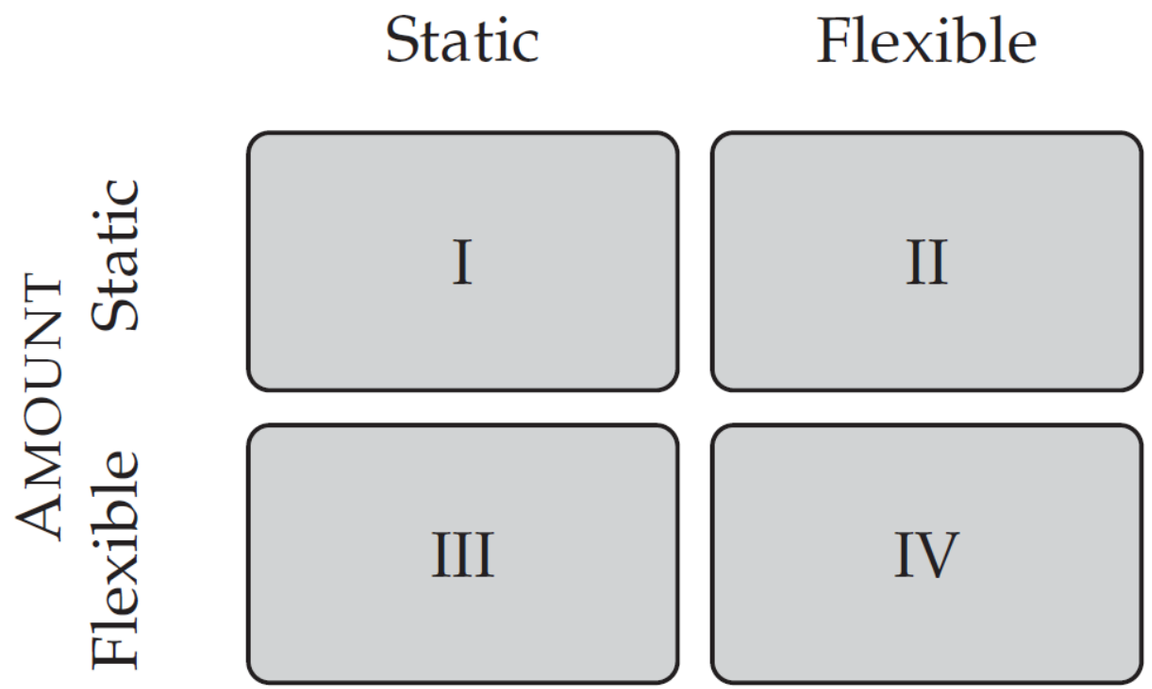
DR RESOURCES AND POTENTIALS

DR Resources in Residential Areas

- Fully static consumption (also PV and wind)
- Static amount, flexible timing of consumption (behavioral)
- Flexible amount, static timing (controllable load and generation)
- Fully dynamic consumption



Source: Ch. M. Flath Flexible Demand in Smart Grids Modeling and Coordination

DR Resources in Residential Areas

- **Electro-thermal storage**
  - Warm water boilers
  - Cooling / freezers
  - Heating (HVAC) / Heatpumps (“Smart Grid Ready”)
- **Electric storage**
  - Electric vehicles (controlled charging)
  - Stationary batteries, home battery systems
- **Other Shiftable Processes**
  - Public services: Water pumps, Waste water / sewage

→ **Load shifting** for network operation is already in place for many years (ripple control)

→ **Aggregation** makes it more robust (Virtual Power Plant)

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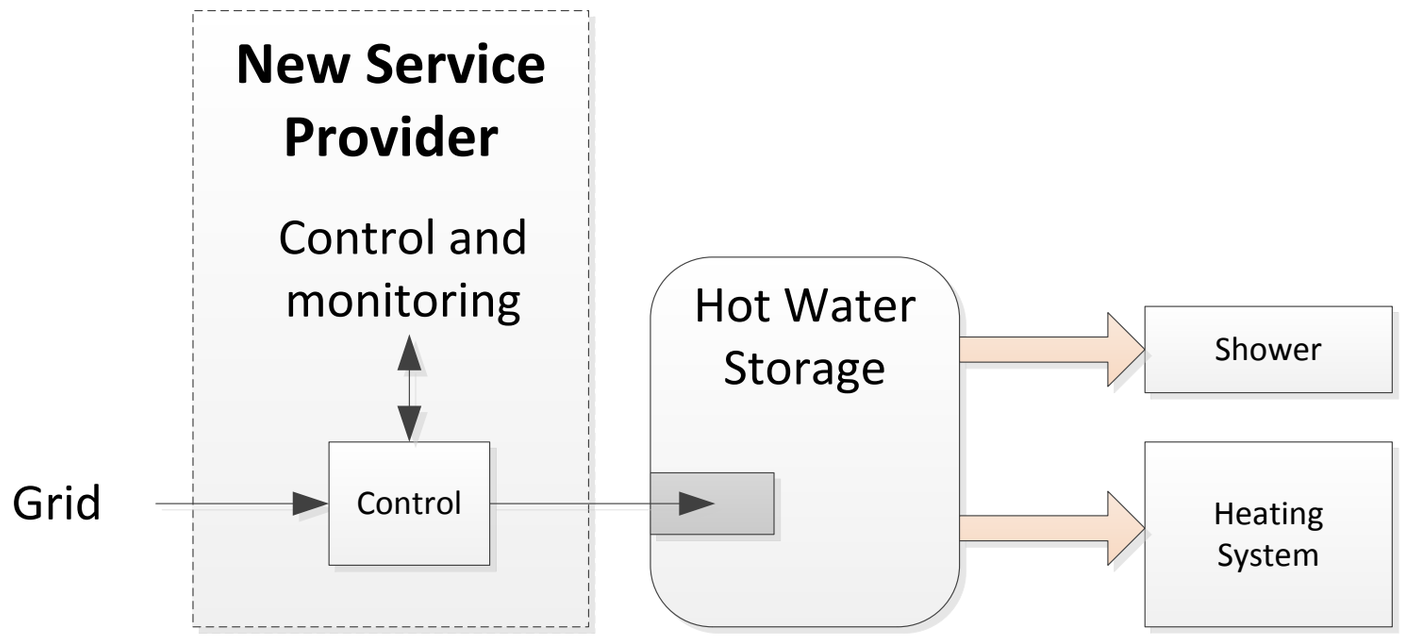
Example for DR Resource and Business Case

- Shifting water heating to optimize with volatile generation
- No customer impact, preserve comfort
- Pooling of „very small units“
- Boiler prepared and can be upgraded with GPRS connectivity
- System control and permanent monitoring (status of storage)
- New market player deals with data, security, customer involvement



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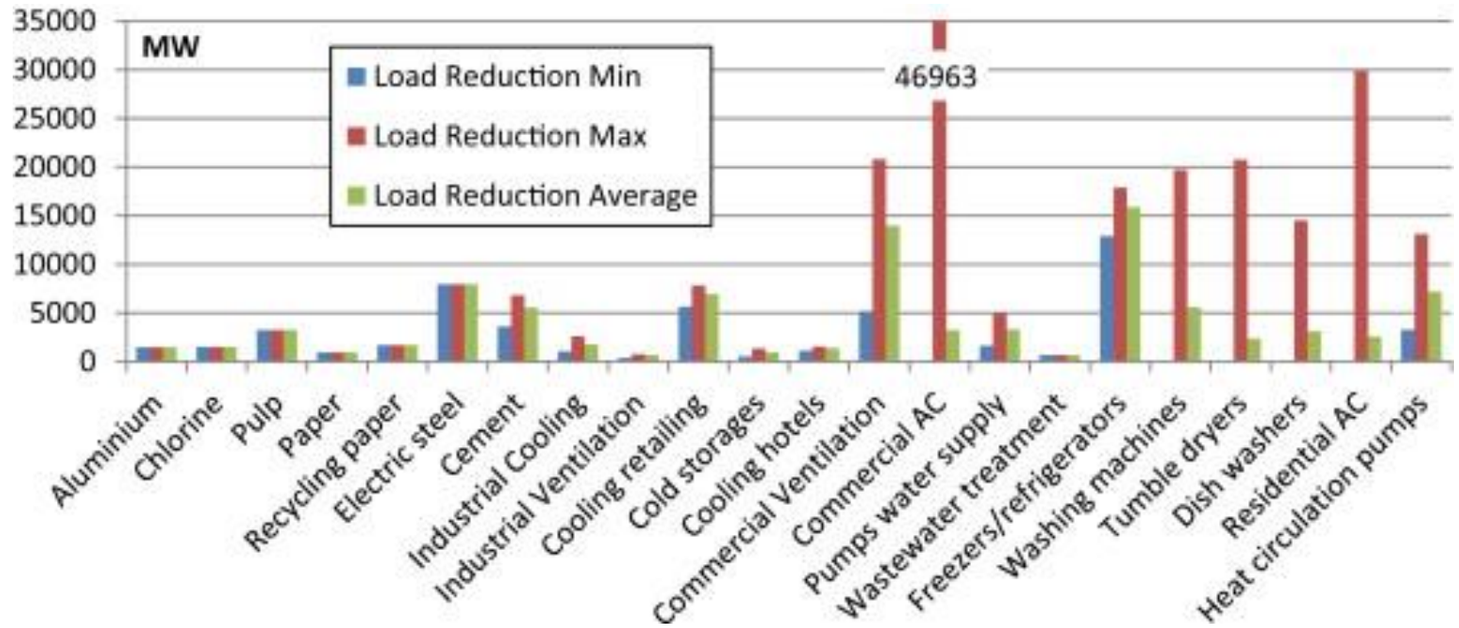
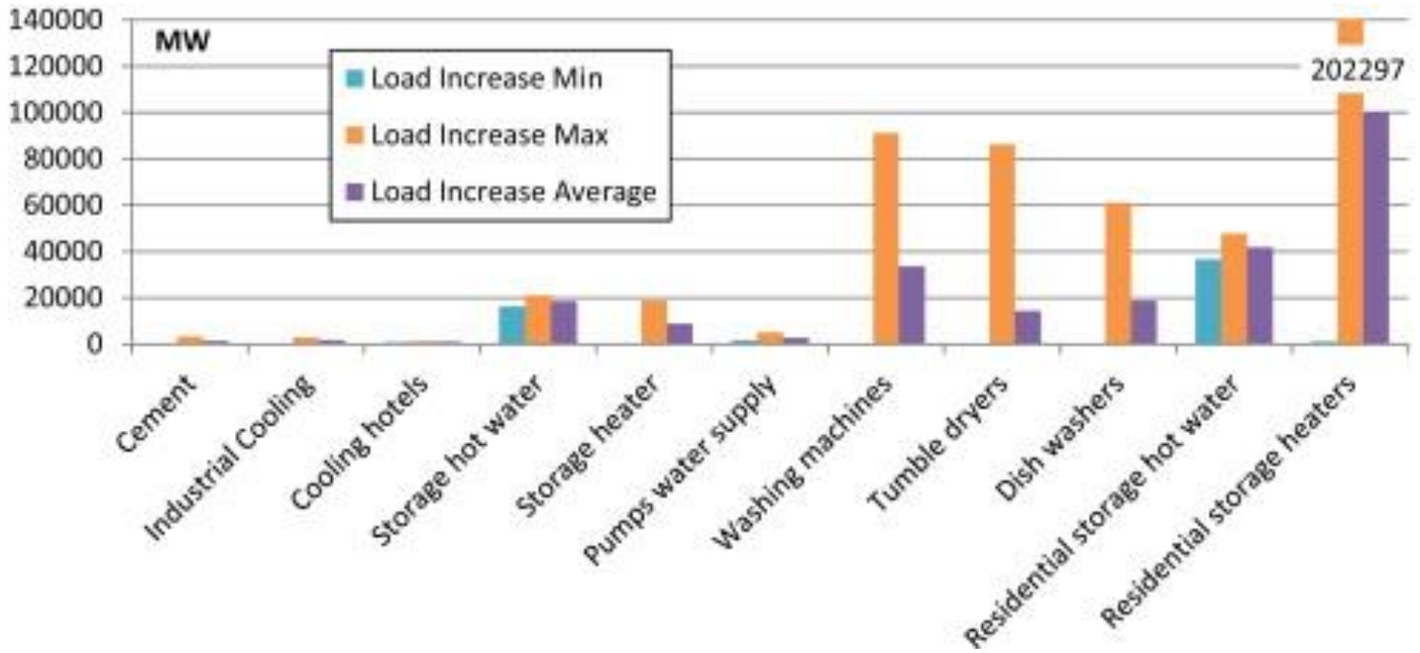
Theoretical DR Potential in Europe

- Potential load reduction



- Average potential load increase



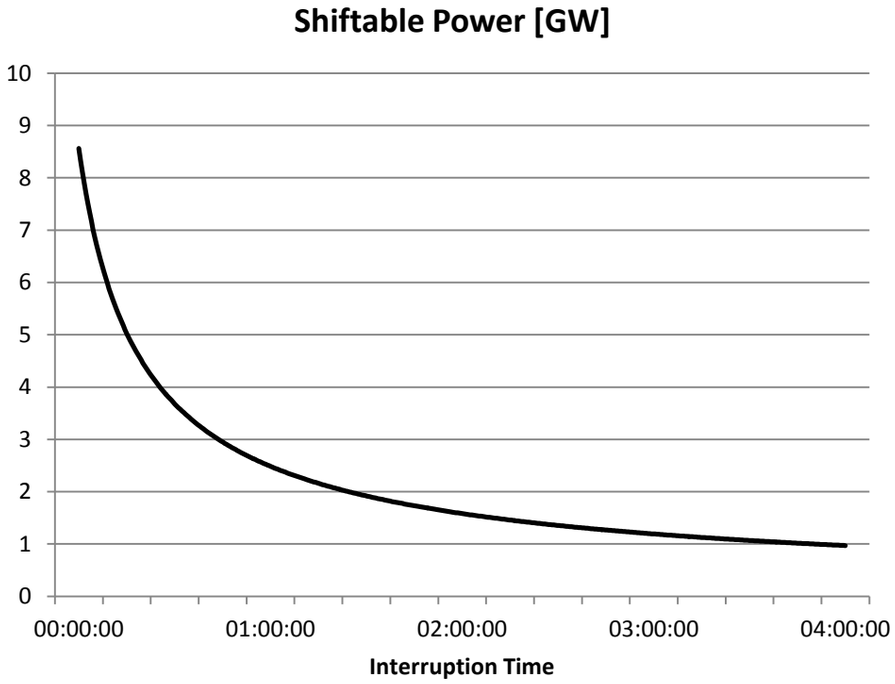
Source: Hans Christian Gils, *Assessment of the theoretical demand response potential in Europe*, Energy, Volume 67, 2014, 1–18

Practical Potential (example Germany and Austria)

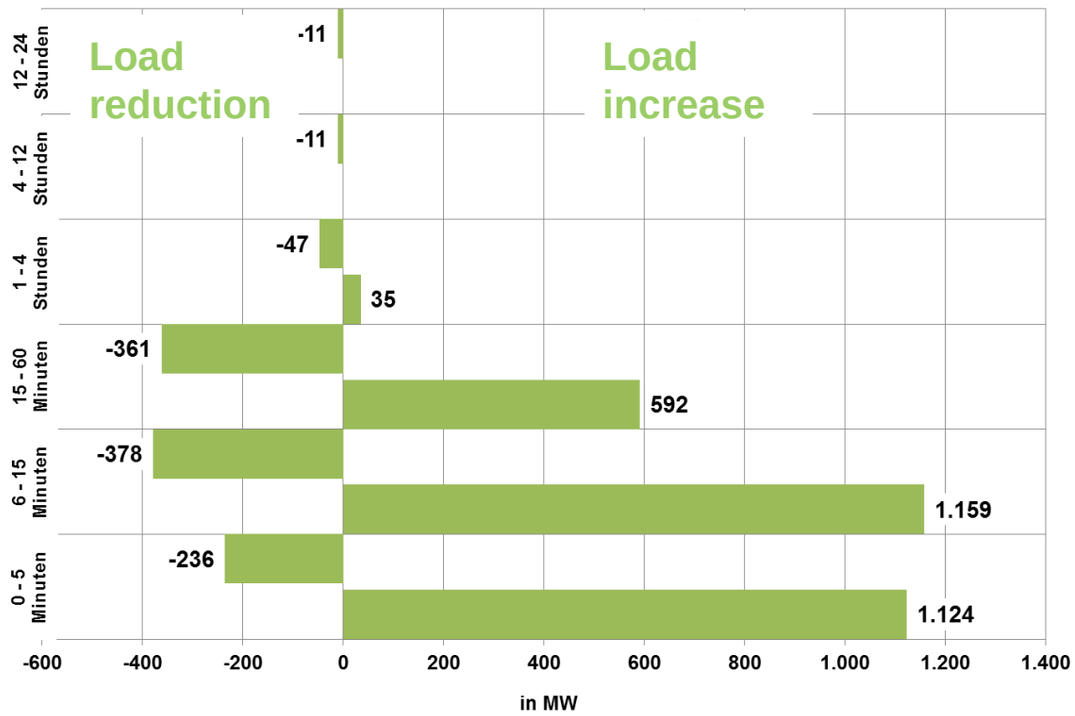
- **Practical load shift** demand at households in Germany and Austria

→ depends on duration

→ rebound effect for „re-charging“



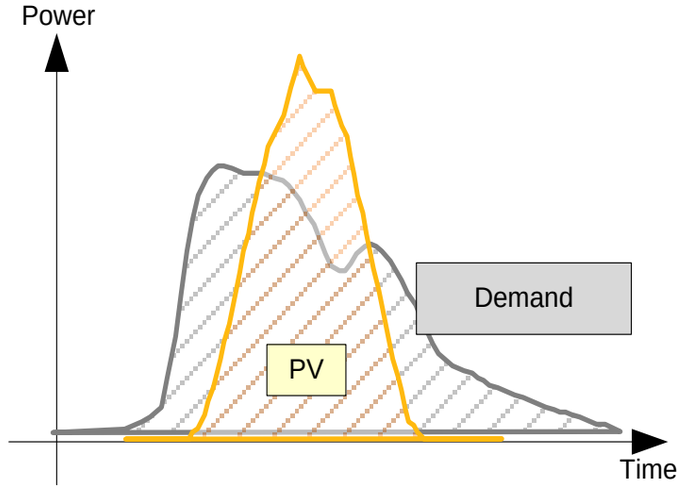
Source: Load shifting potentials in Germany B.A.U.M. Consult – own illustration

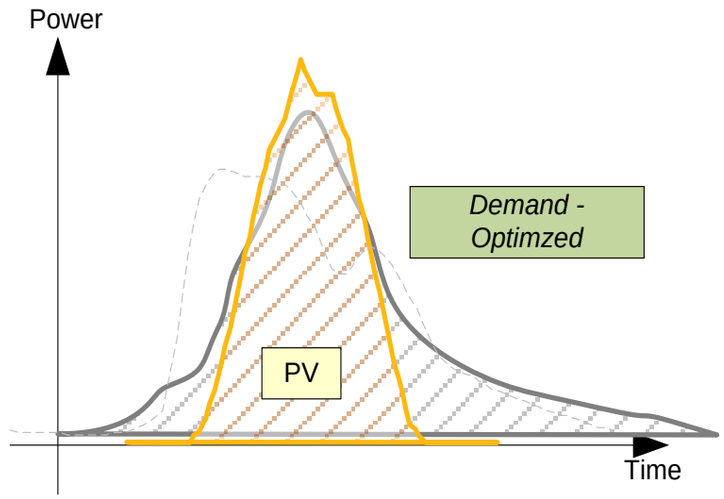


Source: Energy Institute JKU Linz – Project „LoadShift“

DR Motivation, Applications and Services

- Reduce peak demand power
- Provide balancing services
- Portfolio optimization
- Integration of renewables
- Avoid network congestion
- Market participation (better energy prices)
- Optimization of self-consumption
  - Germany: Grid Parity / 70% curtailment





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Challenges and Opportunities

- **Increase in information systems** used in energy grids
  - Confusion what are smart grids
  - However: more –smartly integrated- applications can be built
  - Smart metering, home SES and monitoring including LV level
  - Communication/message exchange possible between load and generation on all levels
- **Aggregation of loads** to deliver services
  - Virtual power plants
    - Commercial clusters ->supporting market parties
    - Technical clusters -> supporting D**N**O, T**N**O becoming D**S**Os, T**S**Os
    - Community based
      - Community batteries with own clusters of customers (storing PV)

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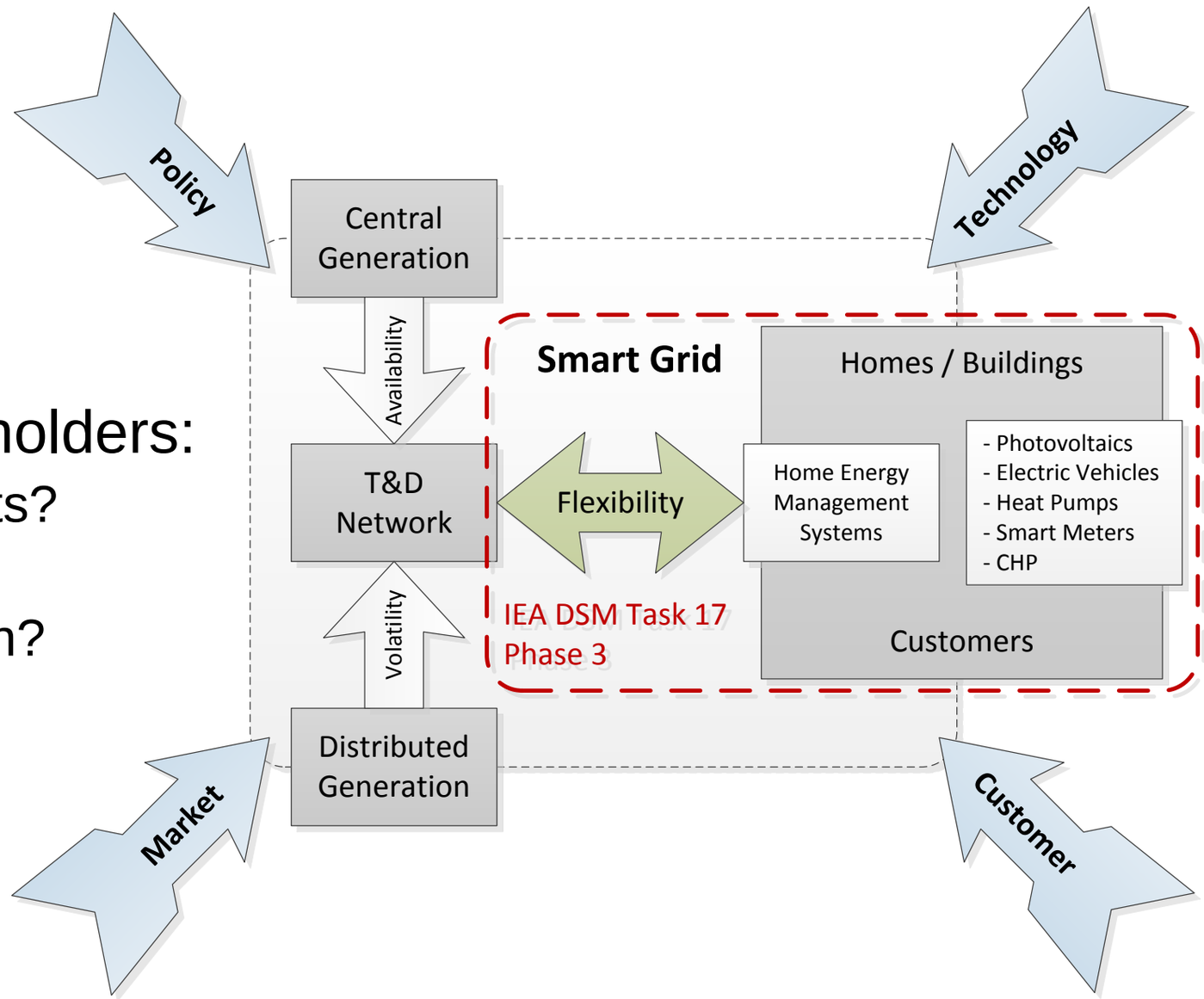
Task 17 Overview: Systems view on enabling Demand Response and DG-RES

- **Different views** on the Smart Grid:
  - Technology
  - Customer
  - Policy
  - Market



- **Enabling of flexibility**
  Impact of it on the stakeholders:
  - What are the requirements?
  - How do we manage it?
  - How will it effect operation?
  - What are the benefits?

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Systems view on enabling DR and DG-RES

- **Behaviour based DR:** passive; incentivised by tariff (e.g. : example red-white blue in France; washing on PV)
  - Utility centered (e.g. congestion management)
  - Low ICT requirements

- **Active DR:** active; incentivised by micro-profiling and micro-pricing by service provider (smart meter allocation in Finland, system Germany; your energy moment)
  - Service oriented (grid and market)
  - Intermediate ICT requirements

- **Transactional DR:** bidding based; incentivised by direct market access (PowerMatcher, Transactional Energy, Intelligator)
  - Prosumer/SmartCity oriented
  - Multi-commodity (kW, kWh_e, kWh_{th})
  - Variable time resolution
  - High ICT requirements

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Pilots, Demonstration and Case Studies

SGMS-HiT –Smart Grid Modelregion Salzburg

- Buildings as interactive participants in the Smart Grids

SGMS-HiT – DR Resources

- Utilizing HVAC-Systems (heating, hot water)
- Separate **usage of energy** from **energy supply**
  → **Buffering** with thermal storages

- Use **energy** which is most **efficient** for the grid
  - Biogas (CHP)
  - PV
  - Grid
  - District heating

→**grid friendly building**

→**Comfort** must be **preserved**.

SGMS-HiT - Consumer Participation

- Consumer Evaluation

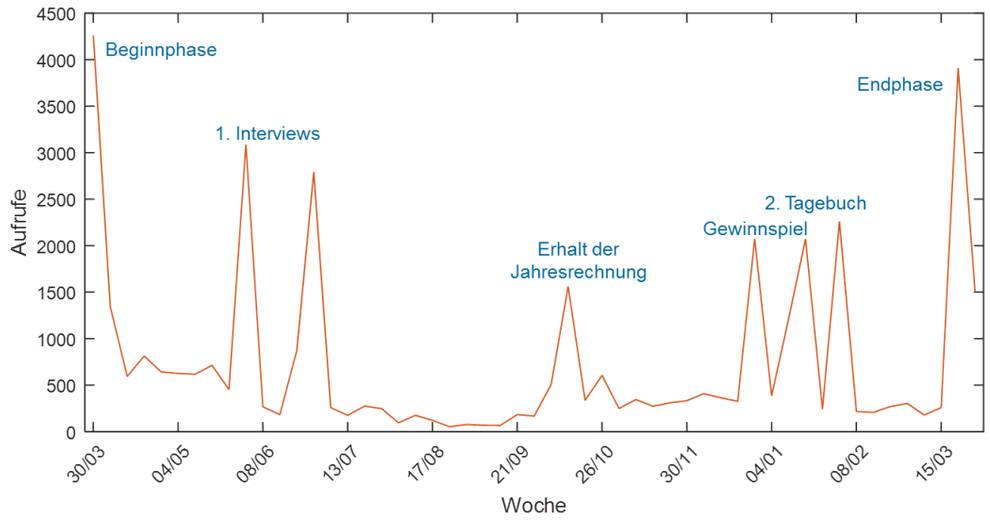
- **FORE-Watch:** 12 hours forecast

- (simulated) **Tariffs**

RED:	Standard Tariff + 5 Cent / kWh
YELLOW:	Standard Tariff
GREEN:	Standard Tariff – 5 Cent / kWh

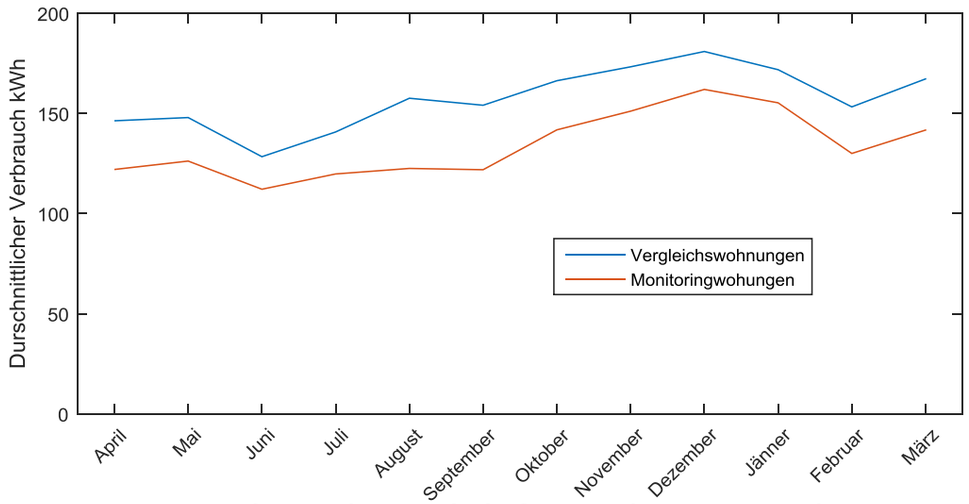
SGMS-HiT - Consumer Evaluation

- Usage of *Smart Center*



Activity only triggered by external events

- Energy consumption
  - EcoButton is used
  - Dish washer shiftable
  - Cooking not shiftable
  - Comfort for consumption



Energy savings through information campaign.

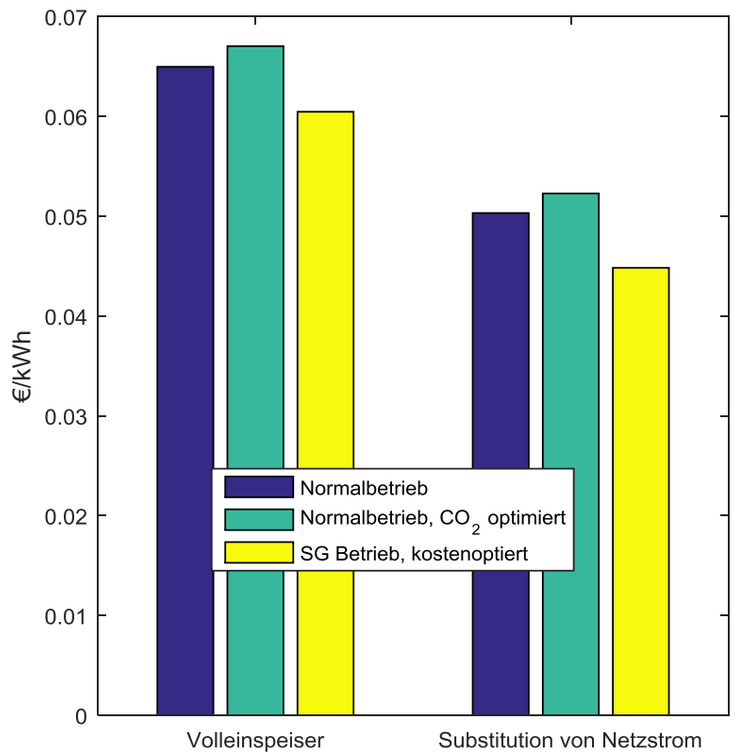
SGMS-HiT – Evaluation of automated DR

- Potentials of automated load shifting:

Heat source	Red	Yellow	Green
CHP	+17 %	-11 %	-6 %
HP	-12 %	+9 %	+3 %

Price forecast for the next 12 hours

- Cost savings



Blue: Normal operation
Green: Normal + CO2 optimized
Yellow: Smart Grid – cost optimized

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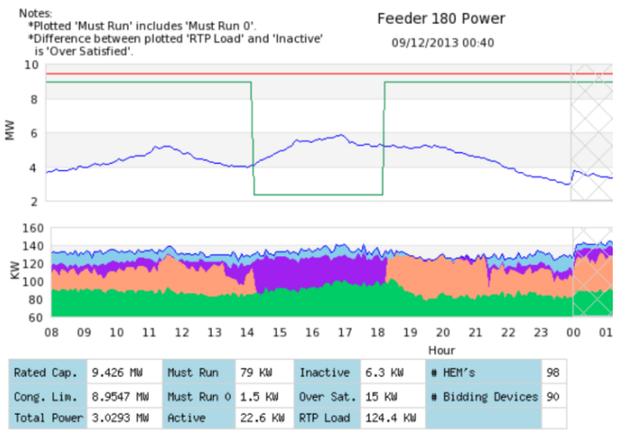
Project: gridSMART® RTPda Demo

Residential Real-time Pricing Experience

gridSMART® RTP - Background

- First **real-time market at distribution feeder level** with a tariff approved by the PUC of Ohio
- **Value streams**
  - Energy purchase benefit: function of PJM market LMP
  - Capacity benefits: distribution feeder and system gen/trans limitations, e.g., peak shaving
  - Ancillary services benefits: characterized, but not part of the tariff
- Uses **market bidding** mechanism to perform distributed optimization – transactive energy
  - ~200 homes bidding on 4 feeders
  - Separate market run on each feeder
  - “Double auction” with 5 minute clearing
- HVAC **automated bidding**
  - Smart thermostat and home energy manager
  - Homeowner sets comfort/economy preference
  - Can view real-time and historical prices to make personal choices



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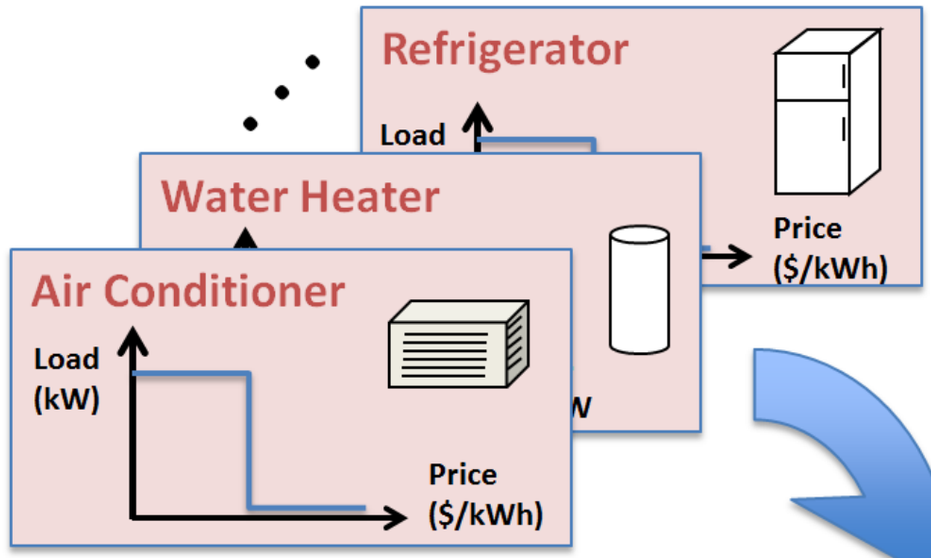
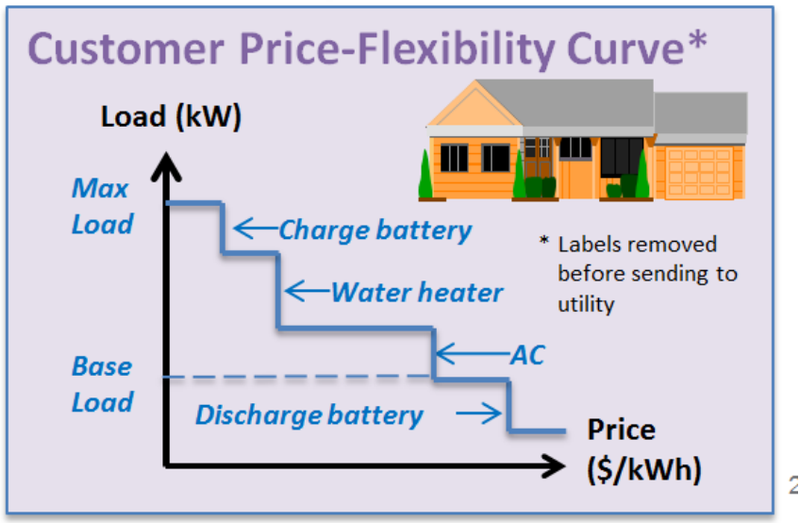
gridSMART® RTP - Transactive Grid Control Overview

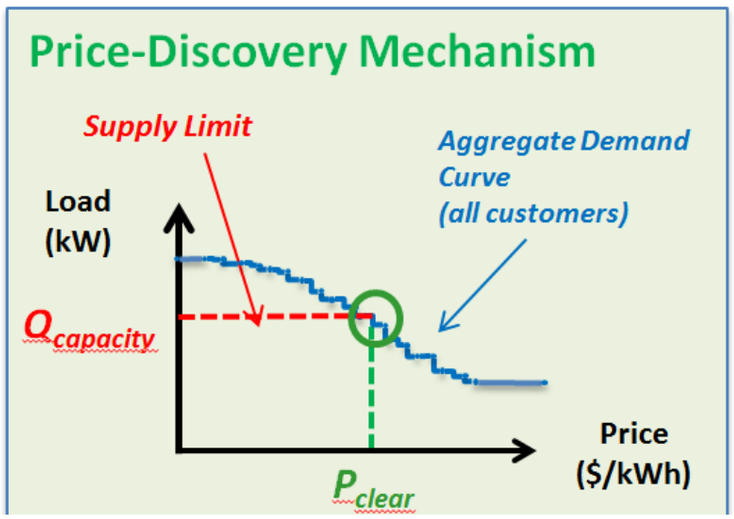
1. Automated, price-responsive device controls express customer's flexibility (based on current needs)



2. Customer system aggregates responses to form overall price flexibility curve



3. Utility aggregates curves from all customers



4. Aggregator determines price at which grid objective achieved, broadcasts to consumers

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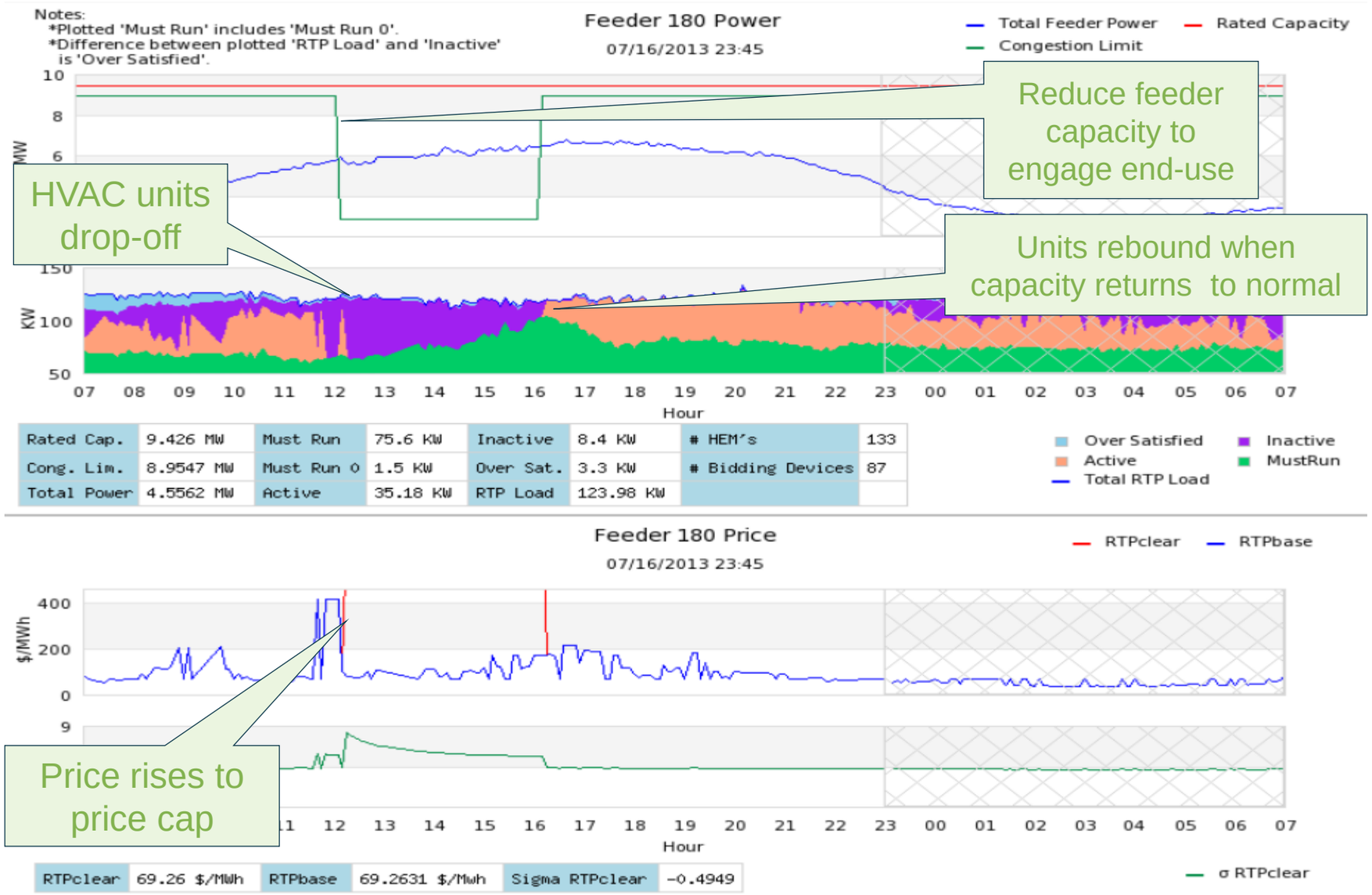
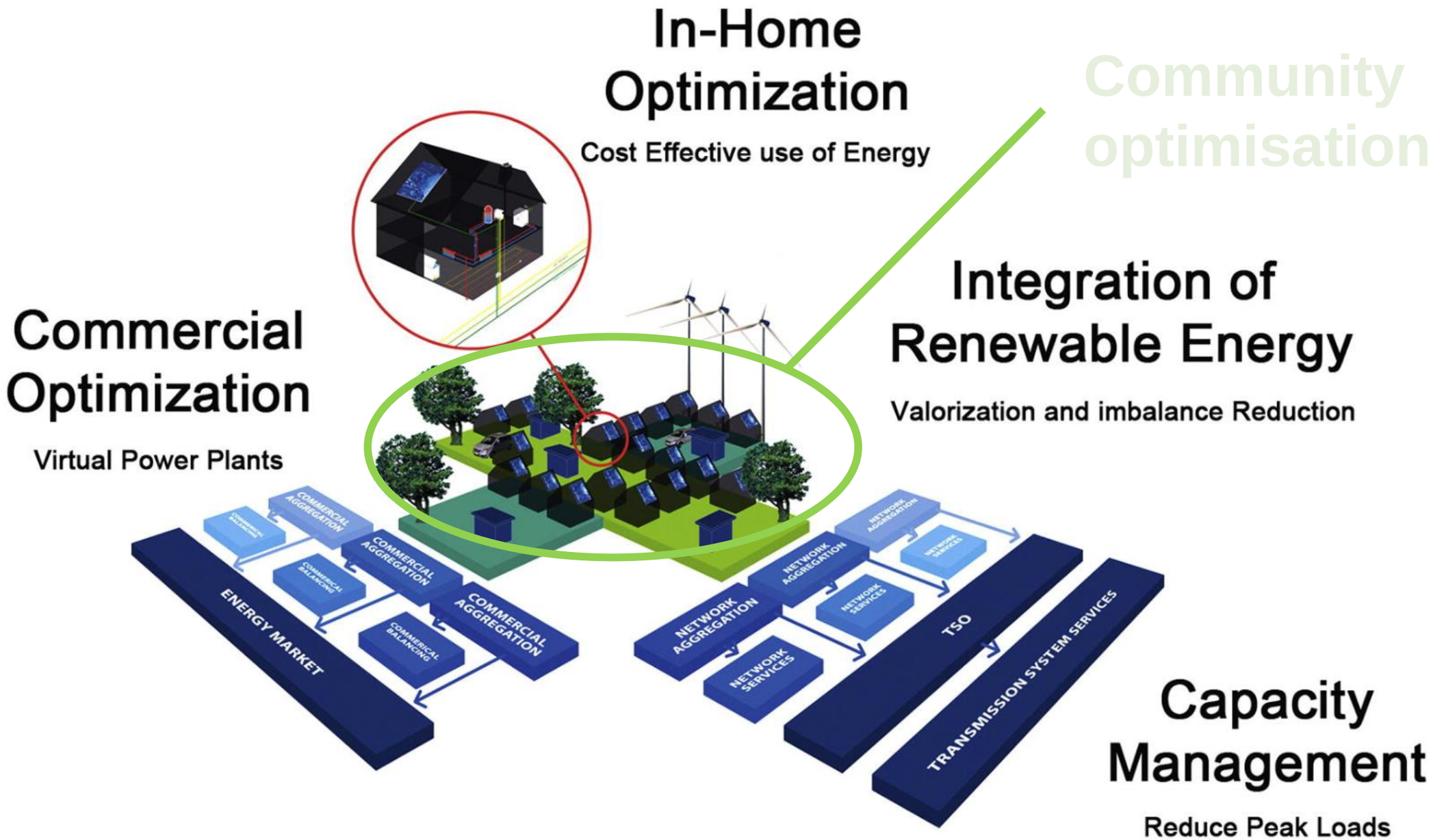
gridSMART® RTP in Action



Power Matcher

Power Matcher



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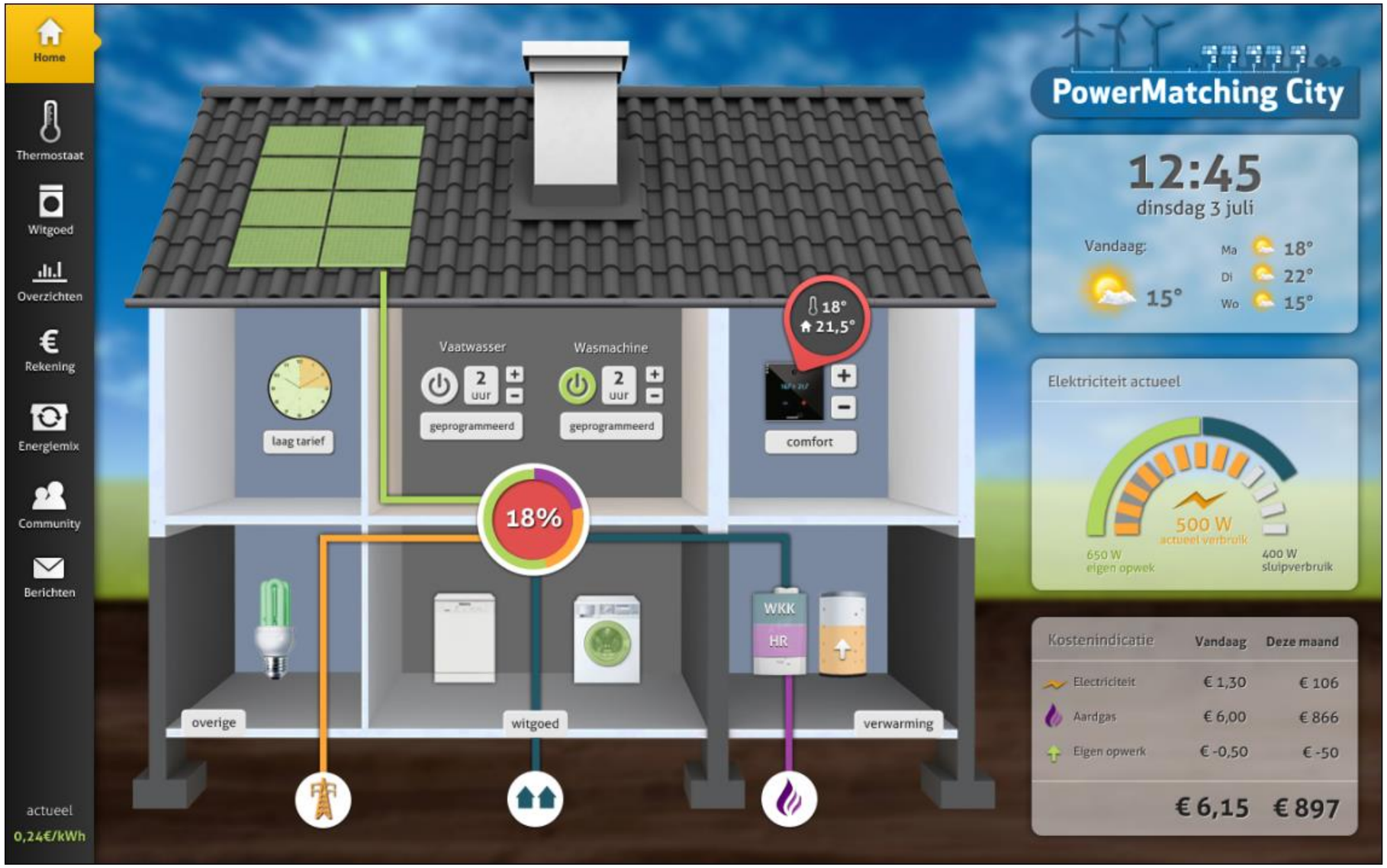
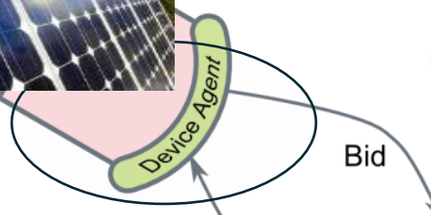
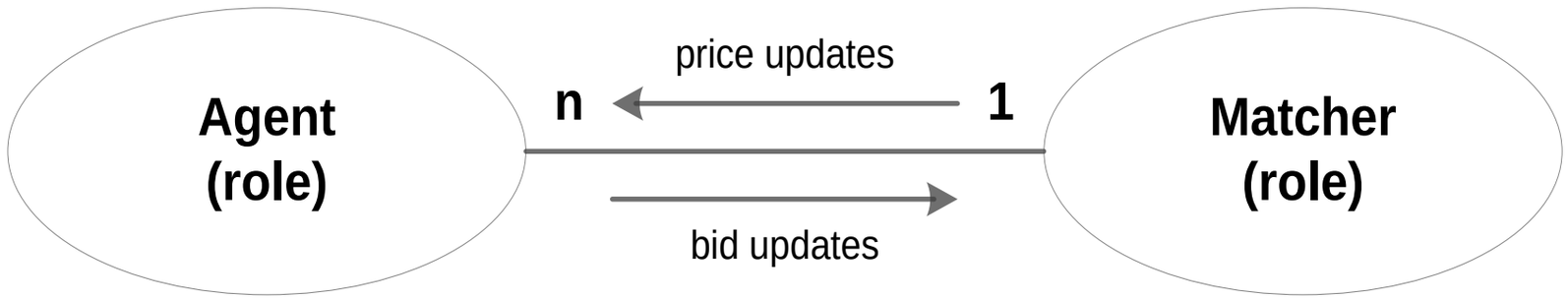
Power Matcher



Example of PowerMatcher Agent VPP-Topology

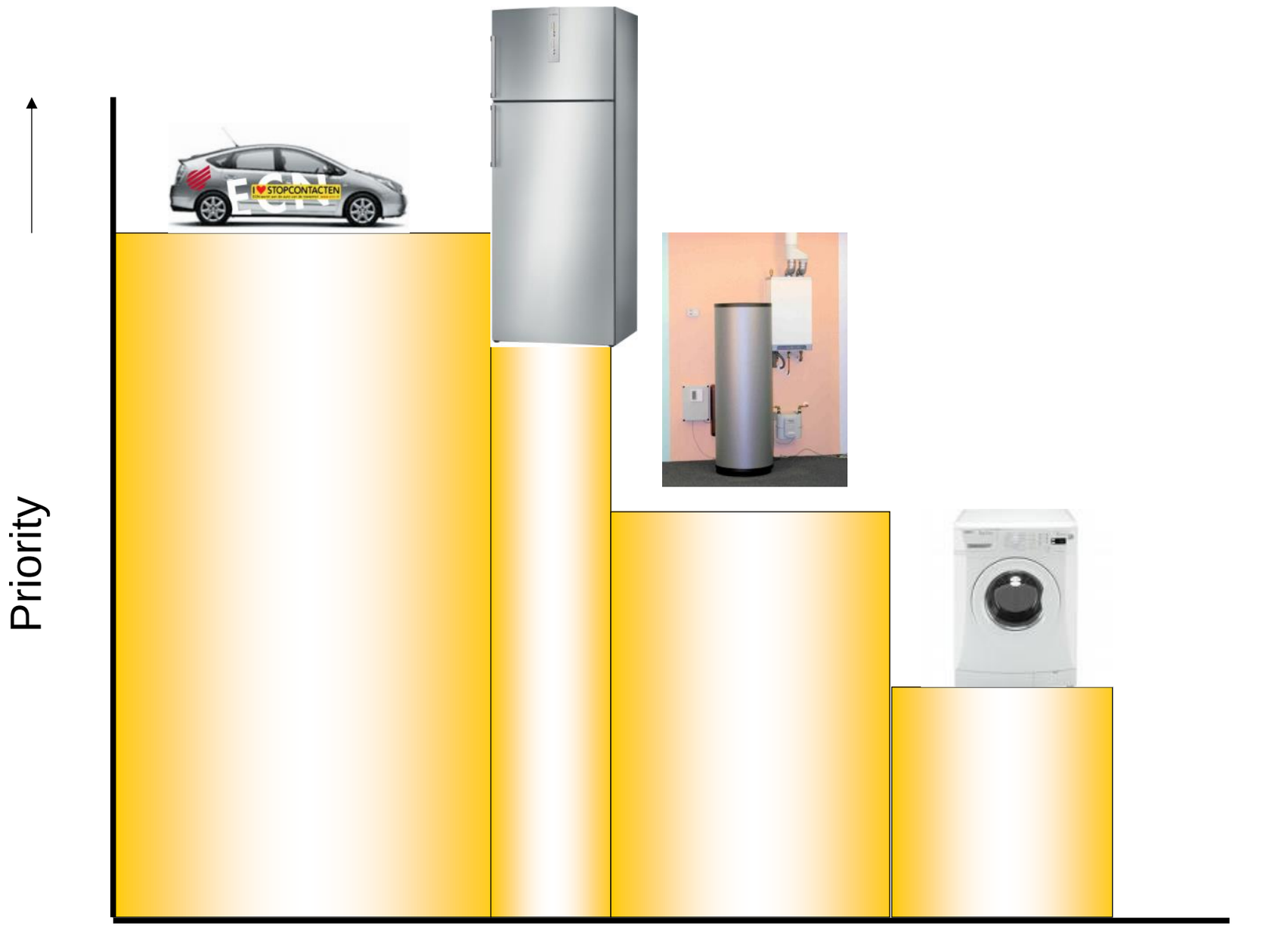


PowerMatcher roles

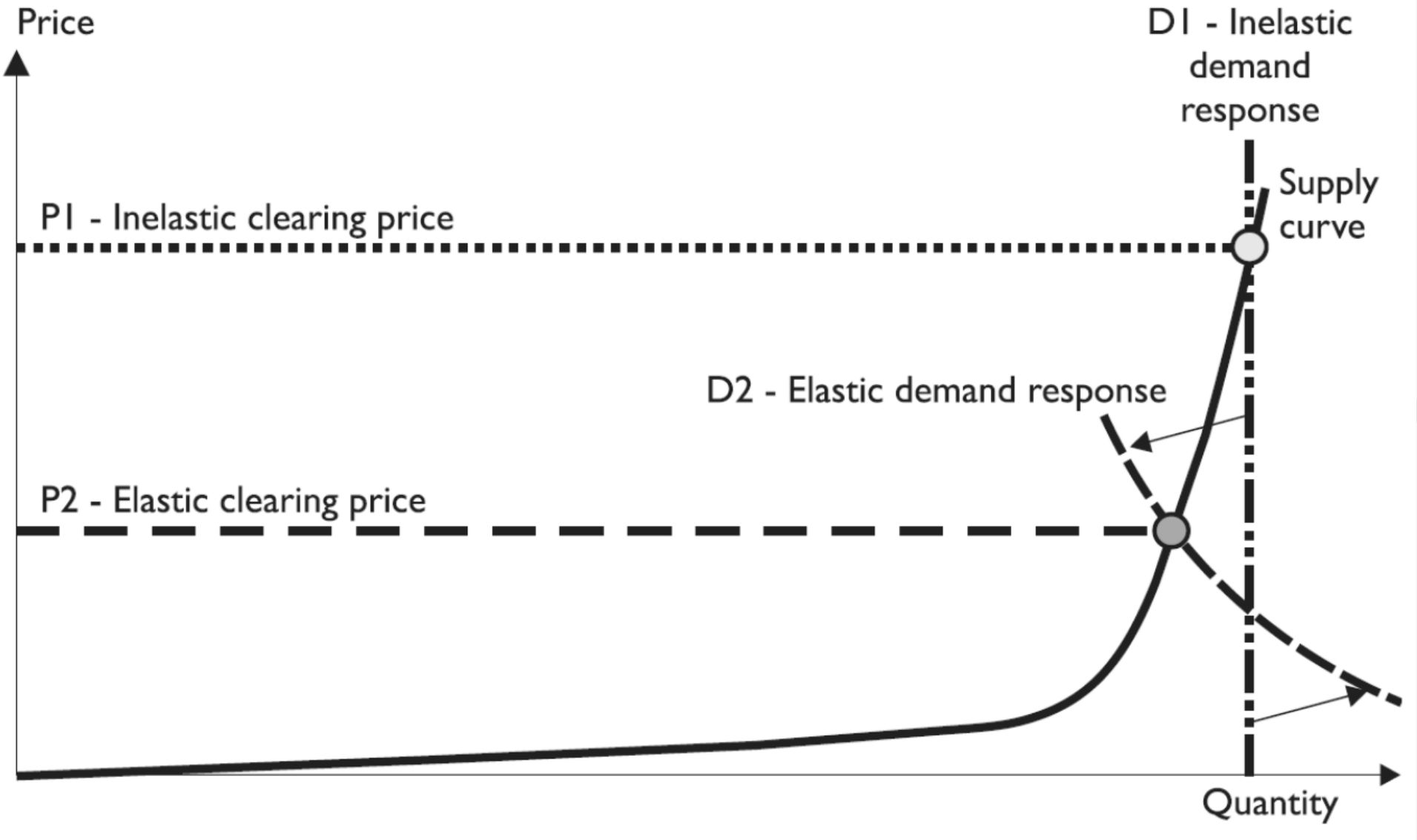


- **Software Agent:** Expresses bids to its matcher based on flexibility in the primary process in electricity supply / demand it represents
- **Matcher:** determines price for its agents based on the supply and demand bids.
- Any agent is associated to exactly one matcher (normally)
- Any number of agents may be associated with one matcher

Priority is translated into a price dependent on the current state of the primary process

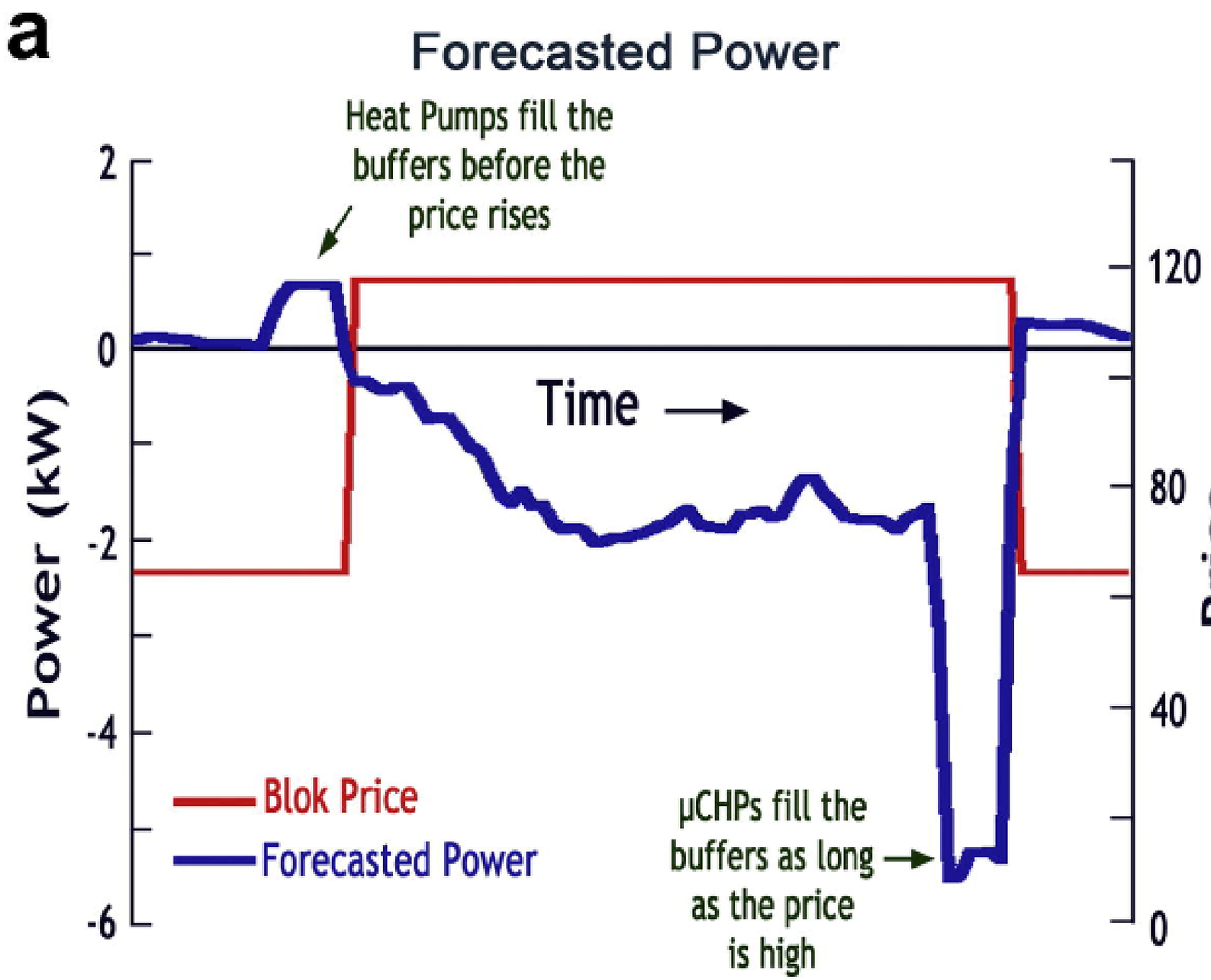


Economics of DR mechanisms on the market



Commercial aggregation of the 25 household cluster

Pre-emptive charging of heat buffers



Conclusions and Outlook

High DG-RES percentages require flexible demand

New Roles: **Aggregator**

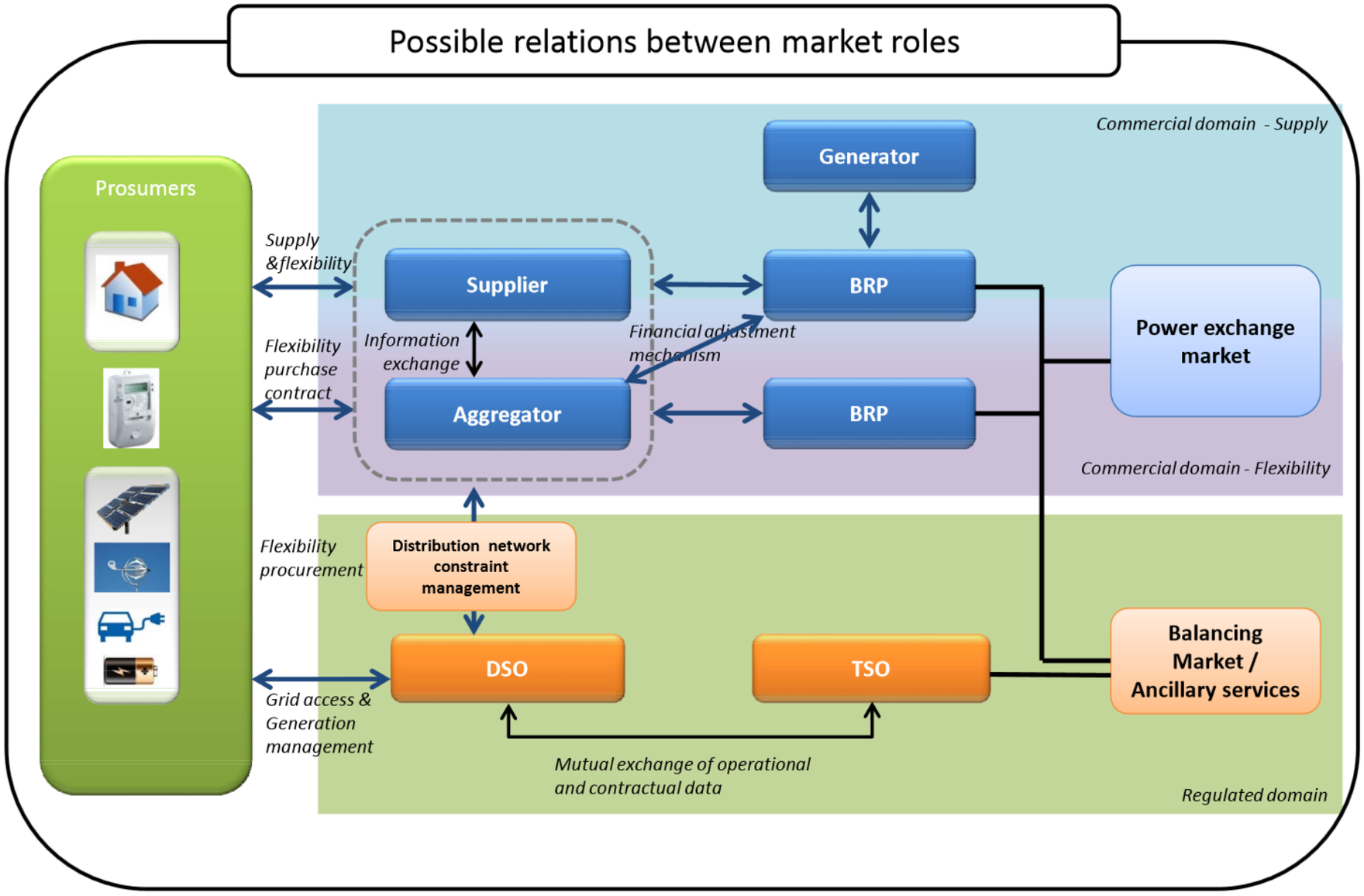
- Provides access to market/network for small resource (pooling)
- Directive EE:
  - *„a demand service provider that combines multiple short duration consumer loads for sale and autciton in organized energy markets“*
- Necessity to include small generation
- Avoid discrimination between generation and active demand resources

High DG-RES percentages require flexible demand

New Roles: **Flexibility Service Provider**

- Motivation
  - Other services as system balancing
  - Services between other actors than TSO
- Definiton of flexibility
  - Does it include energy?
  - Does it inlcude power able to be activated?
- Definition should include all resources
  - Regardless the connected grid (TSO / DSO)
  - Aggregated or not aggregated

Possible relations between market roles



SGEG3 – Regulatory Recommendations for the Deployment of Flexibility

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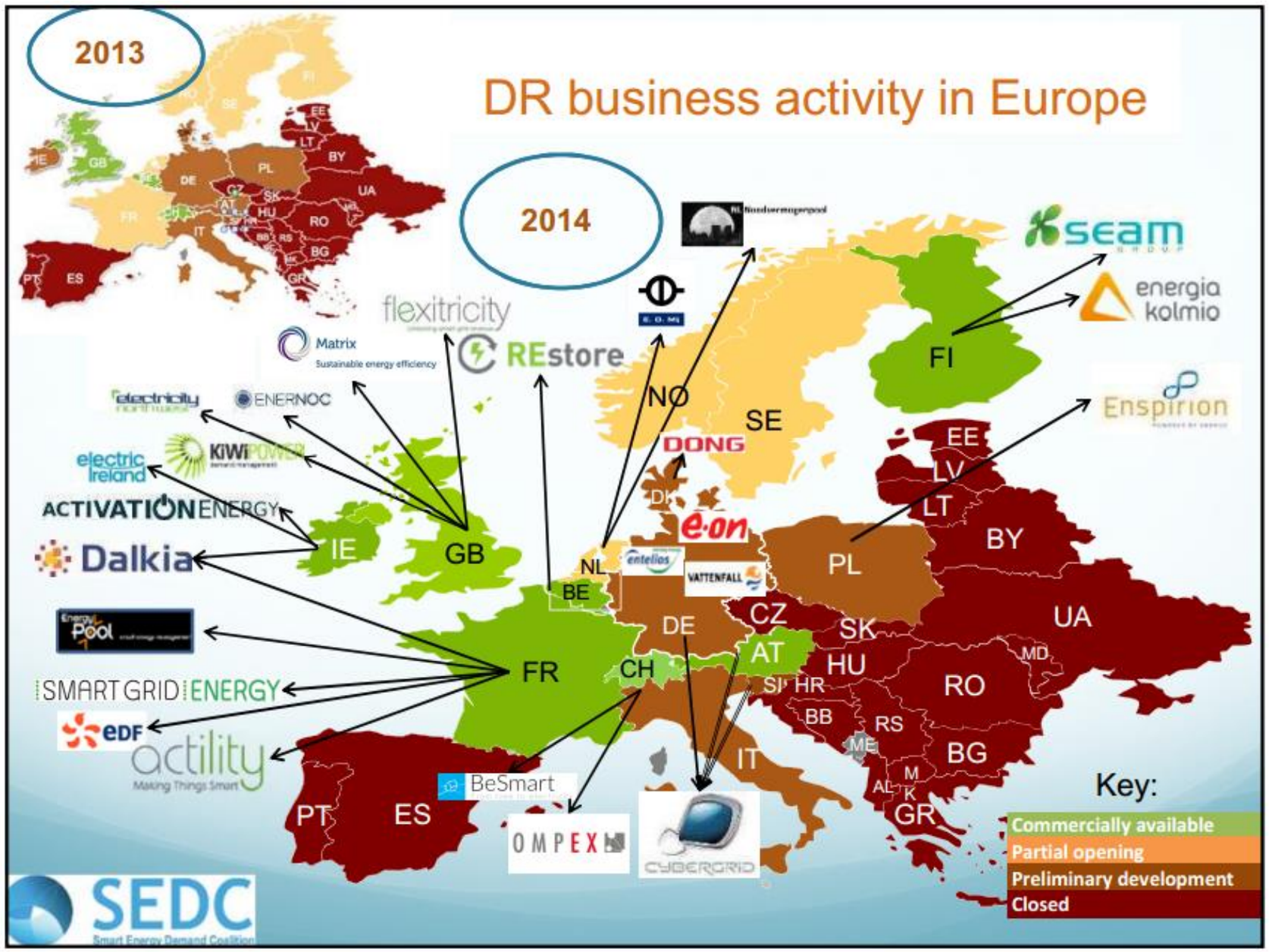
Flexibility is needed SEDC: Smart Energy Demand Coalition



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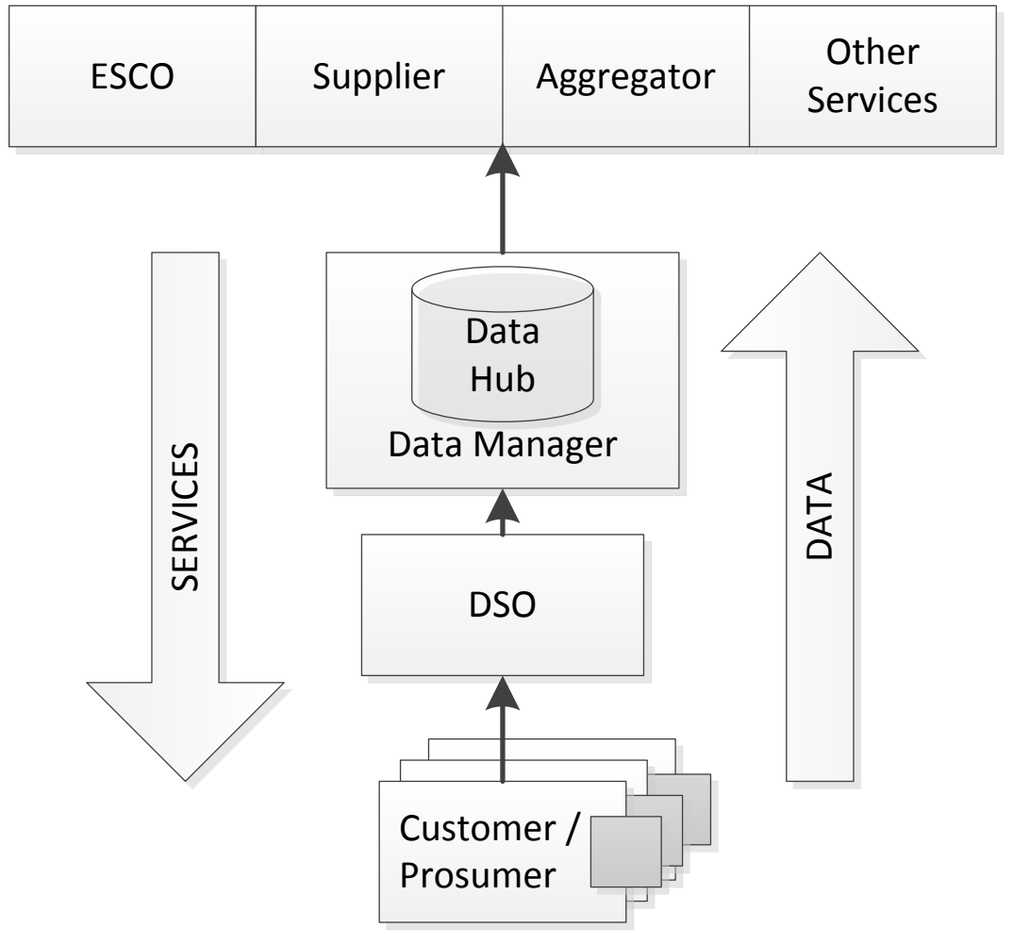
Customer Data Management to enable Flexibility

- DataHub for enabling new business models and services
  - Virtual Power Plants / Aggregator
  - Flexibility Operators / Demand Response
  - ESCO / Energy efficiency
  - Smart Homes



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Business cases and end user interaction

- Most field tests show increase in flexibility can be shown
  - Optimization of energy use decrease costs and increases comfort
- In current tariff and market situation not optimal
  - Definition of responsibilities and new roles necessary
- Incentives to end-users needs to be clear
  - Flexibility in end-user processes is there; retain energy efficiency
  - Enduring effects -> preference learning and automation
- User behaviour and interaction possibilities need to be clear
  - Changes in control strategies have impact on performance

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Questions

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  - Smart Grid Mandate M/490