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SustainIT 2015

New Services for Energy Demand Management

Dr. Milan Prodanovic

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Institute IMDEA Energy

Mission:

Promotion of renewable and clean energy technologies

Formed of six research units:

1) Thermo-Chemical Processes (sustainable biofuel fuel production, CO2 confinement and valorisation)
2) Biotechnological Processes (energy production of sustainable fuels)
3) Electrochemical Processes (energy storage systems)
4) High Temperature Processes (solar energy, energy storage)
5) Systems Analysis (CO2 confinement and valorisation, life-cycle analysis)
6) **Electrical Systems** (Smart management of power networks, renewable energy and storage integration)

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Electrical System Unit - Objectives

Proactive control of future power networks

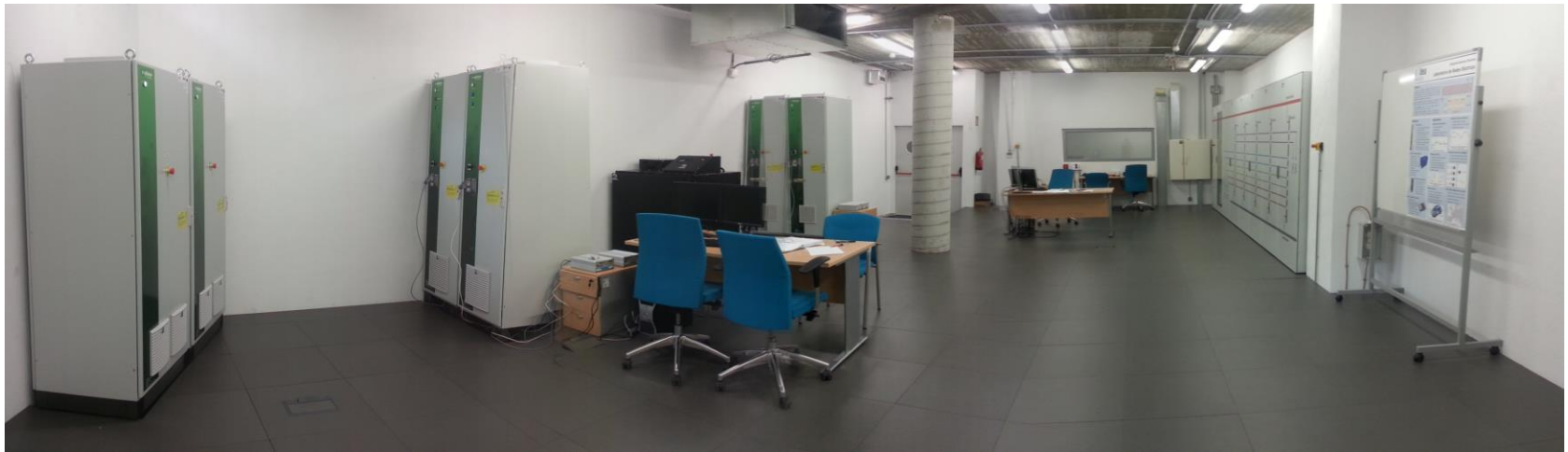
- Management algorithms for future power networks

Renewable and energy storage integration

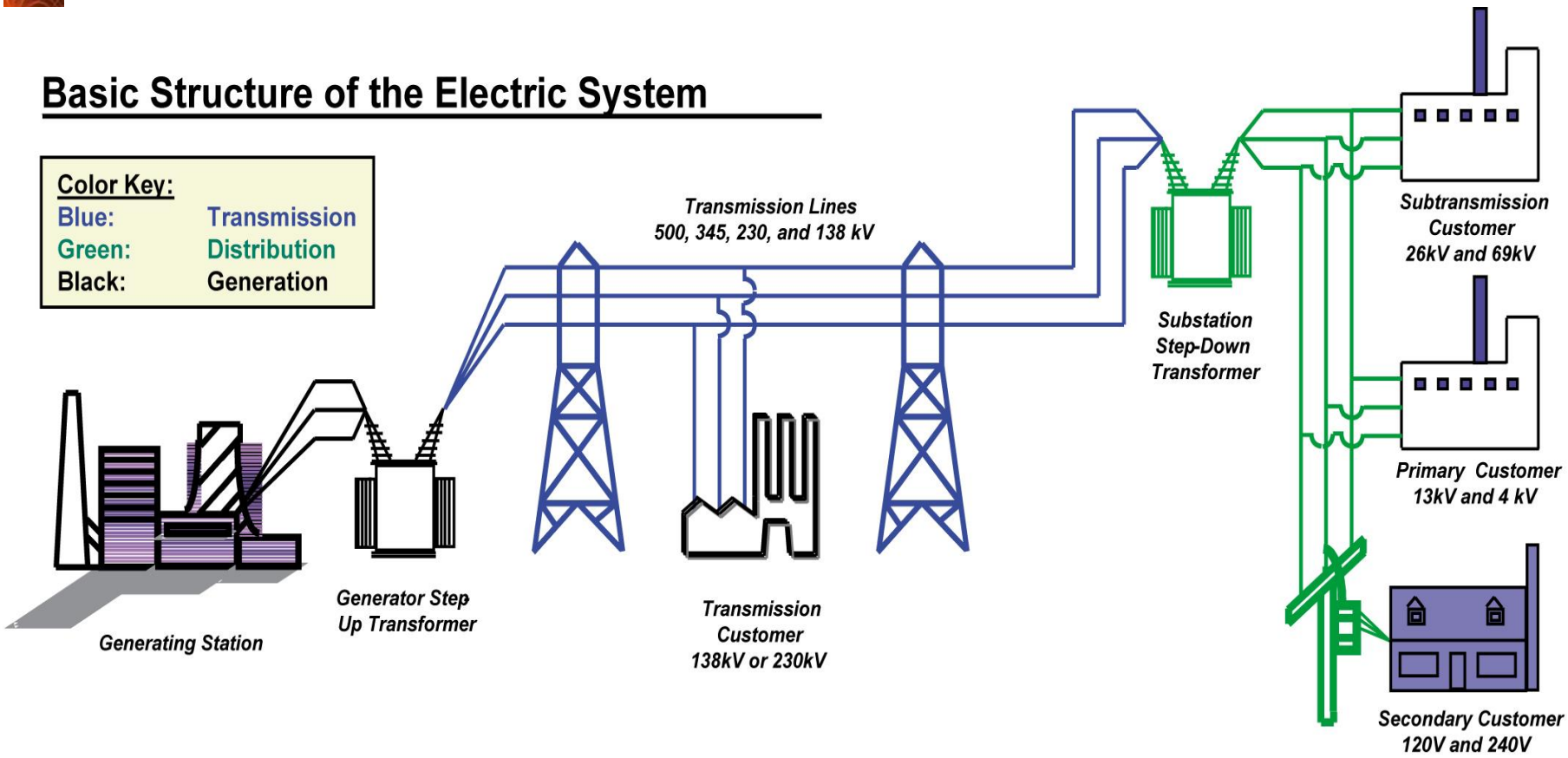
- Holistic approach in integration and control of power resources

Energy efficiency improvement

- Optimisation driven algorithms for energy saving in industrial and domestic applications



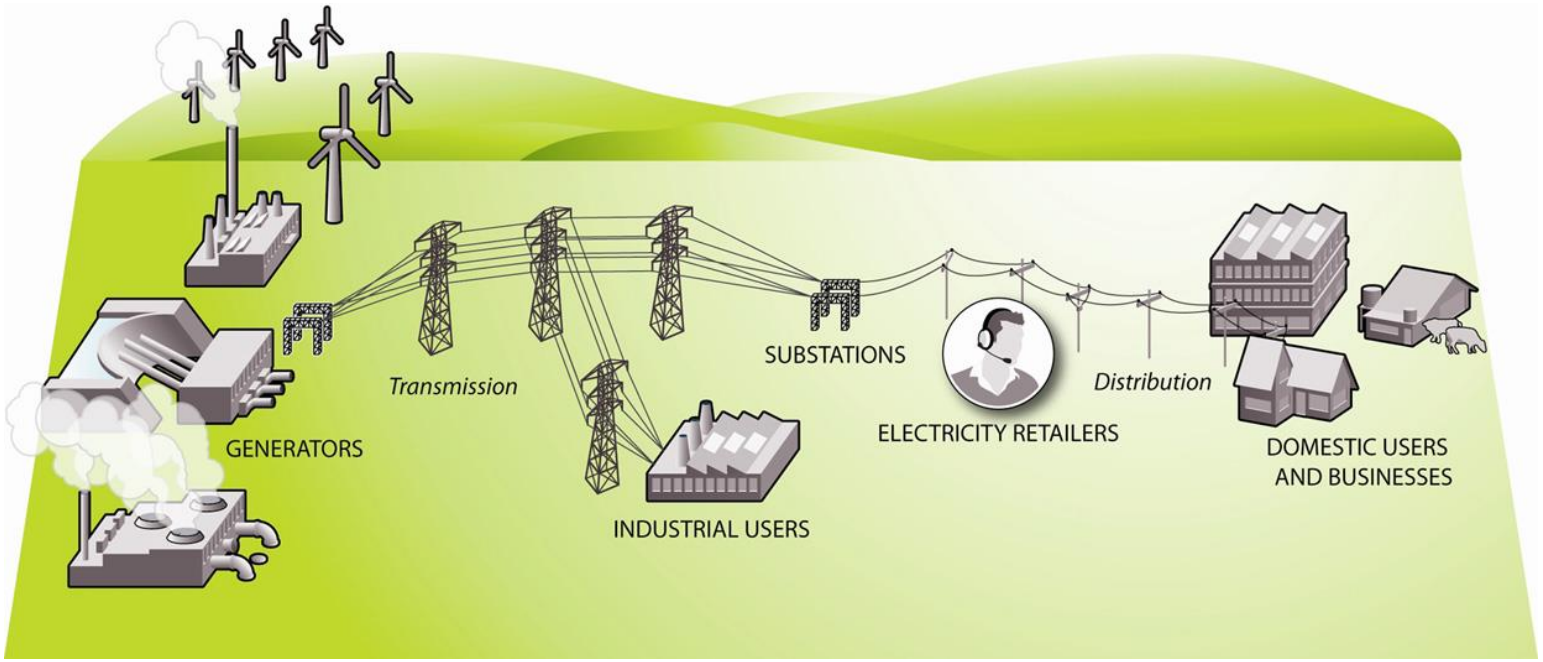
The Electrical Grid



Generation Transmission Distribution

Electricity Industry Roles

Generation, Transmission, Distribution, Retail are now **different companies**.



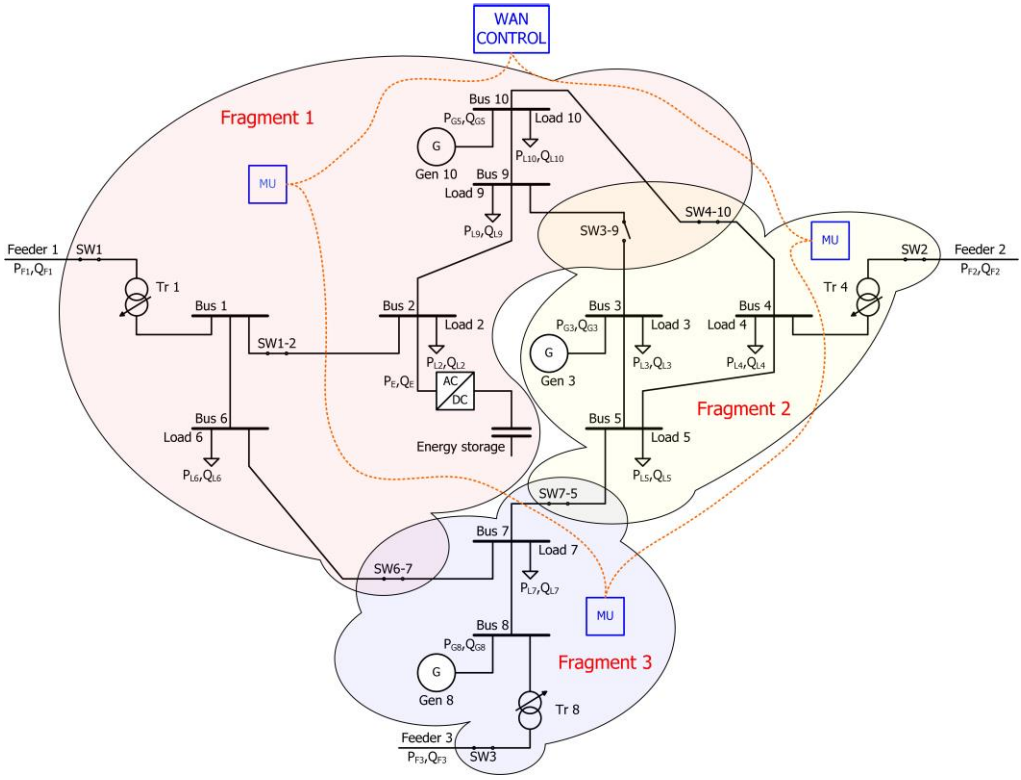
Flexibility in Electricity Networks

Main drivers

- Demand increase
- System deregulation
- Energy diversification
- Electricity markets
- Social challenges

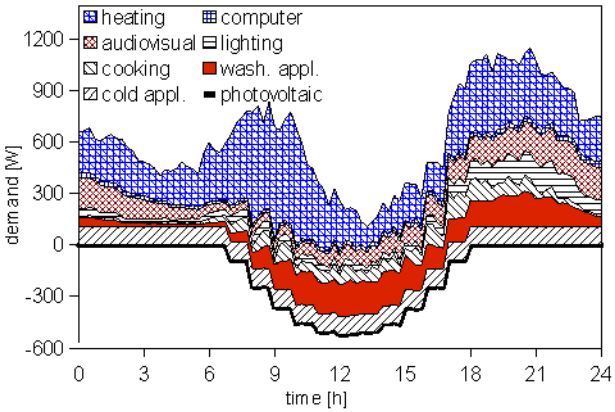
Technical development

- Energy storage
- Demand flexibility
- Energy management
- Power interfaces
- User interfaces

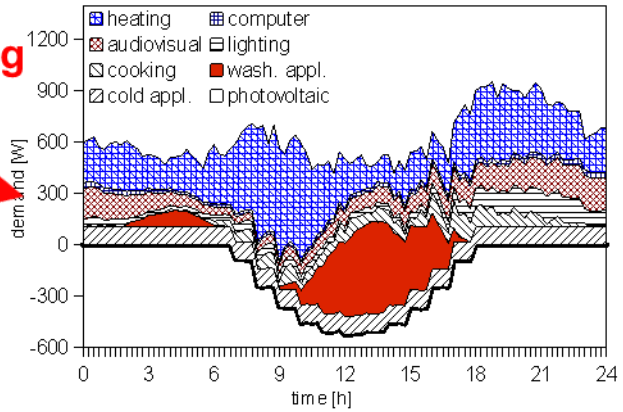


Demand Management

- Residential demand
  - Demand modelling
  - New services for the final users
  - Real-Time pricing
- Industrial demand
  - Demand dispatch, demand response
- Smart buildings
  - Pro-active management



Flattening by using washing appl.



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Residential Demand

General idea

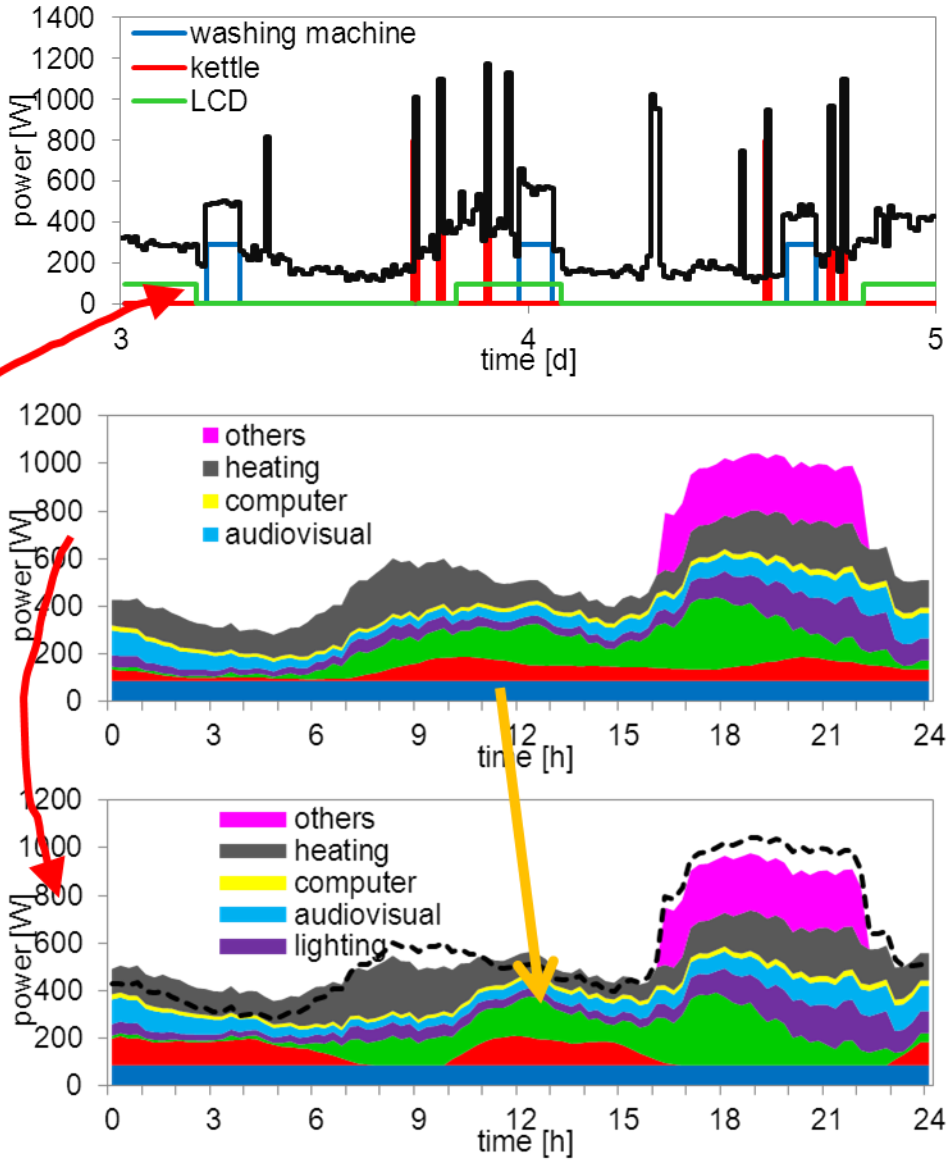
- Demand side management
- Load control – load shifting
- Dynamic price policies
- Customer bill reduction

Detailed smart meter data

- Demand of each appliance known
- User defines its preferences (interval for appliance use)

Approach

- Optimization in each house
- Use of RT energy prices
- Controllable appliances optimized
- Shaping of household demand



Example of Residential Demand Services (SmartHG)

Cost minimisation:

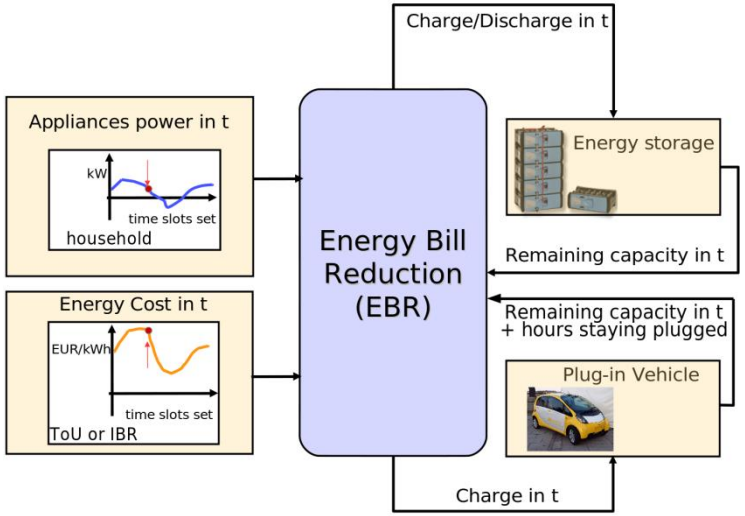
- Variable prices
- Optimal schedule for energy resources

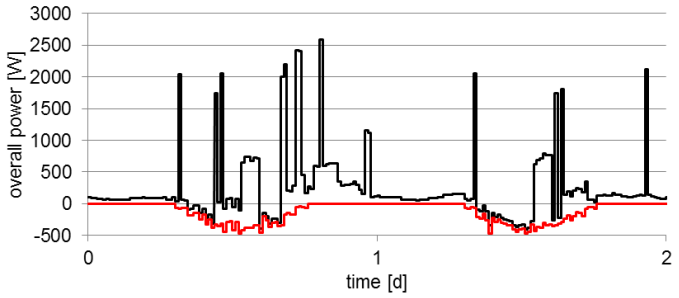
Typical control variables:

- Residential loads
- PV panels
- Batteries
- PHEV

Service opportunities:

- Energy assessment
- Energy bill reduction
- Energy usage forecasting





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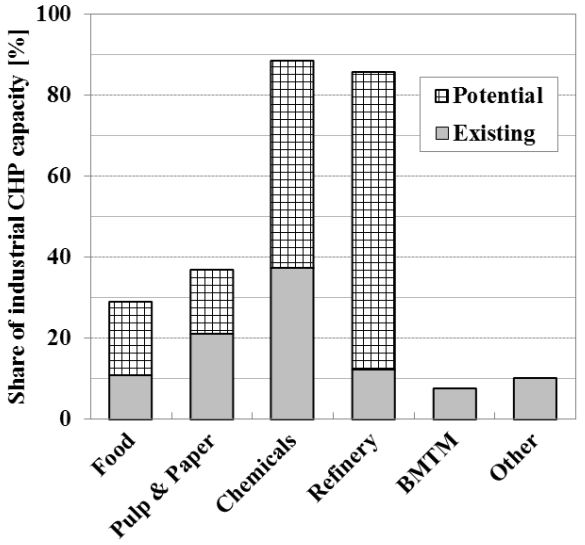
Industrial Demand

General idea

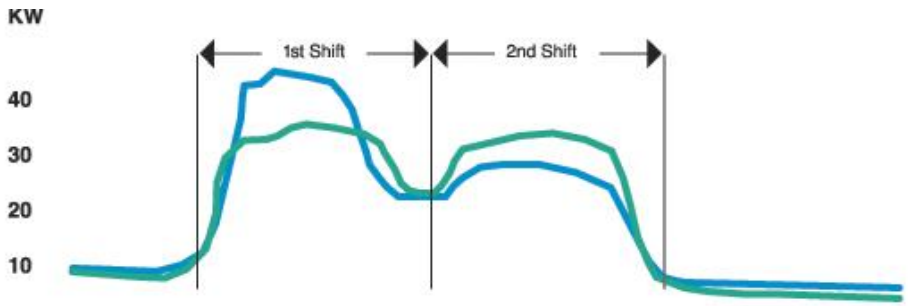
- More flexibility with tariffs
- Significant generation capacity
- Electrical and thermal storage
- “Shiftable” demand

Approach

- Energy diversification
- Demand response
- Demand dispatch
- Dynamic pricing



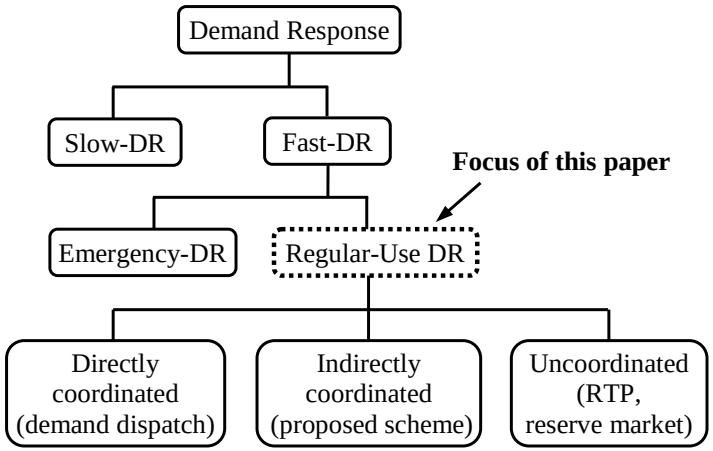
Distribution of industrial CHP capacity in the EU

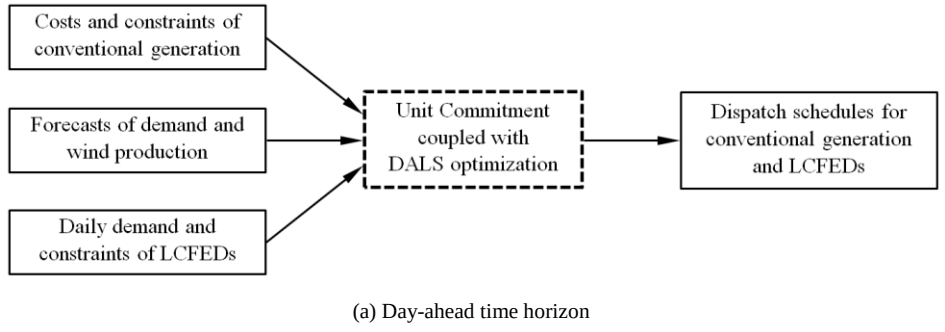


Production shifting

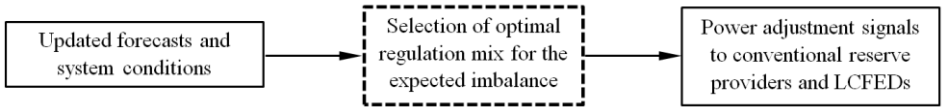
Example of Demand Response

- Regular-Use Demand Response for balancing wind power
- Indirect coordination as an alternative to demand dispatch and RTP
- Aimed at industrial loads
- Reduces effects of variability of wind generation by using demand flexibility
- Preliminary results indicate that at wind share of 25%, only 2% of the RU-DR applied to the system balancing can reduce the reserve needs 24-38%.





(a) Day-ahead time horizon



(b) Time-step-ahead time horizon

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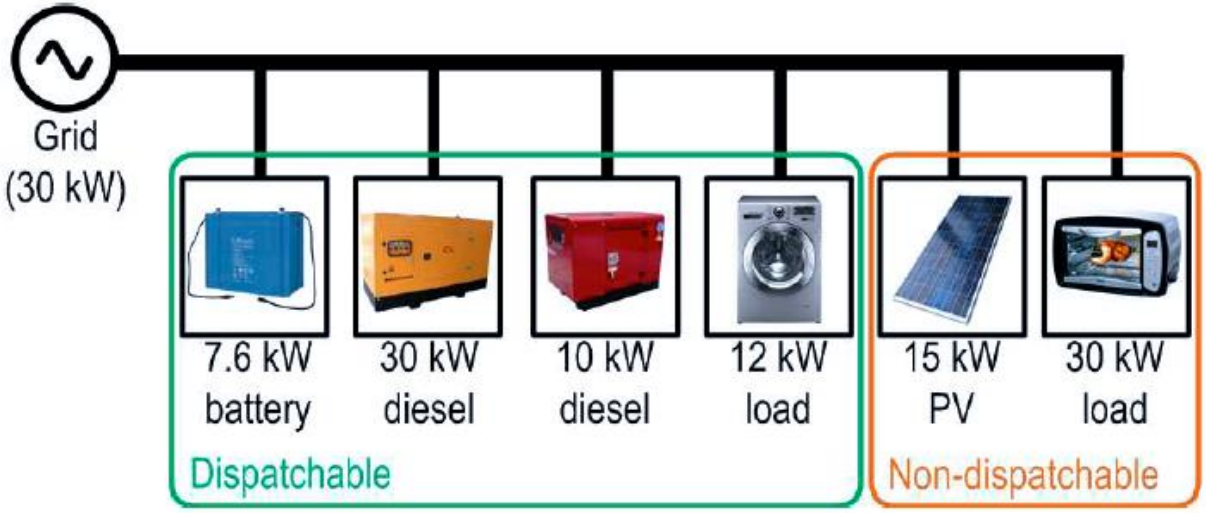
Services for Smart Buildings

- Energy assessment
- Energy bill reduction
- Techno-economic studies (sensitivity analysis)
- Integration of renewables
- Demand modelling
- Real-time energy management



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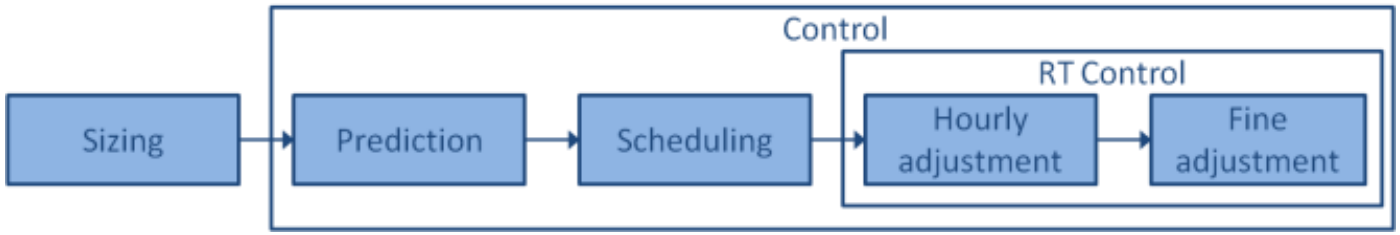
Energy Management in Smart Buildings

- Optimisation approach implies several control steps
- Prediction based on short term forecasts and historical data
- Optimal day-ahead scheduling
- Hourly adjustment of the daily schedule
- Minute based fine adjustments



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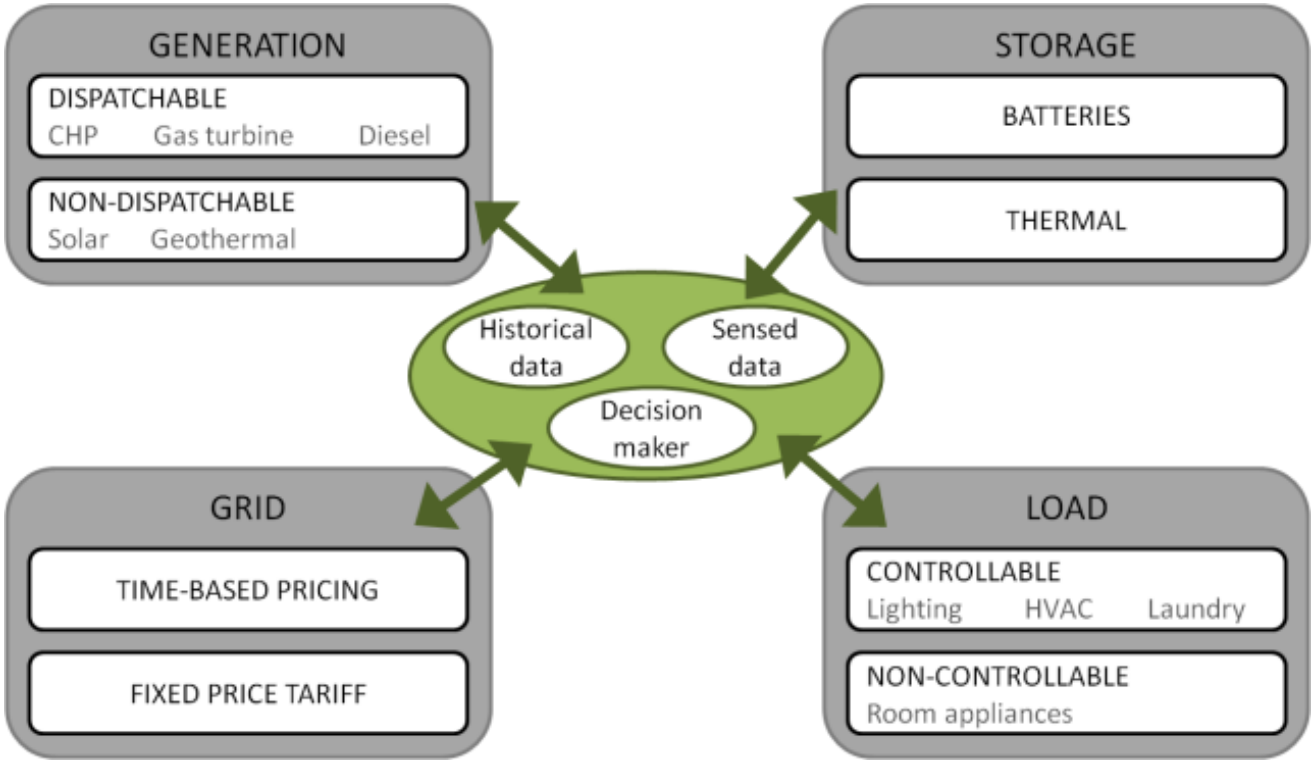
Proactive Management of Smart Buildings

Two most common situation the controller deals with:

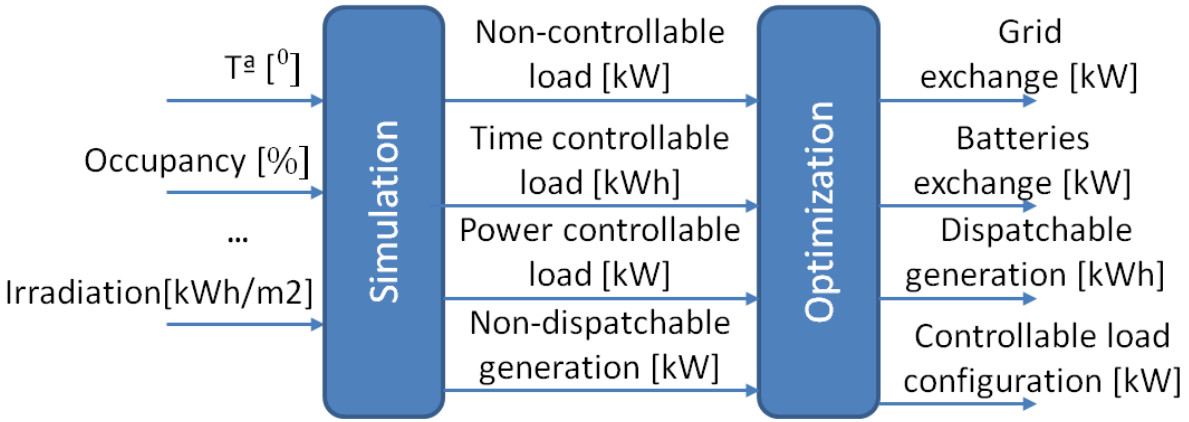
- Energy shortage
- Energy surplus



Proactive Management of Smart Buildings

Real-Time management

- Dispatch decisions continuously made
- Control inputs monitored
- Historical data and decisions taken into account
- All daily and hourly schedules revisited
- Multi-objective optimisation (cost, comfort and favouring local generation, etc.)



A Case Study of Proactive Management

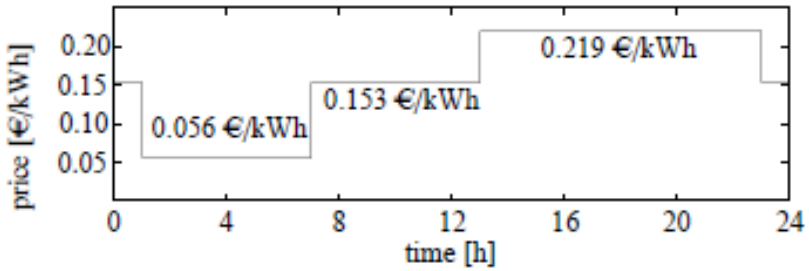
Scenario considers typical loads of a hotel divided in two main types:

- non-dispatchable loads such as kitchen and guest rooms
- dispatchable loads such as laundry and air condition

Energy resource configuration of the hotel consists of:

- a photovoltaic system with an installed capacity
- two diesel generators
- the grid connection of a limited range
- a battery

Resource	Price [€/kWh]
Diesel generator	0.5
Photovoltaic	0
Battery	0.005
Grid export	-0.04
Grid import	0.056 0.153 0.219



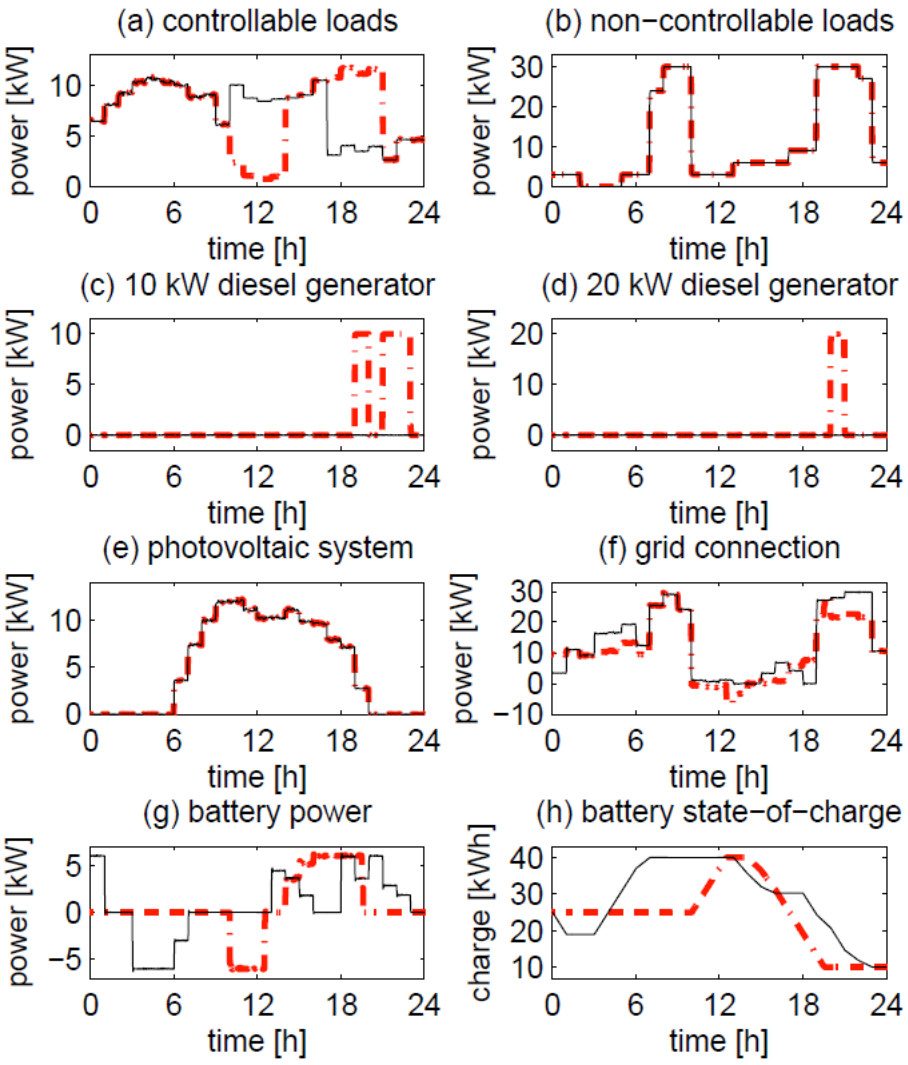
A Case Study of Proactive Management

Simple Energy Balancing:

- only real-time power measurements are used
- predictions are not considered
- energy balancing uses the grid as the primary source, then the battery and finally diesel generators.
- any excess energy firstly charged to the battery and then injected into the grid.

Strategies with and without demand flexibility:

- energy management uses the grid, battery and dispatchable generation (and dispatchable load)



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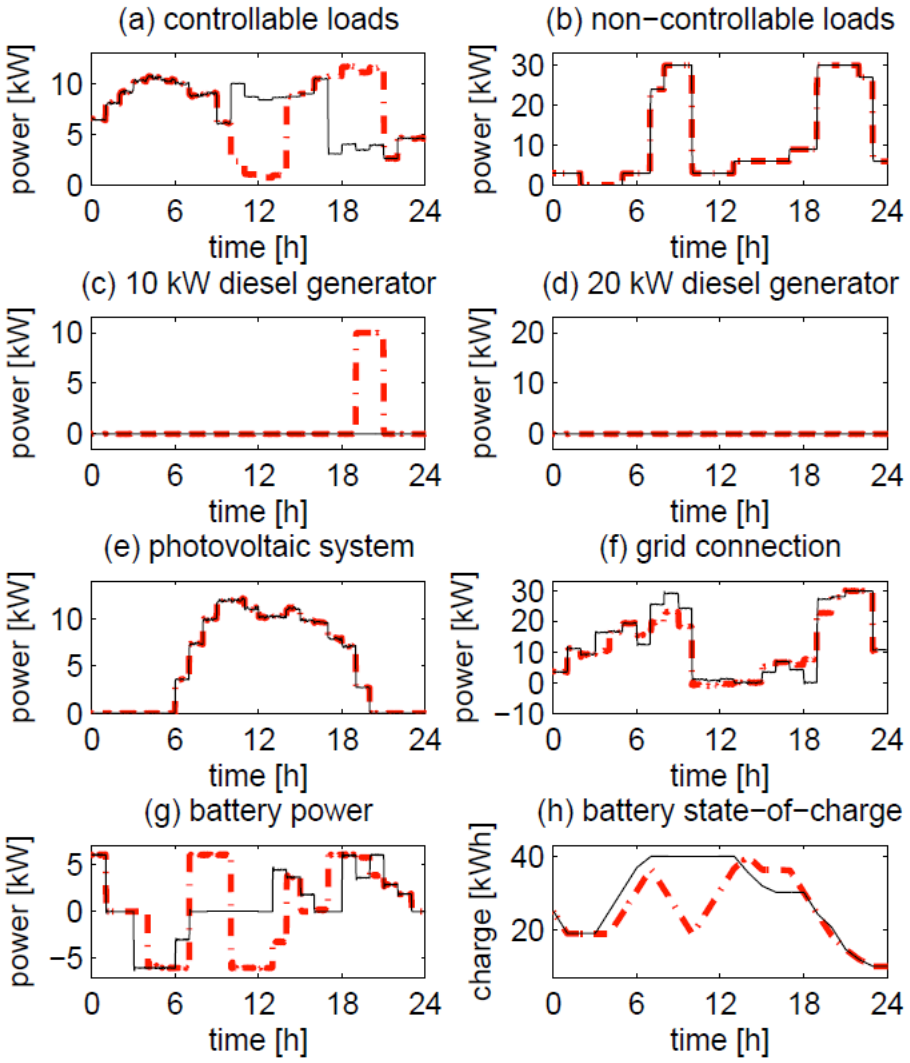
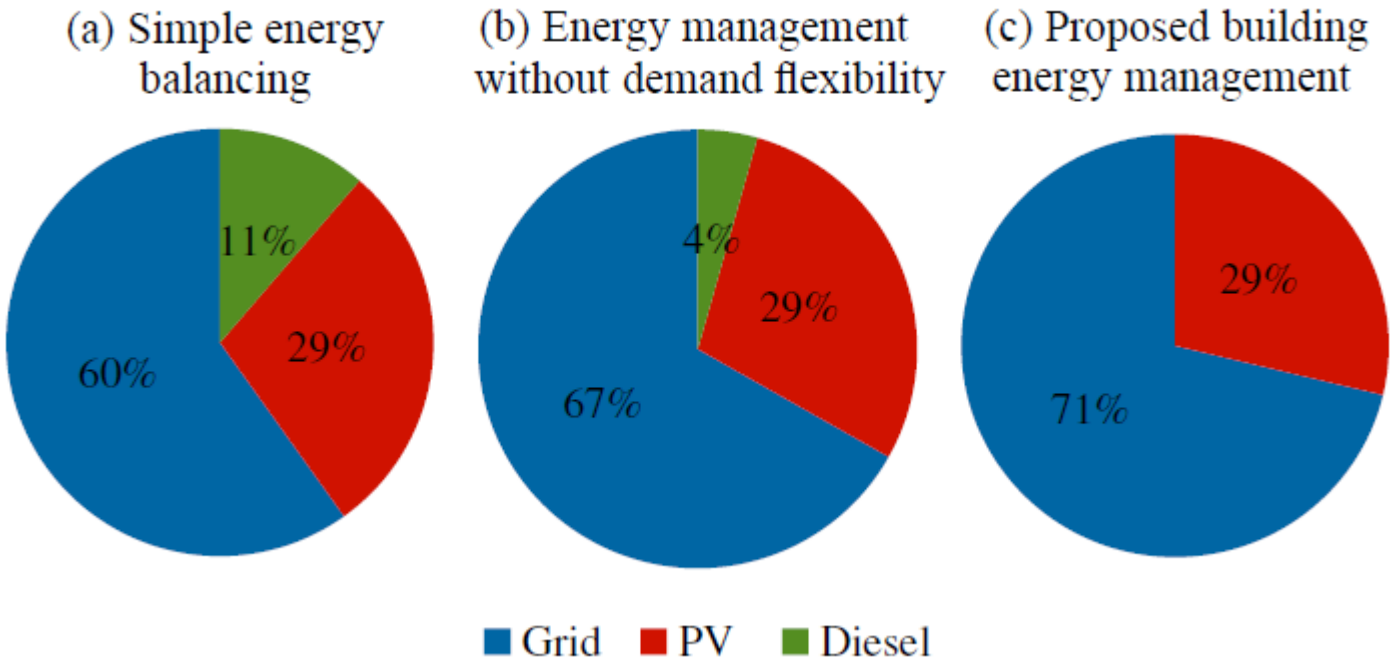


Proactive Management of Smart Buildings

Benefits analysis



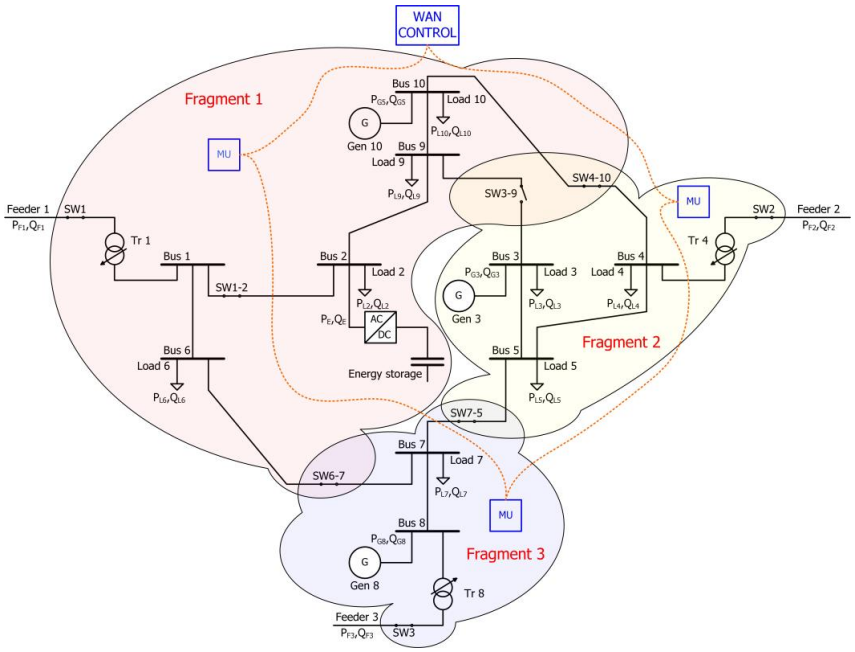
0.201€/kWh

0.167€/kWh

0.145€/kWh

Services for Power Network Management

- New services for Distribution System Operators (DSOs)
- Renewable integration
- Resource management
- Intelligent substation automation
- Decentralised control



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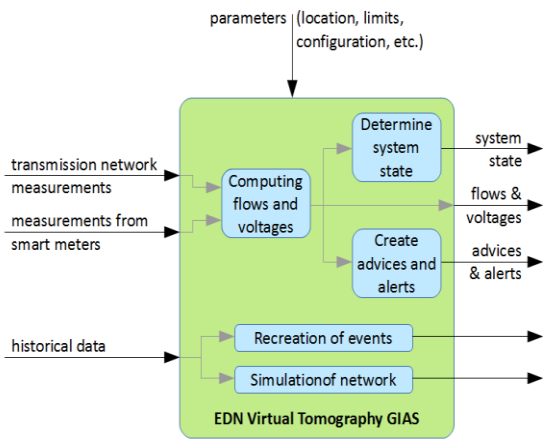
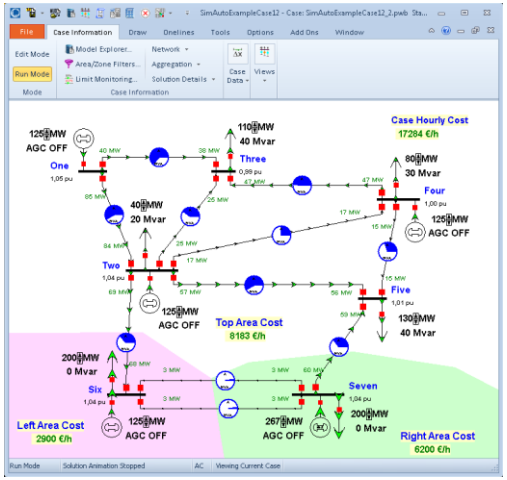
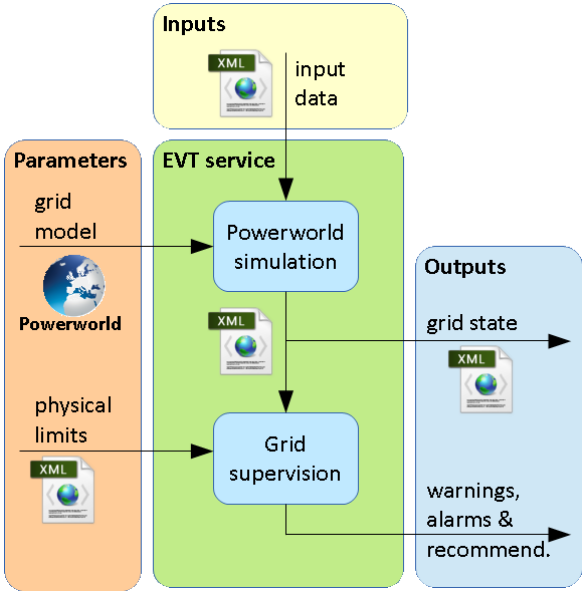
Services for DSOs

- Additional intelligence in planning and real-time operation
- Estimation of network state:
  - Robust to missing measurement data points/errors
- Warnings/Alarms:
  - e.g. line XXXX rating exceeded
- Recommendations:
  - Corrective actions
  - Loss minimization







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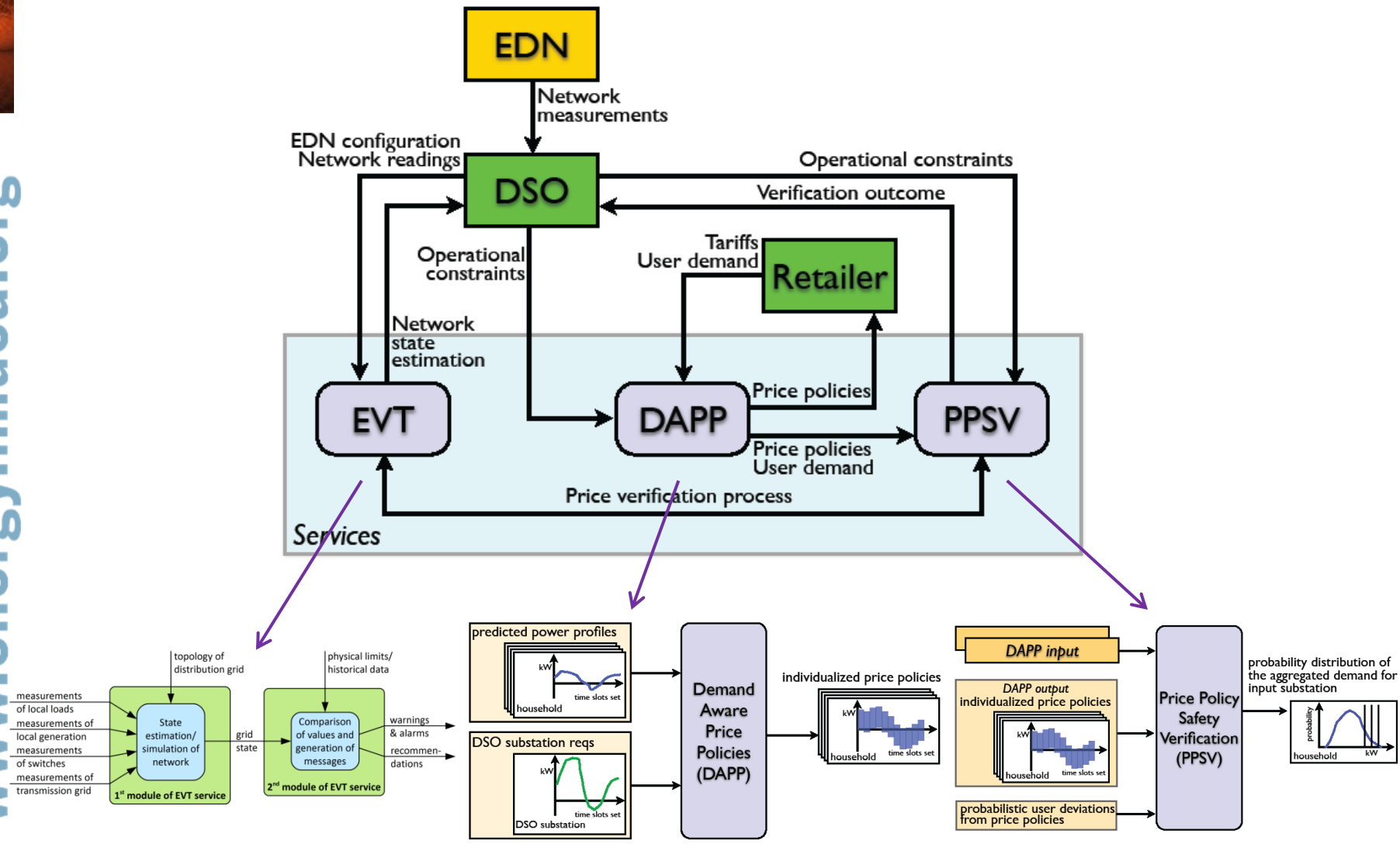
Example of Services for DSO (SmartHG)



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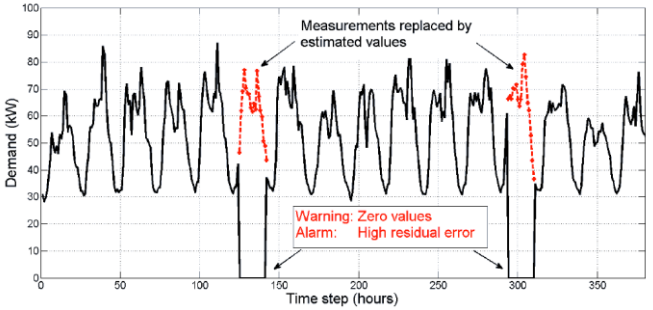
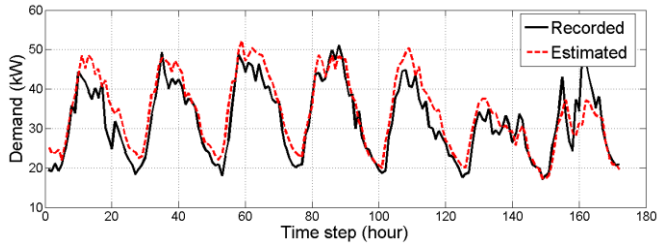
Example of EDN Virtual Tomography

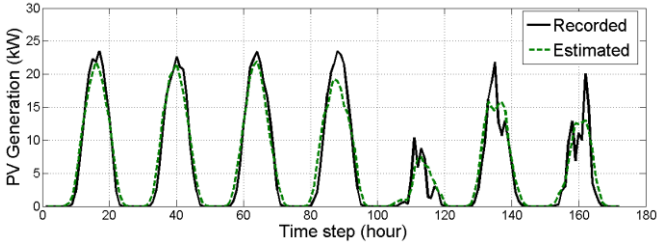
Robust network state estimation
- Identification of bad data
- Detection of changes in network configuration



Demand and generation forecast
- Operational planning
- Renewable integration



Short-time operational planning:
- Normal
- Warning
- Alarm



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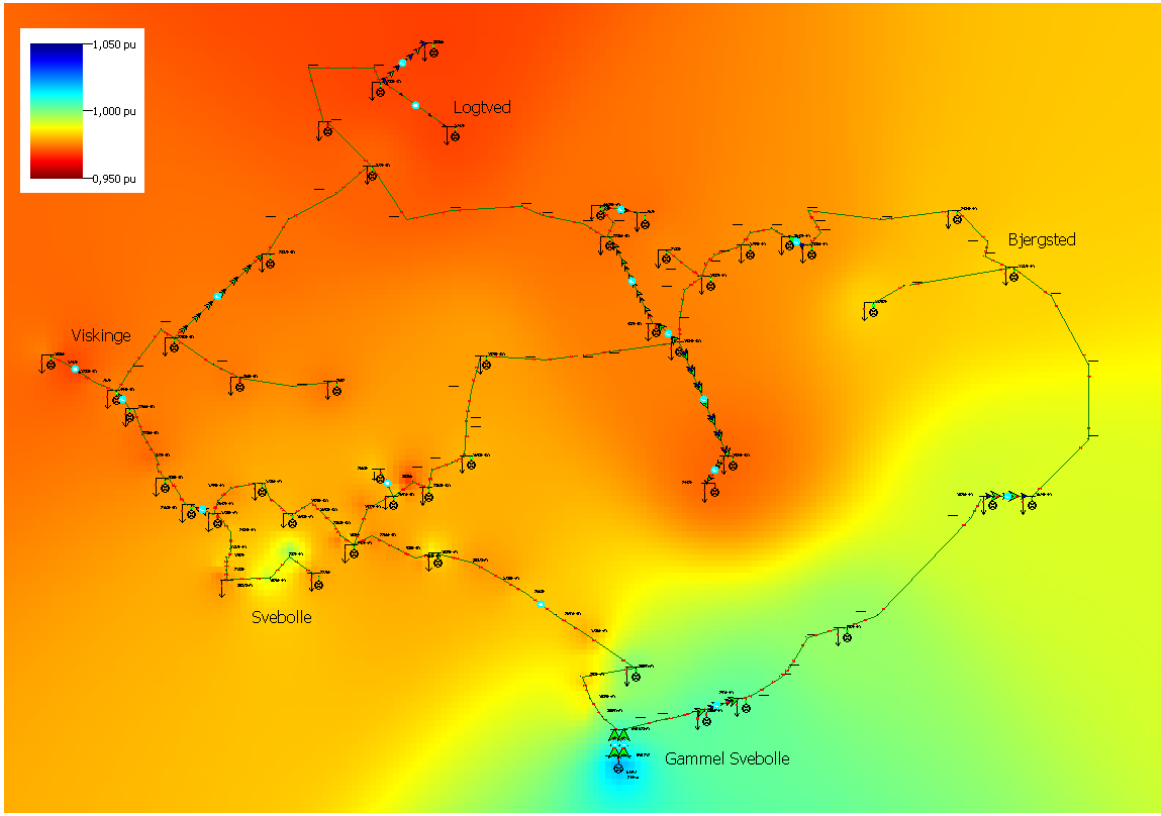
Example of EDN Virtual Tomography

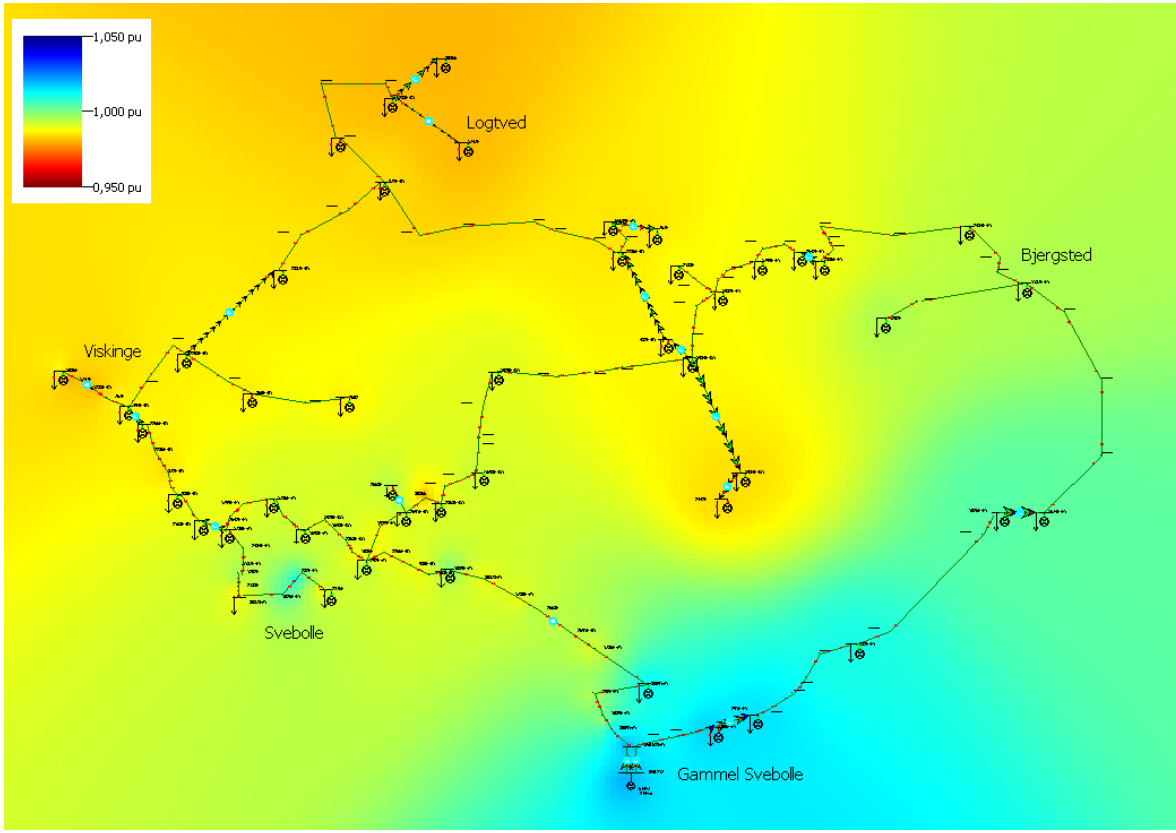
- Kalundborg test network
- Real network
- Real consumption data
- Undervoltage scenario



- Warning / Alarm: Voltage lower than 0.97p.u. detected in busbars 46, 47 y 48.

Example of EDN Virtual Tomography

- Solution recommended
- Implementation followed
- Voltage restored



- Recommendation: Adjust tap-changers of primary transformer (50:10kV) by +2 (2 * 0:00625)

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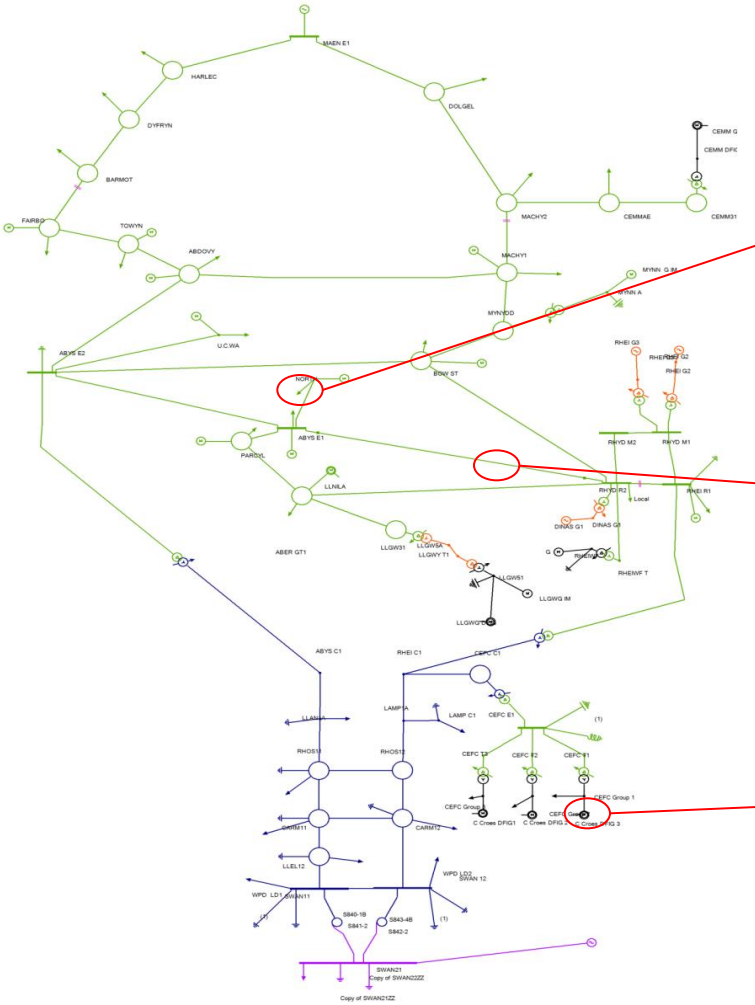
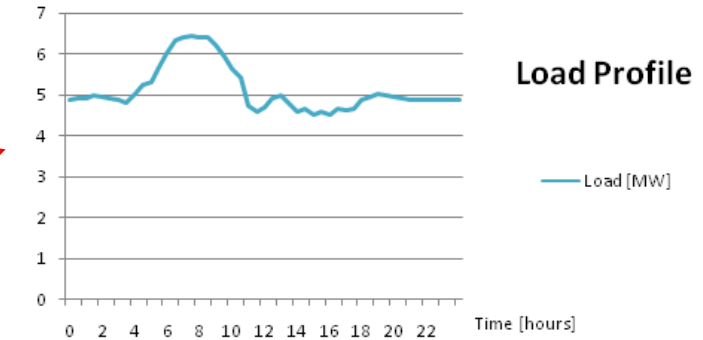
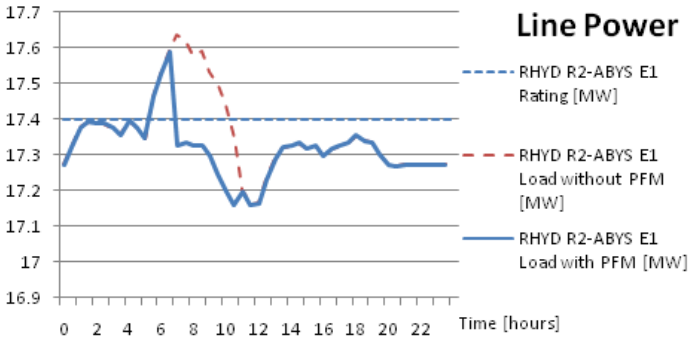
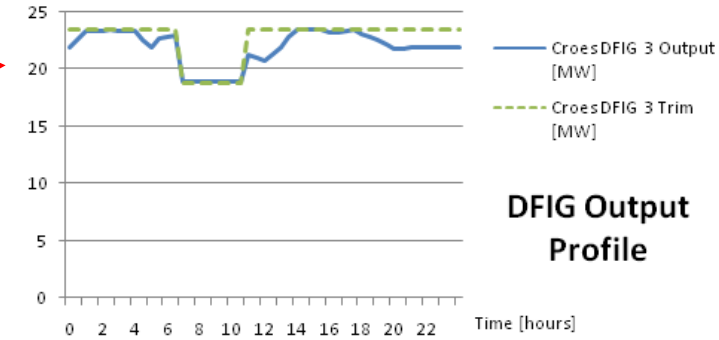
Example of Renewable Integration









Line Congestion Management

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New Electricity Markets – New Opportunities

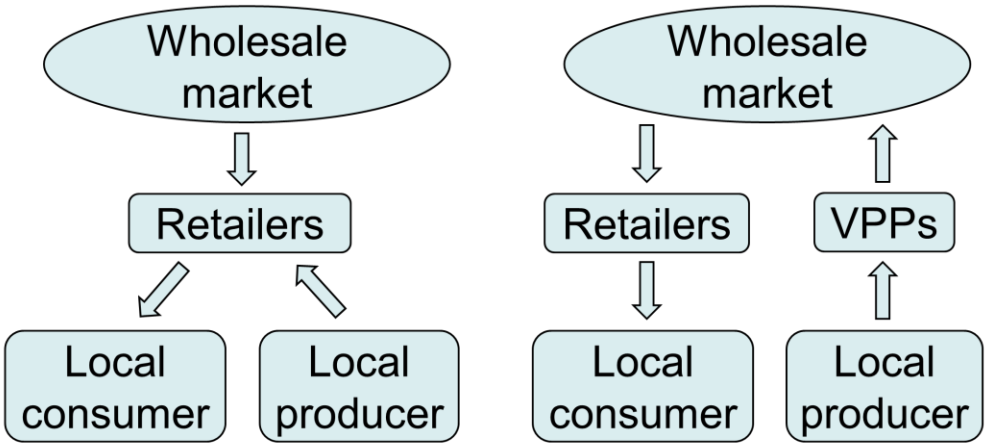
Existing solutions for renewable integration in the market

A) Virtual power plants (VPP)

- Organizational inefficiency (see Fig. 1)
- Risk of misuse in balancing market
- Implementation complexity (IT, control)

B) Real-time retail pricing

- Distortion of natural load diversity
- Ignorance of regional differences in electricity supply



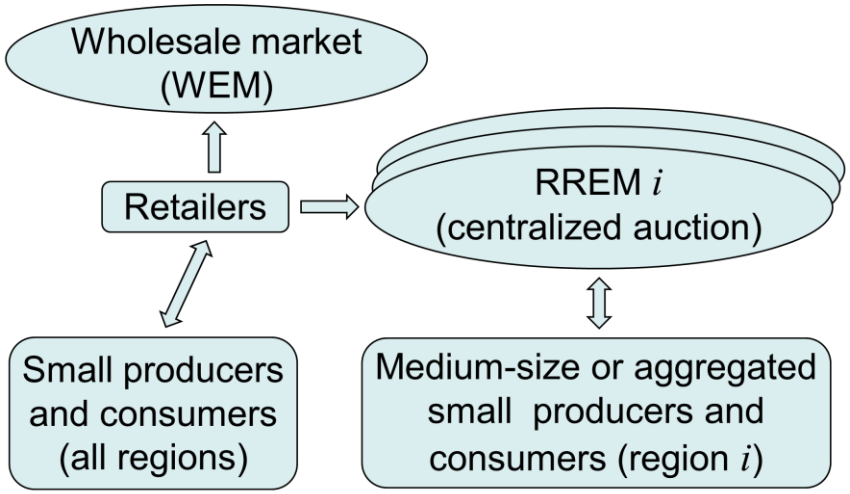
Example of New Electricity Markets

Example retail framework

Creation of regional retail markets (RREM) with dynamic pricing mechanism

Local trade and consumption of the locally generated electricity

Indirect coupling of retail and wholesale market pricing



Benefits

- Direct access to dynamic electricity trade for DER owners
- Increases efficiency of local supply
- Sends adequate investment signals
- Promotes energy flexibility on retail side

Expected Impacts of Service Implementation

- Benefits to all parties involved
- Automatize demand response schemes (and avoid demand dispatch)
- Promote energy service market for DSOs
- Improve energy efficiency in daily operation of distribution networks
- Promote use of local energy resources
- Flexible management of power networks and demand
- Improve reliability and security of electrical energy supply

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Thank you very much for your attention!

Any questions?

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