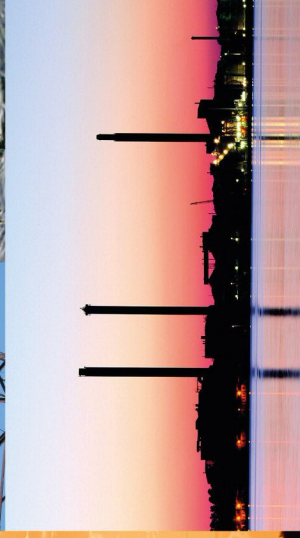
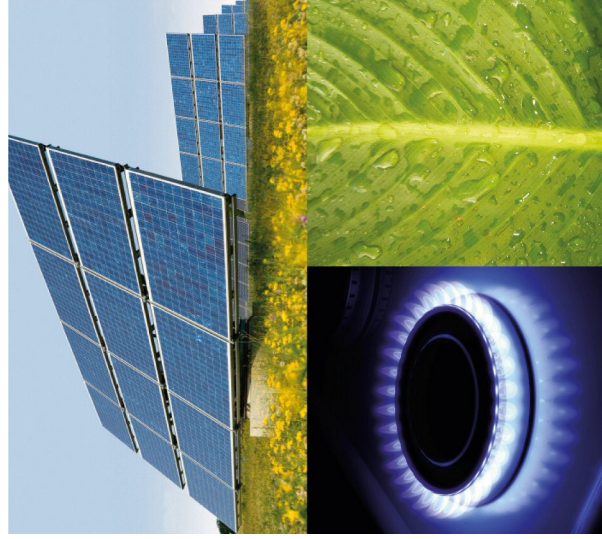




Energy research Centre of the Netherlands

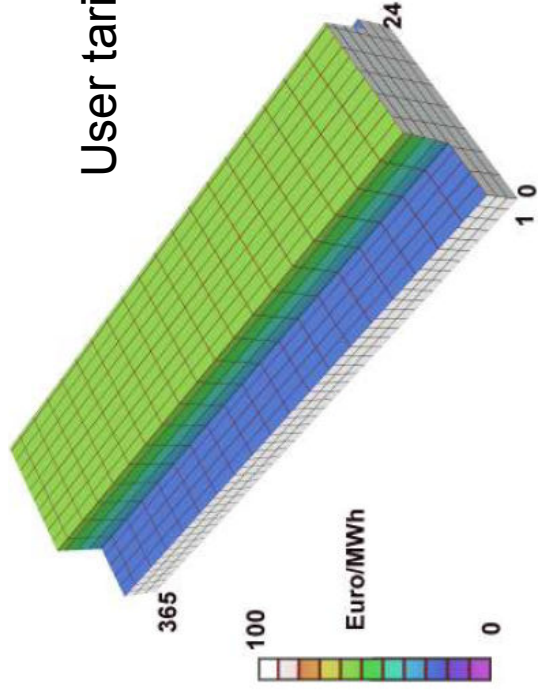
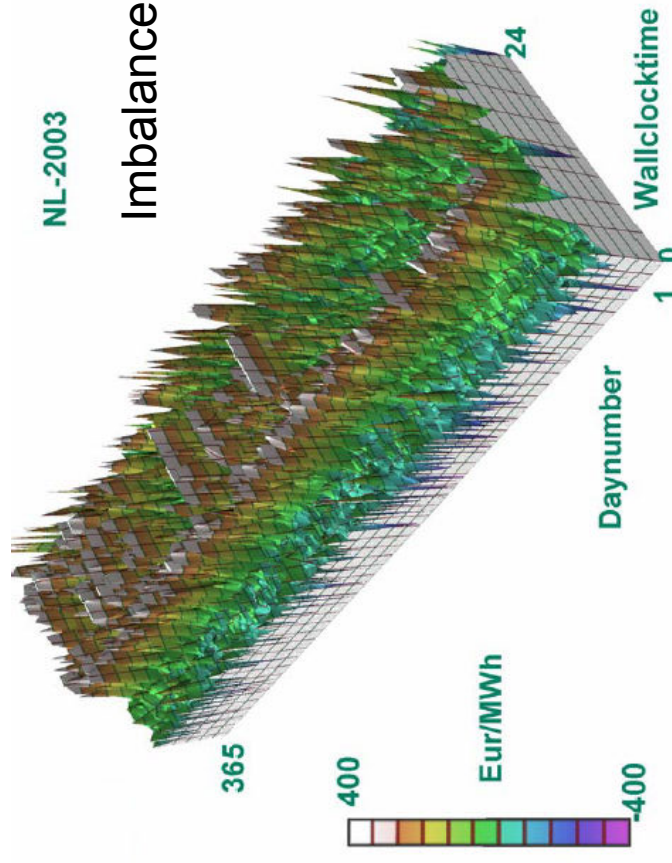
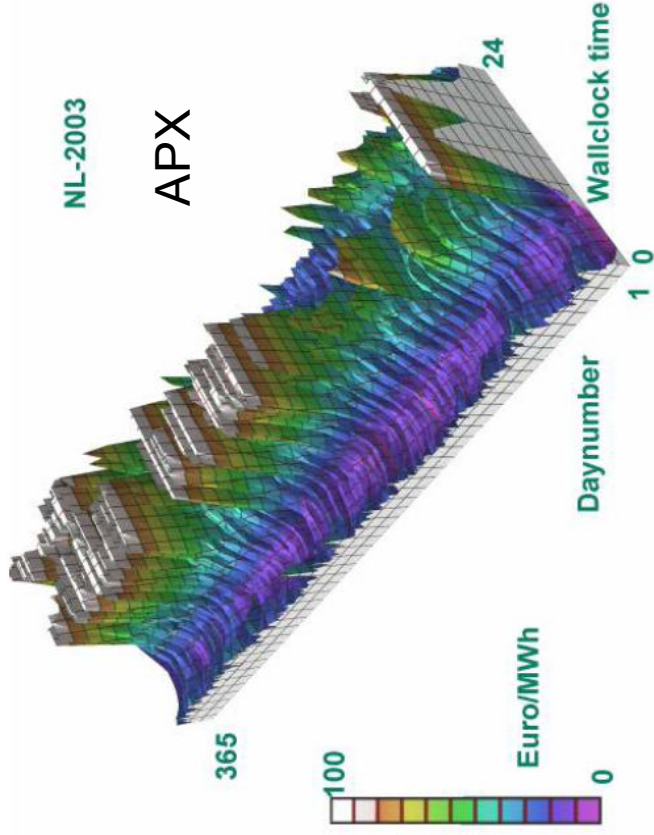
PowerMatcher Technology for the SmartGrid

Cor Warmer



www.ecn.nl

Power Markets



Distributed and Intermittent Generation?

ICT for DER Clustering & Aggregation

Scalability:

- Large number of DER components
- Spread over a large area
- Centralized control reaches complexity limits
- Openness:
 - DER units can connect and disconnect at will
 - All (future) DER types must be able to connect
 - Integration with renewable generation
- Multi-actor interaction:
 - Balancing of stakes: Locally and globally
 - Coordination exceeding ownership boundaries
 - Decide locally on local issues.
- Align with Liberalized Energy Markets

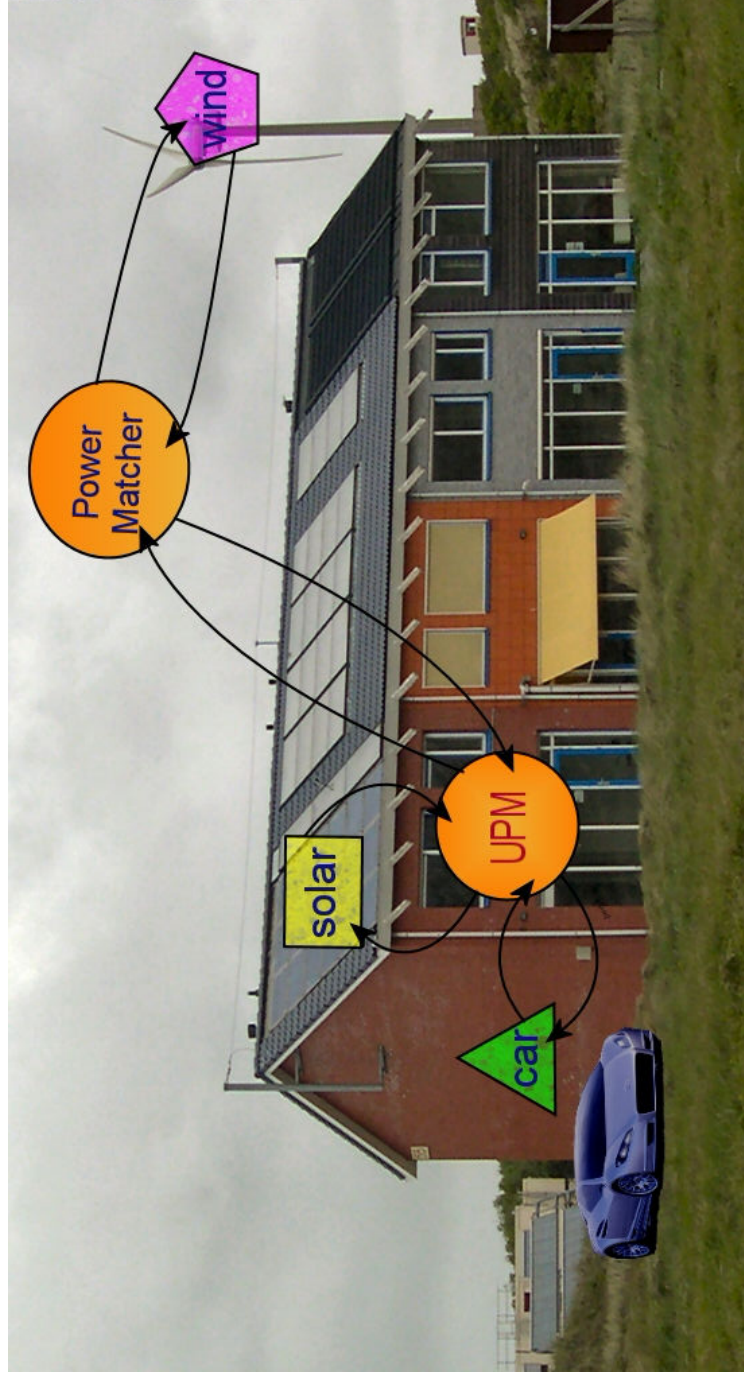
**Multi-Agent
Systems
(MAS)**

**Distributed
Control &
Intelligence**

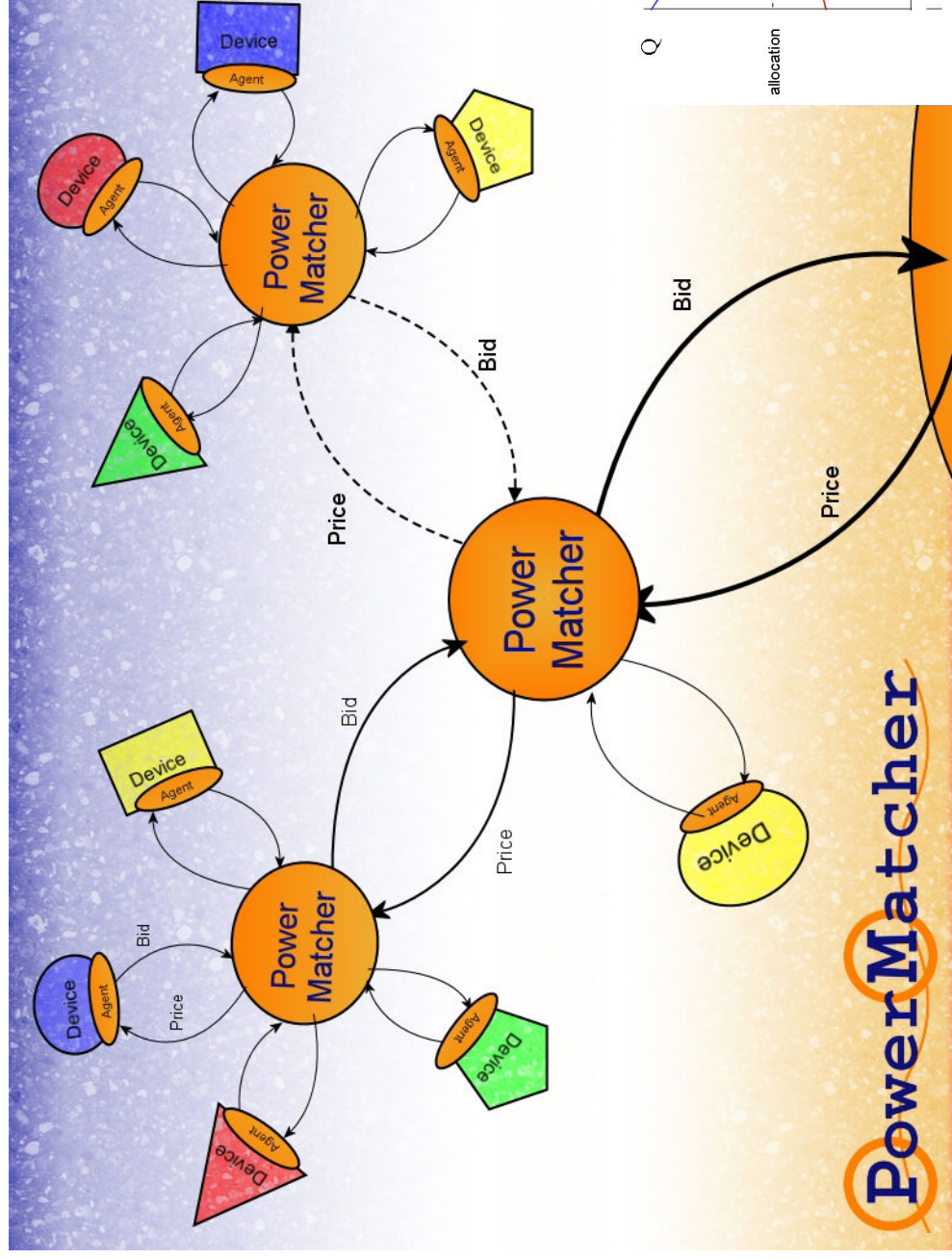
**Electronic
Markets**

P•WERMATCHER

smartgrid technology



PowerMatcher cells - networks of networks



PowerMatcher SmartGrid Technology

Energy optimization of high
numbers small units (<5MW)

Demand
Response

Distributed
Generation

Storage
(Plug-in Cars)

Industrial Installations
Domestic Appliances

PowerMatcher SmartGrid Technology

Business Cases

Energy Trading

Virtual Power
Plant

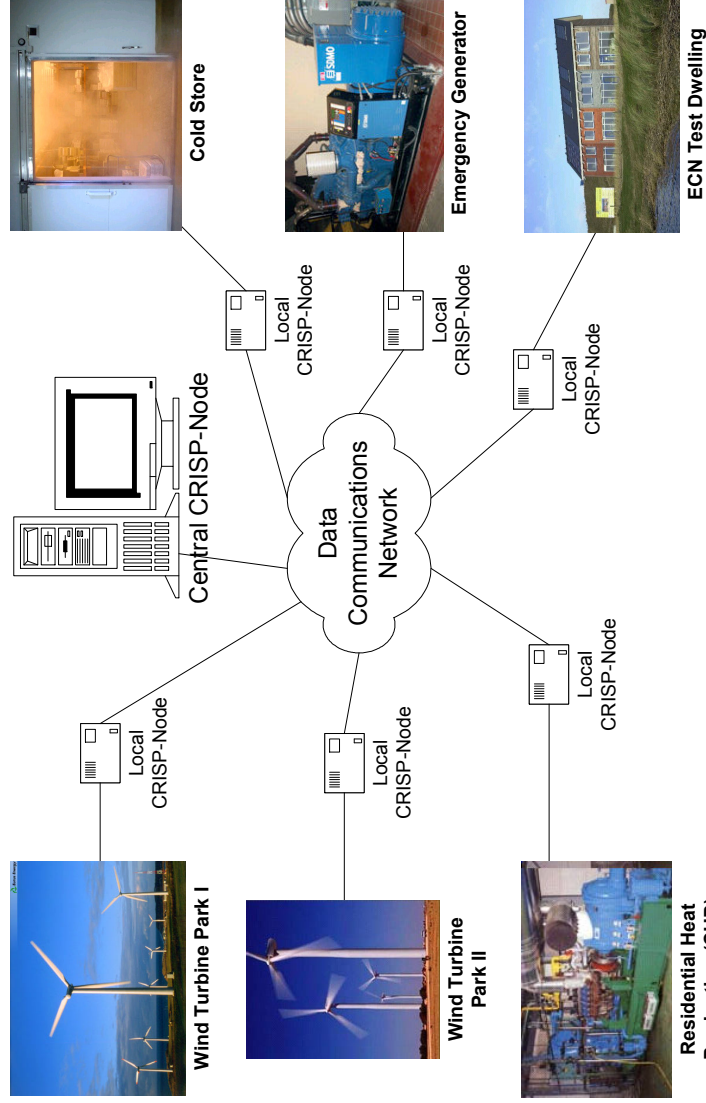
Imbalance
Reduction

Active Distribution

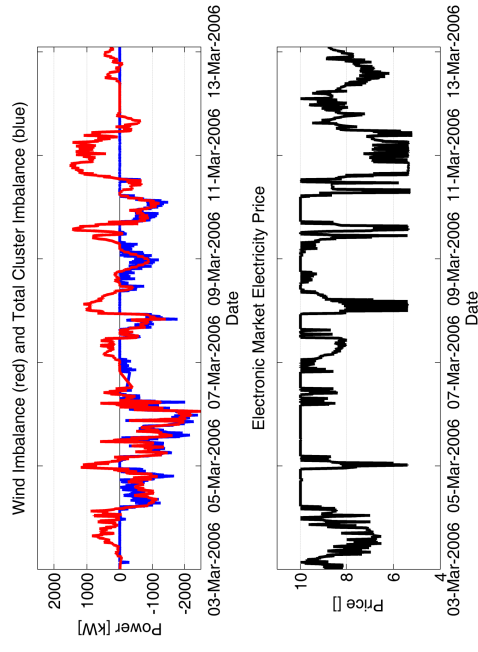
Congestion
Management

Black-Start
Support

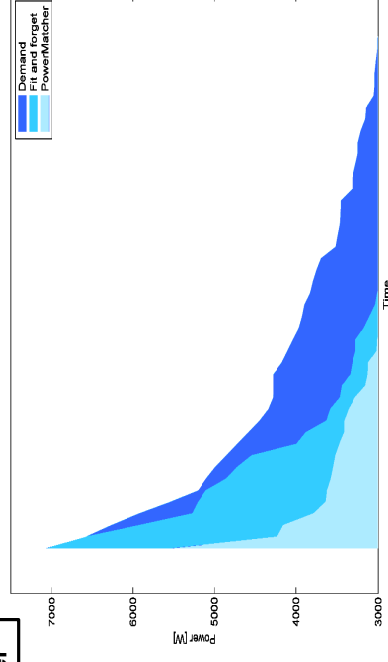
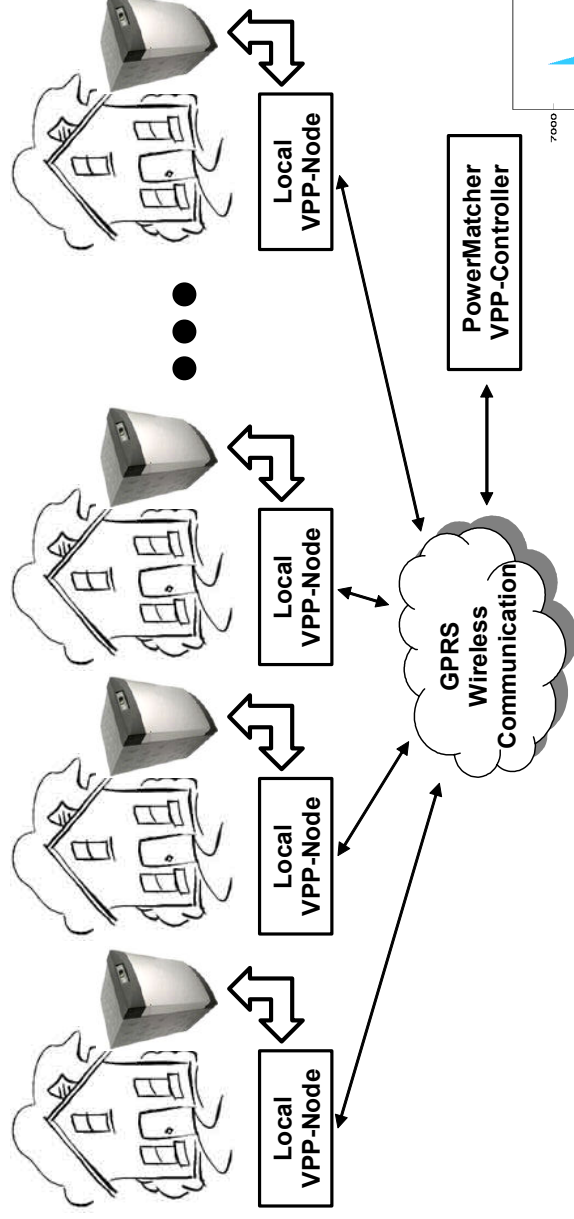
PowerMatcher Imbalance reduction



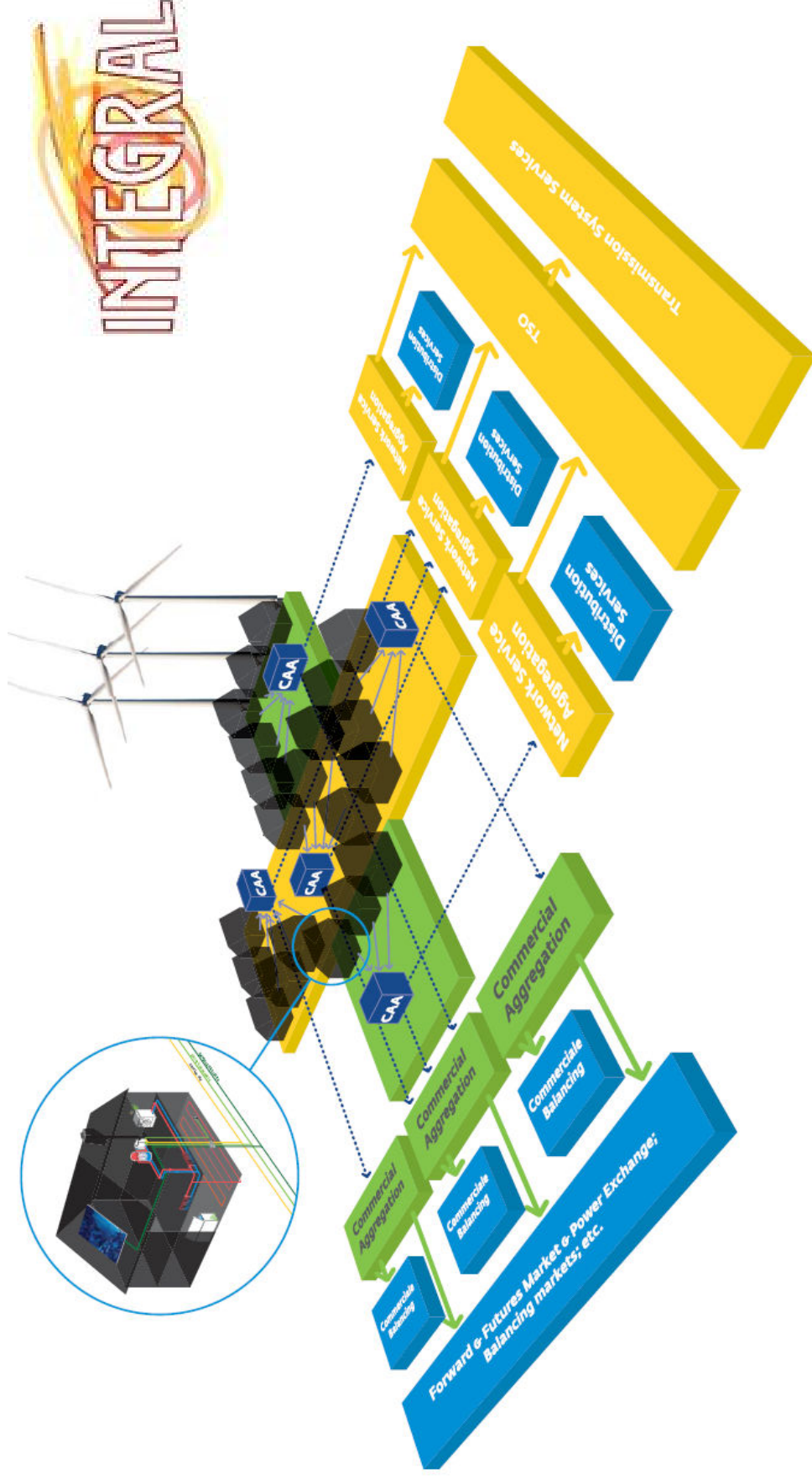
CRISP



PowerMatcher Congestion Management



Virtual Power Plant with dual objectives



Projects involving the PowerMatcher



DER aggregation into
Large Scale Virtual Power Plants (LSVPP)

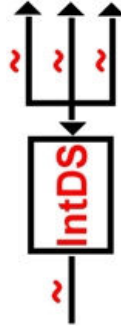


Industry-quality reference ICT-platform for Distributed
Control at aggregated levels in the electricity grid



SmartHouse/SmartGrid

intelligent networked ICT technology for collaborative
technical-commercial aggregations of Smart Houses



Intelligent Distribution Station for power quality
and economic reliability

PowerMatcher characteristics

- aggregation of consumers and producers from industrial to household level
- scalable concept, ~ 1,000,000 units
- real-time price formation from prosumer level to national grid
- within the rules for liberalized markets
- efficient low-bandwidth communication, reaction 1 – 10 sec
- coordination based on economic incentives and technical constraints
- autonomous user behaviour
- event-based operation, reaction to local events and network events
- tested in live situations

Misconceptions about the PowerMatcher

- ECN's PowerMatcher already exists 10 years and it is called APX
- The PowerMatcher is a threat to market pluriformity since it favors micro-chp
- ECN's PowerMatcher leads to unwanted microgrids
- The PowerMatcher leads to local price differences; in this way the central market price as a basis for control of production and consumption will be finished
- Why do we have to do our washes when our neighbour delivers solar power? And why can't our refrigerator work if we need coffee?

RegelDuurzaam and PowerMatcher

Suitability of the PowerMatcher mechanism for creation of open, (near) real-time AS markets, in addition to current APX and imbalance markets?

- real-time contribution to load balancing
- economical value for flexibility
- characterization of clusters: available flexible load; reaction time; reliability; ...
- flexibility of PowerMatcher w.r.t. time restrictions, system dynamics, avoidance of microgrids, ...
- PowerMatcher and network complexities