- IDE4L project overview and ANM concept
- Aggregator concept
- Developed functionalities
- Distributed automation system
- Demonstrations
- Conclusions

# From concept to demonstrations

1. **Defining the concepts**
   - Active network (D2.1)
   - Automation for active network management (D3.1)
   - Aggregator system (D6.1)
2. **Developing planning methods and automation functionality**
3. **Building and running the demonstrations in:**
   - Denmark (Østkraft Holding A/S)
   - Italy (A2A Reti Electtriche SpA)
   - Spain (Unión Fenosa Distribución, S.A.)

# Expected outcomes (1/2)

- **Planning tools** to design active distribution network and to evaluate costs and benefits of developed concept and technical solutions.
- **Advanced automation system** to extend monitoring and control functions deep in the distribution network.
  - Increment of network hosting capacity for DG
  - Management of fast changing conditions and integration of large number of DG and DR
  - Use of standards, like IEC 61850, for reusability and general applicability to other EU scenarios
  - Aggregation of information from small-scale DERs and flexibility services for distribution network management

# Expected outcomes (2/2)

- **The same automation infrastructure to be utilized to enhance the distribution network reliability**
  - Automatic fault location, isolation and supply restoration algorithm will be developed and demonstrated to improve the reliability of distribution network.
  - Design of a universal controller to enable flexible operations of microgrids, smoothly transitioning from grid-supporting mode, grid-connected mode and islanded mode, while guaranteeing quality of service.

# Breakthroughs

## WP7 Demonstrations

### WP2
Planning tools for distribution network management

- ANM concept
- Target and expansion planning including ANM
- Operational planning including DER uncertainty

### WP3
Distribution network automation architecture

- Automation concept
- Smart meter as a sensor
- Testing Platform for monitoring & control systems
- Hierarchical and decentralized automation

### WP4
Fault location, isolation and supply restoration

- Decentralized FLISR
- IEC 61850 Distribution Protection System Reconfiguration
- Microgrid interconnection switch

### WP5
Congestion management

- Decentralized state estimation and state forecast
- Tertiary control – Network reconfiguration
- Secondary control – Coordination of voltage controllers
- Dynamic tariff

### WP6
Distribution networks dynamics

- Aggregator concept
- Optimal scheduling of flexibility
- Transmitting synchro-phasors & real-time model syntheses
- Improved microgrid operation

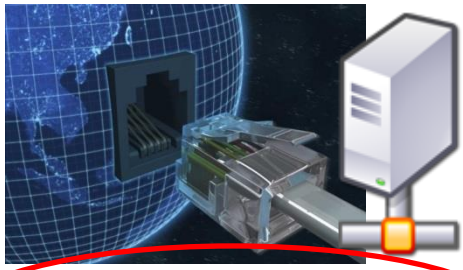
IDEAL
ideal grid for all

# Vision of future smart grid


Market design

Smart charging of EV

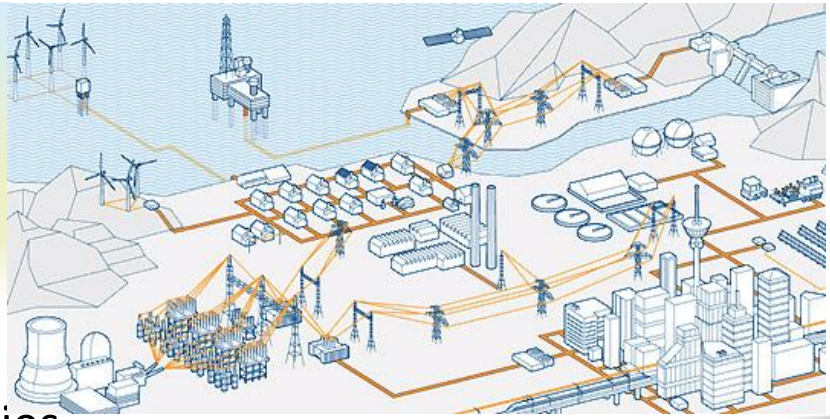
Smart homes and PV



System management and design

Microgrids

Energy communities



Grid infrastructure

Balancing

Distribution automation

Storage

Power to gas

Advanced monitoring


Aggregator

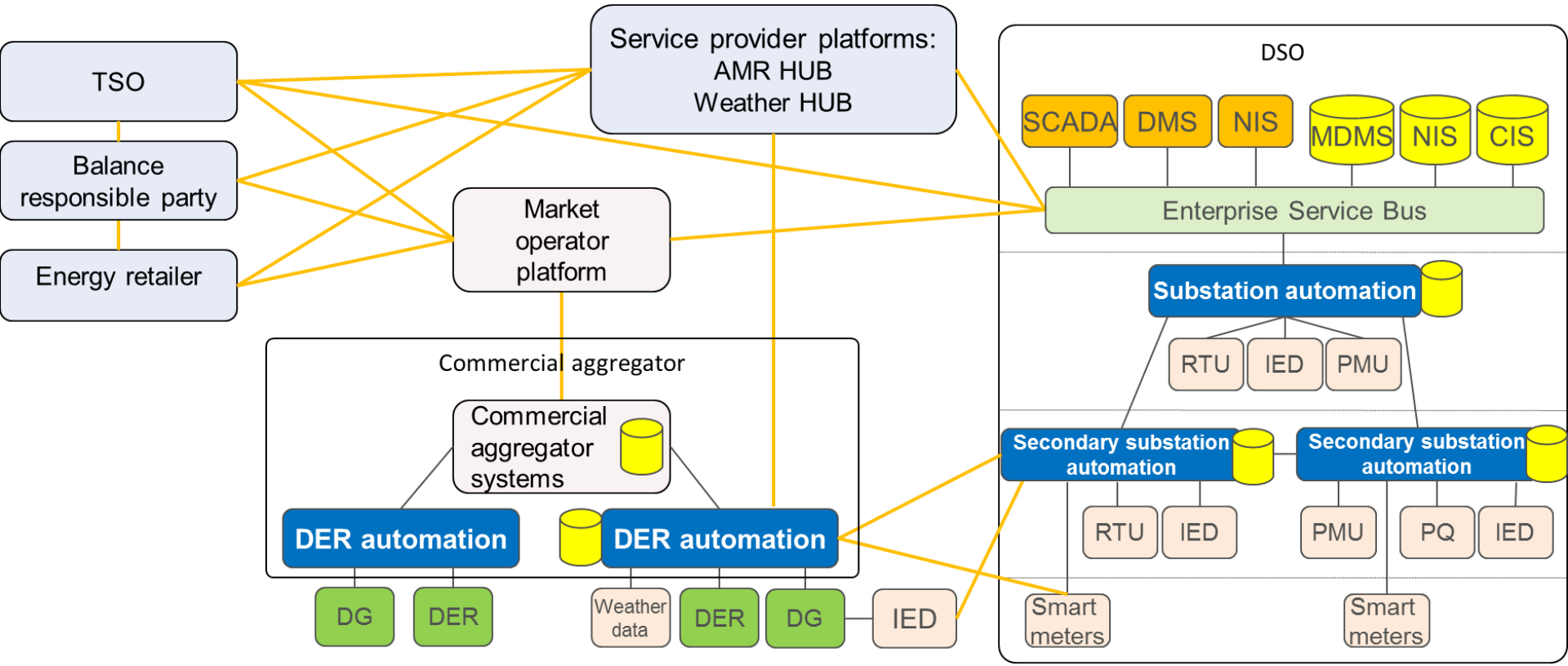
Controllable loads and energy efficiency

Renewable energy resources

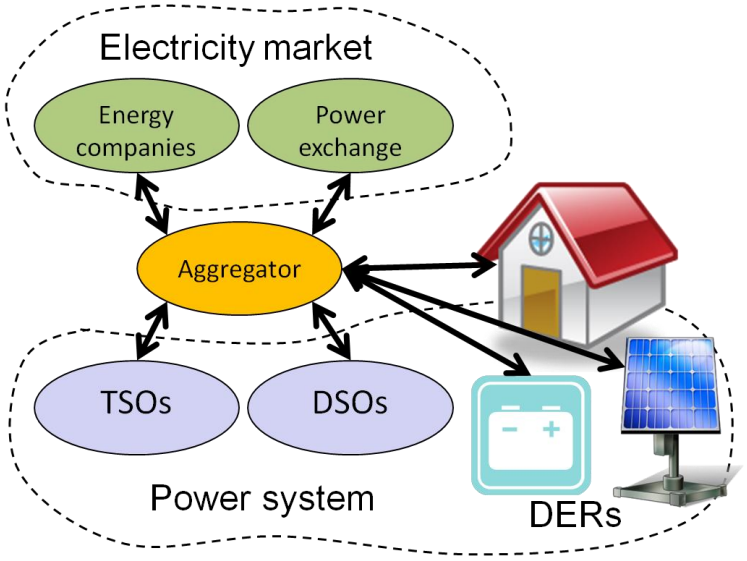
# Policies of electricity network

- Today networks are always **over-dimensioned** due to quality of supply obligations and missing possibility to control DERs
- Some companies are already forced to utilize **production curtailment** to manage their networks
- In future **more flexibility** is needed to integrate more RES and DERs in power system
  - Controllability of distribution network via advanced ICT
  - Decentralization of network management due to scale of the system

# IDE4L automation architecture



# Roles of grid operators and aggregator




1. **DSO/TSO**
   - Validates the submitted offers:
     - Off-line validation
     - Real-Time validation
   - Purchases flexibility services for avoiding network constraints
   - Calculates and provides the Flexibility Table (Limits for each Load Area)
2. **Aggregator**
   - Forecasting of consumption, production, price, etc.
   - Flexibility estimation of customers
   - Commercial optimal planning
     - Determination of market bids
     - Maximization of aggregator profit

# Monitoring, protection and control system

- **Complete network will be monitored and controlled**
  - Intelligent Electronic Devices (IEDs)
  - Coordination and merging of information and decisions at substations
- **DA applies variety of communication technologies**
  - Primary substations - SCADA and possibly other IT systems (fibre optics, wireless)
  - Secondary substations and MV switching stations (wireless)
  - Smart meters (PLC or wireless)
- **Ethernet is becoming the prevalent communication standard for all automation devices**
  - IEC 61850 GOOSE and MMS
  - DLMS/COSEM
  - IEC 60870-5-104
  - Modbus/TCP over LAN/WAN

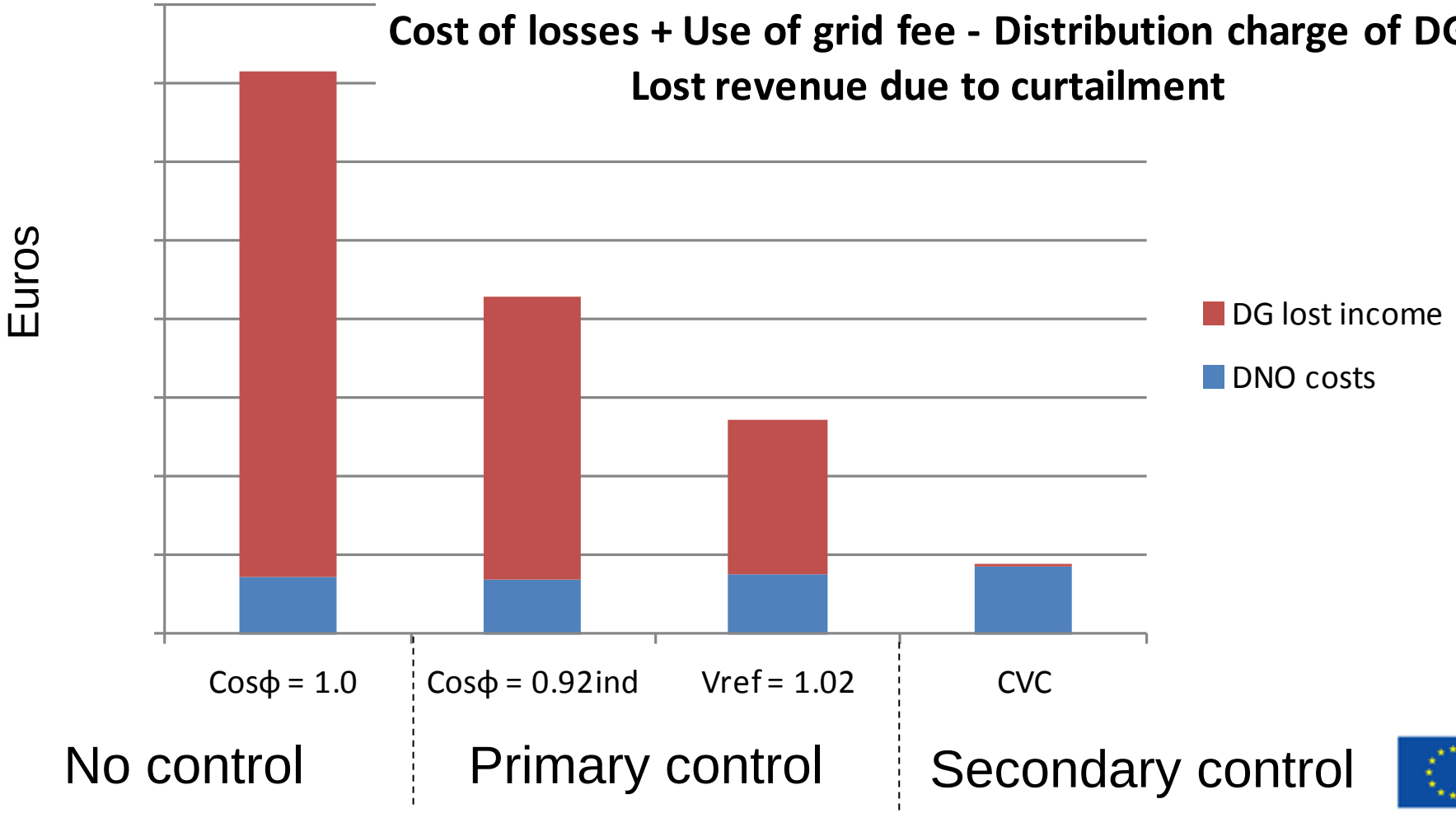
# Control of DERs from DSO's viewpoint

- **Regulation**
  - Connection requirements → technical capabilities for the control of DERs
  - Dynamic tariffs to incentivize load shifting
    - Retail → off-peak day-ahead prices
    - Grid → off-peak network load
- **Direct control**
  - DSO's own resources (OLTC, Reactive power compensation and FACTS)
  - Contracted non-market based control, e.g. voltage control of DG units
  - Emergency control to act just before protection
- **Flexibility services from Commercial Aggregator**
  - Scheduled re-profiling of flexible DERs
  - Conditional re-profiling of flexible DERs

# Active network planning

- **Active network becomes alternative for network reinforcement**
  - Postponing investments of physical infrastructure by ANM
  - Replacing network reinforcement with smart functionalities
- **Traditionally worst case design principle**
  - Firm connection capacity always available for all customers
  - DG impact → maximum production – minimum loading condition
  - Leads to over-dimensioning of network and the evaluation of smart functionalities is limited to peak conditions
- **Stochastic planning of active network**
  - Non-firm connection (based on dedicated contract) increase network hosting capacity remarkably
  - Enable full utilization of ANM

# Benefits of coordinated voltage control in MV network



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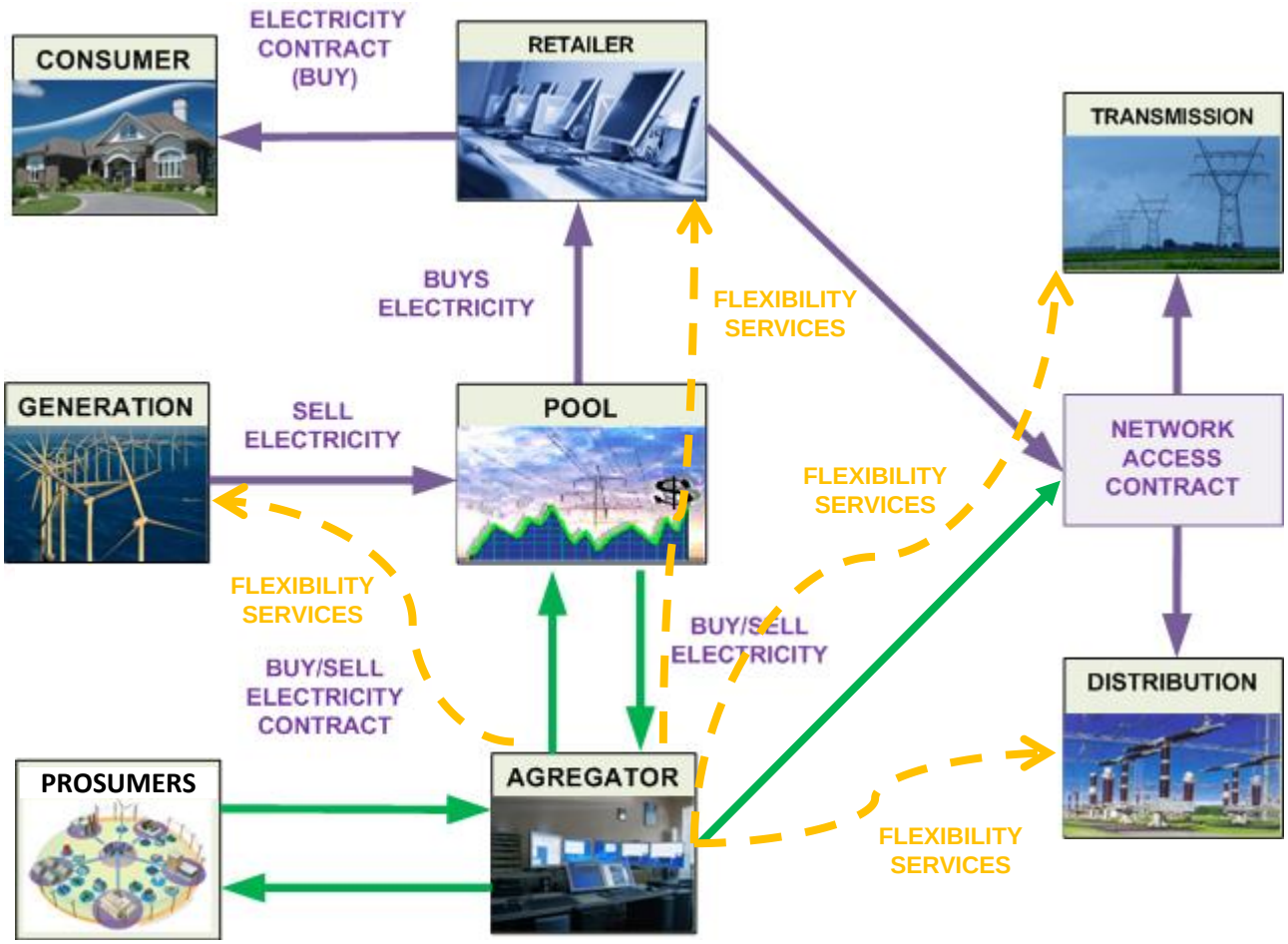
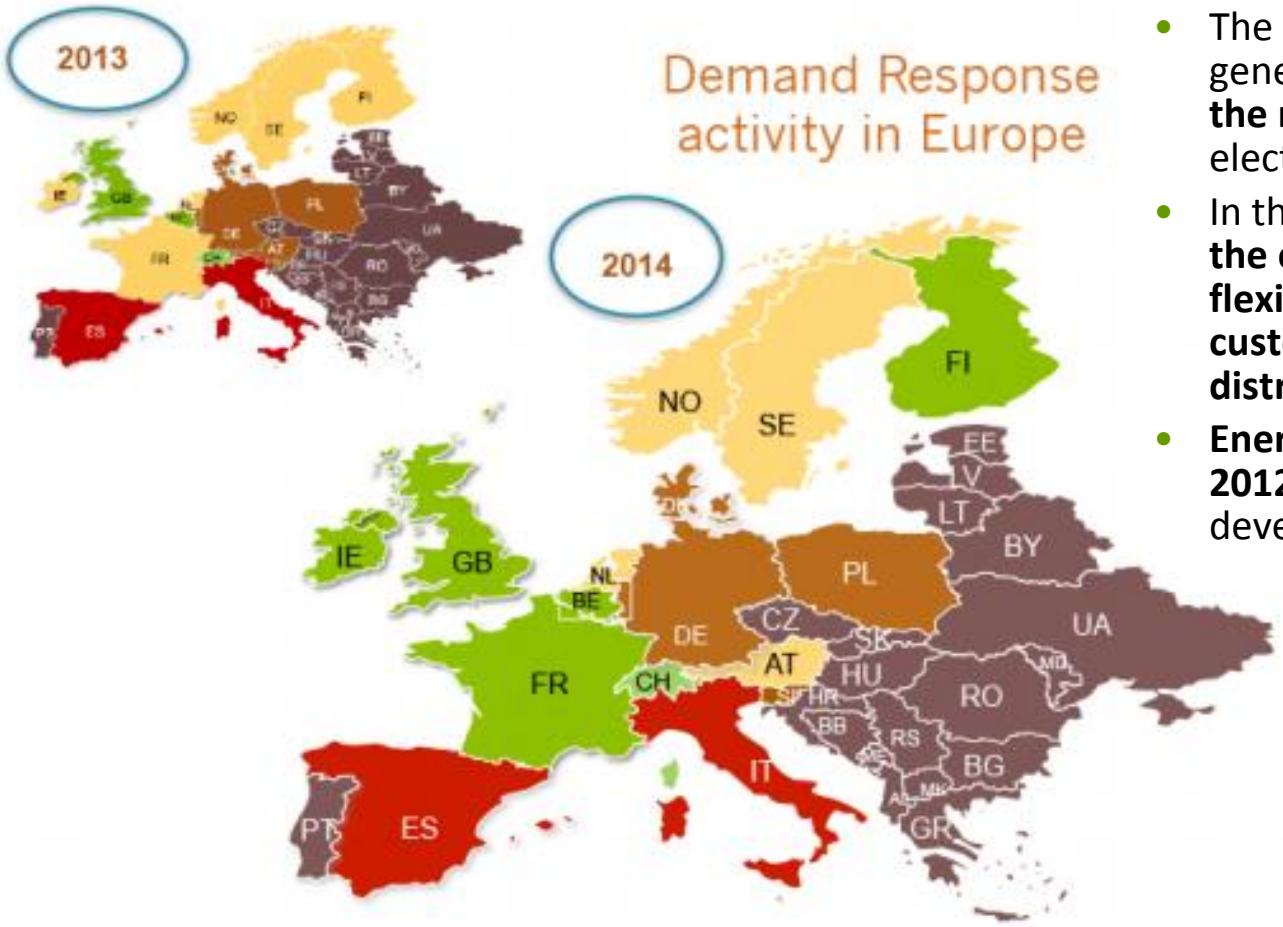
# Aggregation concept: key enabler of "FLEXIBILITY"



# State of the art - markets




*Demand Response Map of Europe 2013-2014*

- The growing share of variable generation in Europe is increasing **the need for flexibility in** the electricity system.
- In this context, **aggregation offers the opportunity to exploit the flexibility potential of smaller customers** connected to **distribution networks.**
- **Energy Efficiency Directive 2012/27/EU** – Legal basis for development

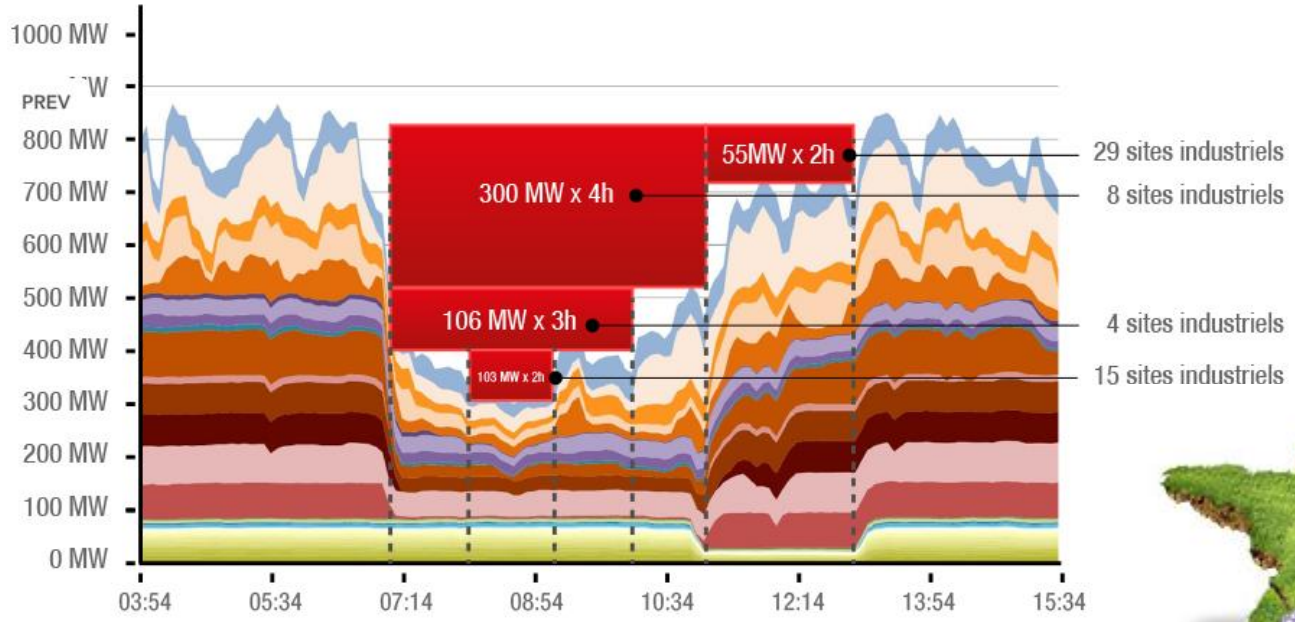
# State of the art - markets

Some European demand response programs…

# State of the art - markets

Some demand response providers…

- Energy Pool (1,2GW capacity):

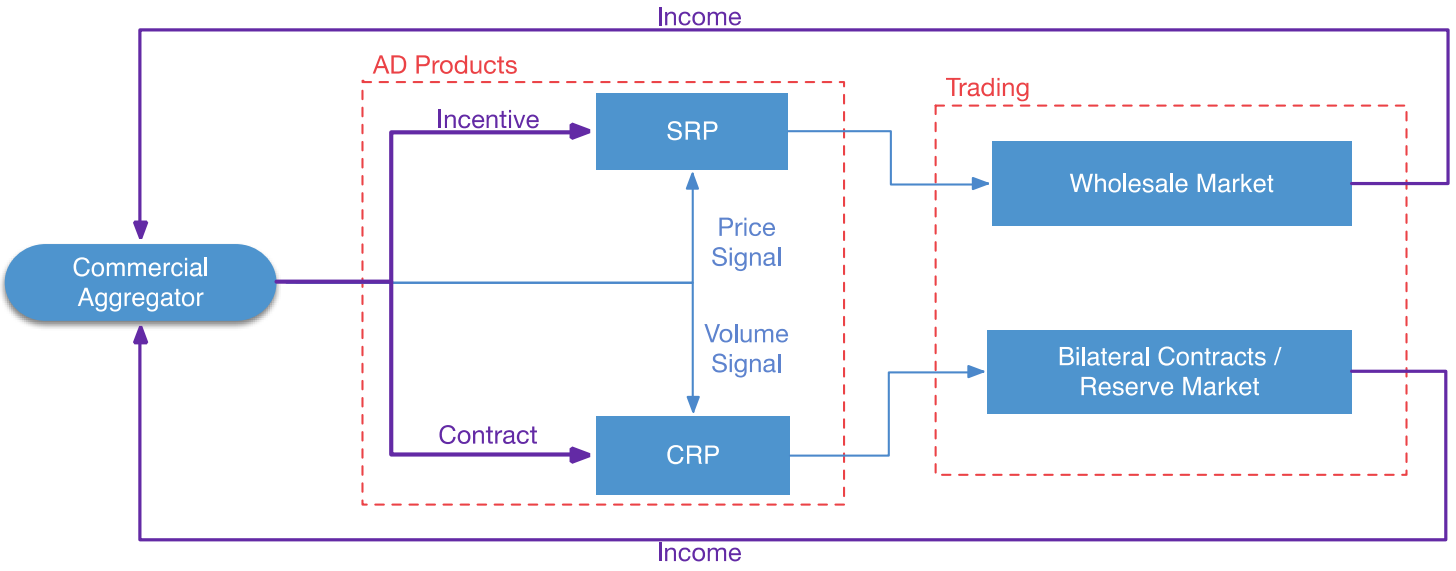



- a fixed rate per MW that is made available
- a variable rate for each MWh of consumption that has been shifted

# Flexibility products

Two types of standardized Flexibility Products

| AD Product | Conditionality | Example |
|---|---|---|
| Scheduled re-profiling (SRP) | Unconditional (obligation) | The aggregator has the obligation to provide flexibility services |
| Conditional re-profiling (CRP) | Conditional (real option) | The aggregator must have the capacity to provide flexibility services |



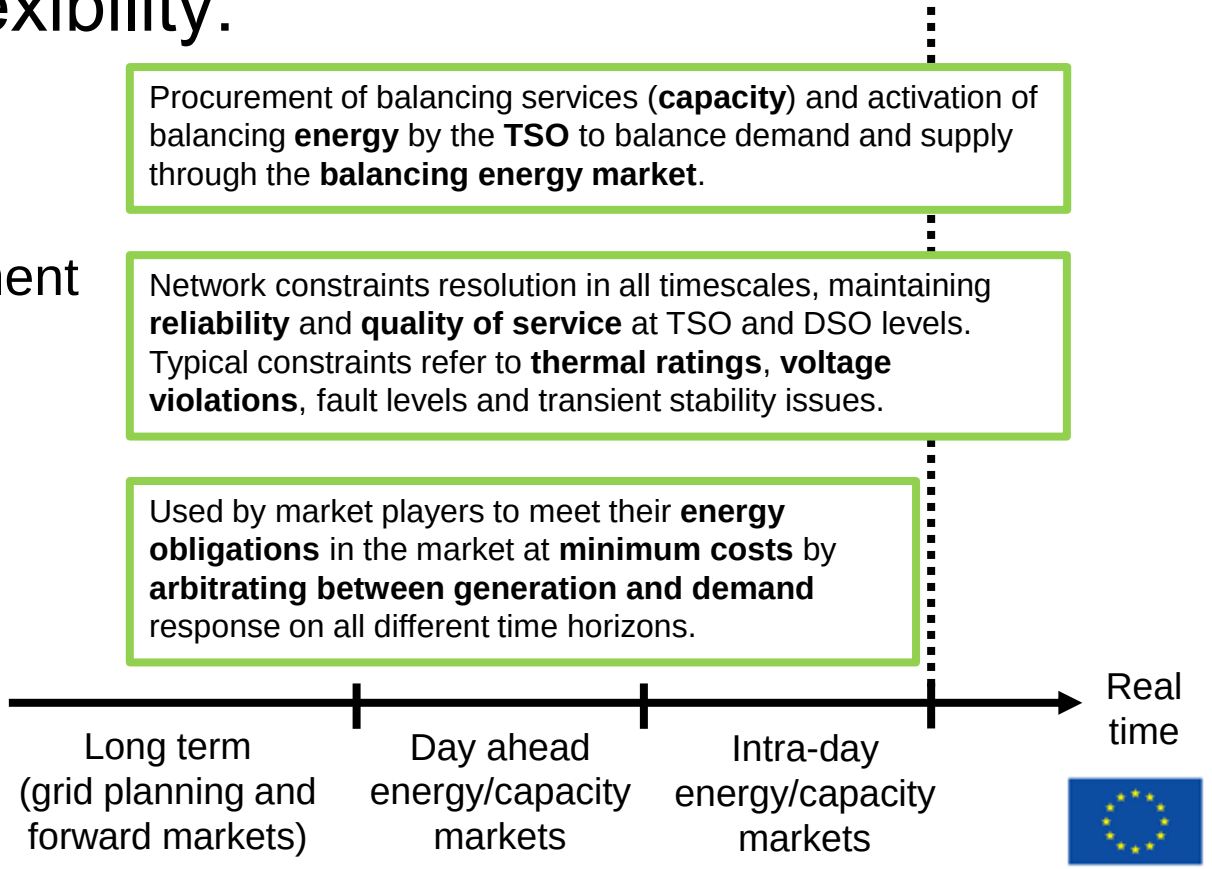
# Aggregator: target markets

- Three possible market uses for the aggregator's flexibility:

1. Balancing markets

2. Constraints management at transmission and distribution level

3. Portfolio optimization

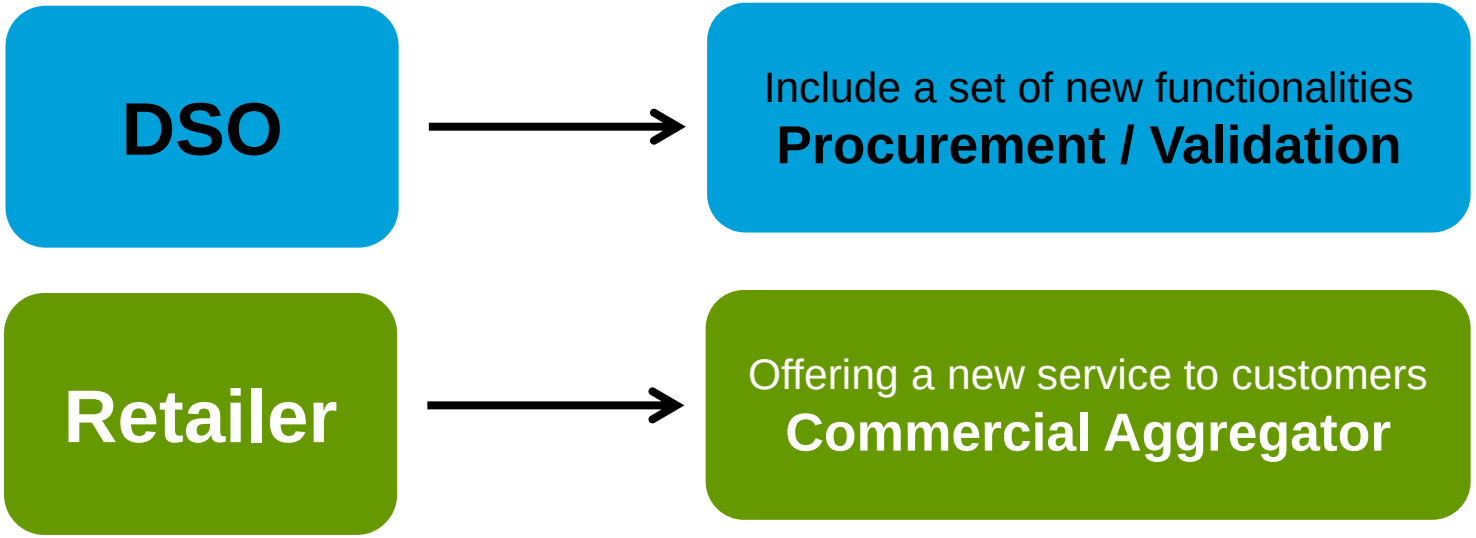


# While ensuring further coordination between TSOs & DSOs

- Activation of **flexibility resources** connected to distribution networks by the TSO for the purpose of system **balancing** or **transmission constraints management** may lead to **constraints in distribution networks**
- Similarly, **DSO constraint management** will also **affect the TSO** grid and balancing of the system and the other way around
- Regarding energy markets, the program should be **validated not only for TSOs but also for DSOs**.
- A robust and **efficient IT framework** is required to ensure the necessary **information exchange** among commercial aggregators, DSOs, and TSOs.

# Aggregator concept

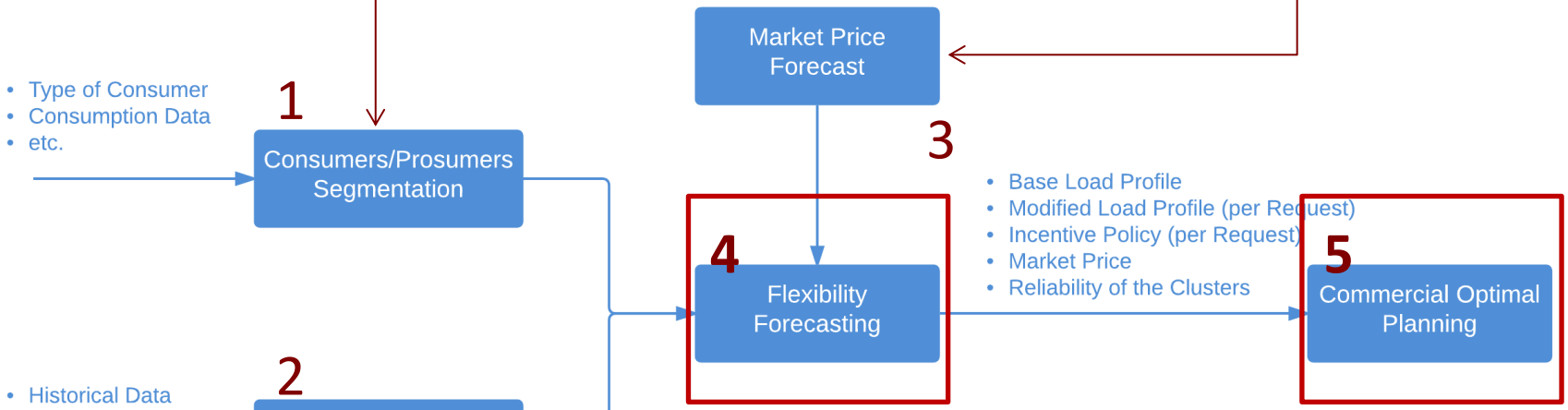
- Within IDE4L project an aggregator concept is being developed trying to ensure a **robust, transparent and equitable** market functioning.
- IDE4L aggregator concept consists of two new agents, **evolving from** their **classical roles** to include new functionalities



# Commercial Aggregator key functions

**Consumer Segmentation**
- Divides the consumers to groups with similar behavior in terms of consumption.
- The groups are called clusters

**Market price forecast**
Classical methods. Historical data




**Consumption and flexibility forecasting**

Estimates the consumers' behaviour/flexibility

# Commercial Aggregator key functions

1) Consumer Segmentation
   i. Divides the consumers to groups with similar behavior in terms of consumption.
   ii. The groups are called clusters
2) Consumption and flexibility forecasting
   i. Estimates the consumers' behaviour/flexibility upon different price/volume incentive signals
3) Market forecasting
4) Operational planning/optimization
   i. Maximizes aggregator profit
   ii. Determines the market bids
   iii. Determines the incentive policy and the price signals
5) Send price/volume signals to prosumers
   i. Price signals (€/kWh) for Schedule Re-profiling Products (SRPs)
   ii. Volume signals (kW) Conditional Re-Profiling Products (CRPs)