The role of automation in future distributed electricity generation

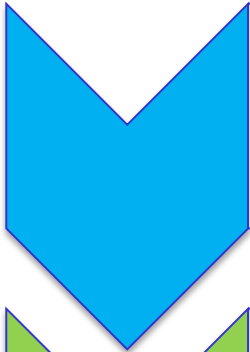*Sami Repo*

Department of Electrical engineering
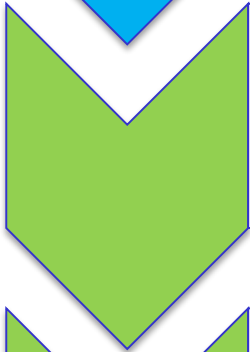*Tampere University of Technology*

24th of October 2015
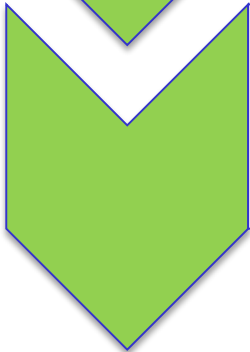
IDEAL
ideal grid for all

COOPERATION

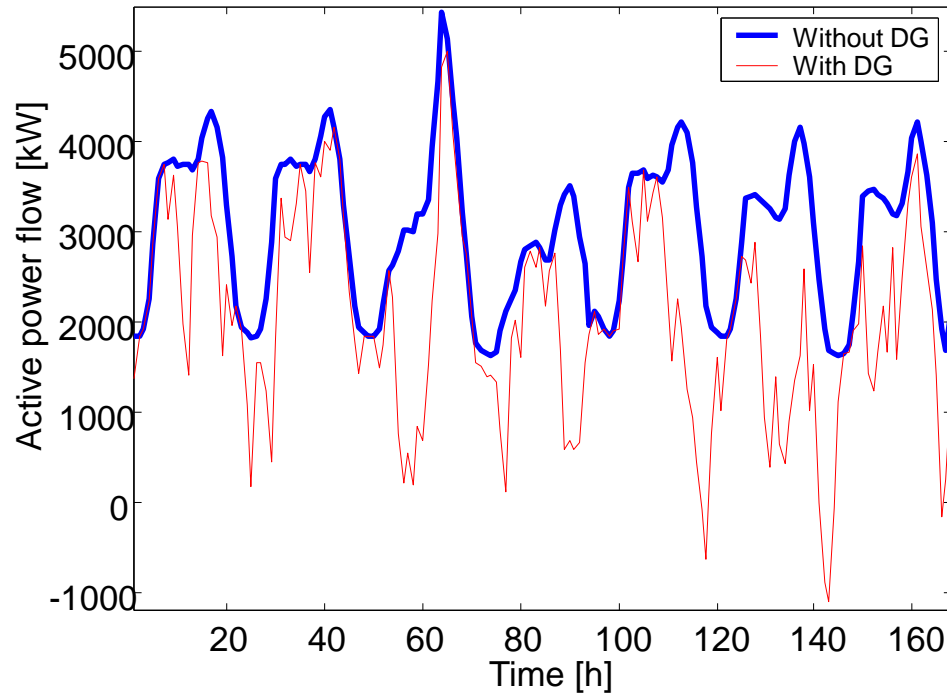- Active network management (ANM) concept and distributed automation architecture

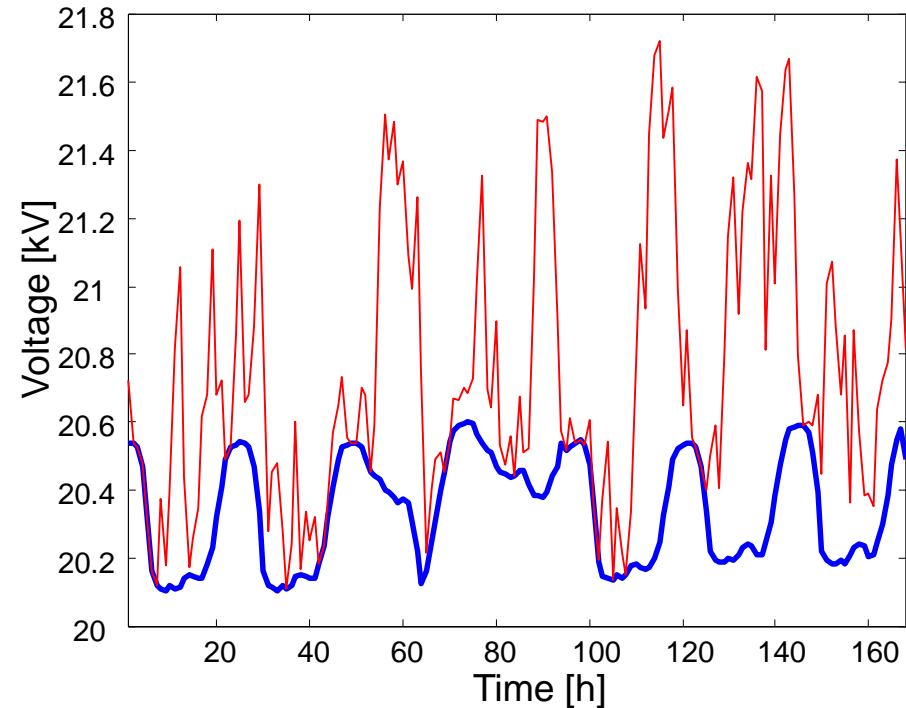- Breakthroughs of monitoring and control

- How IDE4L will change business of DSO?

Changes in production

Power flow through
primary transformer

Voltage at connection
point of wind turbine

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

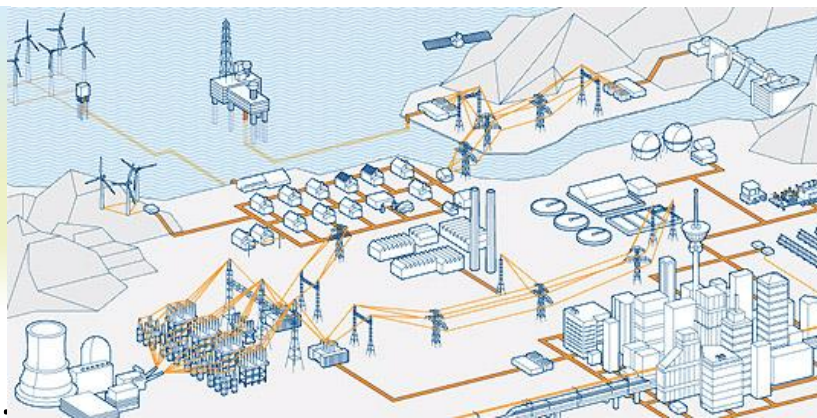# Vision of future smart grid
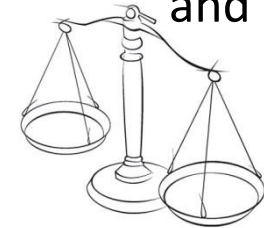
Market design

Smart charging of EV

Smart homes and PV

System management and design

Microgrids
Energy communities

Grid infrastructure

Balancing

Storage

Distribution automation

Aggregator

Controllable loads and energy efficiency
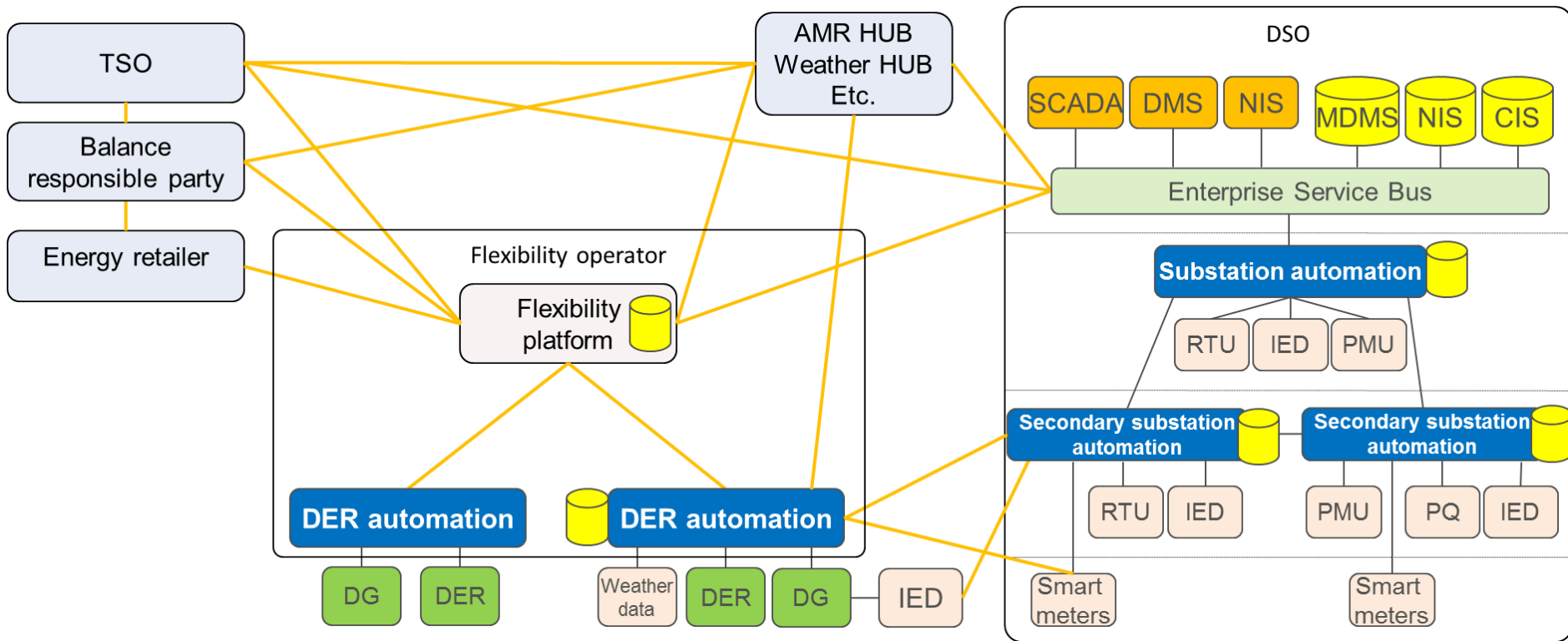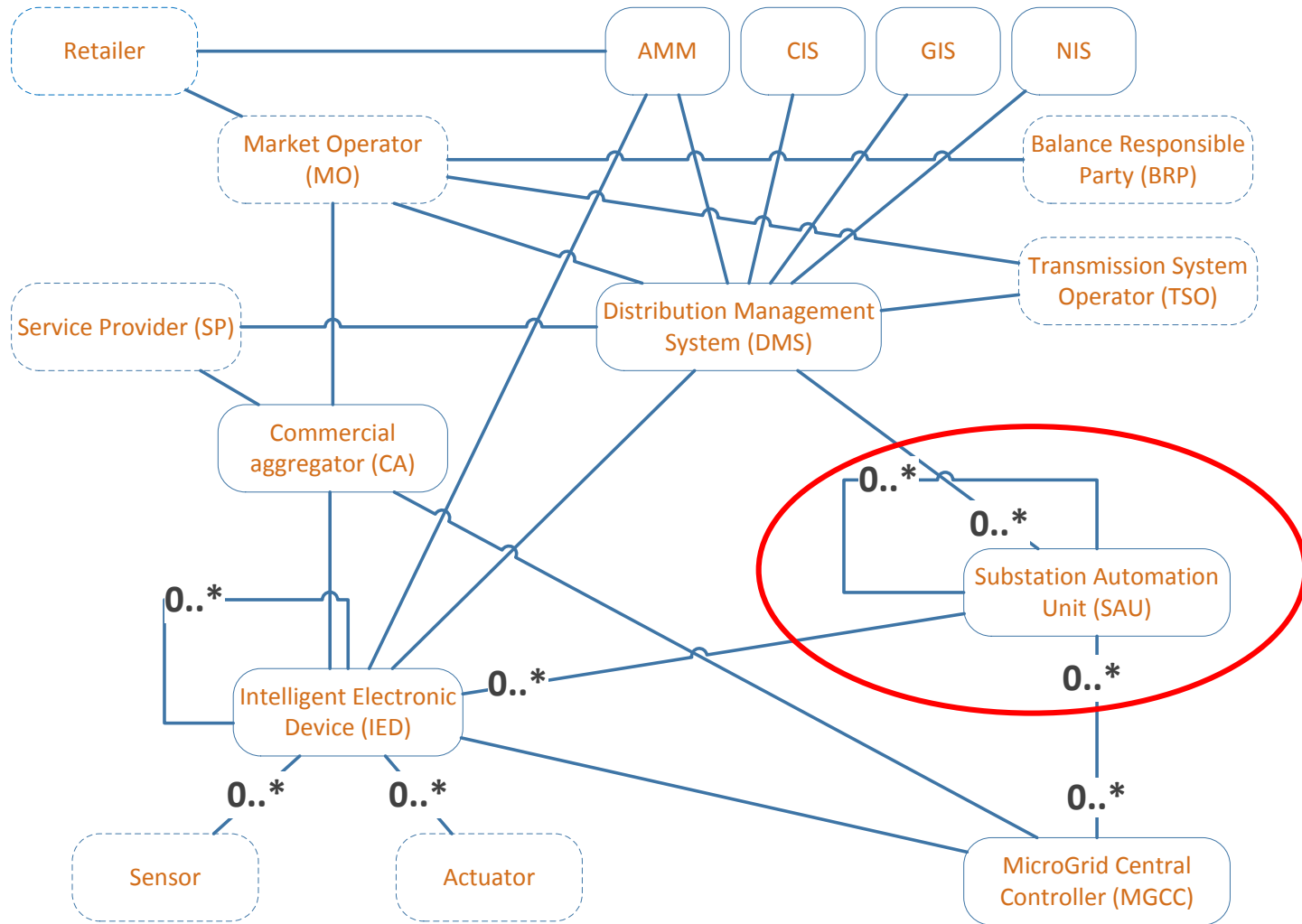
Renewable energy resources

Power to gas

Advanced monitoring

IDE4L automation architecture

Semantics of distributed automation

Extension of monitoring and control functions

Function

Level at which automation is performed

Actor

| Control center Level |
| Primary Substation level |
| Secondary Substation level |
| Microgrid level |
| DERs level |
| Transmission system level |
| Market level |

Actors:
- DMS /control center
- Primary Substation Automation Unit (PSAU)
- Primary substation IED
- Secondary Substation Automation Unit (SSAU)
- Secondary substation IED
- Microgrid central controller
- Commercial aggregator
- HEMS
- TSO
- Market operator

Functions:
- Control center power control
- Grid tariff
- Network reconfiguration
- Market agent
- Network and protection description update
- State estimation and forecast
- MV power control
- Measurement acquisition
- State estimation and forecast
- FLISR
- LV power control
- State estimation and forecast
- Measurement acquisition
- Reconnection to main grid
- Microgrid power control
- Buy/sell CRP (conditional re-profiling) service
- Buy/sell SRP (Scheduled re-profiling) service
- Collection of dynamic informations
- Trade of SRPs and CRPs

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)
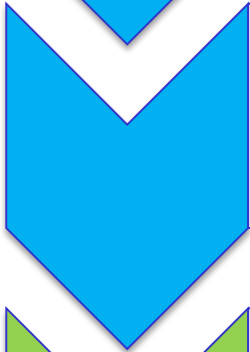
2. **Aggregator / Flexibility operator**
   - Forecasting of consumption, production, price, etc.
   - Flexibility estimation of customers
   - Commercial optimal planning
     - Determination of market bids
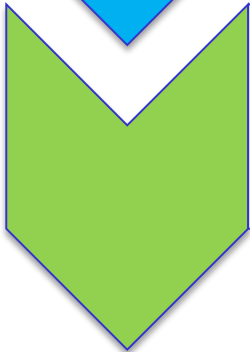   - Maximization of aggregator profit
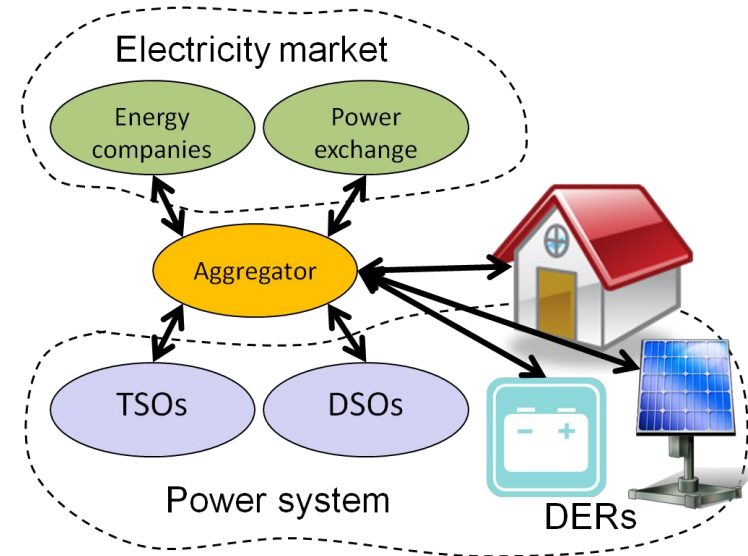
- ANM concept and distributed automation architecture

- Breakthroughs of monitoring and control

- How IDE4L will change business of DSO?

What's missing?

- Decentralized/Standard automation
  - Centralized model / non-standard
  - *Decentralized model / standard-based*
- LV grid ⭐
  - EV, PV, HP and demand-response schemes mainly affect the LV grid
  - *Monitor the LV grid*
- Data management ⭐
  - Data coming from heterogeneous system
  - Incomplete: Some nodes are not monitored; Broken/unreachable device
  - Uncertain: Low synchronization accuracy; Measure corrupted
  - → **MV & LV State Estimation**
 - → **Network Description Update**
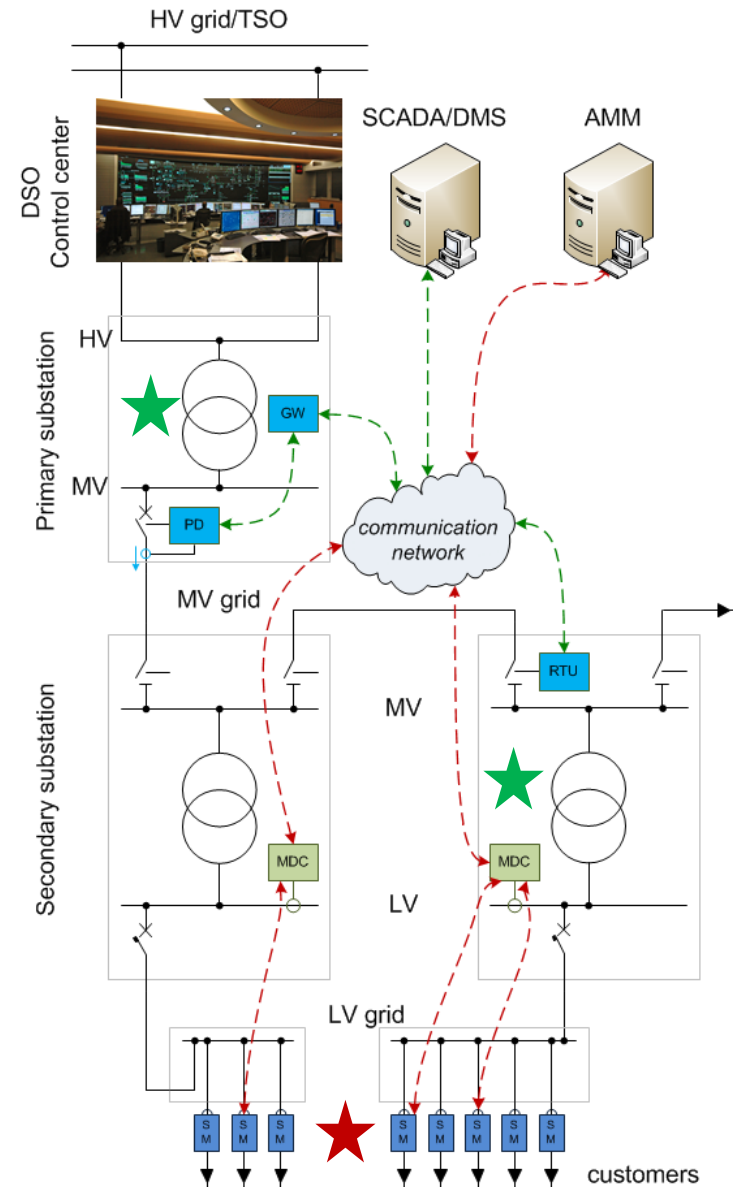
Standard-based decentralized automation

- Number of devices and data increases
  - 10 of PSs -> 10^6 customers
  - mean values -> high-frequency values
- Main standards:
  - 61850: data about the grid
  - DLMS/COSEM: metering data
  - CIM: network description
- <u>Breakthrough</u>: decentralized model
  - Data are collected/processed locally (LV data -> in SS ; MV data -> in PS)
  - Only summary reports to upper levels
- Benefit: impact on CAPEX and OPEX
  - reuse of existing automation components
  - less-demanding communication is required
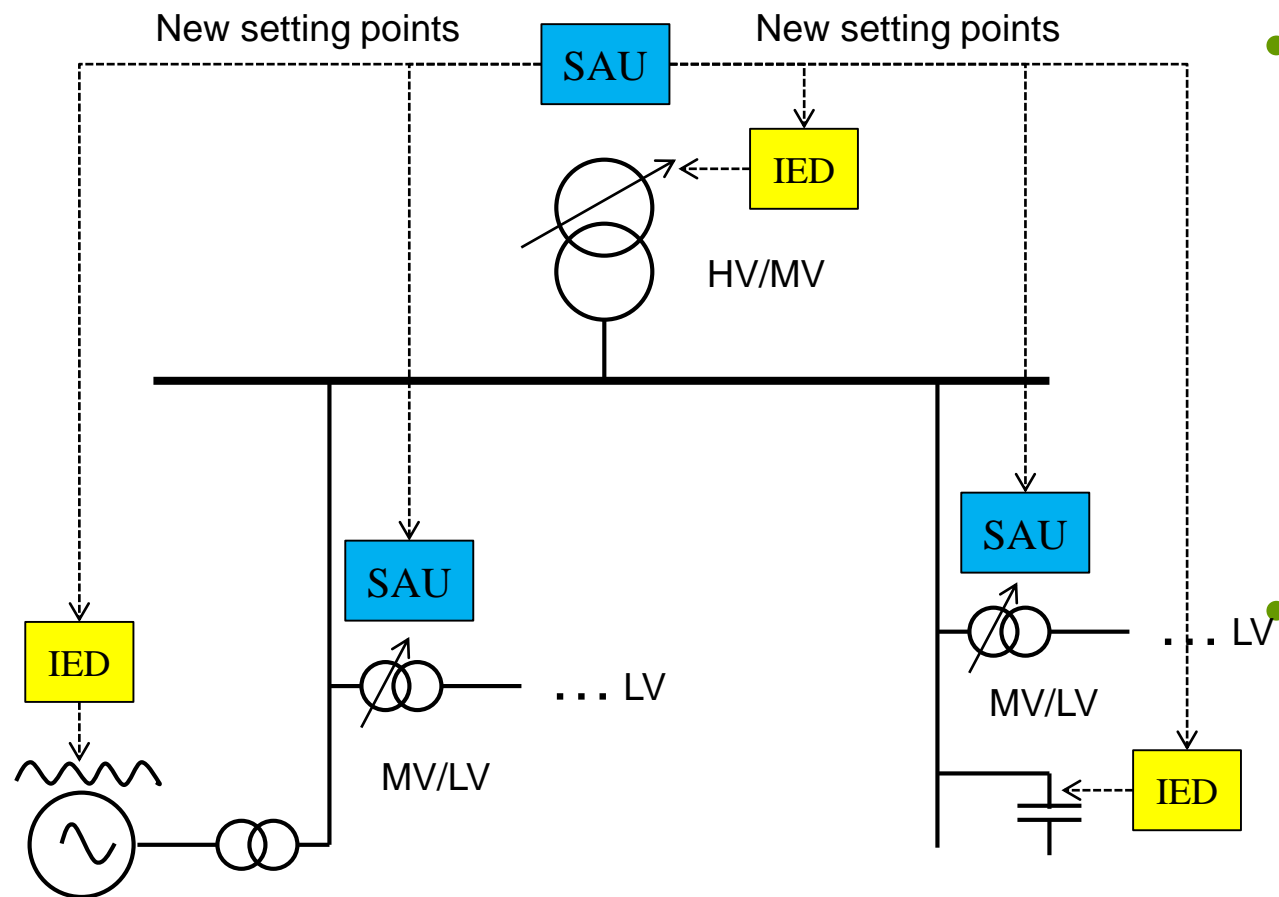 - interoperability
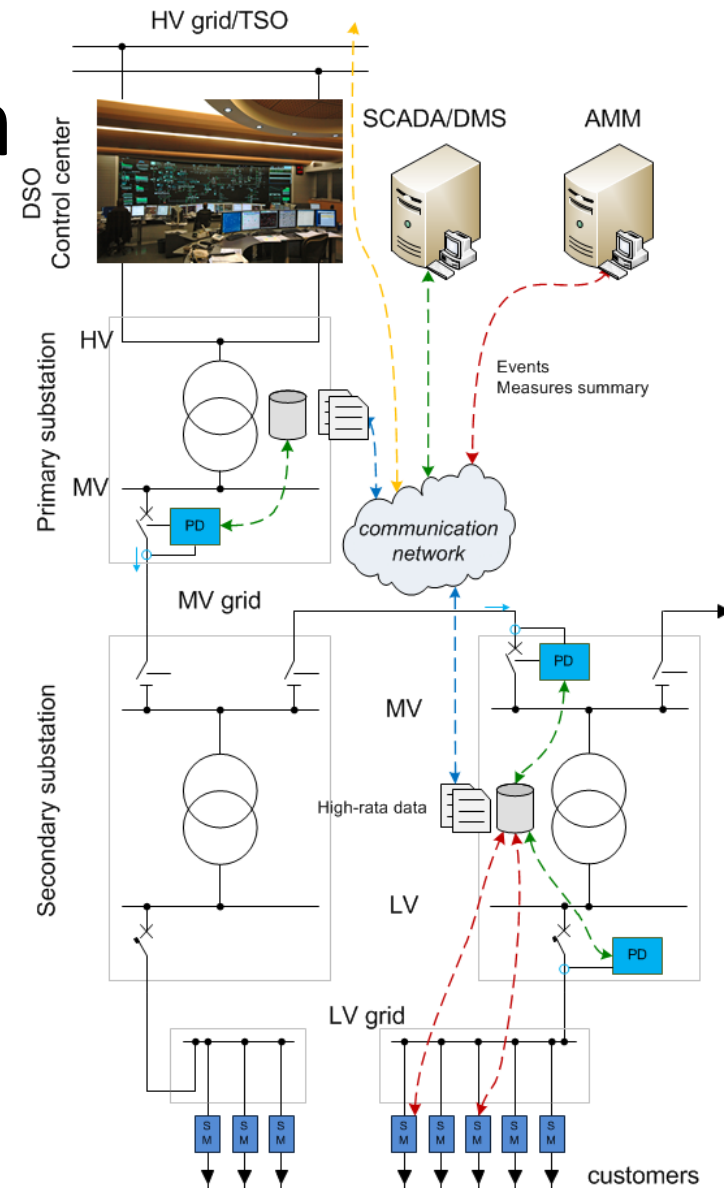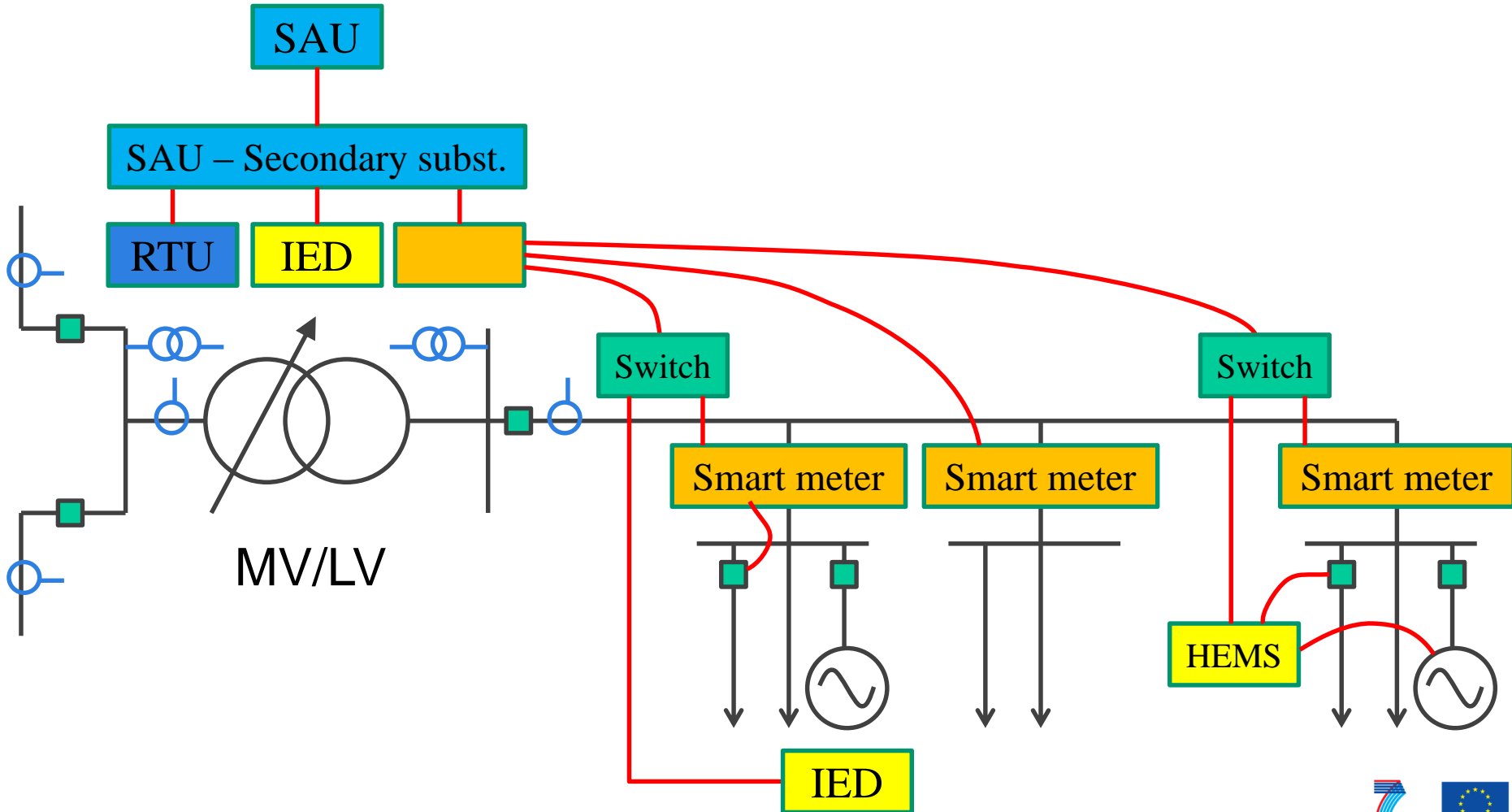
Hierarchy of controllers
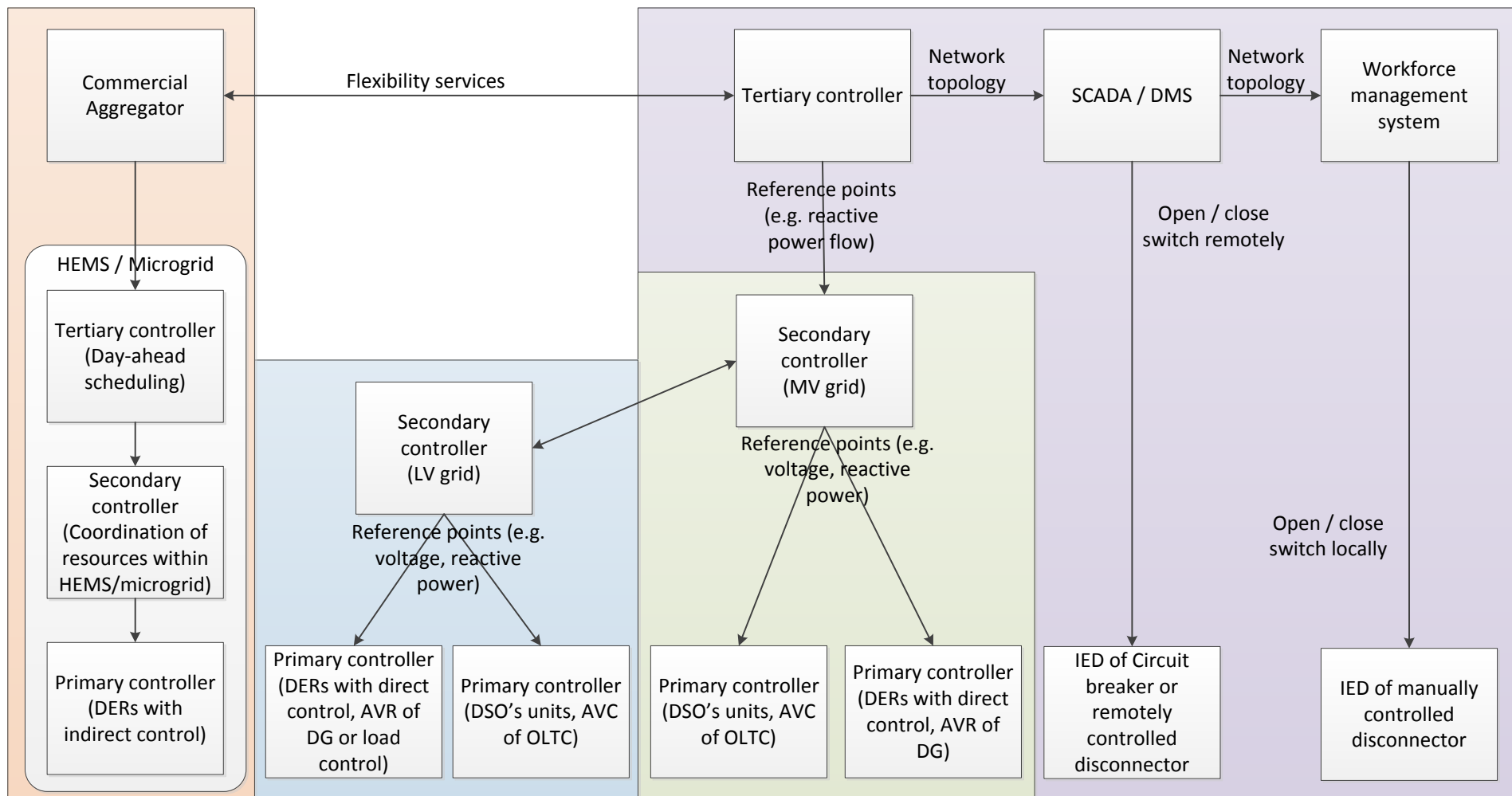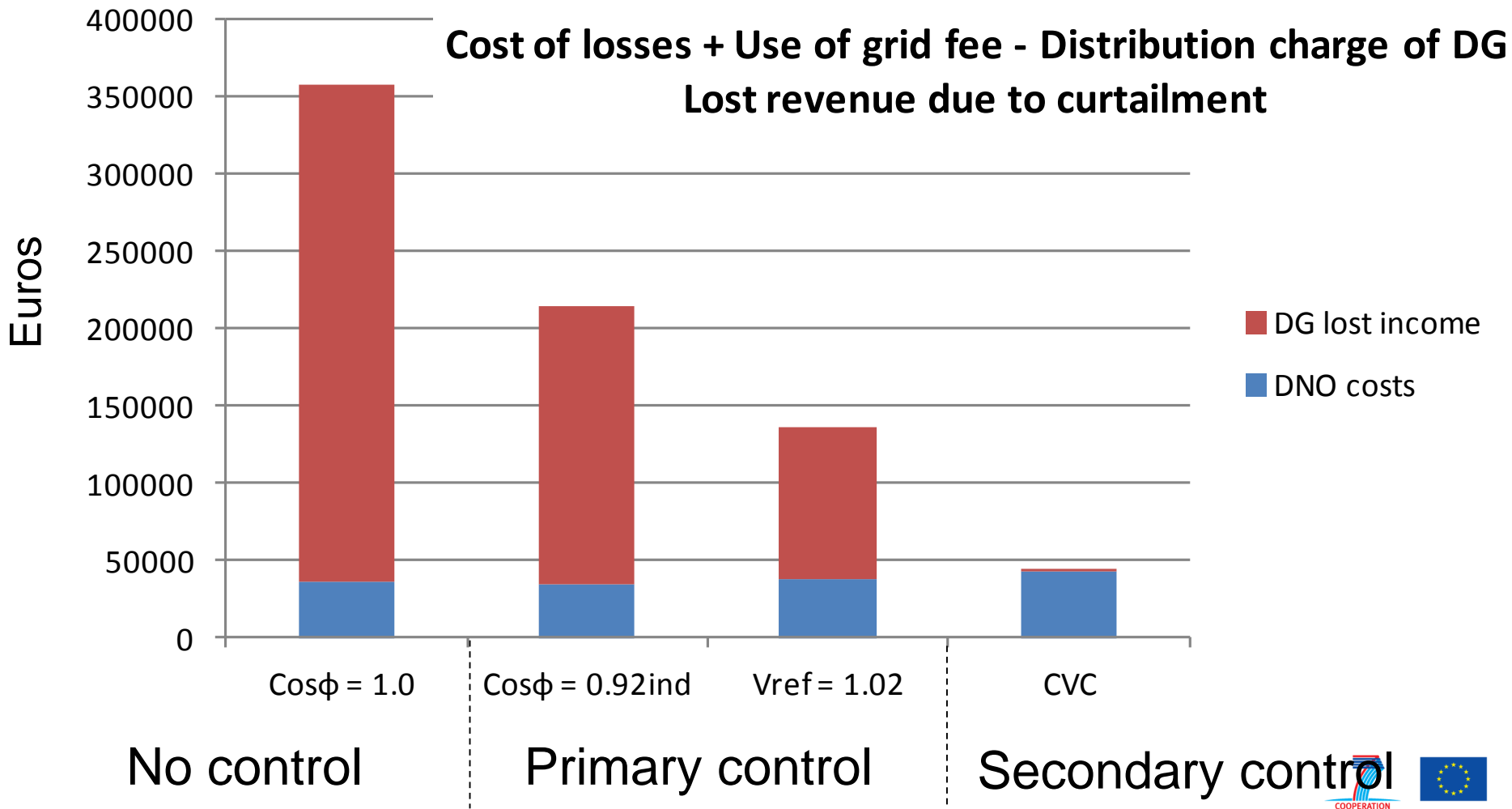
MV grid voltage control scheme

- SAU = Substation Automation Unit
  - SAU coordinates IEDs and SAUs below it
  - Coordination by secondary controller
  - Based on real-time monitoring and state estimation
- IEDs (primary controllers)
  - AVC of OLTC
  - AVR of DG

LV grid voltage control scheme

Benefits of coordinated voltage control

Cost of losses + Use of grid fee - Distribution charge of DG
Lost revenue due to curtailment

Legend:
- DG lost income
- DNO costs

Y-axis: Euros (0 to 400000)

X-axis categories:
- Cosφ = 1.0 — No control
- Cosφ = 0.92ind — Primary control
- Vref = 1.02 — Primary control
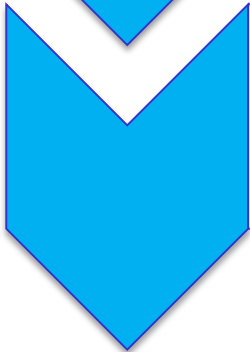- CVC — Secondary control

- ANM concept and distributed automation architecture
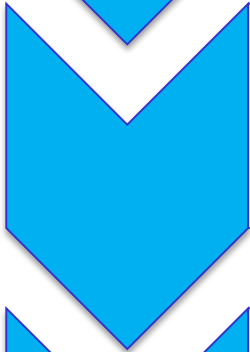
- Breakthroughs of monitoring and control

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How IDE4L will change business of DSO?

- **Design and operational changes**
  - Increase remarkably network hosting capacity for DERs
  - DERs participate indirectly in ANM
  - Complexity of system increases
- **Decentralized and standard based automation**
  - Monitoring and control of whole grid (scalability)
  - Enhanced functionality of distribution network management
- **DSO/TSO enables flexibility services to participate in markets**
  - Validates flexibility service requests
  - Maintain a market for constraints management
- **DSO/TSO may buy flexibility services to solve network congestion**

Thank you

www.ide4l.eu

Future flexible distribution system

Seminar

- Friday 4th December 2015
- Tampere University of Technology
- www.ideal.eu/events/

Agenda

1. Results of IDE4L project
2. Demand response – Practical applications in Finland
3. Flexibility operator at Nordic demand response markets
4. Visit to TUT RTDS lab