TSO-DSO Interfaces and IT-supported Flexibility Control

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Content

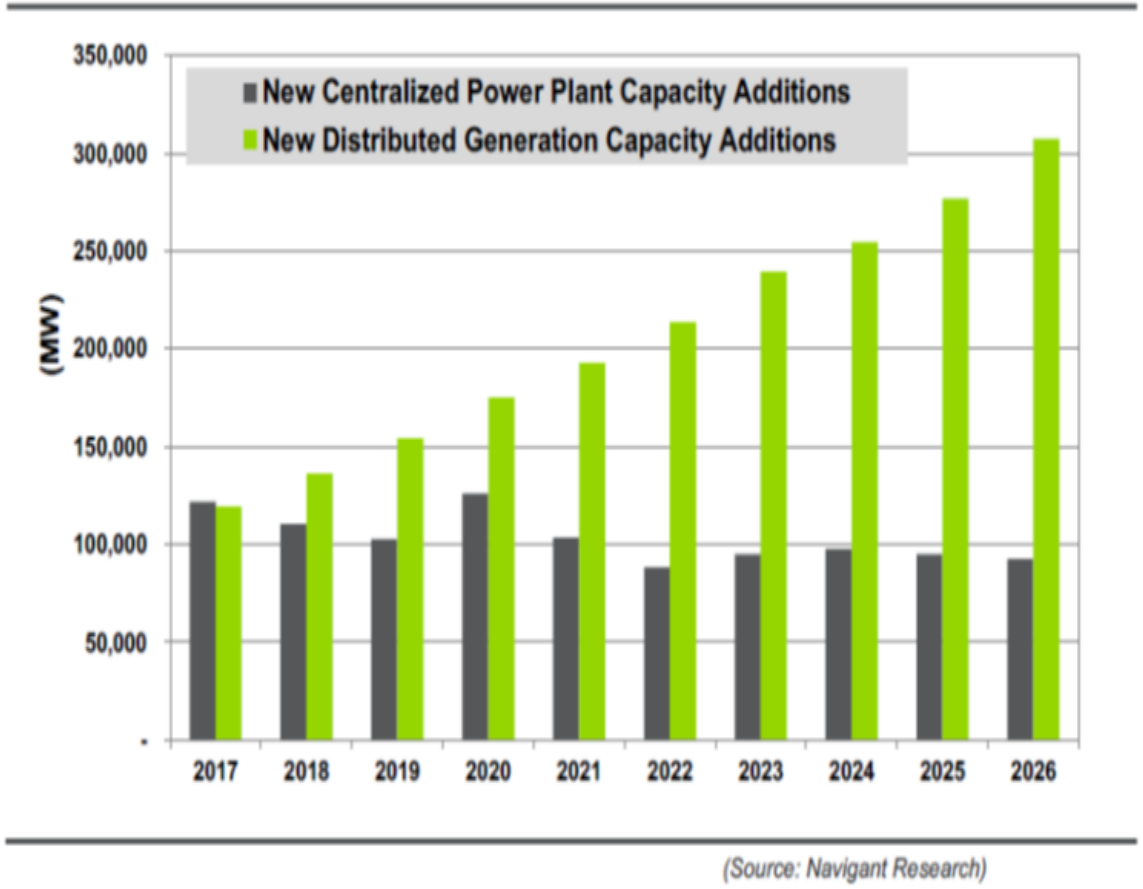
- Motivation/Challenges in ESI
- DER Aggregation (VPP, ADMS, µG), Why?
- Existing DER Management Sys.(VPP, DERMS) solutions, How?
- Developed VPP solution and integration with SCADA/GMS
- Practical implementation and tests of a LDC
- Conclusion
- Message: To shortlly overview problems and the field and present initial design efforts of IMP on DER aggregation architecture and its integration to on-going SCADA/GMS project.

Motivation/challenges

- With liberalization volumes of trading are increasing
- Different market and services emerging
- DG/RES, including small size sources at MV, LV networks, increase in numbers/impact, non observable, neither controlable
- Their uncertainty and variability afects sys. operation
- Currently, less flexibility, less resources for Balancing/AS
- Need to include customer capabilities: generation, DR, storage
- Unexpected power flows (bidirectional at distribution level)

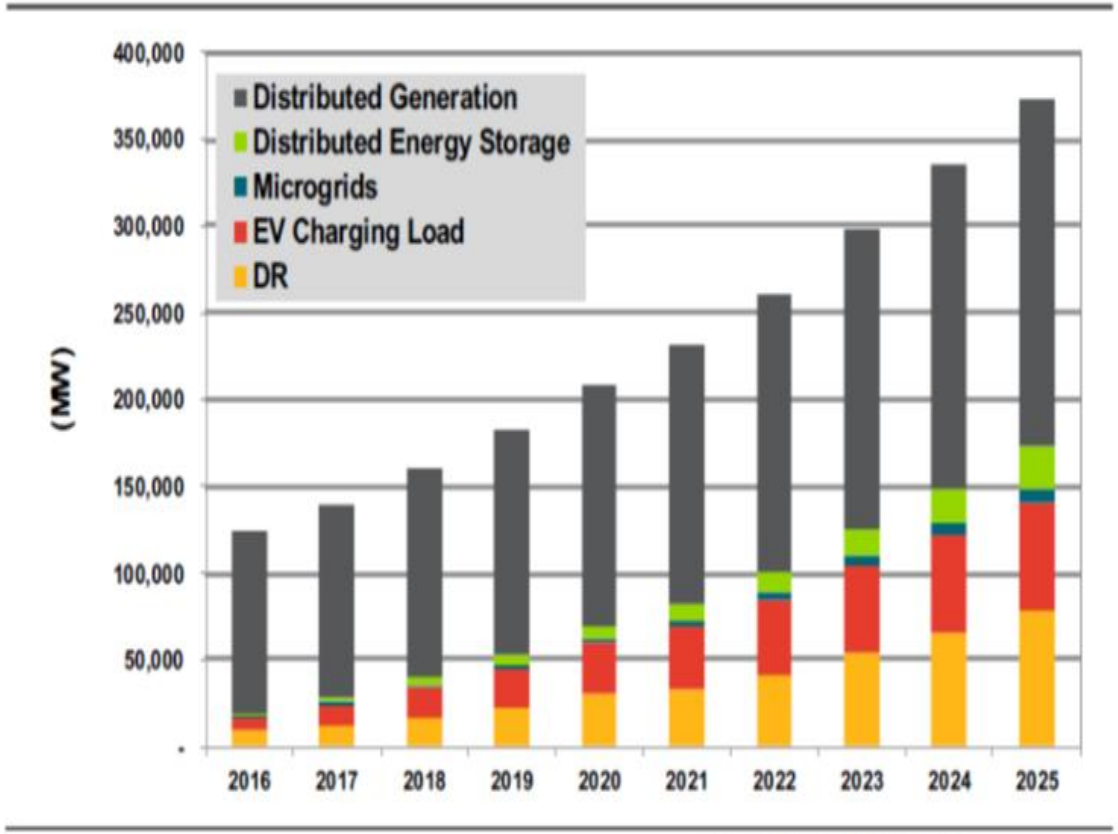
DER expansion trends

Installed Centralized versus Distributed Power Capacity, World Markets:2017-2026.



(Source: Navigant Research)

Annual Installed DER Power Capacity by Technology, World Markets: 2016-2025



(Source: Navigant Research)

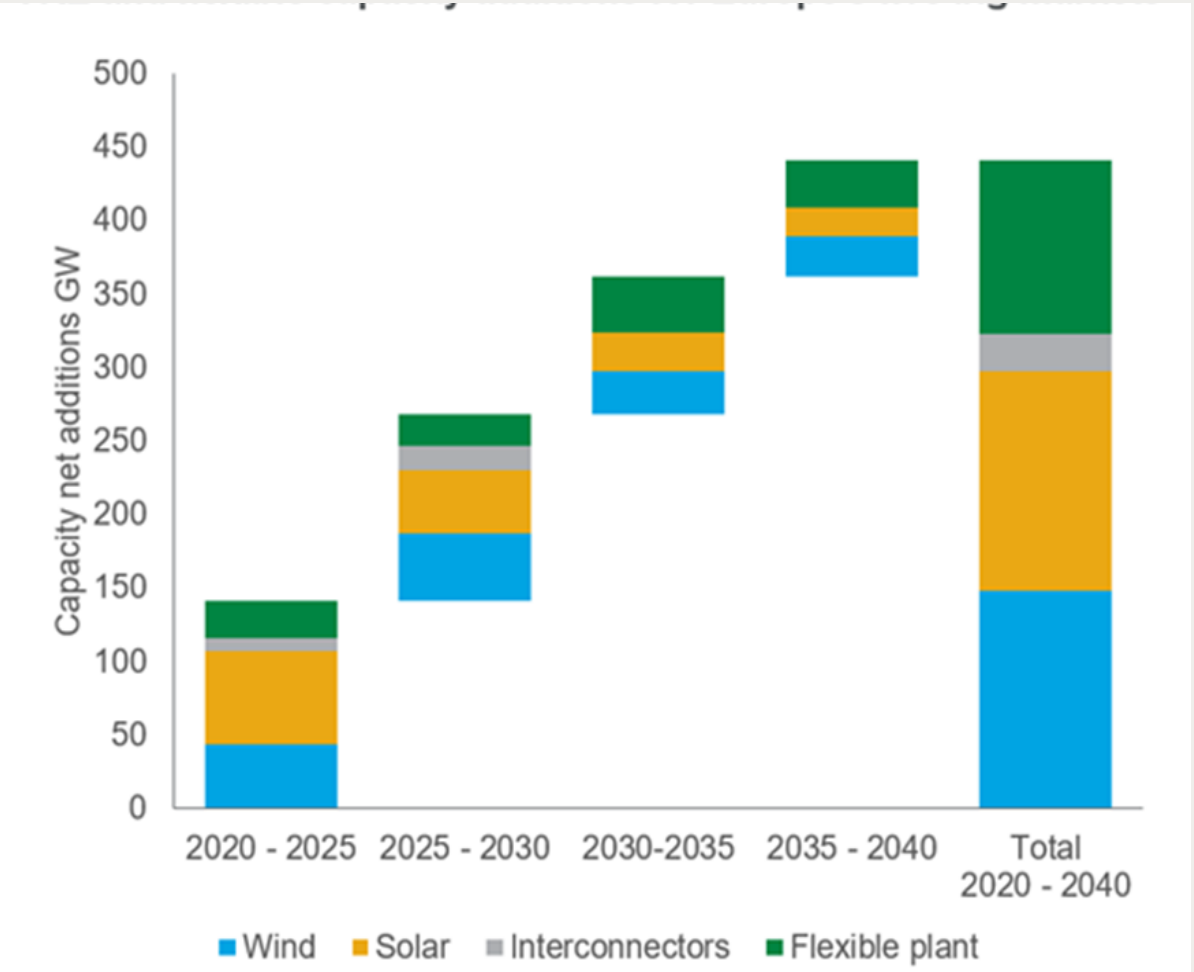
Future: Europe system flexibility resource outlook to 2040

The process of Europe's decarbonisation will ask for 298 GW build out of Variable Renewable Energy (VRE; wind and solar PV generation) between 2020 and 2040.

118 GW new build flexible plant will be required to balance 298 GW new VRE by 2040.

What is flexibility?

How to do that with DER/RES?



TSO-DSO Interface (tipically HV/MV SS) **constraints**

- **On the loading side**

Interface loading is limited with capacity of transformer. It can be increased by adding/upsizing TR or using DTRL devices.

- Depending on the TR type, P flow can be regulated or V can be regulated, or noting can be regulated
- **On the information-control side**

Inteface is normally equiped with standard IED/SAS (RTU) monitored/controled (TR and MV) by the SCADA from DSO CC, and HV side by SCADA from the TSO CC.

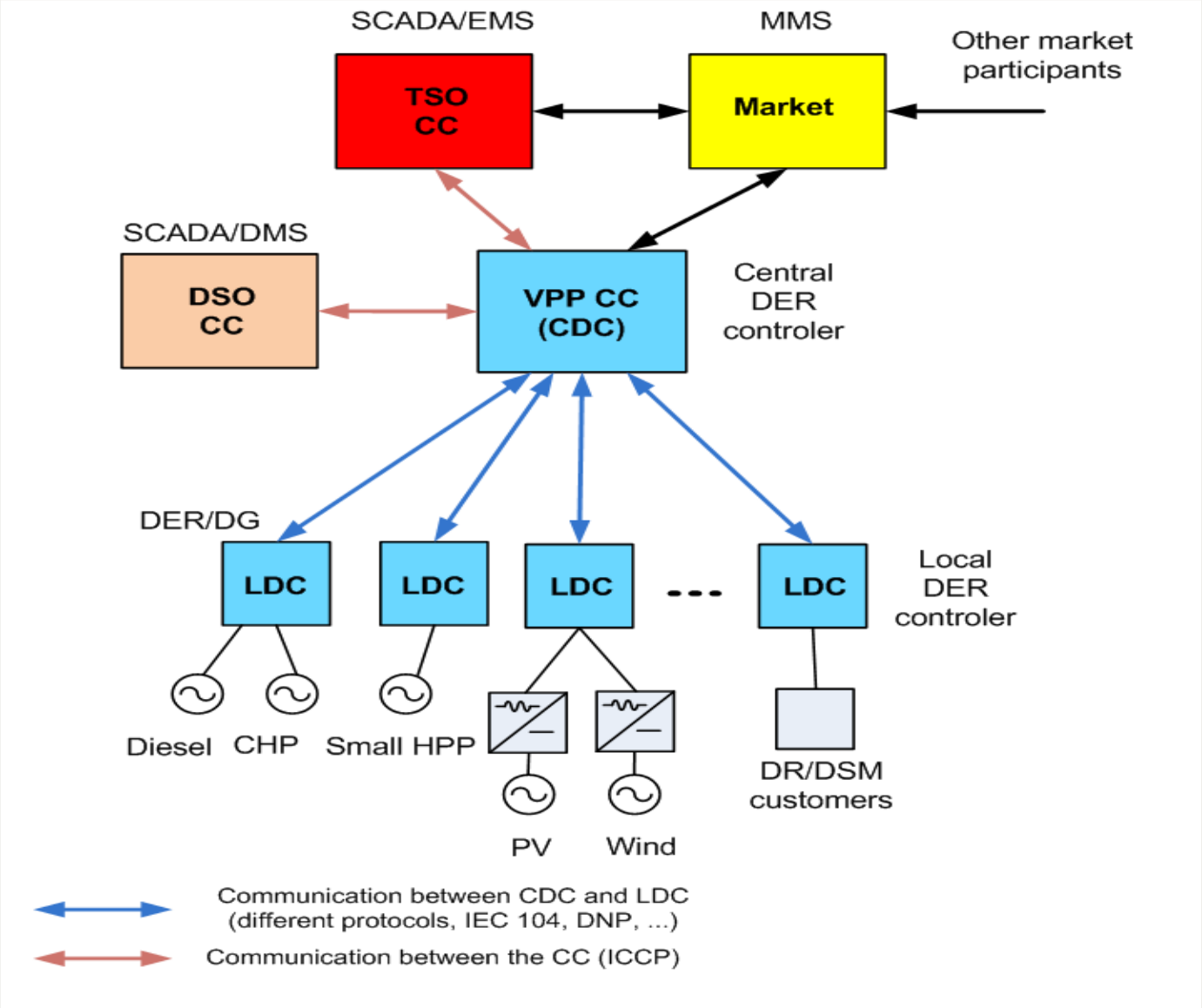
Impact of the DER capacity increase and posible remedies

- **In some op. states and meteo. conditions, DG production and location might endanger TSO-DSO interface (overload, voltage,...)**
- **Uncoordinated operation of DER's might restrict their potential to participate in the Market, and provide network services.**
- **To solve above problems there is a need to aggregate DER resources and integrate them in the overall control paradigm, i.e. DER management approach. Different ones proposed:**
  - **The internet model** (**VPP**, Virtual utilities, Power Hub)
  - **Active networks** (from **distribution**, with DG/RES, ADMS
  - **Micro grids (μG)**

DER aggregation, what it is?

- **DER=DG+DR+DSTO + (μG)**
- **DG resources: classic and RES, numerous and expanding on customer side (micro turb CHP, EV, appliances,...)**
- **Terminology: VPP, μG,…not fully settled yet**
- **Importance of ”smart inverters” as PE devices are developing**
- **Different situation at different countries**
- DER owner might be a **DER Aggregator,** but separate DERA is preferable in case owner has limited technical knowledge/capabilities.

Initially proposed solution architecture



Problem is two fold

- **How to integrate DER in the power system**
  - Dependent on type, size, location, volt. level, etc.
  - **Technical problem** ⇨ Connection rules, at physical level
  - **Interfaces** (portability) **and interoperability**
- **How to integrate DER in the market**
  - Electricity, capacity, AS markets (reserves, P, Q, restoration service, planning, dispatch…)
  - DER Portfolio optimization might be complex, need for simpler approaches
  - Aggregation is essential, different forms possible

Relevant R&D, Lot of research and development, like:

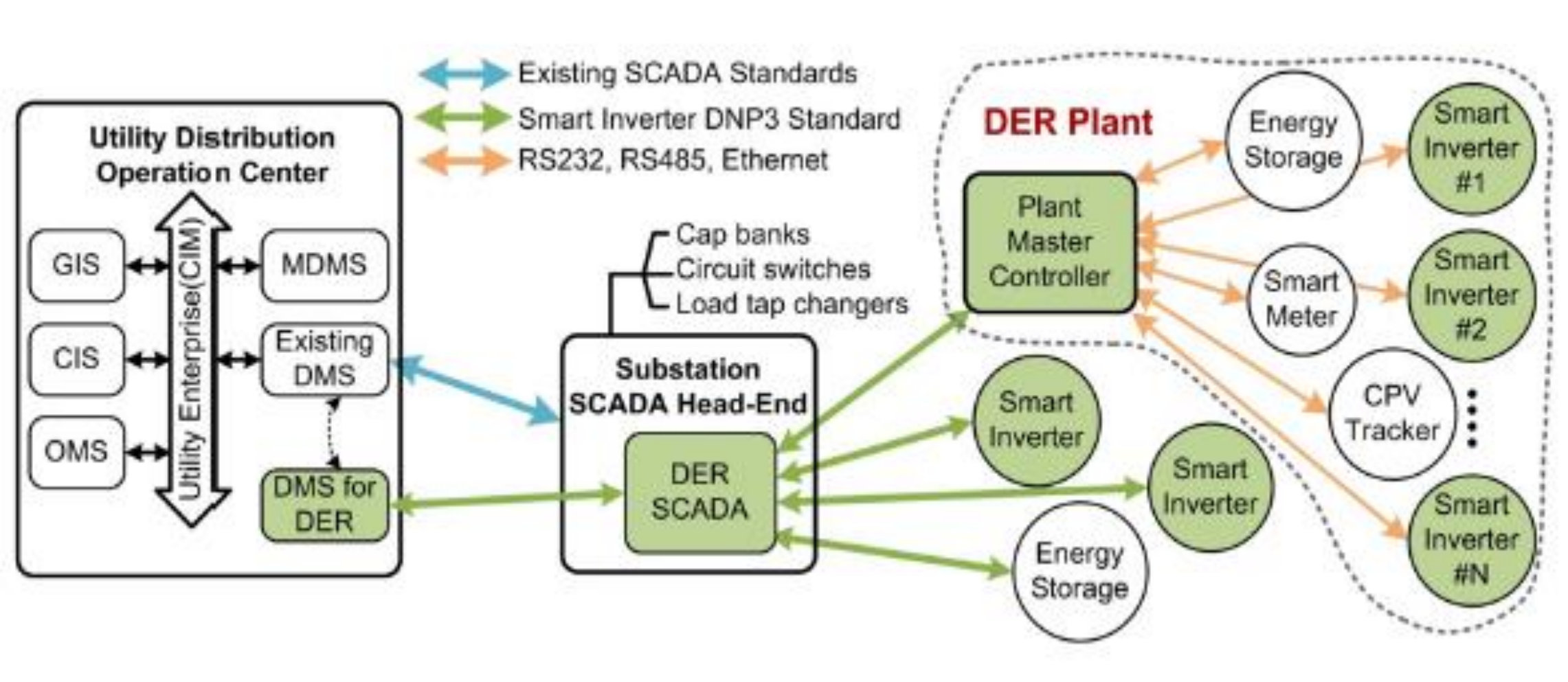
- In US, under DOE (2010-2020), EPRI, Nat Lab (NREL, ANL), IEEE
- Standards: IEEE 1547-2003, for coonnection, IEEE P2030.7 spec of µG contr. (in N. America)
- FENIX under FP6, 2009, 8 countries (CVPP and TVPP concepts defined)
- e-Badge FP7 project (2014), optimal pan-European Intelligent Balancing Mech.
- SmartNet H2020 Project (Italy, Dk, Sp,....9 countries, 22 partners)

Potential exist: VPP market

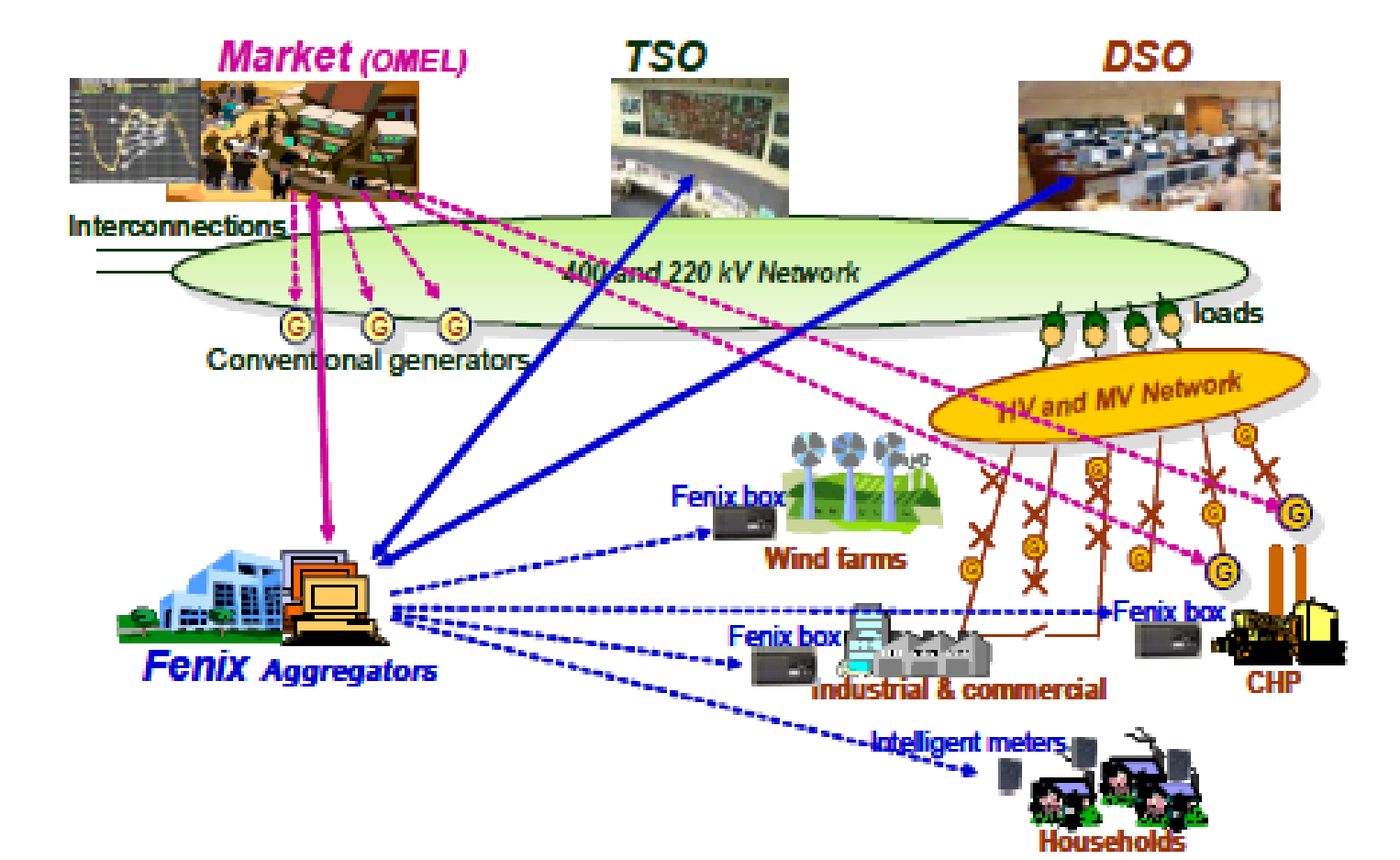
- $1,975.1 million a year by 2017
- $ 4,587 million by 2023 (https://www.alliedmarketresearch.com/virtual-power-plant-market)

EPRI: Integrating Smart DER with DMS, 2012

DERMS: DER Management System, source: EPRI



Fenix VPP solution (test bed in Spain) source:Fenix project



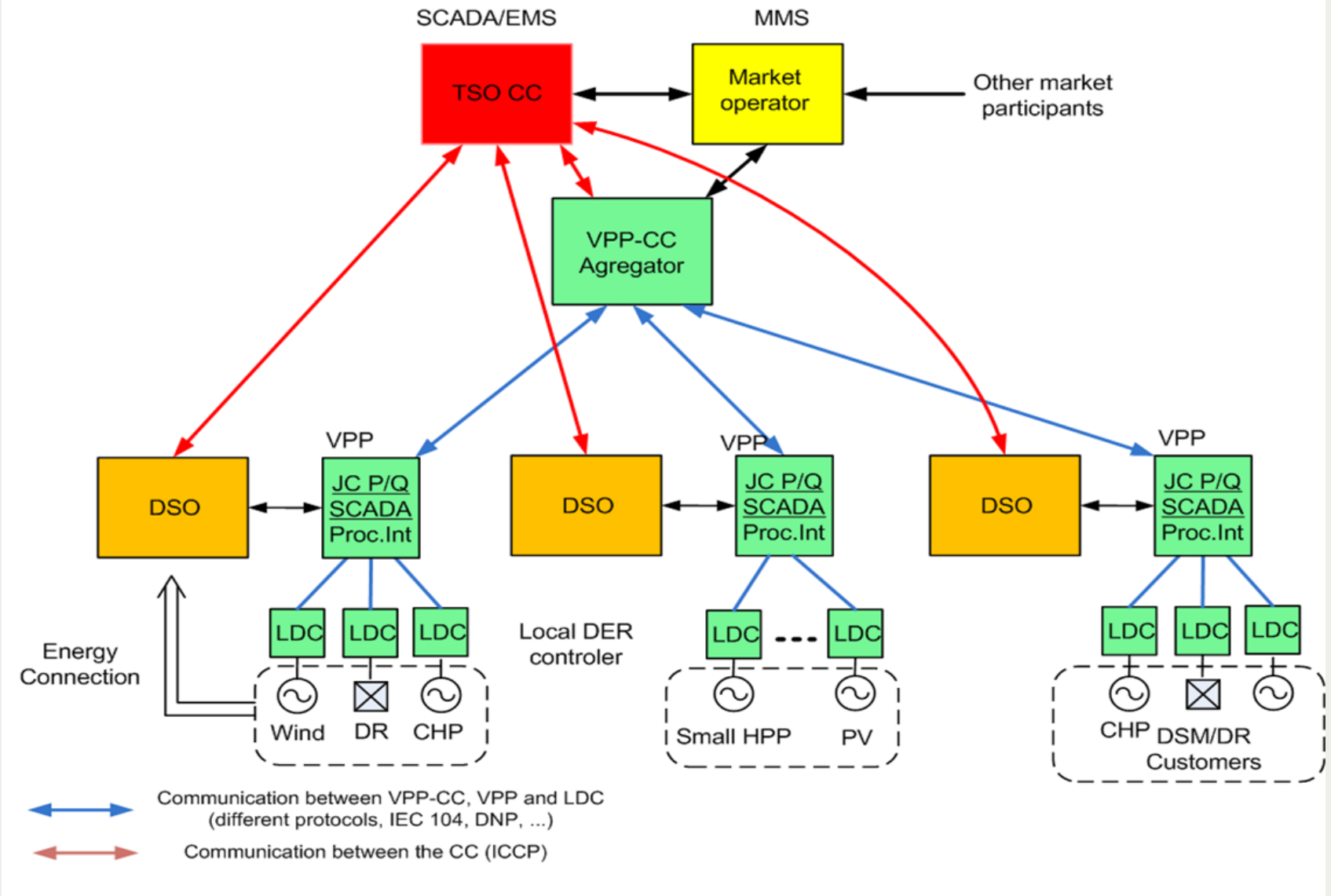
Implications for DER Aggregator ICT solution, where and how?

- Solution can be implemented as traditional **DER Aggregator CC** or it can be a DER aggregation **Service supplyed by service provider** (might be on private cloud). Solution is typically hierarchical, with **central DER controler (CDC)** and **local DER controler (LDC)** devices.
- Due to large numbers and available comm. support, part of VPP/DERMS functionality (SCADA), for DER in MV and LV networks, can be allocated in the HV/MV SS.
- LDC have similar basic functionality but different interfaces towards DER devices.
- LDC functionality is similar to one used in local controlers of µG solutions.

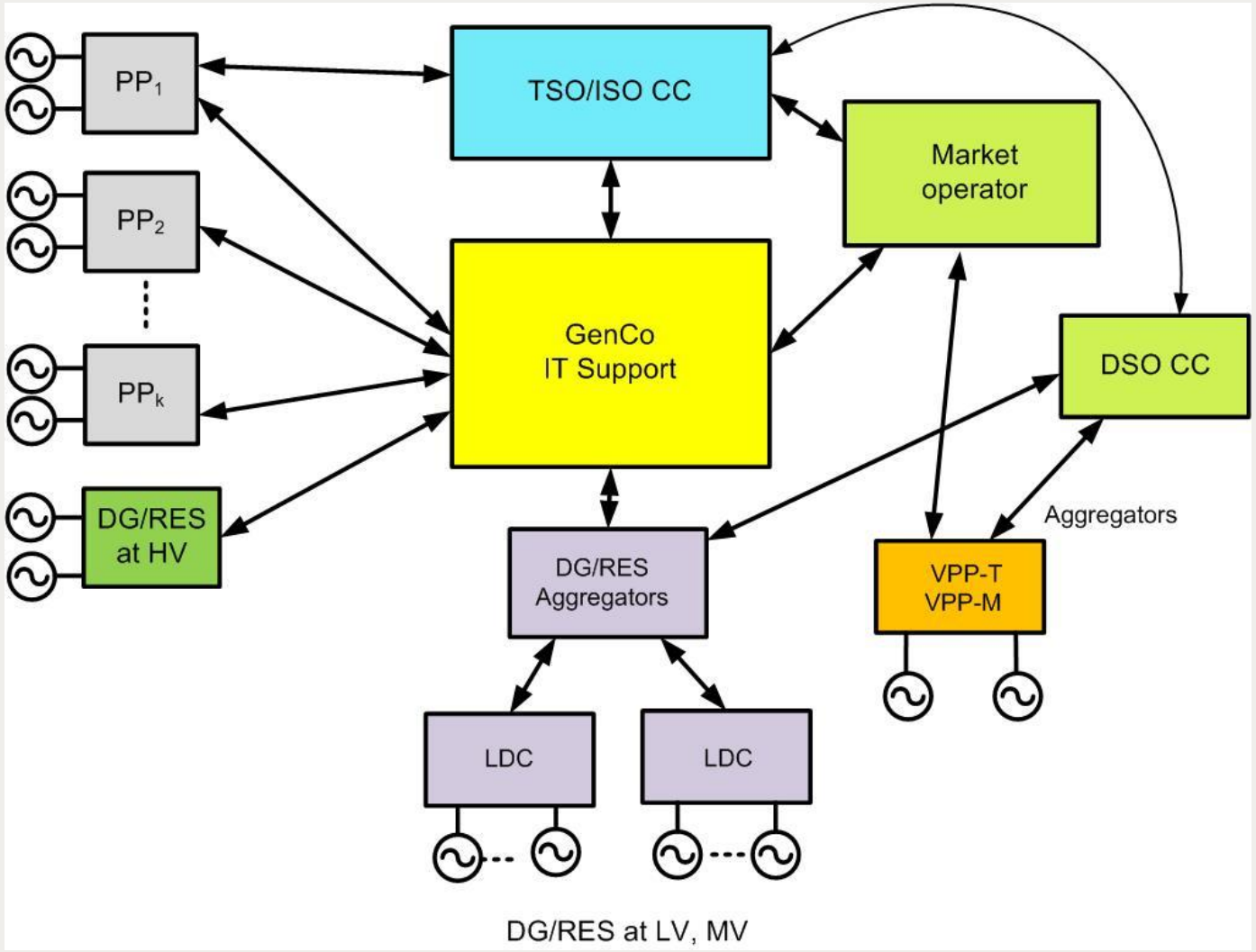
Findings after review, with implications on Control Architecture

- Motivation for paradigm change, i.e. Modify traditional arch.
- Vendors often ”overload” VPP functionality
- Multi level, hierarchical VPP solution
- More flexible approach
- VPP- technically focused (interfacing, comm. , monitor and control, SCADA, JCAP, JCRP…)
- VPP-market focused (scheduling, bidding, forecasting,…)

Hierarchical VPP solution (VPP-CC, VPP, LDC)



Example: SEE GenCo. CC context diagram



So far

Designed

- Architecture of DER aggregation
- Integration with the SCADA/GMS system (+ETRM)

Developed and Implemented

- Multi functional highly configurable gateway as a LDC device
- Specific LDC for multi unit PP, JCAP and JCQP (JC4P/Q)
- SCADA/GMS system for a SEE GenCo

Future ideas, work

- As number of IPP's, DER increase, to grasp small to medium DER owners without enough resources to operate centralized VPP, idea is to move VPP-CC functionality to the cloud as a SaaS, i.e. **DER Aggregator as a cloud based service provider**.
- In paralel with the technolog. development, where devices are already equiped with **multitude of sensors**, it is worth to tray **IIoT solutions**, especially available (M2M) protocols for the **Edge (device) layer**, instead clasical ones.

Conclusions

- **Problem: DER aggregation to enable increase of AS available**
- **Virtual Power Plants VPP are basic part of the solution**
- No mater approach regarding DER aggregation, more observability/controlability for TSO-DSO interface is needed (data exchange)
- **Specific VPP initial solution designed and integrated in the overall Genco IT support architecture**
- **Practical integration of LDC in SCADA/GMS at one SEE GenCo**
- **Future work still neded**

Thanks for your attention!

Questions?