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ISGAN
INTERNATIONAL SMART GRID ACTION NETWORK

Needs, challenges and opportunities of TSO-DSO coordination

Hotel Eden Palace, Montreux, Switzerland

3rd October 2019

iea Energy Technology Network

CLEAN ENERGY MINISTERIAL

Agenda

13:30 - 13:45 : Introduction

13:45 - 14:15 : An Overview of International Activities on TSO-DSO interaction

14:15 - 14:45 : Interaction of DSO and TSO requirements on Distribution Networks

14:45 - 15:15 : IEC 62559-2 Business Use Cases for TSO-DSO coordination

15:15 - 15:45 : Coffee break

15:45 - 16:15 : Smart begins in the heads

16:15 - 16:25 : TSO-DSO cooperation: Where we are at European level

16:25 - 16:45 : TSO-DSO Interaction - Inevitable for Future Power Systems Operation

16:45 - 17:15 : Ongoing Research Activities on TSO-DSO interaction

17:15 - 18:00 : Q/A in a panel

18:00 - 19:30 : Networking apèro

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ISGAN in a Nutshell

Created under the auspices of

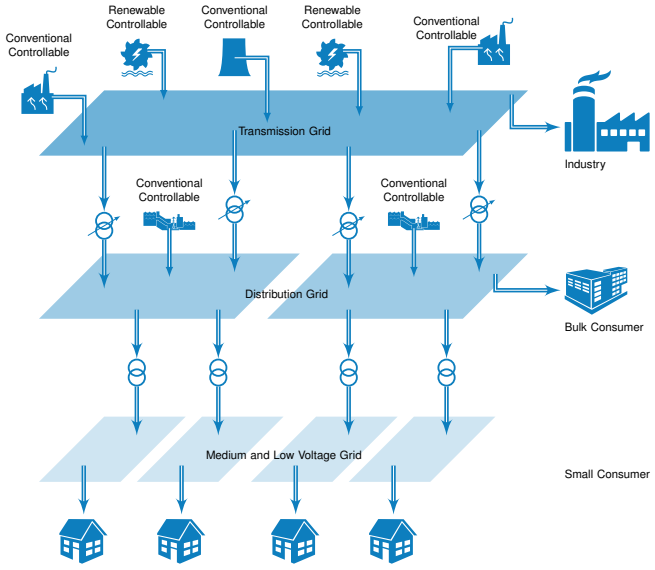
The Implementing Agreement for a Co-operative Programme on Smart Grids

An initiative of the Clean Energy Ministerial (CEM)

Strategic platform to support high-level government knowledge transfer and action for the accelerated development and deployment of smarter, cleaner electricity grids around the world

International Smart Grid Action Network is the only global government-to-government forum on smart grids.

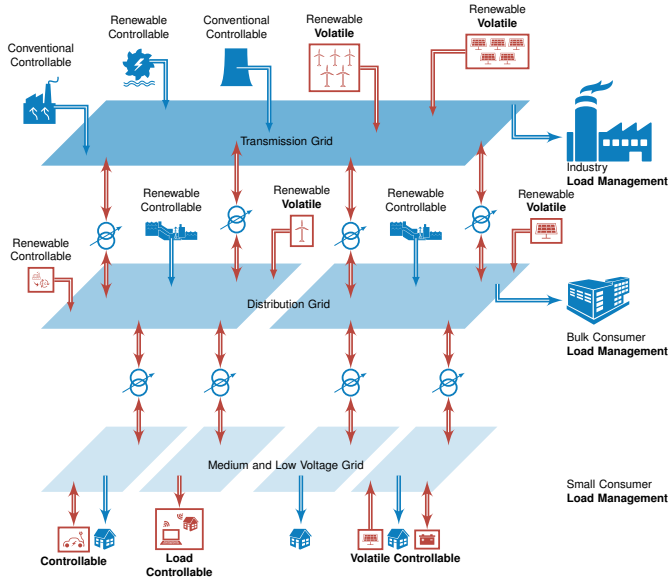
Paradigm Shift from ..



Old Characteristics

- **Generation**
  - **Centralized**
  - **Dispatchable**
- **Loads**
  - **Fixed**
  - **Non-controllable**
- **Network/Grid**
  - **Uni-directional**

Paradigm Shift to ...



New Characteristics

- **Generation**
  - **Decentralized**
  - **Volatile**
- **Loads**
  - **Time-shiftable**
  - **Controllable**
- **Network/Grid**
  - **Bi-directional**

Effects of the paradigm shift

- **Challenges**
  - Increased **variability and uncertainty** on supply side
- **Need**
  - More **flexibility** for TSOs and DSOs for **congestion relief**, **reactive power**, **voltage control** and **frequency reserves**
- **Opportunities**
  - Provision of flexibility from **Distributed Energy Resources** and **„active customers"**
  - Entails exploitation of **less utilized coordination synergies** between TSOs and DSOs.

Objective of the Workshop ...

to give a broader perspective accounting for

- technical,
- market,
- regulatory aspects

and different views

- from national and international TSOs, DSOs
- form smart grids projects

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Mr. Antony Zegers

Austrian Institute of Technology

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Antony Zegers gained experience in the utility sector working on Smart Grid projects at Eandis (now Fluvius), Belgium's largest distribution network operator. In 2013 he joined the AIT Austrian Institute of Technology and is currently coordinating and developing AIT's R&D portfolio for utilities. His main areas of expertise are the integration of renewable energy sources in power systems and their provision of ancillary services to support grid operation. He holds a master's degree in electro-mechanical engineering from the Ghent University in Belgium.

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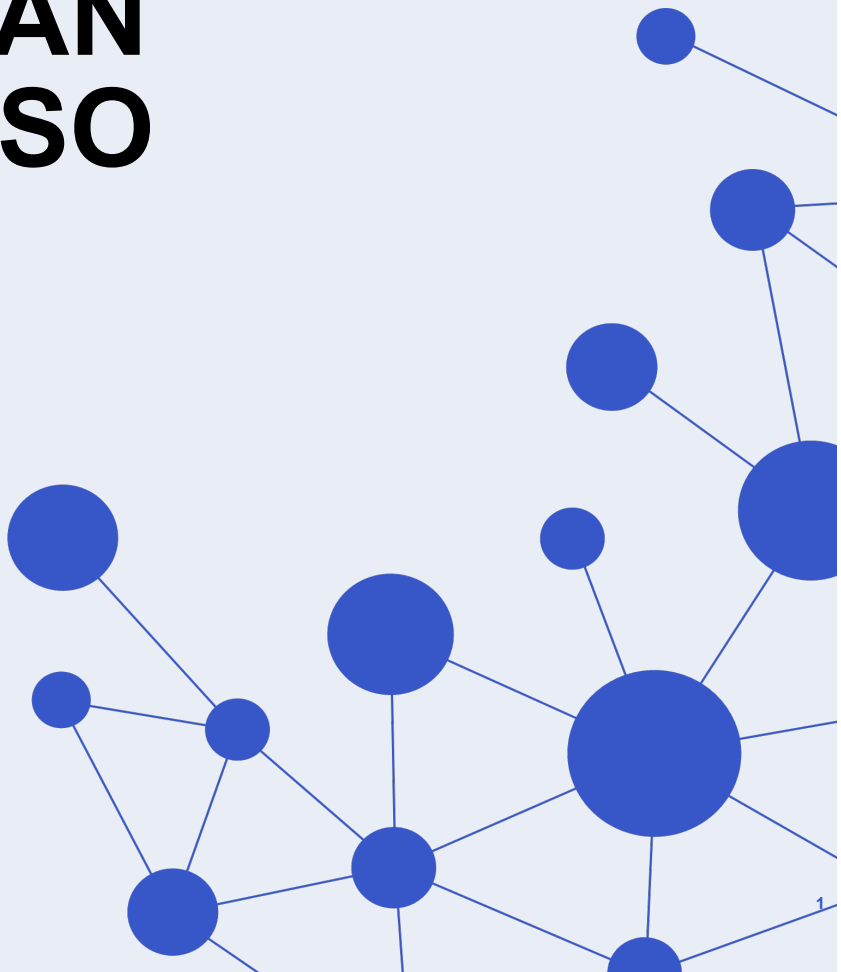
An Overview of ISGAN Activities on TSO-DSO interaction

Antony Zegers

Montreux, 2019



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Background on work

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INTERNATIONAL SMART GRID ACTION NETWORK

2014 TSO-DSO interaction: An Overview of current interaction between transmission and distribution system operators and an assessment of their cooperation in Smart Grids

2017 TSO-DSO interaction: Single Marketplace for Flexibility

2018 ICT aspects of TSO-DSO interaction: data exchange and ICT-requirements along organizational interaction between TSO and DSO

2020 *Best practices on TSO-DSO interaction*

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All deliverables can be downloaded on
https://www.iea-isgan.org/publications/

“Disclaimer”

- ISGAN discussion papers result from
  - Consolidation of Annex 6 expert inputs
  - External review (by invitation)
  - Finalization by authors

- They are meant to open discussions
- Consensus required only within Annex 6
- No bullet-proof solutions
- An open mind comes in handy

- No warranty, liability,…

Observed evolutions

- Increasing need for flexibility is expected, both on transmission and distribution level
- Part of this flexibility will be found at distribution grid
- Closer cooperation/coordination between TSOs and DSOs in one control area will be needed

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- Part of this flexibility will be found at distribution grid
- Closer cooperation/coordination between TSOs and DSOs in one control area will be needed

Some framework to use distribution connected flexibility to support distribution and transmission network operation will be needed

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6 cases to investigate TSO-DSO interaction

1. Congestion of transmission-distribution interface
2. Congestion of transmission lines
3. Voltage support (TSO ←→ DSO)
4. Balancing challenge
5. (Anti-)Islanding, re-synchronization & black-start
6. Coordinated protection

Countries in scope

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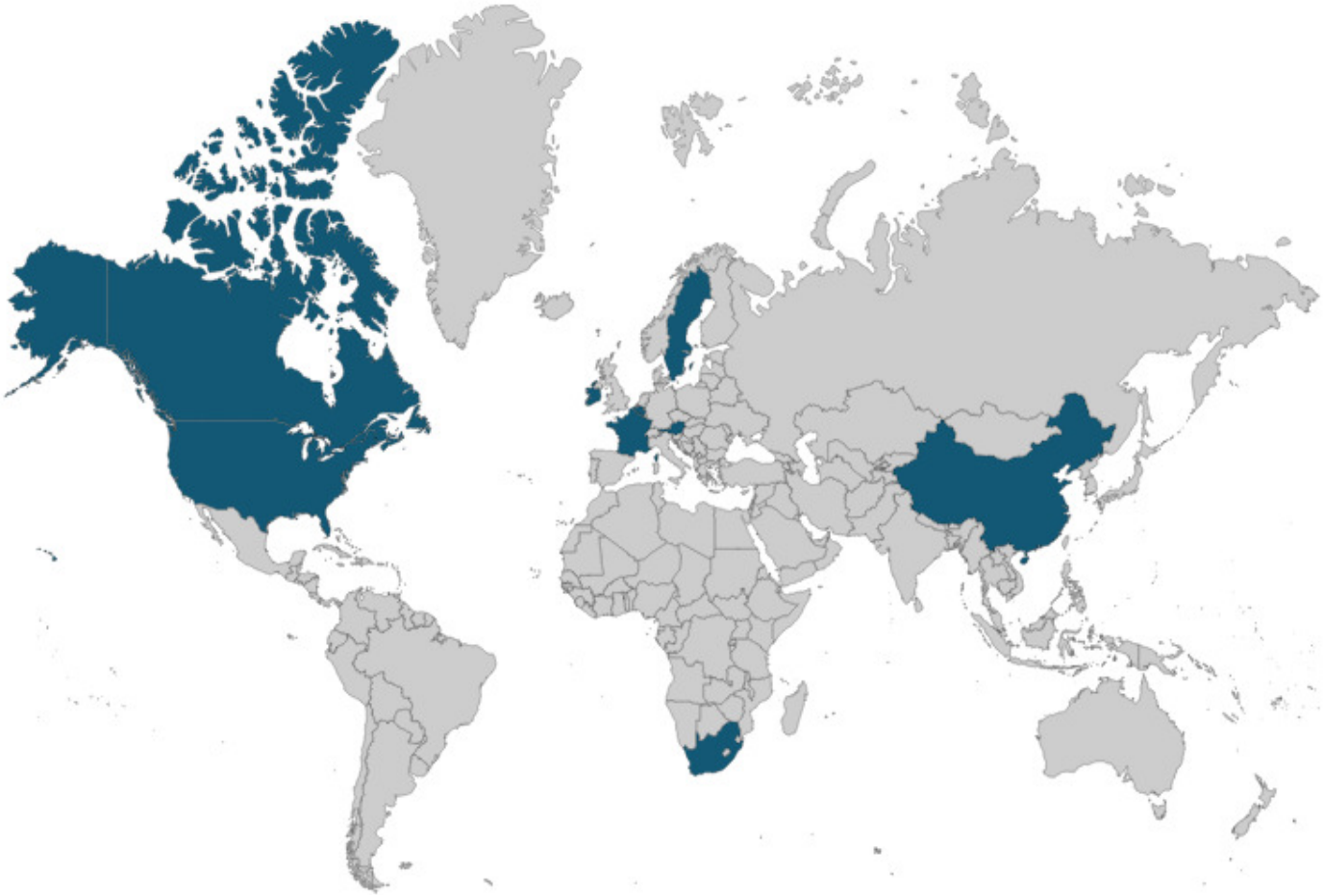
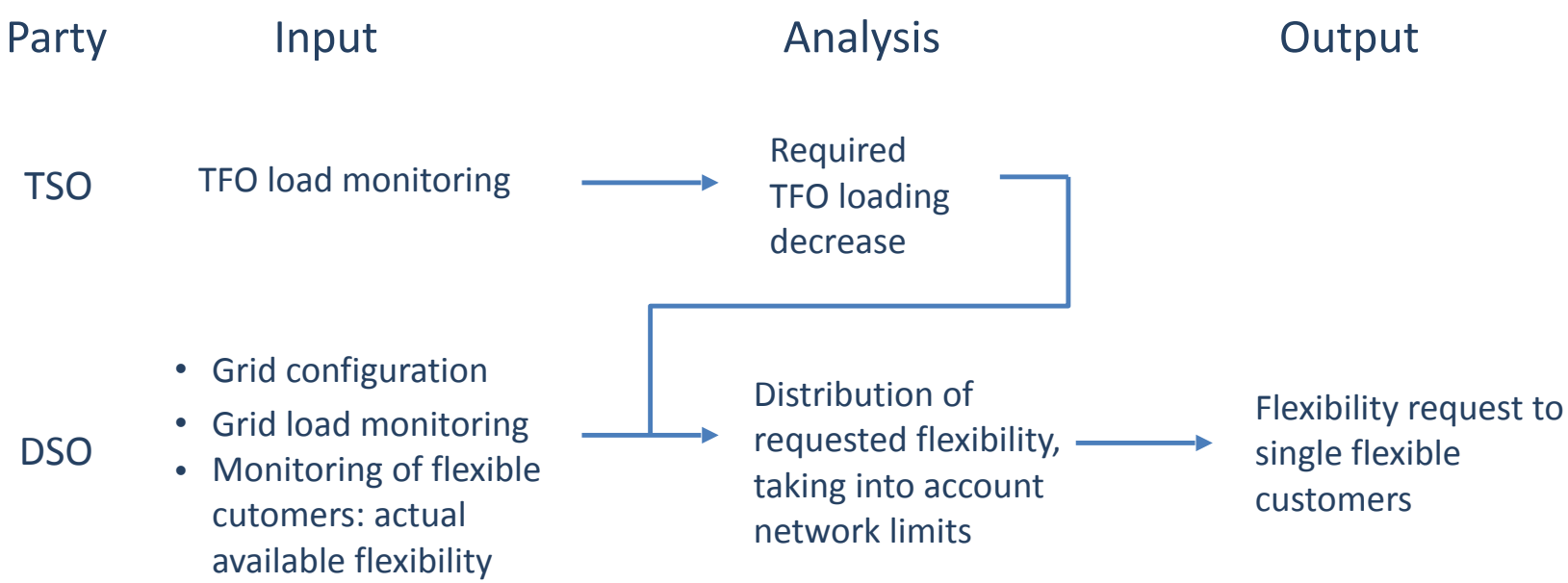


Case 1 – Congestion of TSO-DSO transformer

Current interaction	Future interaction
• Cooperation mostly during planning phase • Emergency situations: TSO disconnects distribution feeders, possibly through a request to the DSO	• Use of flexibility on distribution grid to reduce TFO loading • • Requirement: more grid monitoring, intensified data exchange

Remark: when DSO operates transformer, no coordination is necessary

Case 1 – Process flow proposal



Key findings & discussion points

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Technical aspects

- Flexibility on distribution grid is expected to support grid operation
- Technical requirements similar for identified challenges
  - Grid monitoring
  - Bidirectional communication to customers and other grid operators
  - Algorithms to be implemented
- Current technology is sufficient, practical experience to be gained

Key findings & discussion points

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Non-technical aspects

- Necessary to limit impact of flexibility use (e.g. RES production)
- How to decide between flexibility on TSO or DSO grid?
- New markets versus grid operation solutions

Clear policy framework can push forward Smart Grids solutions implementation

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Single Marketplace Idea

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Would it be possible to install one marketplace in which all flexibility bids are collected and from which TSOs and DSOs can procure flexibility in a coordinated way?

Single Marketplace Idea

products

marketplace requirements

(dis)advantages to other solutions

Would it be possible to install one marketplace in which all flexibility bids are collected and from which TSOs and DSOs can procure flexibility in a coordinated way?

stakeholder roles

feasibility

implementation

regulatory framework

Single Marketplace Requirements

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1. Ensure effective market access for all market participants to valorize their flexibility, directly or through an intermediary
2. Generate sufficient liquidity ensuring the procurement of all required capacities
3. Enable information flows between TSO, DSOs, Flexibility Service Providers and BRPs to allow network operators to coordinate their actions
    1. Technical impact TSO ←→ DSO
    2. Impact on imbalances in BRP portfolio
4. Meet high standards of data security and privacy

Single Marketplace Products

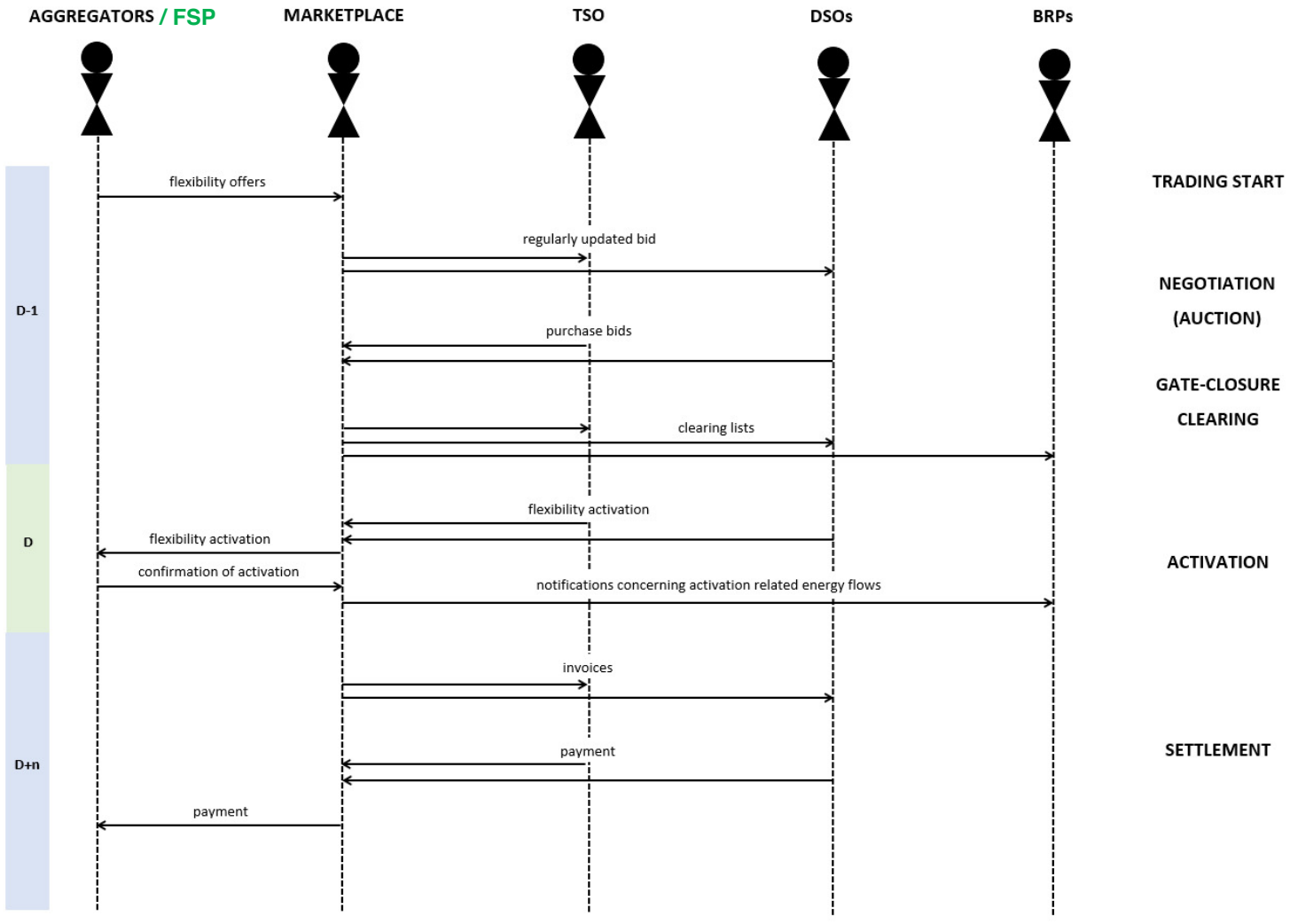
- For TSO
  - The same as in current balancing markets (FCR, aFRR, mFRR)
  - Congestion management
- For DSO
  - Congestion management
- “Standardized products result in larger market liquidity”

Single Marketplace Implementation

- Information collection
  - Collection of flexibility offers
  - Minimum power price & fixed energy price

- Negotiation: coordinate plans of buyers and sellers
  - Procurement of flexibility through an auction
  - Buyers reply to offers by placing purchase bids
  - Bidding process might by repeated

Single Marketplace Implementation



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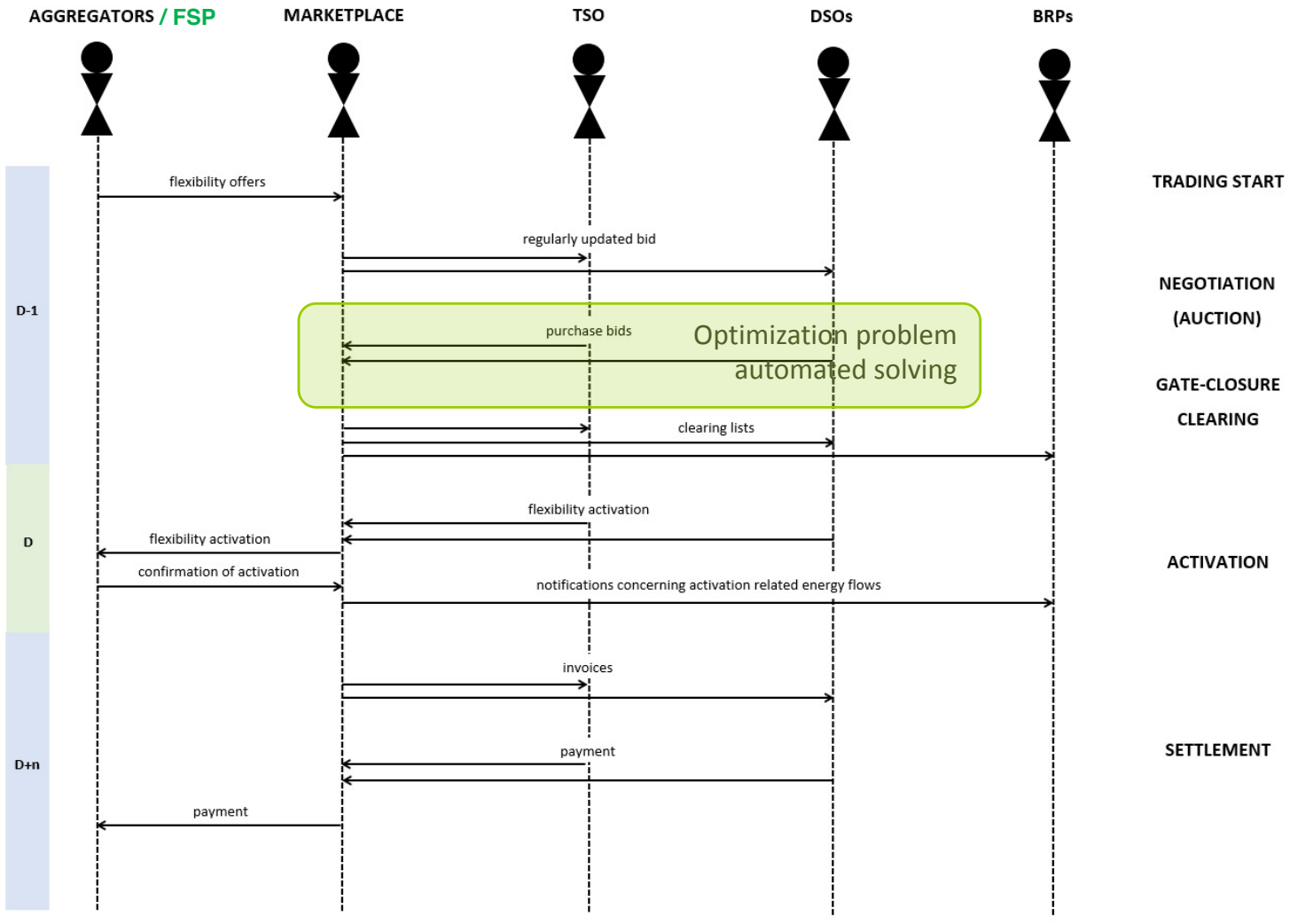

Single Marketplace Implementation

- Challenge: TSO and DSO might compete for same resource
  - Due to locational aspect, DSO has no or few alternatives
  - Assumption: liquid market, in which TSO can procure alternative flexibility at the same or a marginally higher price
  - Consequence: DSO would be able to procure this flexibility

Single Marketplace Attention points

- **Impact of flexibility activation for DSO purpose on system balancing**
  - Expected to be “low”
  - Possible mitigation of impact:
    - Give DSO local balancing responsibility
    - Have TSO procure additional flexibility

- **Impact of flexibility activation on balance of BRP portfolio**
  - Non-technical impact
  - Possible mitigation:
    - Handle this in the BRP imbalance settlement
    - Have BRPs handle the “uncertainty” of their flexible customers (e.g. by charging higher premiums)

Single Marketplace Attention points

- **Monopoly of FSP towards DSOs**
  - Congestion on distribution grid is, by nature, local
  - Likely that only few FSP provide useable flexibility → monopoly on selling side
  - Let market manage itself or are regulatory measures needed?

- **Procurement timeframe**
  - Available flex from DER and DSM is unknown long time ahead
  - Gate-closure might have to be closer to real time (e.g. day-ahead), which is more demanding (e.g. IT, people)
  - Trade-off necessary to ensure liquid market

Single Marketplace Key messages

- The single marketplace is a lean and transparent concept
- Could theoretically lead to an economic optimum for the entire system, while respecting technical boundary conditions
- Concept builds on existing market implementation, role of DSO would evolve

- Prerequisite: a liquid market, with sufficient flexibility offers
- Assumptions and simplifications should be validated first, e.g. through market-theory-based analysis
- ICT requirements

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Best practices on TSO-DSO interation

video

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Thank you

Antony Zegers
Business Manager
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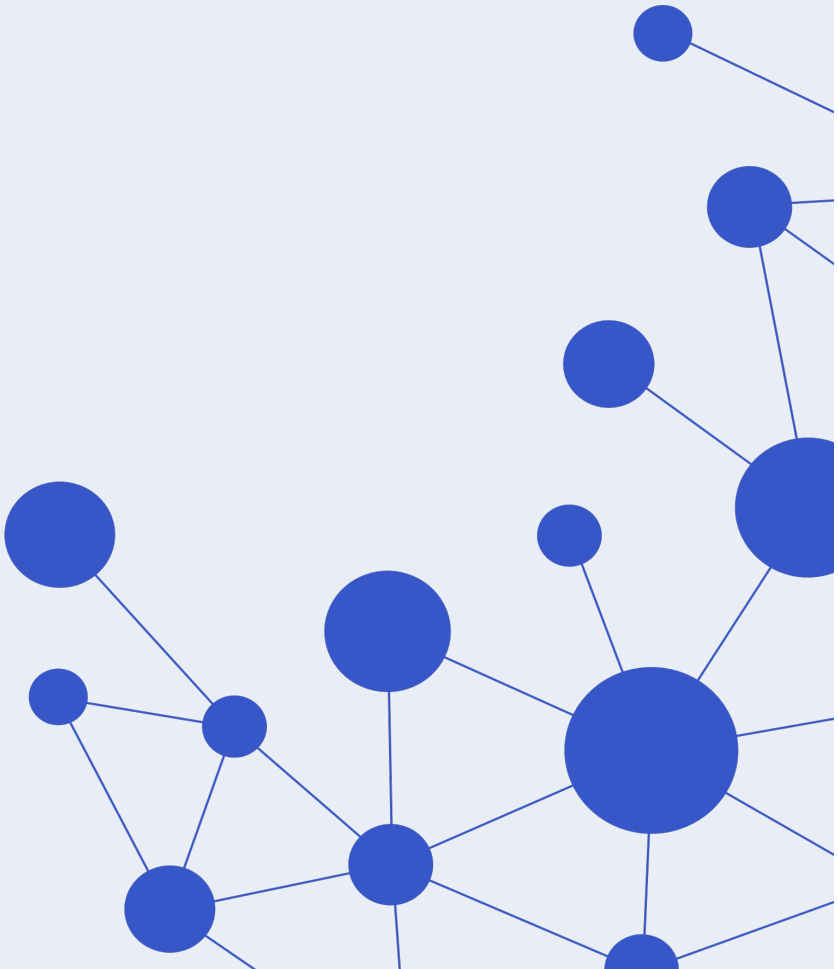

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Mr. Tony Hearne

ESB Networks

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Mr. Tony Hearne began working with ESB Networks in 1978. He has worked as an engineer and technical expert in the areas of Network Operations and Protection, and as Future Networks Manager. In 2019, he was appointed to a newly created role of DSO-TSO Interface Manager with an immediate focus on implementation of first Distribution Outage Programme and other Operations tasks such as Blue Alert, Black start, the implementation of System Operation Guideline and over-arching supervision of implementation of other DSO related EU Network Codes.

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NETWORKS

Interaction of DSO and TSO requirements on Distribution Networks

ISGAN Workshop 3rd October 2019

Tony Hearne DSO-TSO Interface Manager

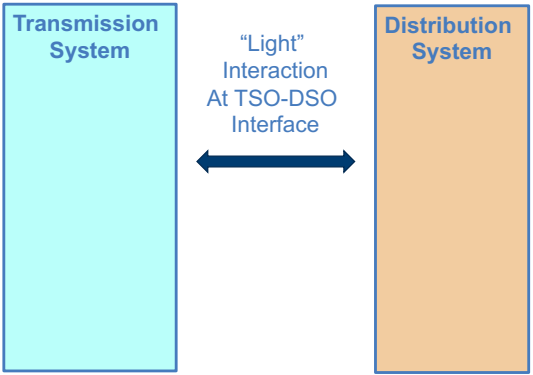
tony.hearne@esb.ie

Presentation Outline

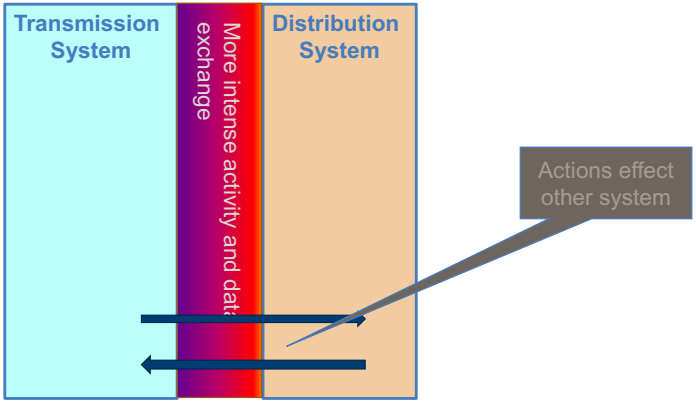
- Context setting – General
- Context setting – Ireland specific challenges
- Reactive Power / Nodal Controller
- ROCOF
- Demand Response / System Services / Congestion Management / Flexibility
- What the future will look like..

Context setting – General

TSO and DSO operation - historically



TSO and DSO operation – Going Forward



Context setting – Ireland specific challenges

ESB NETWORKS

Targets

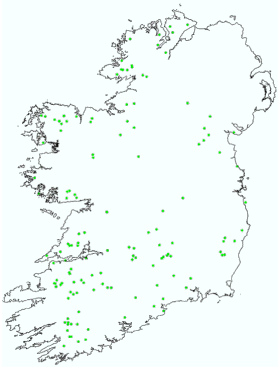
A world of traditional Centralised Generation

A world where up to 75% of power comes from non-synchronous generation

What does 75% SNSP look like?

- 75% of power from Non-Synchronous Sources
- Hence only 25% from large Conventional Power Stations
- Large Conventional Power Stations traditionally provided;
  - System Inertia
  - System Reactive Power / Voltage Support
  - Other various Ancillary Services

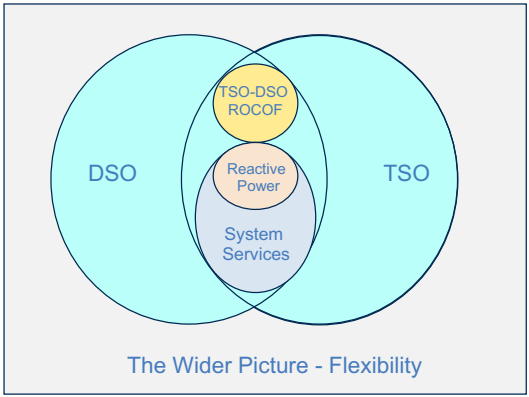
- **So new System is;**
  - Lighter
  - Wobblier
  - Easier to offend
  - Easier to break!



How is ESB Networks involved?

ESB Networks interacts in the following areas.

- Reactive Power Workstream
- TSO-DSO ROCOF workstream
- Facilitation of the provision of System Services to EirGrid by Distribution connected customers
- The wider picture - Flexibility

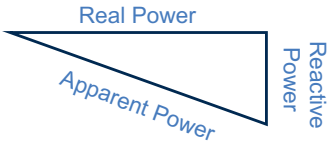


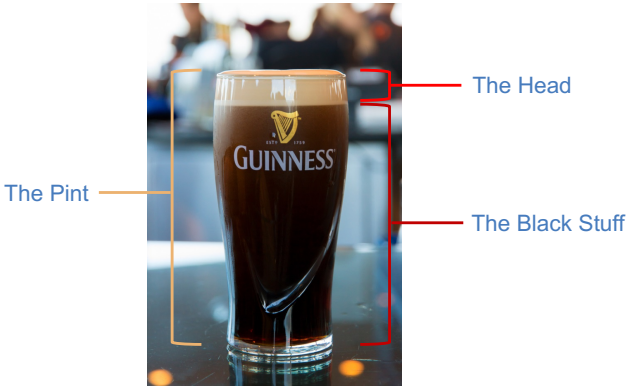
Reactive Power / Nodal Controller

Reactive Power – Voltage Control

So what is Reactive Power?

- There are many technical definitions but….





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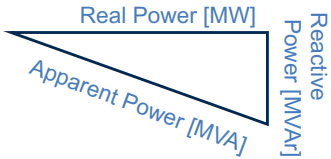
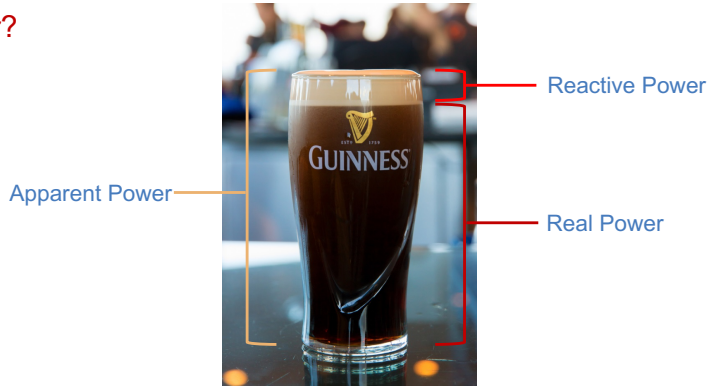
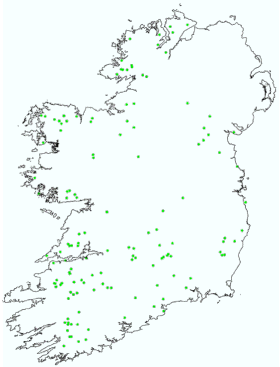




What's this all about?

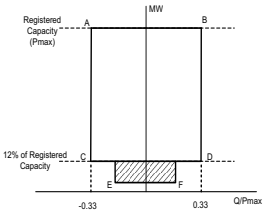
- Heading for a world where 75% of power from wind
- This means less large conventional plants being dispatched
- These historically provided reactive power support to the Transmission System
- General reactive power shortfall – outside Dublin
- Expectation that windfarms would make a contribution in that regard

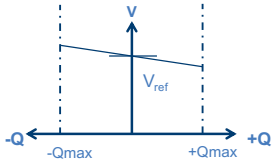


So what?

So mandated Distribution Code requirements for larger [>5MW] windfarms to;

- Be capable of absorbing or producing reactive power
- Be capable of operating in voltage control mode
- Be capable of receiving related real-time analogue signals ie Mvar or Voltage setpoints…..





But from whom…….

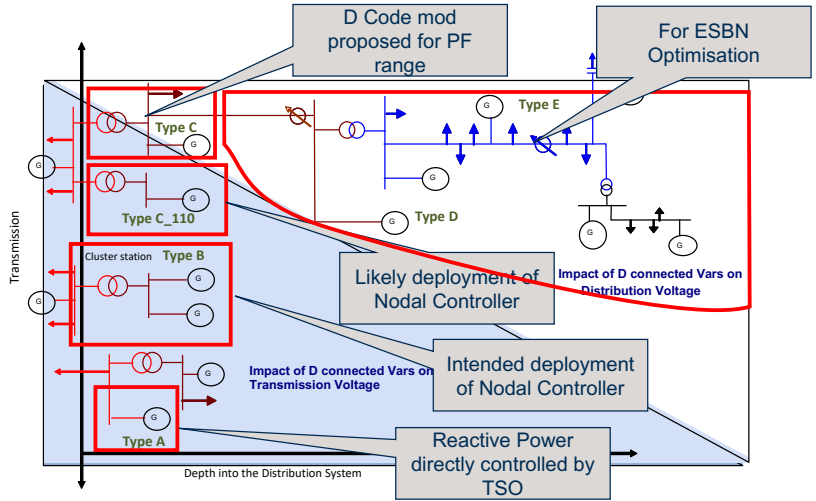
Who's hand on the tiller…….

- TSO say that would be us…

DSO says – ah not so fast! Controlling Vars means controlling Connection Point voltages – that is Distribution – that should be us!

- TSO say but it is for their benefit
- And so began the arguments……
- What's the bigger picture here?

The overall reactive power landscape



Layers of this cake – Type B WF >5MW

Layer 3: Steady State Reactive Power [SSRP] Procurement

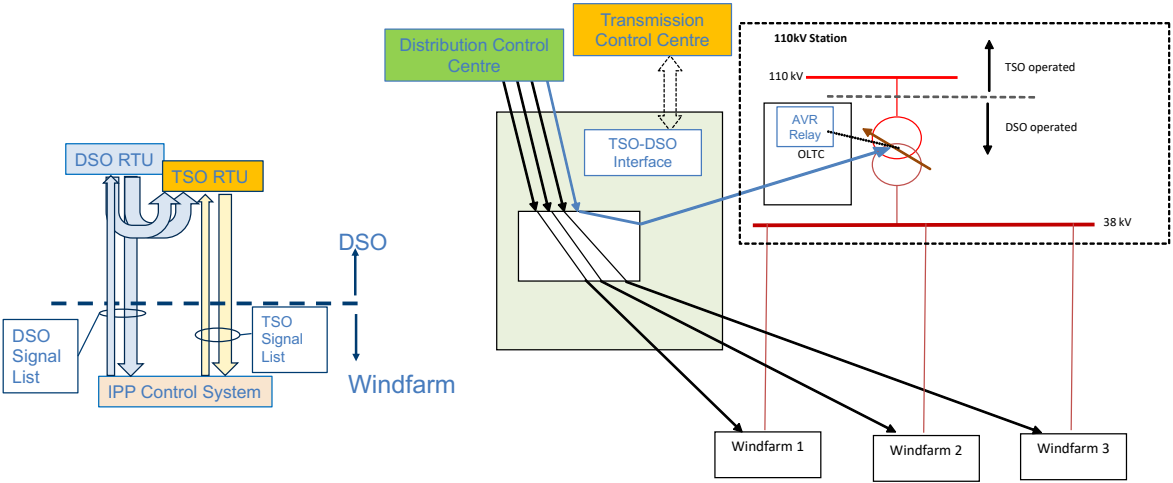
Layer 2: Nodal Controller

Layer 1: Distribution Code compliance / Testing

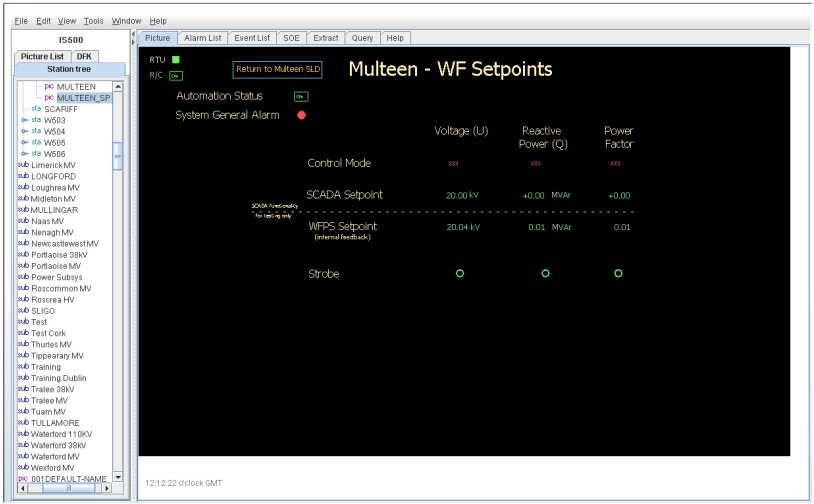
Reactive Power / Nodal Controller

Layer 1: Mandatory requirements

Nodal Controller – Manual mode [Layer 1]



Manual Mode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sub LONGFORD
sub Loughrea MV
sub Midleton MV
sub MULLINGAR
sub Naas MV
sub Nenagh MV
sub Newcastlewest MV
sub Portlaoise 38kV
sub Portlaoise MV
sub Power Subsys
sub Roscommon MV
sub Roscrea HV
sub SLIGO
sub Test
sub Test Cork
sub Thurles MV
sub Tipperary MV
sub Training
sub Training Dublin
sub Tralee 38kV
sub Tralee MV
sub Tuam MV
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RTU
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System General Alarm
Voltage (U)
Reactive Power (Q)
Power Factor
Control Mode
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SCADA Setpoint
20.00 kV
+0.00 MVAr
+0.00
SCADA functionality for testing only
WFPS Setpoint
(Internal feedback)
20.04 kV
0.01 MVAr
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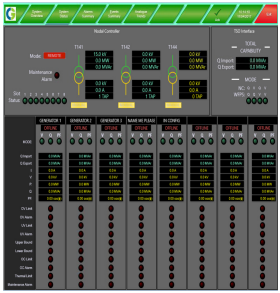
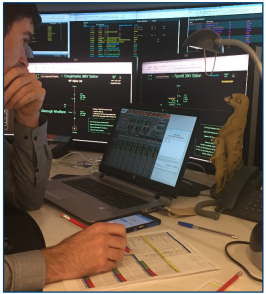
Layer 2: Nodal Controller

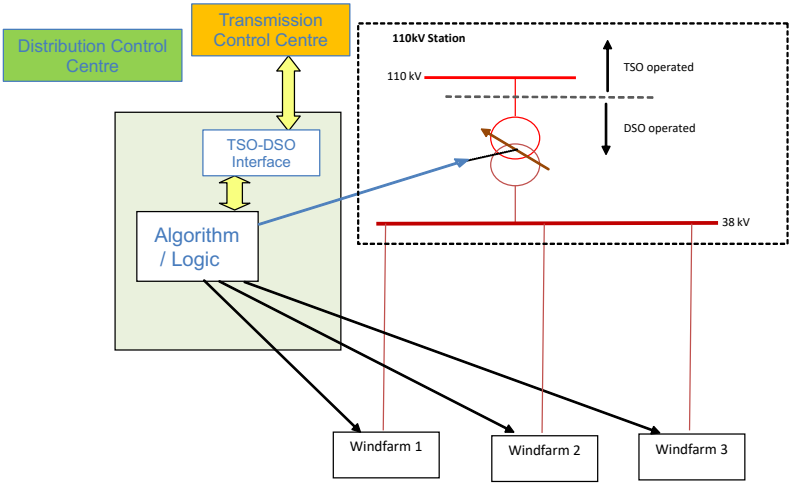
What is a Nodal Controller?

- A means of utilising the mandated reactive power capabilities of the larger windfarms and delivering a Transmission support functionality at the TSO-DSO interface
- Whilst ensuring that all Distribution voltages and current limitations are maintained and protected





Nodal Controller – in operation



The Nodal Controller algorithm – Operating Modes

- Four TSO Aggregate modes supported; QQ, QV, VQ, VV
- QQ: TSO Q setpoint, WFs in Q mode
- QV: TSO Q setpoint, WFs in V mode
- VQ: TSO V setpoint, translated to Q, WFs in Q mode
- VV: TSO V setpoint, WFs in V mode

- ESBN understands that VV mode will be mostly used by NCC

Physical kit involved

- DSO RTU
- OnLoad Tap Change panel

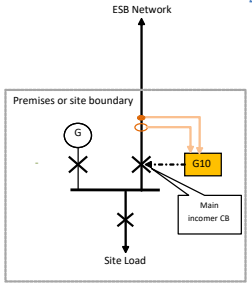
ROCOF

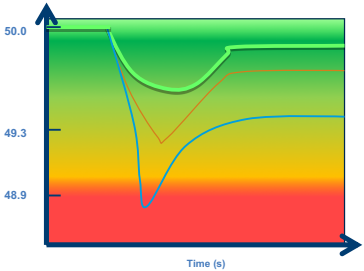
What is ROCOF?

- Sounds like a German heavy metal contest from the 70's!!
- Not Quite…..

What is ROCOF?

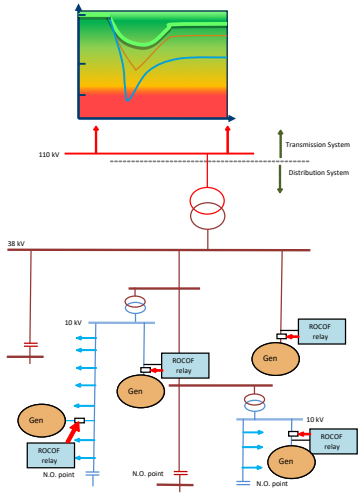
- It stands for “Rate of Change of Frequency”
- In a world where up to 75% of power comes from non-synchronous resources, for a given global event on the system, the frequency will change much quicker than the traditional system – up to 1 Hz/s
- However, generators connected to the distribution system need to have Interface Protection





Why is ROCOF important?

- One element of this protection measures ROCOF and uses it do detect a local islanding situation
- However these have historically been set to operate at 0.4 Hz/s!
- If we were to ignore this issue and go straight to the 75% world…..
- If there is an event such as a trip of the largest Generator
- then, all the distribution connected generation also trips off….
- **Not Good at all!**
- So what's to be done?



RCOF - Challenges

So what's the big deal – change a few settings on some relays!!

- Most relays are concerned are part of "G10" protection – relay is owned by the plant – not ESBN
- Original Equipment Manufacturers [OEMs] /Agents needed to make the changes
- Costs money

Challenges

Wind:

- Have skin in the game but still slow to change
- Needed hounding

Non –Wind, Non-exporting:

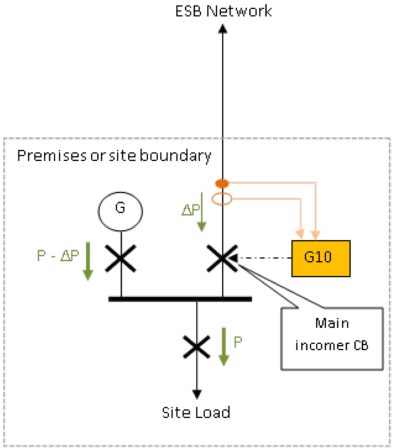
- No skin in the game
- No incentive to co-operate
- Difficult to convey technical message to non-technical plant owners
- Could only have technical conversations with OEMS/Agents

Things leant along the way….

- RoCoF settings do NOT need to be changed when the following components are in place i.e. (*"Good"* Topology):
  - Peak Lopping Mode
  - Peak Shaving Mode – Interface Protection on the Main Incomer **AND** Trickle Import

  Much of the fleet is confirmed to be RoCoF compliant based on having a *"Good"* topology.

- New Representative Organisation "Synchronous generators Ireland" formed to engage on these issues

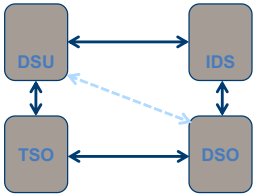


Demand Side Units / System Services / Congestion Management / Flexibility

ESB NETWORKS

Demand Side Units

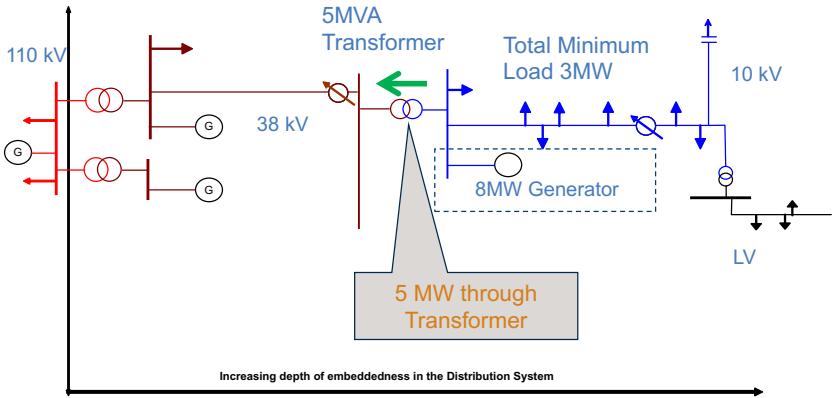
- Demand Side Units [DSU] present to Market as aggregated negative loads
- Each DSU comprises a portfolio of contracted Individual Demand Sites [IDS's]
- When called upon by a DSU, demand reduction at the IDS achieved through
  - Demand Reduction and / or
  - Bringing on of on-site generation
- Each IDS is an ESBN customer with a Connection Agreement
- DSU has contractual relationship with TSO / MO
- ESBN has no contractual relationship with DSU



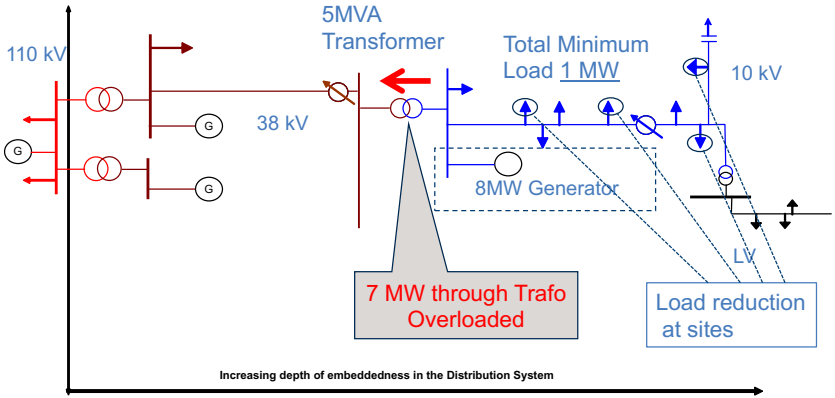
Demand Side Units

- In order to maximise Distribution Generator connection capacity, account is taken of minimum load at substations
- Issue now is that activation of IDS's in a given location can bring the load below assumed min load hence more MW flowing up through network element eg trafo, than was planned for
- Activation of DSU's causing Congestion in Distribution Networks

DSU – Congestion example



DSU – Congestion example



So what happened?

- Issue raised with Regulatory Authorities [RAs] North and South in 2015
- Understanding reached that;
  - DSOs could intervene via issuance of “Instruction Sets” and RA’s would keep parties whole

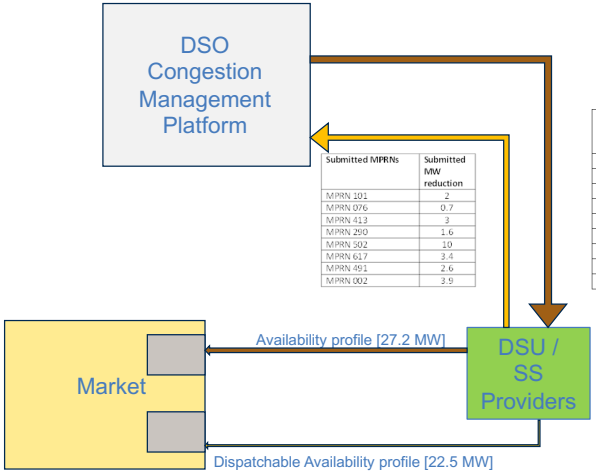
    But
  - Expectation that the granularity of Instruction sets would increase over time
- That understanding no longer in place post I-SEM!
- Yearly studies undertaken by Network Investments to identify potential congestions
- Site identified as “Red” de-selected for Summer months

Operations Management System [OMS] work underway

- Existing DERMS module being enhance to include “Network Capacity Allocation” per agreed DSO functional spec
- Next release of OMS that we are due to take will include loadflow / state-estimation
- Will trial this in a “Sandbox”
- Will build HV and MV model for two selected Bulk Supply Points
- Will mean work to evolve from a connectivity model to a full electrical model
- Would like to trial with DSUs as soon as possible
- Full visibility of all HV and MV network – every part!

Ultimate interaction of ISEM with DSO platform

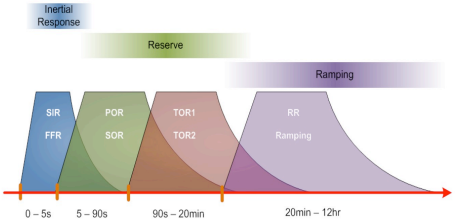
- **All market parties engage with DSO Platform**
- **Could be day ahead or close to real-time**

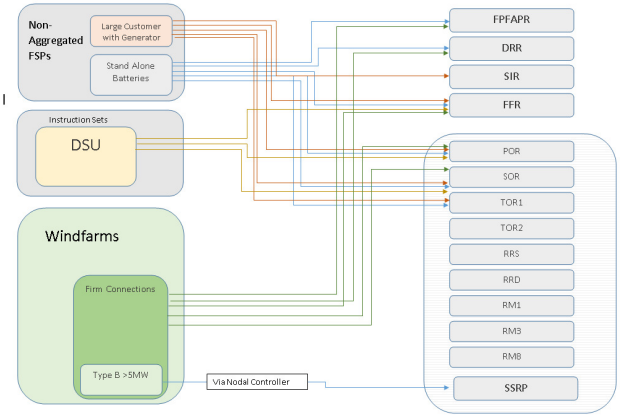


Submitted MPRNs	Submitted MW reduction	Permitted MW Reduction
MPRN 101	2	1.5
MPRN 076	0.7	0.3
MPRN 413	3	2
MPRN 290	1.6	1.0
MPRN 502	10	10
MPRN 617	3.4	2,7
MPRN 491	2.6	1.9
MPRN 002	3.9	3.1
Sums	**27.2**	**22.5**

System Services

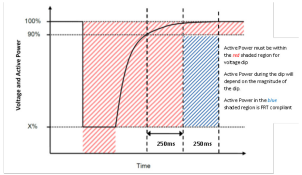
- Suite of 14 System Services products now identified and defined by EirGrid
- Range from “Fast” products to slower

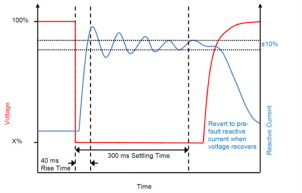


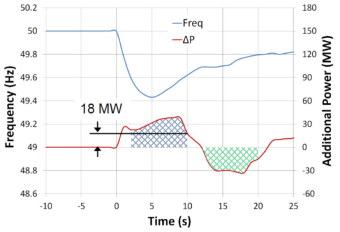


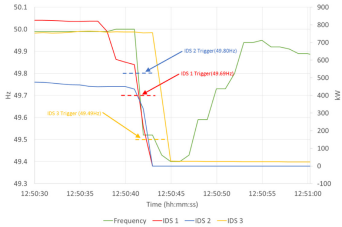
Do they cause us problems?

- Some issues identified for FFR
- Further work needed to fully flesh out
- Potential step-change/ Disturbing aspects for “Fast” products
- Potential thermal issues for “slower” products
- Devil is in the detail!!



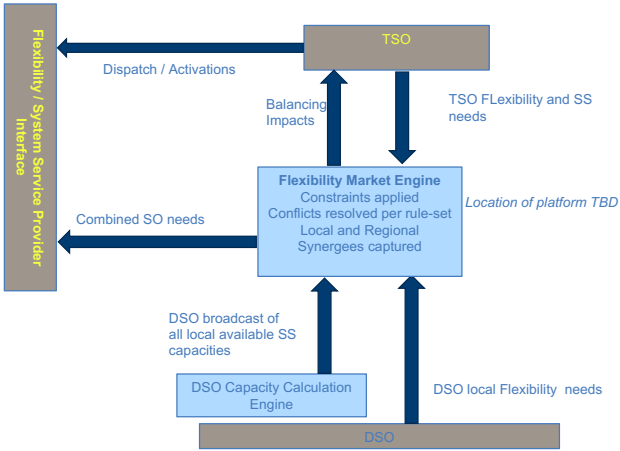






So where is all this going? – Need to Join the Dots

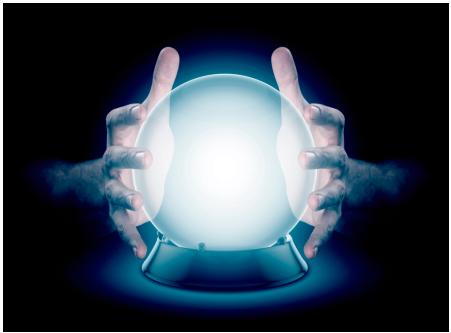
- Need to deal with congestion
- Need to achieve full visibility of all of our network
- Need to understand materiality of interactions with DSUs and System Services
- Need to build platforms and processes to deal with all this in real time
- Need to also cater for elective use of Flexibility for DSO purposes



What the future will look like..

What does the future look like?

- Increased TSO-DSO interaction / data exchange
- Increased inter-dependence between TSO and DSO activities
- Increased interaction with market parties
- Increased dispatch of DER by DSOs
- Pressure to use Flexibility to avoid/defer new physical network build
- Increased electrification of heat and transport



What could go wrong…..

Thank you

Tony Hearne

DSO-TSO Interface Manager

ESB NETWORKS

Agenda

13:30 - 13:45 : Introduction

13:45 - 14:15 : An Overview of International Activities on TSO-DSO interaction

14:15 - 14:45 : Interaction of DSO and TSO requirements on Distribution Networks

14:45 - 15:15 : IEC 62559-2 Business Use Cases for TSO-DSO coordination

15:15 - 15:45 : Coffee break

15:45 - 16:15 : Smart begins in the heads

16:15 - 16:25 : TSO-DSO cooperation: Where we are at European level

16:25 - 16:45 : TSO-DSO Interaction - Inevitable for Future Power Systems Operation

16:45 - 17:15 : Ongoing Research Activities on TSO-DSO interaction

17:15 - 18:00 : Q/A in a panel

18:00 - 19:30 : Networking apèro

Mrs. Gonca Gürses-Tran

RWTH Aachen

ISGAN
INTERNATIONAL SMART GRID ACTION NETWORK

Gonca Gürses-Tran graduated in 2016 with her master's degree in electrical engineering and business administration from RWTH Aachen University. Currently, she is a research associate at the Institute of Automation of Complex Power Systems (ACS) with Prof. Monti. Being part of the eon energy research center, one aspect of her work in the scope of H2020 EU Project CoordiNet, is supporting the Swedish demo developments of the regional DSO, EON.

Schweizerische Eidgenossenschaft
Confédération suisse
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Swiss Federal Office of Energy SFOE

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FEN
RESEARCH CENTER FOR ENERGY NETWORKS
FORSCHUNGSSTELLE ENERGIENETZE

IEA ISGAN Public Workshop

IEC 62559-2 Business Use Cases for TSO-DSO coordination

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824414

Introduction

Large-scale TSO-DSO-Consumer demonstrations of innovative network services through demand response, storage and small-scale distributed generation

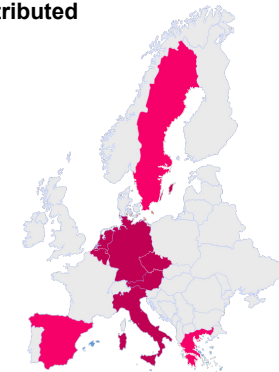
Project Timeline: 1° of January 2019 – 30° of June 2022

Project Budget and funding : 19.2M€ - 15.1M€

Total number of partners: 23 + 10 Linked Third Parties

Objectives:

- Demonstrate the activation and provision of services through a TSO-DSO coordination
- Define and test standard products that provide services to the network operators
- Develop a TSO-DSO-consumer collaboration platform in demonstration areas to pave the way for the interoperable development of a pan-European market

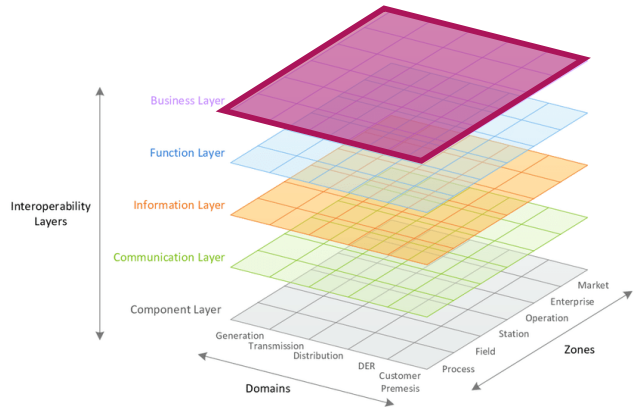


The Consortium

Type of company	Number of participants	Company logo
TSO	3	RED ELÉCTRICA DE ESPAÑA; SVENSKA KRAFTNÄT; AAMHE
DSO	5	VATTENFALL; IBERDROLA DISTRIBUCIÓN ELÉCTRICA; e-distribución; E.ON; HEDNO
Research Centres and Universities	8	COMILLAS UNIVERSIDAD PONTIFICIA; tecnalia; RWTH AACHEN UNIVERSITY; OFFIS; vito; N-SIDE; Energiforsk
DSO associations	1	E.DSO
Technology provider	1	etra I+D
Flexibility providers and aggregators	3	Ayuntamiento de Málaga; Uppsala kommun
Solution providers	2	EXPEKTRA; ENGINEERING

The Use Case Methodology IEC 62559-2

- Objective: Fostering a common understanding of functionalities, actors and processes across different stakeholders
- A single layer of the SGAM is a two-dimensional plane
  - **Domains:** electrical energy conversion chain from generation to consumption
  - **Zones:** task distribution towards management of technical and business processes



Smart Grid Architecture Model (SGAM) (Gottschalk et al. 2017)

Approach

1. Compiled first information from templates

Meeting in Stockholm 04-2019

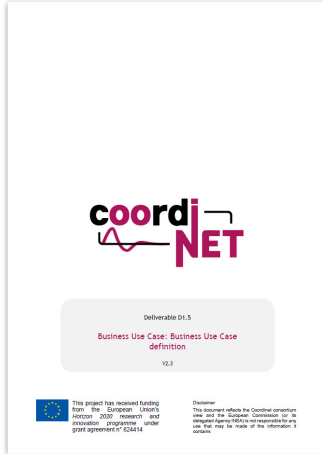
Approach

1. Compiled first information from templates
2. Short recap and feedback in workshop groups

Meeting in Stockholm 04-2019

Approach

1. Compiled first information from templates
2. Short recap and feedback in workshop groups
3. Each BUC detailed out and re-arranged
4. Mapping coordination schemes & products
5. Diagram creation
6. Final Document

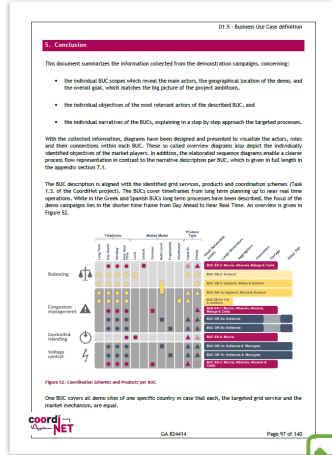

coordiNET

Deliverable D1.5

Business Use Case: Business Use Case definition

V2.3

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 824414



5. Conclusion

This document summarizes the information collected from the demonstration campaigns, concerning:

- the individual BUC scopes which reveal the main actors, the geographical location of the demo, and the overall goal, which matches the big picture of the project ambitions,
- the individual objectives of the most relevant actors of the described BUC, and
- the individual narratives of the BUCs, explaining in a step by step approach the targeted processes.

With the collected informations, diagrams have been designed and presented to visualize the actors, roles and their connections within each BUC. These so called overview diagrams also depict the individually identified objectives of the market players. In addition, the elaborated sequence diagrams enable a clearer process flow representation in contrast to the narrative description per BUC, which is given in full length in the appendix section 7.1.

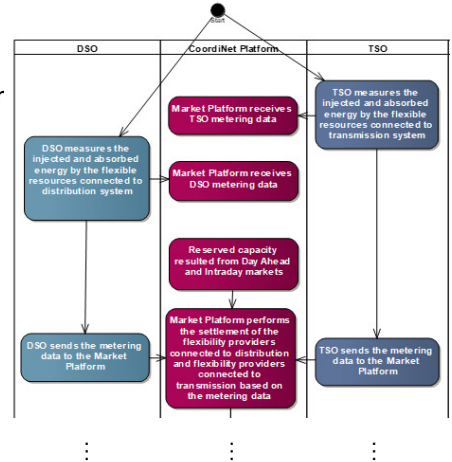
The BUC description is aligned with the identified grid services, products and coordination schemes (Task 1.3. of the CoordiNet project). The BUCs cover timeframes from long term planning up to near real time operations. While in the Greek and Spanish BUCs long term processes have been described, the focus of the demo campaigns lies in the shorter time frame from Day Ahead to Near Real Time. An overview is given in Figure 52.

Figure 52: Coordination Schemes and Products per BUC

One BUC covers all demo sites of one specific country in case that each, the targeted grid service and the market mechanism, are equal.

Terminologies

- **The CoordiNet platform is intended…**
  - … to form an interface to manage interactions between the TSO, DSOs and FSPs,
  - … to coordinate the functions necessary to perform the Use Cases,
  - … to support: data exchange between actors related to market bids, technical limitations on networks, market clearing functions, market results.



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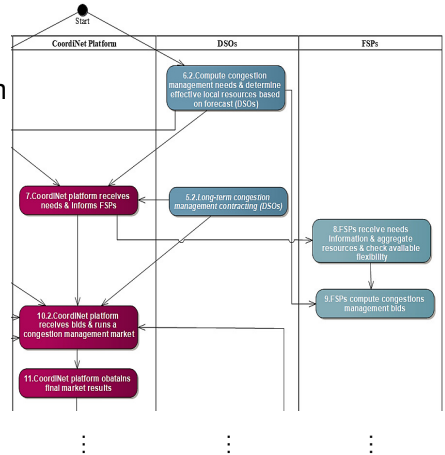
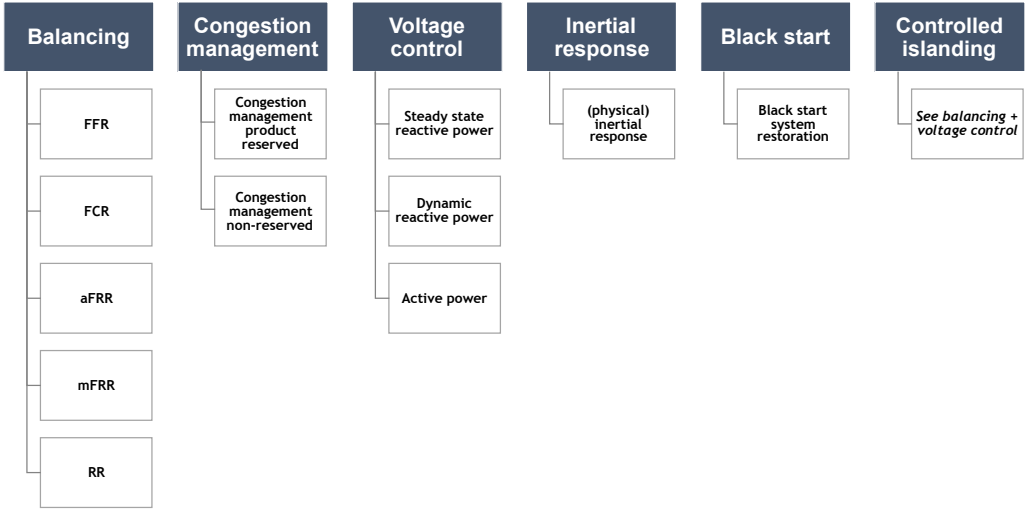
  - … to coordinate the functions necessary to perform the Use Cases,
  - … to support: data exchange between actors related to market bids, technical limitations on networks, market clearing functions, market results.

- **The Flexibility Service Provider is…**
  - … a direct owner of flexible resources, or…
  - … an intermediary such as independent aggregator, or…
  - … a retailer that represents flexible resources and coordinates their response.



Services & Products



Coordination Schemes - Market Models

Where is the need located in the system?

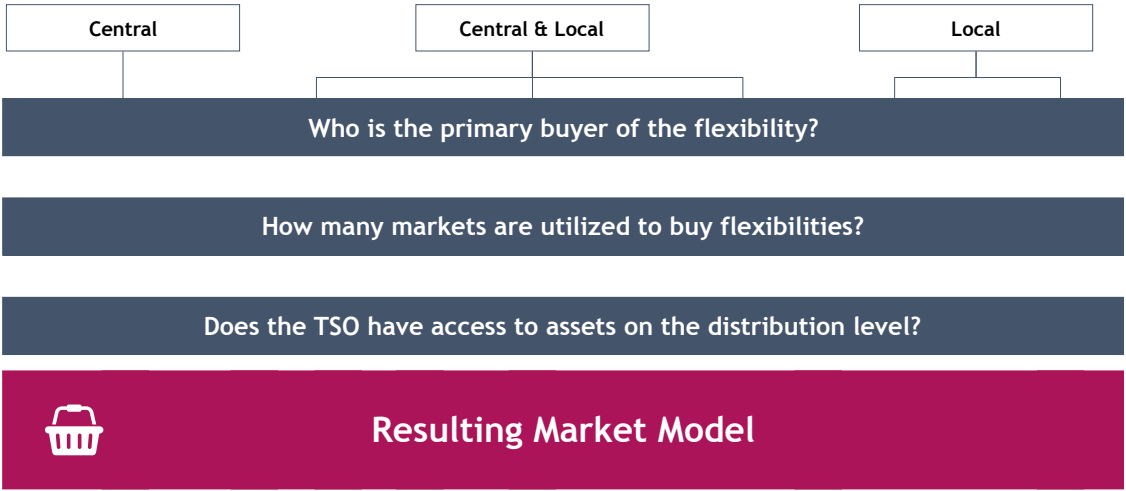
Who is the primary buyer of the flexibility?

How many markets are utilized to buy flexibilities?

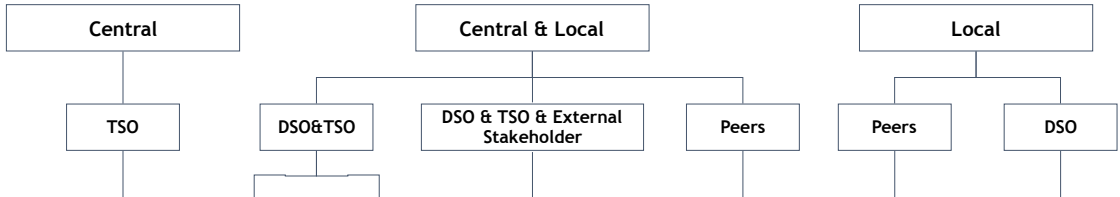
Does the TSO have access to assets on the distribution level?

Resulting Market Model

Coordination Schemes - Market Models



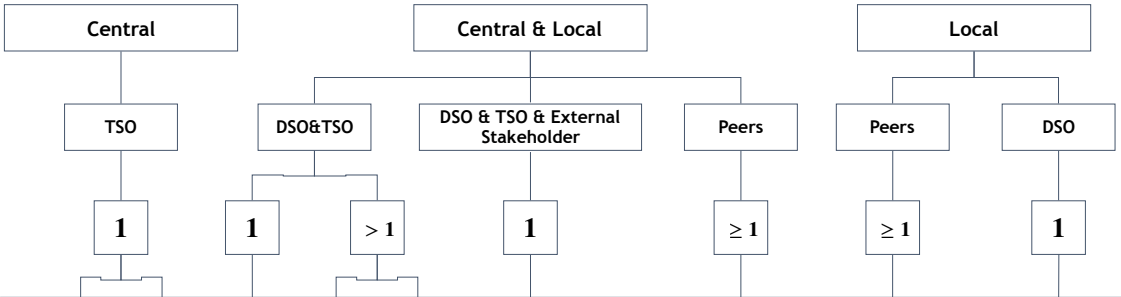
Coordination Schemes - Market Models



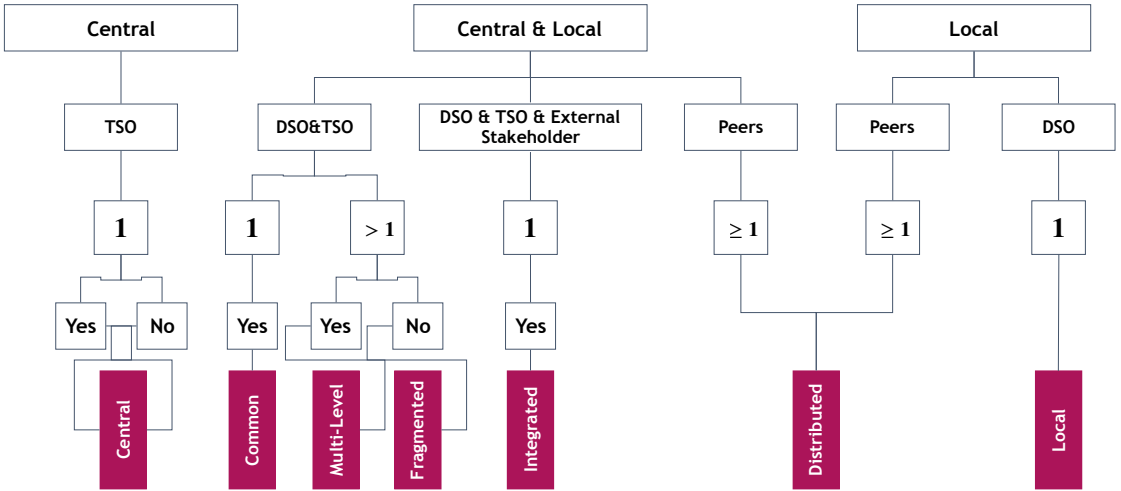
Does the TSO have access to assets on the distribution level?

Resulting Market Model

Coordination Schemes - Market Models



Coordination Schemes - Market Models



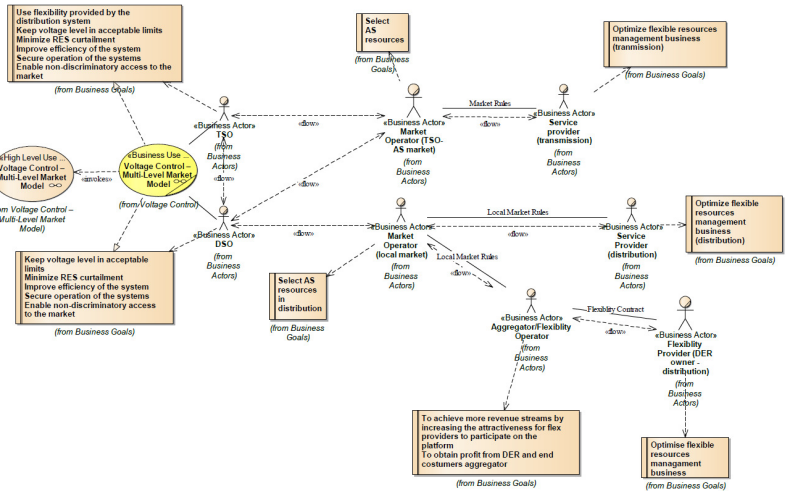
Greek BUCs

BUC GR-1a&b
Voltage control

BUC GR-2a&b
Congestion management

Connected with Hedno

Example Overview, detailed



Actors and Objectives in GR-1a&b

TSO

- Keep voltage level in acceptable limits
- Minimize RES curtailment
- Improve system efficiency and guarantee secure operation
- Use flexibility from TN *(and DN)* for voltage control
- Enable non-discriminatory market access (TSO AS)

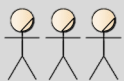
Aggregator

- Achieve more revenue streams by increasing the attractiveness for flex. providers to participate

Service Provider

(separate for transmission, distribution and flexibility)

- Optimize flexible resources management business



BUC GR-1a&b
Voltage control

DSO

- Keep voltage level in acceptable limits
- Minimize RES curtailment
- Improve grid efficiency and guarantee secure operation
- Use flexibility from DN for voltage control
- Enable non-discriminatory market access (local *& TSO AS*)

a)
b) Multi-level Fragmented

Actors and Objectives in GR-2a&b

TSO

- Keep power flows in acceptable limits
- Minimize RES curtailment
- Improve system efficiency and guarantee secure operation
- Use flexibility from TN *(and DN)* for congestion management
- Enable non-discriminatory market access (TSO AS)

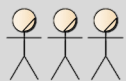
Aggregator

- Achieve more revenue streams by increasing the attractiveness for flex. providers to participate

Service Provider

(separate for transmission, distribution and flexibility)

- Optimize flexible resources management business



BUC GR-2a&b
Congestion management

DSO

- Keep power flows in acceptable limits
- Minimize RES curtailment
- Improve grid efficiency and guarantee secure operation
- Use flexibility from DN for congestion management
- Enable non-discriminatory market access (local *& TSO AS*)

a)
b) Multi-level Fragmented

Spanish BUCs

BUC ES-1
Congestion management

BUC ES-2
Balancing services for TSO

BUC ES-3
Voltage Control

BUC ES-4
Controlled Islanding

Actors and Objectives in ES-1

TSO

- Procure flexibility from resources connected at both TN and DN
- Solve temporary congestions that can occur in both networks <u>using a common AS market</u>

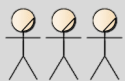
Aggregator

- Achieve more revenue streams by increasing the attractiveness for flex. providers to participate

Service Provider

(separate for transmission, distribution and flexibility)

- Optimize flexible resources management business



BUC ES-1
Congestion management

DSO

- Procure flexibility from resources connected at both TN and DN
- Solve temporary congestions that can occur in both networks <u>using a common AS market</u>

Common

Actors and Objectives in ES-2

TSO

- To reduce balancing costs

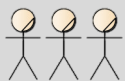
Aggregator

- Achieve more revenue streams by increasing the attractiveness for flex. providers to participate

Service Provider

(separate for transmission, distribution and flexibility)

- Optimize flexible resources management business



BUC ES-2
Balancing services for TSO

DSO

- To avoid unforeseen congestions

Central

Actors and Objectives in ES-3

TSO

- To keep voltage in accepted limits
- To utilize existing RES for voltage control
- To reduce investment cost for reactive power compensators

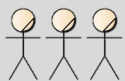
Aggregator

- Achieve more revenue streams by increasing the attractiveness for flex. providers to participate

Service Provider

(separate for transmission, distribution and flexibility)

- Optimize flexible resources management business



BUC ES-3
Voltage Control

DSO

- To keep voltage in accepted limits
- To utilize existing RES for voltage control

Common

Actors and Objectives in ES-4

TSO

- To evaluate the effect of the DSO's islanding operation on balancing

Aggregator

- Achieve more revenue streams by increasing the attractiveness for flex. providers to participate

Service Provider
(separate for distribution and flexibility)

- Optimize flexible resources management business

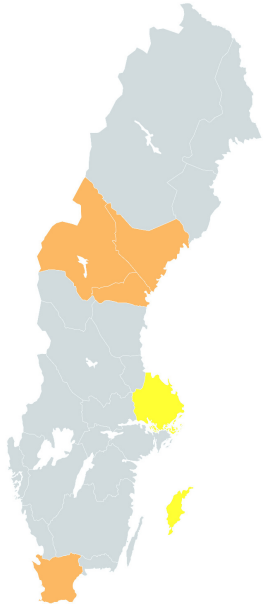
BUC ES-4
Controlled Islanding

DSO

- To operate in islanding mode during outages
- To operate in islanding mode during planned maintenance
- To maintain uninterrrupted power supply

Local

Swedish BUCs



BUC SE-1a&b
Congestion management

BUC SE-2
Balancing services for DSO in Gotland

BUC SE-3
Balancing services for TSO

Connected with Eon

Connected with Vattenfall

Actors and Objectives in SE-1a&b

TSO

- *To increase the liquidity of the mFRR market (only in SE-1a))*

Aggregator

- Achieve more revenue streams by increasing the attractiveness for flex. providers to participate

Service Provider
(separate for distribution and flexibility)

- Optimize flexible resources management business

BUC SE-1a&b
Congestion management

Local & Regional DSO

- To give customers opportunity to optimize their resources *(using a peer to peer market, only in SE-1b)*
- To meet grid needs with a market opportunity

a) Multi-level
b) Distributed

Actors and Objectives in SE-2

TSO

- To increase the liquidity of the mFRR market

Aggregator

- Achieve more revenue streams by increasing the attractiveness for flex. providers to participate

Service Provider

(separate for distribution and flexibility)

- Optimize flexible resources management business

BUC SE-2
Balancing services for DSO in Gotland

Local DSO

- To connect new RES power
- To improve power quality and security of supply

Local & Regional DSO

- To unlock flexibility and increase attractiveness for FSPs to participate on the CoordiNet platform

Local

Actors and Objectives in SE-3

TSO

- To increase the liquidity of the mFRR market

Aggregator

- Achieve more revenue streams by increasing the attractiveness for flex. providers to participate

Service Provider
(separate for distribution and flexibility)

- Optimize flexible resources management business

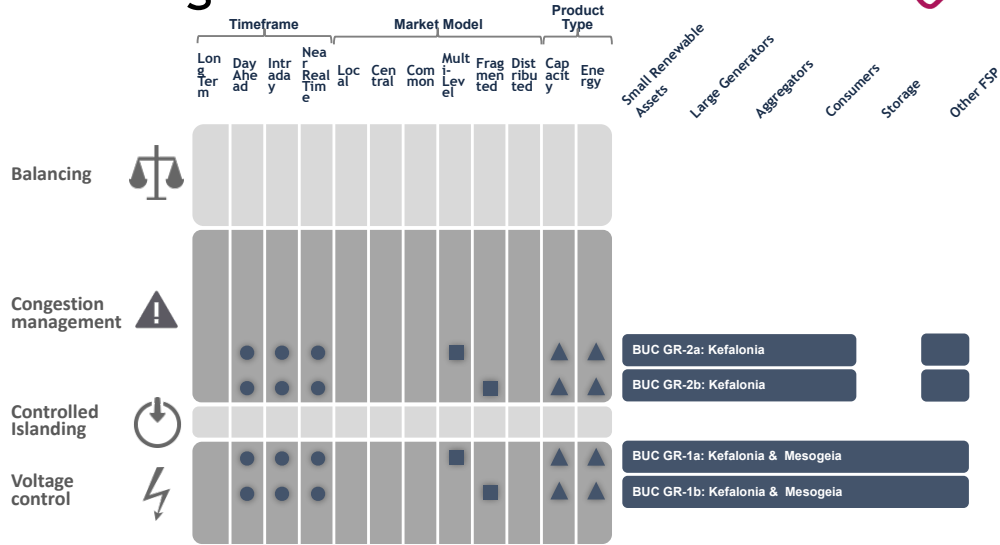
BUC SE-3
Balancing services for TSO

Local & Regional DSO

- To give customers opportunity to optimize their resources
- To meet grid needs with a market opportunity

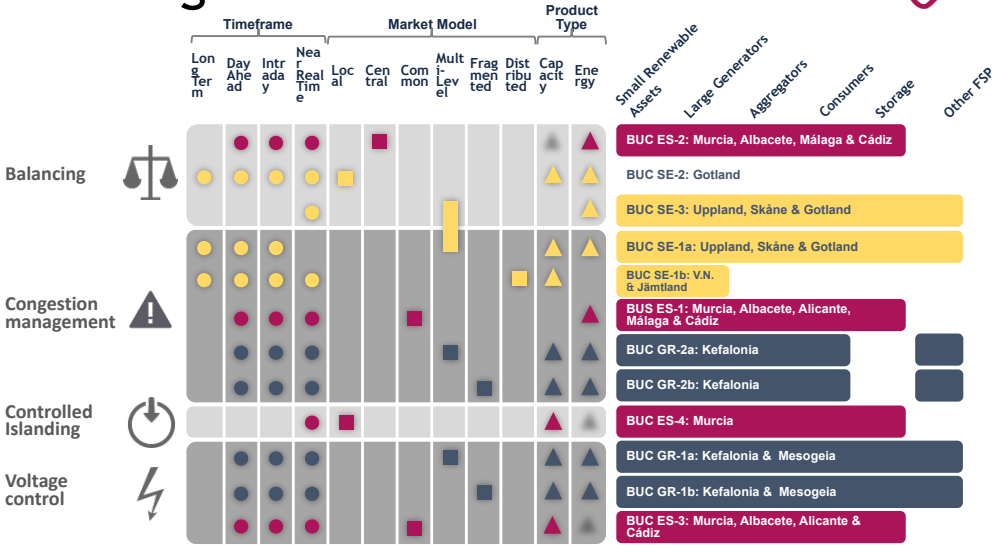
Multi-level

Resulting ambition overview



Resulting ambition overview

Resulting ambition overview



Thank you

More information on the project: https://coordinet-project.eu/

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ACS | Automation of Complex Power Systems
E.ON Energy Research Center
RWTH AACHEN UNIVERSITY

Agenda

13:30 - 13:45 : Introduction

13:45 - 14:15 : An Overview of International Activities on TSO-DSO interaction

14:15 - 14:45 : Interaction of DSO and TSO requirements on Distribution Networks

14:45 - 15:15 : IEC 62559-2 Business Use Cases for TSO-DSO coordination

15:15 - 15:45 : Coffee break

15:45 - 16:15 : Smart begins in the heads

16:15 - 16:25 : TSO-DSO cooperation: Where we are at European level

16:25 - 16:45 : TSO-DSO Interaction - Inevitable for Future Power Systems Operation

16:45 - 17:15 : Ongoing Research Activities on TSO-DSO interaction

17:15 - 18:00 : Q/A in a panel

18:00 - 19:30 : Networking apèro

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Dr. Andreas Beer

Repower

Dr. Andreas Beer is Expert in Product Research and Engineering at Repower AG. He was for 12 years the Head of Grid at Repower and member in the VSE-commission for grid economy. Dr. Beer actively helped shaping the transition to a deregulated electrical energy market and to the renewable energy strategy, both with high regulation impact and solution-expectation on the grid operator. He initiated and promoted different innovative solutions for grid operators to enable this transition, such as new methods and tools for asset management, new tariff models or alternative smart grid concepts. Dr. Beer graduated from ETH Zürich in electrical engineering and holds a PhD in the field of power electronics in energy transmission.

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Federal Office of Energy SFOE

ETH zürich

RESEARCH CENTER FOR ENERGY NETWORKS
FORSCHUNGSSTELLE ENERGIENETZE

ISGAN – International Smart Grid Action Network

Montreux, October 3th 2019

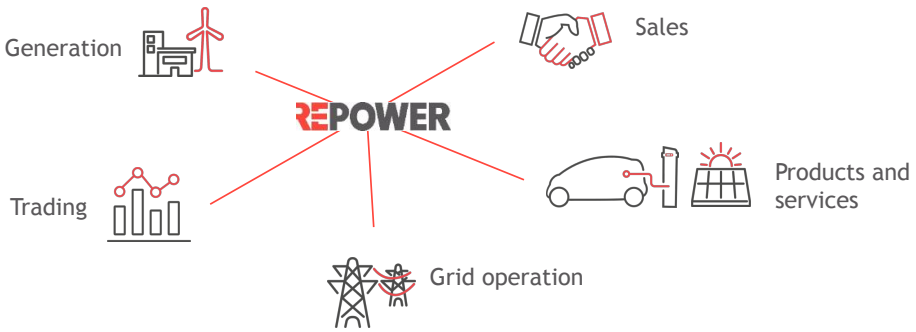
SMART begins in the heads

Dr. Andreas Beer
Expert, Produkt Management

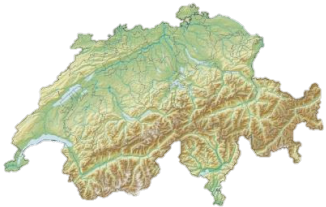
SMARTPOWER
SMART BEGINNT IM KOPF

REPOWER
Unsere Energie für Sie.

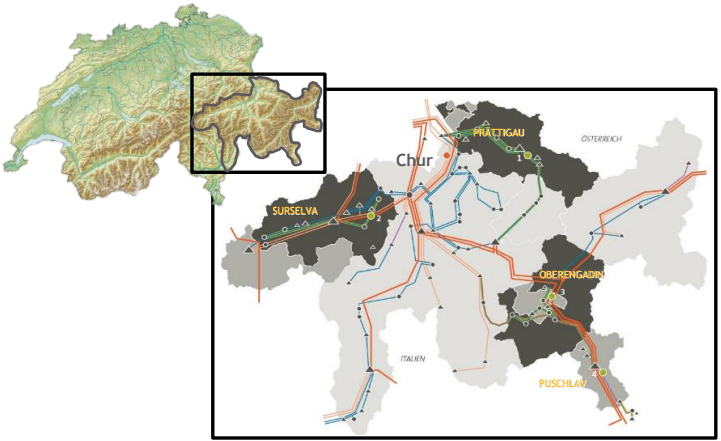
Fields of activity



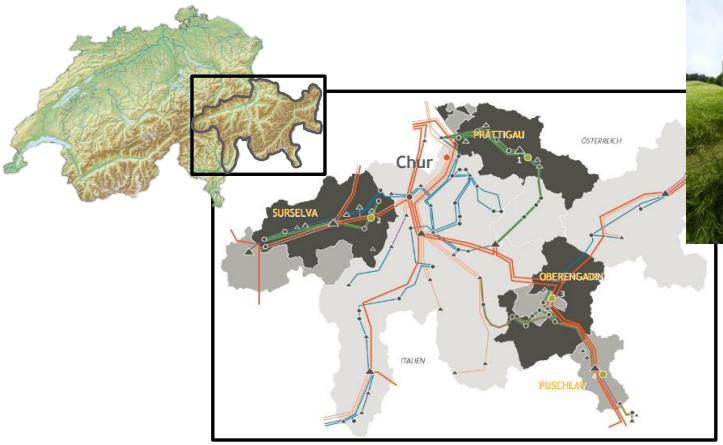
Distribution grid



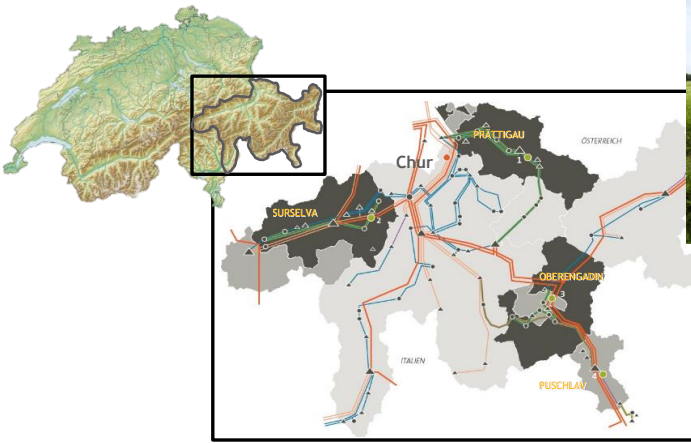
Distribution grid



Distribution grid



Distribution grid



2 substations 380/220kV
20 substations 150/60kV
691 transformer stations 10/16/20kV
2185 km cable
552 km overhead lines
50'000 end customers

THE GOAL IS NOTHING LESS THEN

TO SAVE THE EARTH

Beside the earth salvation politics want to…

Liberalisation of metering

Revenues on PV

Flexibility market

Smart Meter Rollout

Liberalized energy market

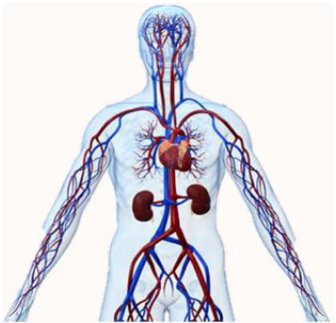
SMART GRID

Grid Regulation

Maximum costs of 40 CHF/year

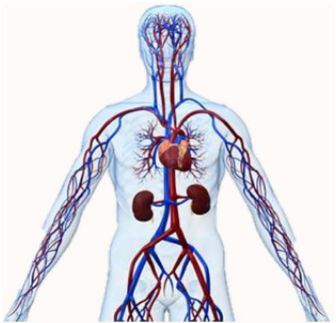
Profit for self-consumption syndicates

Up to now: central



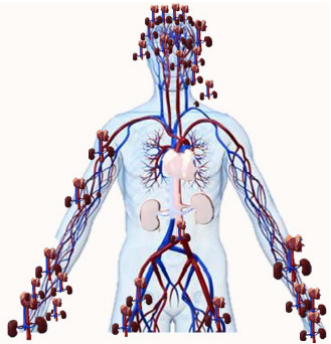
Quelle: Internet

Up to now: central

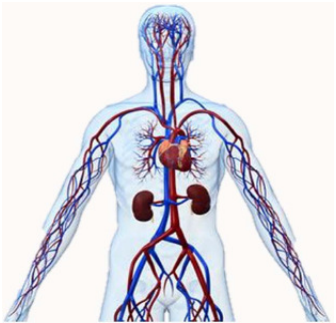


Quelle: Internet

New: decentral



Up to now: central



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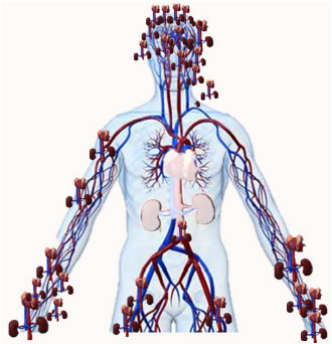
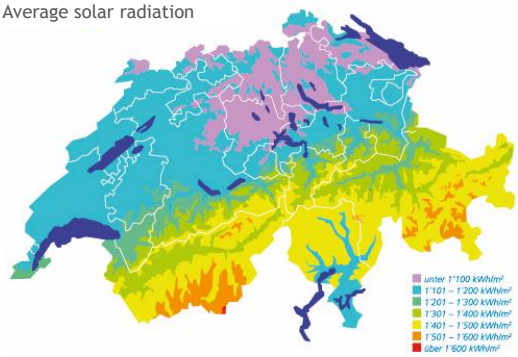


Main person affected by the surgery?

→ patient = user of grid

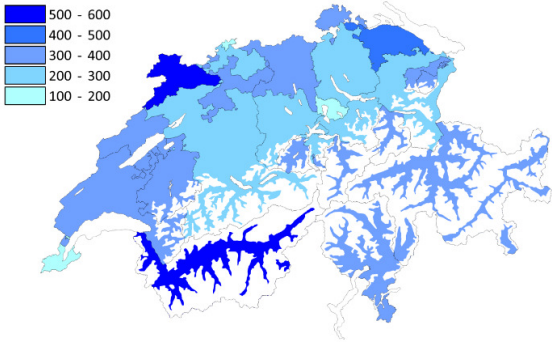
Solar radiation in the alpine region, consumption in the mid-/lowland

Average solar radiation



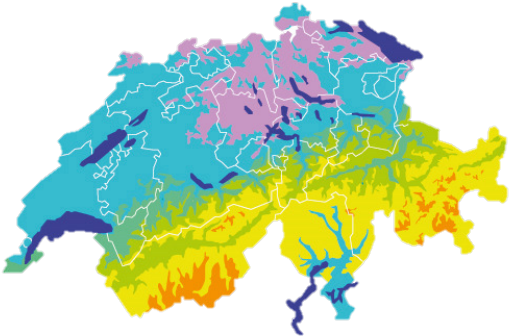
Meteotest

Building zone area per inhabitant



Bundesamt für Raumentwicklung ARE

Solar radiation in the alpine region, consumption in the mid-/lowland



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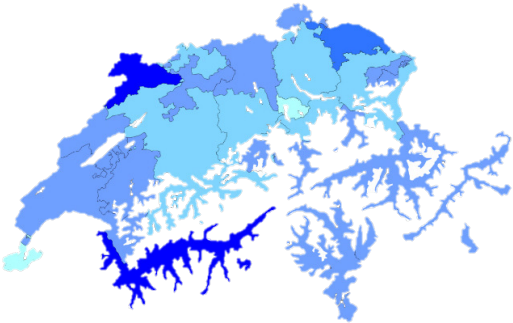

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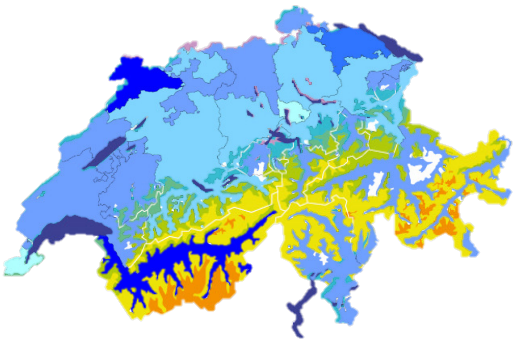
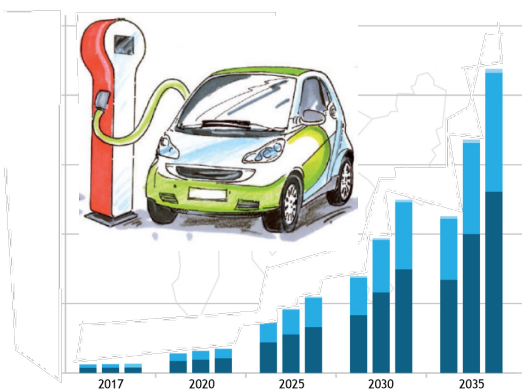


Growth in electromobility



Several scenarios show a

massive expension of the charging infrastructure by 2035.

Upcoming standards:

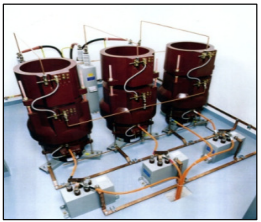
- Private charging stations: 11 kW
  (Previously home-appliance: oven 3-4 kW)
- Public charging stations: >22 kW

Security of supply is not a matter of fact

Copper

Grid expansion
- → Costly projects
- → Long procedures

Control



Ripple control
- → Limited controllability
- → Limited acceptance

Consumer

Consumption Behaviour
- → 100% of the consumption
- → Consumer participation

The magic word: «Smart Grid»

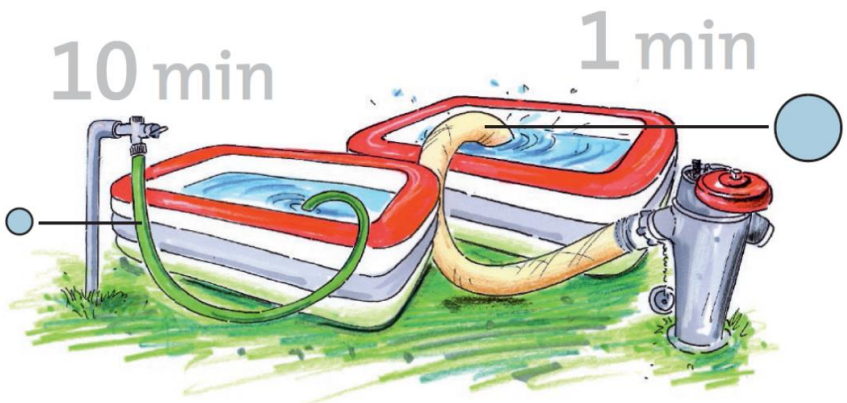
= **Control consumption** according to grid and generation availability

100% of consumption is with the consumers

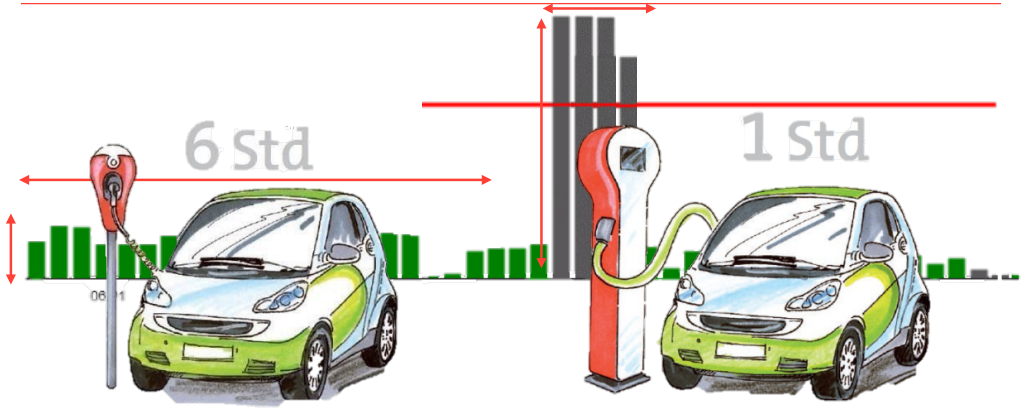
→ Influencing consumption means influencing consumers

→ This requires incentives

Customers need to know the difference between power and quantity



Consumption behaviour expresses itself in time and power

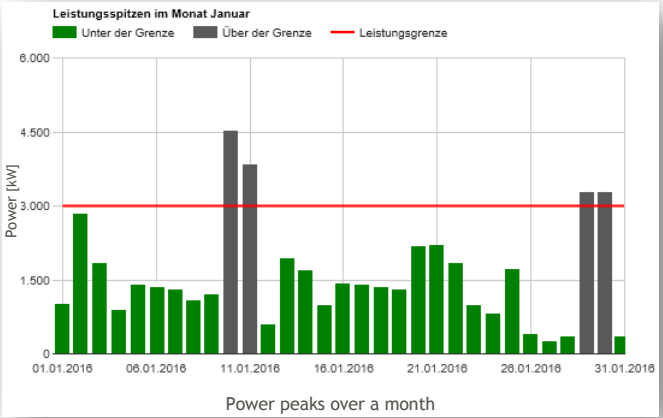


Same quantity (kWh)

Different power (kW)

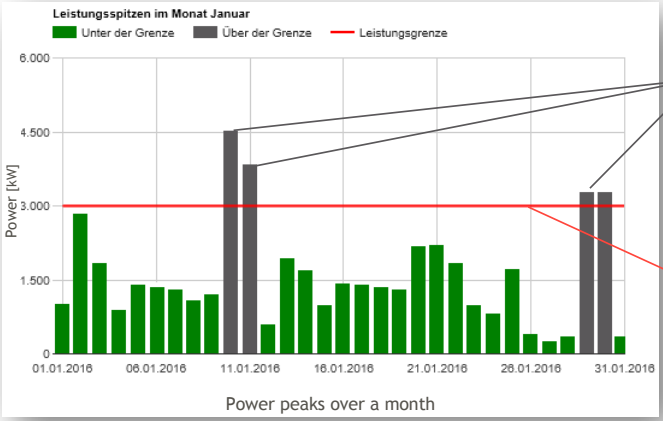
Useful tariff incentives therefore take into account the power

Power-limit and malus if exceeding limit on a daily basis



Power peaks over a month

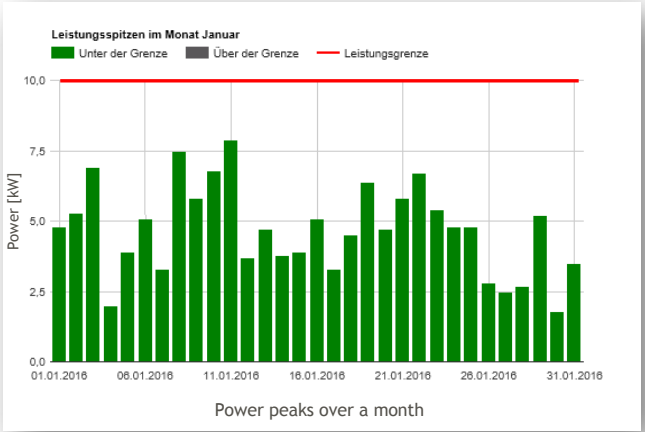
Power-limit and malus if exceeding limit on a daily basis



Exceeding limit on 4 days in the month.
Additional costs:
2.9 kW x 1.1 Fr. = 3.20 Fr.

Tariff power package «S» (3 kW)
Price: 45 CHF/Mt.

Bonus on monthly basis gives an incentive for midterm improvement



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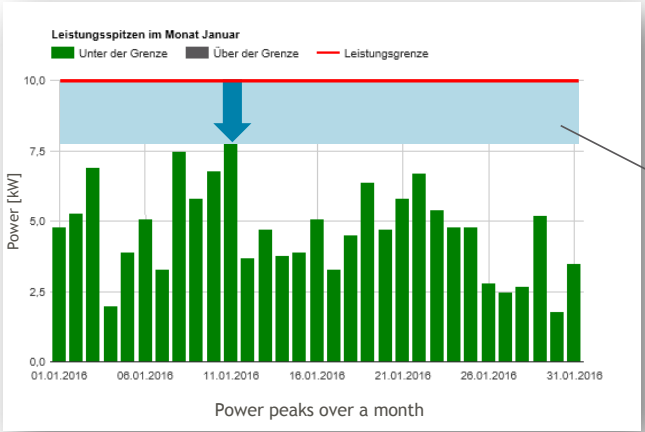
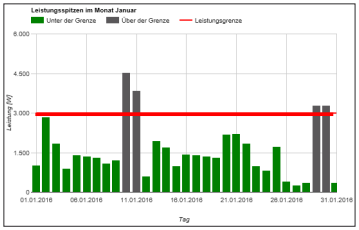
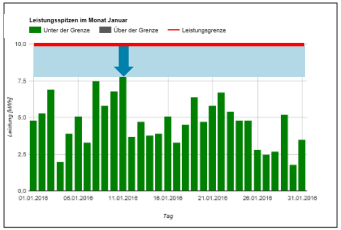


Bonus if remaining below limit for a whole month

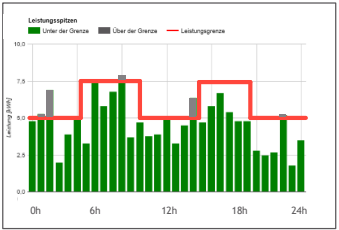
Correct distribution grid tariff ist the basis for grid-friendly flex-market



Power-package with malus if exceeded (daily maximum)



The bonus gives an incentive to behave throughout the month



Performance pricing is a prerequisite for future dynamic tariff models

Flexibility usage

- Grid dimensioning
- Local grid peak optimisation
- Voltage control

DSO

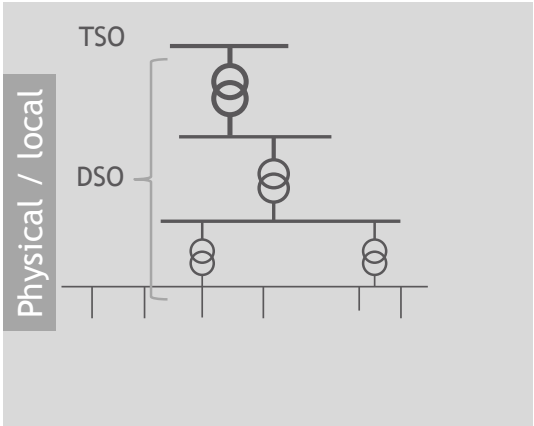
- Day ahead, spot market, prognosis optimisation
- Intraday market
- Balancing energy / post scheduling

Trader

- Ancilliary services PRL, SRL, TRL
- Voltag control transmission grid

TSO

Flexibility Market – physically or on a contractual basis?



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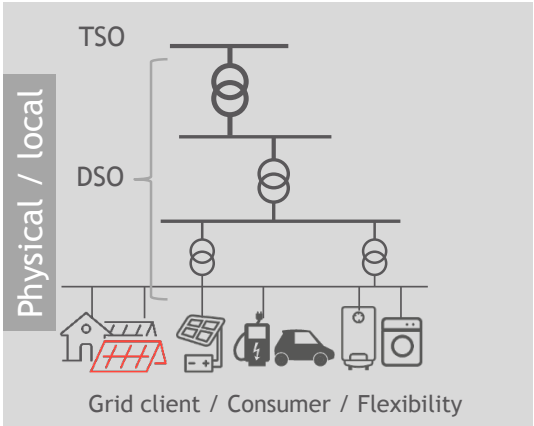
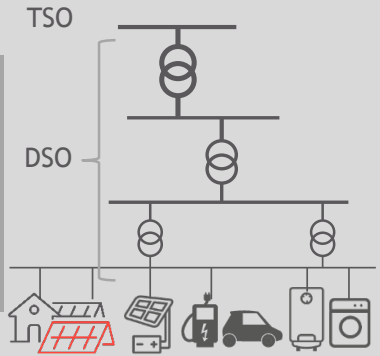


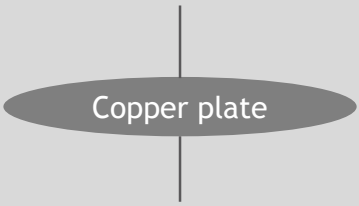
Flexibility Market – physically or on a contractual basis?

Physical / local



Grid client / Consumer / Flexibility

Contractual / virtual



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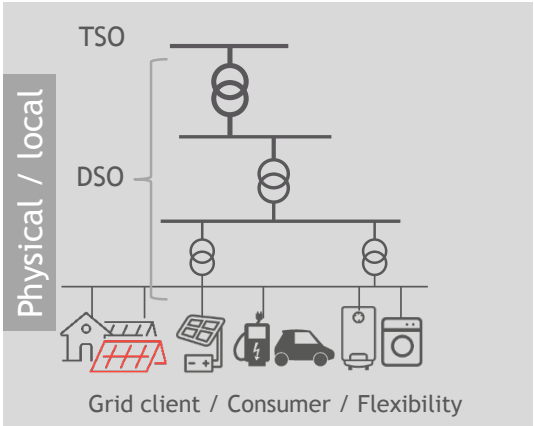
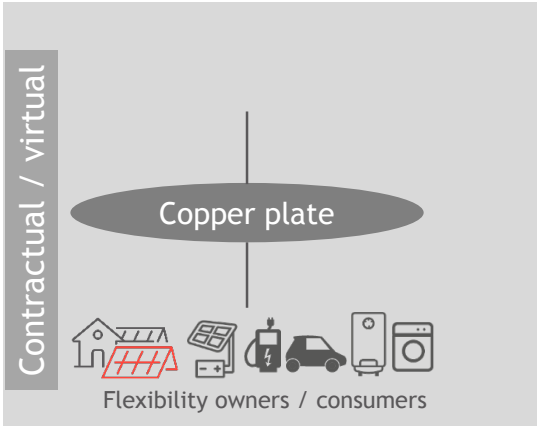
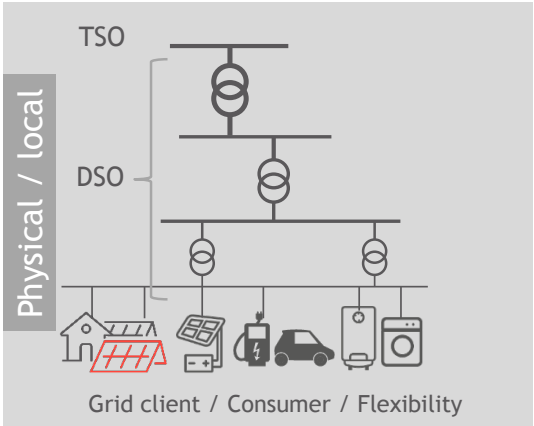
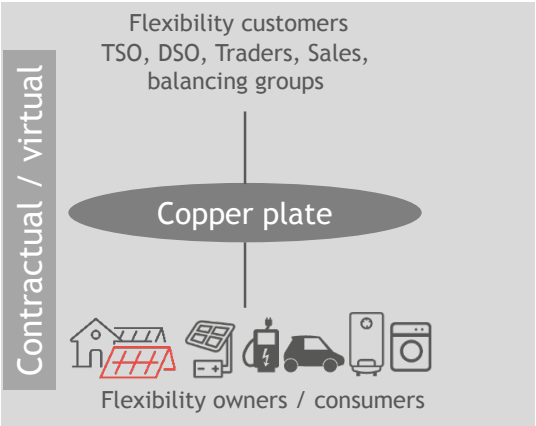




Flexibility Market – physically or on a contractual basis?





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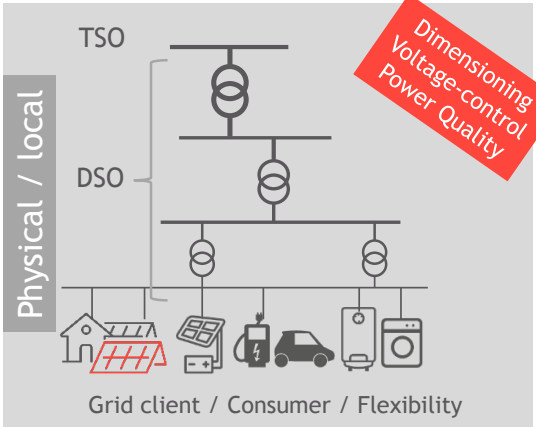

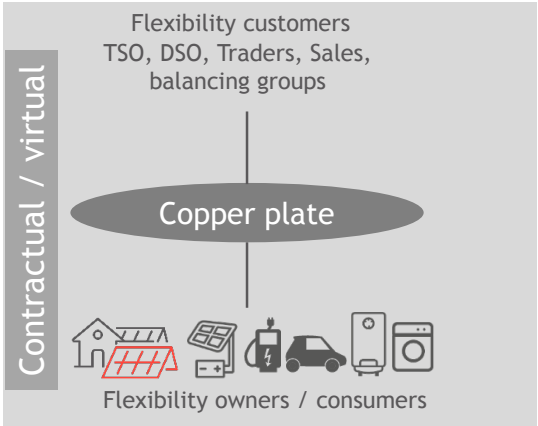

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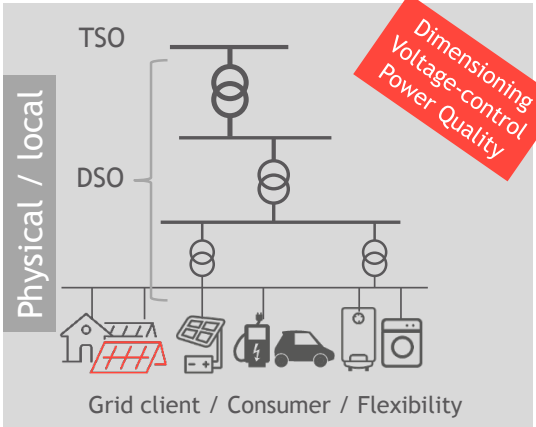
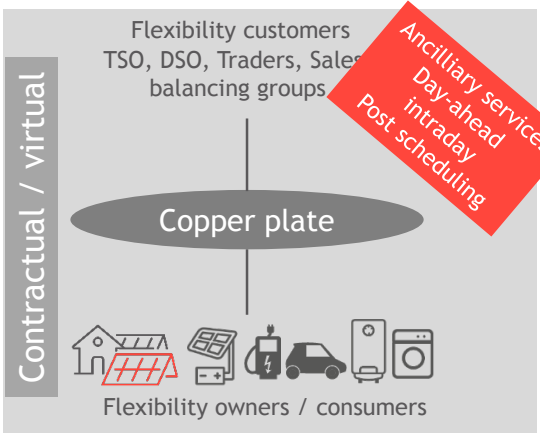


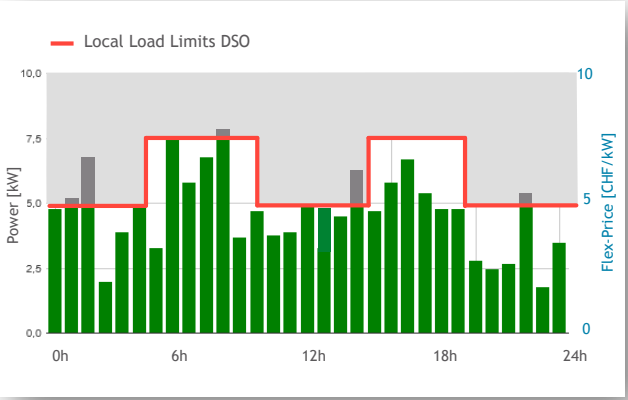


How does a flexibility market work between the stakeholder

Grid / physical / local
- Tariff incentives
- Boundary conditions for the market

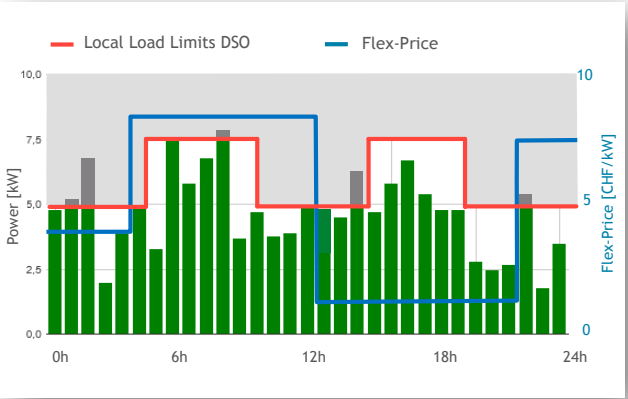
Market / contractual / global
- Flexibility prices on a market
- Depending on boundary conditions grid usage

Flexibility market only works with appropriate boundary conditions



Flexibility available for flex-market.
Local load costs lower then flex revenues.

Flexibility market only works with appropriate boundary conditions



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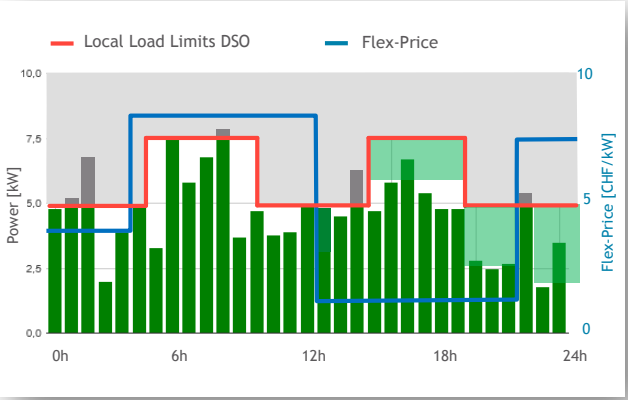

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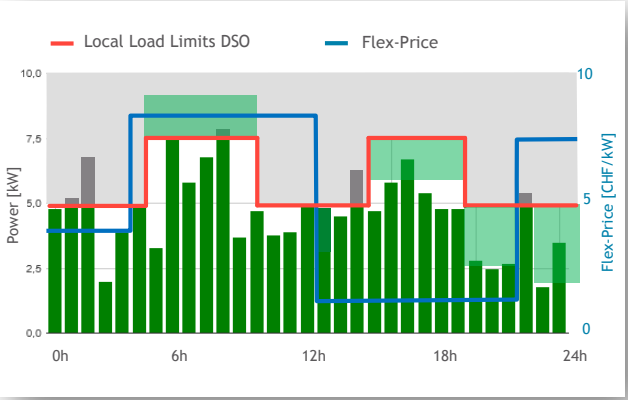

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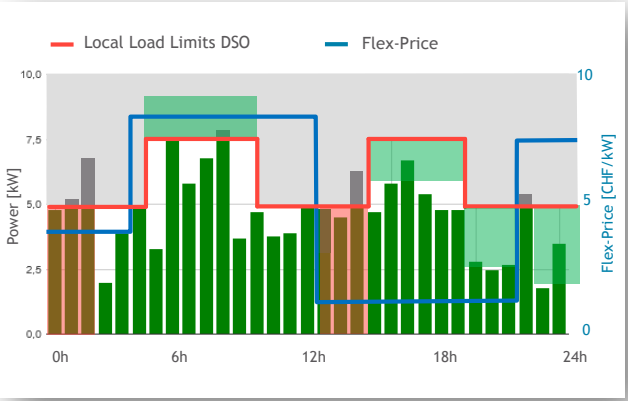
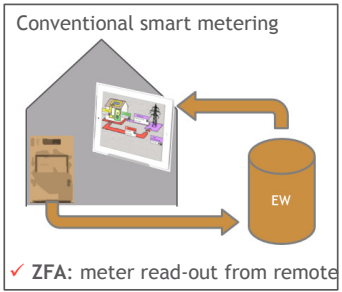


Flexibility available for flex-market.
Local load costs lower then flex revenues.

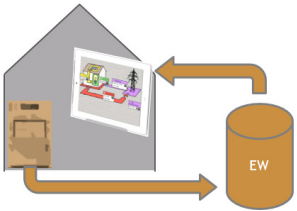
Local load exhausted.
Flex price to low compared to costs caused in local grid.

Local intelligence needed to control the different claims



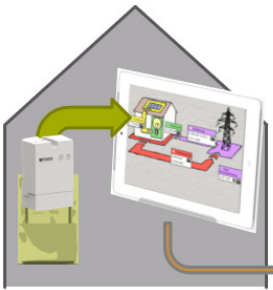
Local intelligence needed to control the different claims

Conventional smart metering



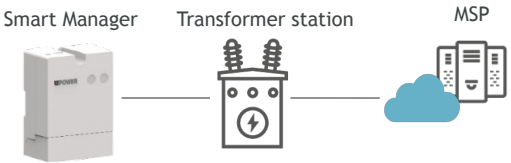
✓ **ZFA**: meter read-out from remote

Smartpower: local intelligence



- ✓ **ZFA:** meter read out from remote
- ✓ **Real-Time**: for visualization and control
- ✓ **Security**: Data and cyber security
- ✓ **Future needs**: Dynamic tariff models
- ✓ **Customer**: add-ons, optimisation, calc
- ✓ **Flex Market:** Access for third party possible

SMARTPOWER technical components



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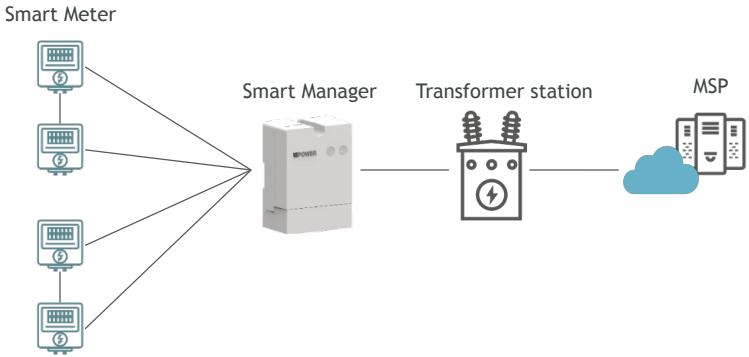

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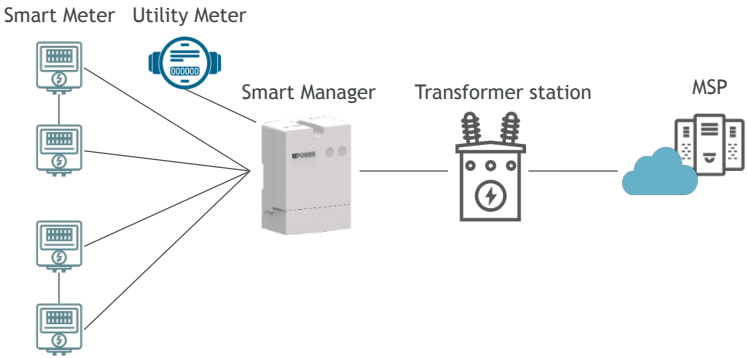

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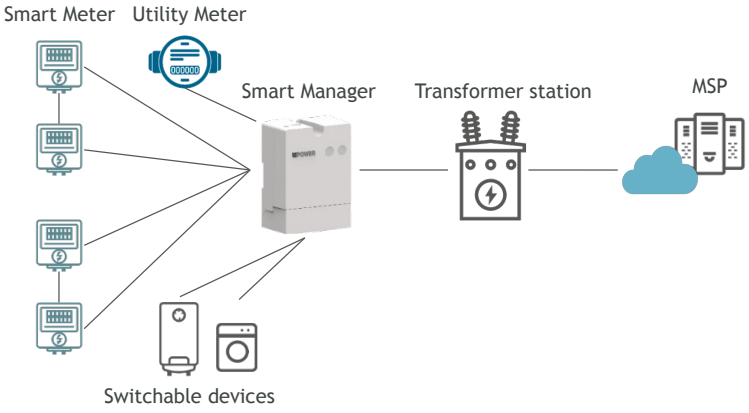

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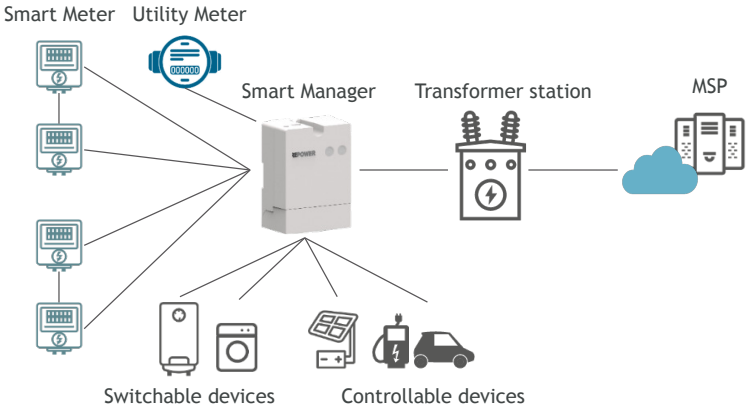

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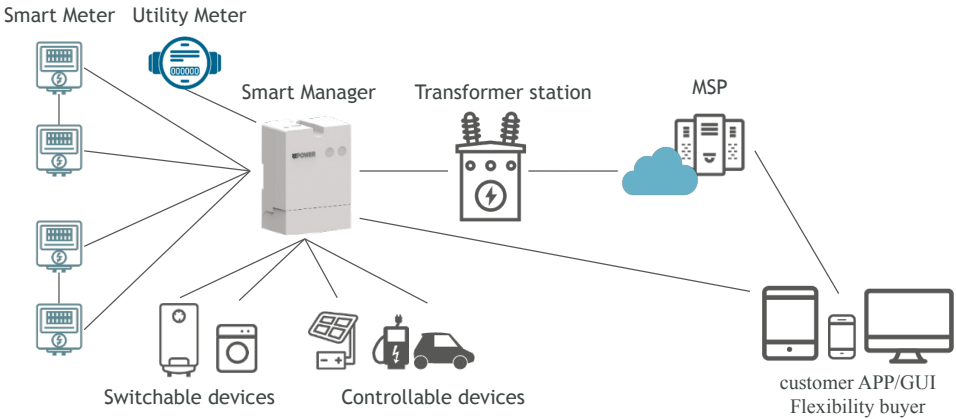

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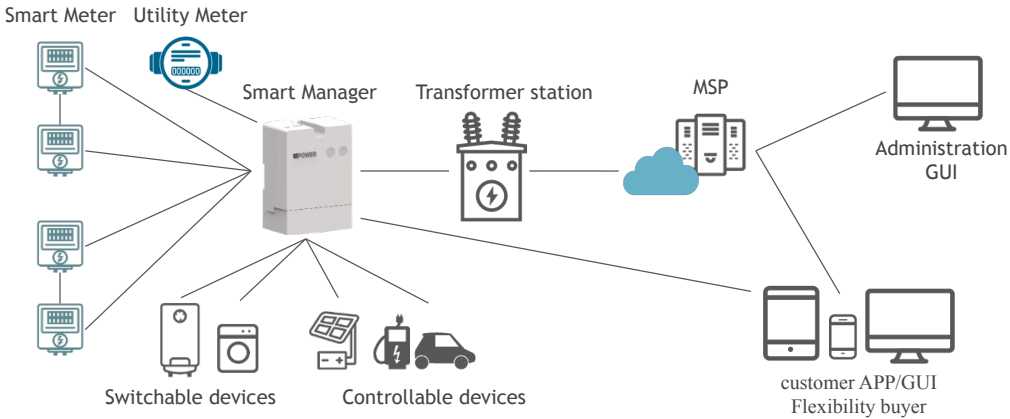

The smart manager: the indispensable local intelligence of an IMS

- Local monitoring / alarm / control
- Real-time customer visualization
- Replacement ripple control
- Offline executable
- Easy to install
- Multi-Utility
- Various communication technologies
- Value added/additional services for customers

- AND: Flexibility access for third parties possible

Conclusion

- ✓ Future security of supply depends on smart grids
- ✓ Smart Grids require controllable loads
- ✓ Controllable loads are with the customers/consumers
- ✓ Customers are encouraged to use flexibility with tariff incentives

- → Customer involvement is crucial for smart grids
- → Correct grid tariffs are necessary preconditions for a useful flexibility market


Thank you very much for your interest.

Agenda

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Dr. Markus Imhof

Swissgrid

ISGAN
INTERNATIONAL SMART GRID ACTION NETWORK

Markus Imhof studied at ETH Zurich Electrical Engineering with a following PhD at the Power Systems Laboratory at ETH Zurich with Prof Dr. Göran Andersson. He investigated control schemes how HVDC Links can contribute to voltage control and inter-area oscillation damping. After his PhD he worked two years in consulting before he joined Swissgrid, the Swiss Transmission System Operator, in 2018 as Senior Specialist Product Development. He is responsible for the introduction of the new voltage remuneration scheme for Switzerland. Furthermore he is the convener of the work stream Algorithm and Bid Structure in the MARI Project, a European implementation project for the creation of the European mFRR platform.

Schweizerische Eidgenossenschaft
Confédération suisse
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ETH zürich

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RESEARCH CENTER FOR ENERGY NETWORKS
FORSCHUNGSSTELLE ENERGIENETZE

TSO-DSO cooperation: Where we are at European level

Victor Charbonnier

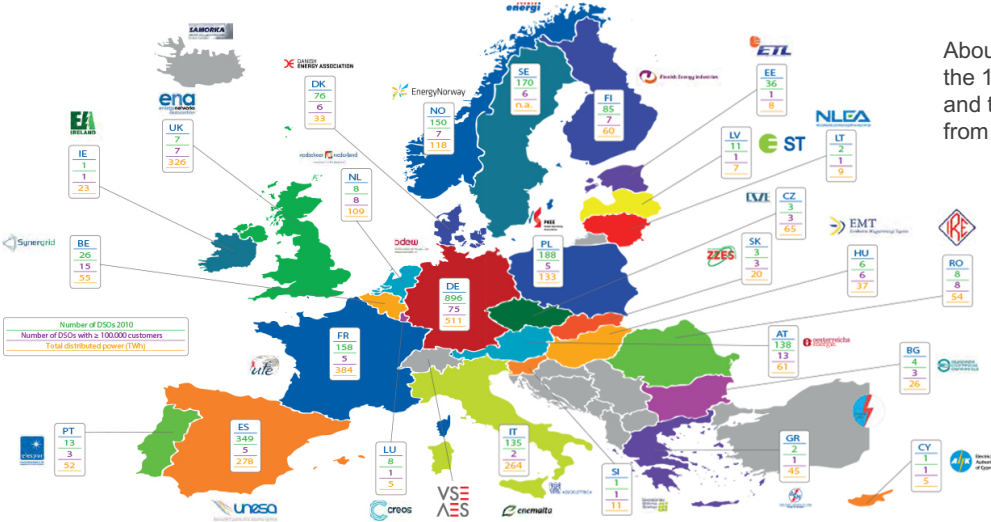
Mathilde Lallemand

Needs, Challenges and Opportunities of TSO-DSO Coordination, Montreux October 3rd

Context of system operators across Europe

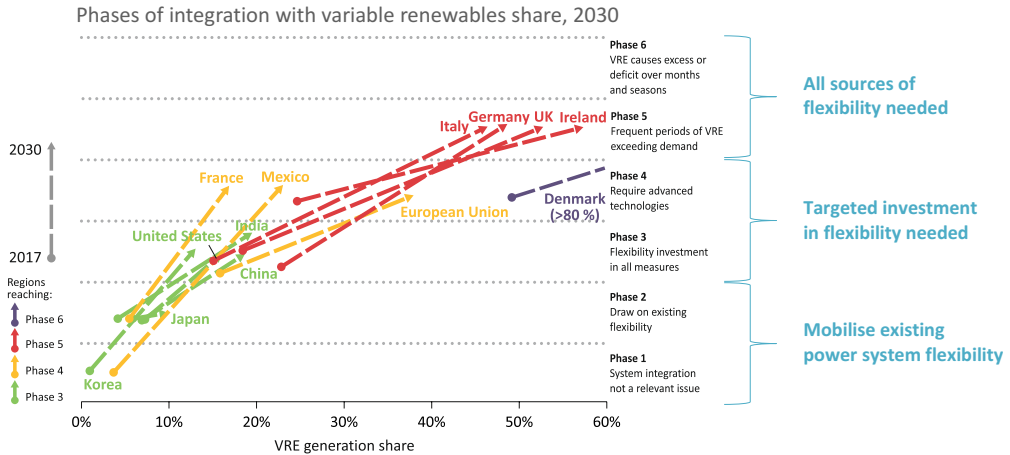
Setting the scene:

Comparing 43 TSOs vs. 2700 DSOs in Europe



About 2200 are below the 100 K threshold, and thus exempted from unbundling

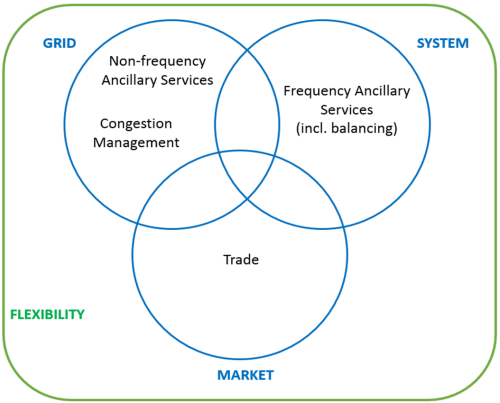
Evolving flexibility needs by region, New Policies Scenario

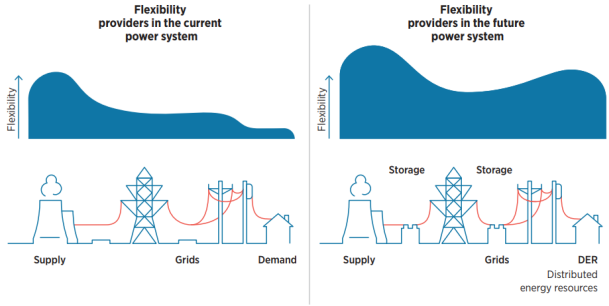


The size of the power system, flexibility of thermal generation, shape of demand profile, imply different needs for additional flexibility even at the same levels of VRE

Source: World Energy Outlook 2018

Flexibility services/providers are evolving





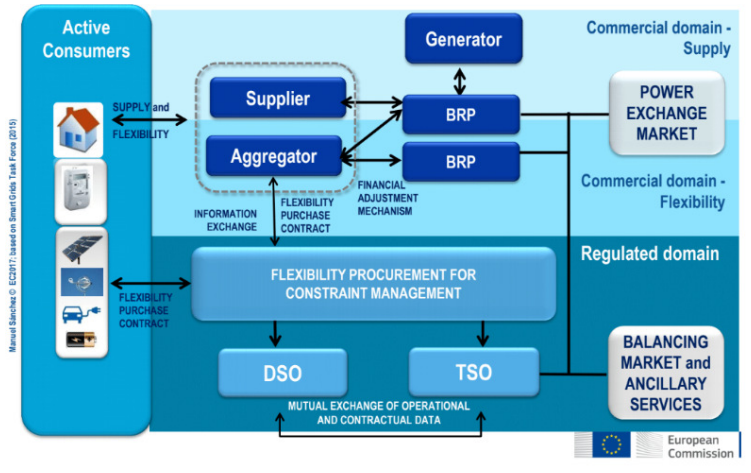
Source: IRENA report on innovation and renewables (2019)

A conceptual framework for flexibility

Active consumers

Citizen energy communities

Aggregation



Exchange of data

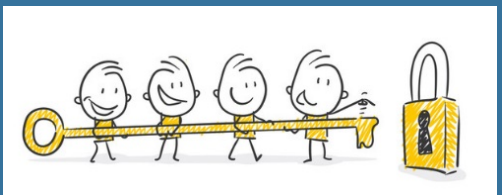
Market facilitation

Designing the framework

Source: adapted from EC, Manuel Sanchez Jimenez. EG3, Smart Grids Task Force (2014, 2018, 2018)

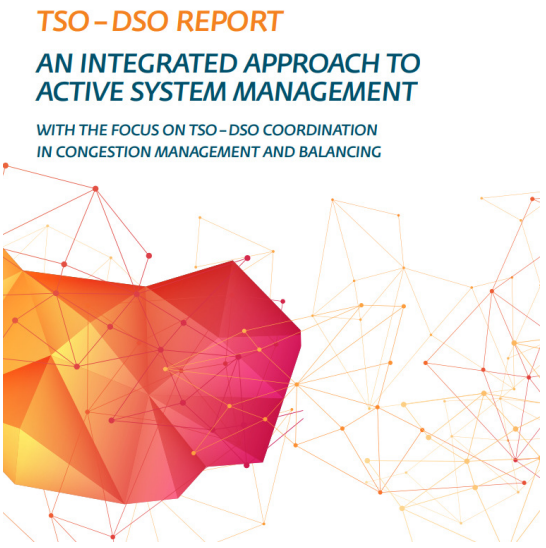
entsoe

Framework for cooperation



A need for TSO-DSO cooperation

The way forward for a complex, multi-layered and multi-dimensional energy system



Various actors to deliver different services at different scales

➔ **TSO and DSO roles and responsibilities as system operators and as neutral market facilitators**

➔ **An efficient level playing field for market parties is required, fostering new services and valuing flexibility services**

➔ **TSO-DSO coordination on mutual processes and data exchanges between them to guarantee a reliable, efficient and affordable operation of the electricity system and grid, and to guarantee non-discriminatory and efficient market operation**

The toolbox of TSOs and DSOs to unleash flexibility potential, beyond network reinforcement: Active System Management

Technical solutions using network assets

Market-based solutions to activate explicit flexibilities

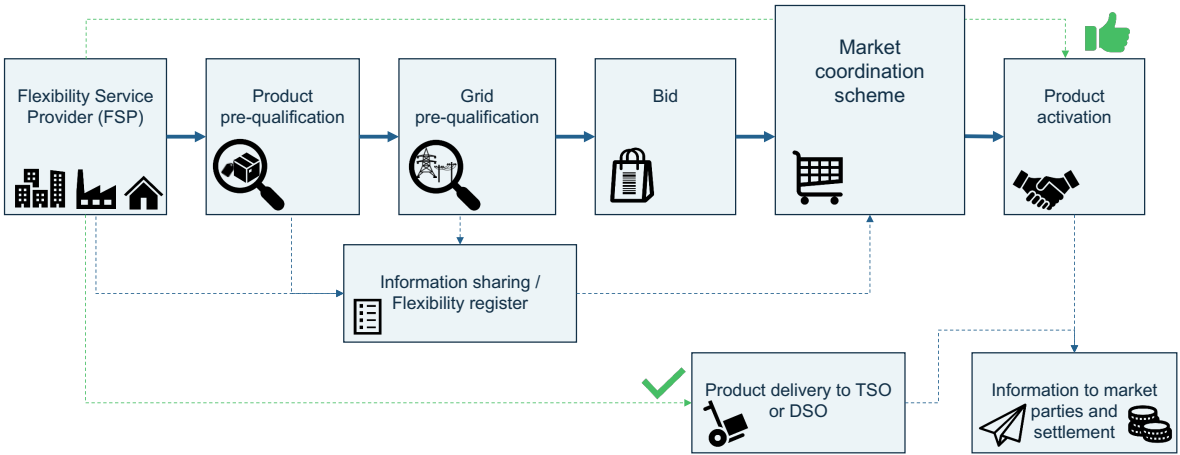
Connection agreement solutions

Tariff solutions to trigger implicit flexibility

Rule-based solutions like curtailments, in last resort or emergency situations

A common report at EU level on Active System Management to advise regulation on TSO-DSO cooperation

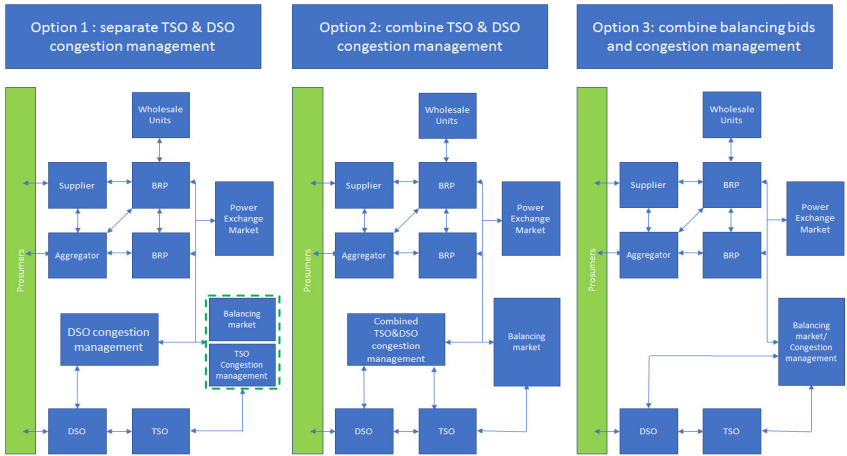
To coordinately use a set of market-based instruments to cost-efficiently and securely manage the electricity systems, across all timeframes and different areas



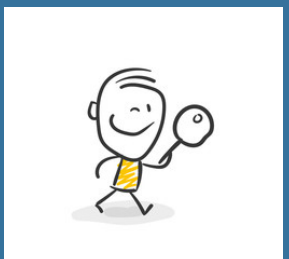
Bringing together flexibility providers and flexibility users

Which services? How to foster new actors participation and value them?

Zoom on the market coordination scheme options

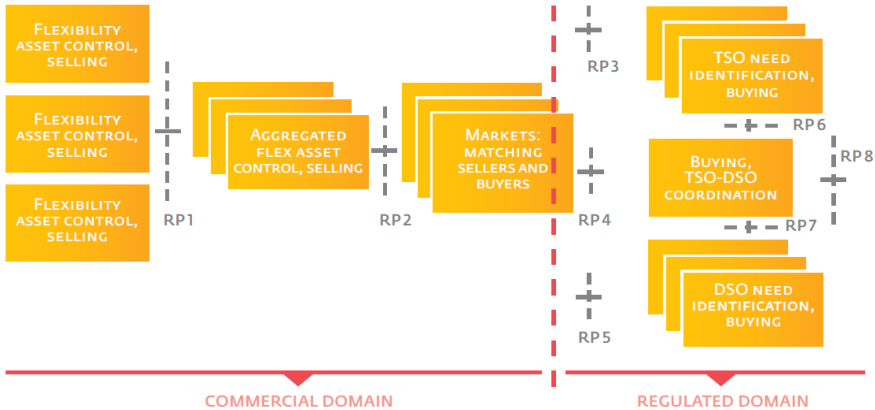


And in reality?



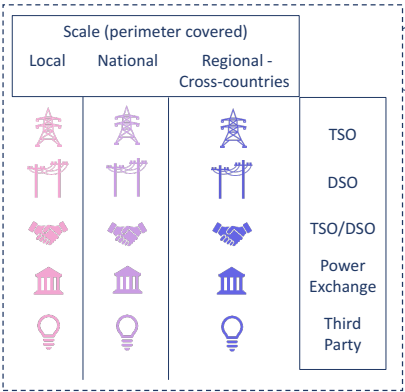
Implementation of market models: platform options

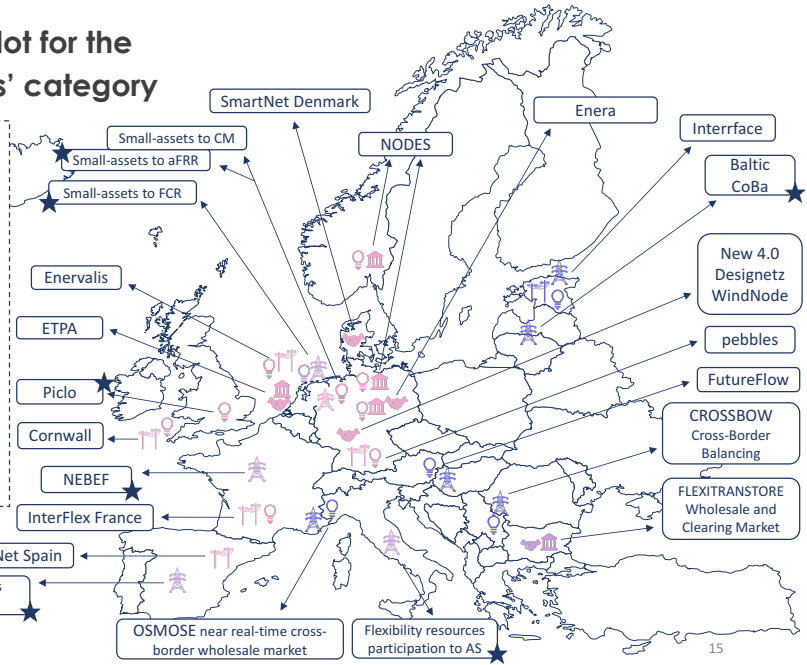
Reference points (RPs) identifying data exchanges in both the commercial and regulated domain.



RP_X= REFERENCE POINT X

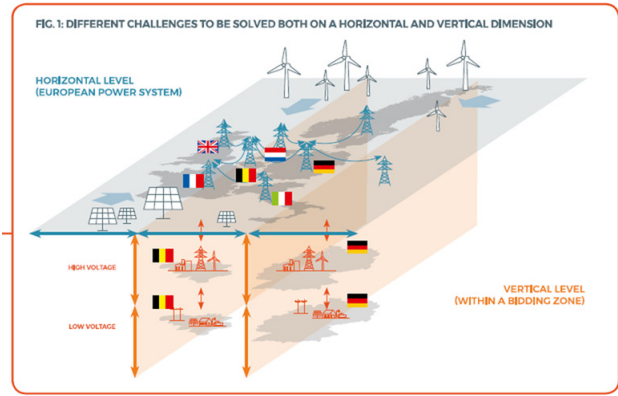
Characteristics of the pilot for the ‘flexibility market places’ category





Summing up

- ✓ Integrated system approach
- ✓ Market-based procurement (long-term view)
- ✓ Standardisation at national level
- ✓ Common marketplace conceptual framework and principles at EU level
- ✓ Easy access for customers



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TSO-DSO Interaction - Inevitable for Future Power Systems Operation

ISGAN - International Smart Grid Action Network

Dr. Markus Imhof, Senior Specialist Product Development
Montreux, 3rd October 2019

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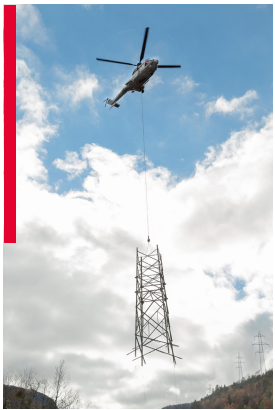
Agenda



1. Challenges
2. Technical Interaction
3. Stakeholder Interaction
4. Conclusion

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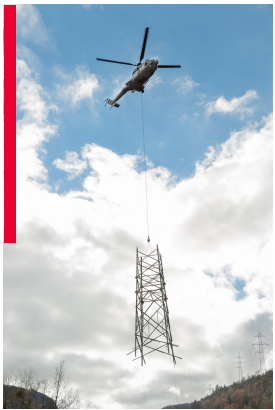

1. **Challenges**
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4. **Conclusion**

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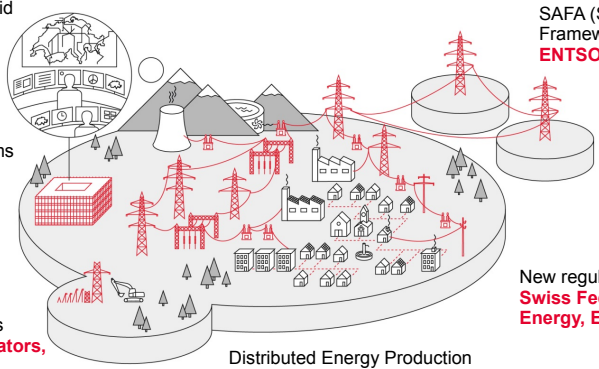
Challenges

Enhanced operational security
DSOs, Power Plant Operators

International energy trade
Power Plant Operators

Intelligent grids and new grid solutions
DSOs, Power Plant Operators

SAFA (Synchronous Area Framework Agreement)
ENTSO-E



Transformation of energy systems and integration of renewable energies
DSOs, Power Plant Operators,

Standardisation of regulations
ACER, ENTSO-E

New regulations
Swiss Federal Office of Energy, ElCom

Network extension projects
DSOs, Power Plant Operators, Consumers, Residents

Distributed Energy Production
DSOs, Consumers

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Challenges

Technical Interaction

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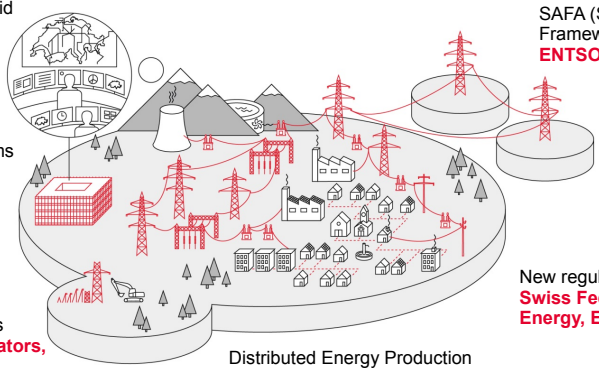

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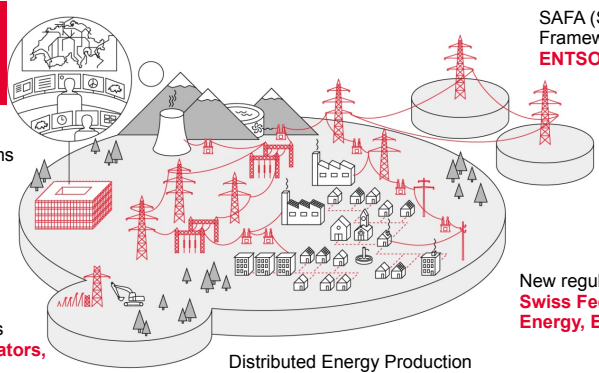

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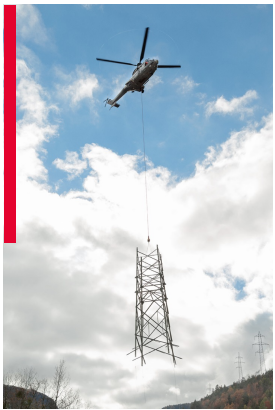
Agenda



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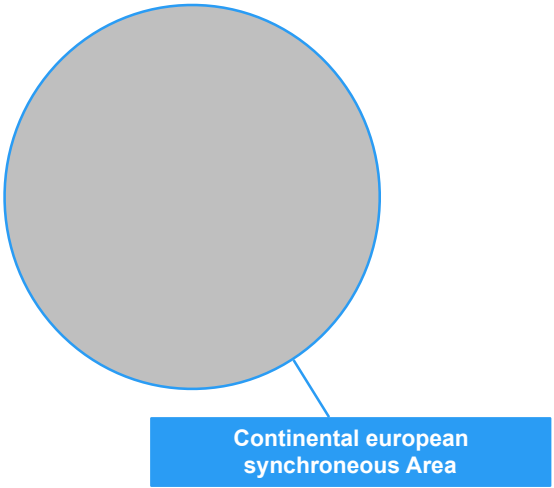
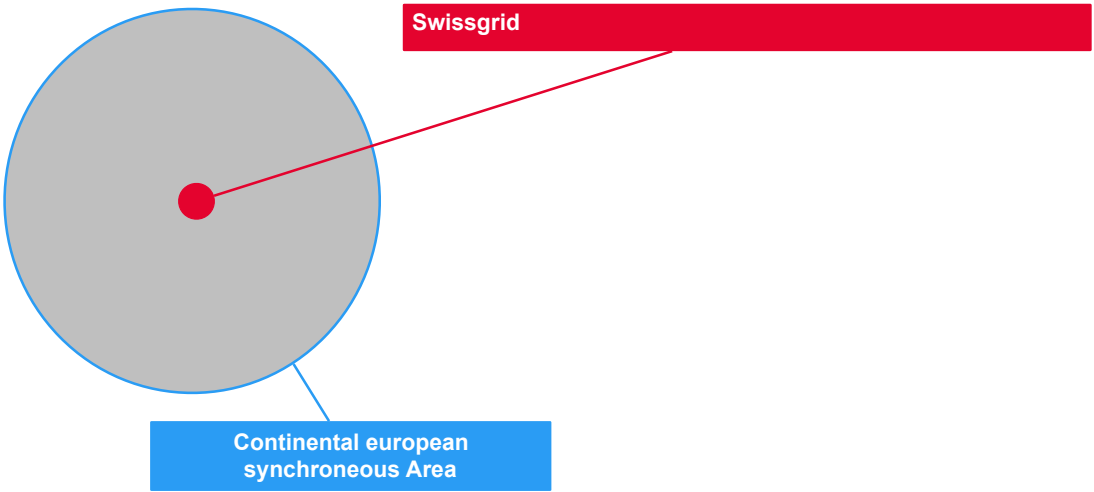
What is the Observability Area?



swissgrid

What is the Observability Area?



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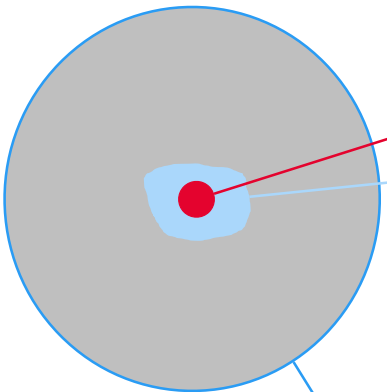

Swissgrid

Observability Area of Swissgrid

Foreign network elements and grid users with relevance for Swissgrid

Continental european synchroneous Area

swissgrid

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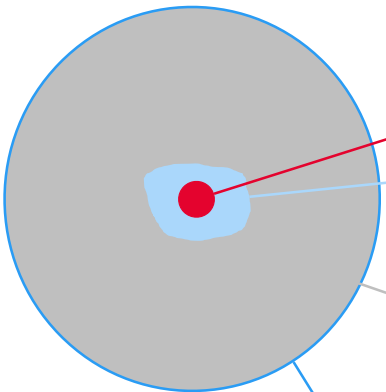


Swissgrid

Observability Area of Swissgrid

Foreign network elements and grid users with relevance for Swissgrid

Not observed grid

Foreign grid elements and grid users without relevance for Swissgrid

Continental european synchroneous Area

swissgrid

Observability Area: Information and Coordination

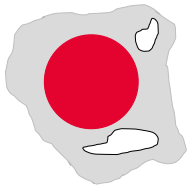
Own Grid
List of all network elements within Swissgrids responibility

swissgrid

Observability Area: Information and Coordination

Own Grid
List of all network elements within Swissgrids responibility

External list of contingency*)
- List of relevant network elements and significant grid users
- Coordination of outages
- Information of disturbances
- Grid modelling



swissgrid

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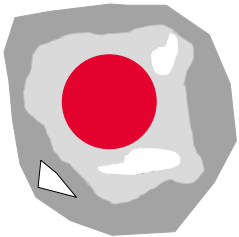

swissgrid

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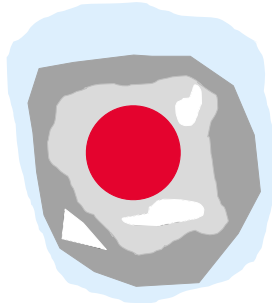
Enlarged external grid*)
- List of relevant external network elements and grid users
- Completing the grid model



swissgrid

Observability Area: Information and Coordination

Own Grid
List of all network elements within Swissgrids responibility

External observability list
Coordination and information of availiability

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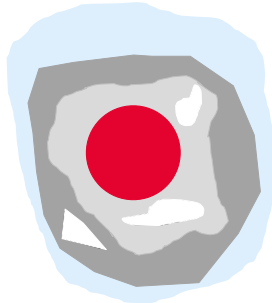

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Observability Area: Information and Coordination

Observability Area
for operational planning and system operations of the transmission system

Own Grid
List of all network elements within Swissgrids responibility

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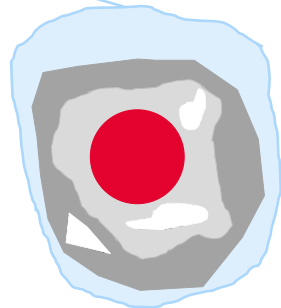
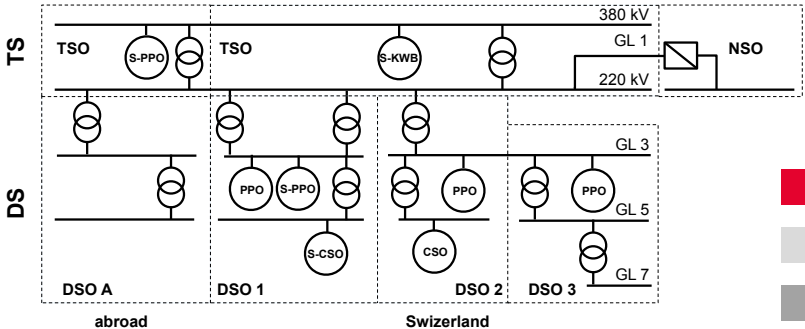


*) excluding all non-relevant network elements and grid users

swissgrid

Example of the Observability Area of Swissgrid



Swissgrid grid

External list of contingency

Informative external grid

Enlarged external grid

swissgrid

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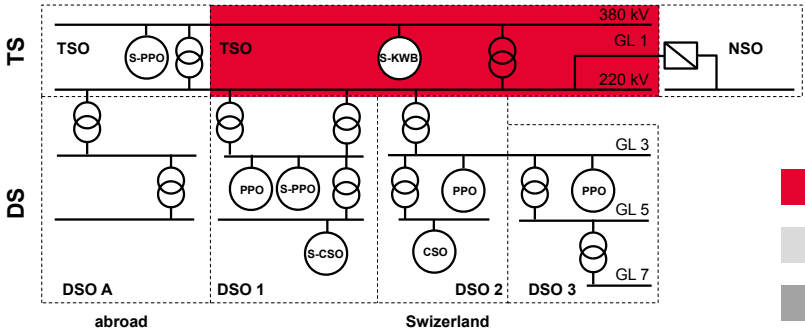

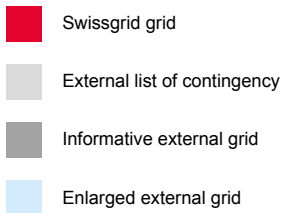

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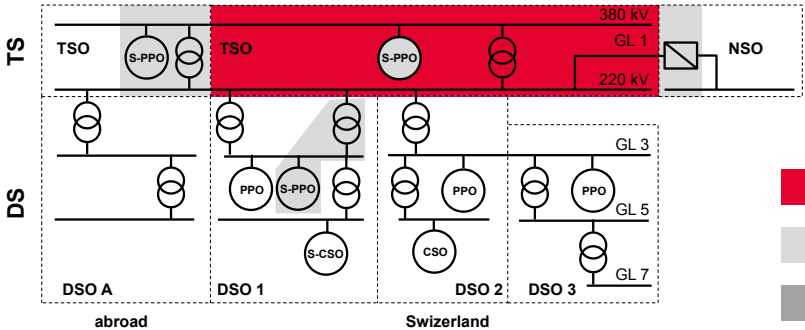

Swissgrid grid

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swissgrid

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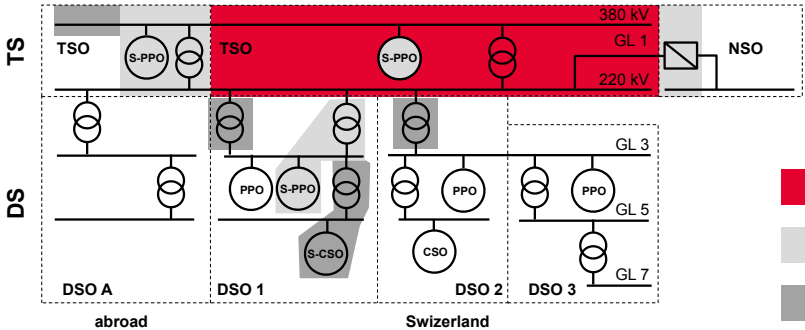

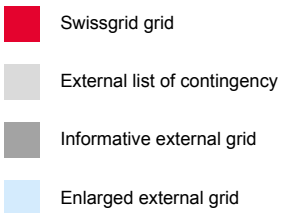

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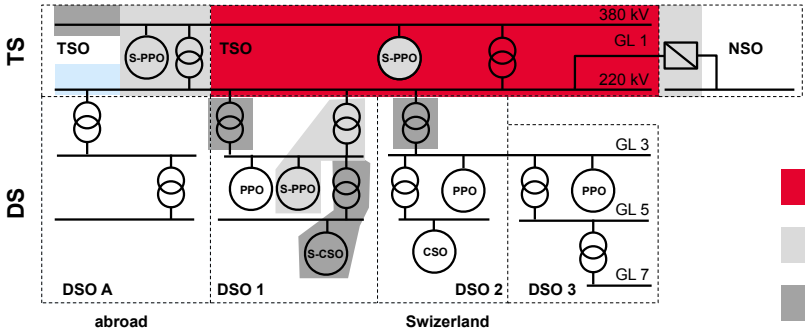

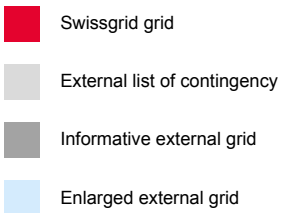

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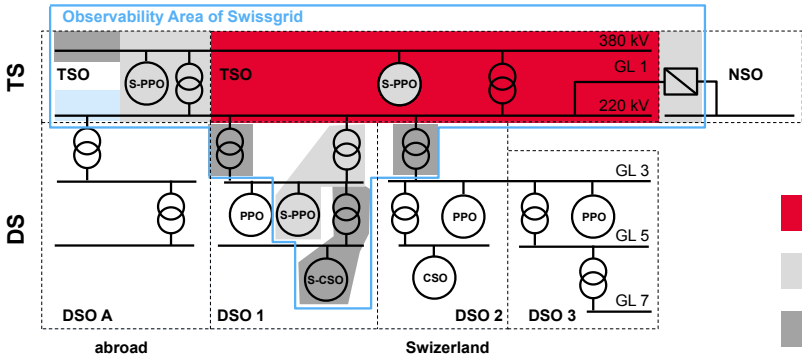


Swissgrid grid

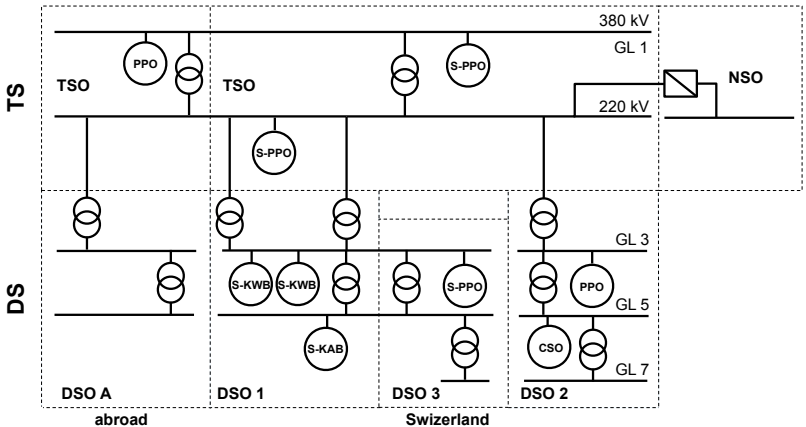
External list of contingency

Informative external grid

Enlarged external grid

swissgrid

Example of the Observability Area of a Swiss DSO Connected to Swissgrid



Distribution grid

External list of contingency

Informative external grid

Enlarged external grid

swissgrid

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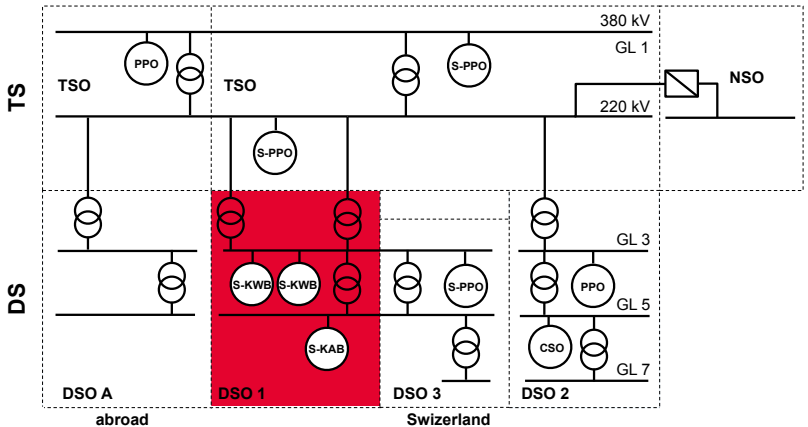

Distribution grid

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swissgrid

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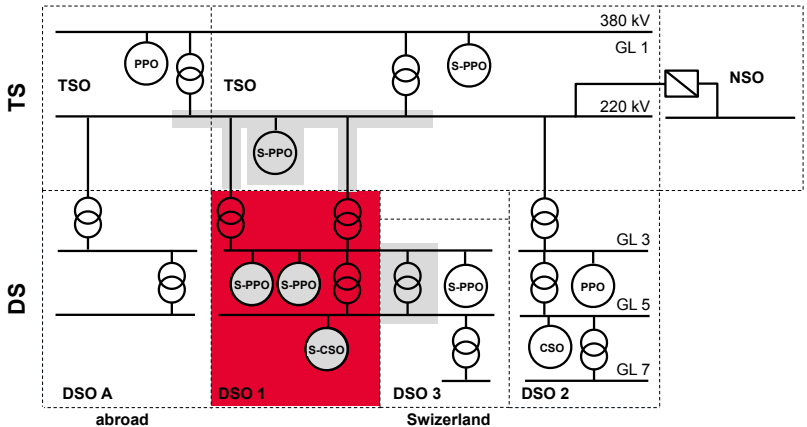

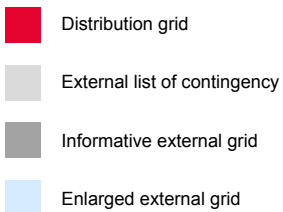

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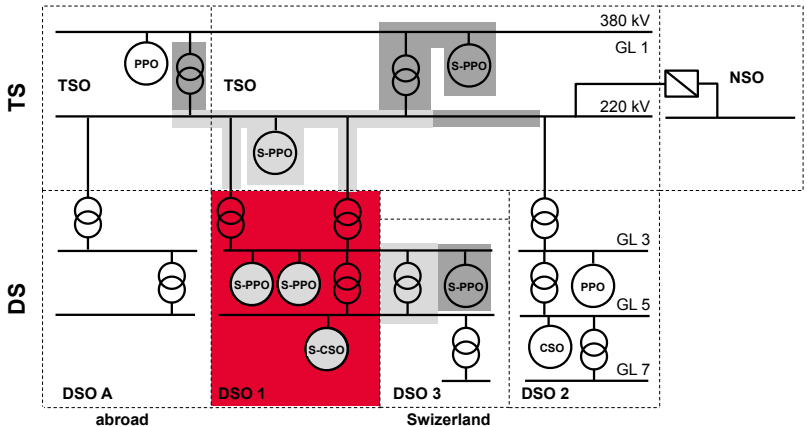

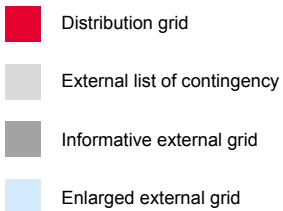

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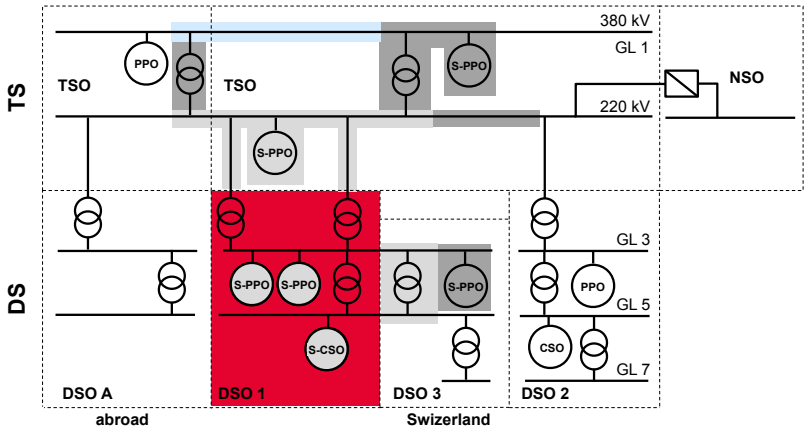

Distribution grid

External list of contingency

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swissgrid

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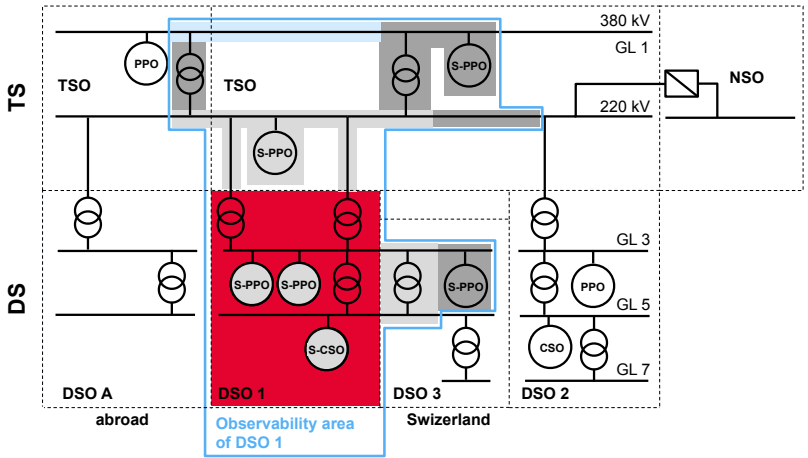

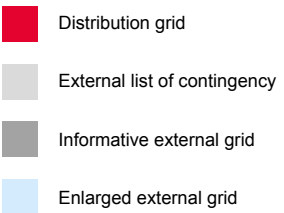

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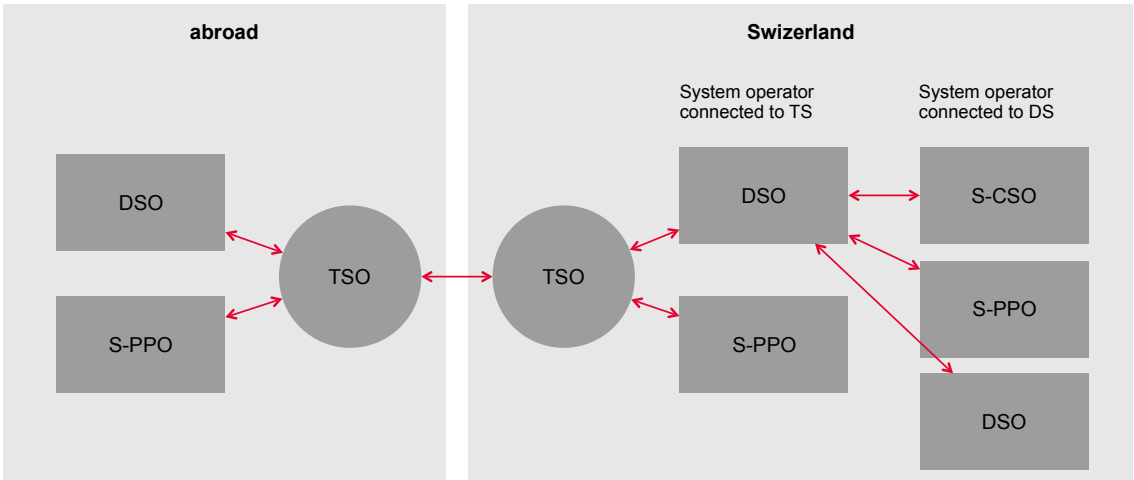
Data Exchange Within the Observability Area



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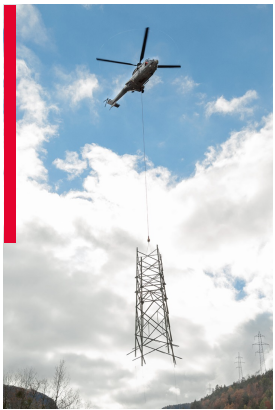
Agenda



1. Challenges
2. Technical Interaction
3. Stakeholder Interaction
4. Conclusion

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New remuneration scheme

Operational Challenge

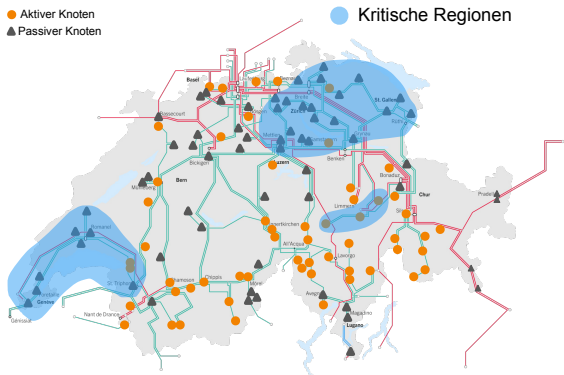
- Increase of high voltages and voltage violations in
  - regions of high loads (Zurich / Geneva)
  - Low load areas (Surselva)

Reasons

- Not enough controllable reactive power resources due to
  - Low line loading because pump storage power plants are not available for voltage control
  - DSO changed their reactive power exchange behaviour from balanced exchange to mostly capacitive exchange due to increased cables and renewables

Action

- New remuneration scheme with incentives for DSO to exchange reactive power supporting the voltage



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Ambitious Project Plan

- **Project Start:** Q1 2017
- **Go Live:** January 1st 2020

Challenges:

- Create a new concept which is accepted by the industry
- Get approval of the regulator
- Change all voltage related contracts with the industry
- Change all related IT systems and internal processes
- Adapt interaction with the industry according the new concept

Only way to success is a close interaction with the industry, i.e. the DSOs and power plant operators

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DSO – TSO Interaction

Working Group Voltage Control

- 2017 WG Voltage control was created
- DSOs as well as producers where invited, all large stakeholders are part of WG
- Involvement in the development of the new scheme as well as contracts

Public Consultations

- 2018: Public consultation about the new remuneration scheme. Feedback was mostly positive
- 2019: Public consultation of new operational agreement

National Regulator

- Coordination with ElCom and explaining the advantages of the new remuneration scheme

Contract Negotiations

- Incorporating feedback from the public consultation, the WG Voltage Control as well as direct feedback from the industry

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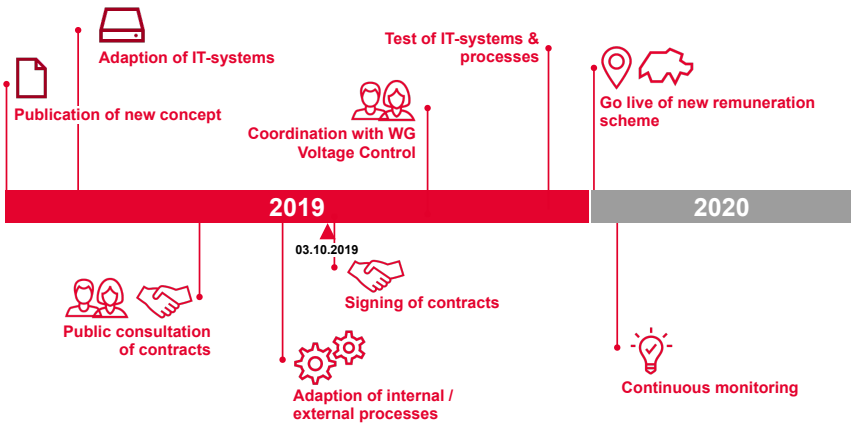
Project Roadmap



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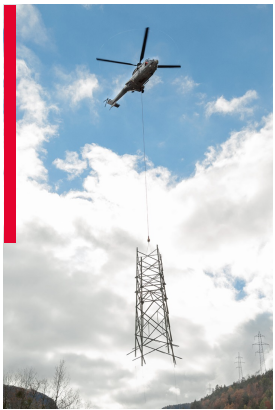
Agenda



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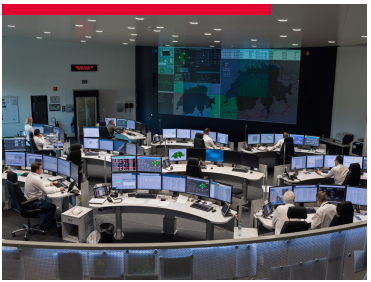
DSO-TSO Interaction

To ensure future power system development as well as future power systems operation DSO-TSO interaction is inevitable

DSO Involvement
Involvement of DSOs in new concepts and regulation from the very beginning

Technical Collaboration
Exchanging technical data with DSOs to ensure an safe and secure operation of the transmission system as well as the distribution system

Open Communication
Openly communicate about new regulations, new concepts and operational challanges



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Danke für Ihr Interesse

Swissgrid Ltd
Bleichemattstrasse 31
P.O. Box
5001 Aarau
Switzerland

swissgrid

Agenda

13:30 - 13:45 : Introduction

13:45 - 14:15 : An Overview of International Activities on TSO-DSO interaction

14:15 - 14:45 : Interaction of DSO and TSO requirements on Distribution Networks

14:45 - 15:15 : IEC 62559-2 Business Use Cases for TSO-DSO coordination

15:15 - 15:45 : Coffee break

15:45 - 16:15 : Smart begins in the heads

16:15 - 16:25 : TSO-DSO cooperation: Where we are at European level

16:25 - 16:45 : TSO-DSO Interaction - Inevitable for Future Power Systems Operation

16:45 - 17:15 : Ongoing Research Activities on TSO-DSO interaction

17:15 - 18:00 : Q/A in a panel

18:00 - 19:30 : Networking apèro

Dr. Alexander Fuchs

Research Center for Energy Networks

ISGAN
INTERNATIONAL SMART GRID ACTION NETWORK

Dr. Alexander Fuchs is a Senior Researcher with the Research Center for Energy Networks at ETH Zurich. At the interface between theory and application, he develops methods and software for the analys, planning and optimal operation of electricity grids. Topics of interest are the integration of renewable energy sources, storage and network security in transmission and distribution grids. His Phd work (2014) focused on the dynamic stability of the European transmission grid using HVDC links.

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Federal Office of Energy SFOE

ETH zürich

FEN
RESEARCH CENTER FOR ENERGY NETWORKS
FORSCHUNGSSTELLE ENERGIENETZE

TSO-DSO Interaction in Switzerland:

Future Tasks, Roles and Challenges

Dr. Alexander Fuchs
(ETH Zurich, Research Center for Energy Networks)

October 3rd, 2019

Agenda

Overview

Interviews

Reserve power from Distribution Grids

TSO-DSO Congestions and coordination

Topic and Goals

Analysis of the current and future interaction between TSO and DSOs in Switzerland.

- Swiss Electricity System: Structure and organization
- Direct collaboration with the TSO, DSOs and other participants
- Review of current coordination procedures and future roles
- Identification of potential congestions between participants and network levels
- Illustration with characteristic case studies
- Conclusion and recommendations to improve interaction

Projektphasen und Arbeitspakete

- Project *TSO-DSO Interaction* (2016-2018)
- Project phases:
  1. Literature review, data collection, interviews
  2. Case study on reserve power from distribution grids
  3. Case study on coordinated congestion management

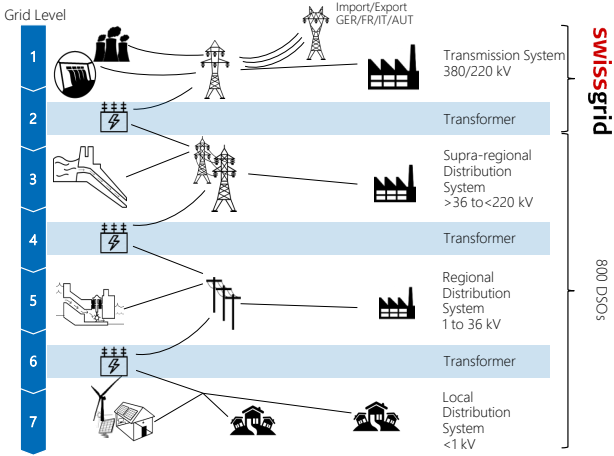
Agenda

Questions

What is the organizational interface between TSO and DSOs?

What areas of TSO-DSO Interaction are active in Switzerland?

Swiss Electricity Grid



- Meshed Network on grid levels 1 and 3
- Tree-shaped distribution grids on levels 5 and 7

Participants and responsibilities

- TSO (Swissgrid):
  - Planning and Operation of the Transmission Grid,
  - Ancillary services (frequency reserve)
  - Supervision of grid security
  - Manager of the Swiss control zone within ENTSO-E
  - Coordination with DSOs and balance groups
- DSOs:
  - Independent grid department (local monopoly)
  - Independent utility/energy supply departments (actor on the energy market, monopoly to supply small customers)
  - Planning and secure operation of the distribution grid.
- Power plant operators: Part of a utility or independent

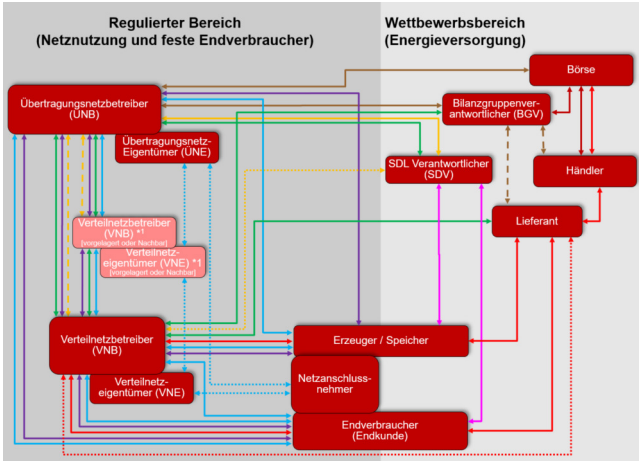
Participants and responsibilities

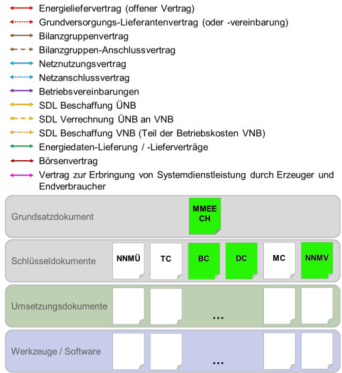
- Customers: Grid connection through local DSO (obligation)
  - below 100 MWh/a energy from DSO to fixed tariff (This restriction should be lowered or abandoned soon).
  - above 100 MWh/a free access to energy market.
- Balance Groups:
  - Assignment of all grid connections into groups (not necessarily geographically connected)
  - Act like small control zones for balancing the power schedule of all participants
  - Balance group manager reports to Swissgrid.
- Ancillary Service Provider, Aggregator:
  - Interaction with all participants
  - Example: aggregator of reserve power from customers and power plants for the TSO

Participants and responsibilities

- ElCom: State agency, supervision of monopolies and network tariffs.
- SFOE: State agency
  - interface to the policy makers and the parlament
  - development of new policy directions, coordination of state-funded research activities

Organization: Contracts (many), technical agreements





Overall 10'000s of pages of paper...

TSO-DSO Interaction: example Balancing

- Starting point ISGAN report 2014:
  Overview of international TSO-DSO Interaction.
- Balancing covers scheduling within balance groups, reserve power and redispatch
- Examplex:
  - Belgium: DSO-customers offer TSO their flexibility. Available flexibility and network capacity is determined through metering and communicated to the TSO in real-time.
  - Ireland: TSO has full responsibility for balancing the overall network (no balance groups)
  - Canada: DSO reduces load following a signal to make room for more export towards the South
  - Switzerland: Aggregated reserve power possible, no integrated coordination between TSO, DSO and customers

TSO-DSO Interaction: more Examples

- Congestion Transmission Grid:
  - Hierarchical load shedding of DSO following TSO signal (Ireland)
  - Flexibility of renewables in the distribution grid (France , Belgium, planned)
- Voltage support
  - Reactive power compensation of DSO following TSO signal (USA)
  - Cooperation of the grid control rooms of TSO and DSO for voltage support (South-Afrika)

Future:

- Relieve TSO-DSO Trafo with DSO flexibility
- DSO-Support for Anti-Islanding and Black-Start
- Coordinated protection and fault localization

Summary

- For identified repeating issues (planned outage, construction) fixed procedures for TSO-DSO Interaction
- Overall, interaction usually only when absolutely required
- Many ideas for future interaction, possible potentials
- International pilot projects, no coherent picture

Agenda

Questions

What is the current situation of TSO-DSO Interaction in Switzerland?

What are open questions and areas requiring further investigation?

Interviews with Swiss Electricity system participants

- Interviews with ABB, Alpiq, SFOE, EKZ, EPFL, EWZ (3), Swisscom, Swissgrid (3), VSE
- Structure of the questions like survey from ISGAN-working group TSO-DSO
- Identification of key questions
- Further investigation of 2 key topics in case studies

1. Congestion at TSO-DSO interface

- Swissgrid and DSO supervise interface (Trafos)
- Partial information exchange between Swissgrid and DSO
- Possible identification of N-1 violations by estimating the trafo flows day-ahead
- Coordination of service and construction
- Little informations at Swissgrid and DSO about the network situation of one another

How could Swissgrid and a DSO profit from a better information exchange?

2. Congestion in the TSO Network

- Classical Redispatch situation
- Occasionally Swissgrid asks DSOs to change their trafo settings
- Integrated market for nodal redispatch is planned (potential for DSO)
- Possible future auctioning of critical line capacities within Switzerland (risk for DSO for balancing between areas)

Can a DSO help with congestions in the TSO network (redispatch, meshed DSO grid)?

3. Balancing and reserve power

- Aggregation of reserve power can lead to congestions in distribution grids.
- Example solution: Veto or traffic light system from DSO.
- Future finer granularity of reserve products procured by Swissgrid:
  - Shorter time horizons
  - Locational reserves
  - Smaller minimum power requirements

  $\rightarrow$ opportunity for DSO customers
- Security of the distribution grid must remain ensured
- some measure helping the TSO harm the DSO

What is the structure of an integrated TSO/DSO/Customer-Reservemarket?

What are the useful levels of communication between the participants?

Further topics from interviews

Estimated added value of TSO-DSO-interaction for ...

4. Voltage support: unclear, rather small
5. Blackstart, Synchronisation, Anti-Islanding: possibly long-term
6. Coordinated protection: rather small
7. Dynamic grid stability: possible in the future
8. Further aspects: Integrated grid security for TSO and DSO on different time scales (intra-day, day-ahead, ..., seasonal).

All new ancillary services need to be harmonized with regulatory aspects.

Summary

- Current TSO-DSO interaction is perceived as sufficient
- New potentials of increased interaction are expected (economic, security related)
- Core questions for case studies:
  1. *Use of aggregated reserve power from the distribution grid.*
  2. *TSO-DSO coordination for congestion management.*
- Partners for case study: Swissgrid and EWZ

Agenda

Overview

Interviews

Reserve power from Distribution Grids

TSO-DSO Congestions and coordination

Questions

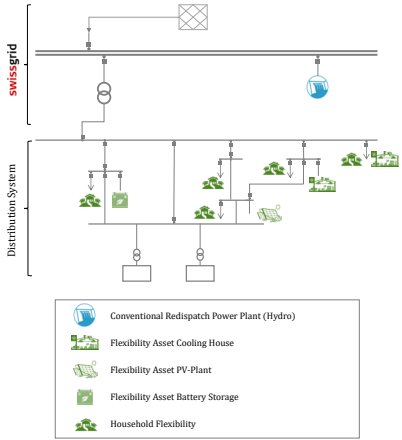
How can an integrated reserve power system take into account TSO, DSO and customers?

What levels of communication between are useful?

Case study 1: Reserve power from Distribution Grids

- Due to power size ($>$1MW or $>$5MW) mainly from hydro power.
- Customer of distribution grids take part in primary and secondary reserve power.
- Problem for DSOs:
  - Sudden power jumps and peaks
  - Load estimation for scheduling more difficult, uncertainty
  - Impact on network tariffs and balance groups?
- Increased coordination between TSO, DSO and customer desireable

Example for reserve power and coordination



- Distribution grid (part of city of Zurich)
- Increased time profiles for loads and PV-sources
- Flexible units with different flexibility costs: cool-house, PV-sources (negative), battery, diesel units, households

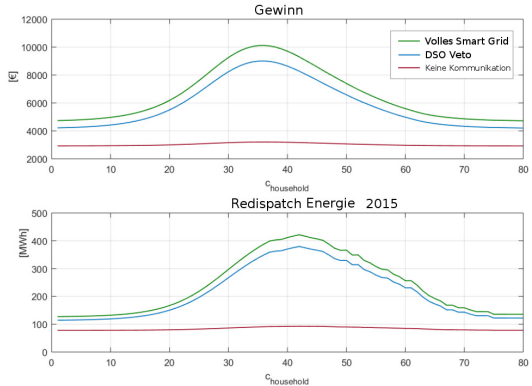
Example for reserve power and coordination

Procurement of reserve power from distribution grids possible, but:

- Procured Reserve power must always be available
- Capacity of the distribution grid could be limited
- Either conservative planning or partial coordination between TSO, DSO and customers (aggregators)

→ Illustration with Time series for Redispatch 2015

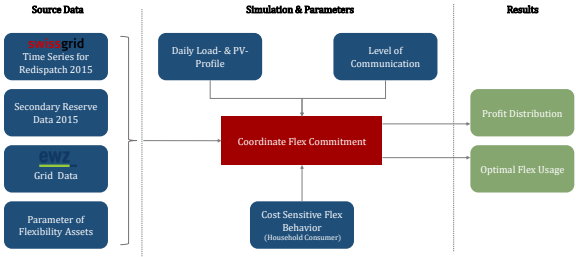
DSO limits and coordination levels (Example Redispatch 2015)



1. Full Smart Grid: Optimal coordination of flexibility the DSO
2. Decentralized control: DSO gives Veto if any limits are violated
3. No communication: Worst-case flexibility limits, conservative

Veto of DSO allows almost as much flexibility as full coordination.

Outlook to integrated reserve system (example illustration)



- Added value through communicated and coordination with DSO when distribution grid is limiting
- Smaller time granularity for secondary reserve enables assets from distribution grid to participate despite temporary congestions.
- Signal-based Redispatch und reserves to relieve local congestions

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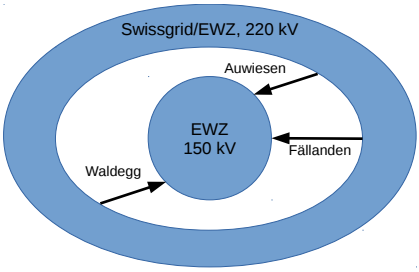
Case study 2: TSO-DSO Congestions and coordination



- Example: 150kV-EWZ-Network (city of Zurich)

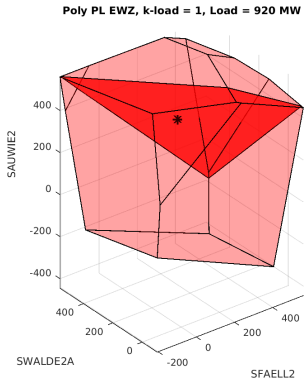
- Background: Meshed TSO-DSO grid. Are there congestions and added value from coordination?
- 3 trafos (with phase shifters) are the interface between TSO and DSO
- Levels of coordination between TSO and DSO
  - No exchange
  - Exchange of network model
  - Coordinated control of the 3 trafos

Method

1. Analysis of the isolated DSO network
2. Analysis of hte coupled TSO-DSO network with increasing information exchange
   - Isolated TSO grid
   - Operation with model exchange
   - Coordinated trafo operation
3. Comparison of the added value from the interaction

Isolated DSO network

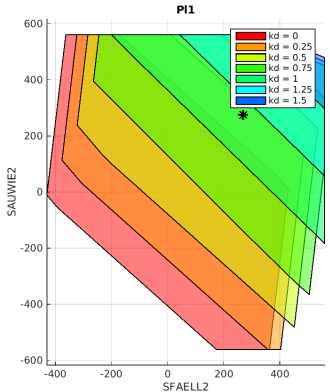
- Analyse limitation on power flow through trafos
- (optimistic) estimation of the available trafo capacity in the DSO network
- For the TSO: How much transit power can the DSO take?
- For the DSO: Impact of TSO actions and global power flows on the DSO grid.



DSO grid: Available trafo capacity and operating surface

Lastabhängigkeit der Betriebsfläche

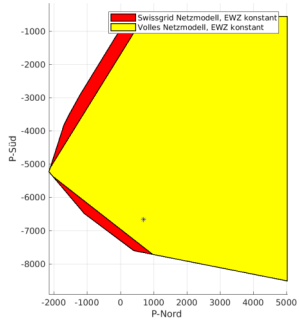
- Analyse of maximum transit flow in certain direction
- Actual operating surface smaller (controllability of trafo, TSO limitations)
- Higher DSO security and flexibility when the coupling between TSO and DSO is considered

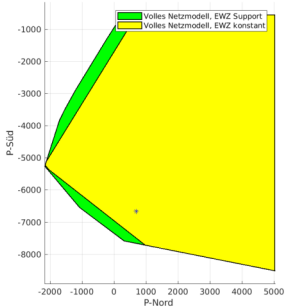


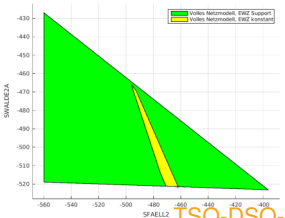
DSO grid: Available trafo capacity and operating surface for different loads

TSO isolated, DSO-coupling und DSO-support

Transit North-South Transit North-South DSO trafos





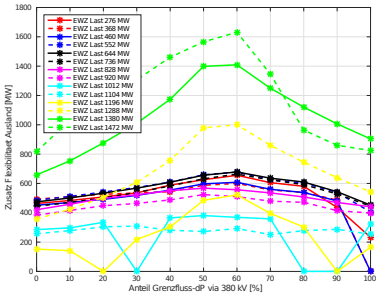


TSO-DSO-coupling

limits the available range. Without coupling risk of unsecure grid states. The flexibility can be recovered with DSO-support via the trafo settings.

(DSO-Load 1472MW, Transit flows 60% over 380kV, 40% over 220kV)

Added value from trafo coordination



- Additional transit flow through Switzerland (buy cheap in Germany, sell higher in Italy)
- Variation of DSO-load and voltage distribution at the boundary
- No (N-0) congestions in the TSO or DSO network
- More flexibility (about 500MW) through coordination
- Communication of individual aggregated parameters for network and trafos sufficient

- Physical power flow couples the networks in any case.
- Coordination improves security, flexibility and scheduling.

Summary

- Small steps changes required to increase collaboration
- Continuing investigations for Switzerland:
  - Implementation of short term TSO-DSO coordination: Similar problem of Swissgrid (TSO) with different DSOs
  - Study on TSO-DSO interaction, expansion of case study 2 (voltage, congestion, security)
  - Analysis of tariff systems

Thank you for your attention!

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13:30 - 13:45 : Introduction

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14:15 - 14:45 : Interaction of DSO and TSO requirements on Distribution Networks

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15:15 - 15:45 : Coffee break

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16:15 - 16:25 : TSO-DSO cooperation: Where we are at European level

16:25 - 16:45 : TSO-DSO Interaction - Inevitable for Future Power Systems Operation

16:45 - 17:15 : Ongoing Research Activities on TSO-DSO interaction

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