Digitalization and the Energy Transition, 3rd Year Study

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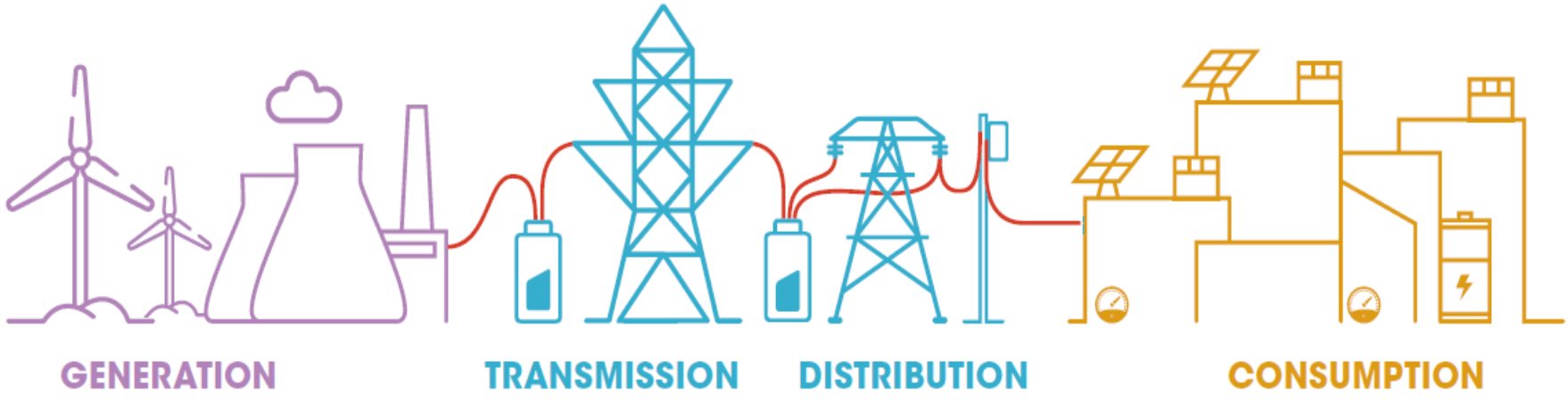
Use of digitalization to optimize grid operation utilizing AI and Big Data collected from DERs (distributed energy resources)

Conceptual background

Functions of grid and flexibility operation needed to avoid congestion/bottlenecks



1 Improved wind and solar generation forecast

2 Maintain grid stability and reliability

3 Improved demand forecast

4 + management/ curtailment of RES

4 Efficient demand-side management

5 Optimised energy storage operation

6 Optimised market design and operation

Source: IRENA (2019) with own adaptation

Conceptual background

Functions of grid and flexibility operation needed to avoid congestion/bottlenecks

Functions for the use of flexibilities from DERs for grid stabilization:

- **Technical functions** include **forecasting** (weather, demand, VRE generation, grid status), **monitoring** of grid status, **control of DERs,** and **metering**
- **Economic functions** include the **design, installation and operation of flexibility markets or incentive programs;** and for their operation, the **offer and selection or activation of flexibilities** in these markets or following these incentives; and the **billing** of the flexibilities used

Conceptual background

Uses of digital technologies in relation to functions of grid and flexibility operation needed to avoid congestion/bottlenecks

Uses of digital technologies	Functions of grid and flexibility operation needed to avoid congestion/bottlenecks
Both **IoT** (collect smart meter data as well as generation and weather data) and **AI** (recognize patterns and improve forecasts)	- Improved demand forecast - Improved wind and solar generation forecast (possibly also physical approaches)
IoT (1. collect status data from grid components, 2. Smart meters at DERs and safe data transmission, 3. in case of DERs, activate changes in operation, if these can be activated automatically; otherwise, safe and reliable control data transmission to decision-makers)	- Monitoring the status of the grid - Smart Metering and data transmission - Control of DERs: efficient demand-side and solar and wind generation management; optimized operation of energy storage and further flexibilities
AI (develop grid models able to integrate and assess demand, generation, and grid status data and to calculate trends and forecast risks of congestion)	- Maintaining grid stability and reliability
AI and other software: Server infrastructure and software for optimized market operation	- Optimized market design and operation
AI for offer/selection: Protocols or smart contracts and software for offer, selection, and activation of flexibilities	- Offer and selection or activation of flexibilities
Software (e.g., blockchain) for billing	- Billing

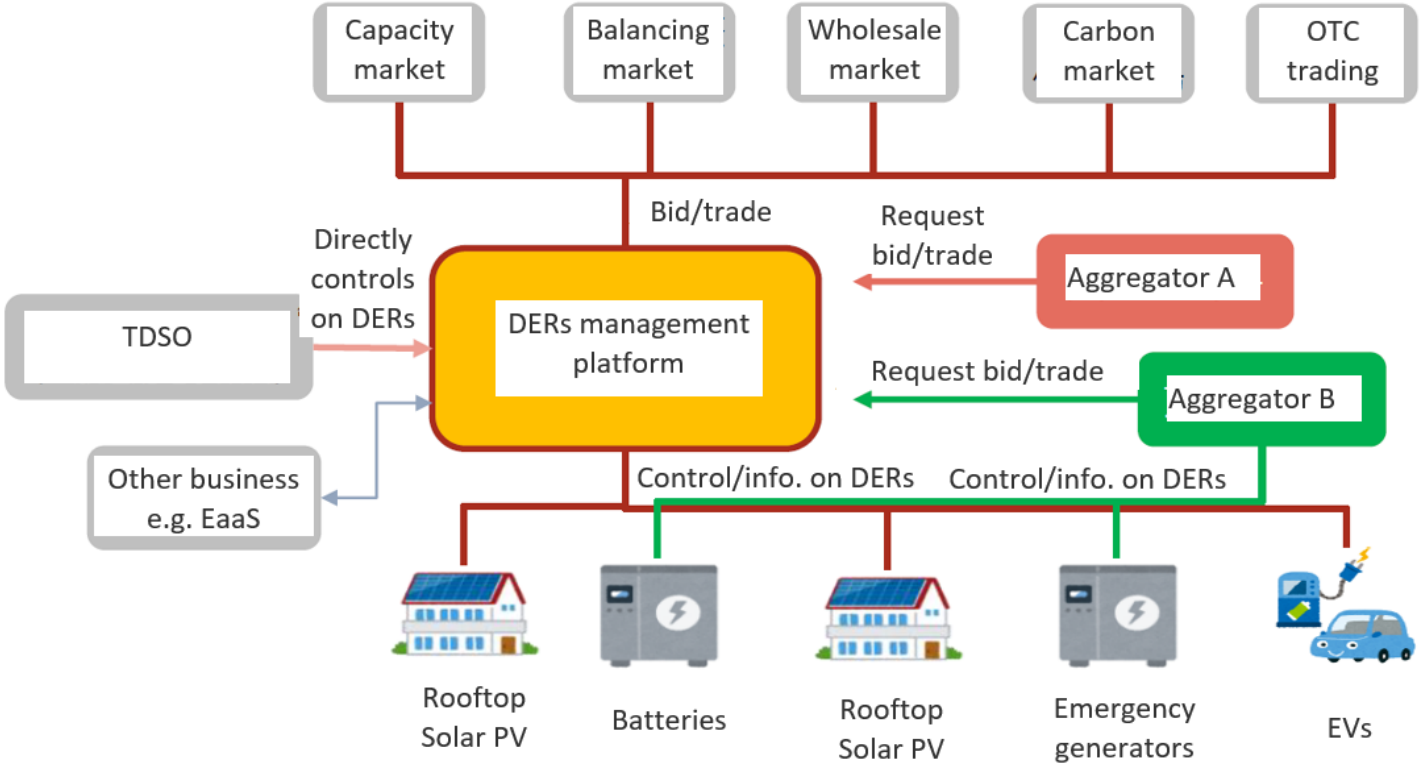
Conceptual background

Roles of DSOs, TSOs, DSO/TSO interconnection, DER owners, aggregators and other relevant third parties in relation to functions

Roles of actors / Functions needed	Consumers	Generators	TSOs/ DSOs	Aggregators	Suppliers	(Flexible) DER owners	Smart meter operators	Market operators
Improved demand forecast	X	X	X	X	X			
Improved wind and solar generation forecast		X	X	X	X	X		
Monitoring the status of the grid			X					
Maintaining grid stability and reliability			X					
Control of DERs			X	X		X		
Smart Metering							X	
Optimized market design and operation			X					X
Offer and selection or activation of flexibilities in markets			X	X	X	X		X
Billing			X	X	X	X		X

Digital business models in Japan

- **DERs management platform** is the core element of the model currently tested
  - All relevant information on DERs, monitored via **IoT embedded in each DER**, is collected intensively
  - **TDSOs control the flexibility** of DERs using the DER management platform with AI to manage their grid operation, particularly elimination of grid congestion
  - A **demonstration project** was just launched (TEPCO TDSO); no tangible results are given to date

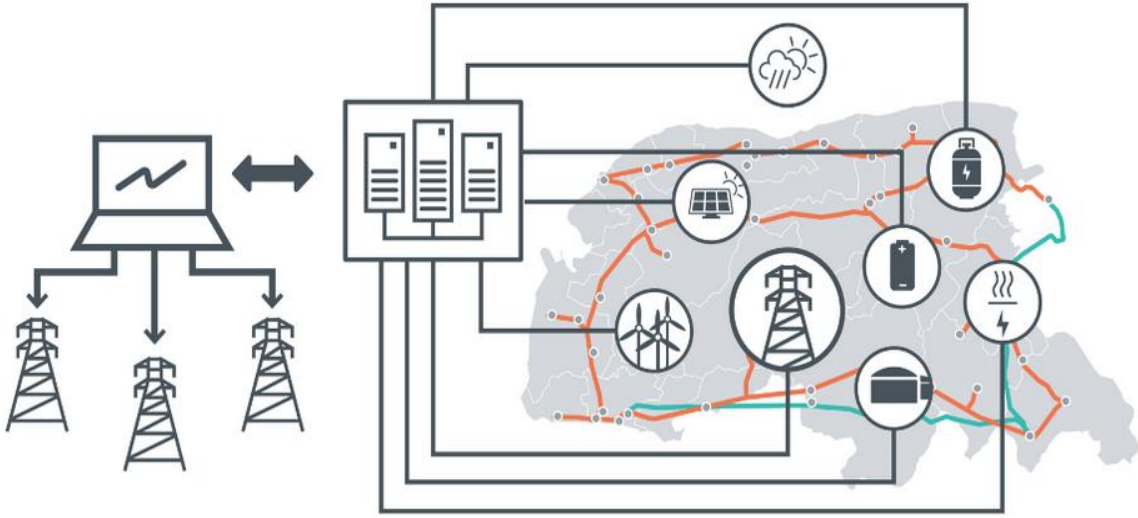


- The functions of the DERs management platform are:
  1. Resource monitoring and selection/grid management, 2. Resource procurement,
  3. Resource control (activation)/management

Digital business models in Germany

Monitoring and maintaining of grid status/smart grids, enera project

- **SINTEG showcase** in the Northwest of Germany
- **Simulation platform**: evaluation of flexibility potentials, development of operating scenarios and future scenarios of the network
- **Models** of high-voltage level of the electrical distribution grid and the energy conversion units that are connected to this grid



Source: enera (2020)

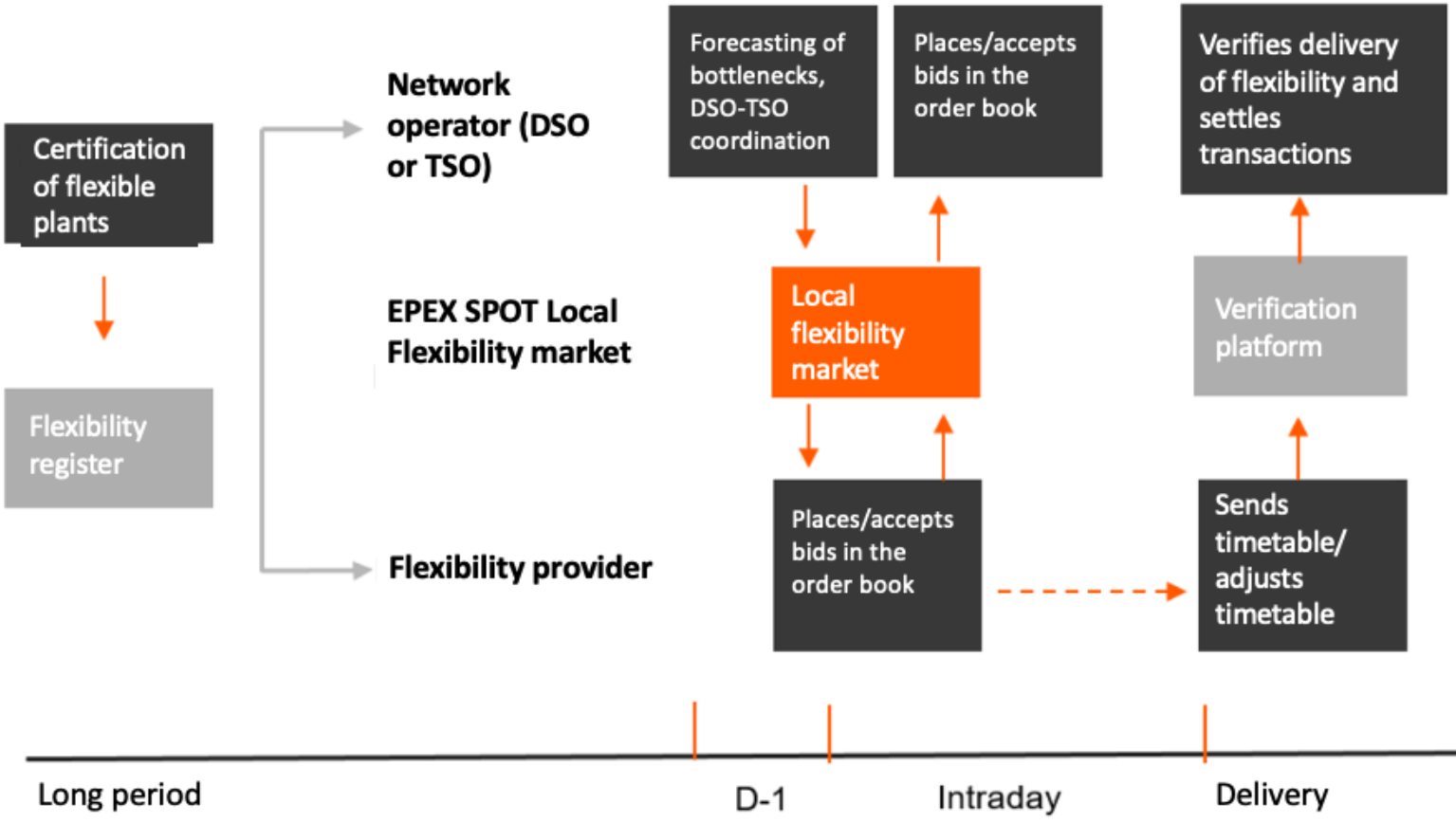
Crucial elements:

- Time- and location-resolved quantification of the flexibility *demand*
- Determination of the flexibility *potential* of decentralized energy conversion units (DERs and transformers)
- Scenarios for the analysis of the future grid-serving flexibility demand

Digital business models in Germany

Regional flexibility markets and platforms, enera project

- **Regulatory experiment**/SINTEG showcase
- **Flexibility providers as active participants** in the energy system provide local flexibility with their generation and consumption plants as well as storage facilities
- **Demonstration phase** with six flexibility providers, two DSOs, one TSO, over 4,000 orders sent and 130 calls completed

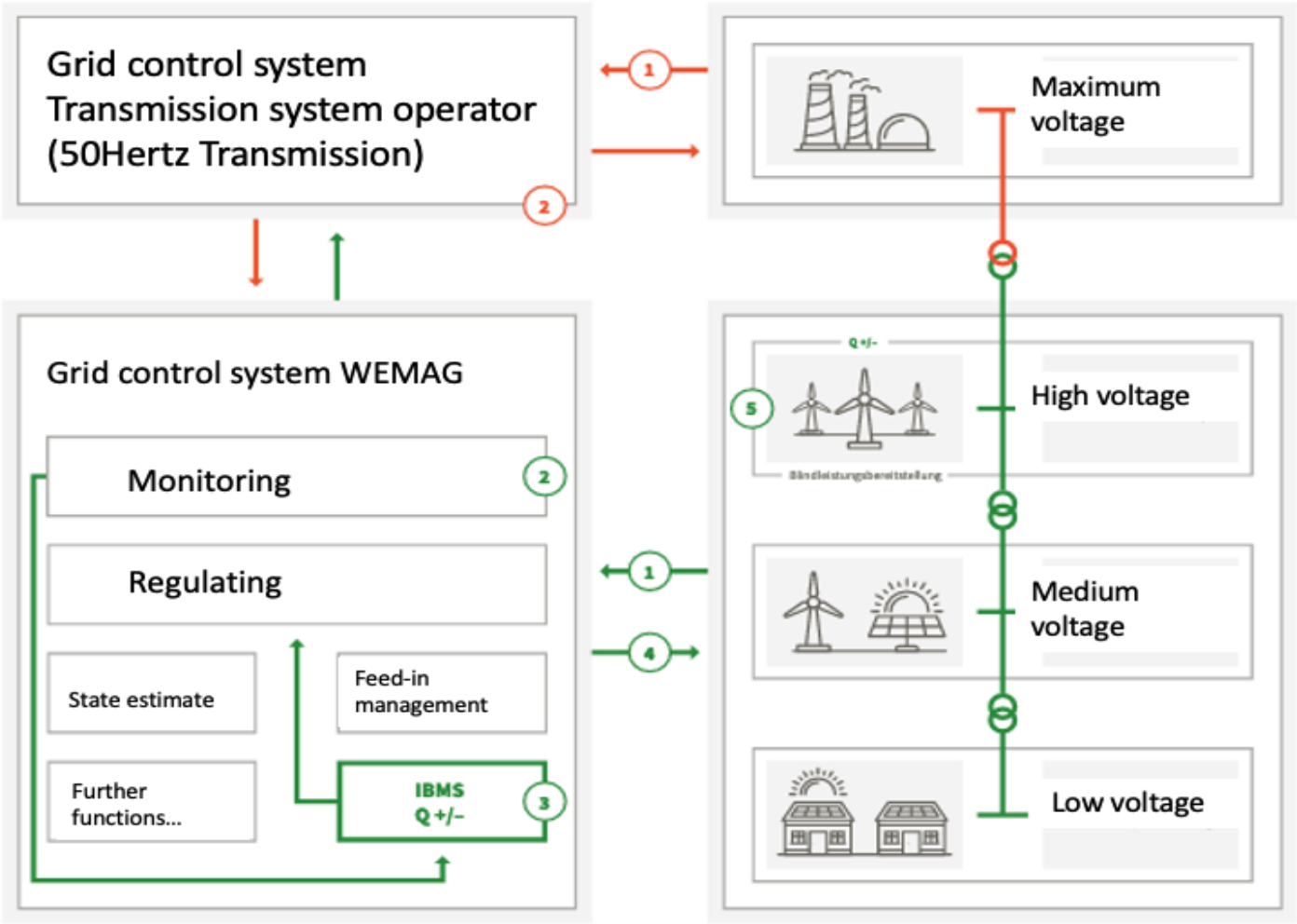


Source: enera (2020b)

Digital business models Germany

Controlling of DERs by DSO WEMAG, Windnode showcase

- **Control options** for wind and PV plants directly from the control system
- **(Automatic) provision of reactive power** by reactive power management system (IBMS)



1. Monitoring of network operation
2. Determination of requirements for reactive power control from the distribution and transmission network
3. Continuous calculation of reactive power potentials per generation plant
4. Transmission of control specifications to generation plants in the high-voltage grid
5. Reactive power provision in the high-voltage grid by individual plants

Source: Windnode (2020)

Discussion of use cases and business/market models identified

- For the establishment of a smart grid, **optimized demand and supply forecasts** are absolutely necessary
- **Monitoring of grid status and the forecast of (near) critical status** needs to be advanced
- **Use and control of DERs** for flexibility needs to be advanced as well
- **Regulatory environment** for using DERs would need to be created or improved in Germany and Japan
- Further investigation needed, at which **scale the optimization of the grid** should happen

Recommendations on policies and regulations for Germany

- **Create or improve regulatory environment** for using DERs for grid stabilization; determine if 1) via price signals, and then a) via control by DER owners, or b) via control by the DSO? Or 2) via a local/regional flexibility market
- **Determine scale of implementation and role of DSOs / coordination with TSOs**

For example, further suggestions by SINTEG project C/sells:

- **Simplify market access for small plants and open up new opportunities for action**
- **Design the system of levies, charges and fees** in such a way that a systemically reasonable, interference-free integration of flexibility is made possible and incentives are created for grid-serving behavior
- **Commission area-wide flexibility potential and feasibility analysis and a further roadmap**
- **Develop standardization of interfaces and processes as well as labels** for smart, sustainable buildings and factories with a standardized smart grids interface, making the gateways a safe communication and control component.

Recommendations on policies and regulations for Japan

- May be premature to suggest any recommendations on policy and regulation at this stage since no results have been given yet
- Lesson learnt from the experiences in Germany could be applied to Japan as well
- Despite the main focus of the demonstration project is extensively on the technical aspects of the functions of the DERs management platform, Germany's experiences highlight the importance of consideration on the economic aspects of utilization of DERs, such as the regulatory environment for utilizing DERs via price and realization of local/regional flexibility markets
- In a similar context, the experiences in Germany also indicate that a reform of the existing regulatory framework may be necessary in Japan for full use of DERs as flexibility resources by grid operators

Thank you for your attention!

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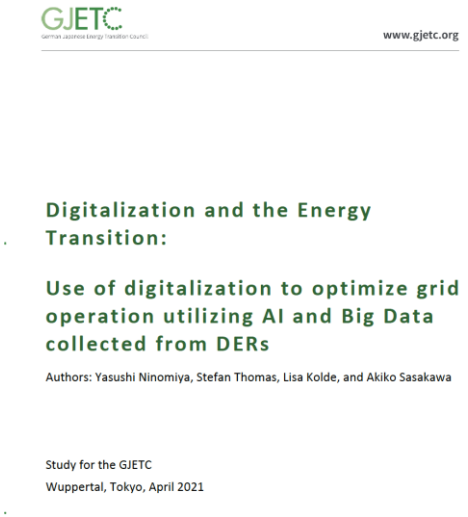
The Institute of Energy Economics, Japan



Find the study at: http://www.gjetc.org/publications/