

Ancillary services in the distribution network: Where are the opportunities?

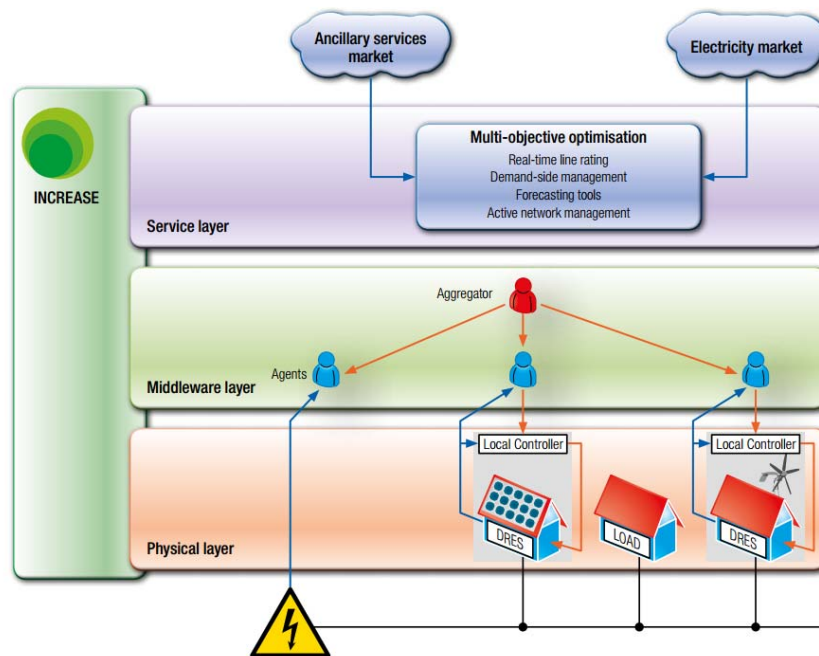
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Assoc. Prof. Andrej Gubina
Head, Laboratory of Energy Policy
Faculty of Electrical Engineering
University of Ljubljana, Slovenia



- Title: Increasing the penetration of renewable energy sources in the distribution grid by developing control strategies and using ancillary services
- FP7, Integrated Project with 10 partners, 5 countries



Austria

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www.joanneum.at
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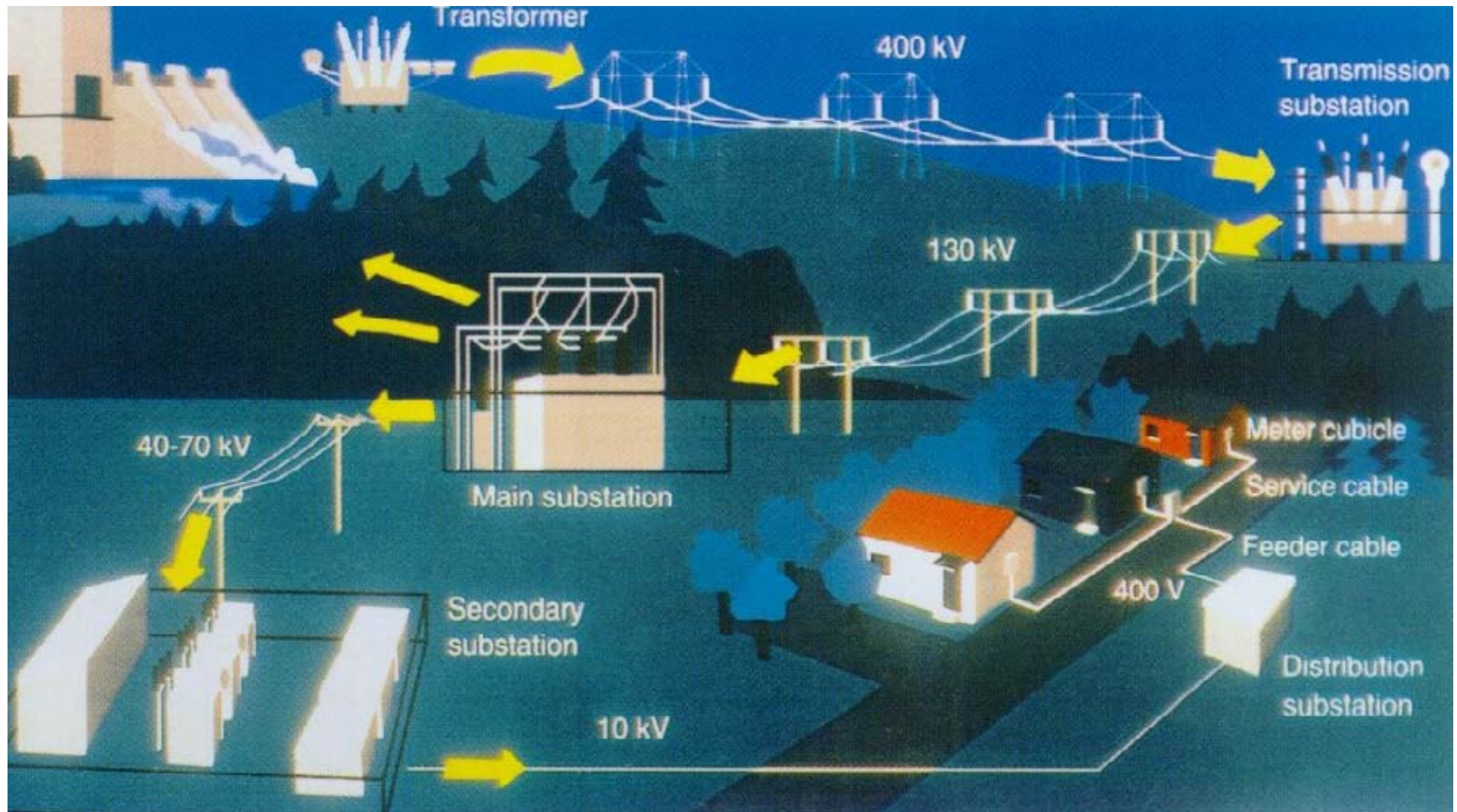
Slovenia

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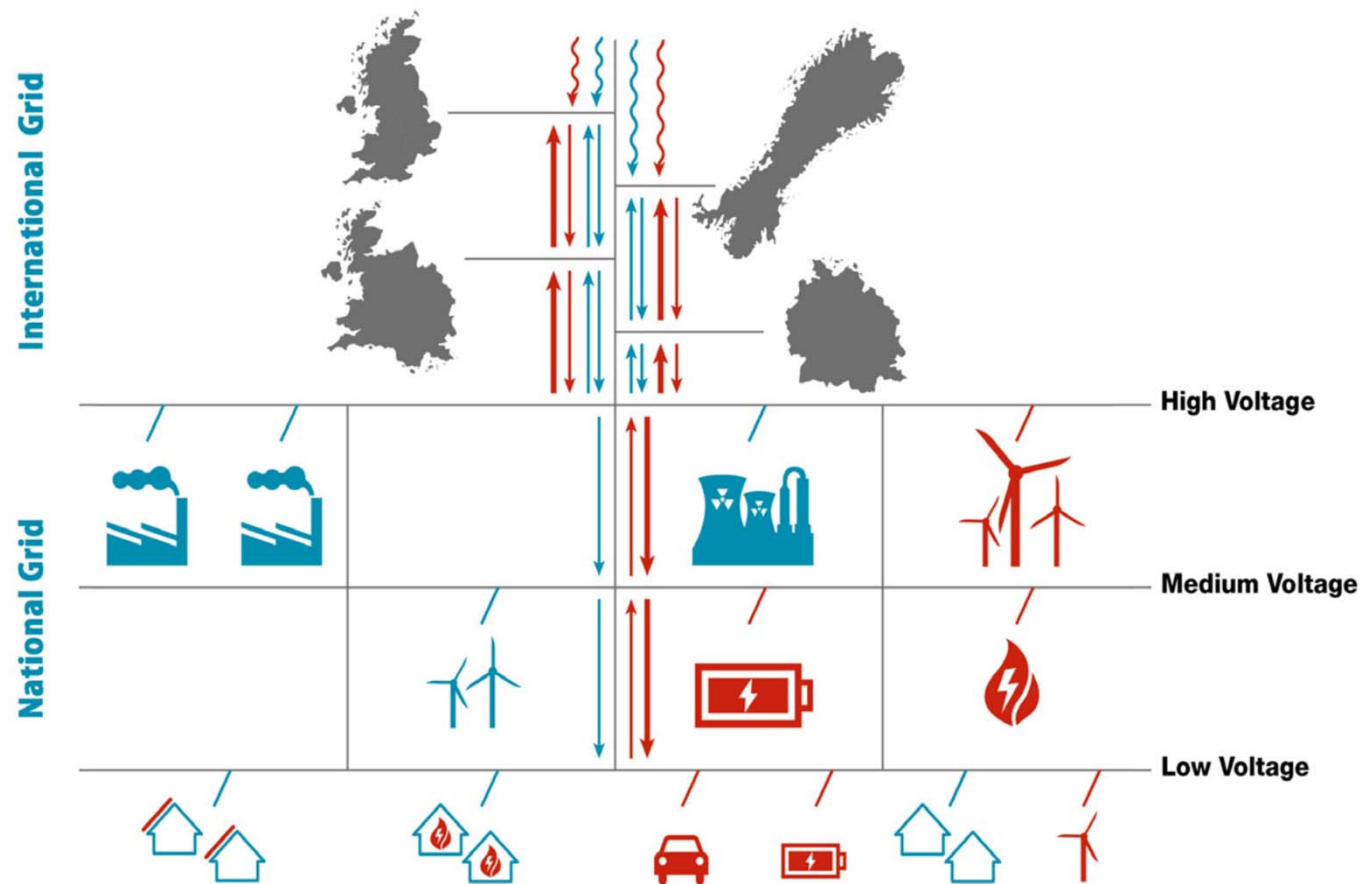
1. Power system deregulation and markets
2. Market roles
3. Ancillary Services: definitions
4. Ancillary Services in distribution system

Electric Power System

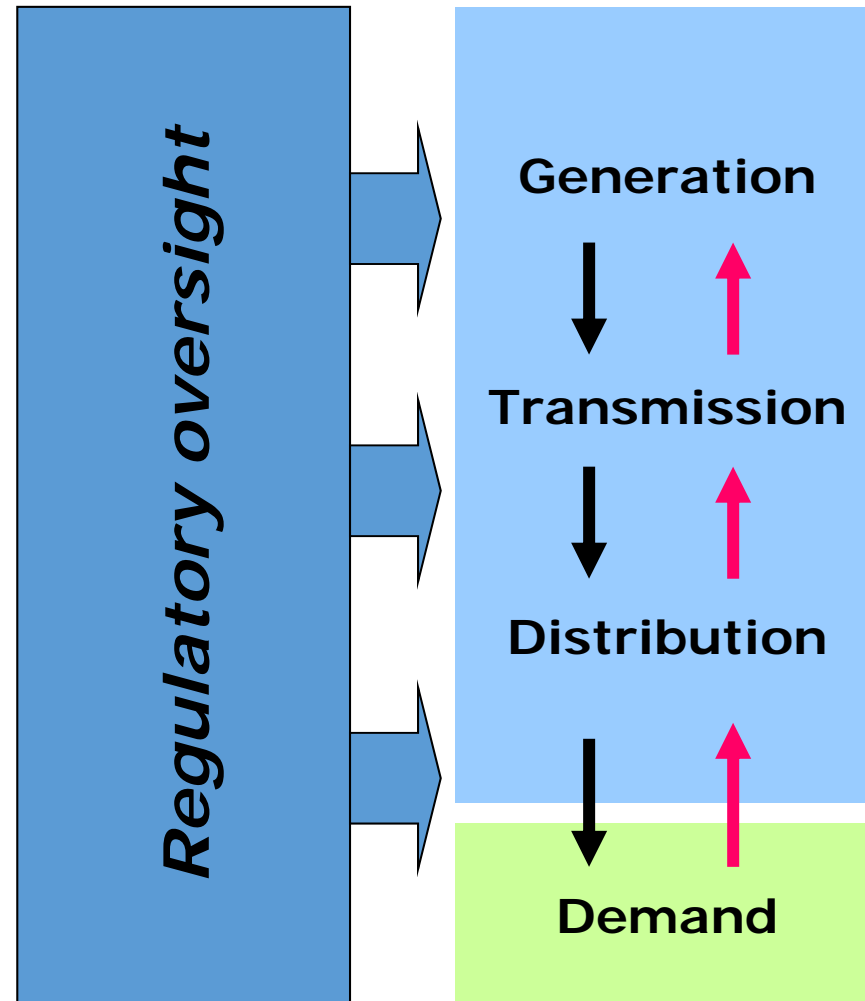


Power system transition

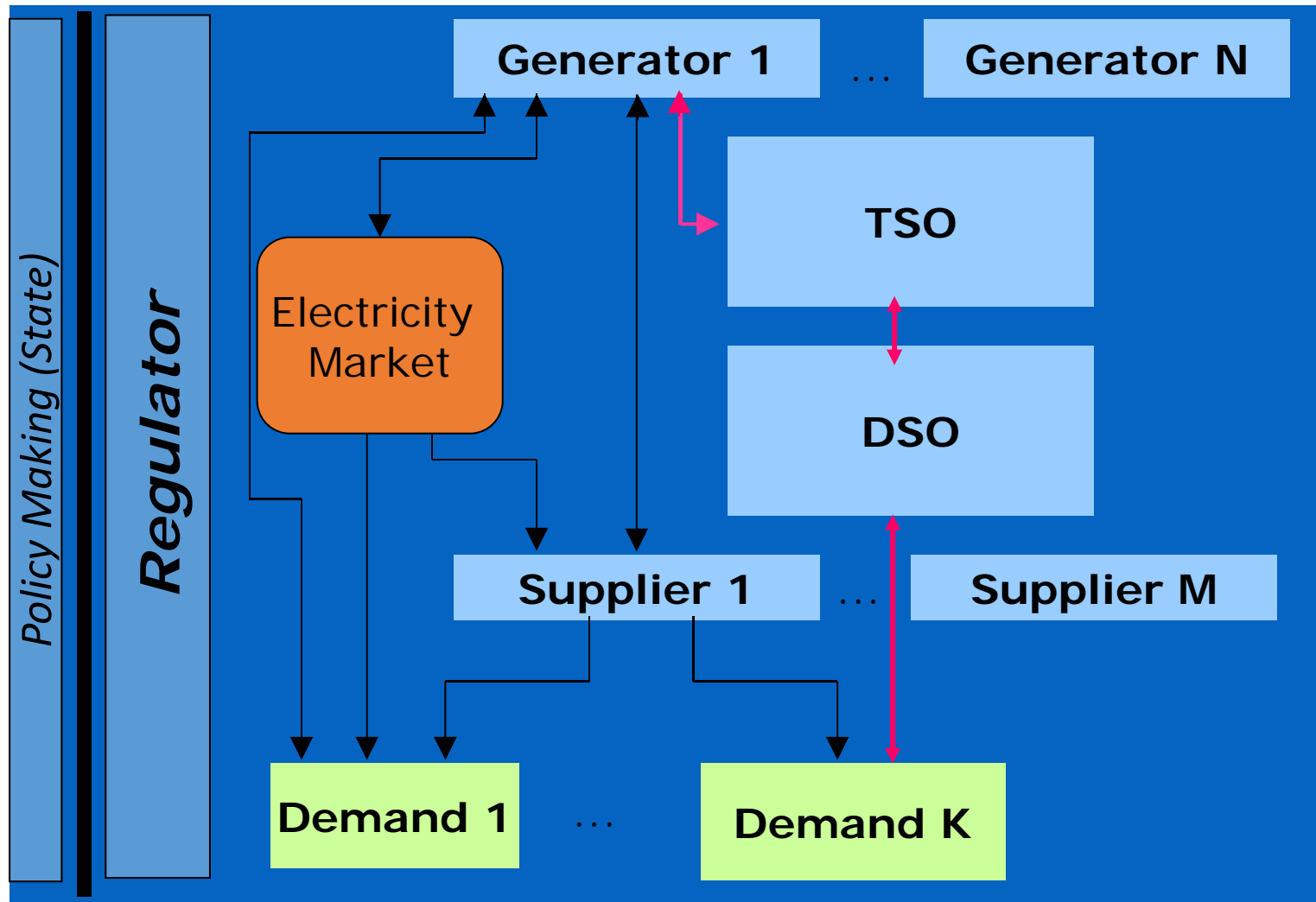
- Existing (blue) and new (red) assets and energy flows



Power System Regulated - Deregulated



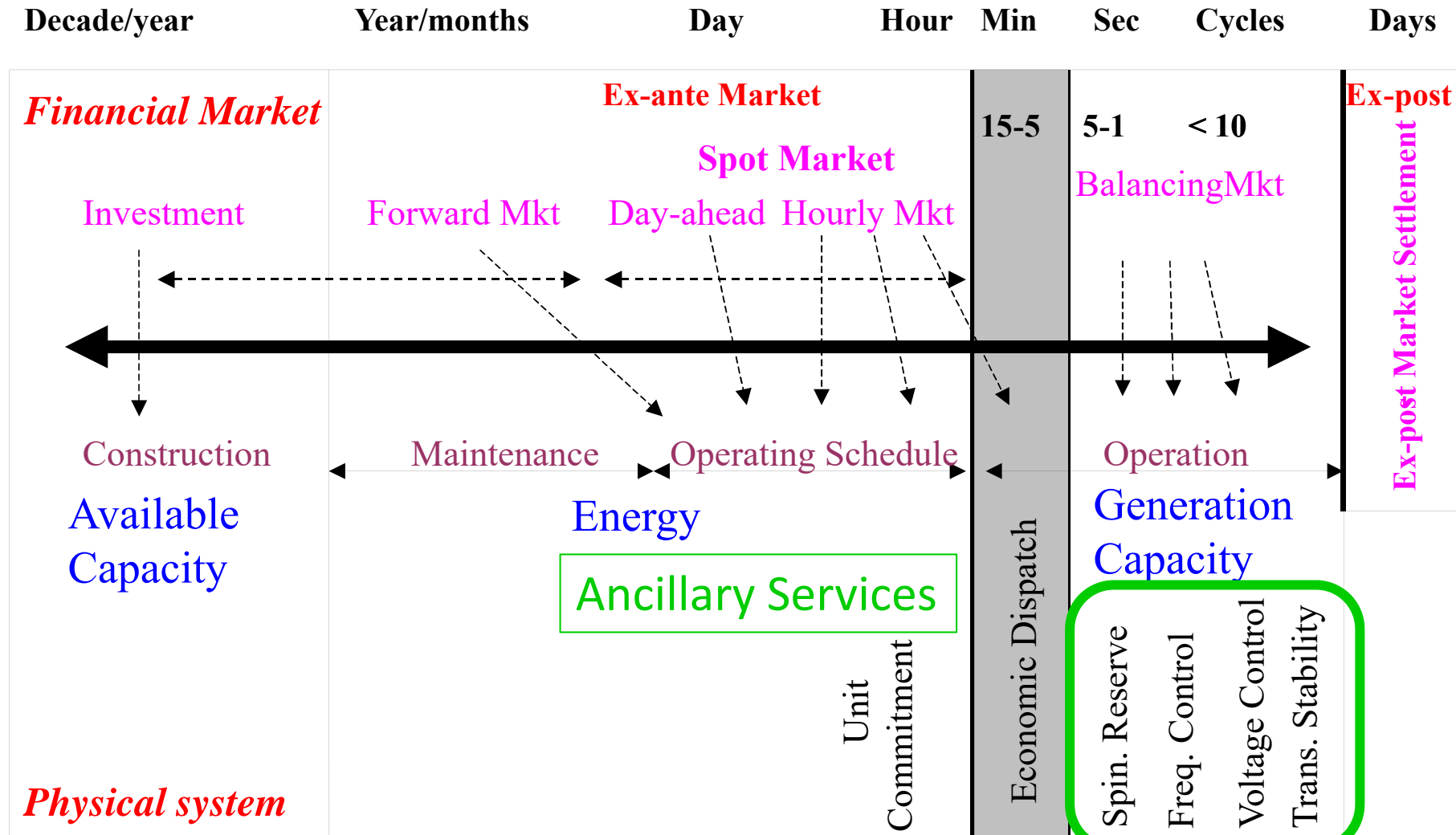
Power System Regulated - Deregulated



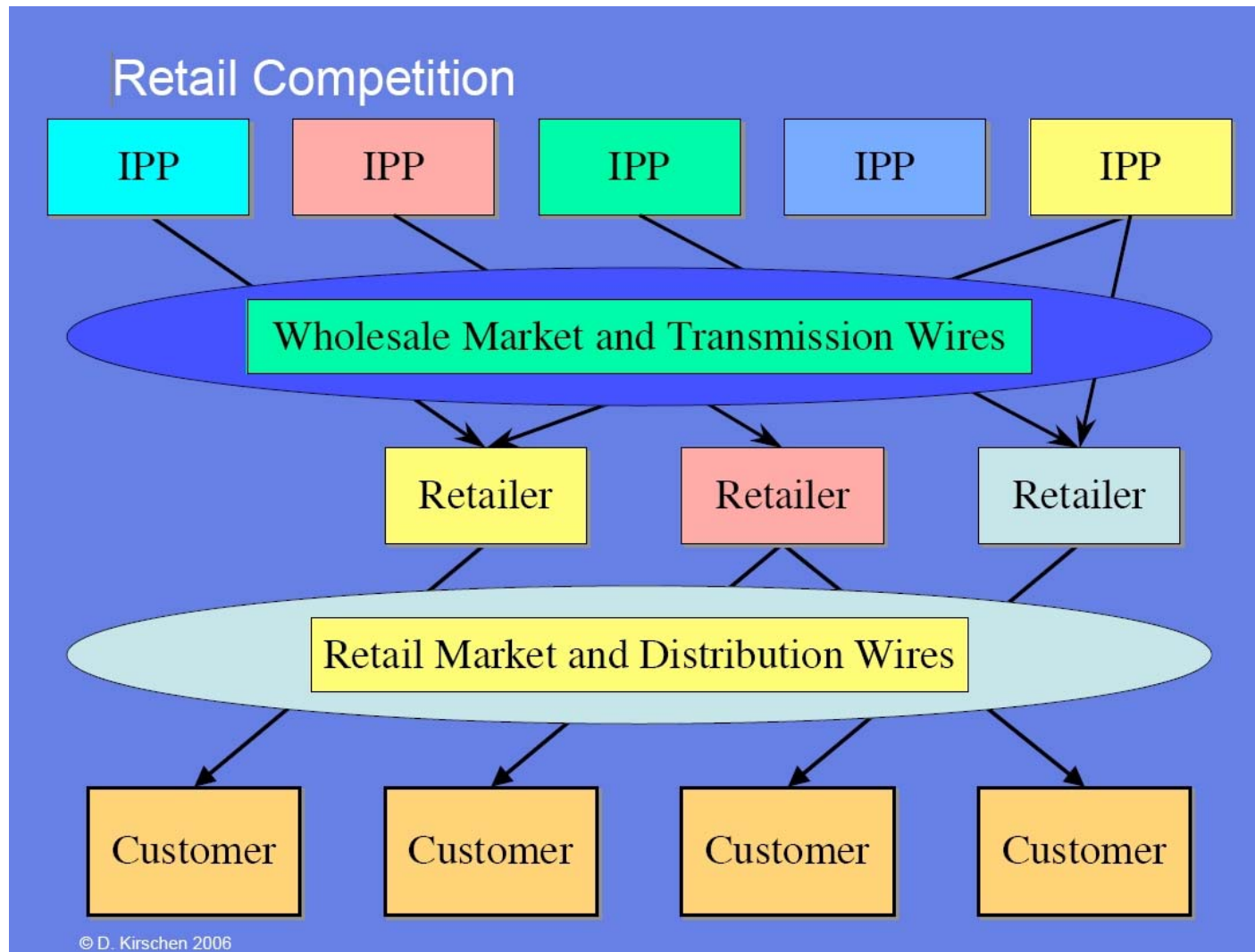
Types of electricity markets

- Markets can be classified as:
 - Electricity market
 - Wholesale, Retail
 - Capacity Market (CRM Mechanisms)
 - Ancillary Services Markets
- Wholesale market
 - Sales and trading of large quantities of electricity
 - Forward markets: hedging
 - Spot markets: Day-ahead, Intra-day, Balancing market
- Retail market – sale of electricity to consumers
 - Demand aggregation
 - Simpler access to the network
 - Multi-utility concept: provision of different commodities and services (electricity, gas, water, telecom, ...)

Operation Timing



Market Organization

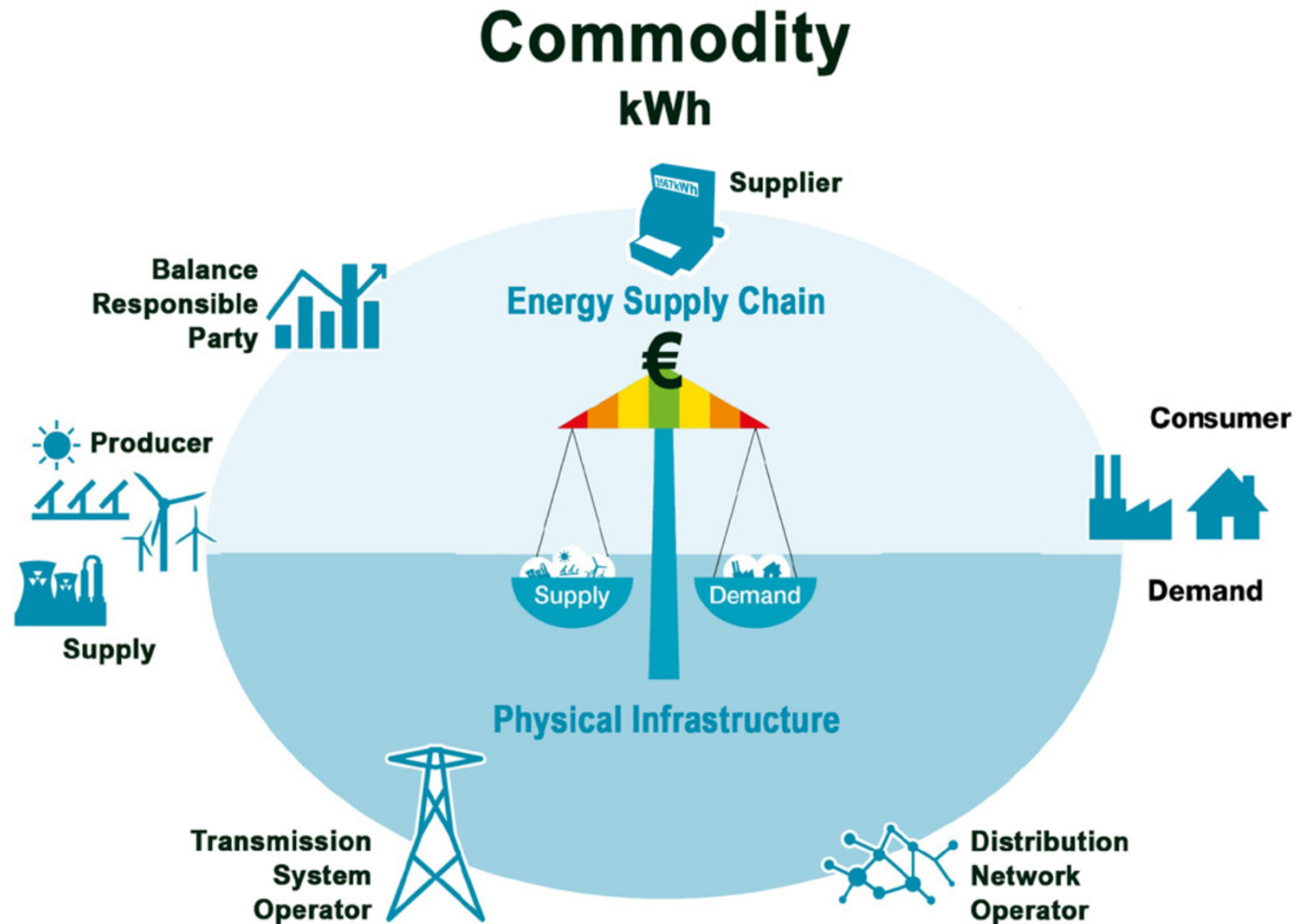


1. Power system deregulation and markets
- 2. Market roles**
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- Entities with **public obligation to serve**
 - TSO: Transmission System operator
 - DSO: Distribution system operator
 - Market regulator
 - Electricity Market operator – Power Exchange
- **Commercial Market Players**
 - Producer - Generator
 - Consumer - prosumer
 - Supplier
 - BRP: Balance Responsible Party
 - Aggregator

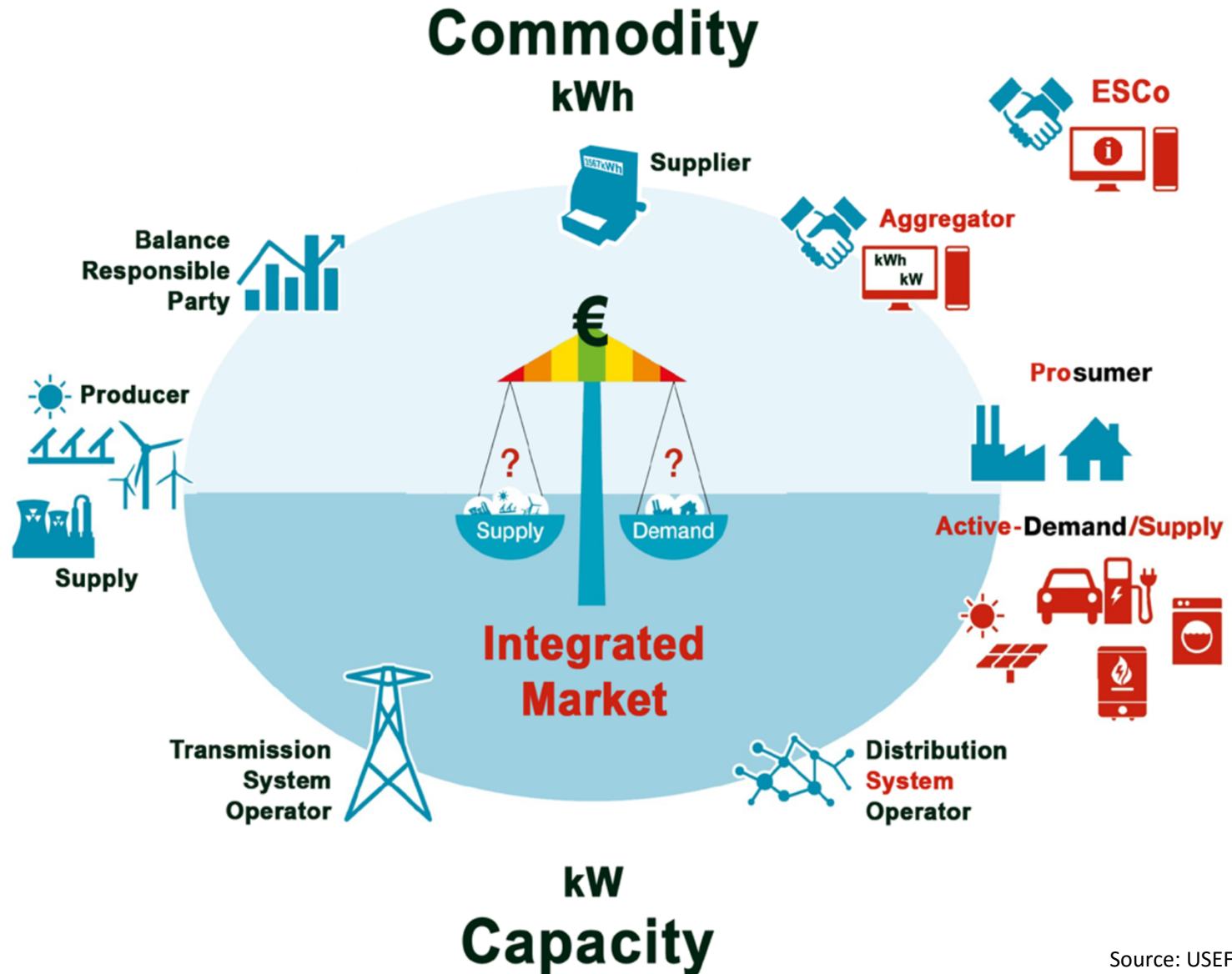
Liberalized energy markets

Market roles



Liberalized energy markets

Market roles



- **Transmission System operator: TSO**
 - Secure operation of the power system
 - Power system balancing in a balancing area
 - Measurement of electricity demand on HV grid
 - Ancillary Services procurement
 - Maintenance of HV grid
- **Distribution System Operator (DSO)**
 - Operates and maintains MV and LV grid
 - Delivers electricity to consumers
 - Manages grid capacity to minimize grid capacity costs.
 - Measurement of electricity demand on MV and LV grid

- **Market Regulator**
 - Transparent and unbiased market oversight,
 - Network charges determination,
 - Ancillary Services prices determination,
 - Oversight of TSO and DSOs,
 - Conflict resolution.
- **Electricity Market Operator – Power Exchange**
 - Organized market – standardized products of electricity
 - Public price signal: System Market Price
 - Serves as a reference for bilateral trading
 - Financial settlement and credit risk mitigation

- Producer
 - Invests in generation capacity
 - Sells energy and Ancillary Services on the market
 - Profit maximisation
- **Consumer** transforms into a **Prosumer**.
 - Active up- and downloader of energy.
 - Uses its Active Demand & Supply to offer its flexibility to the market.
 - Economically optimizes the use of its assets and improve its energy efficiency.

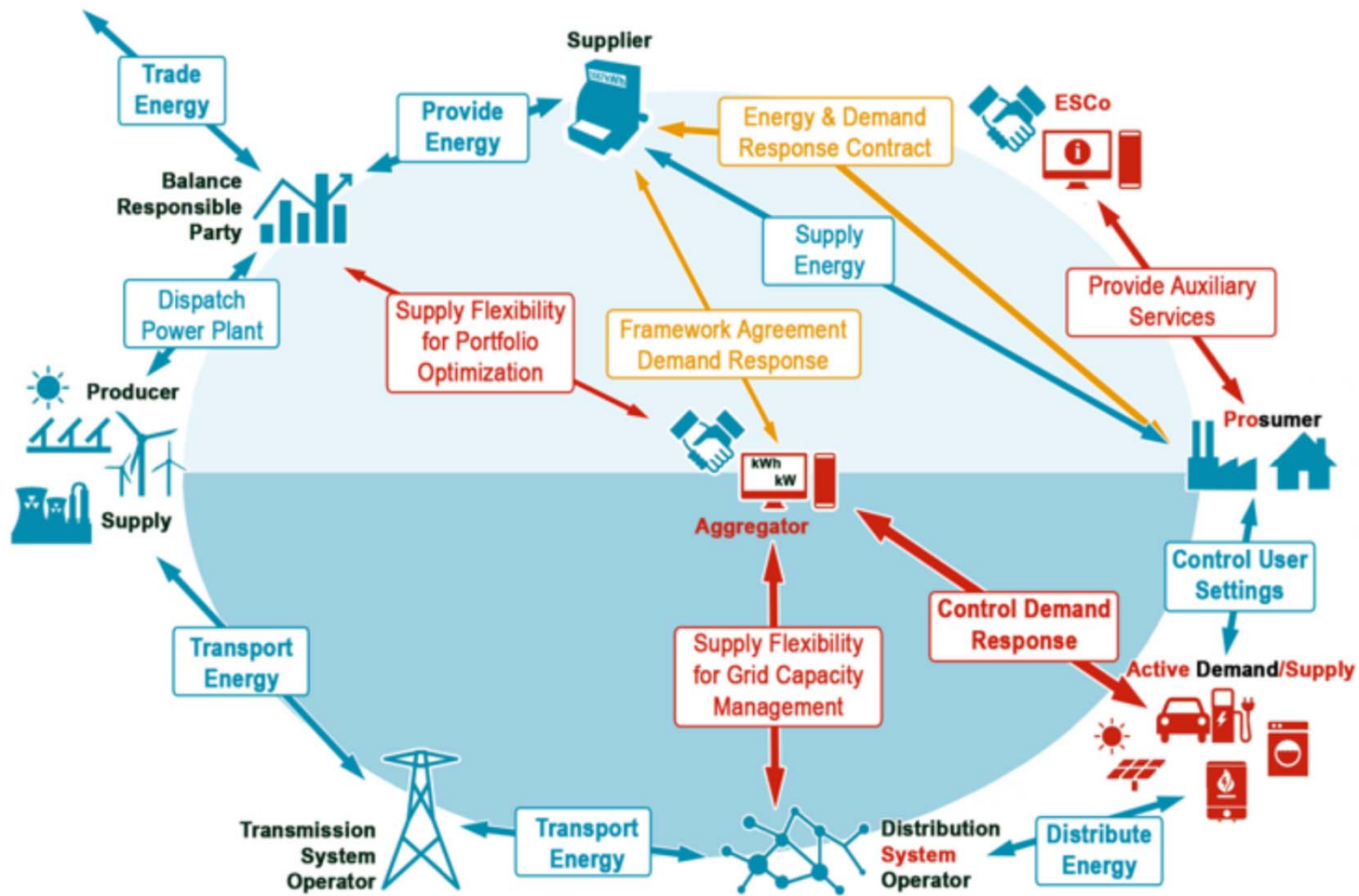
Market roles

Commercial market players

- **Balance Responsible Party (BRP)**
 - Energy balancing of the Balancing group
 - Portfolio of Producers, Aggregators and Prosumers
 - Sourcing the requested energy in two ways:
 - Directly by dispatching power plants with which it has a contractual agreement or
 - Indirectly via trading on the various energy markets.
 - Activating the flexibility that Prosumers offer through Aggregators.
- **Supplier (Retailer)**
 - Contract with Prosumers for supply and procurement of energy and flexibility
 - supply and invoice energy to its customers.
 - invoice or reimburse the flexibility that Prosumers have provided.
- **Aggregator**
 - Accumulating flexibility from Prosumers and their Active Demand/Supply,
 - Selling this to the BRP and/or the DSO.
 - Maximize the value of flexibility,
 - customer needs,
 - economical optimization
 - grid capacity.

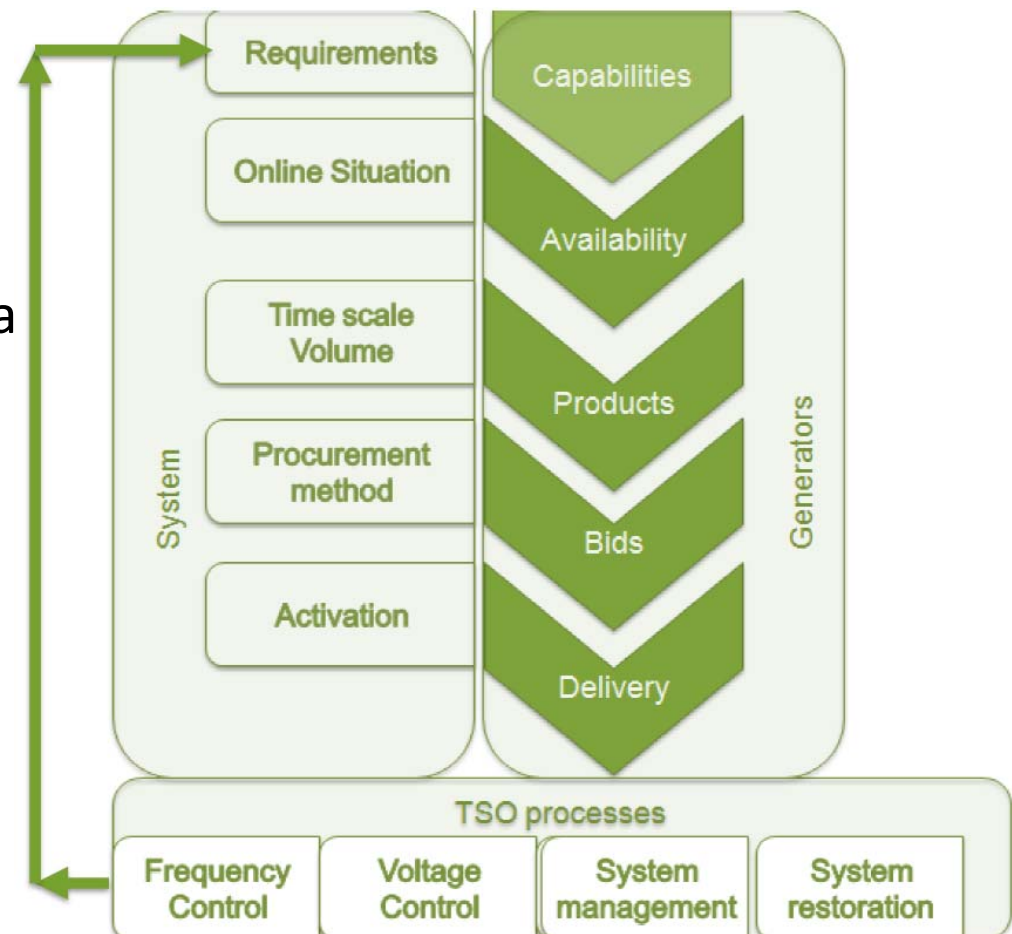
Wholesale vs. Retail market

- **Wholesale market** (day-ahead market)
 - Supplier buys energy in the name of its consumers
 - Supplier is exposed to **high price and volume risk** due to
 - The purchase of energy at the day-ahead market and
 - The sale at a fixed price at the retail market
- **Retail market**
 - A consumer buys the electricity from its supplier
 - Suppliers contract with their consumers for the supply of electricity at fixed prices (longer period of time)
 - **Unified fixed price**: single **tariff** system between suppliers and customers
 - The price at which the contract is concluded is the internal reference price of a DR unit



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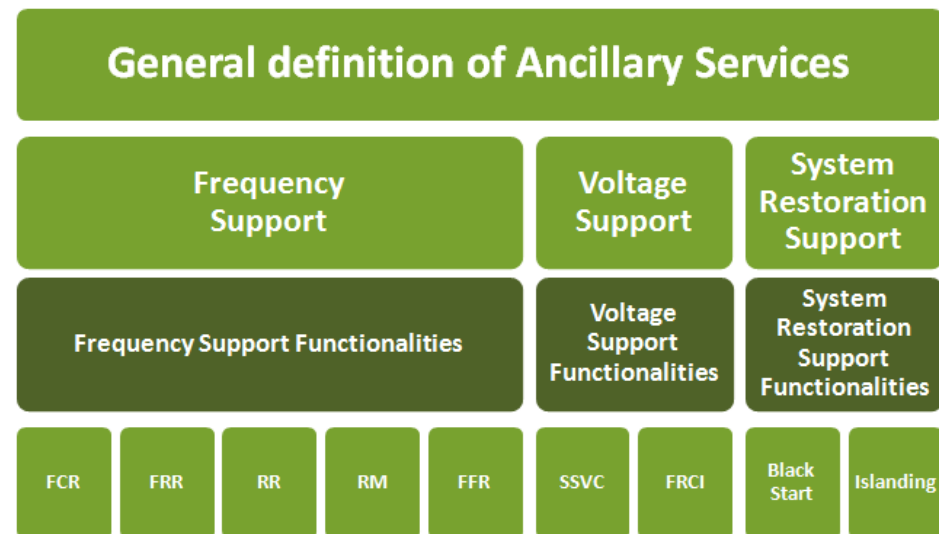
- Ancillary Services definition
 - A service, other than the production of electricity, which is used to **operate** a **stable and secure** power system
 - Definitions based on **technical capabilities** of generators
 - Frequency Control, Voltage control, System management, System restoration



REserviceS: System Support Services in focus

- Ancillary services are defined on Transmission System
 - Definitions vary among TSOs
 - ENTSO-E is developing a common framework
 - REserviceS project
- In distribution networks, AS definitions are only emerging
 - Together with the evolution of DNO to DSO

Frequency support	Voltage support	System restoration
Frequency Containment Reserve FCR (<5, 10 or 30 sec)	Normal Operation: control of power factor, reactive power or voltage	Black start
Frequency Restoration Reserve FRR (<15 min)		
Replacement Reserve RR (15 min to hours)		
Fast frequency response (synthetic inertia) (< 2s)	Fast reactive current injection	Islanding
Ramping margin (1, 3, 8 hours ahead)		



What is the cost for providing the Ancillary Services?

Ability / Capability

- Investment cost related to providing the capability
- (Increased maintenance costs)

Readiness / Capacity / Availability

- Cost for capacity reserved,
- Opportunity cost losing energy that cannot be sold
- Link to other markets

Utilisation / Energy / Response

- Actual provision of the service cost
- Fuel cost, wear and tear

AS Procurement Methods

Capacity / Availability vs. Utilization / Response

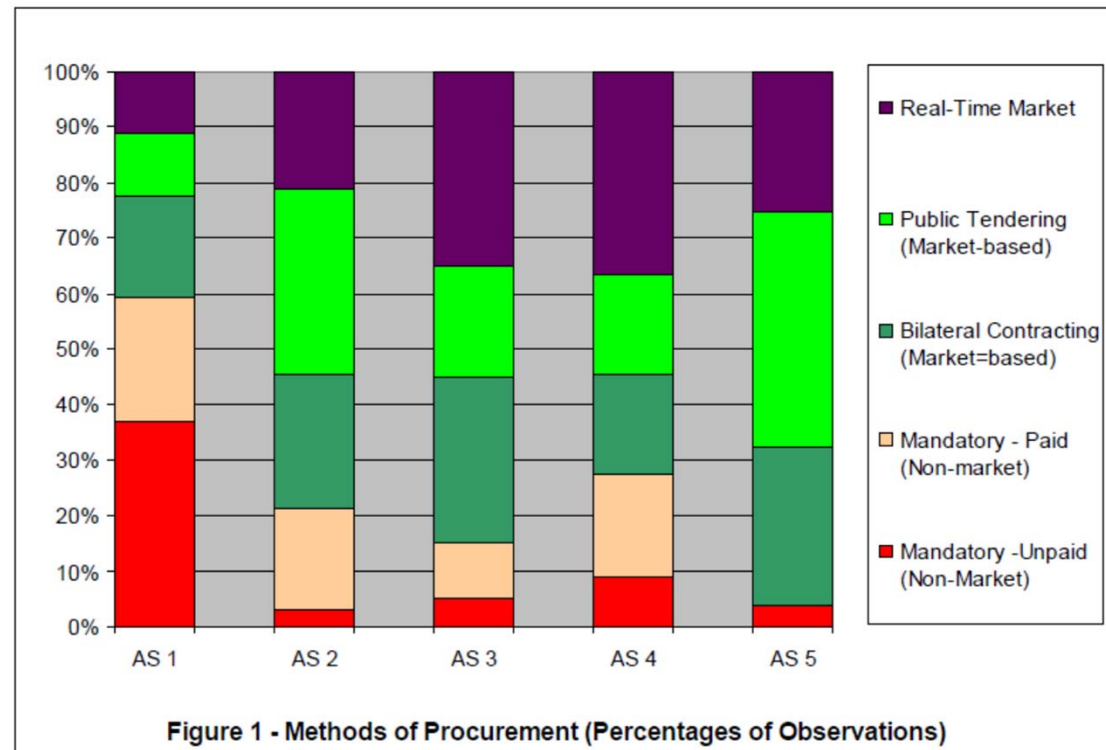
	AS-1 Frequency Control		AS-2 Regulation		AS-3 Reserves (Spinning)		AS-4 Reserves (Non-Spinning)		AS-5 Replacement Reserves	
	Capacity	Energy	Capacity	Energy	Capacity	Energy	Capacity	Energy	Capacity	Energy
Mandatory Unpaid	BR, PT, SLO, ES	AR, BE, BR, NE, PT, SLO, ES	AR, BR		BE		BR		FR	
Mandatory Paid	E&W(2), FI (2)	JP	E&W, JP	AR, CZ, JP, SLO	FI	AR		AR, JP		
Bilateral Contracting	BE, E&W(2), FR	FR	BE, E&W, FR, PT, SLO	BE, FR, PT	BE, E&W, FR	BE, E&W, FR	E&W	E&W	BE (2), PT, SO (2)	PT, SO (2)
Public Tendering	BE, CZ, DE		BE, CZ (2), DE, NE, SLO, ES	BE, DE, SLO, ES	E&W, NE	E&W, ES	CZ	AR	BE (2), CZ, DE, SLO(2)	BE (2), DE, SLO(2), ES
Real-Time Market	AU (2)	AR	AU (2), USA	AR, BE, CZ, NE	AR, AU (2), ES, USA	AR, NE	AU (2)	AR, CZ	ES	BE (2), CZ, FR, NE, USA

Source: CIGRE WG C5.6

Ancillary Services

Methods of procurement

- Most common methods of **procurement** include
 - Mandatory – paid (at regulated / administrated prices)
 - Mandatory – unpaid
 - **Bilateral contracting**
 - **Public tendering**
 - **Real-time market**



Source: CIGRE WG C5.6

Ancillary Services

Mandatory vs. Market Provision

- Grid Codes: is it wise to **oblige** generators to provide certain AS levels?
 - **Mandatory requirement**: likely to result in
 - Only the **minimum Grid Code required levels** of service
 - Without necessarily the requisite level of reliability
 - **Separately remunerated**: AS become short or scarce
 - Mechanisms **to reveal the cost** of AS provision are more efficient
 - Efficient choice of alternative methods of AS provision is stimulated.

Ancillary Services Remuneration Approach

- **Remuneration** should be **relative** to the **value of AS to the system!**
- Methods for **allocation of this benefit** to the new AS:
 - Additional costs:
 - **Capability**: Capital costs incurred to provide these new services.
 - **Dispatch**: Operating costs - impacts on the operational efficiency of technology
 - **Balance** benefit allocation between **consumers** and **providers**
 - Methods to remunerate them:
 - Look at the **cumulative benefit**,
 - Possible **costs incurred** (e.g. cost to the consumer, financial risks of the implemented remuneration arrangements, the incentive for potential providers).
 - **Long term certainty for the investors**
- Define **eligibility rules** for providers
 - **Technology neutral**
 - Generators, Prosumers and DR units should be able to participate!

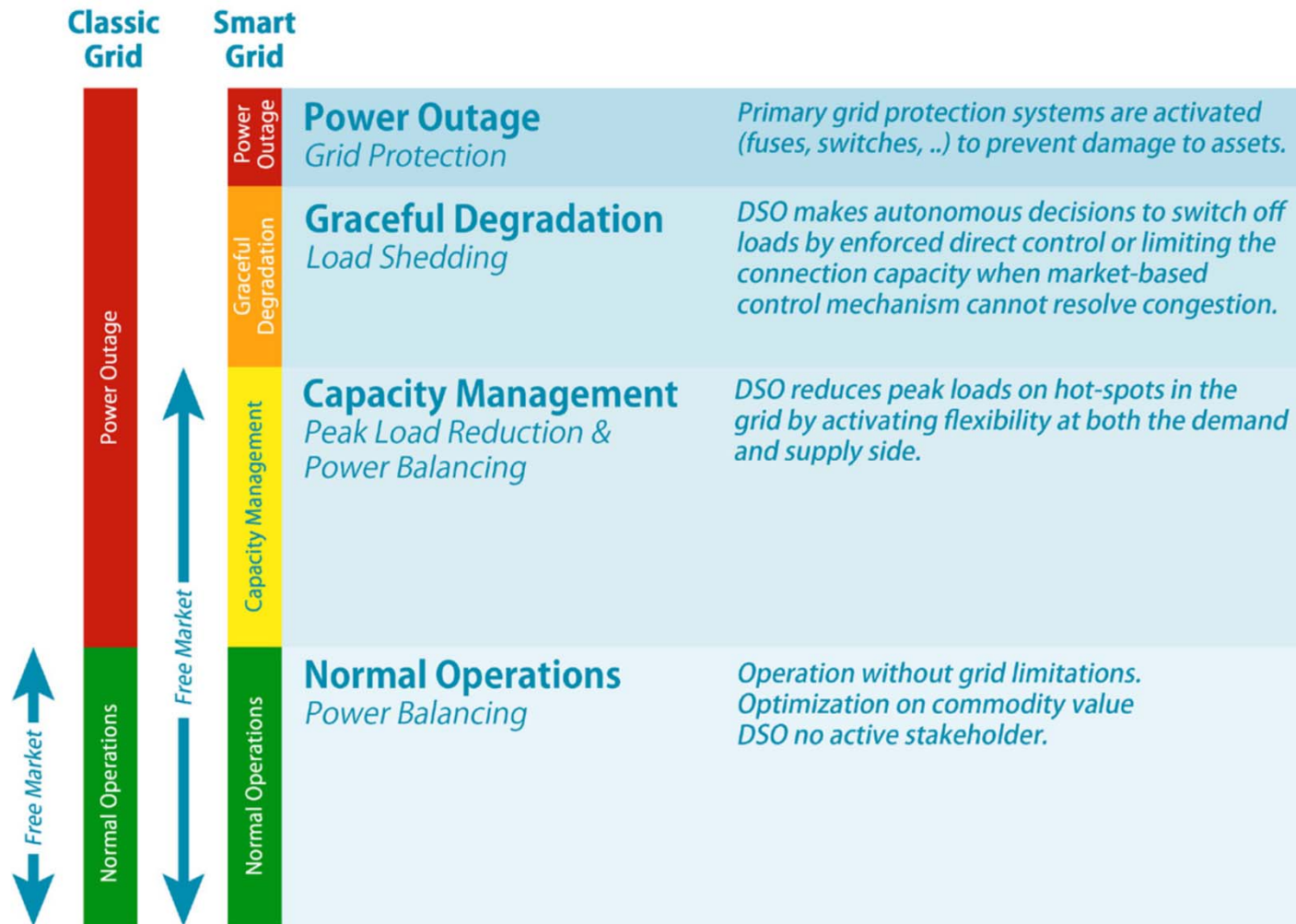
Ancillary Services

The definition process

- A multi-stakeholder, multi-year **consultation process**
 - Determine problems ahead, discuss solutions and propose a set of solutions to the regulator.
- A **methodology** to determine possible **solutions**
 - Definition of the technical and operational problems,
 - Analysis of the solutions,
 - Their validation by multi-scenario simulation-based approach.
- **Economic evaluation** of the proposed solutions,
 - Benefit analysis to the system
 - Costs to the consumers.
 - Possible remuneration strategies to the AS providers and the impact they have on them.

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New roles for DSO in SmartGrid



Source: Eurelectric

- Typically, **AS in distribution network** include:
 - Distribution Network operation;
 - Voltage control;
 - Supply restoration after an outage;
 - Provision of energy to cover network losses.
 - Reactive power support;
 - Power quality maintenance.
- With the advent of **Smart Grids** and **increased DRES** penetration in DN, **additional AS** arise:
 - Advanced Metering (using AMI)
 - Active Demand (Demand Response)
 - Virtual Power Plants
 - Current congestion mitigation

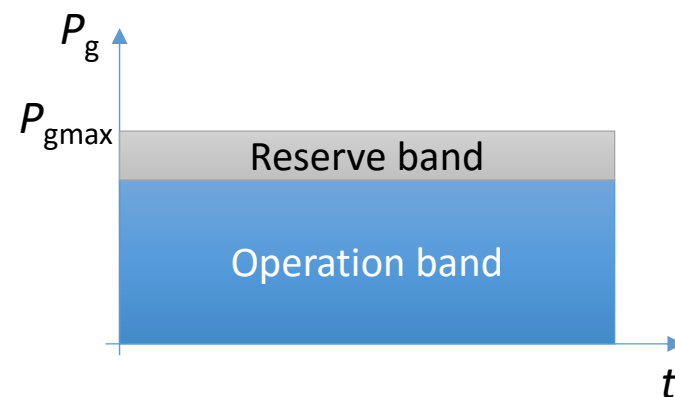
AS	LC	OC	SC	Activity
Voltage Control	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Voltage Unbalance Mitigation	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		Reactive
Current Congestion Mitigation	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Reserve Provision			<input checked="" type="checkbox"/>	Proactive

- **Reactive AS**
 - Provided by INCREASE technologies and MAS control of DRES
 - The value to the stakeholders will be assessed against the costs
- **Proactive AS**
 - Complementary scheduling of DR by MAS control
 - The value will be directly assessed via market signal against the costs
- **Stakeholders**
 - Providers and takers of the AS
 - Regulated: TSO, DSO
 - Commercial: generators, aggregators, Demand Response units

Active power reserve

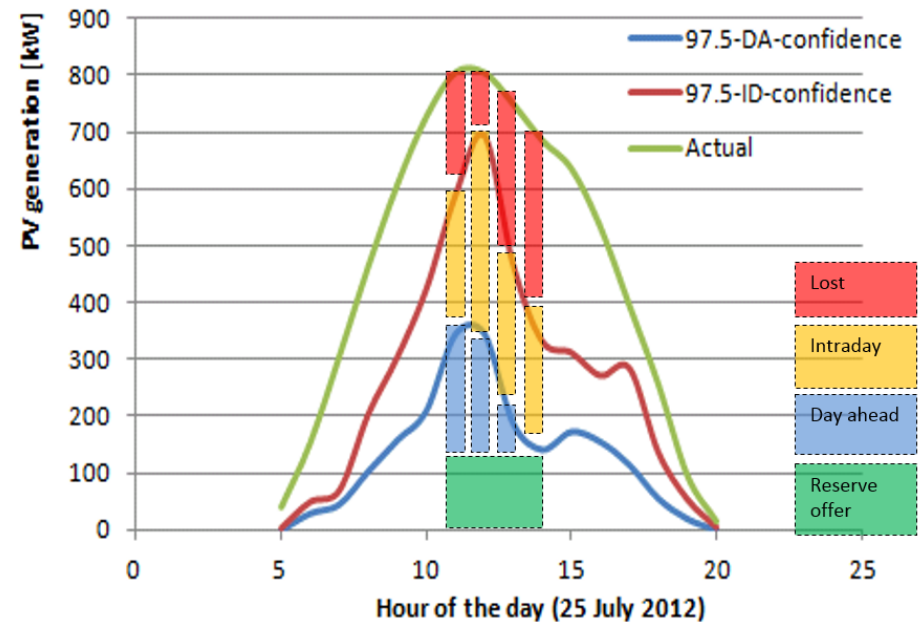
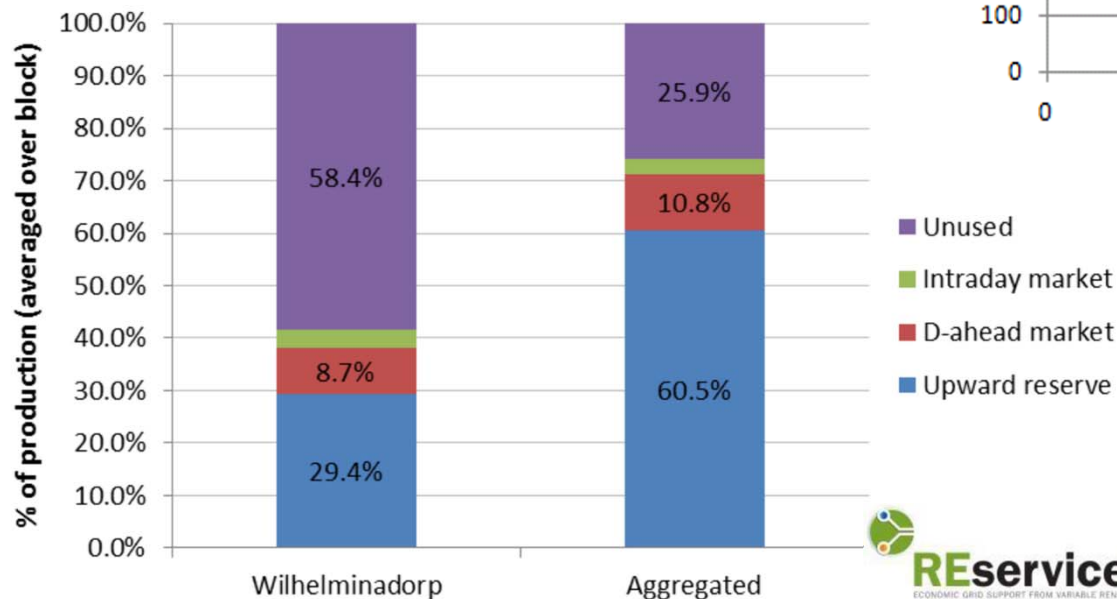
Provision by a synchronous generator

- Traditional **reserve provision** by a syn. generator
 - Reservation of a **generation band**
 - Sold on long-term auctions (12m)
 - Operation capacity reduced for Reserve band
- Activation of reserve
 - When called upon by the TSO, generator has to **activate additional power**
 - It can be between $[0, P_{gres_max}]$
 - Hourly schedule
 - TSO pays the Generator for
 - Availability: reserve band
 - Dispatched energy



Active power reserve Provision by PV generator

- Downward reserve:
 - No energy is lost
 - Fully valorised on reserve market.

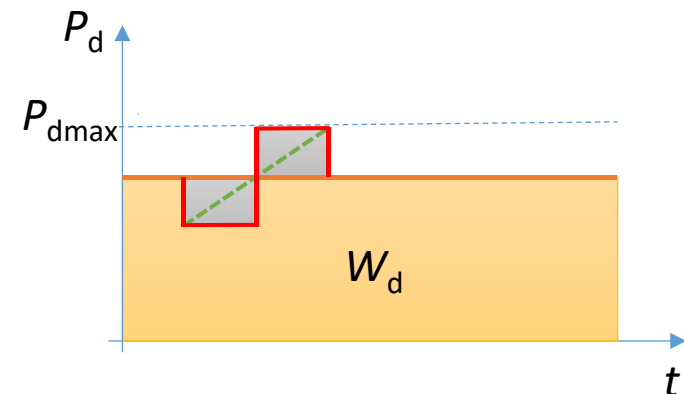


- Upward reserve:
 - Single site: extremely costly
 - Large portfolios: still significant

Active power reserve

Provision by DR unit

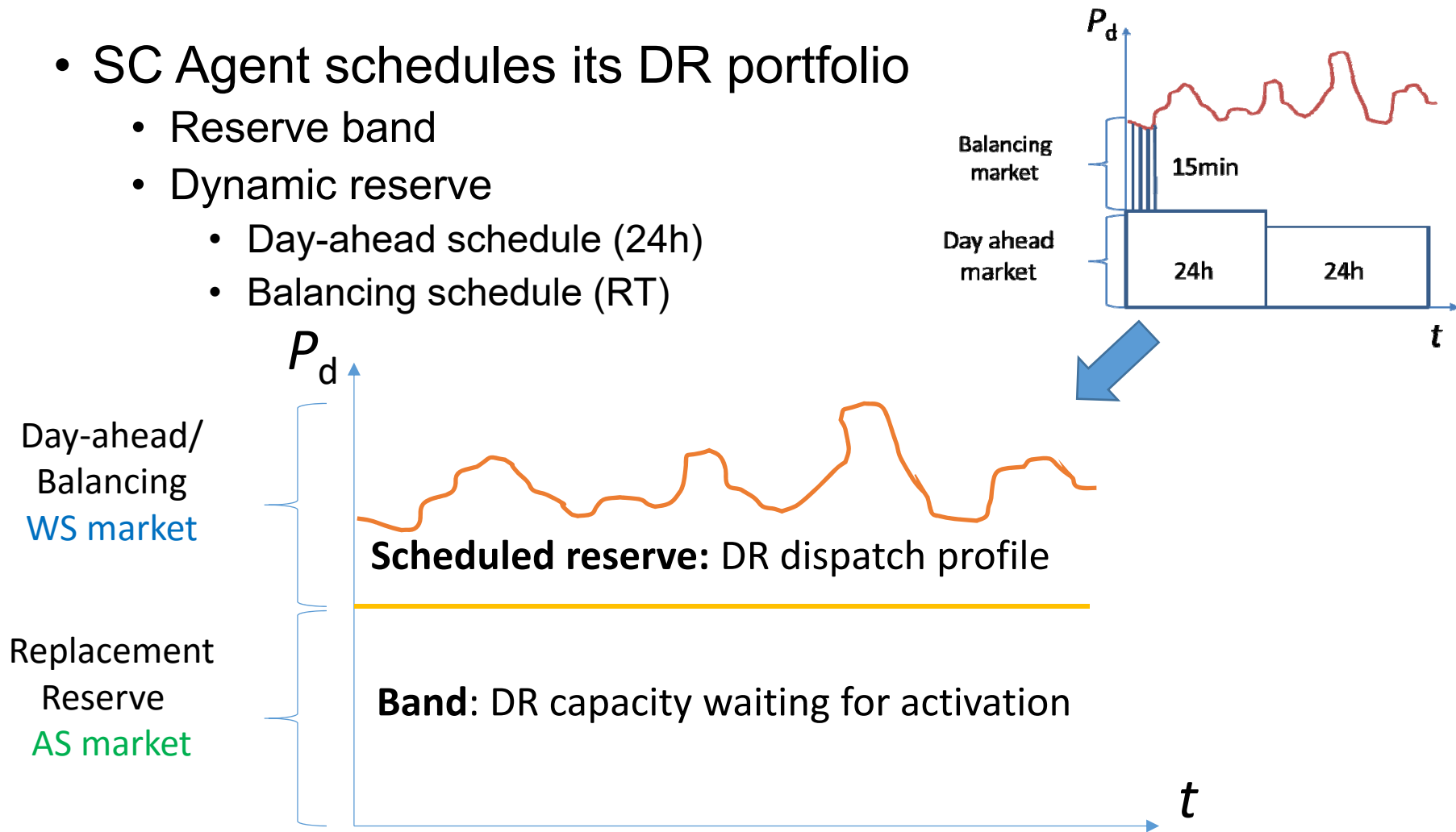
- Demand Response reserve provision
 - Aggregator schedules its DR portfolio
 - DR receive a daily schedule to modify its consumption
- Scheduling of a DR unit
 - According to its parameters
 - Power P_d
 - Energy capacity W_d
 - Flexibility (ramping)
 - Internal price
 - Compared to market price
 - Subject to other parameters



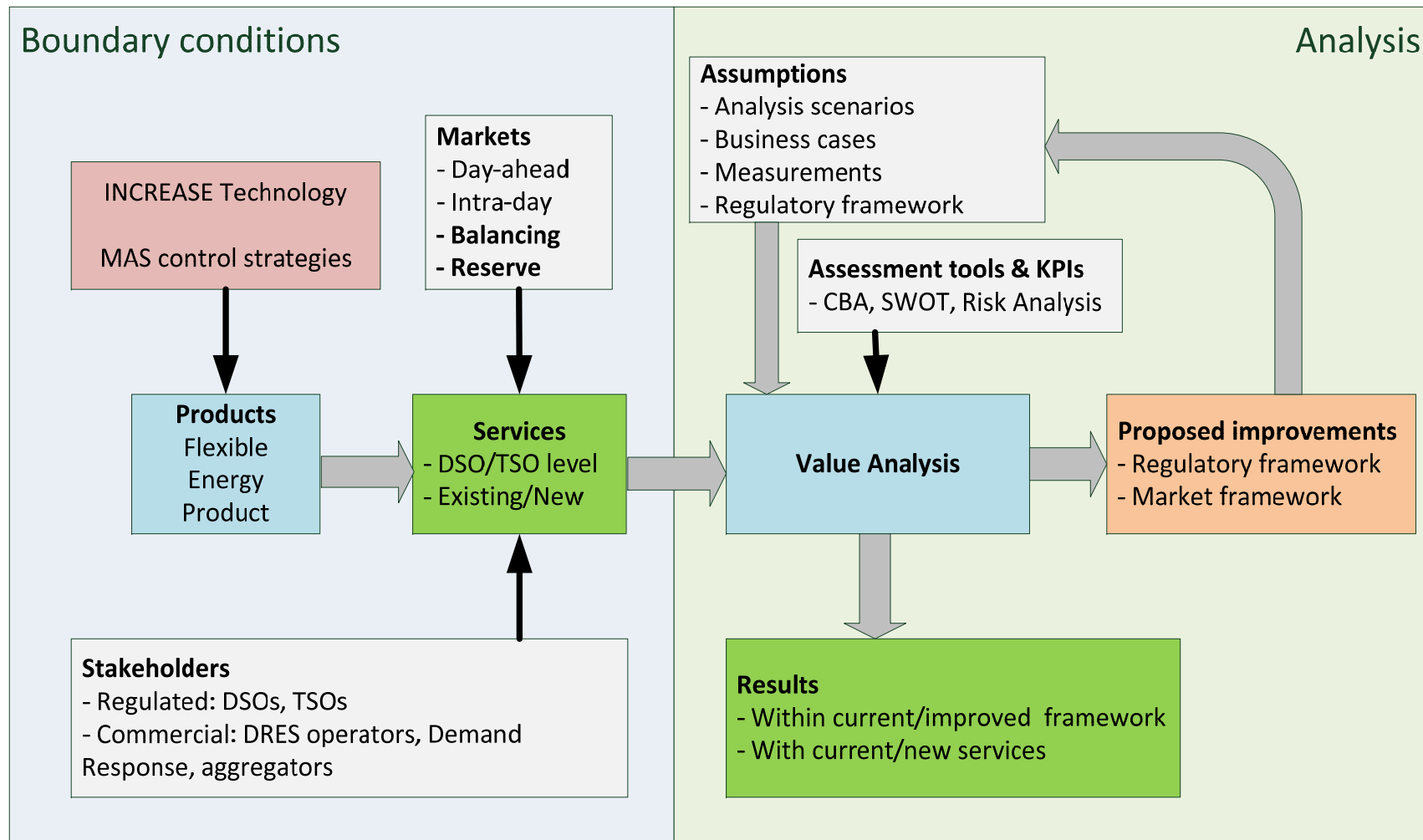
Active power reserve

Provision by DR portfolio

- SC Agent schedules its DR portfolio
 - Reserve band
 - Dynamic reserve
 - Day-ahead schedule (24h)
 - Balancing schedule (RT)



WP 5 Analysis Framework



Thank you!
Questions?



Assoc. Prof. Andrej Gubina, Ph.D.

Head, Energy Policy Laboratory

andrej.gubina@fe.uni-lj.si

Tel: +386 1 4768 830

<http://lest.fe.uni-lj.si>



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