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Introduction to flexibility in a renewables-based energy system

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Overall Structure

What is flexibility?

Why do we need flexibility?

How can flexibility be developed?
(Examples from the Ireland and Northern Ireland power system)

Summary conclusions

What is flexibility?

What is flexibility?

No one single definition

Different people use it to mean different things depending on context

Who is mentioning it:	What is it used for:	How is it being provided:
- Policy makers - System Operators - Industry - Academia - Civil society / NGOs	- Balancing supply and demand - Managing network flows - Maintaining system security	- Technology - Ways of operating

In abstract: Resources with certain characteristics which are useful in the context of the operating conditions which are being used to manage system needs

Consider keywords to explain

What is flexibility?

System Needs

Mainly refers to **supply-demand balance** and/or **congestion management**:

- i.e. able to modify generation or consumption levels to maintain energy supply and demand balance;
- At different granularity to meet different needs e.g. total system balance, or local for network flows;
- Often in the context of "Net demand", i.e. the demand which is left to be met after the demand that is met by variable generation, typically renewable or low/zero carbon sources.

Can also include maintaining power system stability, including:

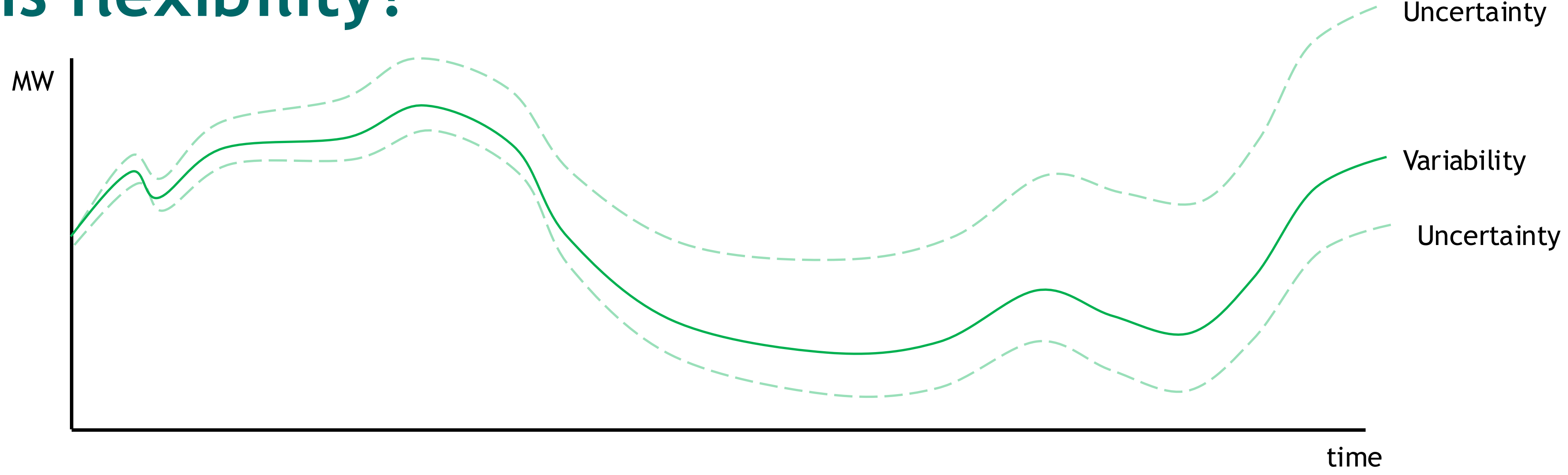
- **Reserves** (maintaining frequency* stability. Resources increasing or decreasing the amount of power they are providing or consuming in a fast enough way to stop a change in frequency and restore the frequency following a disturbance);
- **Inertia** (maintaining frequency* stability. Analogous to the "weight" of the power system, spinning masses from heavy motors which are spinning at frequencies in sync with the power system frequency have physical momentum which makes them slow to change their rate of spinning, and therefore can affect how quickly the system frequency will change from the synchronized level following a disturbance);
- **Reactive power** (maintaining voltage** stability. The power used by grid equipment to make power actually flow on the electrical grid, rather than the power being consumed by customers etc. (which is "active power")).

Brief explanation of fundamentals

*Frequency
a characteristic of Alternating Current (AC) power systems, the number of times per second a current alternates direction. When energy demand and supply is balanced, frequency is at a value of 50Hz in European power systems. Where there is more energy demand than supply, frequency goes lower, where there is more energy supply than demand, frequency goes higher. It is important to keep energy balanced and maintain frequency within a tight margin of 50Hz because all electrical equipment are designed to work at this frequency – otherwise such equipment could be damaged.

**Voltage
analogous to the "pressure" enabling the flow of power throughout the grid.

What is flexibility?



Variability

A feature of many sources of electrical energy but in particular renewables such as solar and wind that are dependent on weather patterns which change in ways which are not consistent over time.

Uncertainty

Whether the resource will be there when it is expected or needed, and the impact that would have of relying upon it, difference kinds in different timeframes, e.g.:

- in shorter timescales: forecast errors;
- in medium term timescales: forced outages;
- in longer term timescales: security of supply and capacity adequacy.

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What is flexibility?

External Signal / Request

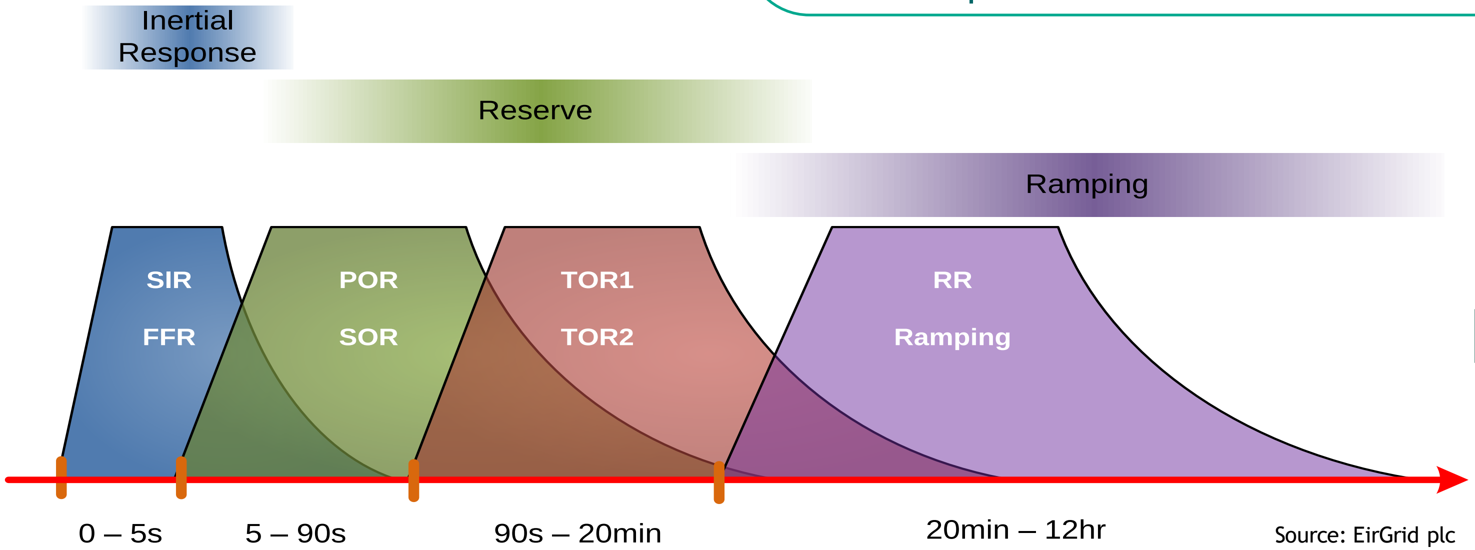
Trigger to make available or utilise the flexibility.
- "Explicit": comes from a System Operator.
- "Implicit: comes from information generally available, e.g. response from customers with smart meters with information on market or tariff prices in different periods.

Timescale / Timeframe

Being able to meet needs in different timescales whether very short term and quick or very long term, could mean:

- instantaneous/synchronised/millisecond response to system event;
- daily and weekly responding to wind and sun patterns;
- seasonal responding to seasonal weather patterns;
- all the way up to multi-year.

Some solutions could meet shorter and longer timeframe needs while others would be optimised to focus on shorter or longer timeframe needs.



Source: EirGrid plc

Hours
Days
Weeks
Seasons
Years

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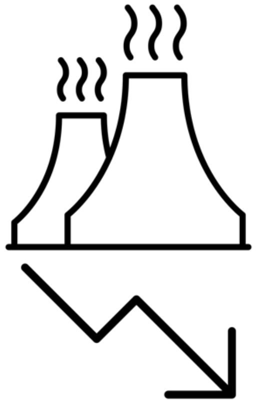
Why do we need flexibility

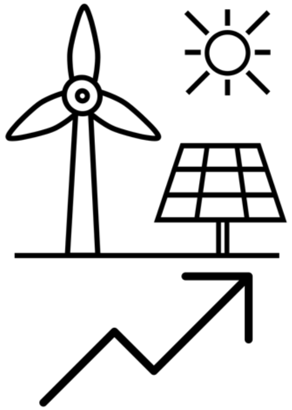
Why do we need flexibility

Decreased ability to meet system needs flexibly



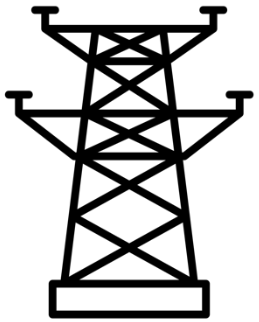
- Move towards decarbonized power systems
- Many sources of low or zero carbon energy future are not inherently able to meet system needs in a flexible way
- “Inverter-based resources” are those resources connected to the power system via a converter from Direct Current (DC) to Alternating Current (AC) power. This is the case for wind and solar generation, batteries, some interconnectors, etc. This means that they cannot be synchronised to the AC grid, and therefore cannot support the system with automatic synchronised responses like other technologies
- These resources are replacing conventional fossil fuel generators which historically have been synchronized to the AC power system and could meet system needs in a more flexible way
- Therefore, other flexible resources are needed to replace this flexibility

Increased requirement to meet system needs flexibly



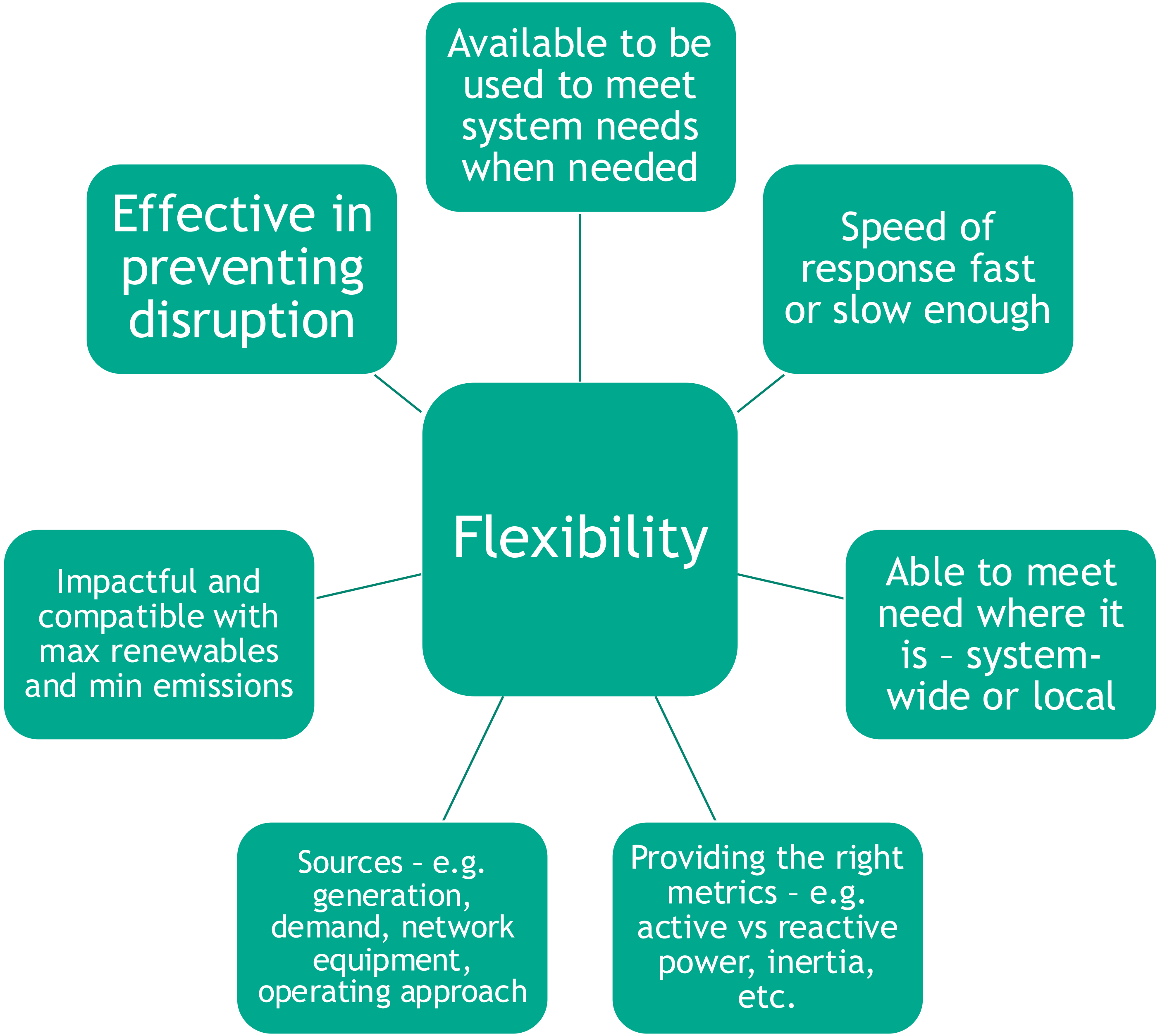
- Not only are the inverter-based resources less able to meet system needs in a flexible way, they can also cause additional insecurity and instability on the system
- Their reactions to disturbances on the system (e.g. a generator trip) can make changes in frequency and voltage worse, they can often be more variable and uncertain, and they can also be spread out to wider locations on the system
- These increase the complexity of operating the power system, increase instability and insecurity locally and system-wide, increase the need to manage power flows and support the system, and increase the requirement to balance supply and demand
- Therefore, flexible resources are needed to meet these increased needs

Maximise use of network and renewable energy sources



- Managing the network, and trying to enable demand and renewable generation to connect quicker, is important in the transition to a decarbonized future power system
- Constraints to develop network upgrades in time, alternative approaches which can be done quicker or defer network development should be considered
- Manage congestion through flexible technology and/or operational approaches to prevent disruption
- Want to use all renewable energy available in useful ways, not waste it at times when there is too much and need other less carbon-friendly resources when there is too little

Why do we need flexibility



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How can flexibility be developed?

Examples from the Ireland and Northern Ireland power system

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Drivers for flexibility

- **Shaping Our Electricity Future** is our plan to achieve government policy targets
- To achieve an 80% RES-E target we will need to raise System Non-Synchronous Penetration (SNSP, the level of system demand and export which can be met by non-synchronous resources) to **95%**

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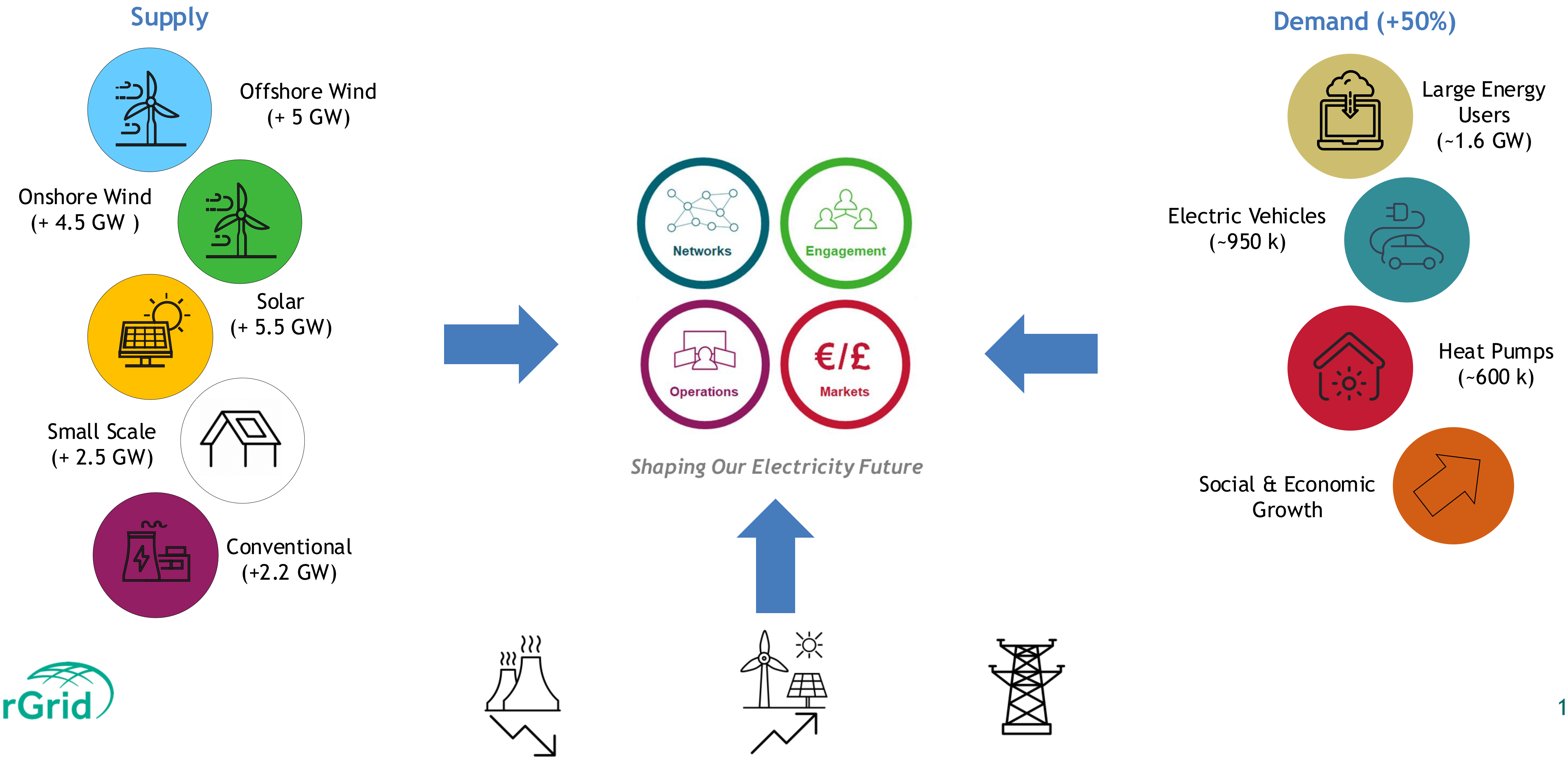
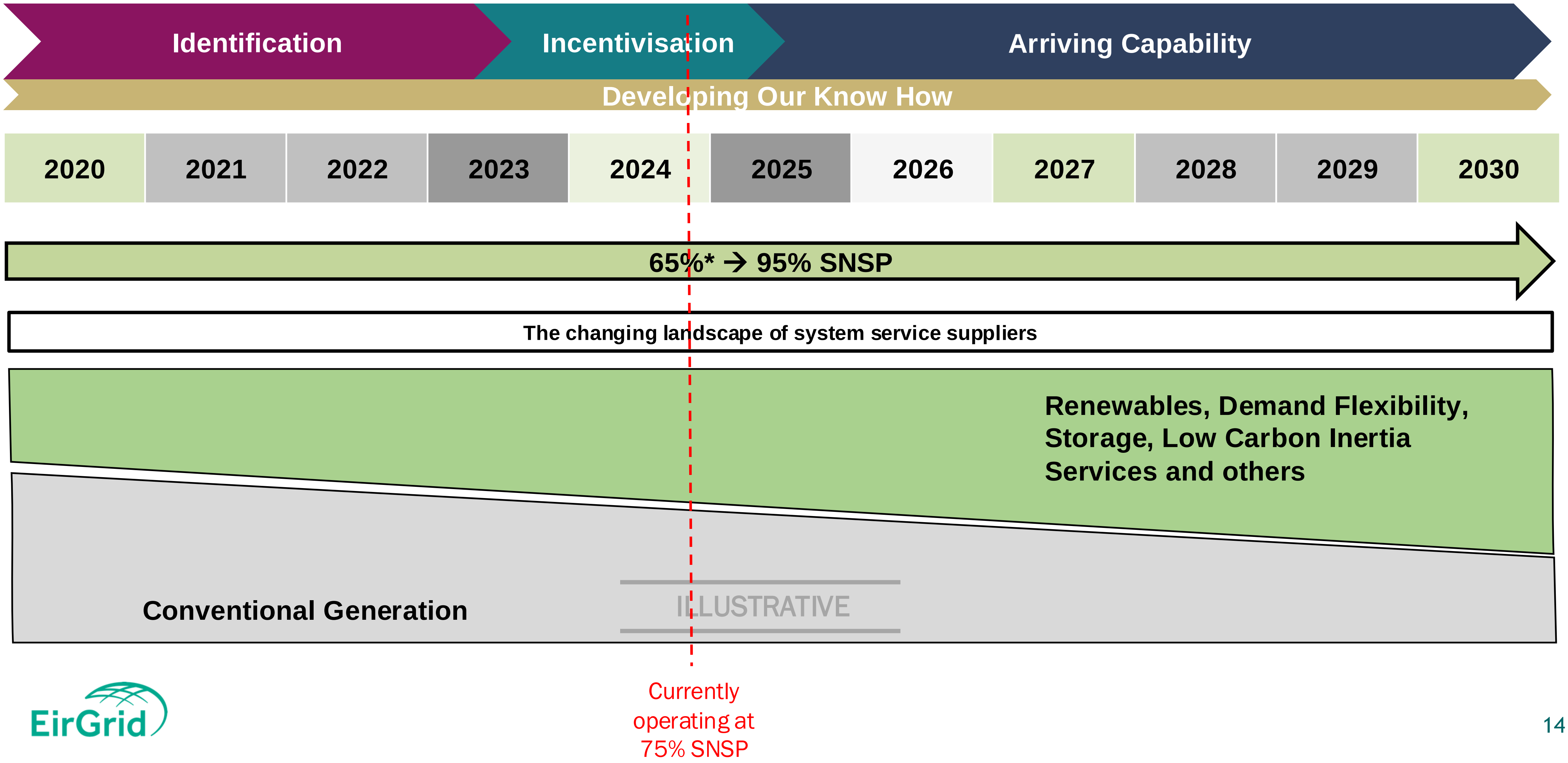
Drivers for flexibility

Whole electricity system challenge



Drivers for flexibility



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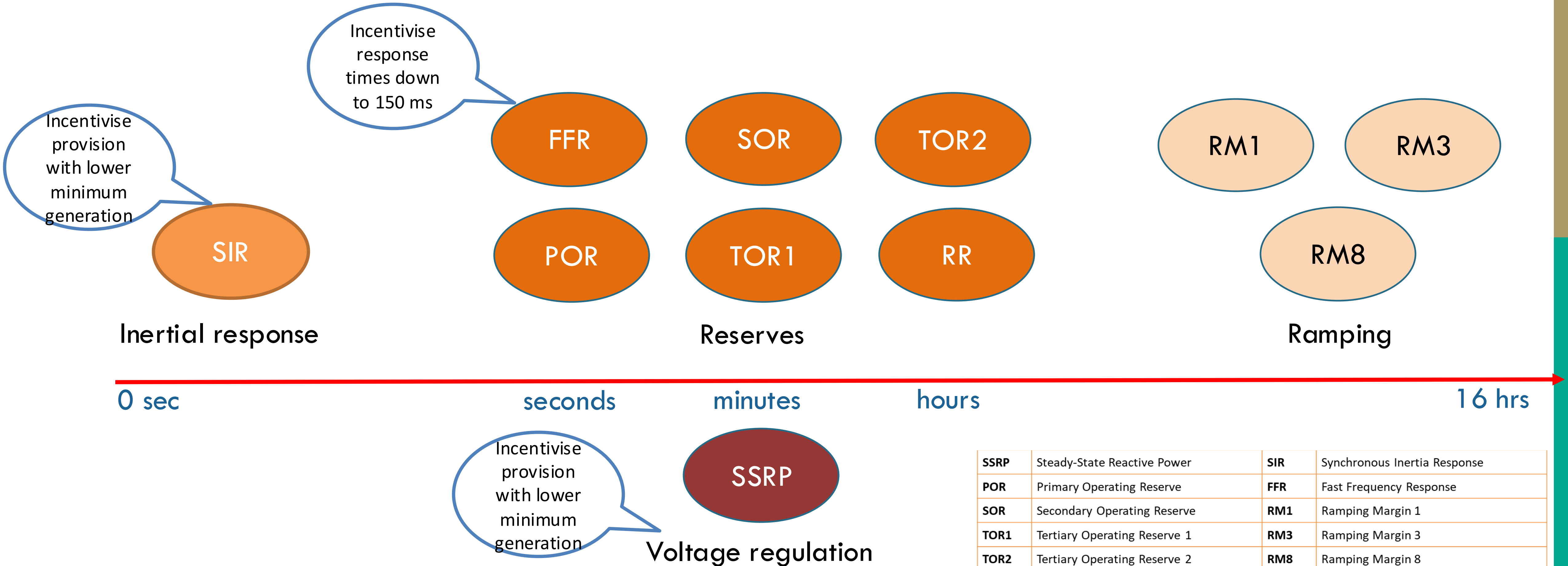
Flexible markets - System Services



SSRP	Steady-State Reactive Power	**SIR**	Synchronous Inertia Response
POR	Primary Operating Reserve	**FFR**	Fast Frequency Response
SOR	Secondary Operating Reserve	**RM1**	Ramping Margin 1
TOR1	Tertiary Operating Reserve 1	**RM3**	Ramping Margin 3
TOR2	Tertiary Operating Reserve 2	**RM8**	Ramping Margin 8
RRD	Replacement Reserve De-Synchronised		
RRS	Replacement Reserve Synchronised		

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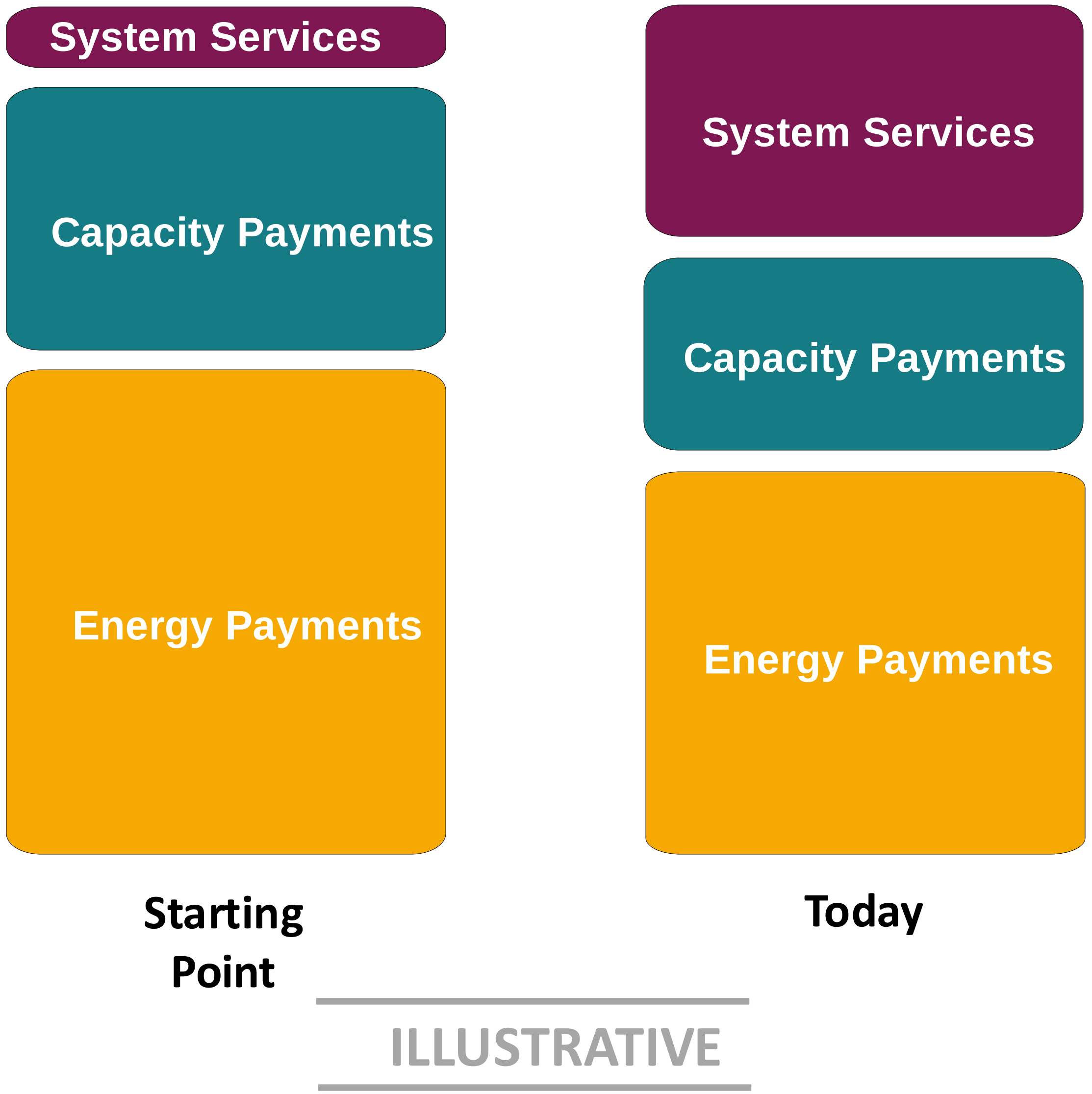
Flexible markets - System Services



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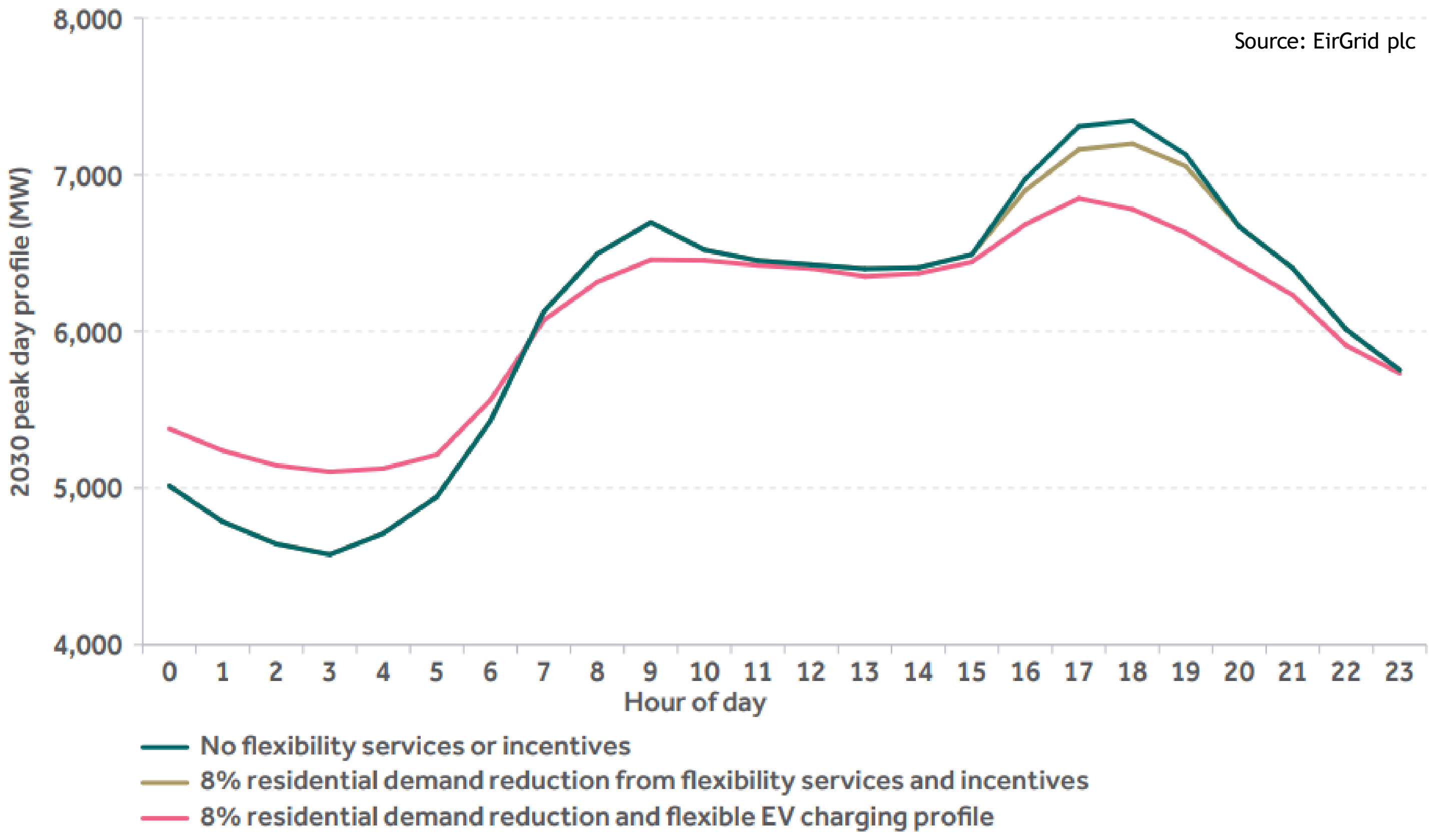
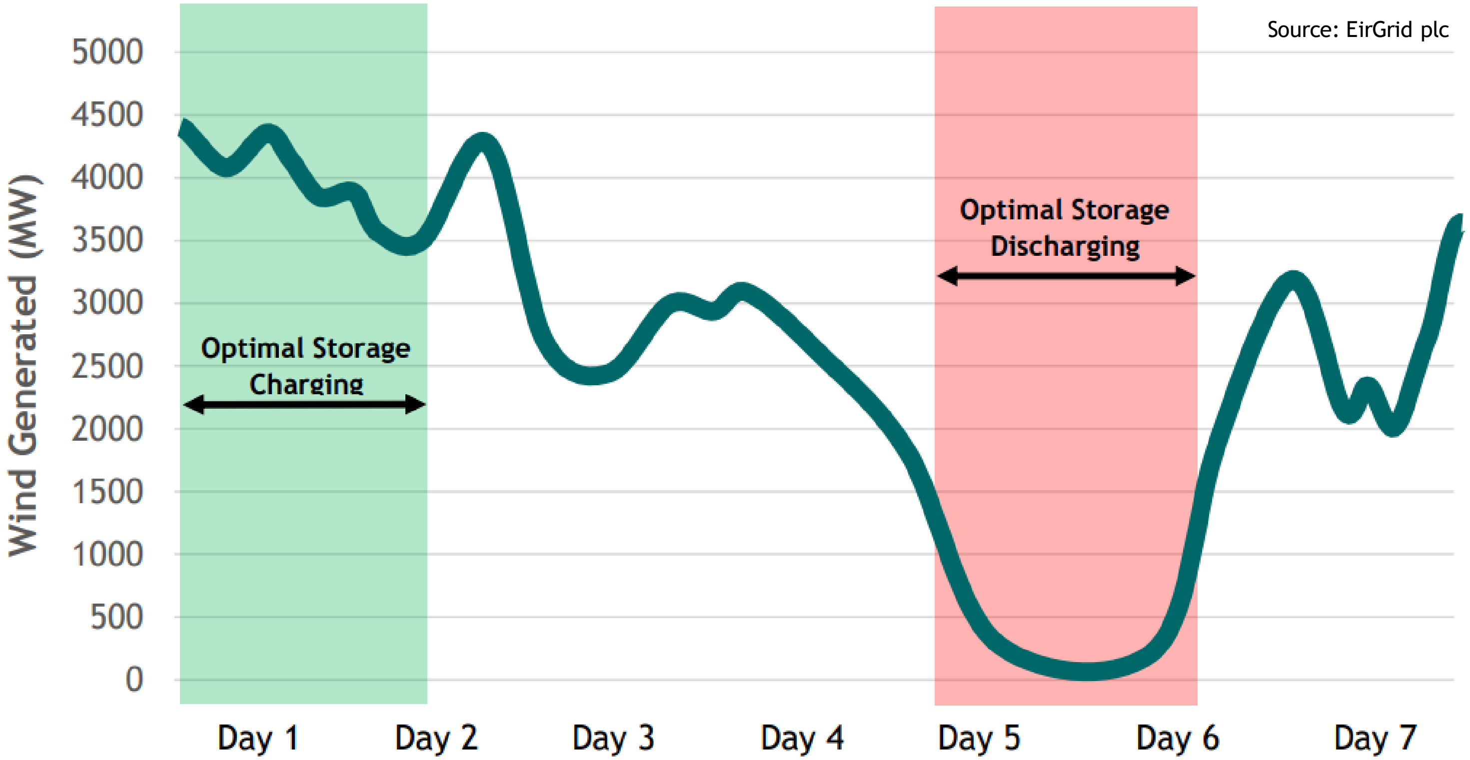
Flexible technologies – Demand Side

- Demand side response involves users of electricity (business, residential, commercial, or industrial consumers) having the capability to change their electricity usage patterns from their normal or current consumption patterns, i.e. to temporarily turn down, or turn up, or shift demand from one time to another, in response to signals (explicit obligations or implicit incentives);
- Some can also provide services ranging from fast acting reserves to longer term ramping capability;
- Focus in European policy, e.g. Network Code for Demand Response;
- Focus in National Policy for Ireland, National Energy Demand Strategy (NEDS), Demand Flexibility target of 20-30% by 2030.



Flexible technologies - Storage

- Long duration energy storage is a technology storing energy in various forms including chemical, thermal, mechanical, or electrochemical. These resources dispatch energy or heat for extended periods of time ranging from hours, to days, weeks, or seasons*;
- In particular, storing renewable energy at times when it is abundant and in surplus to have it available at times when renewable energy is less available and in deficit, to prevent or reduce the need to utilise non-renewable sources;
- Different resources can provide services potentially ranging from fast acting frequency response.



* Source: https://www.ldescouncil.com/

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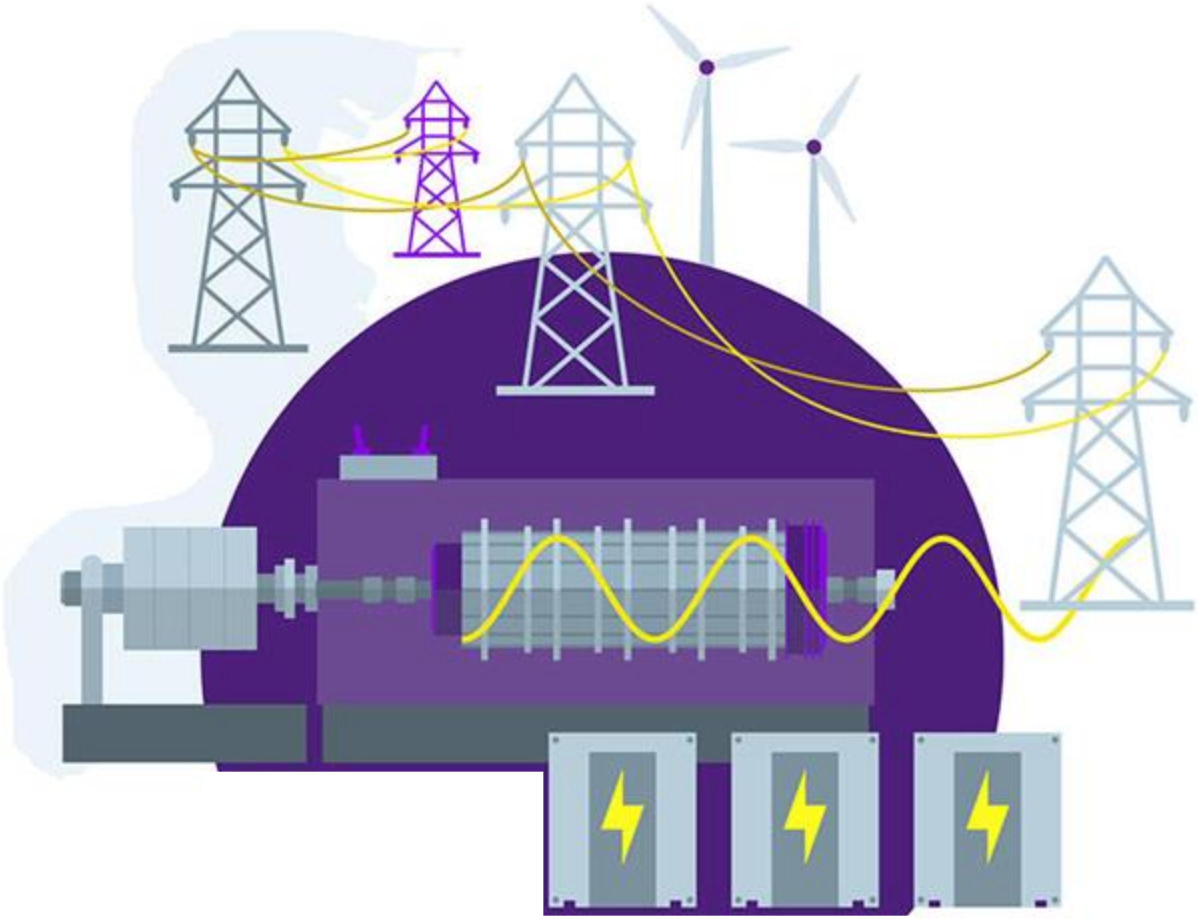
Flexible technologies – Low Carbon Inertia Services (LCIS)

- New sources to provide services like inertia and reactive power to manage local and system-wide needs;
- **Synchronous Condensers** – can provide stability services like generators, spinning motors which have physical mass to provide stability through inertia, reactive power, but consume power from the system rather than burning fossil fuels to do so;
- **Grid Forming** – where non-synchronous resources which normally cause problems with stability (e.g. wind, solar, battery) can operate in ways which mimic the behaviour of synchronous generators in providing inertia and voltage support.



Source: https://www.siemens-energy.com/global/en/home/press-releases/two-become-one-siemens-energy-combines-two-technologies-to-stab.html

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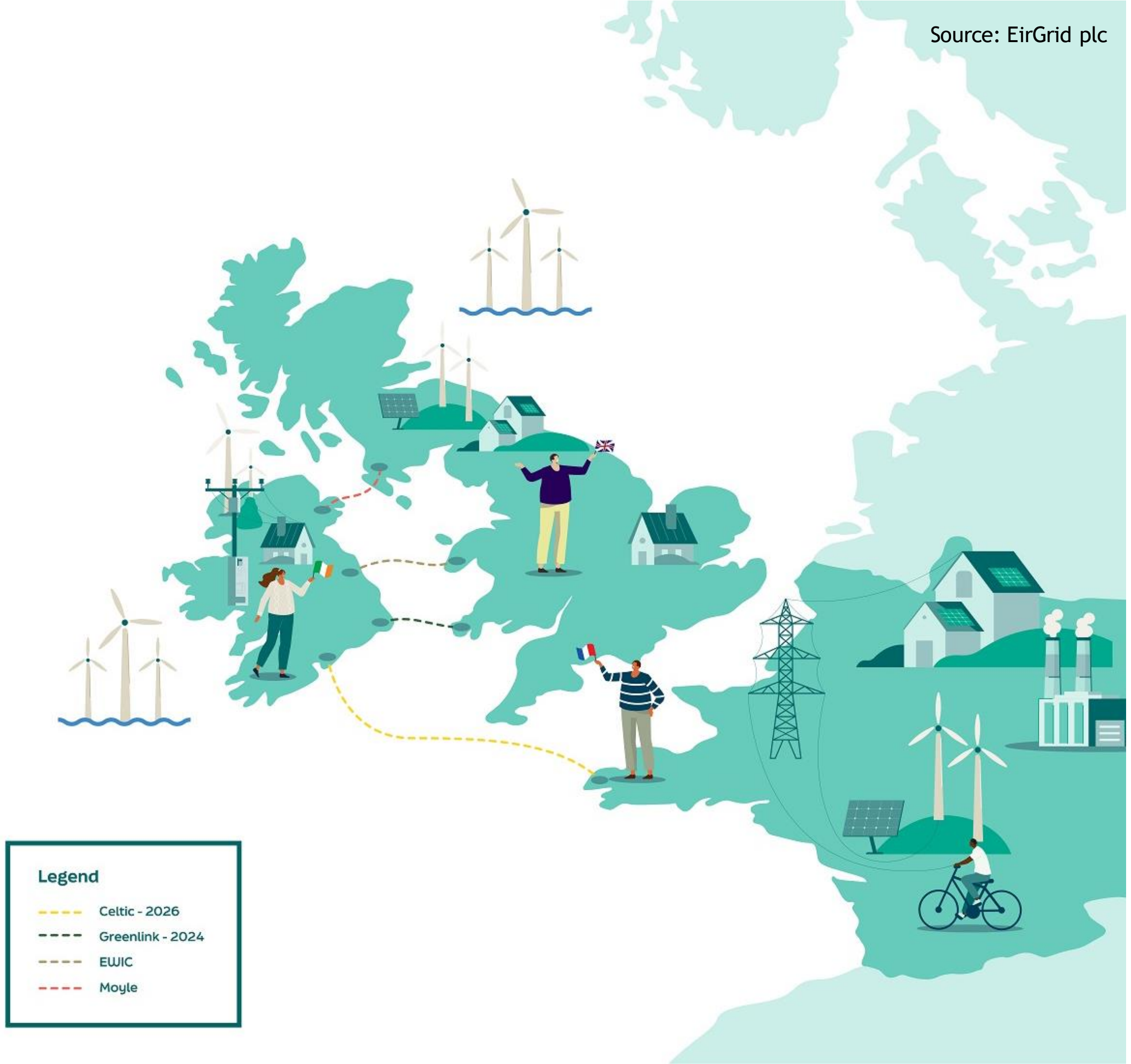
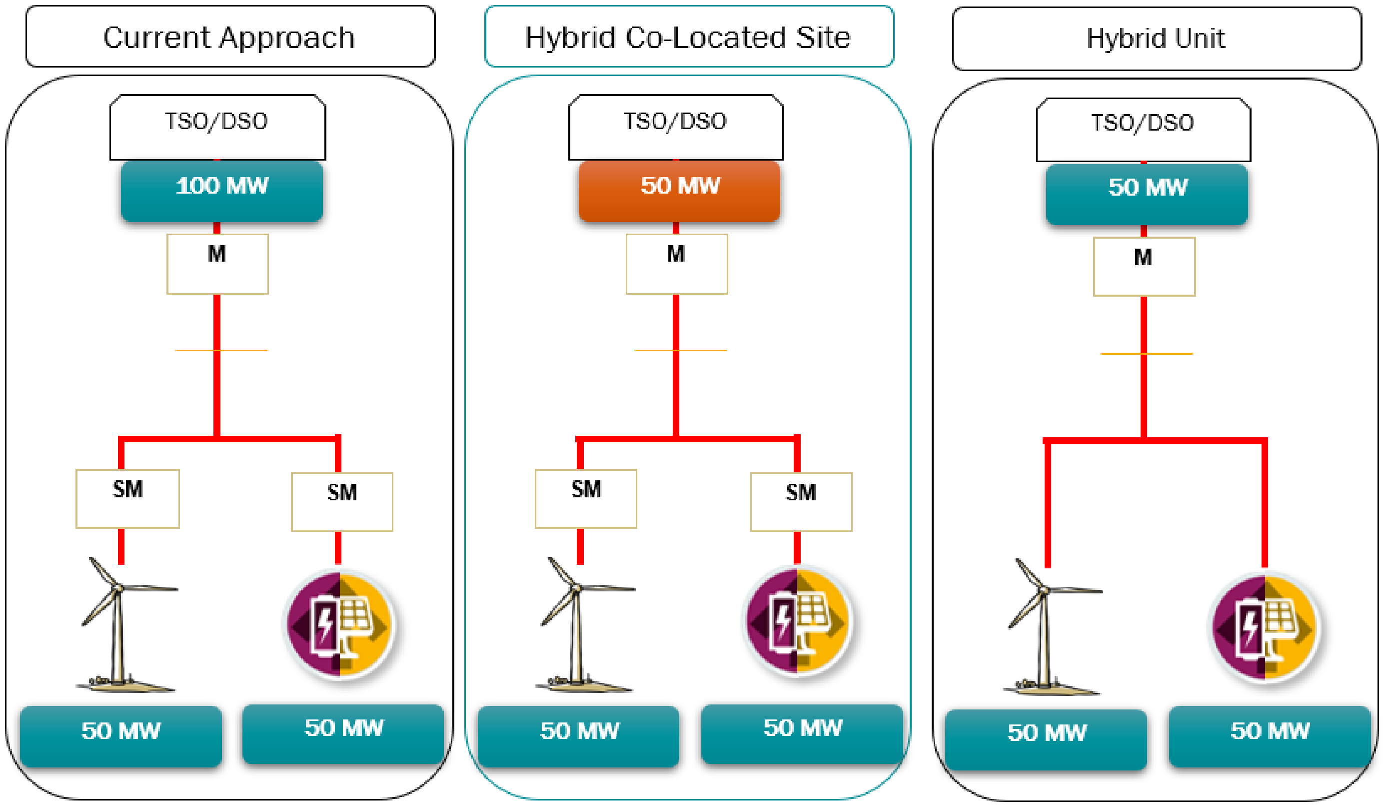
Flexible technologies - Interconnection

- Different weather and operating conditions in different areas means one area which has better conditions in a particular period (e.g. has a surplus of renewables, no system concerns) to the other area which has less good conditions (e.g. a shortfall of renewables, system issues);
- Can often provide other fast acting services, and operate in modes which are more sensitive, to help with changes in frequency.



Flexible operations – Hybrid connections

- Sharing of Maximum Export Capacity (MEC) and Hybrid Units;
- Enabling multiple technologies to be connected behind a single connection to the network where they can share the connection without needing to develop additional network capacity (net export from the combination of each resource less than or equal to the single connection point's MEC);
- Increasing efficiency and maximising of the use of the network, and increasing capacity factors of the connected resources;
- Enabling quicker connections of renewables and flexible technologies (such as battery storage); without needing to match with increased network development.



Source: EirGrid plc

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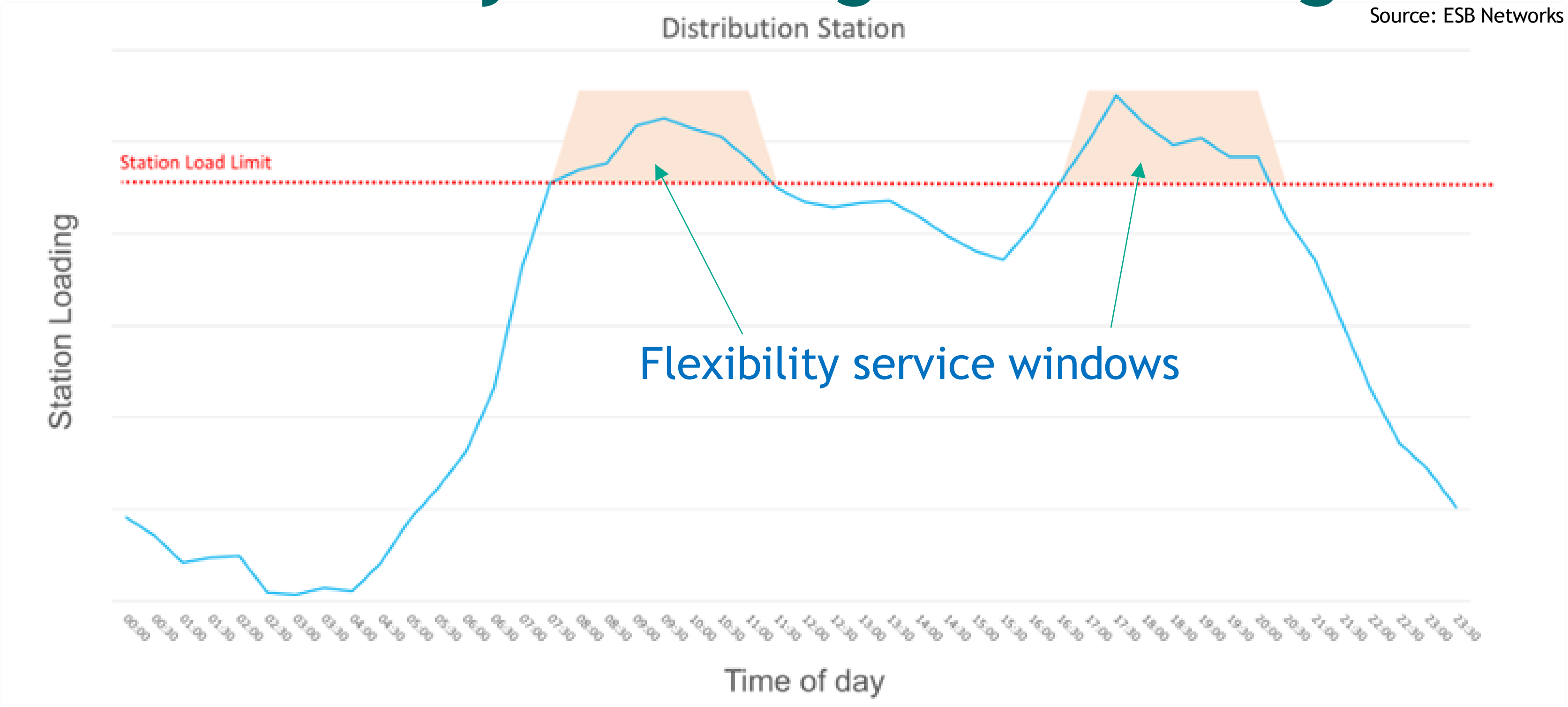
Flexible operations - TSO-DSO Operating Model for coordination to enable distribution system congestion management

Source: ESB Networks



1. Forecasting & Bid Management
2. Optimisation & Scheduling
3. Activation & Dispatch
4. Settlement

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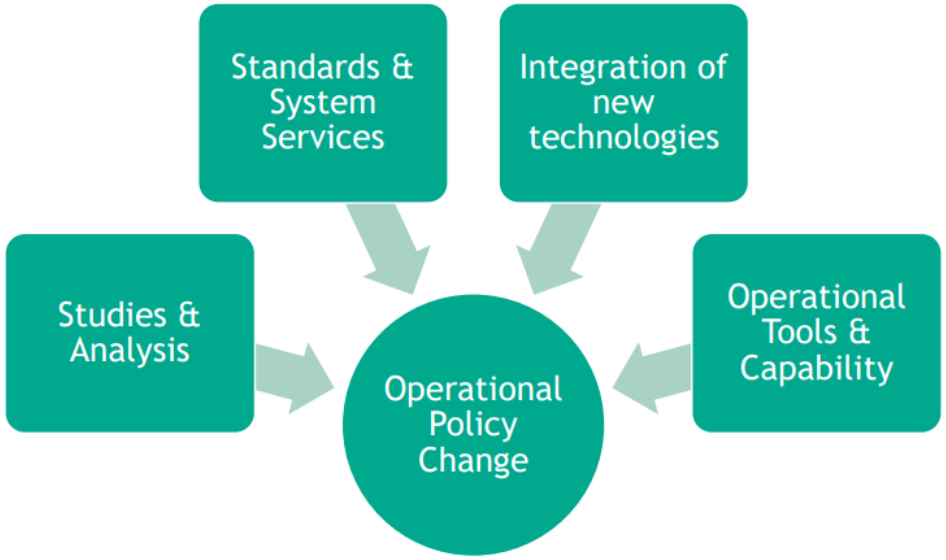
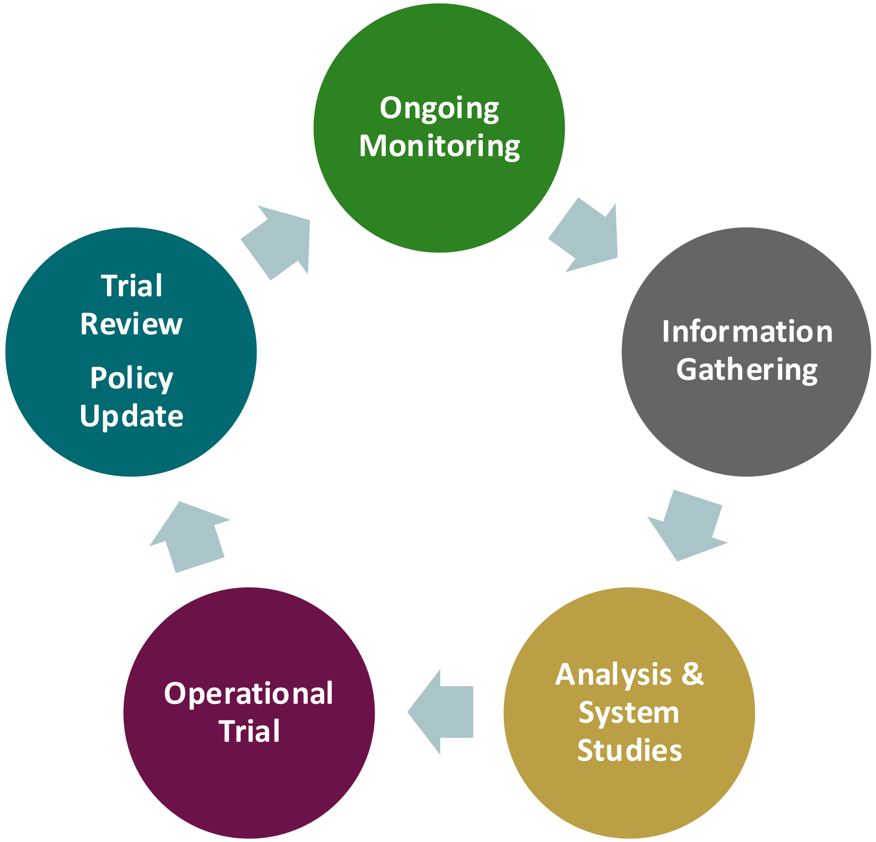
Flexible operations – Operational Policy Change Process

Existing policies and standards used to operate the power system may have been suitable based on considering conventional generation, but to transition to 2030 there is a need to change these policies considering new system capabilities.

Operational policy in EirGrid is monitored, reviewed, and updated according to a five-stage process, and governed by a joint Operational Policy Review Committee (OPRC) with SONI in Northern Ireland.

With enhanced control centre tools, can analyse, forecast, and prevent issues more accurately to operate in a secure way in conditions and to standards which in the past would have been considered insecure, enabling changes in operational policy.





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Summary conclusions

Summary conclusions

1. Flexibility means different things depending on the context of who is mentioning it, when they are mentioning it, and for what it is intended to be used for

2. However, could be useful to think of flexibility as technology resources or ways of operating which can be used to meet one or many system needs, with certain characteristics which are compatible in the context of the operating conditions

3. The drive for increased flexibility comes primarily from overarching goals of decarbonization, increasing renewable generation, and trying to maximise the use of the network especially to increase the speed of the transition

4. There are various different new technologies and ways of operating can be considered flexible, and how they are developed and enabled needs to be based on a balance of incentives (e.g. through markets) and standards (e.g. changing operational policy)

5. Lots of work is needed to increase flexibility, but it is important to recognise that the value of this is to enable the transition to a low carbon power system in the most cost efficient way possible while maintaining system security

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Thank you!