Regulating Non-Traditional Business Models in the Context of the Energy Transition

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07/11/2024

AFRY

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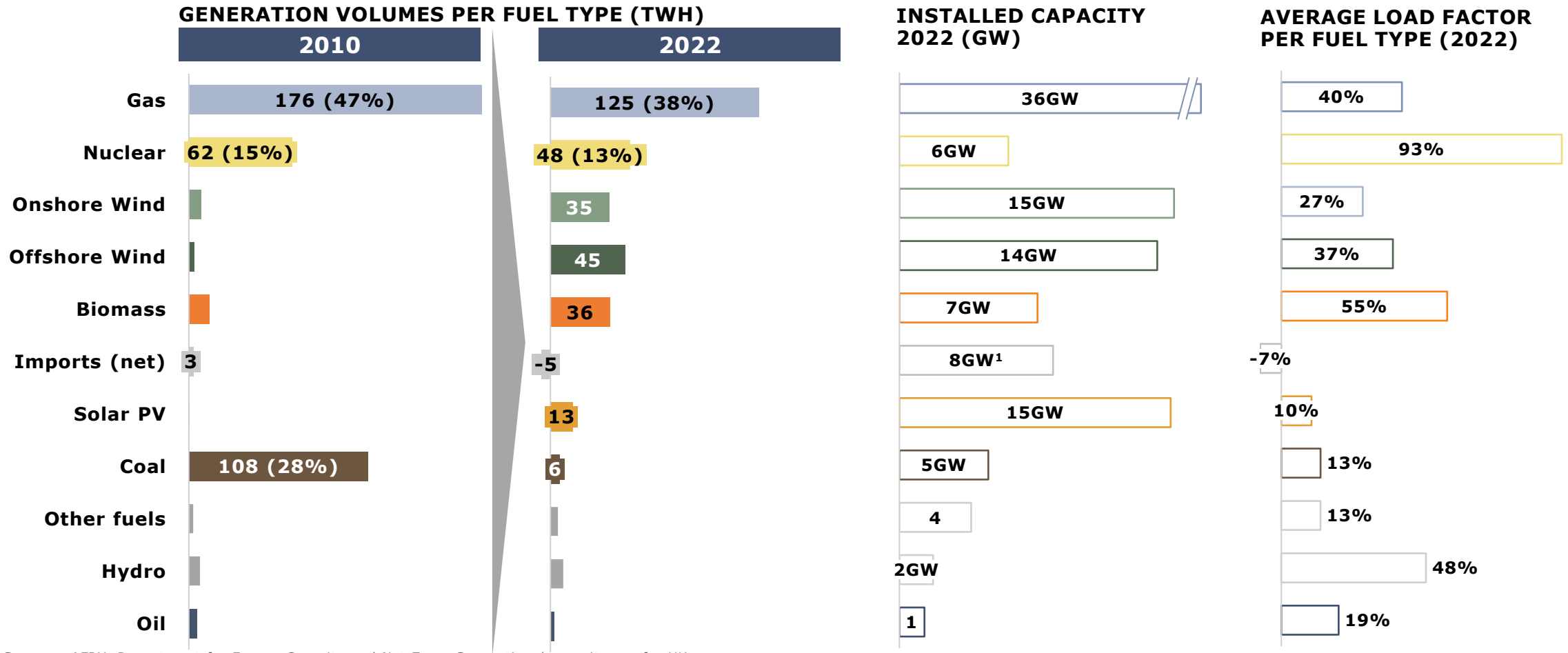
Renewables are rapidly replacing coal and gas, but gas retains a dominant role in generation mix and in pricing



Sources: AFRY, Department for Energy Security and Net Zero. Generation / capacity are for UK
1. Total interconnector capacity UK. This does not include interconnection from northern Ireland to GB.

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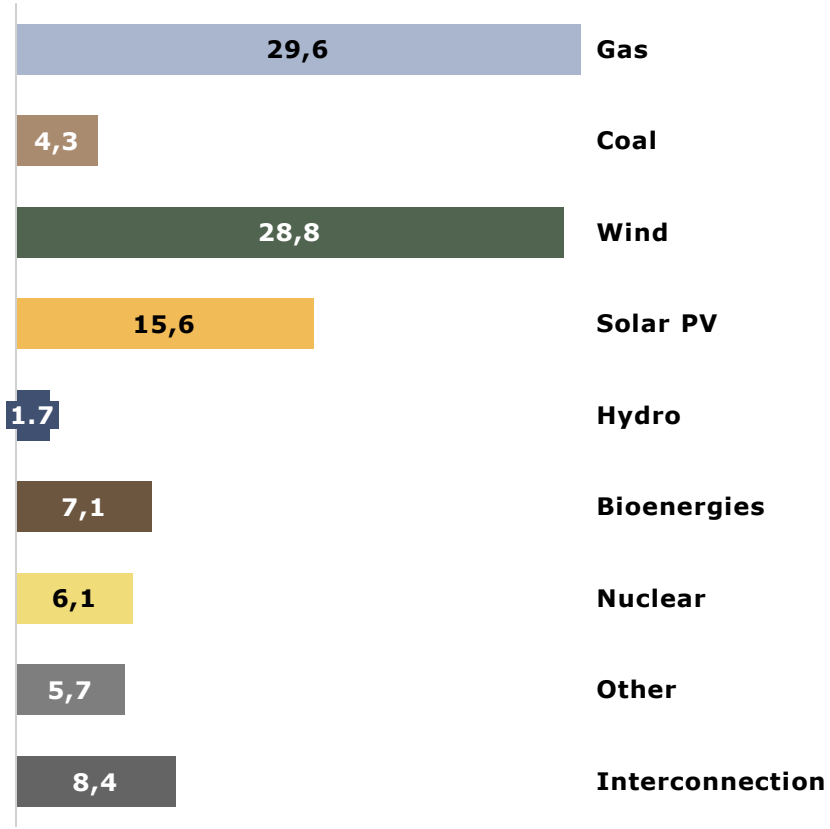
The GB energy mix is based on gas-fired and RES technologies, particularly wind, that have seen a rapid growth in recent years

INSTALLED CAPACITY (107 GW[1]) 2023



MARKET OVERVIEW (2023)

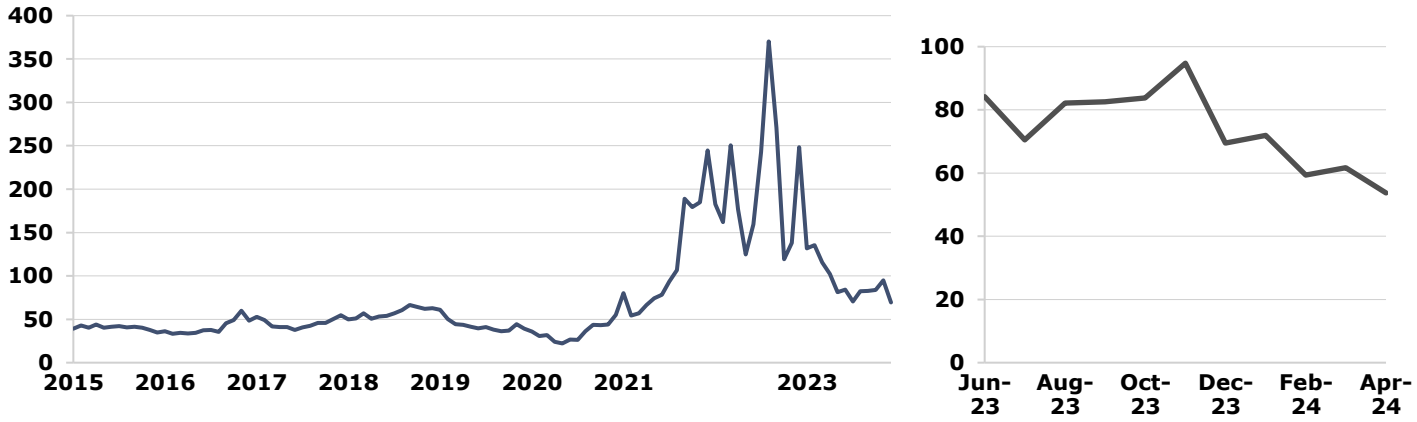
47% RES-E penetration by capacity wind, solar PV and hydro

34% Fossil fuels by capacity

316TWh annual demand
55GW peak demand

0.2$tCO2_e$/MWh

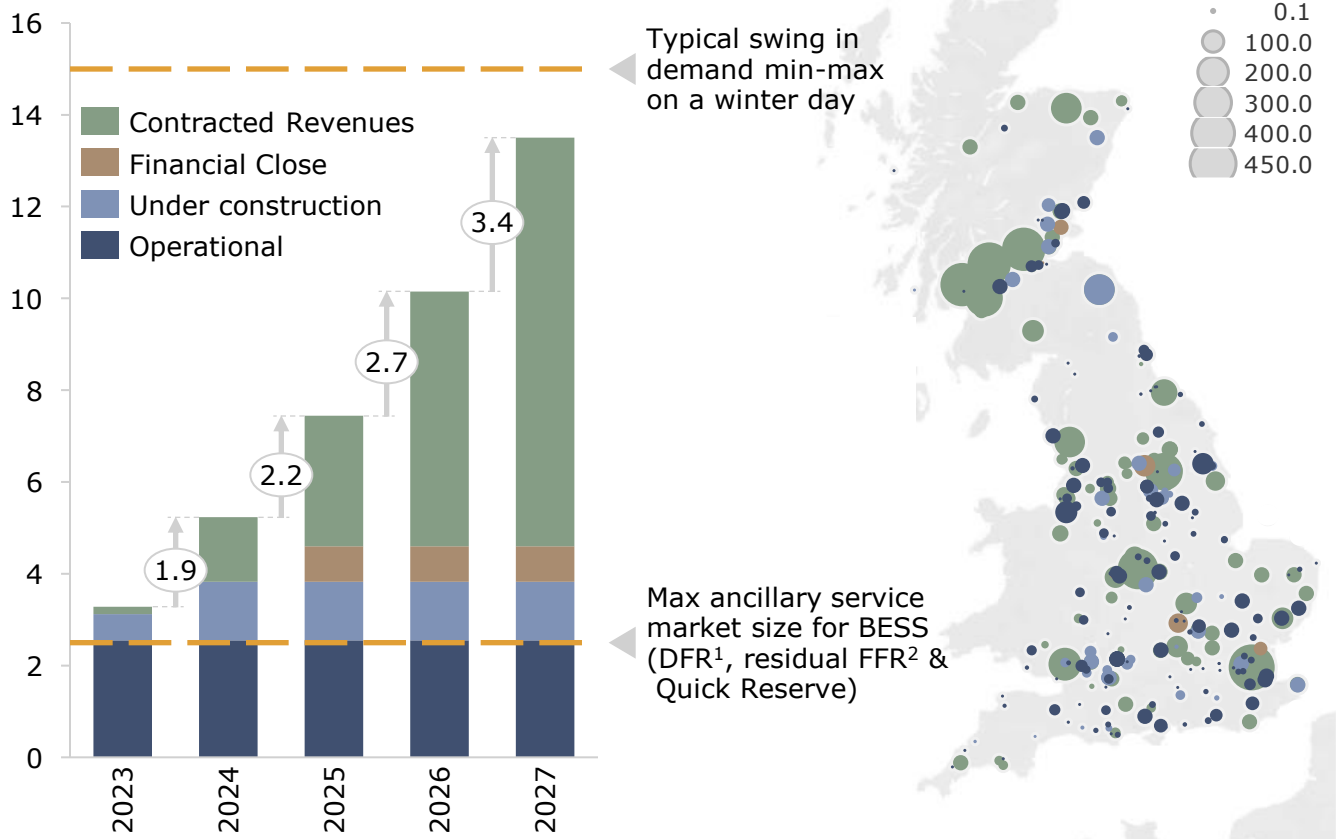
Day-Ahead Market electricity prices in £/MWh, nominal



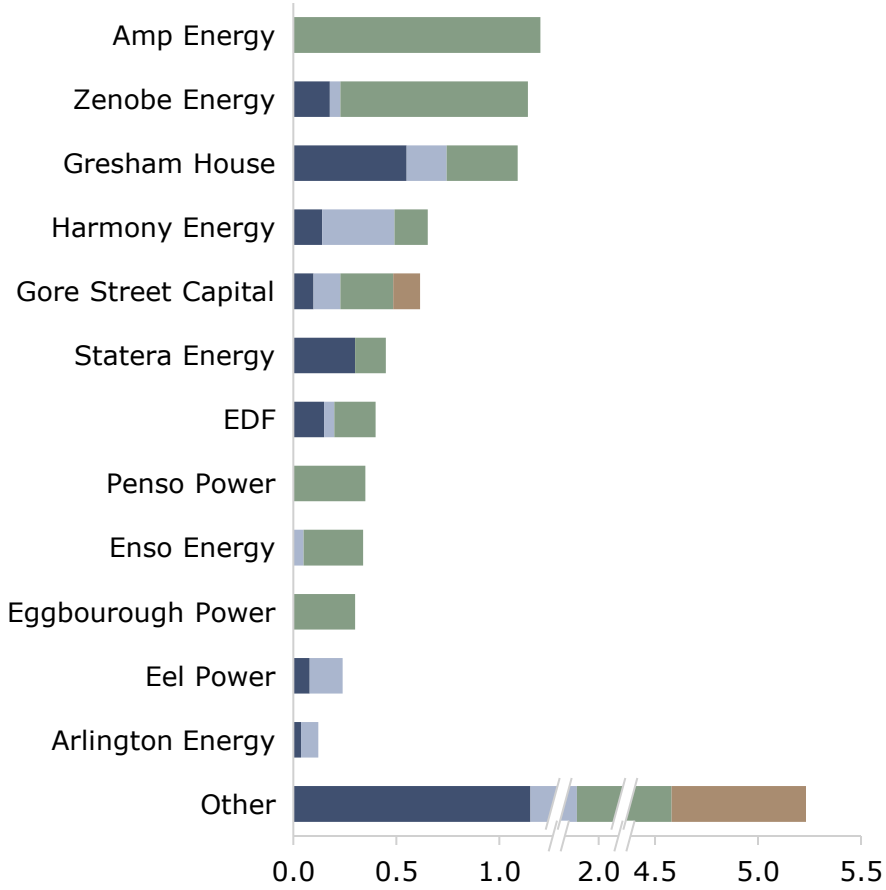
Notes: 1 - Excluding Interconnection capacity. 2 - From Electricity sector only
Source: National Grid, Department for Energy Security & Net Zero, Nordpool, AFRY analysis

There is a large pipeline of battery projects, and we expect ancillary services to become saturated

EXISTING AND FUTURE BATTERY STORAGE ASSETS, GB CAPACITY (GW)



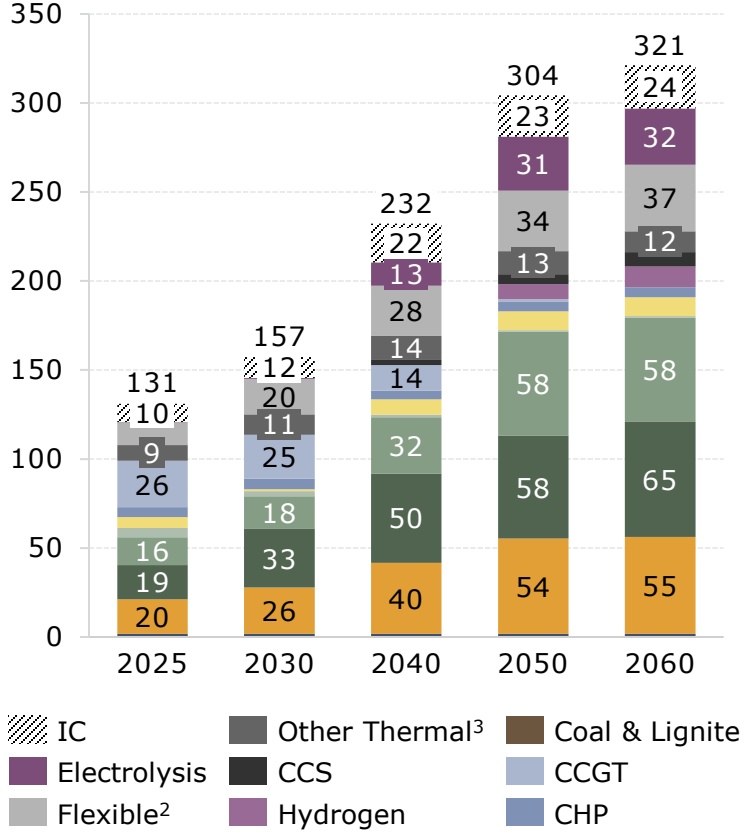
SELECTED GB PORTFOLIOS (GW)



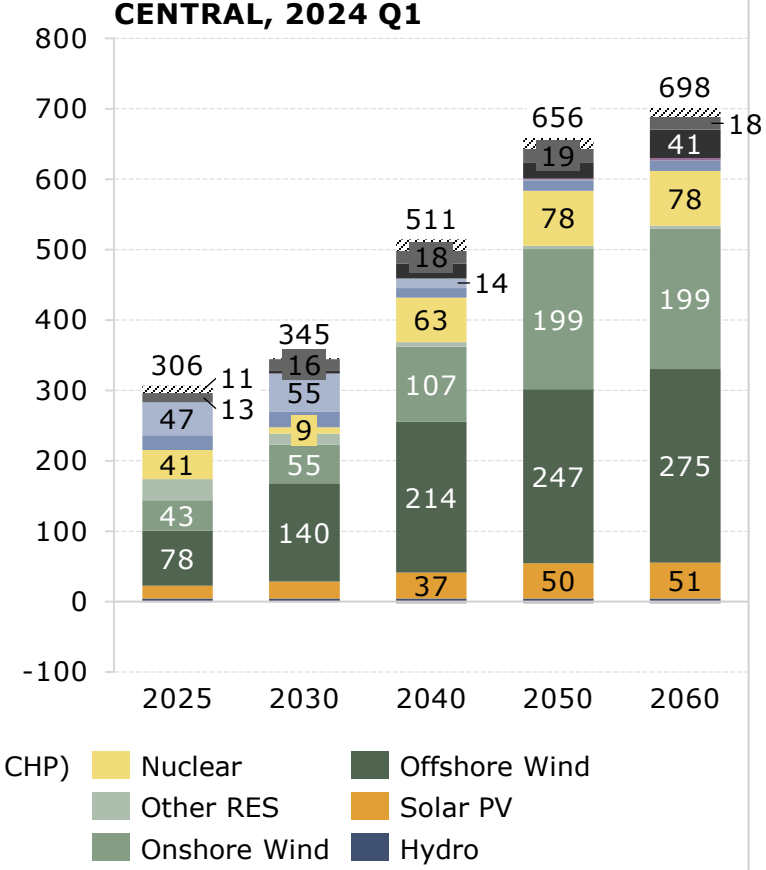
[1]DFR = Dynamic Frequency Response, [2]FFR = Firm Frequency Response | Source: AFRY analysis

Renewables are expected to dominate the capacity mix going forward

GW PER TECHNOLOGY – AFRY CENTRAL, 2024 Q1



TWH PER TECHNOLOGY – AFRY CENTRAL, 2024 Q1



IC
Electrolysis
Flexible[2]
Other Thermal[3]
CCS
Hydrogen
Coal & Lignite (incl. CHP)
CCGT
CHP
Nuclear
Other RES
Onshore Wind
Offshore Wind
Solar PV
Hydro

OVERALL OUTLOOK

- Significant growth in offshore wind during 2020s, reaching the Government's 2030 50GW target in 2040
- Initially, growth in onshore wind and solar PV is driven by assumed policy-supported capacity. In the longer-term (from the 2030s), this is mainly wholesale-driven onshore wind and solar.
- Wholesale-driven solar and onshore wind becomes economic in the 2030s
- Wind becomes the dominant form of generation from the 2030s, due to high LFs and a large assumed increase in capacity.
- Despite a clear commitment towards net-zero emissions, UK has still not explicitly provided specific target for Onshore Wind. There is an 'ambition' to reach up to 70GW solar PV by 2035.

Source: AFRY Q1 2024 Central Scenario. 1- Negative numbers indicate either exports (IC) or consumption (Pumped Storage, Batteries); 2- Pumped storage, batteries, Demand-Side Response; 3- Engine/Gas and oil turbines/other

The UK has set very ambitious decarbonisation targets, leading the way for renewables to replace conventional power plants

1 The UK has a target to reach net zero by 2050 and a Clean Power system by 2030

- Net zero by 2050 is a legally binding target
- To ensure the UK stays on track to achieve these targets, there is a 'carbon budget' system which caps greenhouse gas emissions over a 5-year period under the independent Climate Change Committee
- The new Labour Government reinforced its commitment to achieving 'Clean Power' system by 2030

2 The government has highly ambitious plans when it comes to RES supply

- The UK has ambitious offshore & onshore wind and solar PV plans, and a strong pipeline of projects
- These are currently supported by the Contracts for Difference. Auctions are held annually
- However, bottlenecks in permitting and grid connection may hinder progress

3 Other low carbon technologies; nuclear, CCS, and flexibility, hydrogen, BESS

- New nuclear ambition, 1 reached FID in the last parliament, 2 expected in this, including SMRs
- Two CCUS clusters by mid-2020s, four by 2030, and at least one power CCUS project by 2030
- 10GW of low-carbon hydrogen production by 2030, half of which is from electrolysis
- The BESS pipeline in GB is very strong
- New Long Duration Electricity Storage support mechanism to come online 2025 to speed up delivery

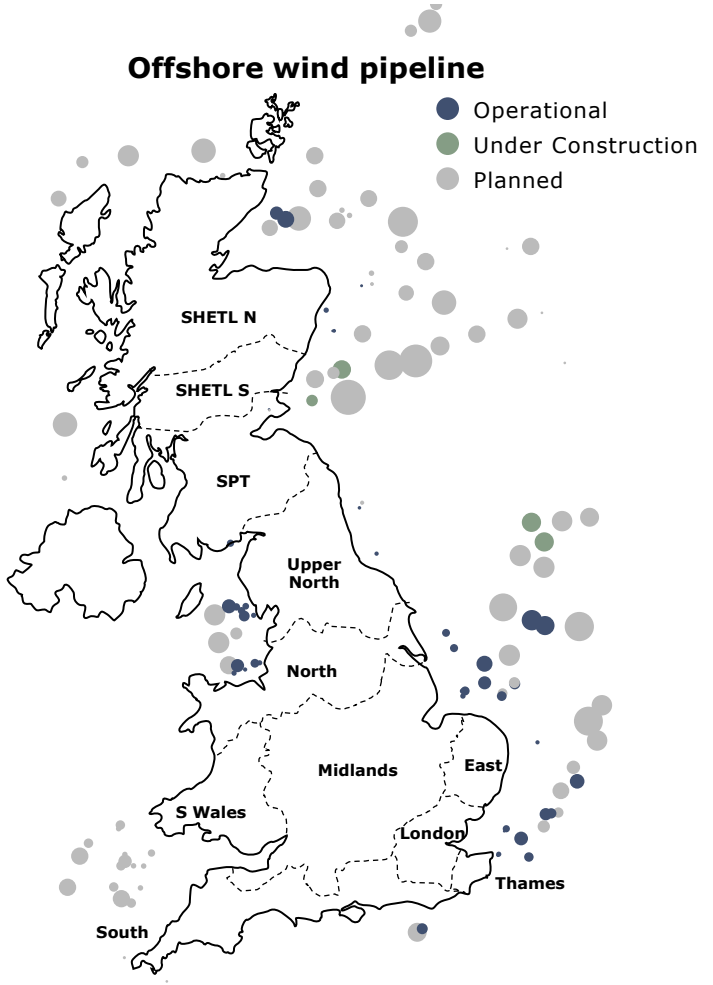
4 How is the market going to accommodate all these changes: Review of the Electricity Market Arrangements (REMA)

- An ongoing consultation on a proposed major overhaul of current power market design
- Aim is to encourage investment in a range of technologies and establish modern markets which are set up to decarbonise by 2030

5 NESO's grid connection reform aims to connect capacity faster

- An ongoing implementation of the 'grid connection reform' aim to shorten the grid connection queue substantially, speeding up connection of renewables and storage assets

Offshore wind pipeline

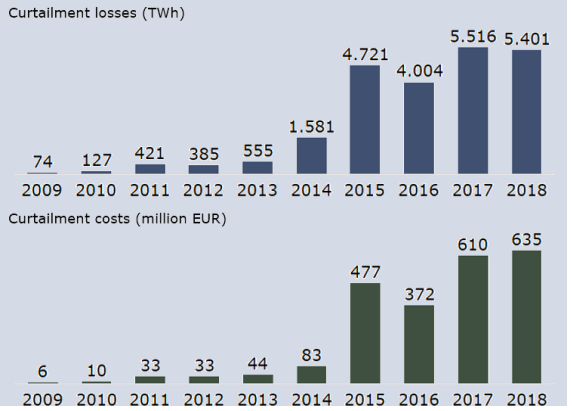


All markets will face the same challenges arising from decarbonisation

DECARBONISATION CHALLENGES

Location

Curtailment loss estimate across EU*

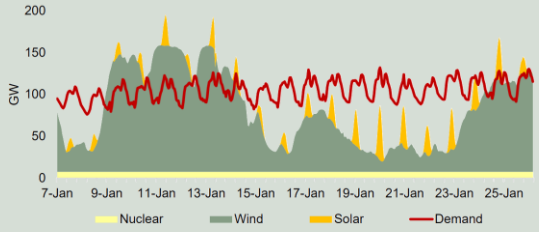


Minimising curtailment from locational network congestion requires increasing transmission capability and flexibility through storage

Distributed resources such as DSR and batteries can absorb exceeding RES energy, reducing curtailed volumes

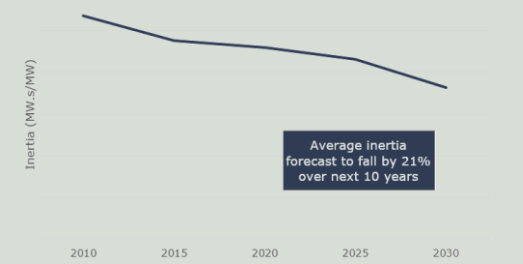
Balancing and stability

Generation and consumption gap in Great Britain - 2050



New demand and renewables generation requires steep ramping and rapid dispatch of non-renewables capacity and short and long duration storage

Falling Grid Inertia in the UK**

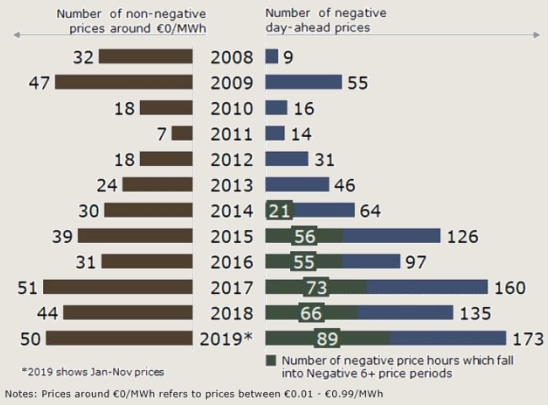


Growth in variable renewables will reduce inertia and voltage stability

Flexible demand/ local generation can support the system during period of demand/supply mismatch and grid instability

Commercial and investment risk

Negative prices in EU*



Failing to reward scarcity or flexibility risks create 'missing money' problem, requiring other solutions

Enabling market access to local flexible sources would mitigate price and volume volatility

EU: European Union; DSR: Demand Side Response; RES: Renewable Energy Sources

Business Models have to change to respond to decarbonisation goals, new technologies and to maintain a reliable and effective power grid

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Three mega trends are at play in the energy transition which is paving the way to the future energy system, often called "**the 3 D's**"

DECARBONISATION

- Renewable energy capacity has become a major source of power generation – T&D networks will need to adjust
- Heating and transport are to be electrified, as well as industry
- Coal and gas share in generation mix is decreasing - H2 and CCS will start playing a role to complement renewables

DECENTRALISATION

- With rising solar, battery & EV penetration, the share of self-produced electricity from small-scale units (B2B & B2C) increase
- The overall energy demand balance will shift away from gas towards electricity consumption, as heat pumps enter the heating sector at large scale
- Flexibility will be decentralised

DIGITALISATION

- Entirely new business models will evolve around new asset classes and from digital solutions, where value is created in the orchestration of assets
- Peer-to-peer energy trading platforms will revolutionise power markets
- There are new developments for 24/7 matching of clean energy

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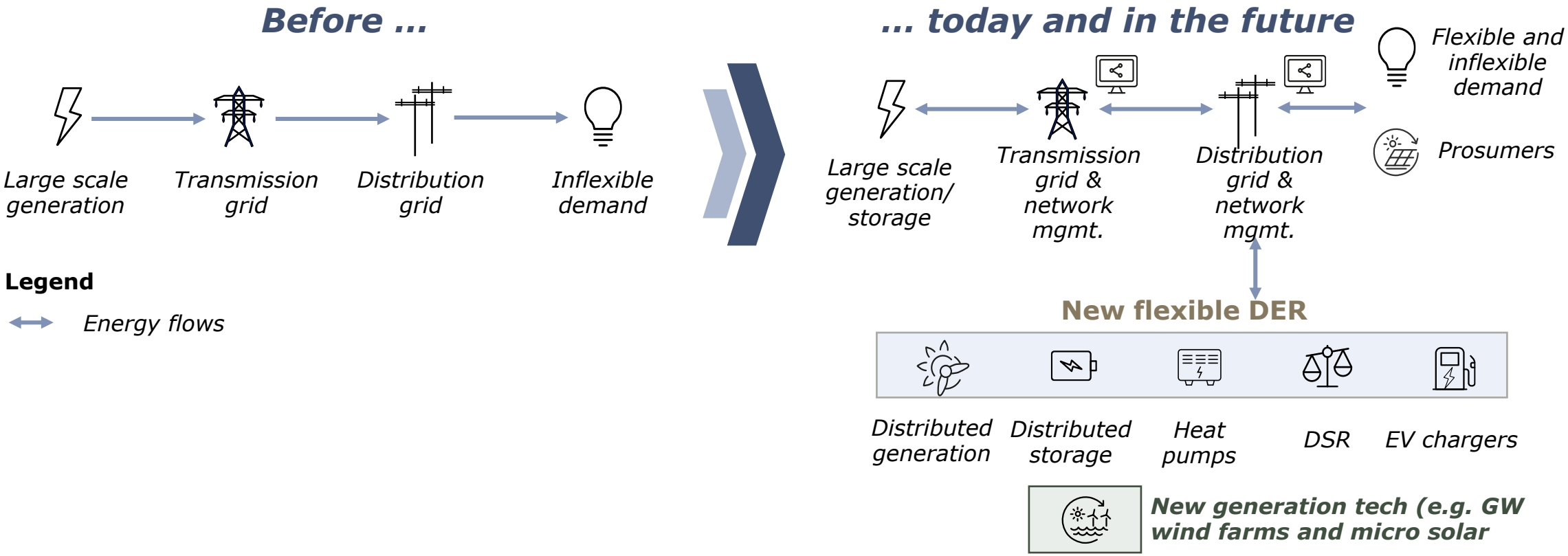
The set up of energy markets has been changing, starting with the entry of new distributed energy resources (DER) and the need to manage them

HOW THE SETUP OF ENERGY MARKETS HAS EVOLVED



DSO: Distribution System Operator; TSO: Transmission System Operator; DER: Distributed Energy Resources; DSR: Demand Side Response; EV: Electric Vehicle

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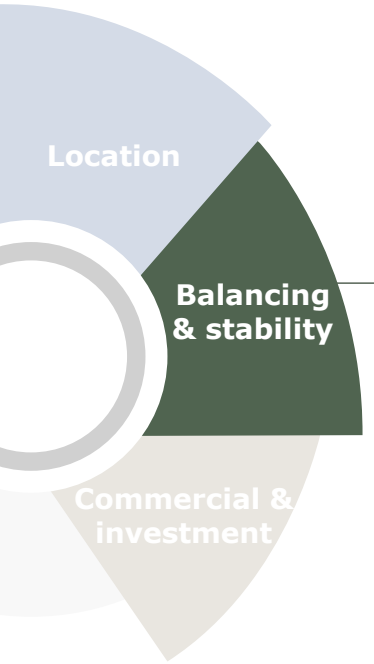
EXAMPLES OF NON-TRADITIONAL BUSINESS MODELS – DIFFERENT WAYS TO RESPOND TO MARKET

The future electricity system requires new providers of all types of flexibility, with new buyers (incl. DSOs) and new product definitions

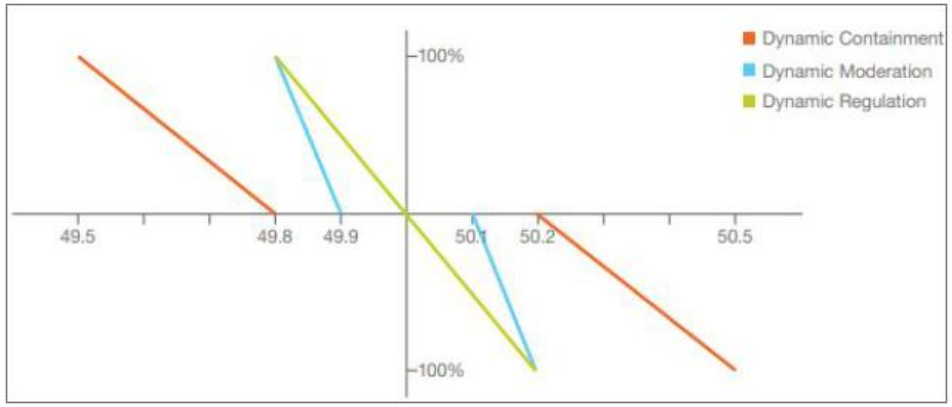
Period	Flexibility Challenges		Grid Challenges		Example Solutions							
Real Time Stability	**Maintaining System Stability**	Inertia Voltage Short circuit levels	 Lower inertia	 Increased largest loss	 AC (or DC) transmission	 Static VAR compensators	 Grid-forming converters	 Synch comp/ condensers	 Flywheels			
Intraday Frequency Intraday Flexibility **Peak** Capacity adequacy	**Balancing Demand and Supply**	Imbalance correction Ramping Daily Cycles Frequency response	 Lower capacity & LF of thermal plant	 Daily Renewable generation profiles	 Enhanced transmission	 Battery systems	 C&I DSR	 Flexible EV charging	 Water tank storage	 Residential DSR		
Seasonal Seasonal flexibility	**Seasonal and locational patterns**	Seasonal Cycles Price signals Load shifting (time & location)	 Lower capacity of thermal generation	 Seasonal Renewable generation profiles	 Enhanced transmission	 Long-term thermal storage	 Hydrogen deployment					

New faster response products have been developed to allow NESO to manage frequency as RES generation increases

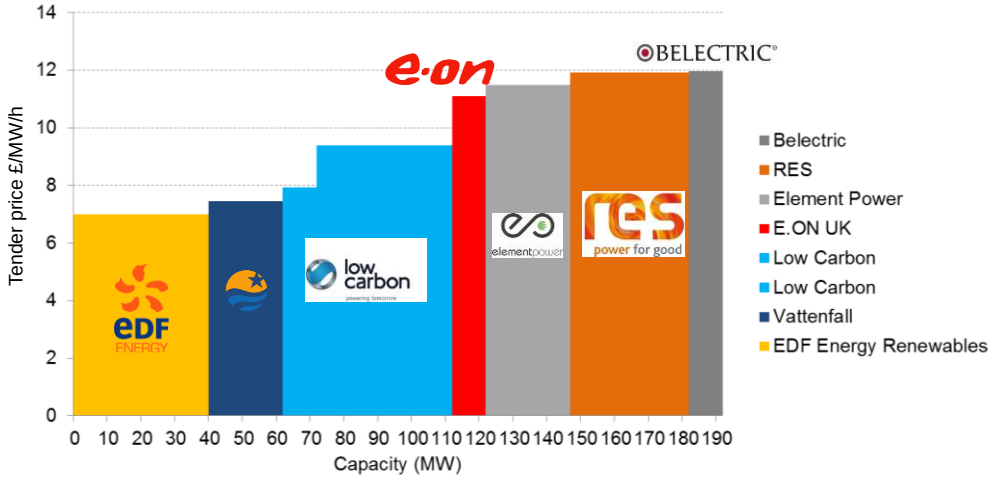


- NESO is developing its product suite to access faster forms of response; dynamic containment, dynamic moderation and dynamic regulation
- NESO also ran a one-off tender process for enhanced frequency reserve, which offered 4 year contracts to new providers – this secured 200MW of new battery capacity across 8 facilities, at a total cost of ~£66m over the 4 years

New / upcoming response products



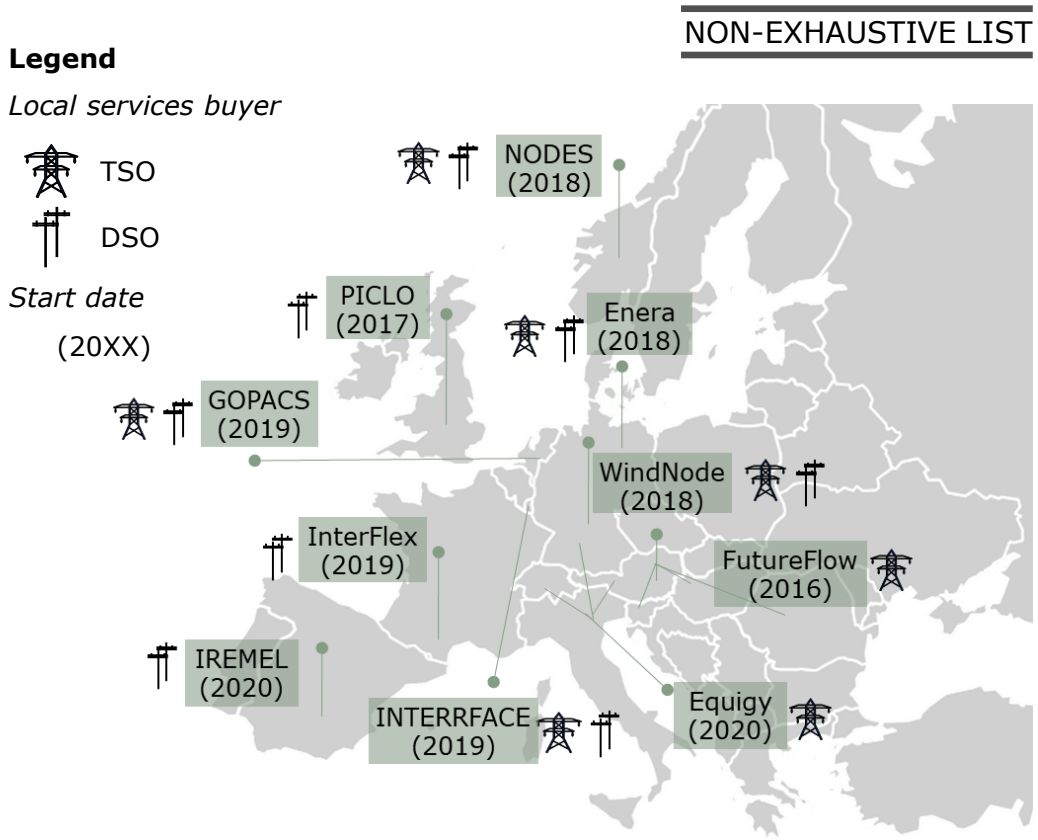
EFR tender results (2016)



Flexibility initiatives such as those being piloted across Europe are testing new ways of electricity system management including at local level

EXAMPLES OF EUROPEAN INITIATIVES FOR LOCAL FLEXIBILITY

NON-EXHAUSTIVE LIST



CRITICAL DRIVERS TO FURTHER OPTIMISE LOCAL FLEXIBILITY

1. **Flexibility strategies**
Government entities to set rules guiding SOs and users through use of flexibility (e.g. Ofgem has initiated the process to implement a flex strategy)

2. **Suitable incentive arrangements for DSOs**
Incentive structure (e.g. TOTEX) should incentivise DSOs to use flex sources when more efficient than building new grid capacity

3. **Innovation and digitalisation**
Innovation funding to enable use of digital tools to visibility and control (e.g. TSO-DSO Digital Twin[1])

4. **Smart metering (and sub-metering)**
Smart meters (or sub-meters) with appropriate market settlement are a key enabler for participation of DR in electricity markets

5. **Harmonisation of flexibility markets**
Greater harmonisation of design to enable scaling of flexibility service provision

Sources: flex initiatives/platforms - AFRY analysis | 1. European Commission has mandated the EU DSO Entity and ENTSO-E to develop a Digital Twin at DSO-TSO level | TSO: Transmission System Operator; DSO: Distribution System Operator; SO: System Operator; DR: Demand Response; RES: Renewable Energy Source

EXAMPLES OF NON-TRADITIONAL BUSINESS MODELS

Grid modernisation has been driven through incentivised innovation and the proactive role of NESO and Ofgem to develop new markets and services

- **MW Dispatch Service**: the service supports management of transmission network constraints, allowing NESO to use DER units as well as those already available through BM.
- **Demand Side Response and Flexibility Service**: service put in place for the 2022/23 winter, involving 1.6 million households and businesses which have been incentivised to reduce use of electricity.
- **Local Constraint Market**: trial market to access flexible DER to help managing most constrained network boundaries in Scotland.
- **RIIO price control and strategic innovation funding from Ofgem:** regulates energy network companies in the UK, incentivising them to deliver reliable, cost-effective services while supporting strategic innovation.
- **Half hourly settlement for smart meters:** allowing for precise billing that encourages consumers to shift usage away from peak times, supporting grid efficiency and renewable energy integration.

Source: National Grid ESO – MW Dispatch Service, Demand Flexibility Service, Local Constraint Market | DNO: Distribution Network Operator; DER: Distributed Energy Resources; BM: Balancing Mechanism

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Colombia has set ambitious targets for decarbonization by 2030 and 2050, driven by the increase of energy efficiency and RER penetration

Energy National Plan 2022-2052

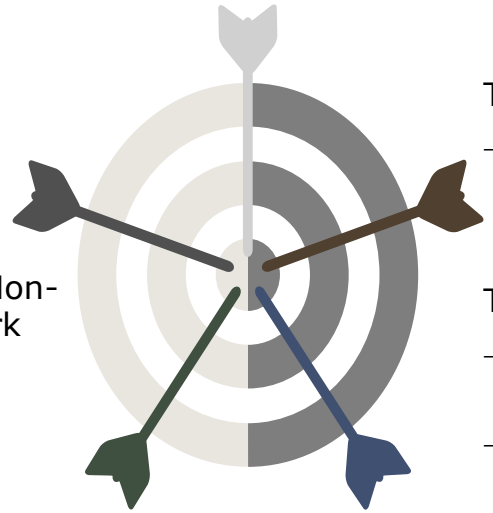
Targets by 2050:

- Increase the share of non-conventional sources of energy to 50-70% of the generation.
- Reduce emissions associated to energy consumption by up to 50%.
- Increase R&D and innovation in the energy sector.

Energy Efficiency

Develop Rational and Efficient Use of Energy and Non-Conventional Forms of Energy (PROURE) framework targets by 2030:

- 10% potential reduction of energy consumption.
- Savings associated to good practices in the thermoelectric sector reach 44.7% of potential.



Nationally Determined Contribution

- In line with the Paris Agreement, Colombia has expressed it´s compromise with reaching carbon-neutrality by 2050, starting a reduction in emissions from 2027 onwards.

Offshore Wind Roadmap

Targets by 2050:

- Between 1.5 and 9GW of Offshore Wind installed capacity.

Hydrogen Roadmap

Targets by 2030:

- Develop a minimum of 1GW of electrolysis capacity for green hydrogen production near demand.
- Reduction of green Hydrogen production costs to the considered optimal level: USD1.7/kg.
- Deploy 2.5 to 5.5 billion dollars of total investments.
- Contribute to the decarbonization of Colombia with the reduction of 2.5-3Mton CO2eq emissions.
- 40% low-carbon hydrogen penetration.

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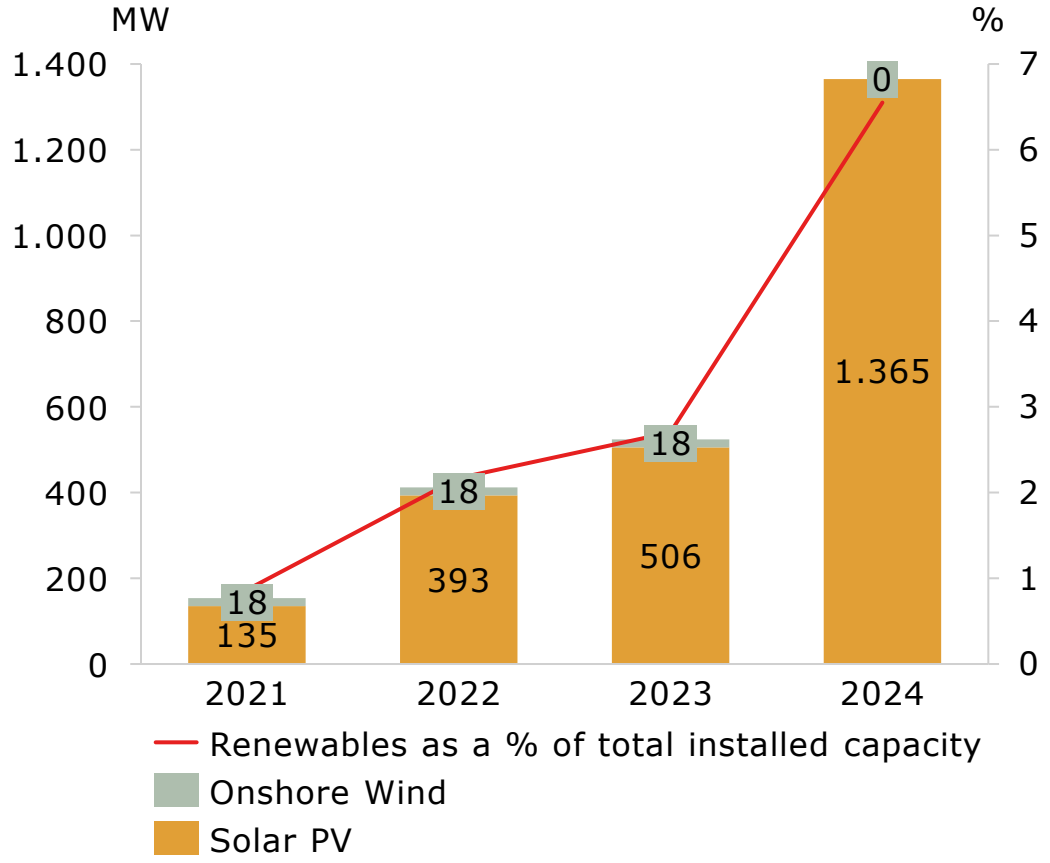
In Colombia, renewable capacity increased significantly in recent years, but the accomplishment of the 6GW short term target seems unlikely

KEY TAKEAWAYS

- The Colombian national government target to achieve 6GW of renewable energy installed capacity by 2026 appears to be unlikely.
- Despite an increase of over 800 MW between 2023 and October 2024, the slow pace of short-term progress casts doubt on meeting longer-term decarbonization targets for 2030 and 2050.
- Renewable energy currently contributes less than 5% to total generation in Colombia.
- While more than 7.5 GW of connection points for renewable energy projects have been awarded, bureaucratic and socio-environmental challenges significantly reduce the number of projects reaching commercial operation. These obstacles threaten the viability of Colombia's long-term decarbonization ambitions.

ONSHORE WIND AND SOLAR PV INSTALLED CAPACITY AND ITS PERCENTAGE OVER THE TOTAL SYSTEM´S CAPACITY



Digitalisation along with reduced bureaucratic hurdles and future-oriented regulations are cornerstones for a strong energy infrastructure

Key enablers

Regulatory frameworks: Establishing clear regulatory frameworks as grid operators need reliable, long-term and future-oriented investment security for electricity, gas and heating grids

Bureaucracy: Alleviating bureaucracy for system operators to shorten approval processes for major grid-related investments in the electricity sector arising from increasing connection requirements for decentralised renewable energy projects

Cooperation: Developing a high degree of social interactions between stakeholders as climate transition is complex, particularly in finely structured distribution grids

Digitalisation: Using software-guided process sections and artificial intelligence to enable scaling, automation and standardisation of decisions that must be repeated millions of times

Strategic actions

Utilities: Leapfrog in front of the wave as soon as utilities can, by investing heavily in their competencies to manage uncertainties, changes and a massively growing number of requests successfully

Industrial players: Clarify early on the development and production needs of industrial players with their clients, enhance their long-term procurement competencies and further develop software agnostic equipment

Governments: Ensure a robust investment framework with long-term incentives such as tax credits, grants, subsidies or loan guarantees, and reduce bureaucratic hurdles by streamlining permitting process for network operators

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Digitalisation of communications alongside Smarter Grids will allow network companies to operate in new and exciting ways

KEY CHALLENGES FOR DSOS AND TSOS ALONG THEIR DIGITALISATION PATH

Roadmap and Value Proposition for digitalisation

Advanced analytics for real-time operations and strategic planning

Digital and operational transformation

OVERVIEW OF THE MAIN MARKET CHALLENGES

- Network companies are combining rich sources of data with new analytical tools to support their asset and network management, such as machine learning for short term forecasts, predictive maintenance strategies for network assets as well as security measures to prevent cyber attacks

In Colombia…

- Only 3% of consumers currently have smart meters. Given high wholesale electricity prices, the significant investments required to expand network digitalisation through smart meters seem unfeasible in the short term.

DSO: Distribution System Operator; TSO: Transmission System Operator

There are substantial barriers to building stable and scalable business models from flexibility

The **economic value** of flexibility (to the system) comes from 3 main sources:

1. Wholesale
2. Transmission system services
3. Distribution networks

Participation to monetise these economic benefits may be direct or indirect: i.e. direct: selling services; indirect: avoiding charges (or avoiding connection delays)

Key barriers to commercialisation of flexibility:

1. ***Complexity and uncertainty*:** Some are (direct) paid services, others are monetised indirectly (avoiding fees, connecting faster) with frequent changes to the commercial arrangements
2. ***Participation rules/discrimination*:** these services often limit participation by smaller participants and non-conventional technologies:
   - Batteries are often overlooked by system operators due to the lack of an Ancillary Services market in Colombia
   - Lack of coordination between DSO and TSO services blocks opportunities for revenue stacking
3. ***Fragmentation*:** there is limited harmonisation of the services and value streams between markets (for distribution services this is very localised).
4. ***Incentives (especially on DSOs) are poor***: in many countries the DSOs have strong incentives to build networks and not to use flexibility services however typically there is lots of opposition and limited movement

OPPORTUNITIES FOR COLOMBIA

Regulation needs to ‘catch up’ to support accelerated innovation whilst involving industries and communities

Innovation-Driven Regulation

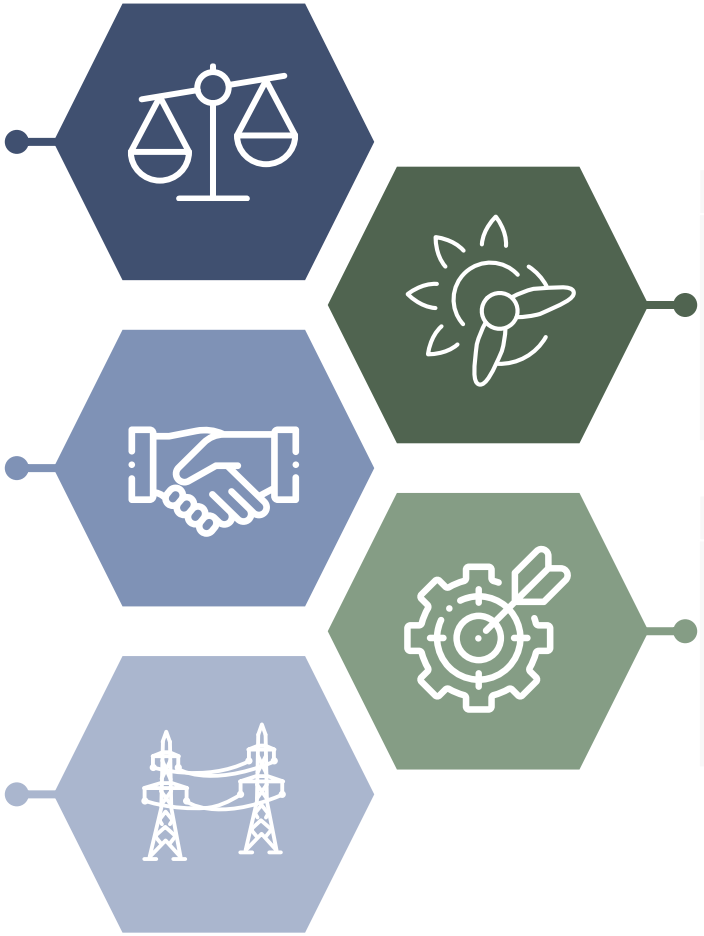
Colombia might adopt regulatory frameworks that incentivise innovation in energy technologies, supporting pilot projects and scaling solutions like smart grids, battery storage, and EV infrastructure.

Community and Industry Involvement

Collaboration among policymakers, industry leaders, and communities is key; involving local stakeholders in energy projects promotes public acceptance and shared investment, enhancing the resilience of Colombia's energy landscape.

Flexible, Resilient Energy System

By building on the UK's experience, Colombia can implement a regulatory approach that supports a flexible and decarbonised energy landscape tailored to its unique needs, contributing to long-term energy resilience.



Incentives for Decarbonisation

Regulatory bodies in Colombia can offer financial mechanisms and policy support for renewable energy projects, similar to Ofgem's role in the UK, to accelerate a shift to low-carbon energy sources.

Locally-Rooted Solutions

Encouraging community-based renewable projects, especially in rural and off-grid areas, can create a resilient energy infrastructure that is less dependent on external factors.