Expert Exchange Workshop – Summary report

Flexing EU's Pathway to Net Zero

DISCLAIMER

All statements in this document have been summarised by *Renewables Grid Initiative*, based on the common understanding of the discussions carried out at the workshop. The opinions expressed in this document are independent to the PAC project consortium, and shall not be used to reflect the view of specific participants.

1. Context and relevance

The energy landscape in the European Union and globally is rapidly evolving, characterised by the increasing penetration of variable renewable energy sources (RES). This transition presents new challenges and opportunities for grid operators and energy systems at large, particularly in ensuring system flexibility to efficiently integrate variable generation and accommodate fluctuating demand.

Pursuing the binding target of at least 42,5% renewable energy in the final energy consumption across the EU by 2030[1] – with projections showing that RES will generate 66% of EU electricity generation by 2030[2] – and the need to massively electrify end-use sectors will only exacerbate these dynamics. Flexibility in power systems is key for managing operations and balancing supply and demand during normal conditions and times of high disturbances, supporting the security of supply.

Flexibility needs to double by 2030[3]. The revised Electricity Regulation[4], envisages a framework to assess the different types of flexibility needs, including seasonal, daily and hourly, every two years and for a timeframe of 5 to 10 years. For this, the integration of RES and the different sectors, the interconnected nature of the electricity market and sources of flexibility in other Member States should be taken into account. Based on these assessments, Member States shall define indicative objectives for non-fossil flexibility and may introduce dedicated support schemes. This process could

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[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023L2413&qid=1699364355105

[2] https://ember-climate.org/insights/in-brief/draft-necps-show-eu-just-falling-short-of-repowereu/

[3] https://publications.jrc.ec.europa.eu/repository/handle/JRC130519 and https://www.acer.europa.eu/sites/default/files/documents/Publications/EEA-ACER_Flexibility_solutions_support_decarbonised_secure_EU_electricity_system.pdf

[4] https://data.consilium.europa.eu/doc/document/PE-1-2024-INIT/en/pdf

potentially lead to an EU strategy on flexibility, with a particular focus on demand response and energy storage.

Flexibility solutions should respond to all timeframes and encompass power system stability, reliability and adequacy. They can be provided on the supply- and demand-side, through energy storage and transmission and distribution grids. However, while solutions and technologies for short-term flexibility are widely available today, further action is needed to leverage solutions for long-term flexibility. Moreover, today, the electricity system still meets flexibility needs mainly through fossil fuels, compromising the achievement of decarbonisation targets, and deepening dependencies and volatilities. The challenge that lies ahead is to switch to decarbonised flexibility solutions at a pace that keeps up with the RES deployment.

To address these challenges and unlock the full potential of a net-zero and flexible energy system, it is imperative to explore strategies, technologies, and policies that lead to optimisation, enhance grid resilience, reliability, security and efficiency, remove barriers and empower end-users.

Building on the success and insights gained from the last RGI Expert Workshops on flexibility and decarbonisation of industry, carried out under the umbrella of the PAC Project, on 11 July 2024 RGI organised another expert workshop *Flexing EU's Pathway to Net Zero*[5]. This workshop has deepened the discussions around the role of flexibility, including demand response and storage, in achieving the 2030 climate and energy targets and contributing to the pathway towards 2040. In view of the upcoming flexibility assessments and the 2026 TYNDP cycle, the workshop has also explored the flexibility potential and challenges through the lens of energy system modelling, increasing understanding around uncertainties, sensitivities and related next steps. This present document summarises the discussions and insights extracted from the workshop.

[5] All materials presented at the workshop have been circulated among the participants and are available at the dedicated page on the RGI website.

2. Summary of discussions

Key takeaway 1: Flexibility is crucial in a power system increasingly reliant on RES. Meeting flexibility needs requires developing robust, transparent, and context-specific methodologies. In this process, regional cooperation will also play a key role to help managing the increased variability caused by renewable energy integration.

The workshop kicked off by ENTSO-E highlighting the crucial role of flexibility in the power system as an enabler of the energy transition, underscoring it as a key principle for achieving climate neutrality. The discussion emphasised the need for a sustainable, resilient, and affordable energy system, which will require significant increases in renewable energy sources, leading to greater variability. To manage this variability, the power grid—particularly the transmission system—must become more flexible and supported by investments in short-, medium- and long-duration flexibility solutions. At the same time, enhanced grid infrastructure, as well as improved operational collaboration between distribution system operators (DSOs) and transmission system operators (TSOs) will also support a more flexible grid. Evolving market designs can support these changes, ensuring that the power system can adapt quickly and efficiently to the demands of a renewable energy future. In this sense, the support of the Member States will be pivotal in establishing national targets and objectives for non-fossil flexibility solutions, with interconnectors being one of the most promising and impactful solutions for achieving greater flexibility.

Under the Electricity Market Design Reform (EMDR), ENTSO-E and the EU DSO Entity are tasked with developing a methodology to assess the flexibility needs of national power systems, which must be transparently defined and communicated. This methodology is expected to address the contribution of technologies such as hydrogen storage, Electric Vehicles (EVs), heat pumps, and batteries to flexibility needs. National flexibility reports must assess non-fossil flexibility needs across different timescales, incorporating flexibility potentials from other Member States. It should integrate existing methodologies to reflect the different needs and contexts of Member States. The new methodology should also take stakeholder input into account, while acknowledging the complexity and variability of different technologies and revenue schemes. However, the transparency required in developing such a methodology poses a significant challenge due to difficulties in data collection and modelling constraints.

Developing a robust methodology for assessing flexibility needs, will ultimately, among others, influence energy storage targets at the national level. Some of the suggested key principles which should accompany the development of this methodology, shall include defining what constitutes a flexibility need, ensuring technology neutrality, and maintaining robustness in modelling scenarios. Notably, the methodology should account for various electricity storage applications and revenue streams, ensuring that all relevant aspects of flexibility, including supply-demand balance, peak capacity, and grid stability, are considered. Clear and transparent criteria for evaluating flexibility resources, addressing potential biases in modelling approaches, addressing challenges in data collection and modelling complexity, as well as ensuring well-defined assumptions, will be crucial for the methodology development process. As the development of this methodology progresses, ongoing consultation with stakeholders will be essential to refine the approach and ensure that it meets the diverse needs of the energy system while maintaining transparency and fairness.

Key takeaway 2: Energy systems require different types of flexibility across infra-hourly, daily, weekly, and seasonal timescales, driven by factors like renewable integration, forecast errors, and changing demand patterns.

A practical example of how to assess and manage flexibility needs in energy systems was given by Artelys, as demonstrated in a detailed study for the PENTA region. The framework for analysing flexibility began with identifying the overall flexibility needs of the system, which are driven by residual load — calculated by demand minus renewable generation. The proposed methodological approach evaluated the need for flexibility using metrics related to various technologies capable of providing flexibility, such as dispatchable assets, interconnectors, and storage solutions. The study revealed that flexibility needs vary across different timescales — infra-hourly, daily, weekly, and seasonal. In the analysed countries, infra-hourly needs arose from factors like forecast errors and congestion, while daily needs were driven by the integration of solar power and related demand shifts, reflected in duck curves. Weekly flexibility needs were influenced by variations in wind power generation and differences between weekday versus weekend flexibility needs, by different demand patterns. Lastly, seasonal flexibility needs were linked to changes in demand throughout the year, with winter typically requiring more flexibility due to higher heating demands and lower solar production, although this varies with solar and wind energy generation patterns.

The study also demonstrated the importance of regional cooperation in managing flexibility needs. By analysing flexibility needs across different countries and scenarios, the study finds a significant increase in flexibility needs through 2050, driven by varying energy mixes and increased renewable integration. Regional cooperation can substantially reduce flexibility needs by 10 to 20% by enabling countries to share flexibility resources.

Assessing and addressing flexibility needs in energy systems currently involves numerous complexities and different methodologies, particularly as they evolve with renewable energy integration and country context specificities. For example, the discussion also touched on the challenges of modelling flexibility, such as the trade-offs between model granularity and computational constraints. The need for collaboration between system operators and policymakers was underscored, particularly in aligning business goals with optimal system-wide outcomes.

Key takeaway 3: Interconnections and clean flexibility solutions are essential to ensure grid stability and reliability, but current plans fall short of what is needed for future energy demands.

The second session of the workshop brought to the discussion table the importance of interconnections between EU countries in stabilising renewable energy output, while acknowledging the ongoing need for long-duration energy storage solutions. It was also noted that while some countries are already achieving significant levels of solar generation during peak hours, the persistence of inflexible generation and the lack of sufficient clean flexibility resources are leading to challenges like negative electricity prices. In that context, EMBER reviewed the current status of key clean flexibility solutions, such as energy storage and electricity grid infrastructure. The findings indicate that while electricity grid expansion and solutions like smart grids or hydrogen production expand, challenges, such as grid connection delays, renewable curtailment, and rising costs due to congestion, remain. The analysis revealed also a discrepancy between TSOs' expected grid growth of 8% by 2030 and what is needed to meet national renewable energy targets. Specifically, 11 out of 26 analysed TSO's grid expansion plans are misaligned with the country's renewables goals, particularly in the case of solar power. This is also true for assessing whether current plans are on track to meet future interconnection capacity needs. EMBER's study identified a gap of 12-51 GW of cross-border capacity (8-27% short) between the capacity projected by system plans, and the required interconnection capacity for 2030. This gap is expected to widen further by 2040. On the storage side, while pumped hydro is historically the main source of the EU storage, this is about to change with batteries experiencing significant growth in the last years, whose capacities were doubled from 8 GW in 2022 to 16 GW in 2023.

Together with electricity grid infrastructure and storage, demand-side response is another essential solution for delivering flexibility needs. According to SmartEn, the demand-side response can be understood as the ability of consumers to adjust their energy use in response to external signals, such as price changes or grid conditions. This flexibility can be achieved through various technologies, including controllable loads in homes and industries, storage facilities (both stationary and EVs), and small-scale renewable generation (e.g., rooftop solar panels). Despite its potential, demand-side flexibility is often underestimated or inadequately considered in modelling exercises and overall energy system planning.

To harvest the benefits of demand-side flexibility, several barriers must be overcome. These include insufficient deployment of flexible resources, inadequate price signals, and limited incentives for system operators to procure flexibility. Furthermore, challenges related to accessing and sharing data limit the potential for fully optimising flexible assets. This data could include real-time energy consumption, access to smart meters data, or pricing information, and access or sharing might involve energy producers and grid operators. The integration of demand-side flexibility into grid planning and system development is also lacking. Some of the barriers mentioned are already covered by EU legislation, especially under the EMDR. However, developing flexibility support schemes can further aid this process by reducing upfront costs for smart assets, helping system operators establish local flexibility markets, and incentivising participation in various market mechanisms, such as demand response programs. While regulatory reforms are essential, additional support mechanisms may be necessary to ensure timely progress and address the challenges effectively.

The need for early and anticipatory planning to accelerate the deployment of clean flexibility solutions was also stressed by the participants. The discussion also touched on the importance of involving consumers in the clean flexibility transition, as many of these technologies will be directly used by households and businesses. It was underscored that with the right policy direction and removal of barriers, the EU could effectively meet its growing need for clean flexibility.

Key takeaway 4: The integration of grid boosters and storage technologies presents promising solutions for supporting grid congestion management. However, achieving this will require addressing technical, regulatory, and operational challenges, as well as rethinking traditional approaches to grid management.

During the second session of the workshop, TransnetBW presented their case study focused on grid congestion management by using grid boosters and battery storage technologies, which help to reduce the need for preventive redispatch. The process relies on activating storage solutions only when a fault is detected.

Two pilot projects are underway in Germany to test these concepts. TenneT is developing 200 MW of battery storage in northern and southern Germany, 100 MW in each location. At the same time, TransnetBW is building a 250 MW battery system in southern Germany, integrated with offshore wind farms. The goal is to scale these systems and incorporate them into congestion management by 2030. Additionally, combining the efforts of DSOs and TSOs can help optimise transformer usage and reduce congestion.

Operational planning needs to incorporate curative measures, which involve changing national processes and updating real-time SCADA systems[6]. This includes addressing technological challenges such as ensuring fast automatic responses, managing communication between control zones, maintaining IT security, and increasing transparency of regulatory frameworks.

Key takeaway 5: The development of detailed models for flexibility is crucial in modern energy systems, especially with the increasing integration of renewables. Modelling of flexibility can help in understanding the dynamic

[6] https://scada-international.com/what-is-scada/

behaviour of the grid, planning for various scenarios, and ensuring stability in real-time operations.

Increased flexibility can support achieving climate neutrality by 2040 within the Paris Agreement Compatible (PAC) Scenario, as mentioned in the presentation of CAN Europe.

On the supply side, the PAC scenario expects significant upgrades and expansion to the European power grid. Specifically, by 2040 the transmission capacities should increase by 144% to accommodate the increased electricity demand and renewable integration. These results intrinsically recognise the need for a more flexible and resilient grid that can handle variable renewable generation, while ensuring reliable power delivery.

Regarding demand-side flexibility, the analysis emphasises demand reduction and the implementation of different measures for different sectors. Some solutions mentioned include deep renovations, heat pumps, and battery storage in buildings. The workshop discussion highlighted the need to improve modelling techniques to better visualise and represent flexible energy systems. This can be achieved by exploring the potential of electrified transport and vehicle-to-grid technologies, which could significantly impact overall system flexibility. Hitachi Energy also touched on the complexity of modelling flexibility, particularly in assigning the right parameters for ramping rates, demand-side management, and storage technologies. They emphasised the need for accurate modelling of storage technologies, such as batteries, pump hydro, and thermal energy storage. Similarly, active electricity grids and interconnection capacity were identified as crucial for optimising the transmission system and ensuring the efficient flow of power across regions. But merely adding transmission capacity is not enough; the grid must also be controllable to handle varying flows and avoid congestion.

The session continued with a presentation of a comprehensive analysis of flexibility requirements and the role of storage in EU power systems. This study, developed by the Joint Research Center and DG ENER, utilised the METIS model and laid the groundwork for important work on the EMDR. The analysis focused on assessing the flexibility needs of the EU power system for the years 2030 and 2050, in the context of increasing shares of renewable energy sources such as solar and wind.

The findings revealed that flexibility requirements are set to grow exponentially, with total needs equal to 30% of total electrical EU demand in 2050. Considering the different timescales assessed – daily, weekly, and monthly – there is a particularly significant increase in monthly flexibility needs. This rise is primarily driven by the variability introduced by renewable energy sources, with solar power affecting daily flexibility, and wind power influencing flexibility needs for longer terms.

In addressing these growing flexibility demands, the report identified various technologies and their time-dependent contributions. Batteries were found to be most effective for meeting daily flexibility needs, while technologies like electrolysis and pumped hydro offer solutions for more extended periods. Interconnections play a dominant role in addressing flexibility needs on all timescales.

From a different perspective, according to Hitachi Energy, there is no one-size-fits-all solution when it comes to flexibility. The characteristics of the energy systems and available resources unique to each market will influence flexible technology choices. By the same logic, flexibility is not just about managing supply and demand, but also involves addressing operational challenges like inertia, voltage control, and short-circuit capacity, especially as the share of renewables increases.

The workshop was closed with the presentation of the French TSO, RTE, that provided an overview of the French Adequacy Report (Bilan Prévisionnel 2023). Their report assessed the French future energy needs, highlighting the rapid increase in electricity consumption and the development of renewable energy sources, especially wind and solar. Three scenario families were analysed. Firstly, a scenario with successful acceleration (FitFor55-based). Secondly, one with partial achievements, considering delay in electrification, energy savings and RES development. Lastly, an impeded globalisation scenario, which manages decarbonisation under global challenges. Based on the result of this analysis, to meet future needs, RTE suggested a balanced approach using a combination of energy efficiency, renewable energy, nuclear power, and various flexibility packages proposed to ensure the security of supply. These packages included a mix of batteries, thermal plants, and other resources, focusing on cost-effectiveness, social acceptability, and technical feasibility. Overall, the report also underscored the growing need for flexibility to manage the variability of renewable energy sources. Specifically considering the intraday and intra-week timeframes, as the former saw a 60% increased need due to solar power growth, while the latter a 70% increased need under the effect of wind power.

Next steps

- The insights from this workshop will feed further RGI's workstreams related to decarbonisation strategies and energy systems flexibility needs.
- It will also support the development of a larger report compiling RGI workshop discussions on larger consumer decarbonisation, energy infrastructure needs, and energy and climate policy.
- For the PAC project, CAN Europe published a final report of the main results of the PAC project's second phase at the end of August.

Contact

Please do not hesitate to reach out with interest or opportunities to collaborate further!

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Read more about RGI's work on energy system modelling and planning and access the workshop presentations here.

Relevant literature

- Artelys: Power System Flexibility in the Penta region – Current State and Challenges for a Future Decarbonised Energy System
- EMBER: Making clean power flexy
- JRC: Flexibility requirements and the role of storage in future European power systems

3. Workshop Agenda

09:30 – 10:00	**Registration and coffee**
10:00 – 10:15	**Welcome, agenda and the workshop's objectives** (RGI)
	Session 1: Assessing Flexibility Needs
10:15 – 10:35	**Requirements for flexibility assessments – regulation and implementation** Samy Geronymos (ENTSO-E)
10:35 – 10:55	**Guiding principles for the flexibility assessments methodology** Martin Roach (EASE)
10:55 – 11:15	**Case study – Cooperation in Penta region** Christopher Andrey (Artelys)
11:15 – 11:45	**Discussion**
11:45 – 12:00	**Coffee Break**
	Session 2: Flexibility Potential – gaps and solutions
12:00 – 12:20	**Overview of clean flexibility in the EU** Harriet Fox (Ember)
12:20 – 12:40	**Demand-side flexibility** Marion Malafosse (SmartEn)
12:40 – 13:00	**Electricity grids and enhancing technologies** Dr. Matthias Kahl (TransnetBW)
13:00– 13:30	**Discussion**
13:30 – 14:30	**Lunch Break**
	Session 3: Flexibility in Energy System Planning & Modelling
14:30 – 14:40	**PAC Scenario and Flexibility** Joni Karjalainen (CAN Europe)
14:40 – 15:00	**Flexibility requirements and the role of storage – modelling assessment** Dr. Derck Koolen (European Commission)
15:00– 15:20	**Modelling flexibility** Alexandre Oudalov (Hitachi Energy)
15:20 – 15:40	**Forecast report 2023 – 2035 and flexibility needs** Lucie Meier & Marion Li (RTE)
15:40 – 16:10	**Discussion**
16:10 – 16:20	**Wrap-up and Final remarks** (RGI)