INTRODUCTORY NOTE

IEA WIND TASK 11 TOPICAL EXPERT MEETING #113

ON

NET ZERO ELECTRICITY SYSTEM STUDIES

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A. VALUE FOR IEA WIND TCP

BACKGROUND

Net zero has gained great importance in discussions surrounding climate change and energy transition. The concept refers to achieving a balance between the greenhouse gases emitted into the atmosphere and those removed or offset. In May 2021, the IEA released a landmark report entitled "Net Zero by 2050, a Roadmap for the Global Energy Sector[1]" which outlines a pathway to achieve global net zero emissions by 2050. The report highlights the importance of rapid and widespread changes across all sectors of the economy, including electricity, industry, transportation, and buildings.

Setting targets for achieving net zero emissions has become one of the primary ways for countries to plan towards their climate change ambitions. Whilst details vary, most net zero plans involve significant reductions in the use of fossil fuels and adopting variable renewable energy (e.g., wind and solar). From a wind perspective, it is important that we encourage the use of well-defined wind cost, performance, and value assumptions and discuss the issues, needs and solutions. In 2023, 32 countries – including all 27 EU Member States – have enacted net zero targets into law, with 2050 as the target date. In addition to the countries with net zero targets encoded in law, more than 120 countries across the world have net zero targets in proposed legislation, in published policy documents, or under discussion, with target dates ranging from 2030 to 2070, though 2050 is by far the most common. Detailed analyses for how net zero targets are achieved, however, are not publicly available for the majority of cases.

Net zero electricity system studies and policies are crucial for:

- **Decarbonizing the Power Sector:** The electricity sector is one of the largest sources of greenhouse gas emissions worldwide, primarily from the burning of fossil fuels, such as coal and natural gas. Achieving a net zero emissions electricity system

[1] Net Zero by 2050 – Analysis - IEA

is essential for effectively reducing carbon dioxide and other greenhouse gas emissions.

- **Energy Transition:** Moving towards a net zero electricity system requires a significant increase in the deployment of renewable energy sources and other non-carbon sources. Studying and developing policies that facilitate the integration of these clean energy sources, each with their own characteristics and implications for system operation, into the electricity grid are essential for achieving decarbonization targets.

- **Energy System Integration:** As countries aim to decarbonize their economies, the electrification of various sectors, such as transportation and heating, becomes critical. Net zero electricity system studies and policies enable the integration of electric vehicles, heat pumps, electrified heat storage, and other electrified innovative technologies, ensuring efficient and sustainable energy use across sectors.

- **Technological Innovation:** The transition to a net zero electricity system necessitates the development and deployment of innovative technologies, such as advanced energy storage, grid-forming converters, smart grids, and demand response systems. Studies and policies provide a framework for fostering research and development, encouraging private investment, and driving technological advancements.

- **System Resilience and Flexibility:** A net zero electricity system requires a resilient and flexible grid that can accommodate variable renewable energy sources, while managing the complexities of energy supply and demand balancing. Studies and policies can address the challenges of grid integration, network development, system stability, storage, and demand-side management, ensuring a reliable and stable power system.

- **Quantifying Economic Impacts and Opportunities:** The shift to a net zero electricity system presents economic opportunities, such as job creation, investment in clean energy infrastructure, and the growth of innovative industries. Studies and policies can identify such opportunities and provide guidance to policymakers, businesses, and investors to leverage the economic potential of a sustainable energy transition. Research collaboration through expert elicitation, techno-economic cost models, and assessment of innovations are critical enablers to support this significantly higher level of zero emissions energy deployment and grid services.

- **Building Societal Support:** Achieving net zero within power systems will require new infrastructure, technologies and behaviours. Net zero system studies should (must) involve the public, in creating a common vision for the future electricity system, to avert potential future implementation challenges due to an absence of consensus.

MOTIVATION

To guide countries in developing robust and credible net zero electricity roadmaps, consenting best practices to help inform them would be useful. The outcomes of international net zero electricity system studies vary and are not easy to compare. Wind energy was the original variable renewable resource to be incorporated at scale in electricity systems, but even today it is not necessarily straightforward to include in power and energy system studies in an appropriate way. In order to ensure that the challenges,

and opportunities, of wind energy are best captured in the studies, IEA Wind TCP involvement is justified. From IEA Wind TCP point of view the main question is how we can ensure the best possible assumptions and modelling approaches for representing wind in net zero studies. The sector would benefit from developing a report detailing current and foreseeable challenges faced by policymakers, network operators, market regulators, and relevant sectors (e.g., industry, transportation, etc.) as well as some findings from the first wave of net zero studies performed so far. Some general outcomes that may arise from a review of international net zero electricity system studies could include:

- **Building Socio-Political Support:** The leading international net zero studies have been commissioned through a variety of circumstances. The impact, and the manner of commissioning and executing studies, in terms of how well the study outcomes are embraced by society should be understood.
- **Methodological Approaches:** The modelling assumptions, analytical methods and sequence of execution for system studies should be reviewed and compared to arrive at conclusions on best practices. Particular characteristics of both renewable energy resources and demand need to be considered in detail e.g. technical progress in the grid compatibility of advanced wind turbine technology.
- **Technological Pathways:** Identification of common wind energy technological pathways and solutions that are consistently explored across studies, such as technology costs, siting constraints, availability of technologies (e.g., floating offshore wind), and coupling with energy storage and hydrogen. Further wind energy's interaction with the extent of electrification of other sectors of the economy, the availability of carbon capture and storage, and demand-side management. System stability and network expansion implications should also be taken into account.
- **System Optimization and Planning:** Understanding the importance of system-level optimization and planning to achieve a net zero electricity system. This could involve modelling assumptions, suitable representation of other energy vectors, and assessments of generation, transmission, and distribution capacities, considering factors such as renewable resource availability, load profiles, energy market dynamics, and system stability. In particular the analytical methods that should be used to appropriately represent wind power in models across multiple timescales.
- **System Flexibility:** Recognition of the importance of system flexibility and the need for advanced grid infrastructure, energy storage, and demand response technologies to accommodate variable renewable energy sources and ensure a reliable and resilient net zero electricity system.
- **Policy and Regulatory Considerations:** Representation of current and potential future policy and regulatory frameworks that can support the transition to a net zero electricity system. This could include analysis of policies promoting zero emissions energy, carbon pricing mechanisms, procurement regimes, public support for necessary infrastructure and the broader regulatory environments.
- **Economic and Social Implications:** Consideration of the economic and social implications of transitioning to a net zero electricity system. This could include evaluating the costs and benefits associated with different pathways, job creation potential, supply chain and infrastructure investment needs, impacts on energy affordability, and equitable distribution of benefits.

ADDED VALUE OF COLLABORATION

The design of a robust pathway for net zero electricity system is a global task, which needs deep knowledge and expertise sharing across different stakeholders. The IEA as well as the TCPs are unique in their global reach and ability to convene relevant government actors and policymakers. Hence, collaboration within IEA framework adds significant value to net zero electricity system studies by facilitating knowledge sharing, harmonizing standards, promoting collaborative research, providing policy guidance, and enabling capacity building. By working together, participants can leverage collective expertise, resources, and experiences to accelerate the deployment of wind power and support the successful transition to sustainable and carbon-neutral electricity systems worldwide.

The topic area is relevant for all renewable energy TCPs (Wind, PVPS, Hydro, Bioenergy) as well as the energy system modelers (ETSAP), and potentially also Hydrogen. Several Wind TCP Tasks could collaborate together to identify best practice methods/standards for wind energy input into net zero studies.

By highlighting the potential cross-disciplinary applications and collaborative opportunities, we can ensure that the research transcends its immediate context, fostering a comprehensive understanding of net zero strategies that resonates with diverse TCPs and contributes to a collective and impactful approach to addressing the challenges of transitioning to net zero.

ALIGNMENT WITH IEA WIND STRATEGY

Wind energy is a critical component of the future net zero electricity system. Its abundance, carbon-free nature, and renewable characteristics make it an attractive solution for combating climate change, reducing emissions, enhancing energy security, and fostering a sustainable and resilient energy system for future generations. This topic has good alignment with the IEA Wind TCP strategy under Strategic Objectives 1, “Maximize the value of wind energy in energy systems and markets”. Moreover, it is aligned with IEA’s mission, “Energy security”. In terms of IEA Wind TCP research priority areas, it may primarily come under Priority Area 3, “The Plant and Grid”, but will also deliver upon Priority Area 6, “Collaborative Communication”. A TEM that brings experts on net zero electricity system studies together will foster the exchange of best practice, as well as steer collaborative research, the other aim of IEA Wind TCP.

IEA Wind Task 25 “Design and Operation of Energy Systems with Large amounts of Variable Generation” has moved from power system studies to include also energy system coupling – critical for net zero studies. Task 25 is in its final year and will start discussions for a proposal of a new Task for 2025-28. Some net zero studies have already been discussed in Task 25 meetings as country presentations, and the topic has been identified as a potential future area of focus for the Task.

IEA Wind Task 53 “Wind Energy Economics” has ongoing work where researchers evaluate cost and value primarily in the context of anticipated deep decarbonization developments and emerging wind energy applications. The task focuses on methods development and data collection of new wind applications, plant configurations and operations, and associated uncertainties that may complement net zero studies.

B. MEETING FORMAT AND GOALS

OBJECTIVES

This TEM will bring together international experts on net zero electricity studies to initiate a discussion on the key considerations for a guiding framework on net zero electricity roadmap studies. Discussion will centre on those elements of net zero electricity systems that are fundamental across jurisdictions in order that the end result benefits the broadest number of jurisdictions.

While the objective of the meeting will be to publish proceedings for dissemination to policy makers and those executing net zero studies, the discussions will directly inform a continuation Task on grid integration (Task 25), potentially in collaboration with other IEA TCP Tasks. The ultimate objective is the identification and synthesis of current global challenges for net zero electricity pathways, lessons learned, and best practices, in order to provide a resource usable across agencies, jurisdictions, and technologies.

SPECIFIC OUTCOMES

A review of international net zero electricity system studies would typically involve an assessment of various studies conducted by different organizations and researchers worldwide, while noting the underlying characteristics and peculiarities of individual systems and individual studies. The objective is to analyse and synthesize the findings and methodologies used in these studies, to better understand their common outcomes and key considerations for achieving a net zero electricity system. A journal article is already under preparation that will be informed by the outcomes of the meeting.

The meeting aims to identify current and foreseeable future challenges and outline observed best practices, potentially in categories aligned with specific aspects of net zero electricity system design. Net zero electricity system design requires expertise well beyond that of the electricity (power) system itself, such that a multi-disciplinary approach must be adopted to ensure robust and comprehensive analysis and decision making. The meeting proceedings should present a draft net zero studies best practices document, outline a plan for dissemination, and specify potential follow up activities such as further, more in-depth work on key aspects of the synthesis and regular updates to the document, as well as a plan for future supports and coordination.

The meeting discussions will provide a basis for scoping the continuation Task for IEA Wind TCP Task 25.

INTENDED PARTICIPATION

This TEM will bring together international experts on net zero electricity studies and in particular those from IEA TCPs, to initiate a discussion on the key considerations for a guiding framework net zero electricity roadmap studies. In addition, potentially also experts on specific energy technologies present in the net zero studies and also experts on communicating the outcomes of complex studies to a wide audience and building societal support. These intended participants bring diverse perspectives, expertise, and experiences to international net zero electricity system studies. Their collaboration and knowledge sharing are critical for developing comprehensive strategies, policies, and

frameworks that can enable the successful transition to a sustainable and carbon-neutral electricity system.

Institutions where experts are currently working on the topic include:

- University of Victoria, Natural Resources Canada, Canada Energy Regulator (Canada)
- DTU, Energinet (DK)
- VTT (FI)
- EdF, RTE (FR)
- Fraunhofer, FfE, Deutsche Windguard (Germany)
- UCD, UCC, Sustainable Energy Authority of Ireland (IE)
- TNO (NL)
- Sintef, NTNU, Norwegian Water Resources and Energy Directorate (NO)
- LNEG (PT)
- Imperial College London, OFGEM (UK)
- NREL, LBNL, Princeton University (USA)
- University of Queensland, University of Melbourne (Australia)
- Renewable Integration and Secure Electricity (RISE) Unit of the IEA

TENTATIVE PROGRAM

The TEM is proposed to be in Dublin, hosted by SEAI, on 8-9 April, 2024.

The meeting will be co-located with Task 25 and Task 53 meetings (on 10-11 April).

The meeting will start with presentations from participants on their experience of net zero studies internationally. The presentations would highlight challenges encountered to set up a net zero electricity system pathway, including knowledge gaps, technological development needs, or procedural difficulties, as well as positive experiences. These presentations would be followed by breakout sessions for specific discussion topics/questions, such as:

- Future net zero power system modelling – how to take into account wind energy, and other technologies, energy sector coupling with power system, system stability and network congestion (expansion)
- Key risks associated with the main components of net zero energy system (e.g., variable renewable generation, hydrogen, energy storage, interconnectors, demand flexibility, system balancing, grid-forming converters, etc.). Increased societal reliance placed on “electricity”, due to electrification of heat, transportation, and other sectors
- Impact of current policies on key energy-related assets (e.g., phase-out of coal reserves and power stations, nuclear power plants, underground gas storage, underground carbon storage, large land area for VREs, interconnectors, network expansion, etc.)
- Future climate forecasts and their incorporation into net zero electricity system studies.