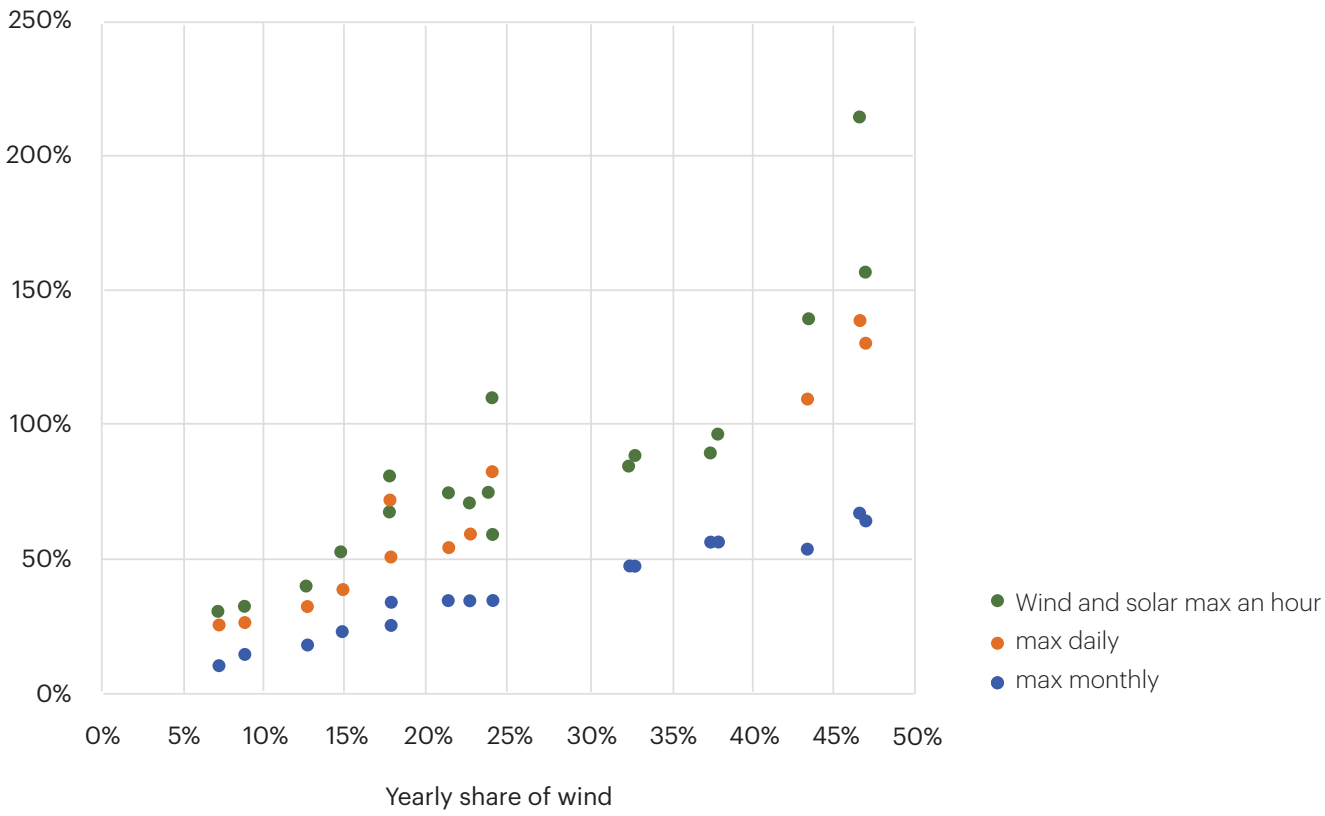

Report 2021

Task 25

Wind energy share in 1 hour, 1 day, and 1 month relative to the average share during a year. Recorded values from the years 2017, 2019, and 2020 from Denmark, France, Germany, Portugal, Ireland, and Texas. Graph from Task 25 Summary report published in 2021 [1].

Design and Operation of Energy Systems with Large Amounts of Variable Generation

Author *Hannele Holttinen, Recognis, Finland*

System impact studies are important for defining targets for wind and other variable renewable energy and also for defining future decarbonising pathways.

Task 25 is working towards commonly accepted standard methodologies to be applied in system impact studies for wind and solar-dominated power and energy systems. International collaboration remains key to learning from both experience and studies in different countries in the evolving power and energy systems of the future.

In 2021, Task 25 started the final 6th phase of collaboration. The summary report was published in Oct 2021 and highlighted in webinars. Both experience and study results for planning and operating power systems with high shares of wind and solar are summarised in the report.

Task 25 brings best practice wind integration experience, study methods, and results to member countries and a wider audience through IEA, IRENA, G-PST, and ESIG. On top of these in-

Table 1. Countries Participating in Task 25
(new participants for the 2021-24 phase are highlighted in blue)

	COUNTRY/SPONSOR	INSTITUTION(S)
1	**Canada**	NRCan (Thomas Levy); Hydro Quebec IREQ (N. Menemenlis, A. Forcione)
2	**China**	SGERI (Wang Yaohua, Liu Jun)
3	**Denmark**	DTU Wind (Nicolaos Cutululis); TSO Energinet.dk (Antje Orths); Ea analyse (Peter Børre Eriksen)
4	**Finland, OA***	Recognis Oy (H.Holttinen); VTT Technical Research Centre of Finland (N.Helistö, J.Kiviluoma)
5	**France**	EdF R&D (E.Neau); TSO RTE (J-Y.Bourmaud); MinesTech (G.Kariniotakis)
6	**Germany**	Fraunhofer IEE (J.Dobschinski); FfE (S.vanRoon, A.Guminski); TSO Amprion (P. Tran)
7	**Ireland**	UCD (D.Flynn); SEAI (J. McCann); Energyreform (J.Dillon); ESIG (M. O'Malley);
8	**Italy**	TSO Terna (Enrico Maria Carlini)
9	**Japan**	Kyoto University (Y. Yasuda), CRIEPI (R. Tanabe)
10	**Norway**	NTNU (Magnus Korpås); SINTEF (John Olav Tande, Til Kristian Vrana)
11	**NL**	TUDelft (Simon Watson, Arjen van der Meer); TNO (Germán Morales-España)
12	**Portugal**	LNEG (Ana Estanqueiro), INESC-TEC (Bernardo Silva)
13	**Spain**	University of Castilla La Mancha (Emilio Gomez); Comillas Pontifical University (Andrés Ramos Galán)
14	**Sweden**	KTH (Lennart Söder)
15	**UK**	Imperial College (G. Strbac, D.Pudjianto), ORE Catapult (P.Keever)
16	**USA**	NREL (B.Frew, B-M. Hodge), ESIG (J.C. Smith, D.Lew, J.Matevosyan); DoE (J. Fu)
17	**WindEurope**	European Wind Energy Association (Vasiliki Klonaris)

ternational network stakeholders, the system operators are the main target group of Task 25 work, following Task 25 work directly and as observers.

The Recommended Practices report update started in 2021, including collaboration with IEA PVPS TCP Task 14. This will be the main effort for the Task in 2022-23.

Introduction

Task 25 work started in 2006 to tackle differences seen in results for wind integration studies and cost of integration. By analysing the multitude of studies investigating the power system impacts of wind power, most differences were explained, and best practices for system studies were drawn. Since then, a convincing amount of experience from wind integration has emerged, as well as targets for wind and solar reaching higher and higher shares of demand. The concerns regarding variable generation are shifting from costs of integration to costs of inflexibility. Assessing the impacts in practice means comparing the costs and reliability of alternative power and energy systems.

International collaboration remains key to learning from both experience and studies in different countries in the evolving power and energy systems of the future. Task 25 is now starting its sixth term (2021-24). The main stakeholders are the system operators, joining Task 25 directly (Denmark, France, Italy) and as observers (Ireland, Romania, Spain). IEA and IRENA are frequent observers of Task 25 meetings, as well as new



Photo: Istockphoto.com

countries aiming to join, most recently India and Romania.

Progress and Achievements

Task 25 has established an international forum for member countries, including their Transmission System Operators (TSOs), to exchange knowledge of and experiences with electricity system operations with large amounts of wind and solar energy. This work was rewarded an ESIG excellence award in March 2021.

The spring meeting in 2021 was held online, enabling more participation from the member countries; almost 70 persons logged in for at least one of the 3 meeting days and also reached out to more stakeholders (TSOs from Denmark, France, Ireland, Italy, and industry observer Ampacimon). The fall meeting was a hybrid, hosted by TUDelft in the Netherlands - 12 people joined in person and 70 people online for some parts of the meeting, about 40 simultaneously.

In 2021, the main publication from Task 25 was the summary report, highlighting the main results of national case studies as well as experience in operating and planning power systems with high wind and solar share [1].

Task 25 work highlights the evolving best practice on system impact studies for the feasibility of wind and solar-dominated power systems. The main challenges are power system stability due to the inverter-based, non-synchronous grid interface and balancing due to the varying resource. For both challenges, there are already mitigation options. However, research, and demonstration will be needed to determine how wind and solar power plants, including grid forming capabilities, can become the backbone of future power systems [2]. For the flexibility needs of 100% renewables systems, storage and flexible demand may provide two cost-efficient pathways in the future. This will depend on how far cost reductions of storage technologies will go and how much new electrification loads can help for both short-term balancing and for seasonal mismatch of future demand and generation [3].

Presentations disseminating the work of Task 25 included:

- WESC Minisymposium 25 May 2021: "IEA Wind Task 25 – Towards 100% Renewables Energy Systems" (H Holttinen, D Flynn, B-M Hodge, M O'Malley, X Zhao, N Cutululis.)
- Presentation for EU Marie Curie WinGrid project 14 June 2021: H.Holttinen
- Powertech studies for IBR dominated systems 23 Jun 2021: N.Cutululis
- Task 25 webinar 16 Sep (B.Frew, D.Flynn, N.Cutululis, M.Korpås, H.Holttinen).
- Wind Integration Workshop WIW21 29 Sep 2021: A session disseminating the summary report (B.Frew, D.Flynn, N.Cutululis, M.Korpås, H.Holttinen).
- NAWEA 2021 webinar session on

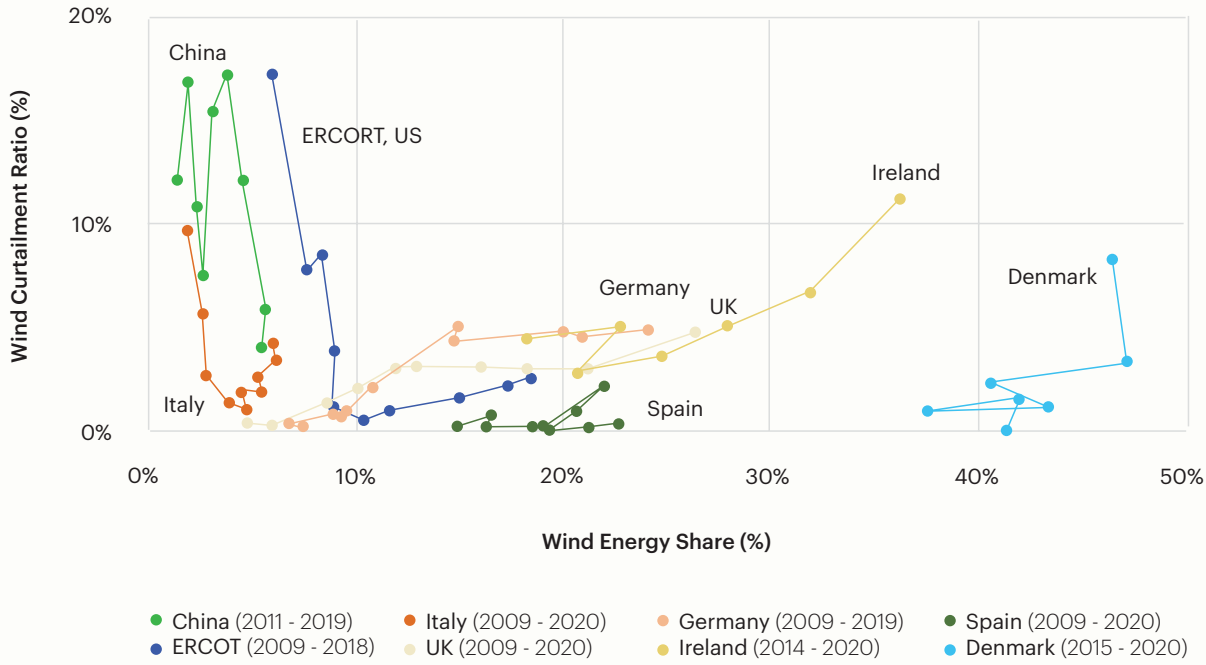

Figure 1. Trends of wind curtailment in some European countries, Texas and China [1]. Some countries have experienced high curtailed energy initially due to lack of transmission or inflexibilities. It is more common to see the curtailment challenge after a 15-30% share of wind energy.

Grand Challenges Grid 13 Oct 2021 (M.O'Malley, N.Cutululis, K.Dykes, J.King, H.Holttinen)

- Keynote speech at RPG2021 Beijing IET conference 14 Oct: H.Holttinen

Highlight: Cross-cutting activities

Task 25 has formed links between other System Operator networks from the start: ENTSO-E and ESIG have seen presentations from the main results of Task 25. Global Power System Transformation Consortium G-PST collaboration in the current phase is highlighted: Task 25 was involved in their Inaugural Research Agenda published in 2021 and is contributing to their research repository in 2022.

IEA and IRENA are joining Task 25 meetings with presentations of ongoing work, and Task 25 has made reviews of their publications regarding system integration.

Collaboration with IEA PVPS Task 14 resulted in an update of the Recommended Practices for Wind/PV Integration Studies (RP 16 Ed 2) in 2018 [4], which was also published as an IEA TCP PVPS report in 2019. Work is starting for the next update of Recommended Practices, including challenges toward 100% renewables.

In 2020-21, Task 25 has had other IEA TCP contacts regarding the value of flexibility of the different technologies (Hydro, Biomass, and Storage) and modelling challenge (ETSAP). In March 2021, Task 25 was presented in an IEA workshop (IESCG (Integrated Energy Systems Coordination Group of the working party End Use EUWP).

More recent Tasks of other TCPs can benefit from the knowledge Task 25 has accumulated, and there is more and more benefit of collaboration between Tasks and TCPs as we go forward and tackle the wider challenge of variable generation in the future decarbonised energy systems.

Pursuing these challenges together, potentially with a joint Task of several TCPs, could be one way forward.

Outcomes and Significance

System impact studies are important for defining targets for wind and other variable renewable energy and also for defining future decarbonising pathways. Task 25 is working towards commonly accepted standard methodologies to be applied in system impact studies for wind and solar-dominated power and energy systems.

An example highlighting the challenges that wind and solar bring to power systems is in the opening graph – showing how large shares of wind (and solar) are seen in the power system operation in a single hour or single day, even if the average share of wind is still moderate. The challenge is further illustrated as the inability to absorb all wind energy for power system use, resulting in curtailments of wind energy (Figure 1).

Task 25 brings best practice wind integration experience, study methods, and results to member countries. It is technically possible to integrate very large amounts of wind and solar capacity in power systems, especially when new electrification loads are integrated in a flexible way and the capabilities of wind and solar power plants are fully exploited.

Next Steps

The year 2022 will see the publication of several Task 25 joint articles – Electrification and energy system coupling (Kiviluoma et al., IEEE PES Magazine July issue), Curtailments and Flexibility chart updates at RSER (Yasuda et al.) as well as Grand Challenge Grid to Wind Energy Science. Other journal article topics currently worked on are intra-hour balancing challenge, wind energy capabilities for Ancillary Services, Dynamic Line Rating benefits for wind integration.

A new outline with a flow chart for Recommended Practices update will be made in 2022, aiming for the report to be ready for review end of 2023.

The two meetings for 2022 are planned to be hybrid meetings allowing online participation: May 2022 in Finland hosted by VTT and fall meeting in either UK or Canada.

References

[1] H. Holttinen et al. (2021) *Design and operation of energy systems with large amounts of variable generation: Final summary report, IEA Wind TCP Task 25.* https://doi.org/10.32040/2242-122X.2021.T396

[2] B.-M. Hodge et al. (2020) *Addressing Technical Challenges in 100% Variable Inverter-Based Renewable Energy Power Systems. Wiley Interdisciplinary Reviews: Energy and Environment.* https://doi.org/10.1002/wene.376

[3] H.Holttinen et al. (2020) *System impact studies for near 100% renewable energy systems dominated by inverter based variable generation.* Open access at https://ieeexplore.ieee.org/document/9246271

[4] H. Holttinen et al. (2018) *Recommendations for Wind and Solar Integration Studies. RP16 Edition 2.* Available at https://iea-wind.org/wp-content/uploads/2021/06/RP-16-Ed-2-Wind-PV-Integration-Studies-Final.pdf

Task Contact

Contact:
Hannele Holttinen,
Recognis
and Niina Helistö,
Technical Research Centre
of Finland (VTT), Finland
Email:
hannele.holttinen@recognis.fi
Web:
https://iea-wind.org/task25/