Report 2023

# Task 50

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# Hybrid Power Plants (HPPs)

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**The goal of Task 50 is to accelerate the development and deployment of hybrid power plants (HPPs).**

The Task's objectives include tracking the state-of-the-art, mapping barriers to adoption, creating a roadmap based on existing research, and developing reference hybrid plants. These objectives are being achieved through five Work Packages (WPs):

1. WP1 - Hybrid Power Plant Definition: The Task aims to define a comprehensive taxonomy for HPPs. Several definitions have been proposed, the most recent being: "a combination of two or more electricity generation and/or storage technologies, used to provide electrical power

services that are coordinated at a single point of connection".

2. WP2 - Design of Reference Plants: The Task has discussed three reference designs for HPPs, one of which incorporates hydrogen. These designs will serve as benchmarks for future developments and deployments.

3. WP3 - Controls and Optimisation: The Task is focusing on developing control algorithms and optimisation techniques for HPPs. Benchmarking of the currently available techniques has started.

4. WP4 - Electrical Design, Market, and Grid Services: The Task is reviewing grid and market ancillary services for the development of an open-source model. This model will assist in designing the electrical components of HPPs while considering market requirements and grid services.

5. WP5 – Outreach and Collaboration: The Task is coordinating with other IEA Wind TCP tasks, including leveraging Task 37's WindIO schema and Task 41's definition of microgrids.

## Introduction

HPPs combine energy technologies such as wind, solar, and storage to provide more traditional energy system services, increase the deployment and utilisation of renewable energy, and ensure profitability for developers, owners, and operators. The purpose of Task 50 is to coordinate international research and development in the field of hybrid wind power plants. This effort includes gathering ongoing research results as well as state-of-the-art in industrial practices, creating an overview of best practices on hybrid power plant design, operation and regulation, and exploring how uncertainties affect the performance and potential for adoption of HPPs. The expected results are guidance for the industry, lawmakers, regulators and researchers on the current modelling efforts, control/optimisation approaches, requirements, test and standards, impediments to adoption, future directions and expected benefits of hybrid power plants.

Specifically, the aim is to support the strategic initiatives of the IEA Wind TCP by:

- **Maximising the value of wind energy in systems and markets** by increasing the capacity of hybrid power plants and the ability to play a role in grid services.
- **Accelerating the development and deployment of HPPs** in various markets across the globe through availability of data, advanced models and tools, and test methods.
- **Determine viability of other end-use products powered by wind-based HPPs** including electricity, hydrogen, desalination, carbon capture, and other renewable-based alternative fuels.
- **Foster collaborative research and the exchange of best practices and data** by developing benchmarks and best practices for realistic HPPs and ensuring easy access to the most up-to-date knowledge, algorithms, and ideas for HPPs.

The Task has international involvement across industry, academia, and research institutions, as described in Table 1. Additionally, the Task has observers from Australia, Spain, and the U.K., which are working to join the Task as participants.

**Table 1. Countries Participating in Task 50.**

| COUNTRY/SPONSOR | INSTITUTION(S) |
|---|---|
| **Canada** | Wind Energy Institute of Canada; Natural Resources Canada; Nergica |
| **Denmark** | Technical University of Denmark (DTU); South Denmark University; Vattenfall; Vestas; Aalborg University; Ørsted; WEPROG; Floating Power Plant A/S; ConWX; Aarhus University |
| **Germany** | Technical University of Munich; BayWA r.e.; ZSW; ENERCON; Reutlingen University |
| **Ireland** | Sustainable Energy Authority of Ireland (SEAI); University College Dublin |
| **Netherlands** | Delft University of Technology |
| **Norway** | Institute for Energy Technology |
| **Sweden** | Uppsala University |
| **United States** | U.S. Department of Energy Wind Energy Technologies Office; National Renewable Energy Laboratory (NREL); Electric Power Research Institute (EPRI); Wind Advisors Team; Lawrence Berkeley National Laboratory (LBNL); Sandia National Laboratory (SNL); HOMER Energy; GE Renewable Energy; Shell |

## Progress and Achievements

Over the course of this past year, there have been nine total iterations of the hybrid power plant definition, with draft definition 1.8 as the most current version. The goal of developing this definition is to design an inclusive – rather than exclusive – definition, thus, if some of a facilities' components or characteristics meet draft definition 1.8's full requirements, then the facility can be considered an HPP.

The consensus for the general "umbrella" definition, in its simplest form, was to define an HPP up until the point of electricity production. Anything downstream from that point on, while still within a hybrid configuration, will require a descriptive phrase to more specifically define the many sub-variants that exist within an HPP, or hybrid energy system configuration.

Due to the inconsistent taxonomy used to describe HPPs, hybrid energy systems, and microgrids, there were challenges early on to set clear boundaries when understanding and defining HPPs. Therefore, there was a need to clearly differentiate between the three, and as a result, the following definitions are how Task 50 defines the three technology design concepts. Furthermore, graphics have been created to help clarify and visualise the difference between the three configuration types and how they might be integrated together (see Figure 1).

The definition of microgrids was coordinated with Task 41 on Distributed Wind, to understand how it defines microgrids. This helped to lead to the distinctions made between HPPs, hybrid energy systems, and microgrids.

- **Hybrid power plant (HPP)** – An HPP is a combination of two or more electricity generation and/or storage technologies, used to provide electrical power services that are coordinated at a single point of connection.
- **Hybrid energy system** – An energy system is one or more hybrid power plants, which provide an energy and/or non-energy product such as electricity, hydrogen, heat, or fresh water, to accommodate specific end-use needs.
- **Microgrid** – Provides local loads and/or products in addition to loads required within a hybrid energy system that can operate on- or off-grid.

The results of this effort are currently being written up in a publication that will be released in 2024.

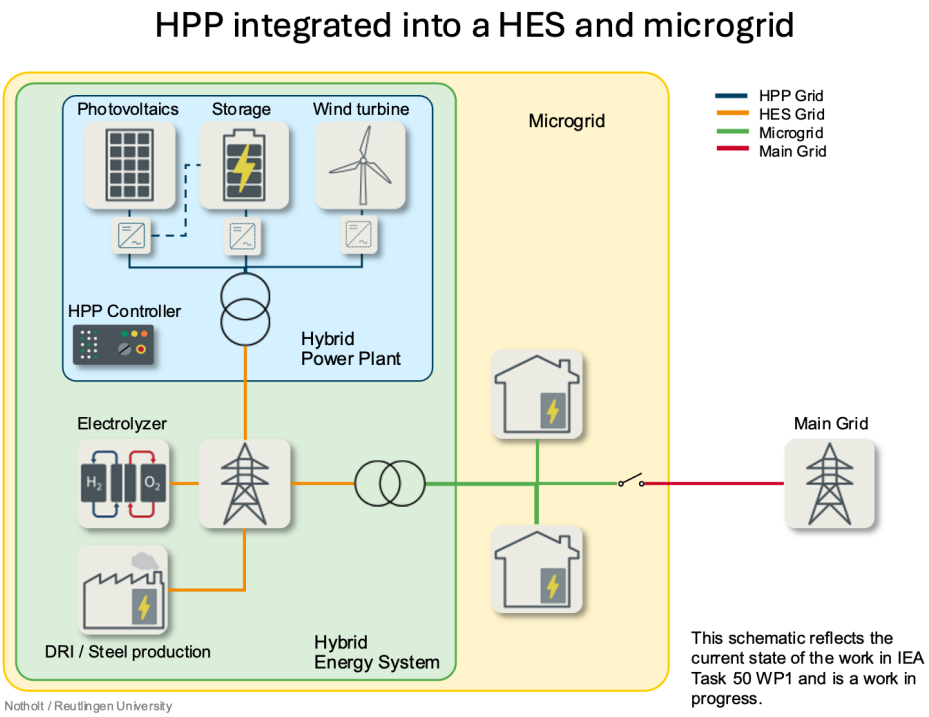


**Figure 1.** Schematic showing a Hybrid Power Plant (HPP) integrated into a Hybrid Energy System (HES) and a microgrid. This schematic displays an example system defined by the current status of the hybrid taxonomy being defined in WP1.

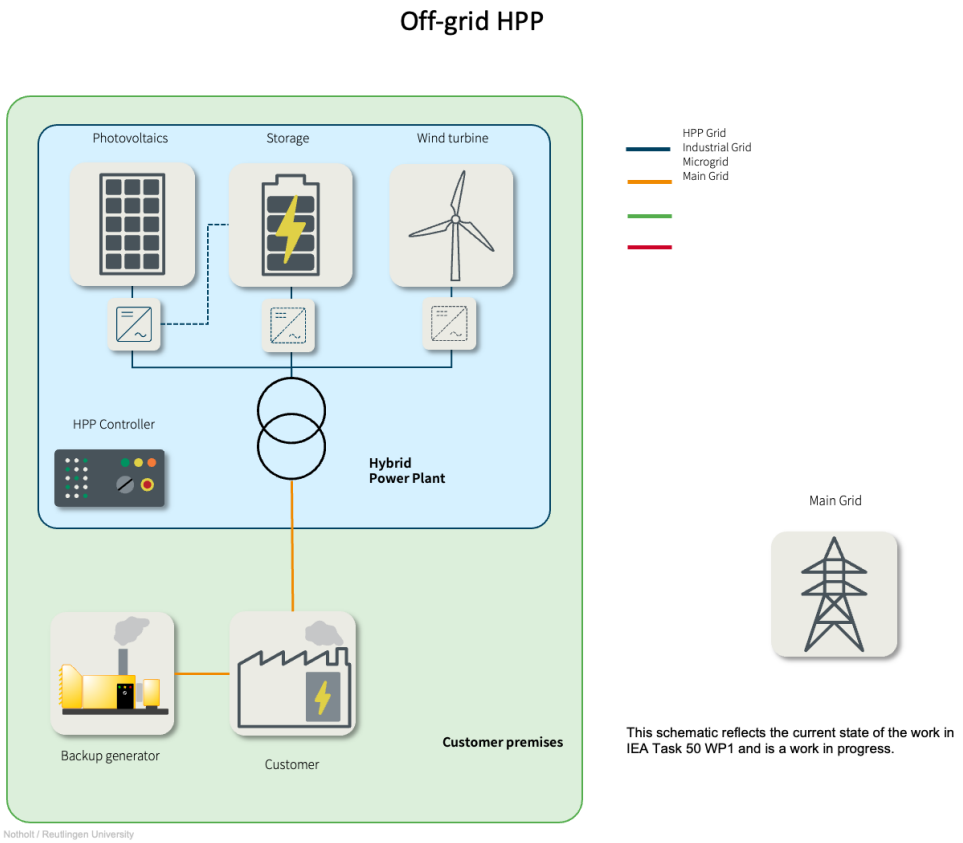


**Figure 2.** Schematic showing an off-grid Hybrid Power Plant (HPP). This schematic displays an example system defined by the current status of the hybrid taxonomy being defined in WP1.

## Highlight(s)

IEA Wind Task 50 had a joint meeting with Task 44 on Wind Farm Control at the Wind Energy Science Conference in Glasgow, UK in May 2023. At this meeting, significant feedback was received on the development of the hybrid taxonomy, as well as the reference cases to be developed. Task 50 also had an engaging conversation with members of Task 44, learning from their Task discussions and organisation.
WP1 completed nine draft definitions of a hybrid power plant, nearing agreement on a definition and identifying the need for a sub-list of definitions. This definition is informed by experts from academia, industry, and research institutions.
Participants within WP4 have made significant progress on their open-source hybrid-grid model, using it within their own research and development. A report is forthcoming.

## Outcomes and Significance

The results and activities of Task 50 bring significant benefits to participants, industry stakeholders, and society as a whole. By collaborating and sharing knowledge within the Task, participants gain valuable insights and expertise that can drive their own research, development, and business strategies in the field of HPPs. The Task's outcomes, such as the comprehensive taxonomy, reference designs, control algorithms, and optimisation techniques, serve as practical tools and guidelines for industry stakeholders. These resources help them streamline the design, implementation, and operation of HPPs, leading to improved efficiency, cost-effectiveness, and performance.

Industry stakeholders, including renewable energy developers, power system operators, equipment manufacturers, and investors, can leverage the results of Task 50 to make informed decisions and investments. The clear definition and taxonomy of HPPs enable stakeholders to identify suitable project opportunities, select appropriate technologies, and optimise system configurations. The reference designs provide benchmarks for industry best practices, facilitating standardised approaches and fostering technological advancements. The developed control algorithms and optimisation techniques enhance system operation and grid integration, leading to increased flexibility, stability, and reliability of HPPs. The dissemination efforts of Task 50, including in-person meetings, virtual workshops, and open-source resources, foster collaboration, knowledge sharing, and capacity building among participants and key stakeholders.

**Figure 3.** In-person annual meeting held at the 2023 Wind Energy Science Conference.

## Next Steps

Work is proceeding on all the work packages, with the hybrid power plant definition in WP1 informing the development of the reference designs in WP2. WP3 will continue their benchmarking exercise and making the data and results publicly available. WP4 will soon publish their open-source hybrid power plant grid model. An extension including the development of a hybrid schema, building off the WindIO schema that was originally developed in IEA Wind Task 37 and is continuing to be developed in Task 55 REFWIND, has been discussed with enough support that Task leadership is developing plans to create such a schema.

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