Atlantic Offshore Wind Transmission Study

Melinda Marquis
Offshore Wind Grid Integration Lead, NREL

Floating Offshore Wind Solutions 2022

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Outline

Project Overview

Task 1 Data Collection, Modeling Framework, and TRC

Task 2 Transmission Expansion Planning

Task 3 Production Cost and Resource Adequacy

Task 4 Technology Characterization

Task 5 Reliability, Contingency Analysis, and Faults

Task 6 Resilience, System Failures during Cascading Events, including Extreme Weather

Project Objectives

- Identification of scenarios, and pathways of OSW deployment with transmission topologies (such as radial lines, shared backbones or a meshed network), sequencing, and build-out in the Atlantic for 2030 till 2050 that meet or exceed reliability and resilience criteria while considering ocean co-use.

- Quantification of impacts such as economic, reliability, and resilience of multiple OSW and transmission scenarios and pathways, including during periods of system stress under typical and extreme weather conditions.

- Characterization and comparison of transmission technologies for the different scenarios, including onshore and offshore substations and cabling, and tradeoffs and costs for high voltage alternating current (HVAC) and high voltage direct current (HVDC) scenarios.

- Identification of a critical point (either in time or in GW of OSW deployed) at which the benefits of a coordinated transmission framework will outweigh the benefits of radial generator lead lines (GLL), identifying critical decision points given uncertainties.

- Collection of data & models that are useable by industry for accelerating their planning studies.

Project Schedule

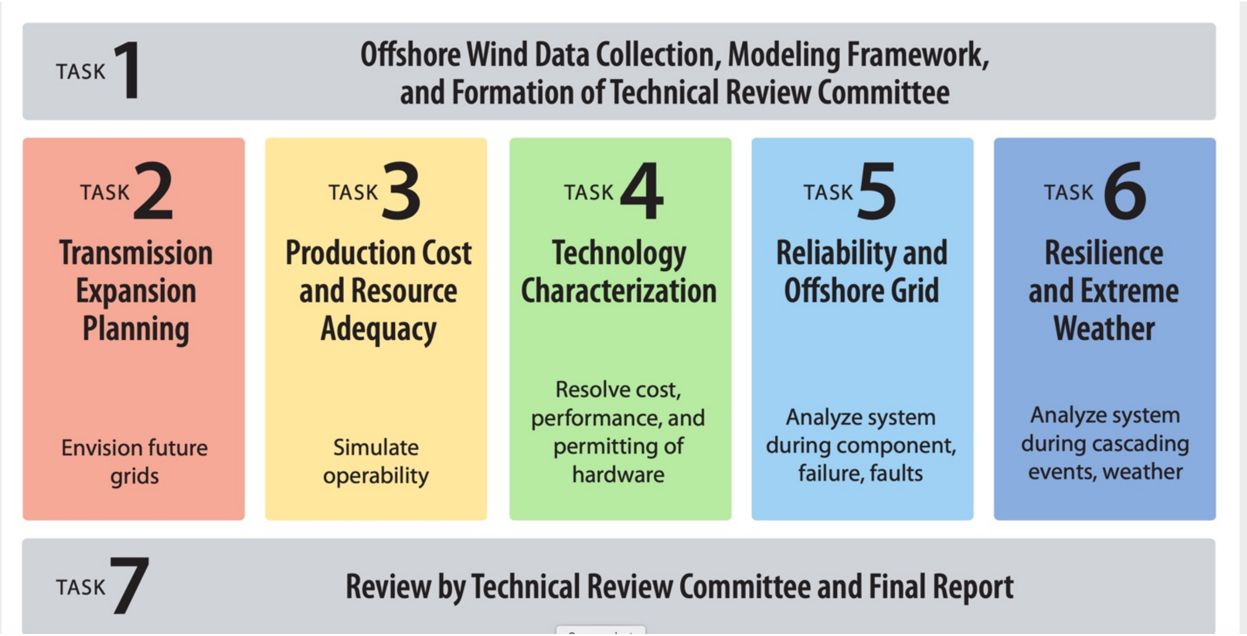
In Year 1 (November 1, 2021 – October 31, 2022)

- Create a technical review committee (**TRC**) with a wide range of stakeholders and expertise
- Establish **plausible onshore and offshore transmission expansion scenarios for 2030 and 2050**, that consider the impacts of cable routing, points of interconnection, landing points, and environmental and community impacts.
- Identify any **critical point** at which the benefits of a **coordinated transmission framework will outweigh the benefits of generation lead line** approach and assess how transmission will evolve over the time.
- Begin to evaluate system **operations, cost, and reliability** of the established, plausible scenarios

In Year 2 (November 1, 2022 – October 31, 2022)

- **Complete** production cost modeling, capital investment estimation, and reliability studies
- Perform **stability analysis, transient fault behavior analysis, and resilience studies** for the onshore and offshore grid
- Deliver the **final report**

Project Tasks



Extensive iteration and feedback (inputs and outputs) among the various tasks.

Task 1: Data Collection, Modeling Framework and Formation of Technical Review Committee

- A technical review committee composed of representatives from RTOs/ISOs, utilities, states, original equipment manufacturers, environmental organizations, and others will provide input, feedback, and guidance to ensure the highest degree of relevance and usefulness of the study results.

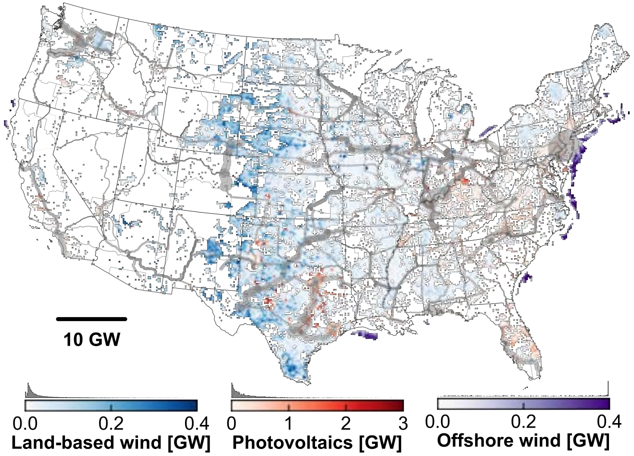
- TRC will likely have three focus areas:
    1. Environmental and Siting
    2. Technology
    3. Generation and Transmission Planning

- Members can self-select to participate in a given focus area and therefore the meetings they attend.

Task 2: Transmission Expansion Planning

- Use NREL Regional Energy Deployment System (ReEDS) model to explore the scenario space of a variety of transmission options through 2050, likely including but not limited to:
  - Business as usual, radial approach with generator lead lines, with and without corridor consolidation
  - Collector systems to consolidate OSW clusters
  - Inter-regional mesh grid
  - Larger land-based HVDC overlay

- At what point do the larger transmission builds become more important? Are there risks to overbuilding?



Example ReEDS output

Task 2: Transmission Expansion Planning

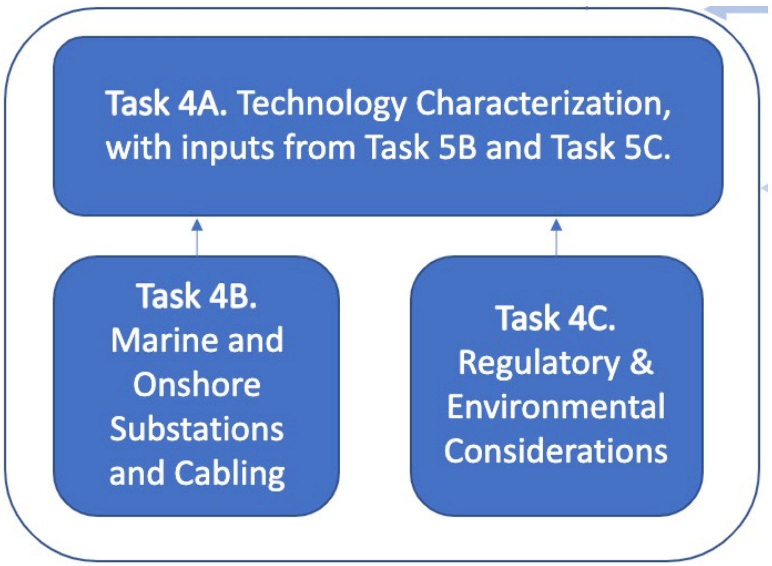
- Scenarios studied for 2030 can be informed by:
  - Stakeholder input through TRC
  - Data analysis (e.g., OSW generation profiles) from Task 1
  - ReEDS modeling
  - Initial results from production cost and resource adequacy (Task 3)
  - Initial results from technology characterization (Task 4)

Task 3: Production Cost and Resource Adequacy

- Perform production cost modeling to **simulate the operation** of the 2030 and 2050 grids to inform:
  - How does the transmission expansion impact the operation of the grid? How is it utilized, and how does that impact curtailment?
  - What time periods would be interesting to study in the reliability work (tasks 5 and 6)?

- Perform resource adequacy modeling using NREL PRAS model to **calculate reliability metrics** and inform:
  - What is the resource adequacy impact of offshore wind?
  - How does transmission topology affect that?

Task 4: Technology Characterization



- Technology characterization of final transmission scenarios
- The following three OSW subsystems will be included along with environmental and regulatory considerations:
  - Delivery from platform to onshore substation,
  - Undersea cabling and installation, and
  - Marine substation design and hardware.
- We will screen for cable route areas and landing points that avoid sensitive areas, such as critical habitat, military sensitive areas, fisheries, and mitigate impacts to communities and key ocean users.
- Estimate capital costs for final transmission scenarios

Task 5: Reliability and Offshore Grid

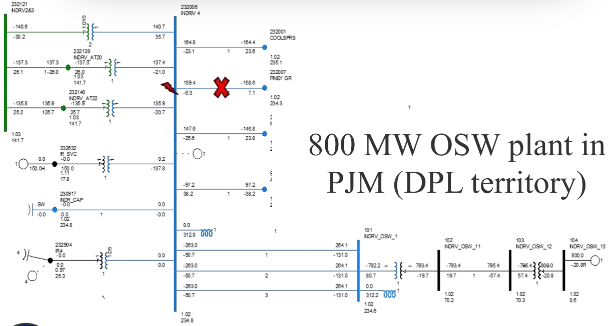
Objectives

- Perform comprehensive reliability studies for several stressed transmission scenarios identified in Task 2 and 3 between years 2030 and 2050
- Evaluate different planned and meshed offshore transmission approaches from the reliability standpoint

Studies: Contingency analysis, dynamic stability, and transient performance during faults

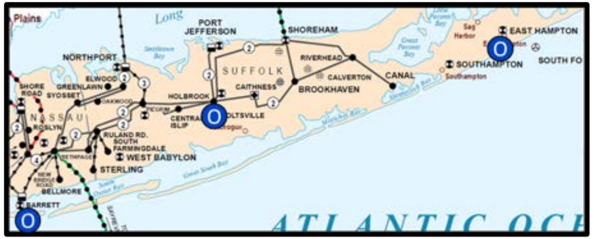
Task 5: Components of Grid Reliability Analysis

Contingency Analysis
(steady-state and dynamic) **5.1, 5.2**



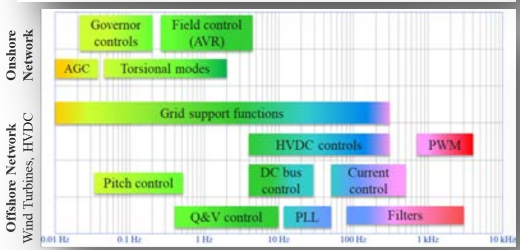
800 MW OSW plant in PJM (DPL territory)

O OSW

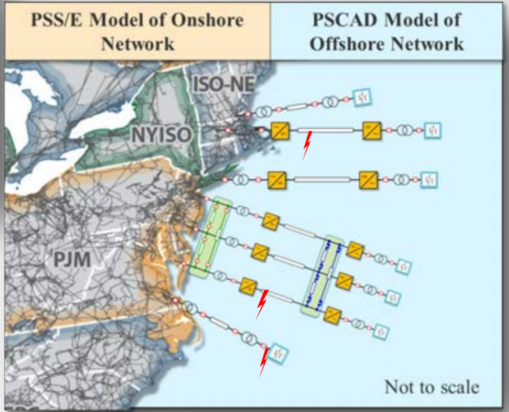


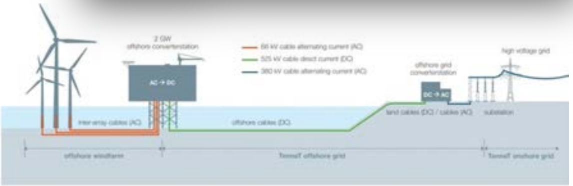
Long Island

Small-signal Stability
(oscillations, control interactions, resonances) **5.3, 5.4**



Transient Performance
(comprehensive for radial; preliminary for meshed) **5.3, 5.4**





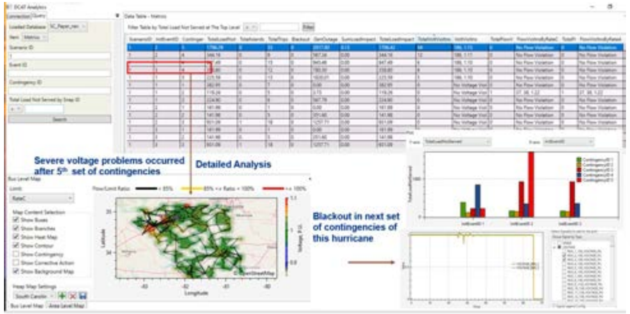
Subtasks, Tools, and Models

Evaluate system reliability for contingencies identified in coordination with TRC

5.1: Steady-state contingency analysis

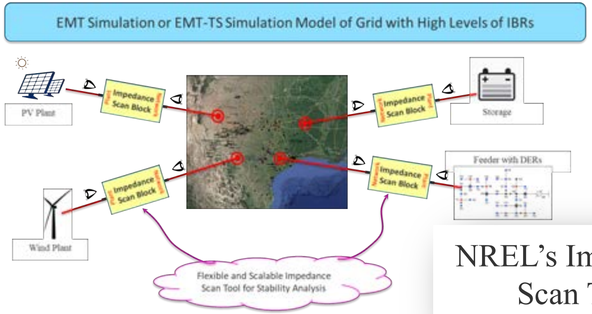
PNNL's Chronological AC Power Flow Automated Generation Tool (C-PAGE)

5.2: Dynamic contingency analysis



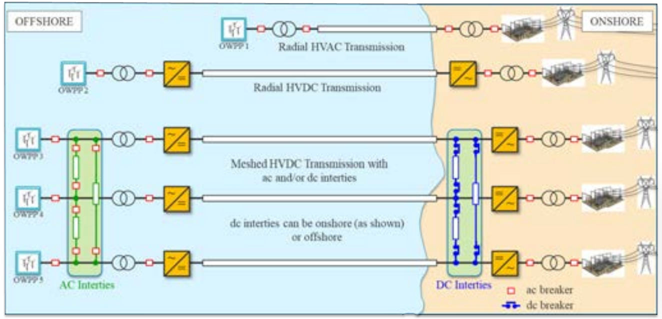
PNNL's Dynamic Contingency Analysis Tool (DCAT)

5.3: Stability and Fault Behavior



NREL's Impedance Scan Tool

5.4: Regional HVDC and Backbone



Sizing and protection

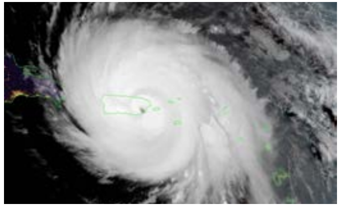
PSSE, PSCAD, and ETRAN Tools

Tasks 6: Extreme Event Analysis

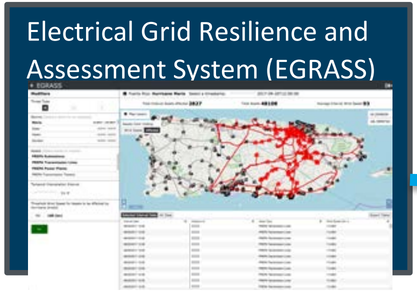
Objectives:

- Identify extreme weather events for further evaluation
- Conduct analysis of system steady-state and dynamic behavior during extreme weather events

Identify extreme weather events for further evaluation using EGRASS tool

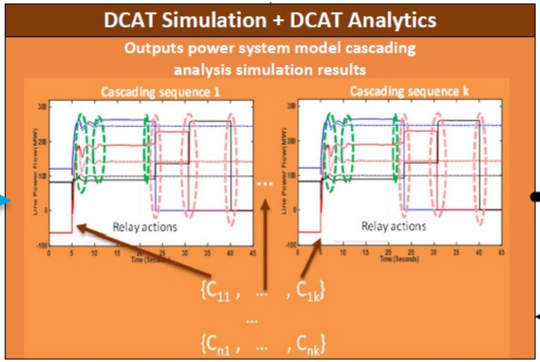


Task 6.1



Generate Monte Carlo outage sequences

Task 6.2



Dynamic cascading grid simulations using Dynamic contingency Analysis Tool (DCAT)

Apply Resiliency Improvements

- Thousands of realistic dynamic cascading simulations
- Analytics in DCAT and EGRASS to derive recommendations for:
  - Transmission hardening; Protection coordination; Preventive operational actions; Voltage support; Asset management and investment prioritization

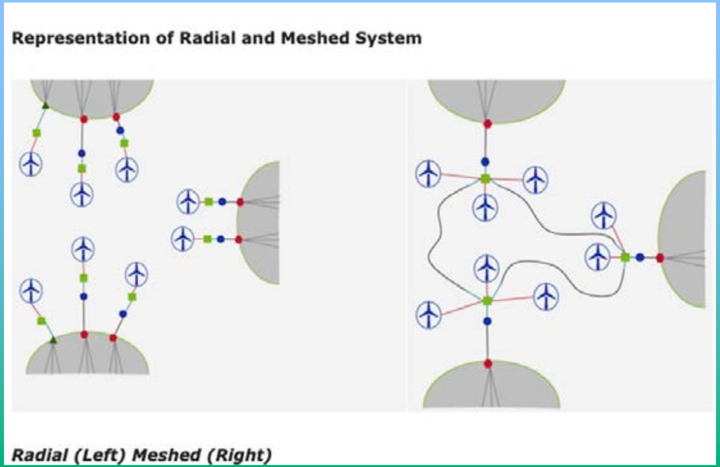
Thank you for your attention!

https://www.nrel.gov/wind/atlantic-offshore-wind-transmission-study.html

Photo Credit : Dennis Schroeder-NREL

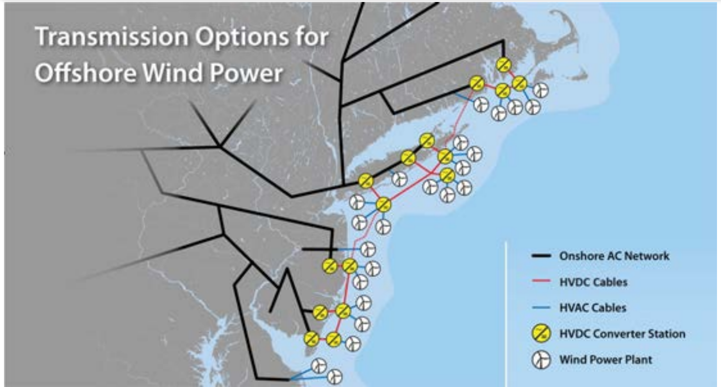
Back Up Slides

Transmission Topologies



- Offshore wind farm
- Country
- Grid connection (to the hub)
- Grid connection (to the site)
- Submarine cable
- Connection to transmission grid
- Offshore AC substation
- Onshore AC substation
- Offshore AC/ DC converter station
- Onshore DC/ AC converter station

Source: European Commission. Environmental Baseline Study for the Development of Renewable Energy Sources, Energy Storages and a Meshed Electricity Grid in the Irish and North Seas



Backbone and **Meshed**:

- These two terms can be used interchangeably depending on the context.
- **Meshed** is an interconnected approach for offshore transmission (mainly hvdc)
- **Backbone** is a single line (either dc or ac) along the coast, that can be tapped at several points. There can be overlap between the two.