U.S. DEPARTMENT OF
ENERGY
Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

PJM/NYISO/ ISO-NE
Inter-Regional Planning Stakeholder Advisory Committee

Atlantic Offshore Wind Transmission Study

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U.S. Department of Energy

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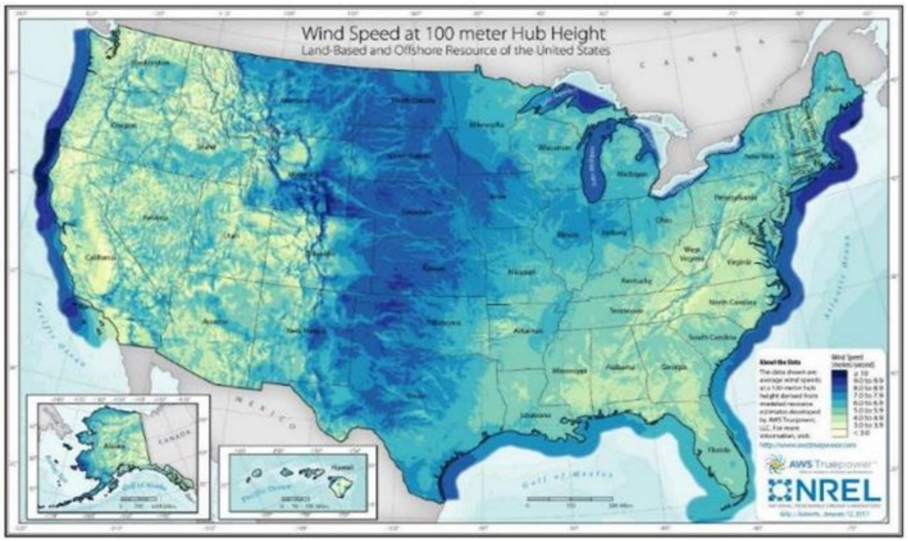
U.S. Wind Energy

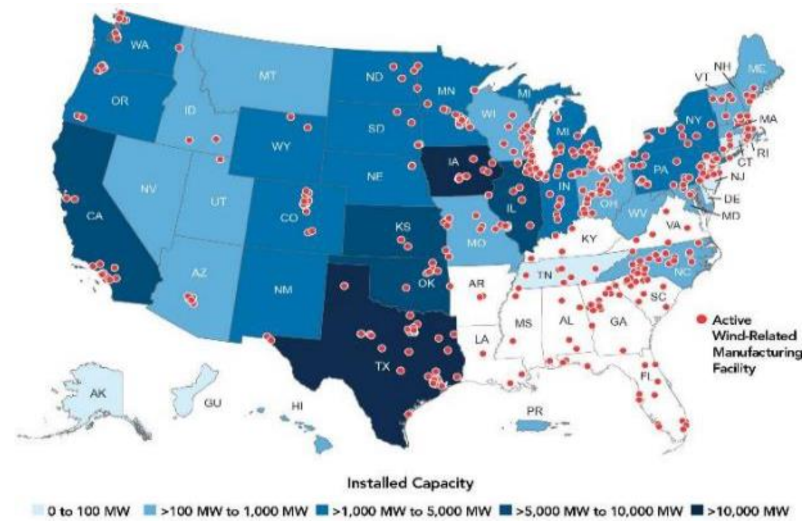
U.S. Wind Resource is Vast

Illustration from AWEA



U.S. Land-Based and Offshore Wind Resources
Annual Average Wind Speed at 100 Meters Above the Ground

U.S. Wind Energy Spurs Economic Growth



Wind Energy Deployment by State & Related Economic Centers
and Manufacturing Facilities of the Domestic Supply Chain

Key Challenges Remain

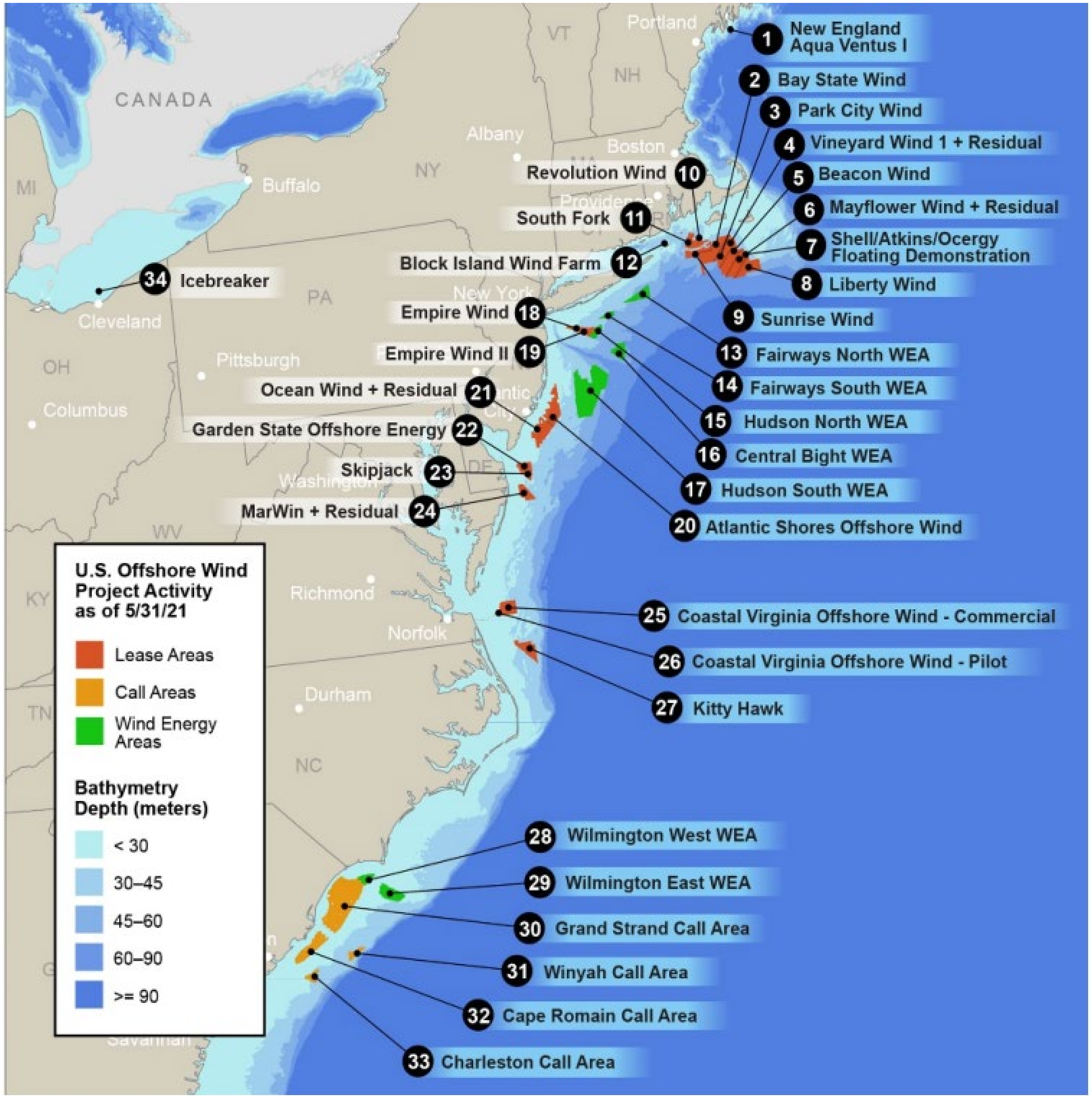
- Unsubsidized costs are still too high for some applications
- Many technical challenges remain especially for floating offshore
- Environmental and siting constraints
- Integration of large-scale power into the grid presents complexities

DOE Wind Energy R&D, by Sub-Program

- Land-Based (Utility-Scale) Wind
- Distributed Wind
- Offshore Wind
- Grid Systems Integration & Analysis

Background for the DOE study

- Offshore wind deployment goals
- DOE's Offshore Wind Transmission Integration R&D RFI
- **Atlantic Offshore Wind Transmission Literature Review and Gaps Analysis (energy.gov)**



Source: Offshore Wind Market Report: 2021 Edition

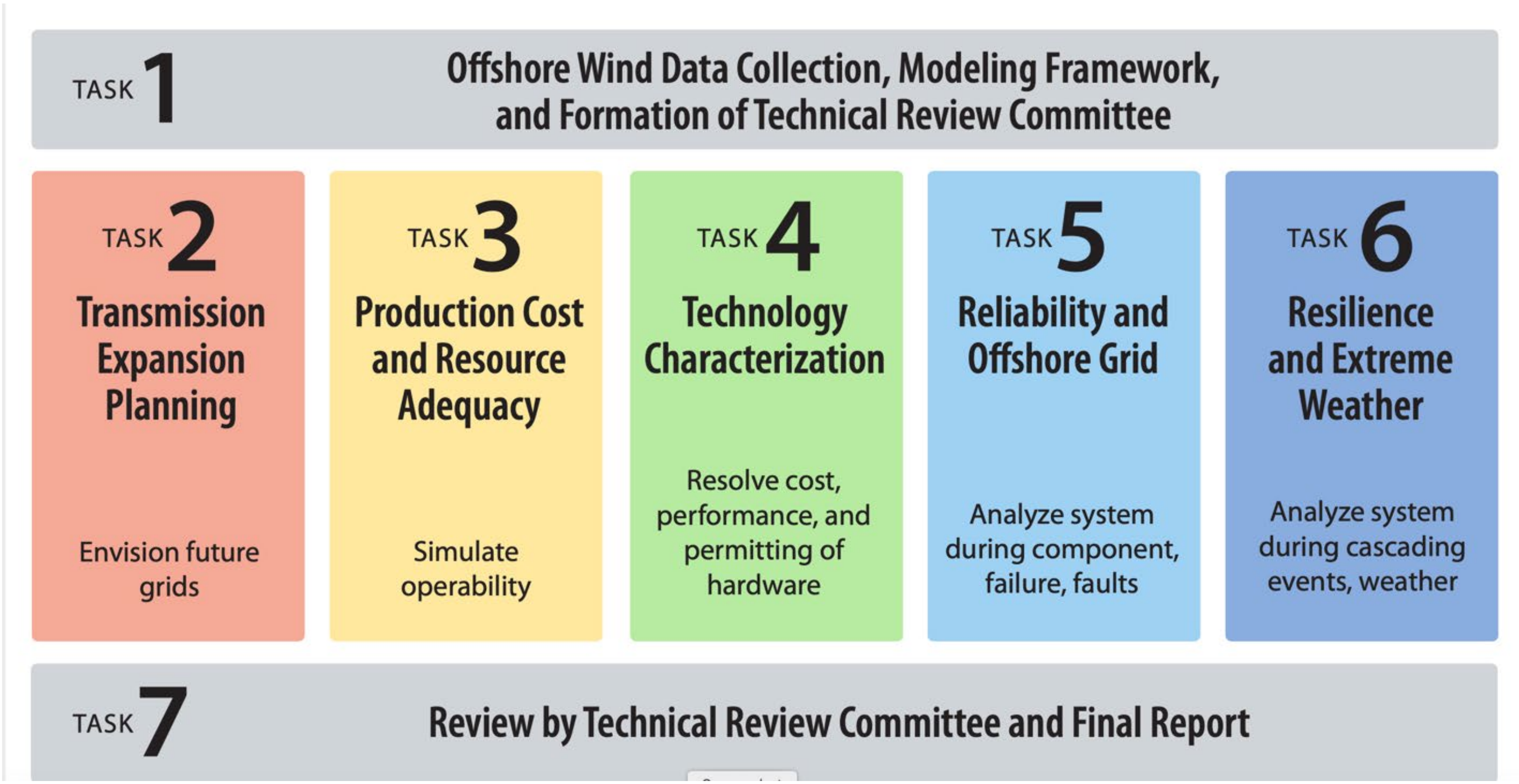
What is the DOE study?

- 2 year's study
- Alignment with state and federal offshore wind goals: near term (2030) and long term (2050)
- Integrated onshore and offshore planning
- Economic, reliability, and resilience analysis
- Considering environmental and community impacts
- Inter-states, inter-regional, from Maine to South Carolina

Project Objective

- 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).
- Collection of data and models that are readily useable by industry for accelerating their own planning studies.

Project Tasks



Extensive iteration and feedback among tasks

Task 1: Data, model, and TRC

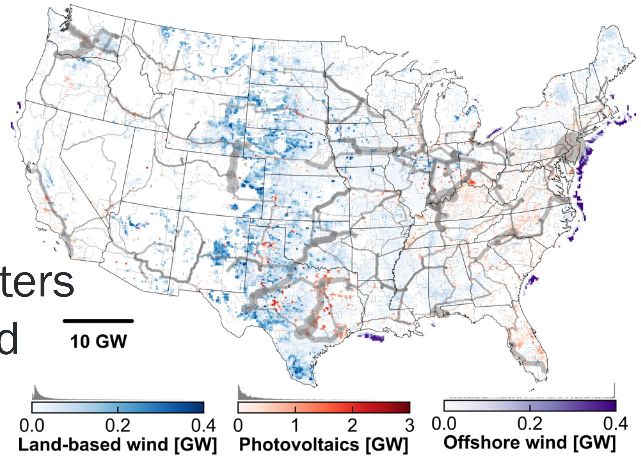
- **Forming of technical review committee (TRC)**

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

- **TRC meetings:**
  – Kickoff meeting Dec. 8, 2021.
  – Plenary meetings on quarterly or bi- annual basis
  – Topic-specific meetings in between

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 consolidated OSW clusters
  - Regional backbones Inter-regional mesh grid
  - Larger land-based HVDC overlay



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

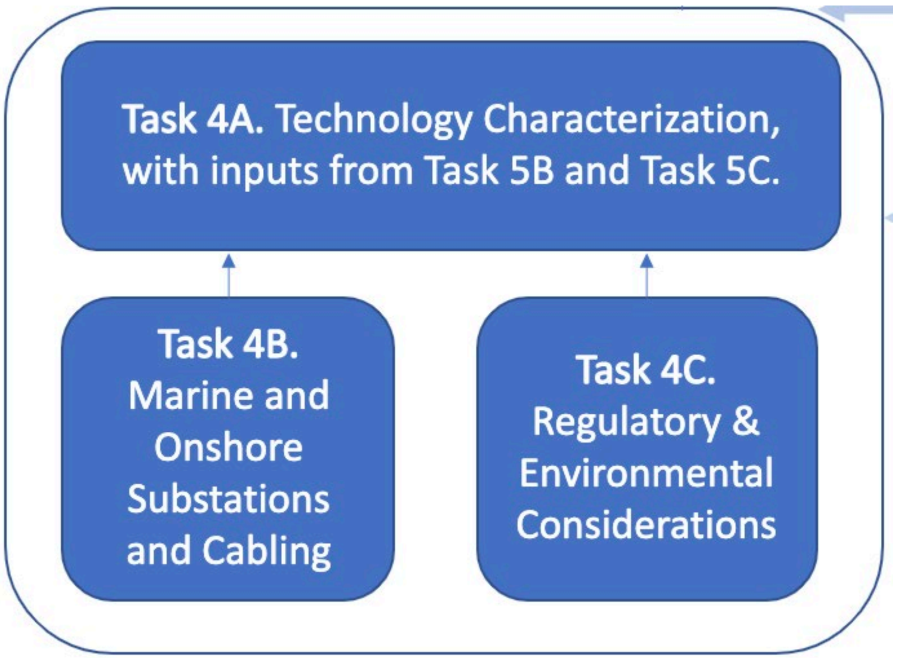
Task 2: Transmission Expansion Planning

- Detailed transmission scenarios will be assembled using information from a variety of sources:
  - ReEDS model build trajectories
  - Stakeholder input: TRCs, project pipeline and queues
  - Data analysis
  - Initial results from production cost and resource adequacy
  - Initial results from technology characterization
- 2030 scenarios may focus more on stakeholder input, with 2050 considering models more

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:

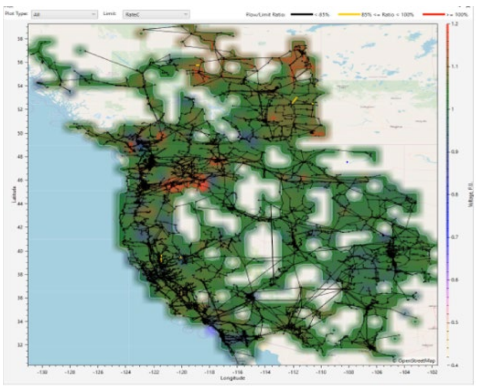
– Perform comprehensive reliability studies for several stressed transmission scenarios identified in Task 2 and 3 between years 2030 and 2050

– Evaluate different planned and meshed offshore transmission approaches from the reliability standpoint

Task 5: Reliability and Offshore Grid

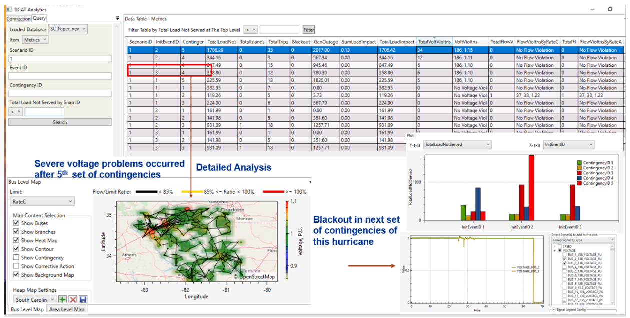
Evaluate system reliability for contingencies identified in coordination with TRC

5.1: Steady-state contingency analysis



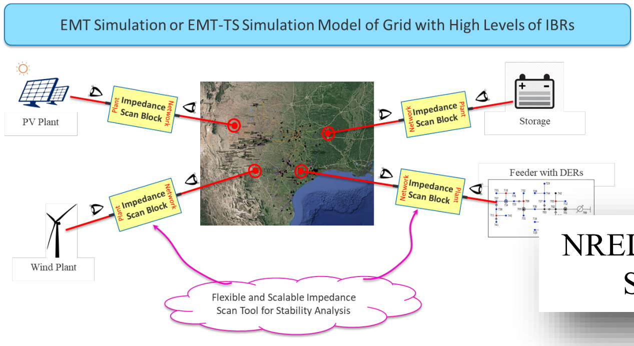
PNNL's Chronological AC Power Flow Automated Generation Tool (C-PAGE)

5.2: Dynamic contingency analysis



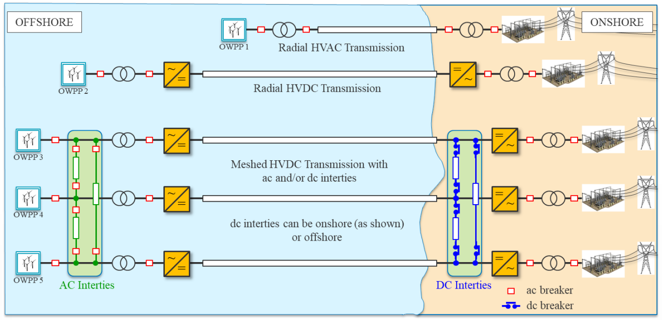
PNNL's Dynamic Contingency Analysis Tool (DCAT)

5.3: Stability and Fault Behavior



NREL's Impedance Scan Tool

5.4: Regional HVDC and Backbone



Sizing and protection

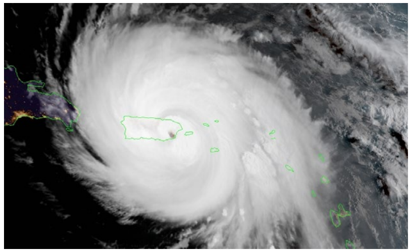
PSSE, PSCAD, and ETRAN Tools

Task 6: Extreme Event Analysis

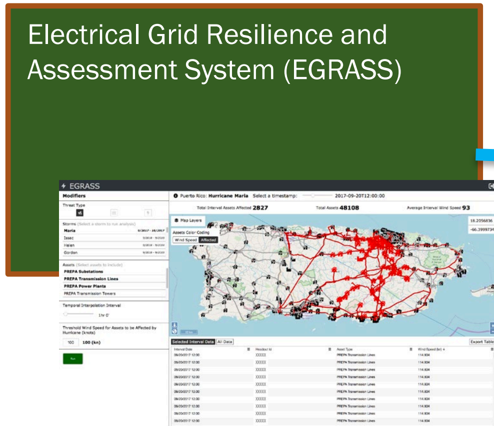
Objectives:

- Identify extreme weather events for further evaluation using PNNL's EGRASS tool
- Conduct analysis of system steady-state and dynamic behavior during extreme weather events using PNNL's DCAT tool.

Task 6: Extreme Event Analysis

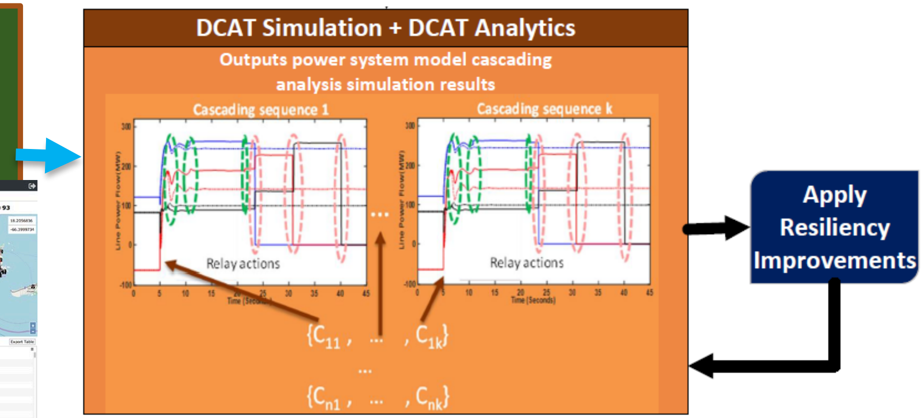


Task 6.1



Generate Monte Carlo outage sequences

Task 6.2



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

- 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

Task 7: Review and Final Report

- Additional runs if needed
- Review and approve final report

Project Schedule

- <u>In Year 1 (November 1, 2021 – October 31, 2022)</u>
  - 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
- <u>In Year 2 (November 1, 2022 – October 31, 2023)</u>
  - **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**

Questions?

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