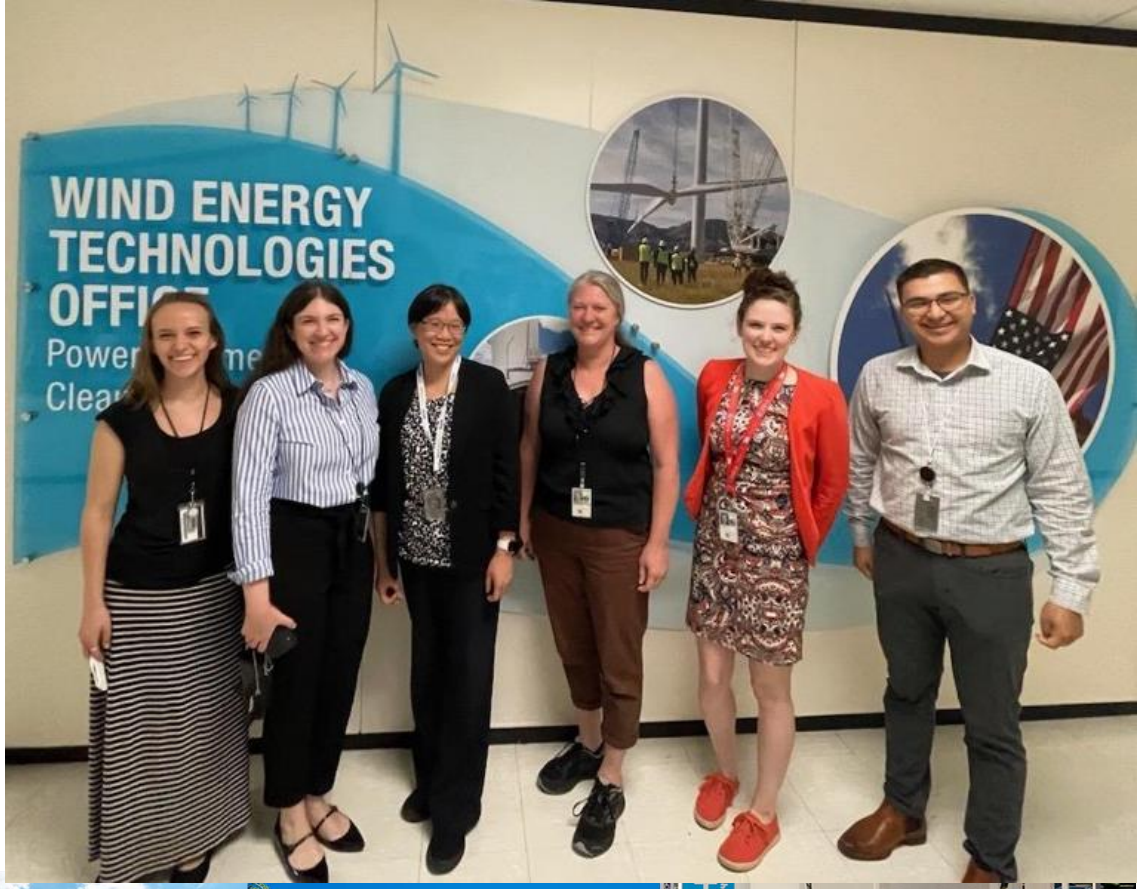
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

WETO
Systems Integration



Wind Energy Technologies Office
U.S. Department of Energy






WETO Office Overview

WETO Systems Integration

Key Activities	**Transmission Adequacy and Access** Transmission planning analysis, interconnection improvement, and transmission technology innovation **Grid Reliability and Resilience** Wind control for grid services, grid monitoring and control, grid stability analysis with increasing IBRs **Wind Hybrid System** Analysis, design, configuration, control, and modeling **Wind Cybersecurity** Hardening legacy systems, tools and information sharing, cybersecurity by design, supply chain
Offshore Initiatives	• Atlantic and West Coast Offshore Wind Transmission Studies • FOA 2828 HVDC Standards, Functional Requirements, and Education for Offshore Wind • FOA 3141 Innovative Designs for high performance, low cost HVDC Converters • Wind Production Database
Other Major Initiatives	• Understanding Atlantic Offshore Grid Protection • Interconnection Innovation Exchange • UNIFI consortium (grid forming inverters) • FOA 2745 Solar and Wind Grid Service and Reliability Demonstration • Wind Cybersecurity Lab Call • Wind-H2-Green Steel/Green

Vineyard I

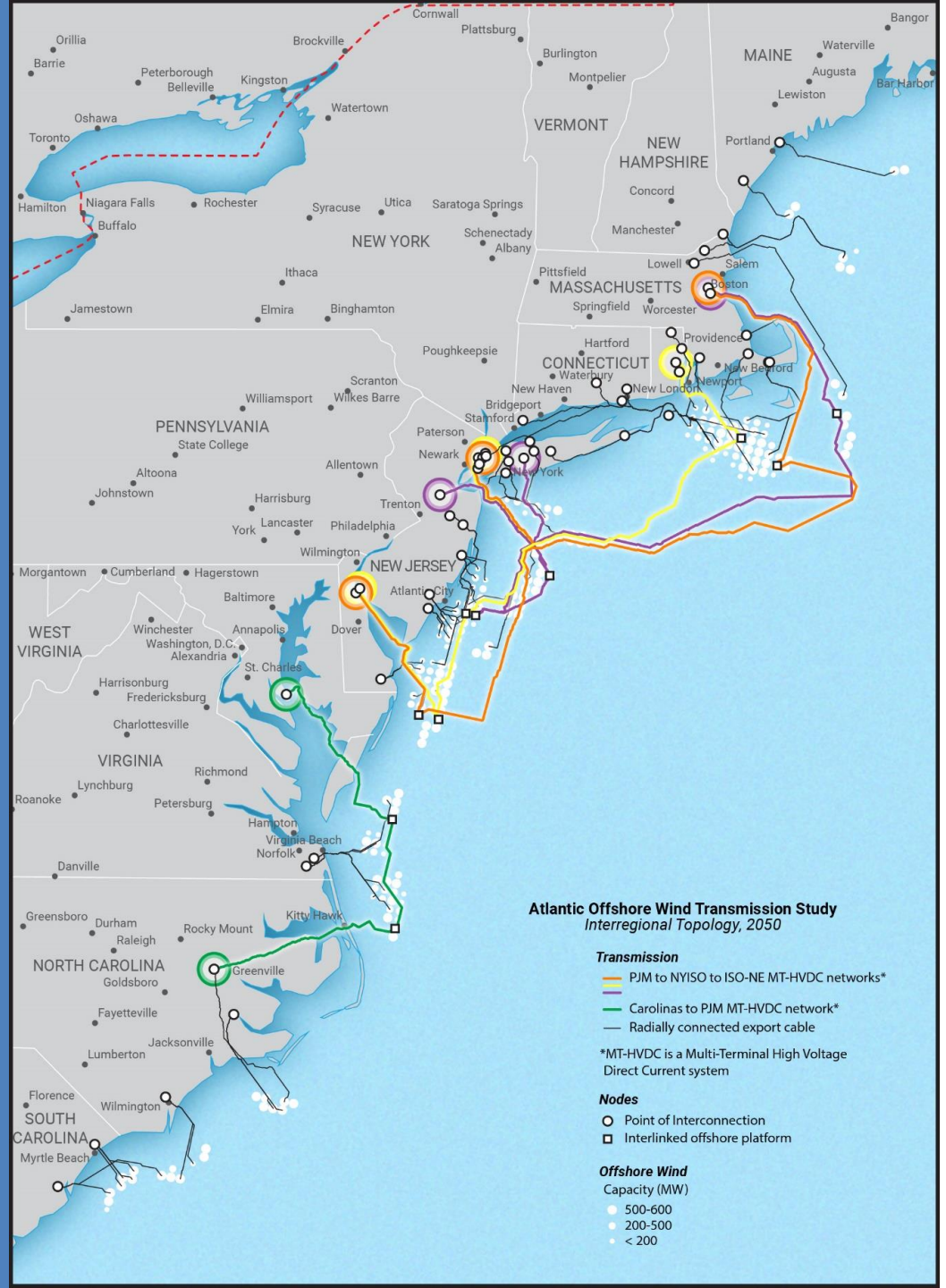
Atlantic Offshore Wind Transmission Study

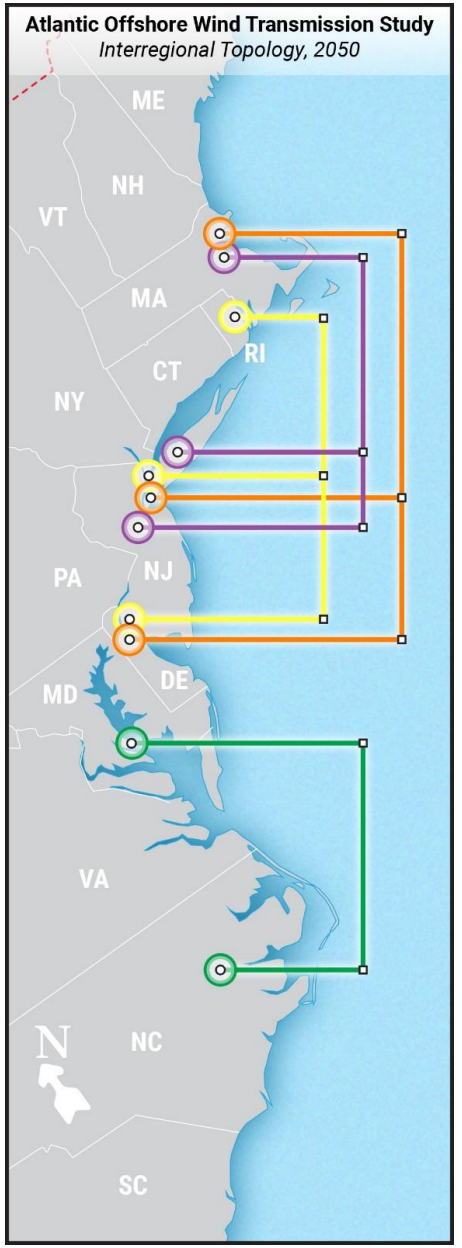
Interregional: What could a topology that links regions look like?

Seven new cables, interlinking 11 platforms

14 GW interregional capacity

Designed using price differentials from initial grid modeling





BIL FOA 2828 to Address Key Deployment Challenges for Offshore, Land-Based, and Distributed Wind

Topic Area 1: High Voltage Direct Current (HVDC) for Offshore Wind

Topic Area	Title	Summary
Topic Area 1, Subtopic 1a	High-Voltage Direct Current (HVDC) Standards and Benchmark System Development for Offshore Wind	Understand gaps in U.S. HVDC standards and begin addressing by developing a benchmark system and proposing and revising standards, especially to incorporate transmission for offshore wind.
Topic Area 1, Subtopic 1b	Multi-terminal HVDC Controls and Functional Requirements	Develop HVDC controls and identify functional requirements to address multi-terminal HVDC deployment barriers.
Topic Area 1, Subtopic 1c	HVDC Curriculum Development for Education and Workforce Training	Develop HVDC curriculum for education and workforce training.

Development of Standards & Benchmark Studies (1a)

A lack of reliability, technical, and interoperability standards, and benchmark modeling capability. currently hinders HVDC transmission expansion in the U.S. This project will address those deficiencies and thereby accelerate adoption of HVDC systems needed to advance offshore wind deployment goals.

Prime Recipient: DNV
Project Partners: NREL, GE Research, University of Texas – San Antonio
Principal Investigator: Dr. Cornelis Plet, DNV
Key Personnel: Dr. Morgan Putnam (DNV), Dr. Shahil Shah (NREL), Dr. Arvind Tiwari (GE Research), Dr. Bin Wang (UTSA)

Proposed Project Goals

•Create a gap analysis for HVDC standards and prioritize the importance of the gaps. This analysis will result in a roadmap for resolving reliability and interoperability issues that will directly impact the timing and scope of U.S. OSW development.

•Deliver benchmark models that will enable public and private entities involved in grid planning to conduct various dynamic and transient stability studies of multi-terminal HVDC (MT-HVDC) OSW transmission designs.

•Collaborate and build consensus with stakeholders to develop concrete proposals to fill standards gaps. Enable initiation of change processes by U.S. reliability and technical standards-setting bodies to consider the proposals.

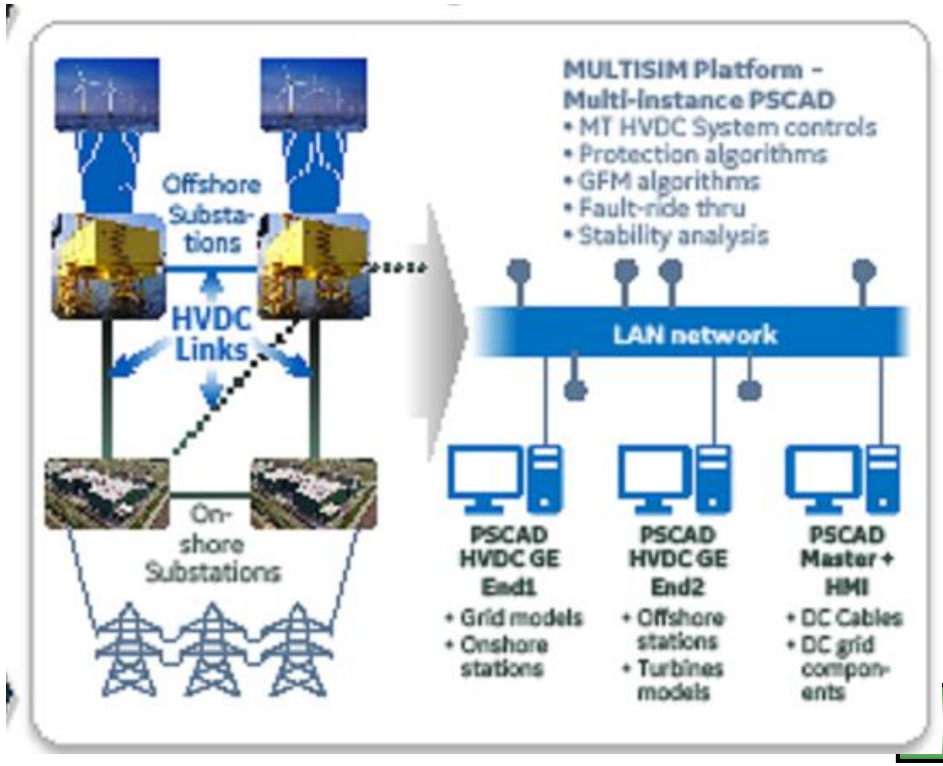
•The project team's extensive technical expertise will be supported by a Developer Consortium and Advisory Committee that includes ISO/RTO and State stakeholders with critical roles in grid reliability, offshore wind expansion, and climate resilience.

DC MULTI-terminal SIMulation (HVDC MULTISIM) (1b)

Dr. Rajib Datta/ GE Research

Technology Summary

The project aims to develop innovative controls and protection for a multi-terminal (MT) HVDC network and implement and validate them on a software-in-the-loop (SIL) environment. The program will deliver (i) a distributed flexible SIL platform, MULTISIM, at NREL as a U.S. national-level infrastructure, (ii) a standardized library of subsystem models, and (iii) novel MT HVDC controls and protection strategies validated on this platform against a benchmark system. The project aims to set the foundation for cost-effective and fast validation of MT HVDC transmission from different vendors, accelerating the development of U.S. offshore wind.



Key Personnel

Dr. Rajib Datta (GE Research – PI), Dr. Pablo Briff (GE Grid Solutions), Mr. Rafael Wilches (PSEG), Dr. Shahil Shah (NREL), Dr. Richard Zhang (Virginia Tech), Dr. Bin Wang (University of Texas, San Antonio)

	Key Milestones & Deliverables
Year 1	• Requirements document, MT HVDC system design, PSCAD model development • MULTISIM platform design • Novel controls and protection strategies
Year 2	• Build and test MULTISIM platform • Validate benchmark system model on MULTISIM

Technology Impact

- Establish a benchmark MT HVDC grid model that vendors, developers, utilities, academics can use to innovate, test, and validate new DC technologies.
- MULTISIM minimizes CAPEX investment in simulation minimizing computational hardware and set-up time
- Provides a U.S. based national level infrastructure for multi-vendor validation of MT HVDC technology and enable interoperability.

Develop MT HVDC Controls & Protection, Validate on MULTISIM

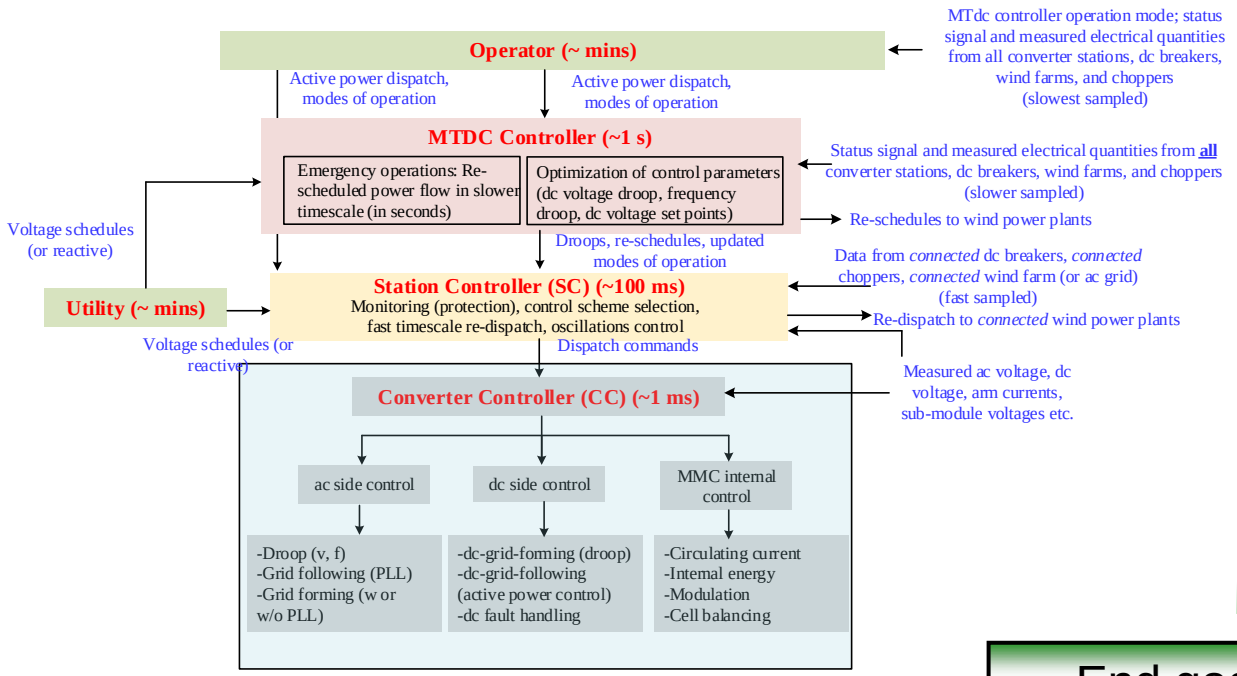
Operation of Vendor-Agnostic MTdc based Offshore Wind Integration (1b)

Suman Debnath / Oak Ridge National Laboratory

Technology Summary

The goal of the project is to enable multi-vendor multi-terminal direct current (MTdc) system that can connect to multiple system operators and utilities in the US. The proposed project will identify technical specifications for wind integration using MTdc systems from multiple vendors. Functional requirements will be developed for normal and emergency operating conditions. A hierarchical control system with key components needed in the MTdc system will be researched and identified that enable the multi-vendor MTdc system operation.

Local disadvantaged and minority communities will be engaged by all project partners in different regions in the US to enhance diversity in STEM education and provide an understanding of opportunities for future generation in wind integration. Diversity will also be promoted within the project team, with voices from minorities included within the project team.



Key Personnel

ORNL: Suman Debnath (**PI**), Sreenivasa Sivaprasad Jaldanki, Yonghao Gui; **Hitachi Energy:** Jiuping Pan, Thi-Ha Nguyen; **Siemens Energy:** Ricardo Orfei, Santos Garza-Romero; **Georgia Institute of Technology:** Maryam Saeedifard; Advisors: ISO-NE, SPP, CAISO, SCE, ConEd, NOWRDC

	Key Milestones & Deliverables
Year 1	• Complete testing of 1 MTdc system architecture with limited control features. • Identifying the communication needs upon testing at least 2 faults.
Year 2	• Station control includes at least 3 features for detecting faults, operating under faults, and re-dispatching power post-fault. • Complete integration of two different vendor converter controllers with the station controller in the MTdc system.
Year 3	• Improved performance observed in 30% better post fault power transfer and 20% chopper reduced requirements • Provide technical specification and functional requirements

Technology Impact

Reliability metrics like the dc fault clearing time, dc voltage restoration time, active and reactive power restoration time and transient energy imbalance will be improved by 10%. Additionally, 30% improved power transfer is expected during fault conditions in the MTdc system along with reduced needs from hardware like dc chopper by 20%.

End goal of enabling interoperable multi-vendor MTdc systems

HVDC-Learn: Modular Education & Workforce Training in High Voltage Direct Current Electric Transmission (1c)

***PRIME RECIPIENT*:** Iowa State University
***PRINCIPAL INVESTIGATOR*:** James McCalley, Distinguished & Chaired Professor

***SENIOR/KEY PERSONNEL*:**

Power Systems

Hantao Cui, Assist. Prof., Oklahoma State
Xin Fang, Asst. Prof., Mississippi State
Eric Hines, Prof. of Practice, Tufts
Fran Li, Chaired Prof., U. Tenn.-Knox.
Per-Anders Lof, Lecturer, Tufts;
Principal Engr, National Grid
James McCalley, Chaired Prof., Iowa State

Power Electronics

Leon Tolbert, Chaired Prof., U. Tenn-Knox.
Alex Stankovic, Chaired Prof., Tufts
Ali Mehrizi-Sani, Assoc. Prof., Virginia Tech
Johan Enslin, Chaired Prof., Clemson
Moazzam Nazir, Rsrch Scientist, Clemson

High Voltage Engineering

David Wallace, Asst. Clin. Prof. Miss. State

Locations of 7 Project Locations

***KEY IDEA*:** Develop & use educational modules to elevate the electric power community's awareness/understanding of the HVDC domain to increase HVDC deployment as an offshore & onshore transmission solution.

36 modules spanning the following 12 areas:
(1) Introductory/Overview Coverage; (2) Station components; (3) Converters; (4) Control; (5) HVDC Protection; (6) HVDC Line and Cable Technologies; (7) Point-to-Point HVDC Configurations; (8) Multi-Terminal HVDC Networks; (9) Planning and Design; (10) HVDC System Simulation and Analysis; (11) Regulatory Permitting Processes/Procedures; (12) Energy Equity and Environmental Justice

Thank You!