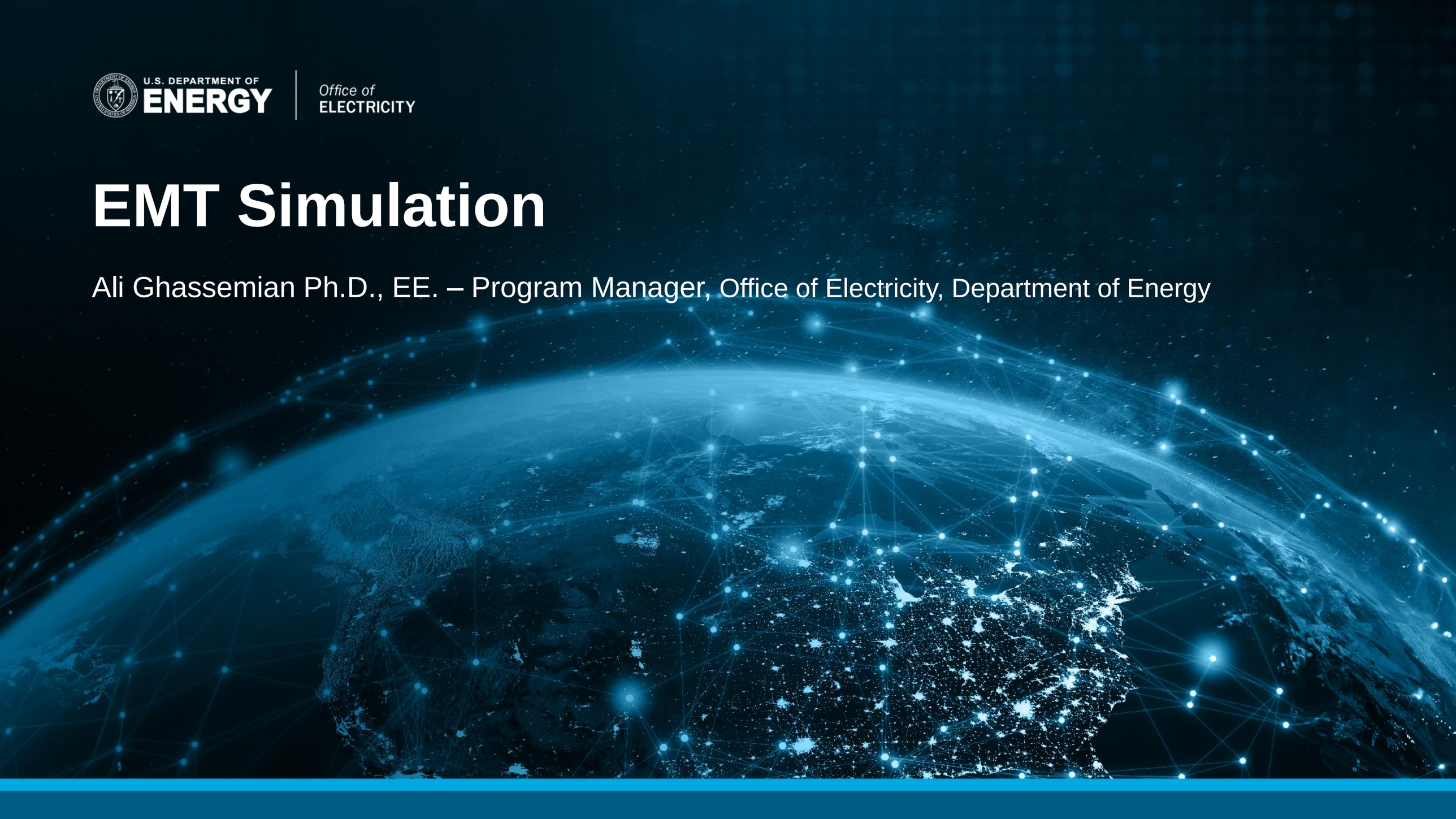
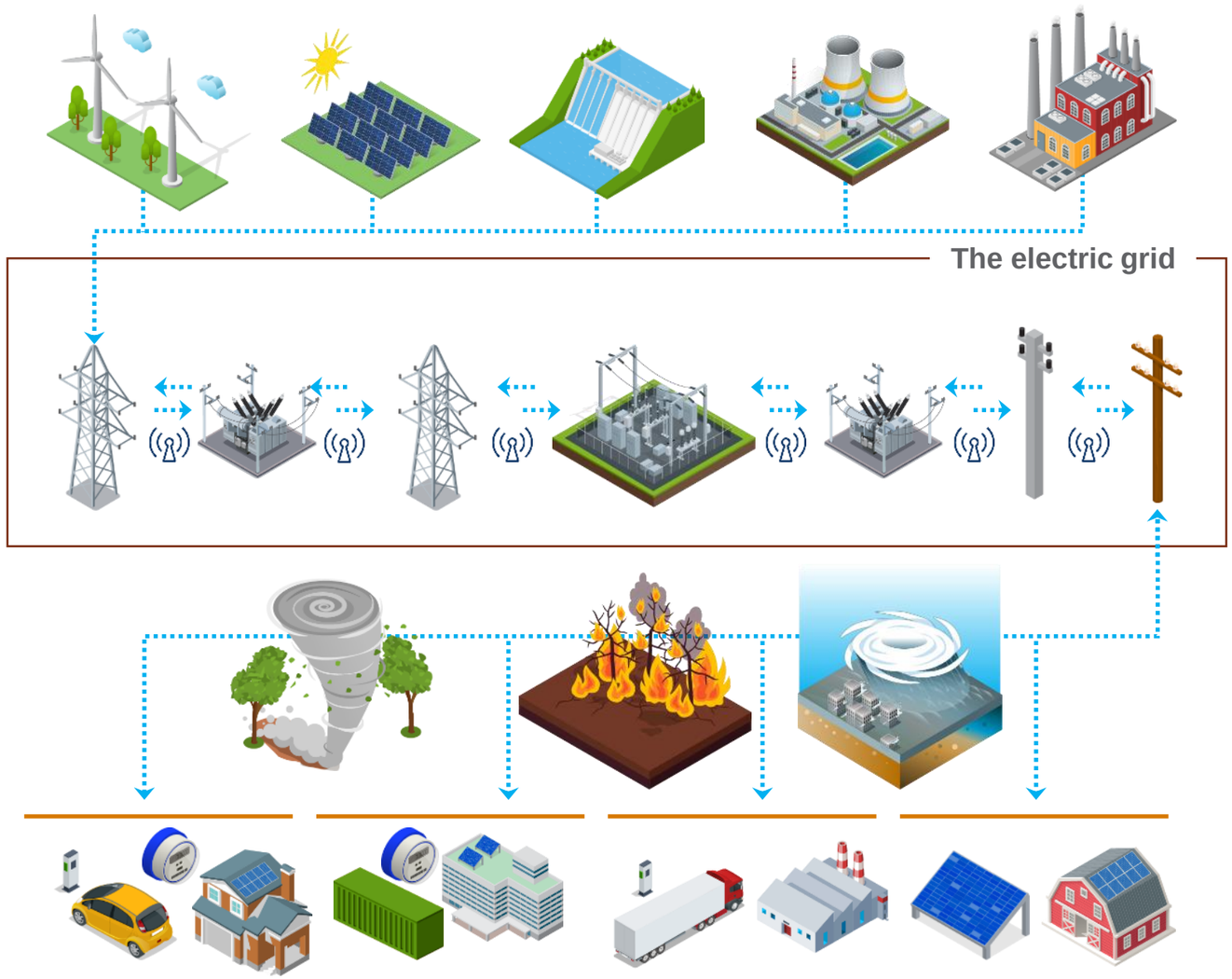
U.S. DEPARTMENT OF ENERGY | Office of ELECTRICITY

EMT Simulation

Ali Ghassemian Ph.D., EE. – Program Manager, Office of Electricity, Department of Energy



More Complex, Dynamic, and Uncertain Than Ever Before



- Utilizes renewable resources with increased variability and quicker response times
- Integrates millions of customer-owned resources that can provide power back to the grid
- Exploits better sensors, meters, and computational power to analyze more data with autonomous, decentralized control
- Faces threats posed by climate change, including more extreme weather events and natural disasters

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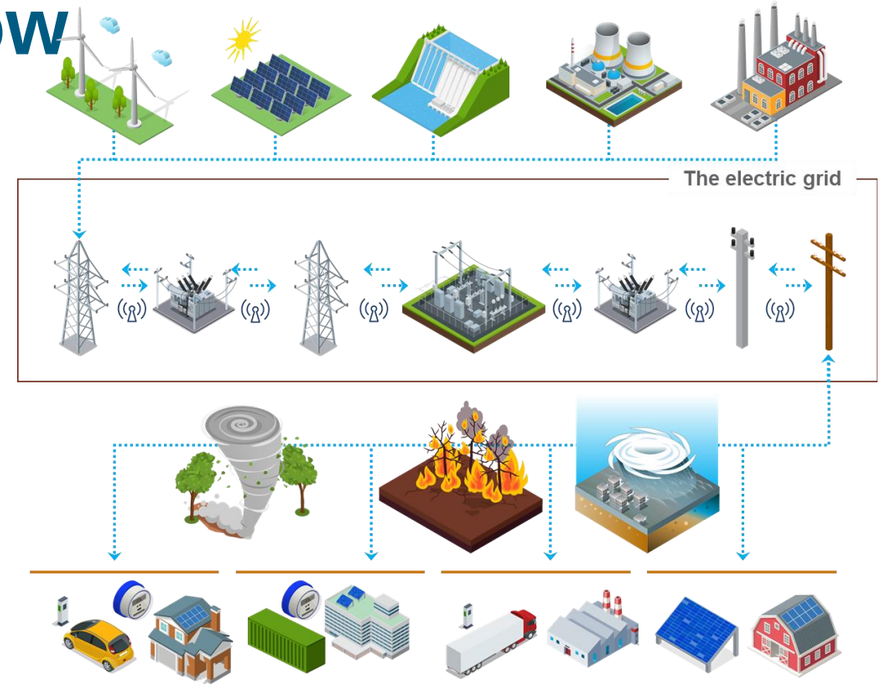
Challenges We Face Today and Tomorrow

- Managing variability and uncertainty
- Taking advantage of distributed energy resources
- Adopting more energy efficient technologies
- Adjusting to dynamic economic conditions
- Broadening electrification
- Accommodating new technologies and techniques
- Planning for zero emission and decarbonization
- Delivering equity and energy justice
- Increasing reliability, resiliency, and security



Better Understanding + Robust Solutions → **Our Path Forward**

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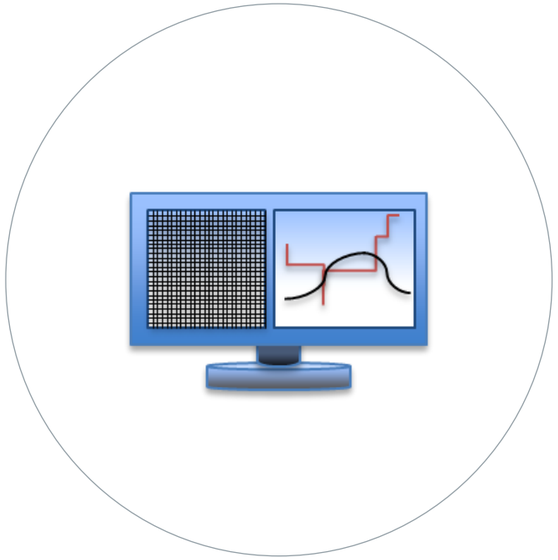
Advanced Grid Modeling

The AGM program support the tasks of *a better understanding of the issues* and *robust solutions* that prepares a path forward to a new set of tools for operators to deal with today's complex electric power system.

Successful research in this area would enable grid operators to optimize their decision-making in real-time giving the industry a sophisticated tool to dramatically improve reliability, resiliency, and grid security.



The Need for EMT

- More Inverter Based Resources (IBRs) like wind and solar generators and battery energy storage are added into the system
- How IBRs operate during an outage? Simulations conducted by ORNL shows that during a fault a response from IBR using the existing simulating tools shows a far less dip in power comparing to when EMT simulation is used (S. Debnath *et al*., "EMT Simulation of Large PV Plant & Power Grid for Disturbance Analysis," *2023 IEEE PES Innovative Smart Grid Technologies Latin America (ISGT-LA)*, San Juan, PR, USA, 2023, pp. 345-349).
- The EMT study use models of equipment and controls to identify interactions between grid components and check that they will work correctly with each other to maintain a reliable, resilient, secure, and efficient grid.
- EMT studies are needed because it captures the fast-changing dynamic which is a characteristic of the IBRs to do a simulation to see how system with many IBRs behave when there is fault
- NERC identified the use of EMT simulations and associated modeling approaches to be an enabler in planning a reliable power grid with significant penetration of power electronics (NERC, “Reliability Guideline Electromagnetic Transient Modeling for BPS-Connected Inverter-Based Resources— Recommended Model Requirements and Verification Practices”, 2023.)

What We Know

- EMT studies are complicated and difficult to perform than traditional studies.
- Gap analysis performed on needs for power grid dominated by inverters shows that 1) EMT simulations are slow, 2) EMT simulations are not scalable
- It is one of the most underdeveloped areas in the electrical power system. The algorithm behind the existing EMT simulation tools has been developed in 60s.
- It is one of the most important areas in the future of the electric power system as more and more IBRs are added into the system and there will be a great deal of interest in conducting EMT studies at an interconnection level which the today's technology is not capable of.
- As a results there is a need for a collaborative plan to address the EMT study issue

Government Role to Spur Advanced Grid Modeling

DOE tackles challenges that private industry is either not financially motivated or doesn't have the expertise to solve to pursue breakthroughs in grid modeling research that will create pathways to the new energy future through:

Convening	**Create new relationships with grid operators, academia, and advanced computing experts to turn complex data analytics into actionable business value**
Catalyzing	**Assess and disseminate successful and innovative modeling solutions throughout the highly fractured electricity industry**
Capacity Building	**Support partnerships with, and between, academic institutions and utilities to create opportunities to build out mathematical capabilities within grid operations**

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DOE Role

- The objective of Office of Electricity (OE) at DOE is to ensure that the gird of the future is reliable, resilient, secure, and efficient.
- OE is supporting the R,D&D projects in the area of EMT study. The goal is to get a better understanding of the gaps, the challenges, and the opportunities, and to set a path forward.
- OE is working with other DOE offices, National Labs, industry partners, and academia to work on enhancing the EMT studies and fill the identified gaps in simulations tools, modeling approaches, Validation, Standards, & Applications.
- The intent will be to simplify the process and make it easier to conduct accurate EMT study on a large system with many IBRs

Some of the On-Going Activities

- Supporting projects that identifies the gaps and need for enhancement
- Working with ORNL, NERC, and DOE-EERE to conduct a EMT workshop that included academia, national labs, industry, and federal government agencies. The goal to build a community around this topic that can help DOE with its investment in this area.
  - 1st workshop took place in August 2023 with a number of recommendations.

Efficient Large-Scale Electromagnetic Transient Simulations Project

- As part of this project the project team will:

1. Identify and document key mathematical and computational challenges in parallel EMT simulations,
2. Deliver effective and accurate modeling strategy for IBRs,
3. Develop novel scalable and portable numerical methods for EMT simulations, and
4. Produce user friendly tools with a graphical user interface that provide easy access to the new capability for domain experts.
5. Identify and document key mathematical and computational challenges in simulations that limit the ability to investigate aggregate effects of adding a large number of renewable inverter-based resources (IBRs) to the grid.

Recommendation Summary (Courtesy of ORNL)

- Make EMT simulations 100x faster (final goal: 1,000x faster or close to the time taken in transient stability phasor-domain).
- Scale EMT simulations by 1,000x (final goal: 1,000,000 3-phase nodes, 100 million inverters/power electronics).
- Change is needed in how reliability is analyzed during planning and interconnection studies.
- Standards are needed for models and validation.
- Annual workshops need to be organized with industry and research working groups.
- ***Form a partnership with industry, academia, and national laboratories to tackle this national-scale extremely challenging problem.***

What is Next?


Thank you.