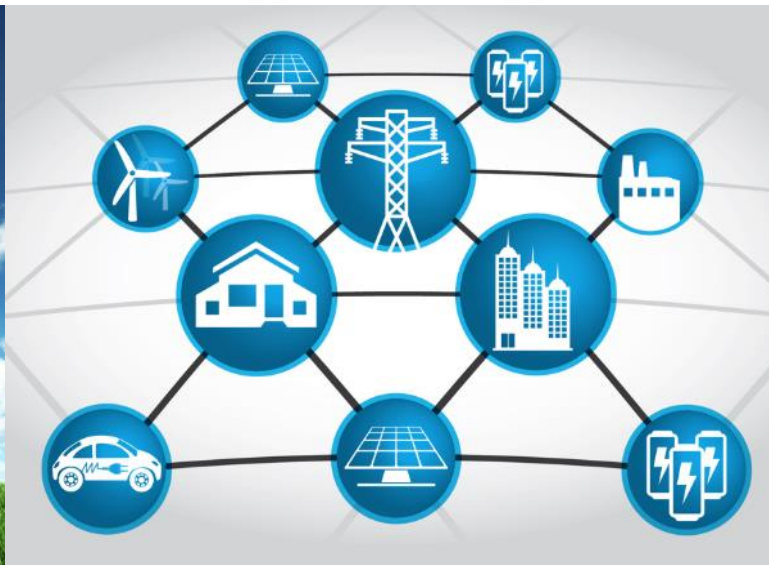


Interconnected – Highly Utilized Grid: New Operation Paradigms

Program Director: Dr. Sonja Glavaski

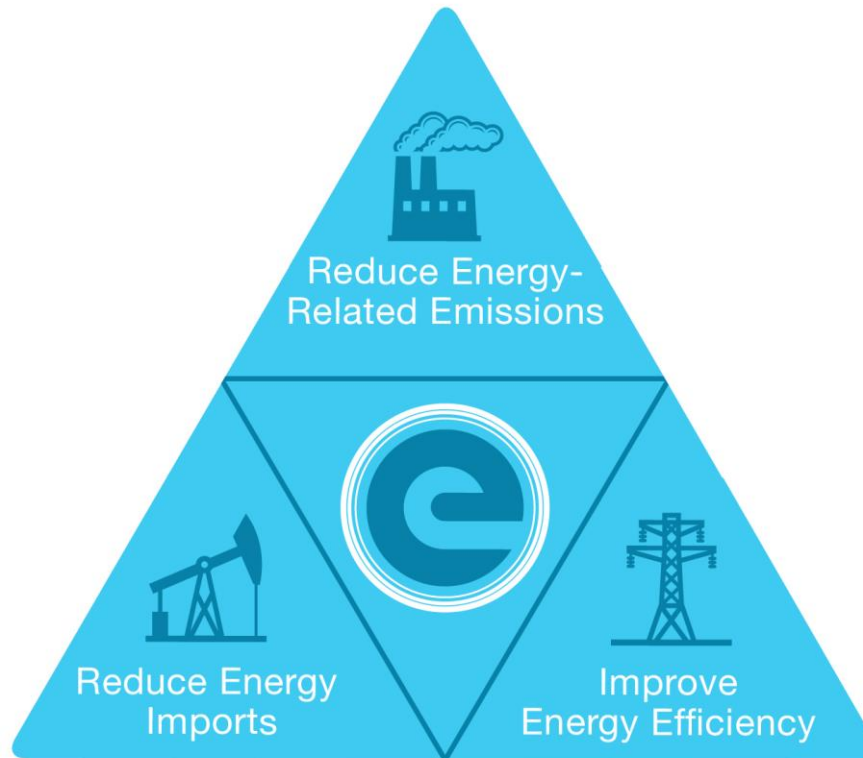


Outline

- ▶ **US Grid is Changing**
- ▶ Grid & Renewables
- ▶ What's Next
- ▶ Workshop Objectives & Agenda

ARPA-E Mission

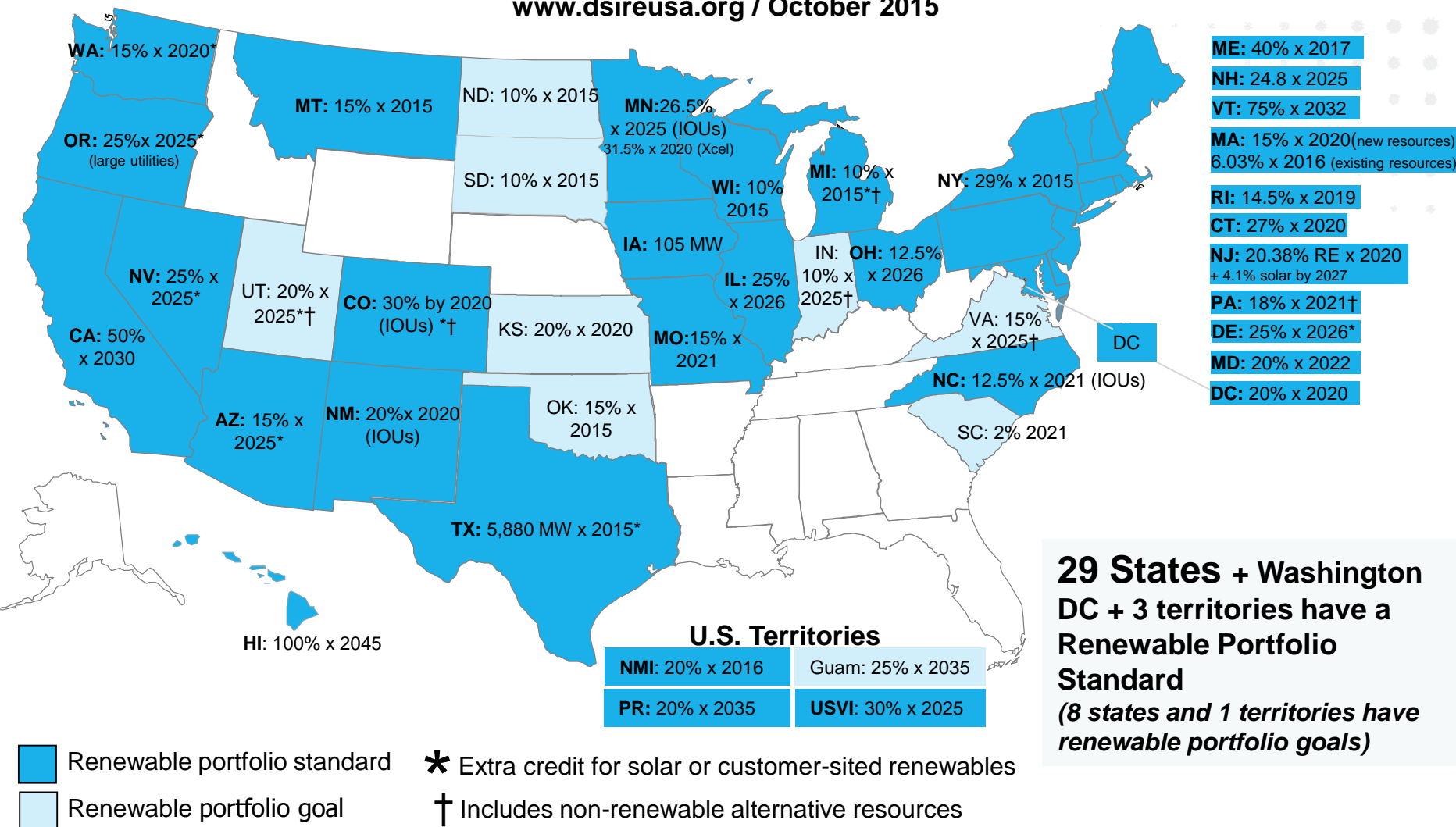
Catalyze the development of transformational, high-impact energy technologies



Ensure the U.S. maintains a lead in the development and deployment of advanced technologies

US Consumers Want Renewables!

www.dsireusa.org / October 2015



29 States + Washington DC + 3 territories have a Renewable Portfolio Standard
(8 states and 1 territories have renewable portfolio goals)

Corporate Sourcing of Renewables Campaign

1,000 world's most influential businesses 100% powered by renewables

- Decarbonize 10% of all electricity used worldwide
- Cut more than 1,000 Mt of CO₂ per year



Enable corporate purchasing of renewable energy
Further unlock corporate renewable energy demand



Provide funding to Renewable Energy Buyers Alliance
Develop green tariffs
50% renewable sources by 2018



Power data centers with at least 50% renewables by 2018
60% renewables early next decade
Maintain 100% carbon neutrality



Encourage procurement of renewable energy
Install more than 4GW of renewables worldwide by 2020

Outline

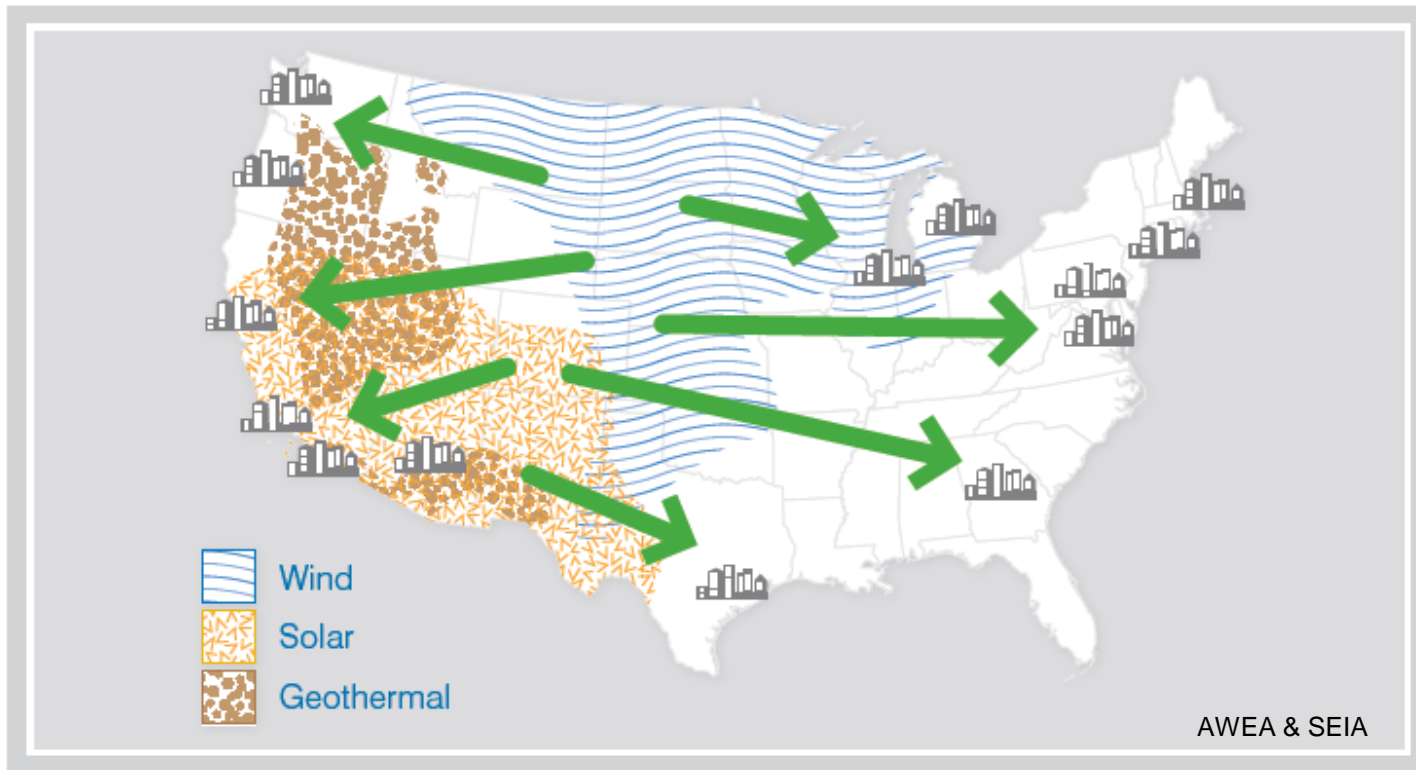
- ▶ US Grid is Changing
- ▶ **Grid & Renewables**
- ▶ What's Next?
- ▶ Workshop Objectives & Agenda

Grid of the Future: Nationwide Green Power Super Highway

“ Like the Internet, the modern electricity grid serves as the backbone upon which a generation of technologies, services, and economies will be built.”

“Five Principles for Tomorrow’s Electricity Sector”,
Jenny Hu, Shayle Kann, James Tong & Jon Wellinghoff

FIGURE 1: **Nationwide Green Power Superhighways: A Conceptual Vision**



Features of the Grid of the Future



Long Term Objectives



Maximize utilization of T&D infrastructure



Maximize deployment of renewables and DERs



Minimize investments into building new T&D power lines

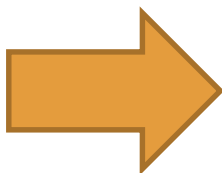
Outline

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Challenges with Renewables Grid Integration



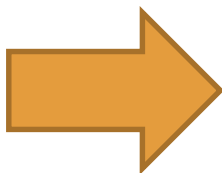
Dispatched generation



Intermittent DG



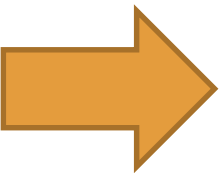
Predictable load



Variable Net-Load



Capacity available



Capacity constrained



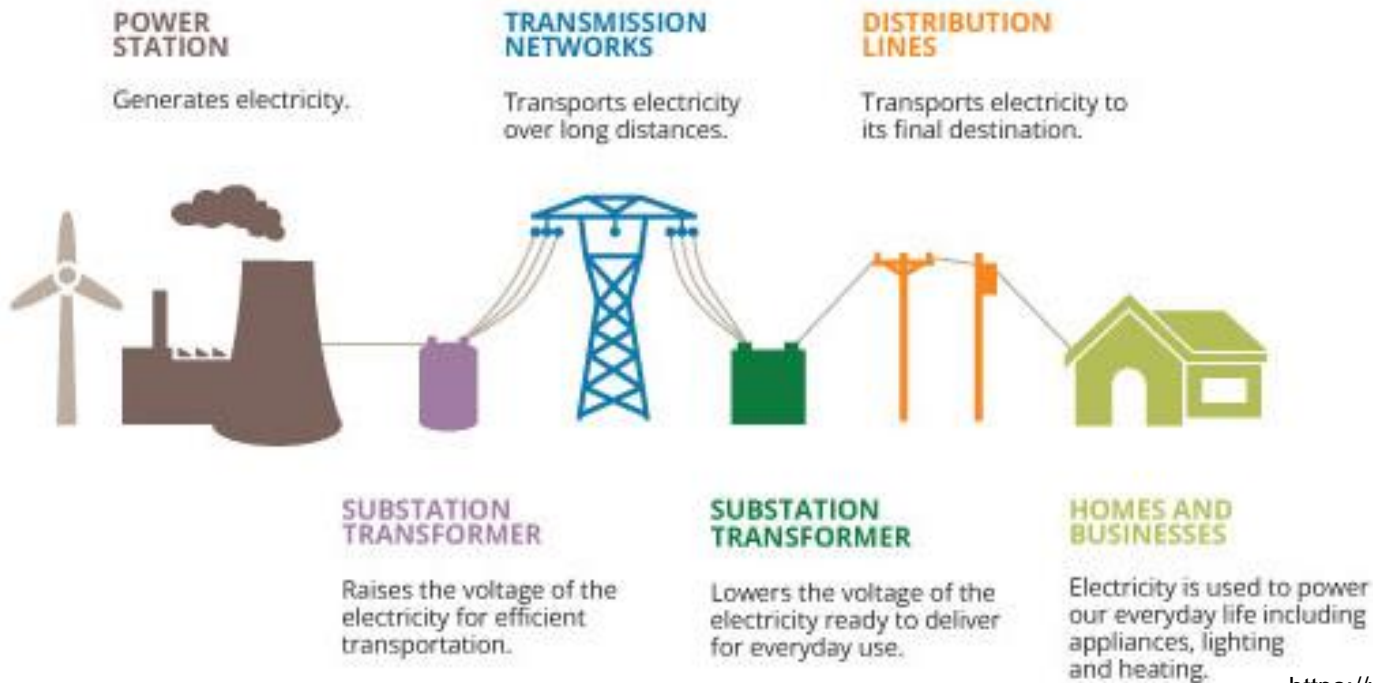
Renewables penetration is limited (< 30%) because of lack of capability to reliably and affordably manage its variability



**With high grid infrastructure utilization
>50% renewable integration is possible.**

Grid Utilization

- ▶ How can we improve grid infrastructure utilization?
 - Would a more interconnected US grid help with utilization?
 - Would tight integration of Transmission & Distribution help with utilization?



<https://www.originenergy.com.au>

Road to Grid with >50% Renewables

Optimize the grid's "Backbone" and "Edge" to enable large scale (>50%) deployment of renewables and DERs

BACKBONE

Optimize transmission capacity and effectively dispatch renewables over long distances and across balancing areas to better leverage spatio-temporal diversity in variable generation and loads

EDGE

Effectively integrate Transmission and Distribution to enable greater utilization of DERs and DG

Optimizing Grid 'Backbone'- Transmission Capacity

Simulation

- Do we have sufficient data to simulate the US grid?
- Do we have tools that can simulate the US grid for planning and operation purposes?

Planning & Operation

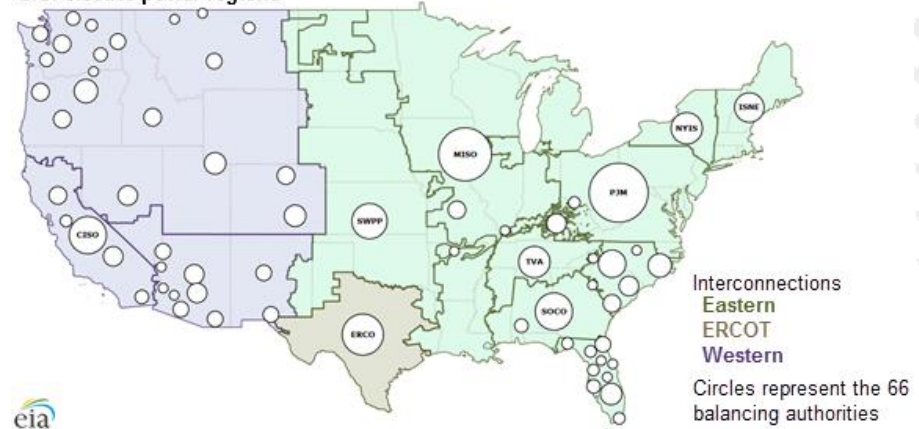
- What planning tools are needed for optimal location & sizing of new grid assets (DERs, storage, T&D assets)
- What operation tools are needed for reliable operation of an interconnected grid?

Grid Interconnections

▶ Plan Interconnected Grid

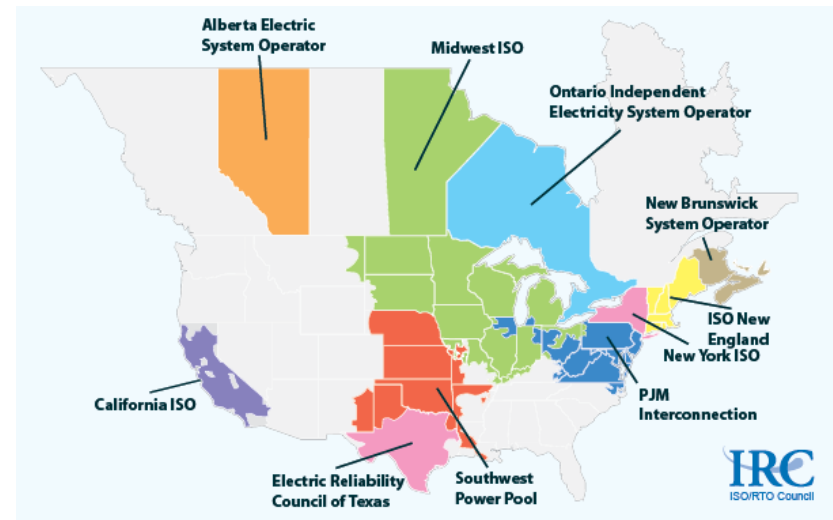
- Simulate the entire grid
- Correlate wind/solar generation & consumer demand patterns across the regions and “balancing” areas
- Optimize location and sizing of new grid assets (power lines, generation, storage, ...)

U.S. electric power regions



▶ Operate Interconnected Grid

- Monitor transmission power lines and equipment utilization
- Dynamically change transmission power lines and equipment ratings
- Move large amounts of renewable power across long distances
- Coordinate regional operations



Optimizing Grid “Edge” – T&D Integration

Simulation

- Do we have sufficient data to simulate T&D jointly?
- Do we have tools that can jointly simulate T&D for planning and operation purposes?

Planning & Operation

- What tools are needed for joint planning of T&D?
- What tools are needed to monitor & operate T&D jointly?

Integrate the Grid Edge

▶ Plan T&D jointly

- Incorporate local resources into broader area analysis
- Determine optimal location and sizing of DERs
- Account for flexible net-load shapes over different time scales

▶ Operate T&D jointly

- Dispatch distributed generation in coordination with bulk generation
- Coordinate flexible loads & DERs with bulk generation & storage
- Coordinate consumers & power generation



Cost & Benefits

Interconnection

- What are the costs and benefits of having an interconnected US grid?
- How will grid stakeholders change business models?

T&D Integration

- What are the costs & benefits of having integrated T&D?
- How will joint T&D operation affect wholesale markets?

Business Models are Changing!

- ▶ DER providers to participate in CA-ISOs' wholesale markets
- ▶ Utilities shifting from “rates of return” on capital toward new performance-based and network-driven incentive models
- ▶ **Utility as a platform that delivers services**
 - Reflect grid usage in billing structure
 - PJM and ISO-NE raise prices in capacity markets
 - Net metering replacement tariff (NY)
 - Develop locational & performance-based services by DER
 - Large coal and nuclear plants retiring prematurely



Outline

- ▶ US Grid is Changing
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- ▶ **Workshop Objectives & Agenda**

Agenda: Day 1



9:30 AM – 9:50 AM

Guest speaker

Dr. Jovan Bebic, GE

9:50 AM – 10:10 AM

Guest speaker

Dr. Paul Denholm, NREL

10:10 AM – 10:40 AM

Coffee Break

10:40 AM – 11:00 AM

Guest speaker

Dale Osborn, MISO

11:00 AM – 11:20 AM

Guest speaker

Dr. Santiago Grijalva, Georgia Institute of Technology

11:20 AM – 11:30 AM

Breakout Sessions Overview

Dr. Sonja Glavaski, ARPA-E

11:30 AM – 12:30 PM

Lunch

12:30 PM – 2:30 PM

Breakout Session: Optimizing Grid “Backbone”

Breakout Rooms: Cabinet/Judiciary, Diplomat/Ambassador, Congressional, Old Georgetown

2:30 PM – 3:00 PM

Break

3:00 PM – 4:30 PM

Breakout Session: Business Models & Markets

Breakout Rooms: Cabinet/Judiciary, Diplomat/Ambassador, Congressional, Old Georgetown

4:30 PM – 5:00 PM

Day 1 Wrap-Up & Plans for Next Day’s Sessions

Dr. Sonja Glavaski, ARPA-E

Agenda: Day 2



- 9:00 AM – 9:15 AM Day 2 Welcome & Recap of Previous Day
Dr. Sonja Glavaski, ARPA-E
- 9:15 AM – 9:35 AM **Guest speaker**
Robert Sherick, Southern California Edison
- 9:35 AM – 9:55 AM **Guest speaker**
Ryan Hanley, Solar City
- 9:55 AM – 10:10 AM **Breakout Session Overview**
Dr. Sonja Glavaski, ARPA-E
- 10:10 AM – 10:30 AM Break
- 10:30 AM – 12:30 PM **Breakout Session: Optimizing Grid “Edge”**
Breakout Rooms: Cabinet/Judiciary, Diplomat/Ambassador, Congressional, Old Georgetown
- 12:30 PM – 1:00 PM Lunch
- 1:00 PM – 2:00 PM Wrap-up Discussion and Closing Remarks
Dr. Sonja Glavaski, ARPA-E



Q&A

Dr. Sonja Glavaski

Program Director

Advanced Research Projects Agency – Energy (ARPA-E)
U.S. Department of Energy

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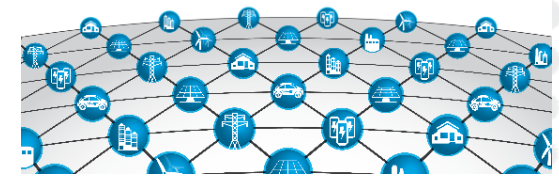


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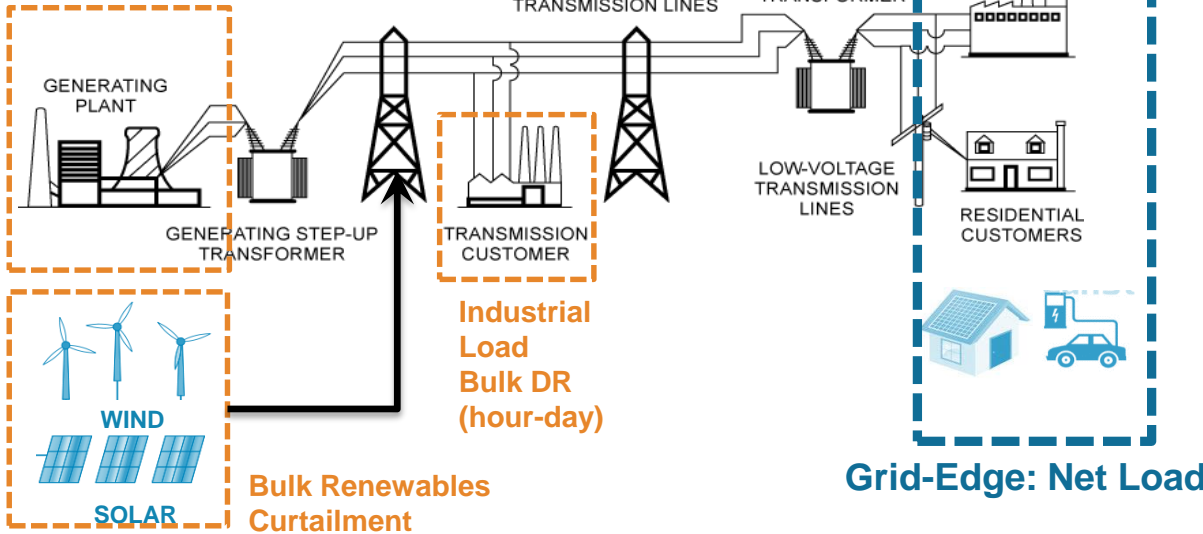
Network Optimized Distributed Energy Systems



What do we want to control?

Bulk Generation

Dispatch, Set-points & Inertia



Mission

Reliably manage dynamic changes in the grid by leveraging flexible load and DERs' capability to provide ancillary services to the electric grid at different time scales.

Goals

- Enable renewables penetration at > 50%
- Improve overall grid efficiency and reliability
- Reduce CO₂ emissions (renewables↑, reserves↓)
- Increase penetration of DG

Project Categories	Response Time	Ramp Time	Duration
C1: Synthetic Frequency Reserves	< 2 sec	< 8 sec	> 30 sec
C2: Synthetic Regulating Reserves	< 5 sec	< 5 min	> 30 min
C3: Synthetic Ramping Reserves	< 10 min	< 30 min	> 3 hr

U.S. Energy Industry is Changing!

- ▶ **California leading renewables energy sector and integration of Distributed Energy resources (DER) – 50% renewables by 2030**
- ▶ **NY Reforming the Energy Vision (REV) to increase renewables & DERs - Cut New York GHG emissions 40% by 2030**
- ▶ **Hawaii planning to use only renewable power within the next 30 years**
- ▶ **Vermont to source 75% of its energy from green sources within 17 years**

