

# Power and Energy Systems Program at the US National Science Foundation (NSF)

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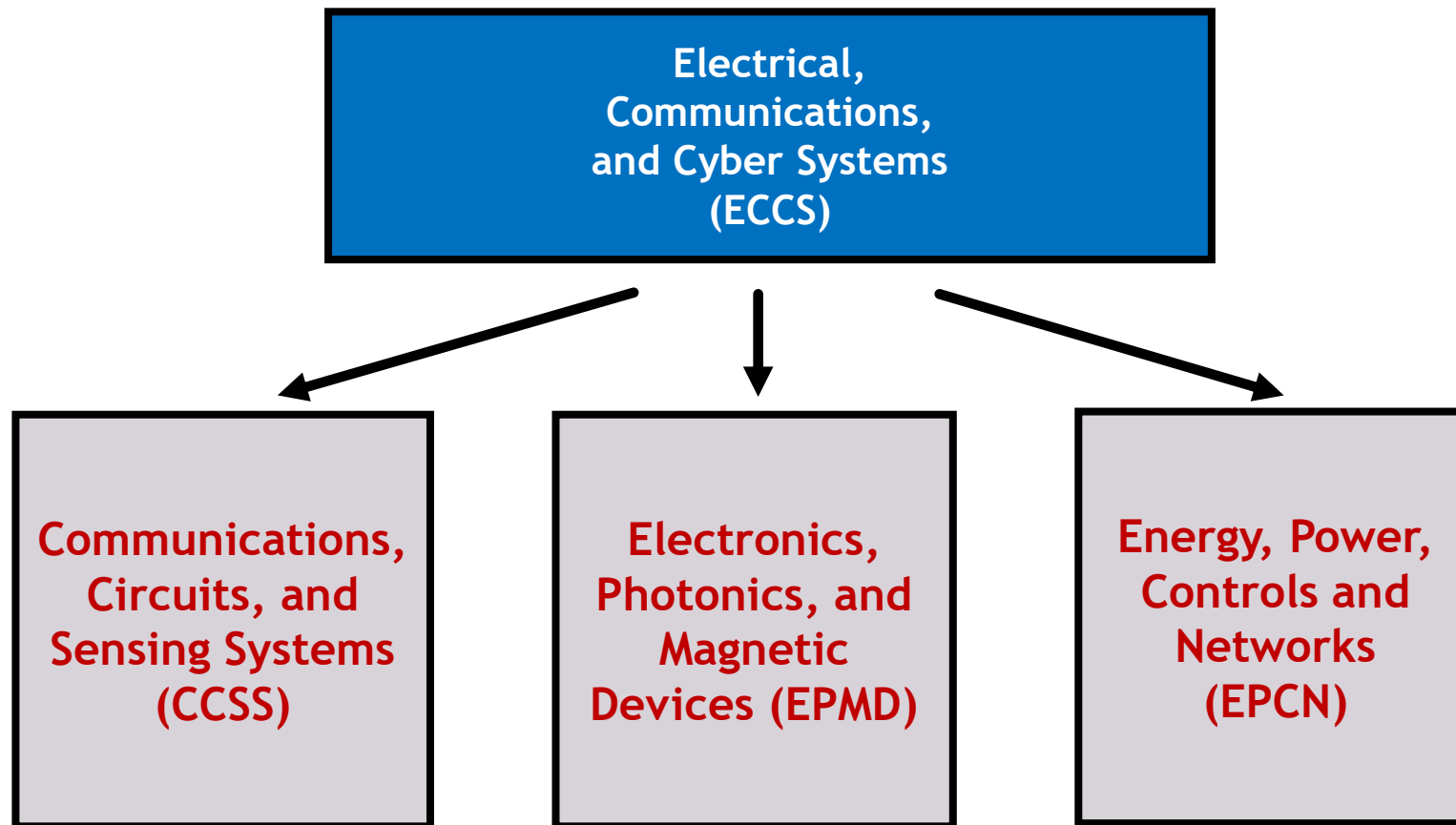
EPCN Program Directors

Energy, Power, Control and Networks (EPCN) Program  
Electrical, Communications and Cyber Systems Division  
Engineering Directorate, National Science Foundation

ECEDHA Annual Meeting Workshop  
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# Electrical, Communications and Cyber Systems (ECCS) Division

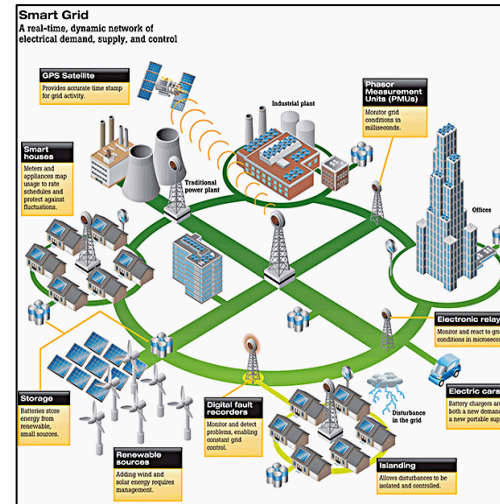
## Research Clusters



# EPCN (Energy, Power, Control and Networks) Program Role and Priorities

## Control System Thrust

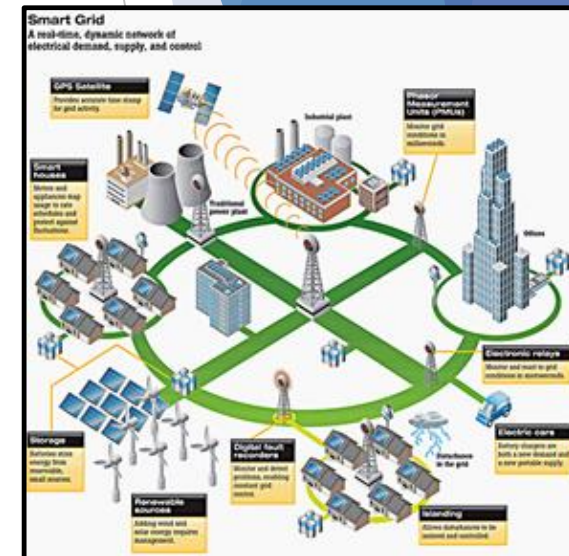
- Robust, Optimal, Nonlinear, Adaptive Control
- Data-Driven Control
- RL/DL in Control
- Massive data sets, real-time decisions
- Network control systems
- Reliability, safety, cybersecurity, and usability
- Applications in robotics, transportation, smart grids, smart buildings, multi-agent networks, machine learning



# Next-Generation Power Systems

- ▶ Distributed energy resources (DERs)
- ▶ Control of inverter-dominated power grids
- ▶ Electrified transportation
- ▶ Resilience against hurricanes and wildfires
- ▶ Changing demand profiles and consumer expectations
- ▶ Extensive deployment of sensing, communications and information technologies
- ▶ Real-time decision-making based on massive data
- ▶ Cyber-security of power grid
- ▶ Integration of power electronics for power system operations

Relevant to  
Climate  
Change





# Power Electronics and Energy Conversion

**Advanced Power Electronics and Electric Machines**

**Electric and Hybrid Electric Vehicles**

**Energy Harvesting and Storage Systems**

**Renewable Energy Conversion Systems**

**Innovative Grid-tied Power Electronic Converters**

**Wide Band Gap Power Electronics and Motor Drives**



# Machine Learning and Data Science Cluster

- ▶ **Learning and Adaptive Systems**
- ▶ Neural Networks
- ▶ Neuromorphic Engineering Systems
- ▶ Data analytics and Intelligent Systems
- ▶ Machine Learning hardware
- ▶ Machine Learning Algorithms, Analysis and Applications
- ▶ Human-machine interaction



# Recently Funded Projects in Power Systems



## Some recently funded NSF CAREER projects:

CAREER: Enabling grid-aware aggregation and real-time control of distributed energy resources in electric power distribution systems  
*University of Vermont, 2021*

CAREER: Beyond Low-Inertia Systems - Grid-Forming Control Foundations for Converter-Dominated Power Systems  
*University of Wisconsin Madison, 2022*

CAREER: Learning-Assisted Optimal Power Flow with Confidence  
*University of Colorado Boulder, 2021*





# Recently Funded Projects in Power Systems



From FY20 through the present ECCS has funded approximately **102 awards in power systems at a total of \$37M, with a median award size of \$360K**





# Recently Funded Projects in Power Electronics

## Some recently funded NSF CAREER projects:

CAREER: Power Magnetics for MHz Frequencies  
*Univ of Texas Austin, 2022*

CAREER: Universal SiC-Based Power Converters for Renewable Energy Systems, *Northeastern University, 2021*

CAREER: Toward a wireless power transfer system: high-frequency power electronics, *University of Minnesota-Twin Cities, 2021*



# Recently Funded Projects in Power Electronics



From FY20 through the present ECCS has funded approximately **48 awards in power electronics at a total of \$18M, with a median award size of \$380K.**



# Cyber-Physical Systems (CPS)

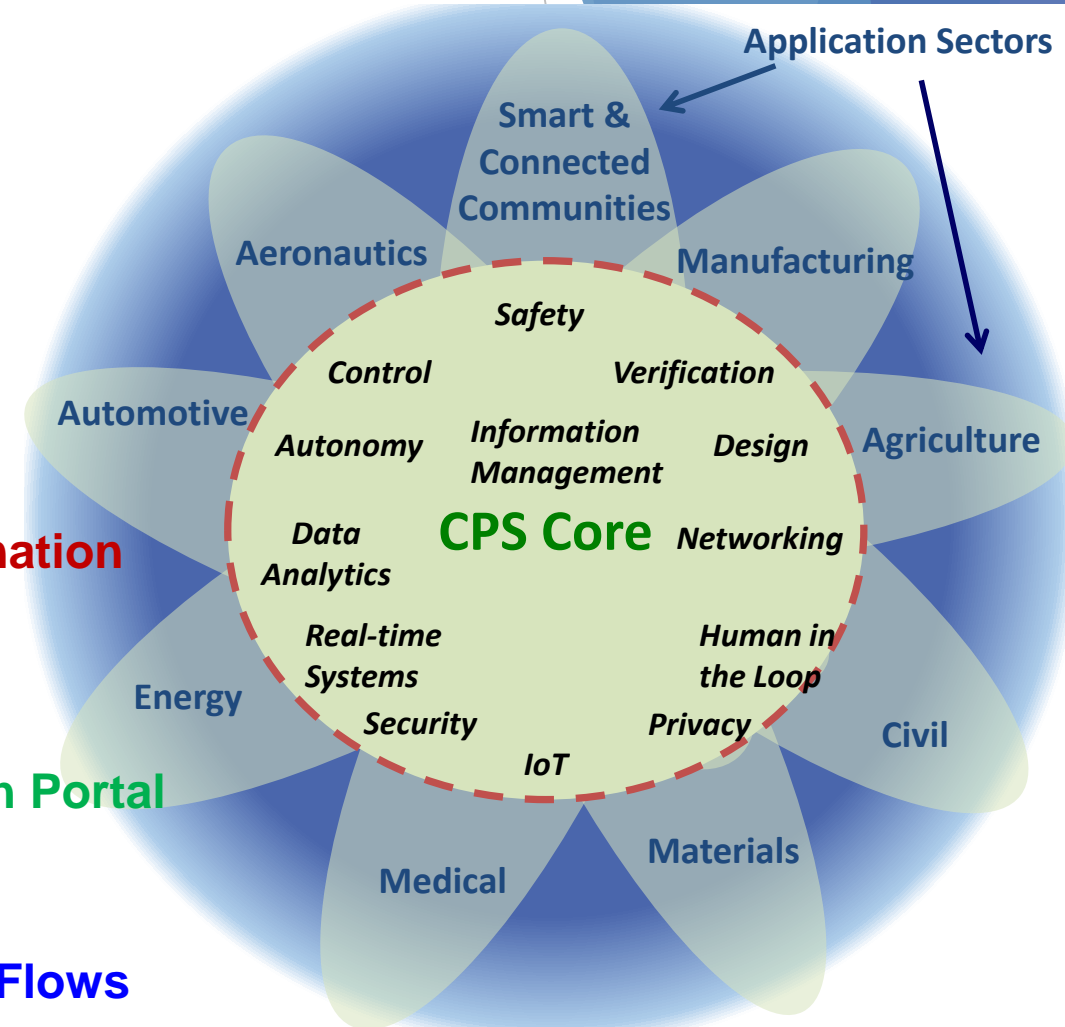
- ▶ Develop the core system science needed to engineer complex cyber-physical systems upon which people can depend with high confidence

Recently funded CPS projects in Energy Systems:

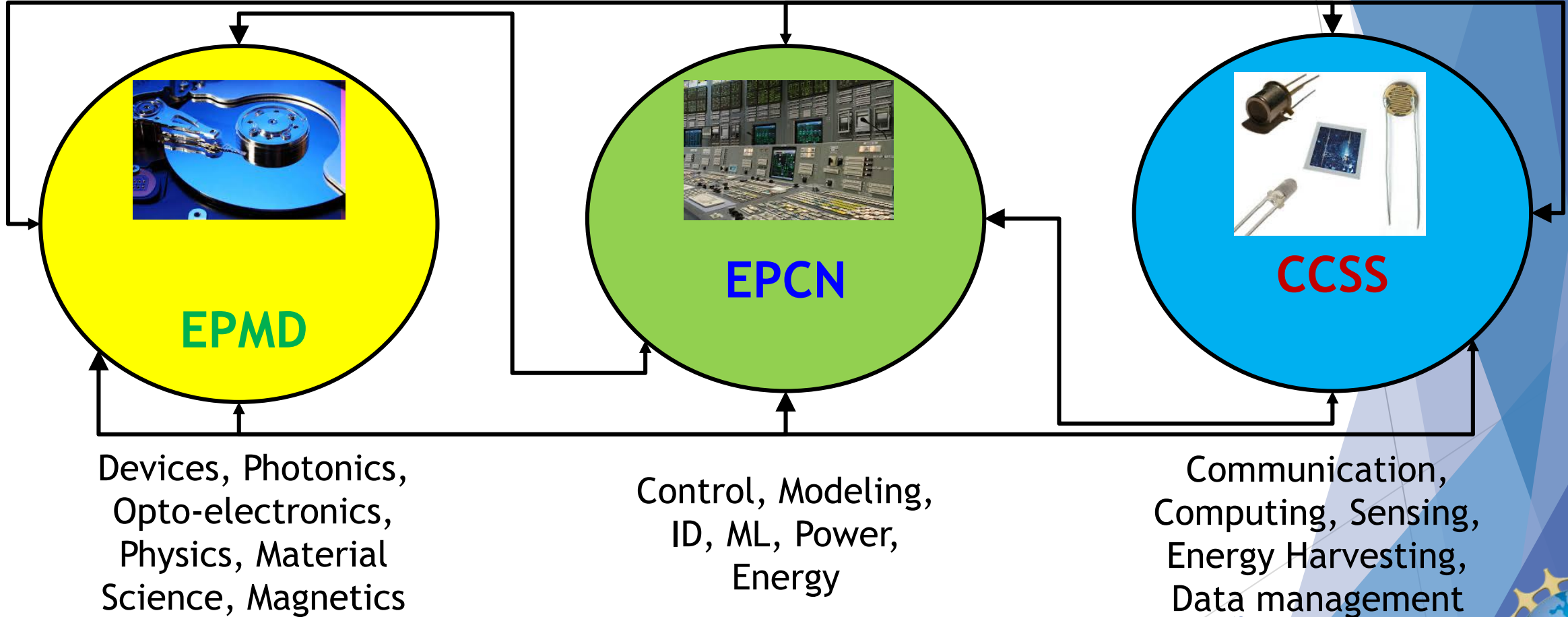
**CPS: Adaptive, Human-centric Demand-side Flexibility Coordination at-scale in Electric Power Networks**  
*Washington State Univ, 2022*

**CPS: TTP Option: Small: Adaptive Charging Network Research Portal**  
*Caltech, 2019*

**CPS: Enabling DER Integration via Redesign of Information Flows**  
*Johns Hopkins University, 2021*



# Addressing Systems Challenges through Engineering Teams (ASCENT)



FY23 Focus Area: “Climate Change Solutions”





## CAS: Climate DCL

- Efficient and massive-scale integration of DERs
- Risk modeling and risk analytics,
- Collaboration between climate science, ML and power systems for better forecasting and decision-making.
- Resilience against hurricanes and wildfires
- Integration of EVs, new control architectures
- Energy equity, economics

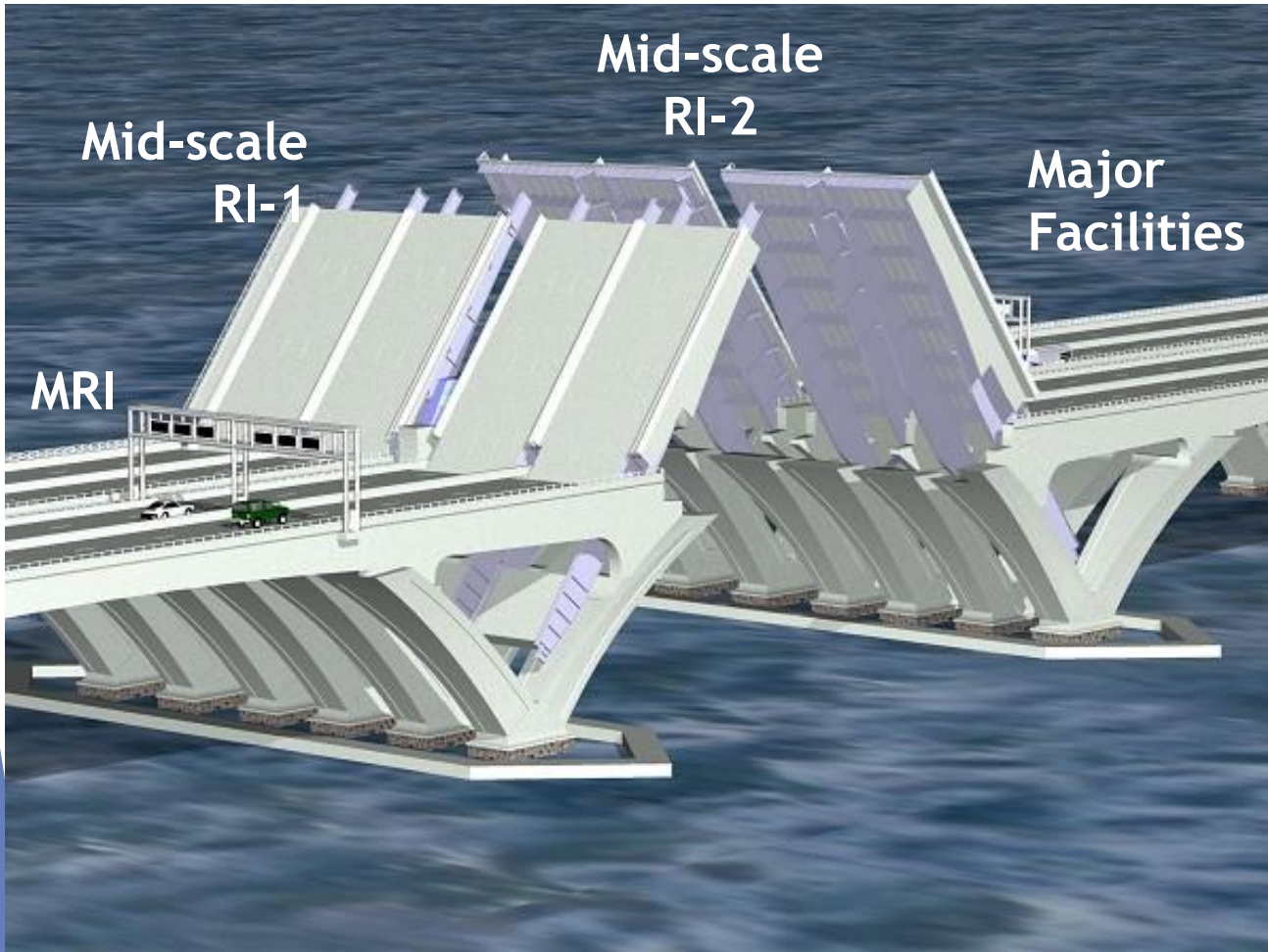


## Sustainable Regional Systems (SRS)

- **Prediction:** Unable to accurately frame and model urban sociotechnical futures and how to improve them
- **Coordination:** Limited understanding on how different actors can effectively coordinate to build and maintain SUS.



# Midscale Research Infrastructure 1 & 2



- **Midscale-2** award to UC San Diego on Microgrid Infrastructure Development (DER-Connect)
- **Midscale-1** award to U Arkansas for SiC testing

- Facilities that fall between Major Research Instrumentation (MRI) program and the Major Multi-user Facilities range.
- NSF needed a new agile process for funding experimental research capabilities in the mid-scale range.
  - Mid-scale RI-1: \$4 - <\$20 M
  - Mid-scale RI-2: \$20 - \$100 M

UC San Diego News Center

thisweek@ucsandiego

By Ioana Patringeraru

Oct 29, 2020

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## \$39 Million Grant to Better Integrate Renewables into Power Grid

The National Science Foundation has awarded \$39 million to a team of engineers and computer scientists at the University of California San Diego to build a first-of-its-kind testbed to better understand how to integrate distributed energy sources such as solar panels, wind turbines, smart buildings and electric vehicle batteries into the power grid. The goal is to make the testbed available to outside research teams and industry by 2025.

# Question & Answer

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