



# Superior Energy Performance – Research and Development

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# NREL Scope

## Sustainable Transportation

Vehicle Technologies  
Hydrogen  
Biofuels

## Energy Productivity

Residential Buildings  
Commercial Buildings

## Renewable Electricity

Solar  
Wind  
Water: Marine Hydrokinetics  
Geothermal

## Systems Integration

Grid Integration of Clean Energy  
Distributed Energy Systems  
Batteries and Thermal Storage  
Energy Analysis

## Partners

Private Industry  
Federal Agencies  
State/Local Government  
International

# National Energy Imperatives



## Security

Ensuring  
resilient and  
reliable energy  
systems

## Economy

Stimulating  
clean-energy  
manufacturing

## Environment

Protecting  
resources and  
environmental  
quality

## Reducing Investment Risk

- Integrating technology at scale
- Enabling basic and applied clean energy technology innovation
- Accelerating technology market introduction and adoption
- Encouraging collaboration in unique research and testing partnering facilities
- Providing analysis and expertise to inform decisions and catalyze market adoption



# Wind Turbine Research

- Patented airfoil designs improved blade efficiency and simplified controls
- Drivetrain and blade testing improved turbine reliability and lowered costs
- Aerodynamic and structural models guided U.S. industry product development
- On-going research in reliability, efficiency, and controls for entire wind farms
- Developing offshore wind and water power technologies
- Dynamics testing analyze interactions with transmission grid
  - ~8 MW dynamometers
  - 7-MW controllable grid interface
  - ~10 MW wind turbines
  - Capable of utility-scale storage



WIND

# Sustainable Transportation

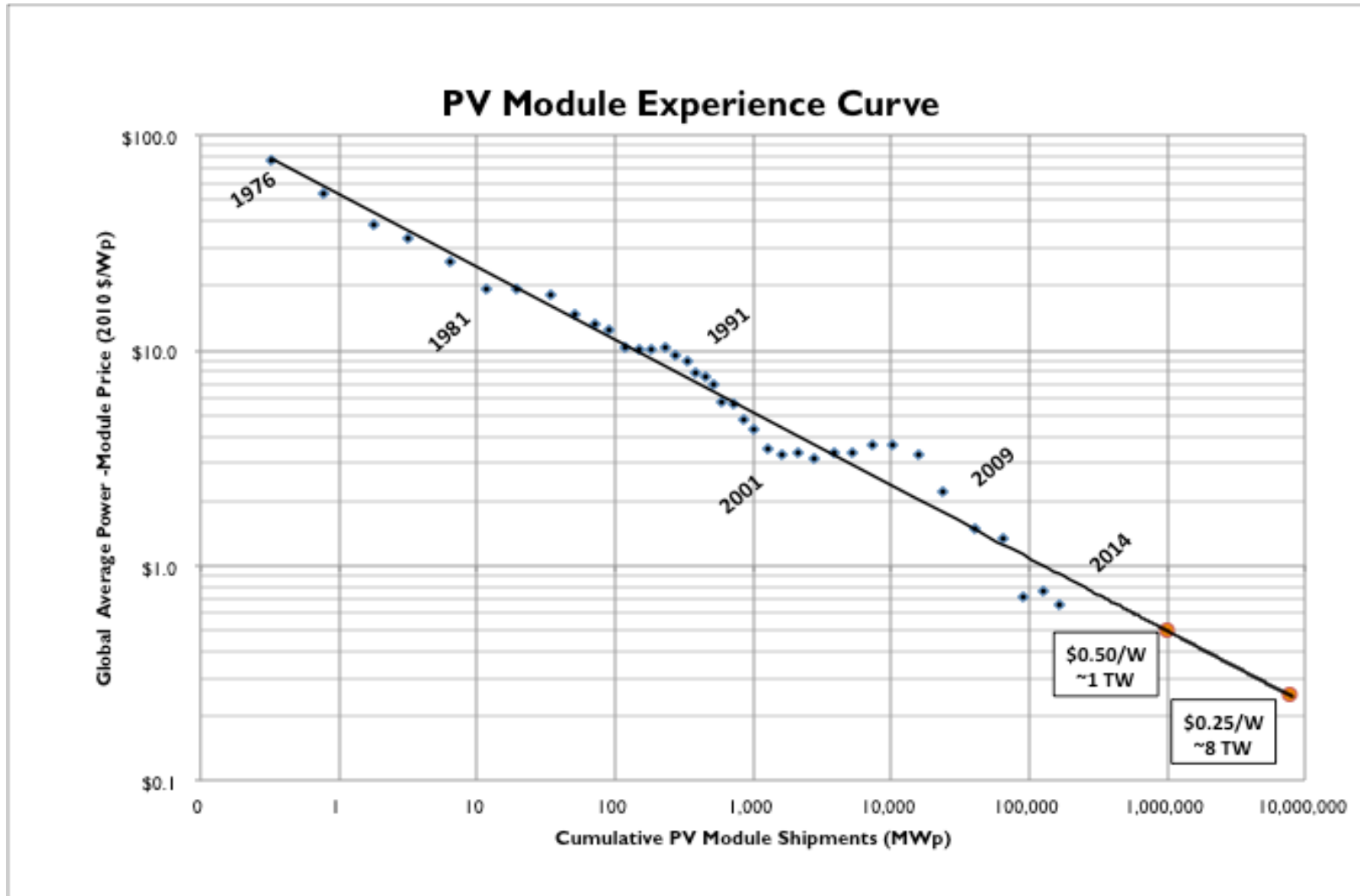
NREL's transportation R&D accelerates adoption of efficient vehicles and clean alternative fuels:

- Computer-aided engineering tools to design better electric vehicle batteries faster
- Platooned trucks that demonstrate ~6.4% fuel savings
- Recruitment of more than 200 businesses for the Workplace Charging Challenge
- Climate control configurations to reduce electric vehicle energy use by ~66.5%
- R&D 100 Award-winning calorimeters that provide the most accurate measurement of battery thermal performance



TRANSPORTATION

# Photovoltaic Strides



Sources: For 1999-2014: SPV Market Research, Photovoltaic Manufacturer Shipments: Capacity, Price & Revenues 2014/2015, Report SPV-Supply2. For 1984-1998: Navigant Consulting (2010), Photovoltaic Manufacturer Shipments, Capacity & Competitive Analysis 2009/2010, Report NPS-Supply5 (April 2010). For 1980-1984: Navigant Consulting (2006), Photovoltaic Manufacturer Shipments 2005/2006, Report NPS-Supply1 (August 2006). For 1976-1980: Strategies Unlimited (2003), Photovoltaic Manufacturer Shipments and Profiles, 2001-2003, Report SUMPM 53 (September 2003).

# Next-Generation PV Power

- Quantum-dot (QD)-based solar cells
  - QDs are nanoscale spheres of semiconducting material
  - QDs have the potential to dramatically increase cell efficiency
  - NREL built the first all-QD solar cell
- Plastic solar cells may incorporate QDs
- Perovskite solar cells have rocketed to high efficiencies during research

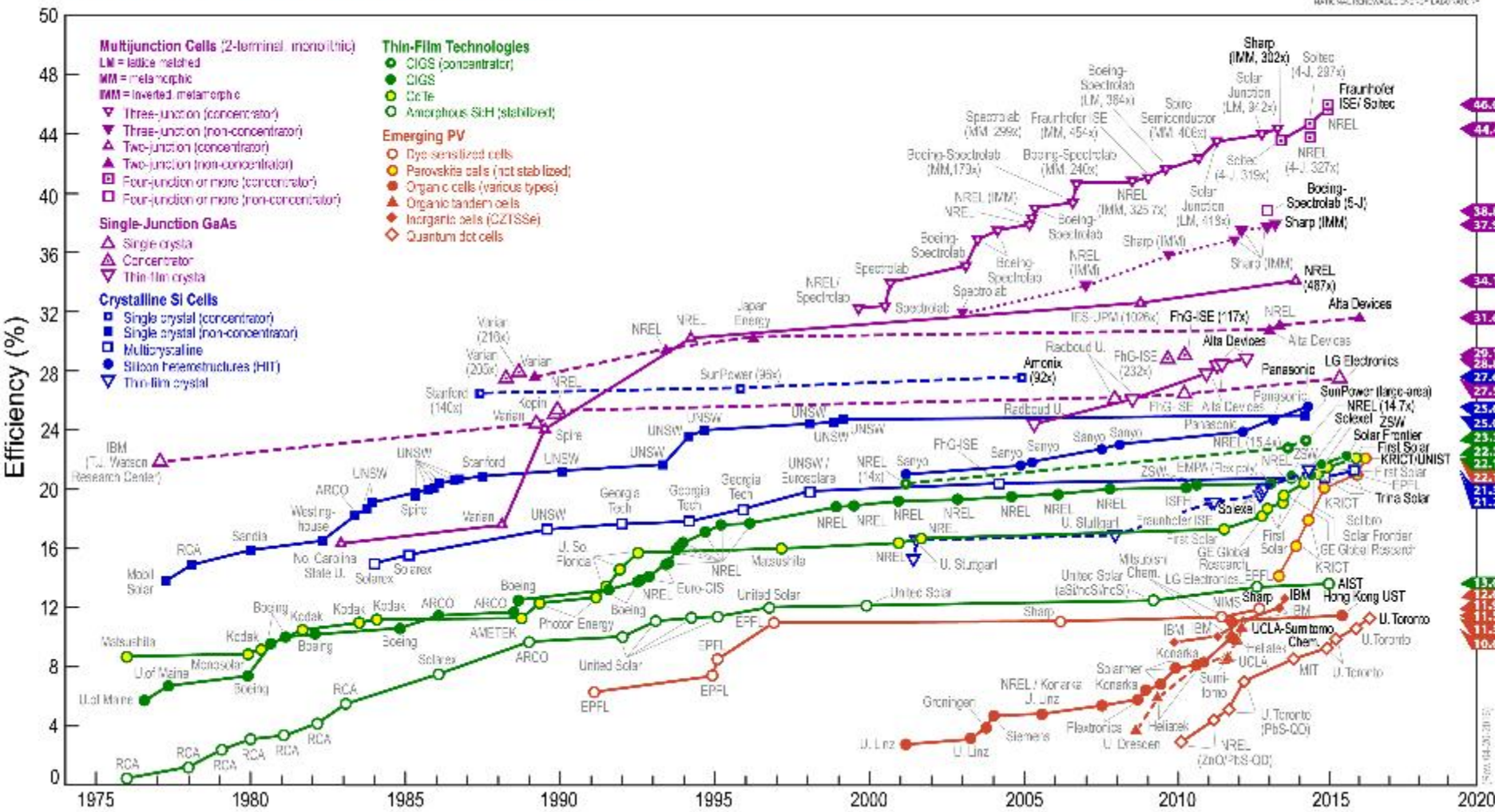


SOLAR



# Photovoltaic Strides

## Best Research-Cell Efficiencies



# Helping Solar Manufacturers

- U.S. market share slipped from 30% to about 2% (2000-2014) ---> manufacturers need to cut costs

## **Black Silicon**

- Developed a simple chemical etch that causes silicon to absorb more light and avoids expensive antireflection coatings

## **Quantum Efficiency**

- Devised a tool to measure detailed PV performance in less than a second; test every cell on a manufacturing line

## **Optical Cavity Furnace**

- Array of light with highly reflective chamber during processing to heat cells, leading to higher uniform temperatures

SOLAR

# Consolidated Utility Base Energy (CUBE) Project



Photo by Dennis Schroeder, NREL

- Diesel, PV and Battery System Optimized
- 31% Fuel Savings
- 1/3 of savings due to battery as regulating reserve
- Partners: NREL, U.S. Army Mobile Electric Power (MEP), Wyle, U.S. Army Rapid Equipping Force (REF)
- 60 kW Load
- Two 30 kW TQGs
- Four 5 kW PV Arrays
- One 30 kW Battery Bank
- One spare 30 kW Battery Connection

# Upcoming Work: NREL, Hawaii Electric, and partners

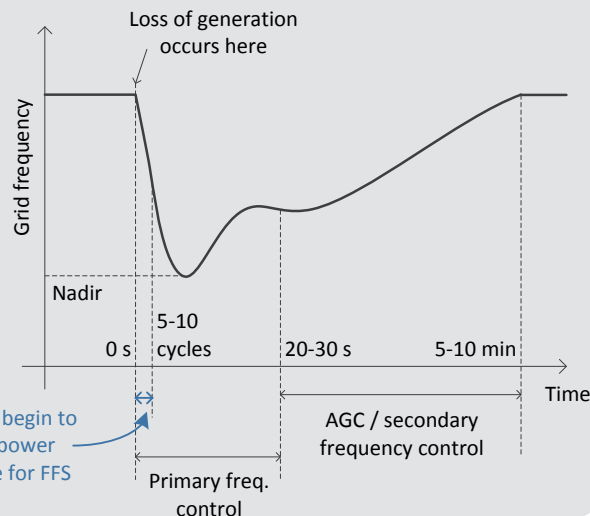
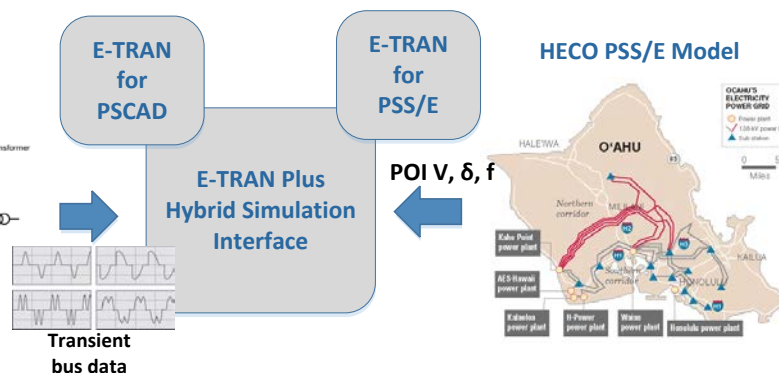
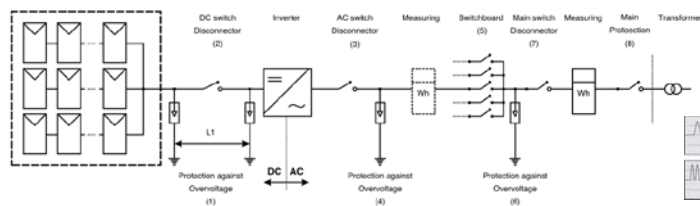
## TECHNOLOGY ADDRESSED

Problem: Degraded grid **frequency stability** (power outages) due to high levels of PV. Solution: Control PV and storage to autonomously help stabilize grid.

## WORK and IMPACT

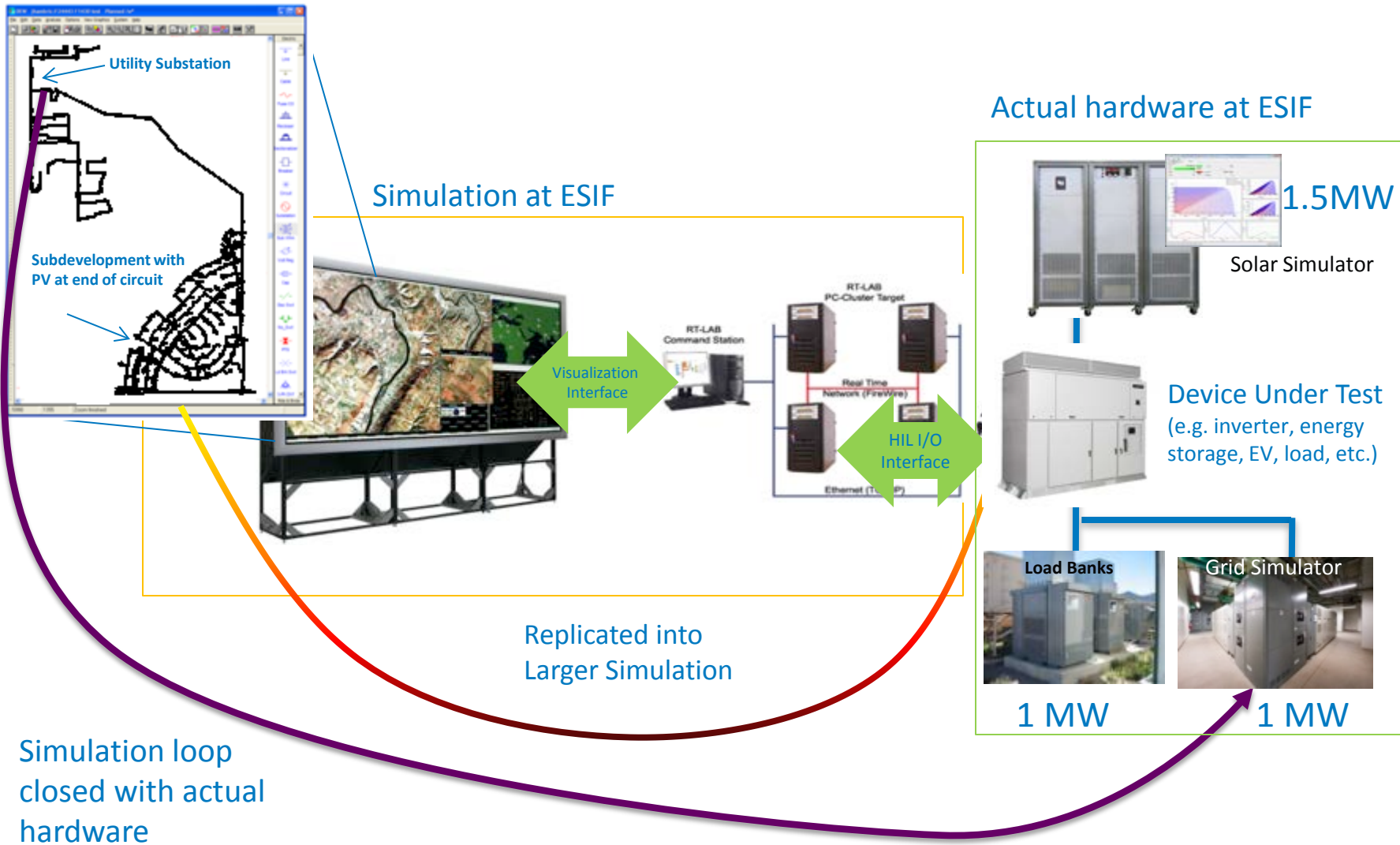
Develop distributed inverter-based controls, validate in the lab, and demonstrate in the field. Result will help maintain a stable, reliable grid as Hawaii moves towards 100% renewables.

PSCAD Model of a Distribution Circuit with PV



- Broad regional partnership led by NREL: HECO, Sandia, Enphase, Fronius, FIGII, and Energy Excelerator
- DOE funded (\$1M) as part of Grid Modernization Lab Call (GMLC)
- Help pave a path to a sustainable reliably-powered future for the rest of the US
- Officially started April 1. First phase will test existing **frequency-Watt function**.

# Power Hardware-in-the-Loop (HIL): Connecting Experiments to Simulations\*



\*This is an overview of NREL/ESIF's capabilities; Details of actual HECO tests will differ

# NREL's Solar Technical Assistance Team (STAT)

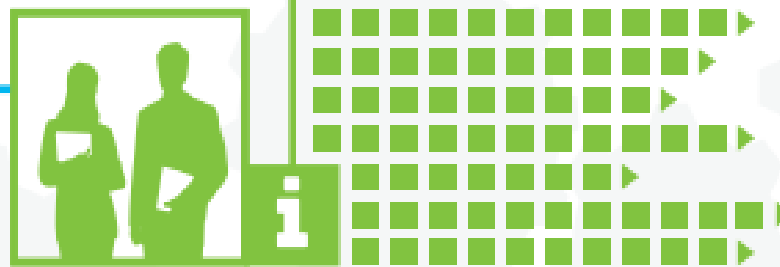
1 Government official asks a question



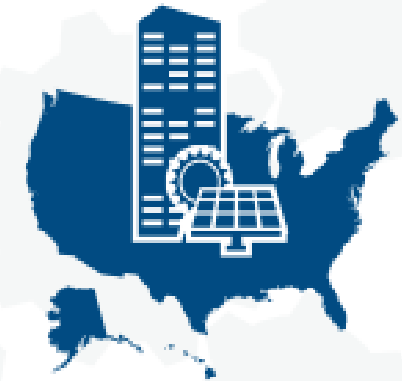
Utilities, state agencies, governments,  
regulatory commissions

Do-it-yourself online education

- Webinars
- Fact sheets
- Blogs
- Podcasts



2 STAT answers the question and shares knowledge at the local and state level through presentations, webinars, and whitepapers



3 Knowledge sharing results in development of solar market in communities across the United States

Source: NREL, 2016

[http://www.nrel.gov/tech\\_deployment/state\\_local\\_governments/stat.html](http://www.nrel.gov/tech_deployment/state_local_governments/stat.html)

# STAT Partnerships with States

## **Illinois Office of Energy & Recycling**

*How can solar PV deployment can stimulate economic development in Illinois?*

Explore solar policy scenarios by employing NREL's Distributed Generation and Market Demand (dGen) and Jobs and Economic Development Impact (JEDI) models.

## **New York State Energy Research and Development Authority (NYSERDA)**

*How to better understand soft costs related to financing in NY?*

Provide a summary of solar financing models available to residential and commercial solar markets: loans, power purchase agreements, and cash purchase.

## **Nevada Governor's Office of Energy**

*How can we learn from other state programs?*

Review a "Green Bank" study, summarizing findings from feed-in-tariff analyses and renewable portfolio standards trends, participate in Task Force meetings.

# State Technical Assistance: Direct, Quick Response

Applicants	Topic
City & County of Denver, Office of Economic Development	Solar contribution to NZE community, strategies
City of Camden, New Jersey	Solar on contaminated lands
City and County of Denver, Mayor's Office	Solar Benefits technical support
Montana Senate District 33	Solar Ready Design presentation
Delaware Public Service Commission	Technology – Inverter accuracy
County of Kauai, Hawaii	RFP Assistance
City of Chicago	Airport project technical support
Louisiana PSC	Net metering caps presentation
City of Tucson	Financing Options for PV
Ranson, WV	Policy Options
Austin Electric Utility Commission	Value of solar methodology

## Program Structure

- Rolling application throughout the year
- Short online application
- Quick turnaround time on request approval
- Up to 40 hours per request

## Apply Online:

[http://www.nrel.gov/tech\\_deployment/state\\_local\\_governments/stat.html](http://www.nrel.gov/tech_deployment/state_local_governments/stat.html)



Any questions?

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