PEV Grid Integration Research

Vehicles, Buildings, and Renewables Working Together

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Electric Vehicle Grid Integration

National Renewable Energy Laboratory

IEEE PES General Meeting

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy LLC.

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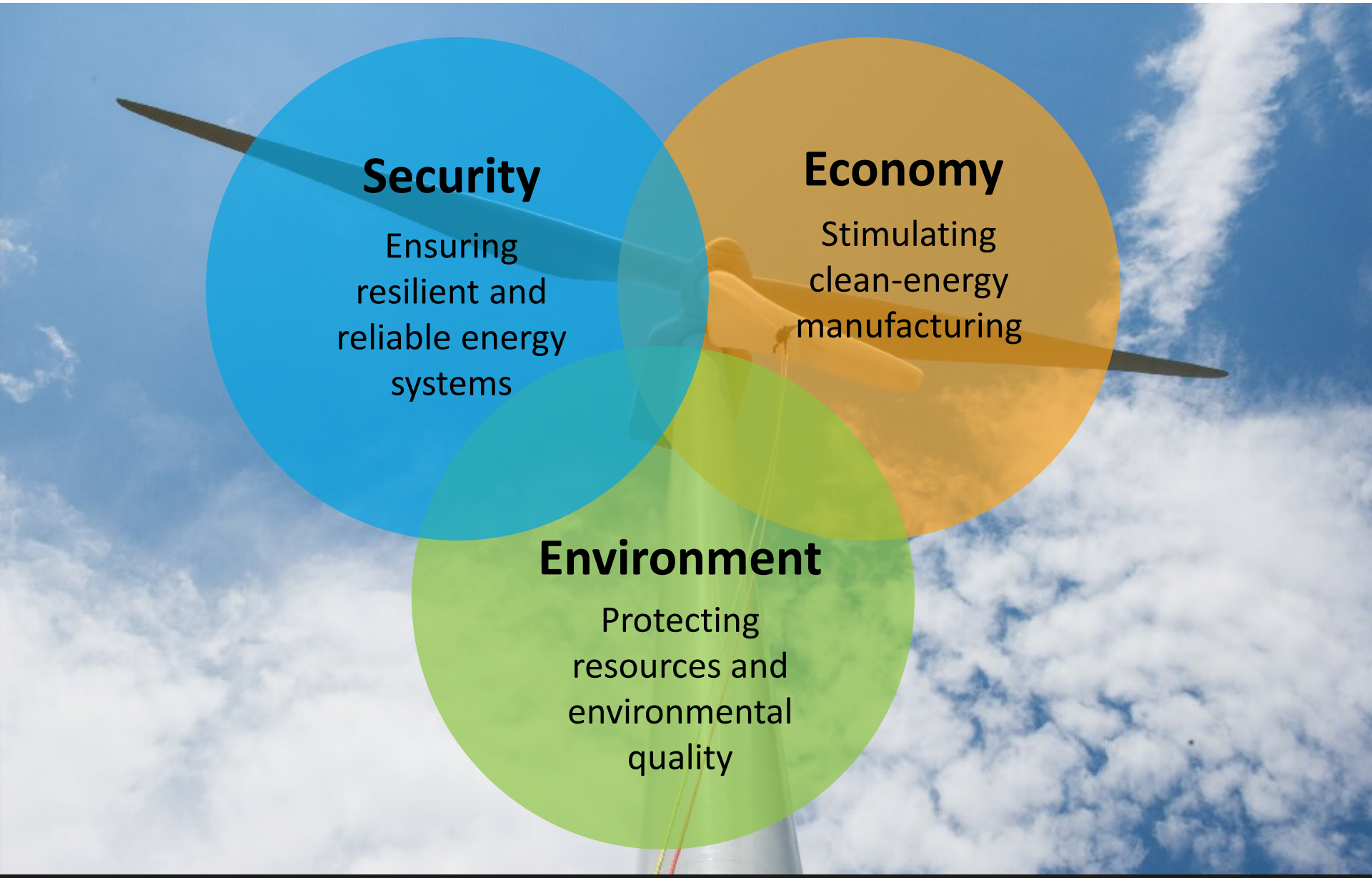
National Energy Imperatives



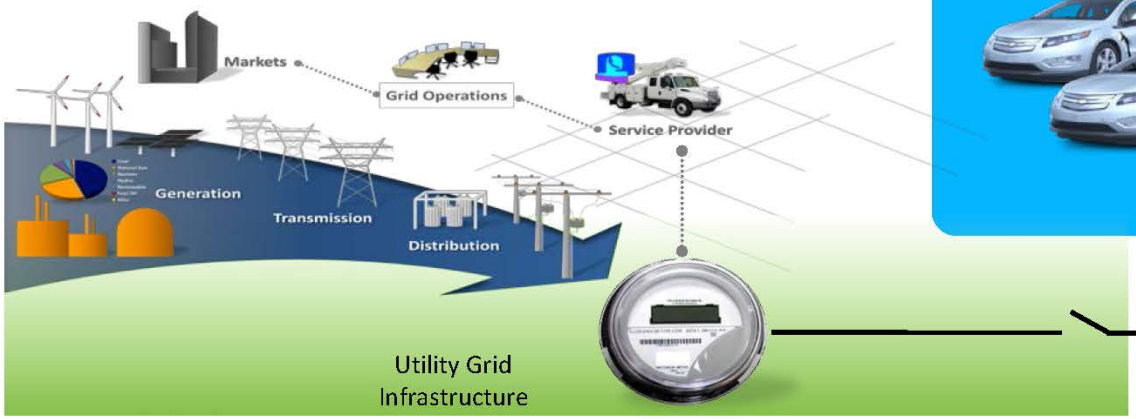
NREL's Solutions Role

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

Grid Modernization Initiative

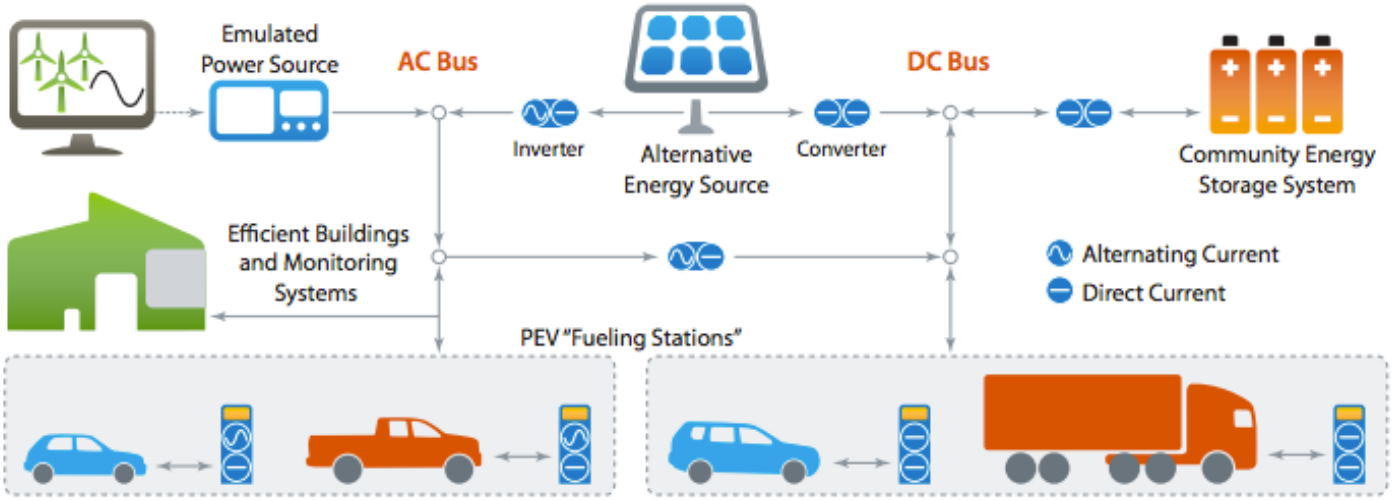
- This new crosscutting effort will build on past successes and current activities to help the nation achieve at least three key outcomes within the next ten years:
  - > 10% reduction in the societal costs of power outages
  - > 33% decrease in cost of reserve margins while maintaining reliability
  - > 50% cut in the costs of wind and solar and other DG integration
- If achieved, these three key outcomes would yield more than $7 billion in annual benefit to the U.S. economy
- Grid Modernization Lab Consortium
  - Mitigate adverse impacts of EV deployment
  - Leverage existing synergies between EVs and the grid, building energy management systems, distributed renewables, and other smart grid assets.



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Electric Vehicle Grid Integration at NREL

Vehicles, Renewable Energy, and Buildings Working Together



Developing Systems Integrated Applications

Managed Charging

Evaluate functionality and value of load management to reduce charging costs and contribute to standards development

Local Power Quality

Leverage charge system power electronics to monitor and enhance local power quality and grid stability in scenarios with high penetration of renewables

Emergency Backup Power

Explore strategies for enabling the export of vehicle power to assist in grid outages and disaster-recovery efforts

Bi-Directional Power Flow

Develop and evaluate integrated V2G systems, which can reduce local peak-power demands and access grid service value potential

Vehicle-to-Grid Challenges

Life Impacts

Can functionality be added with little or no impact on battery and vehicle performance?

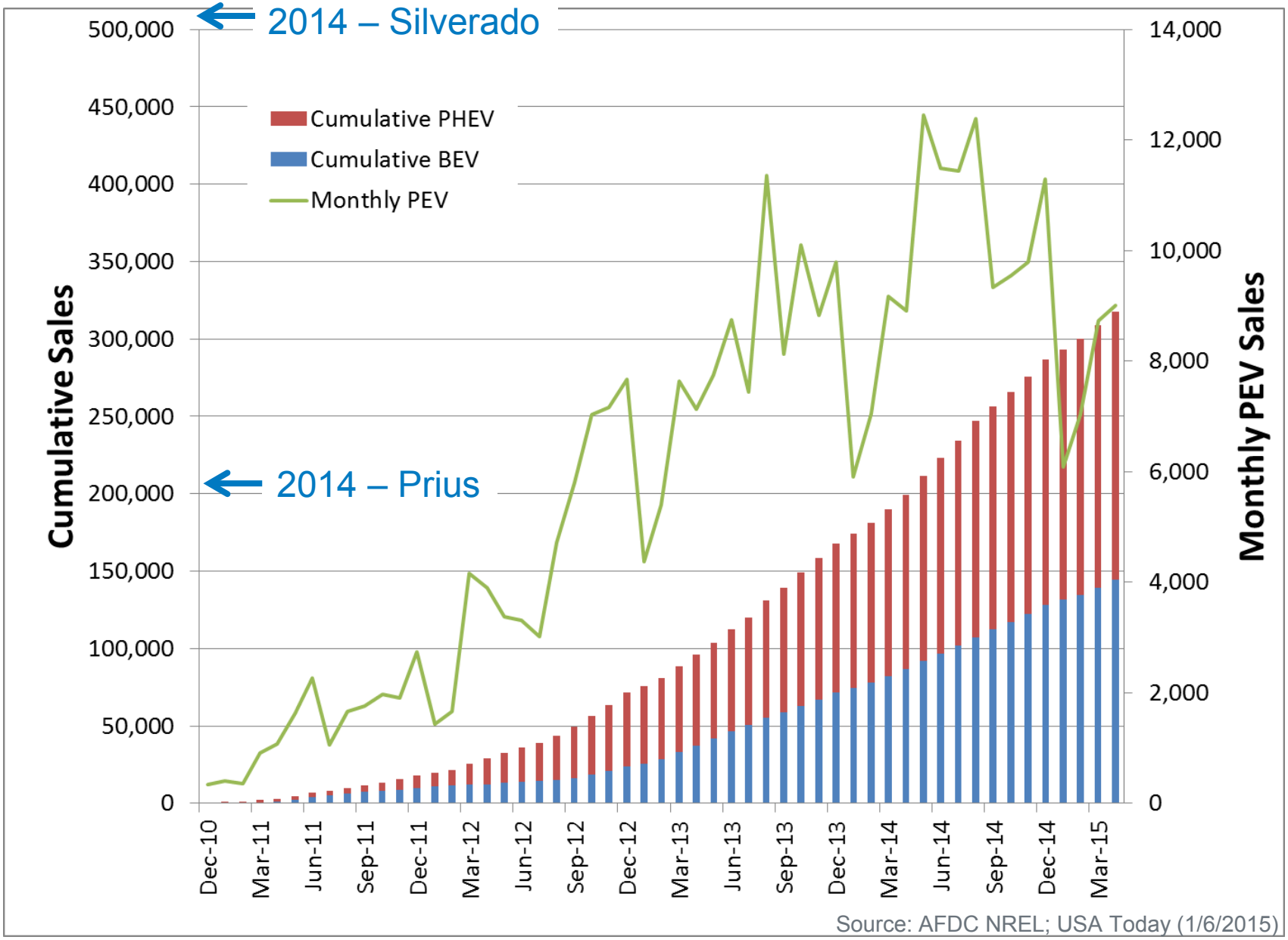
Information Flow and Control

How is information shared and protected within the systems architecture?

Holistic Markets and Opportunities

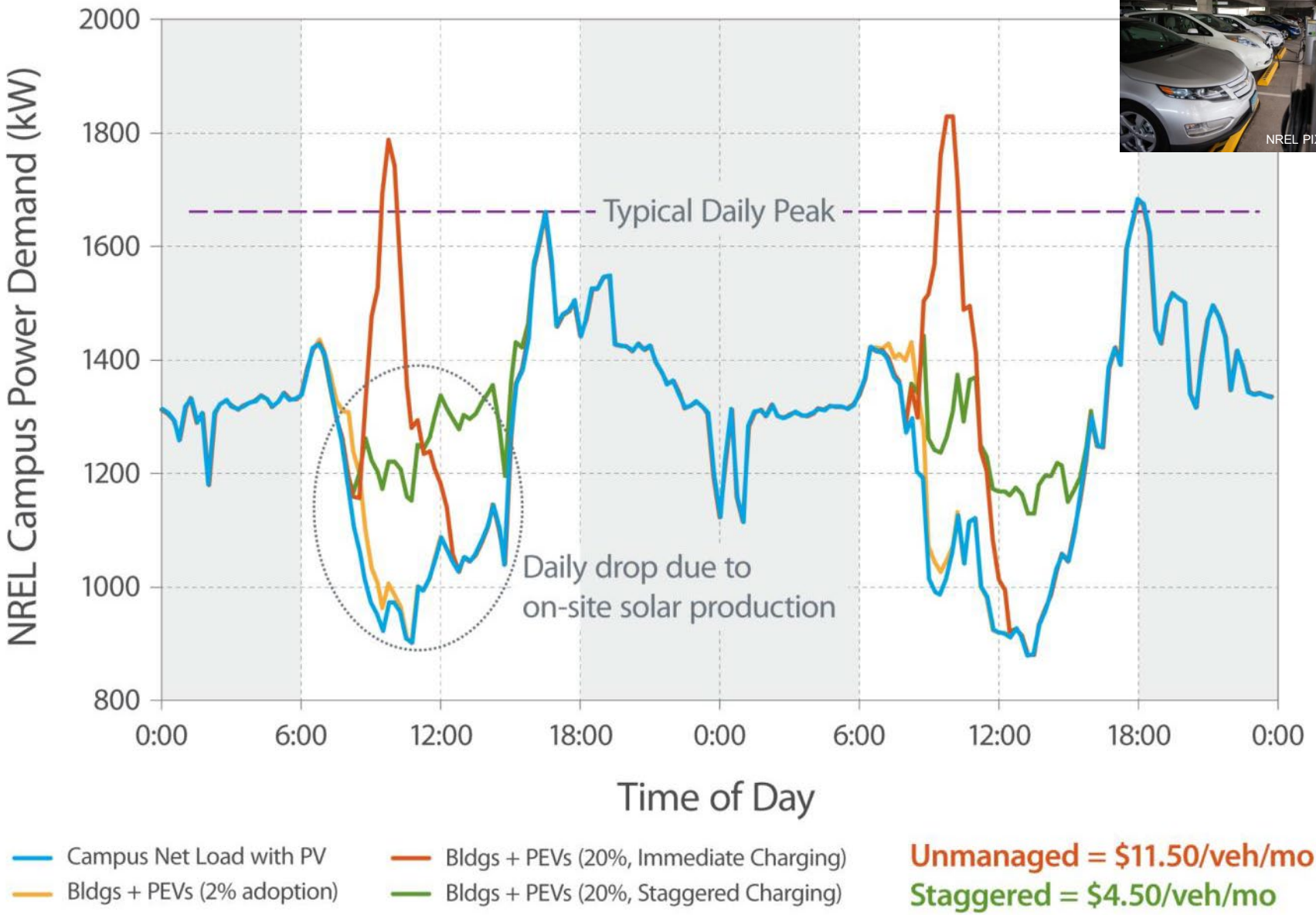
What role will vehicles play and what value can be created?

The State of the PEV Market

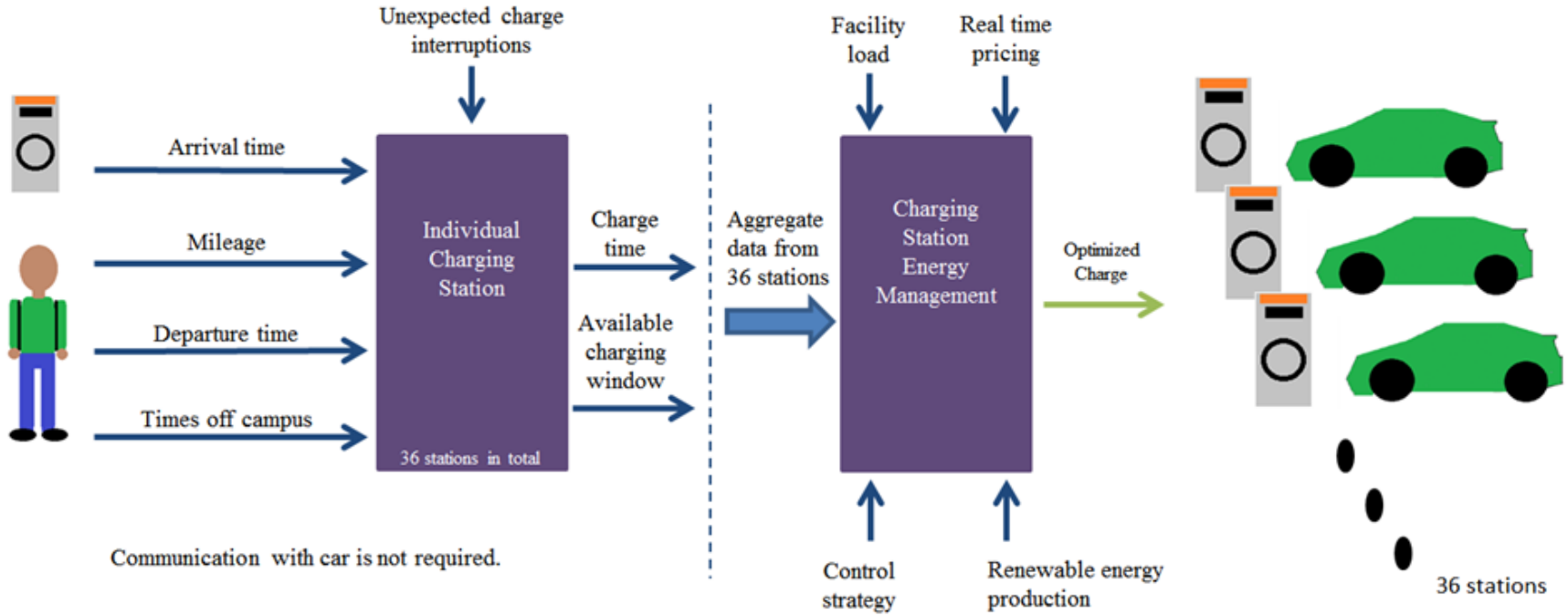


Source: AFDC NREL; USA Today (1/6/2015)

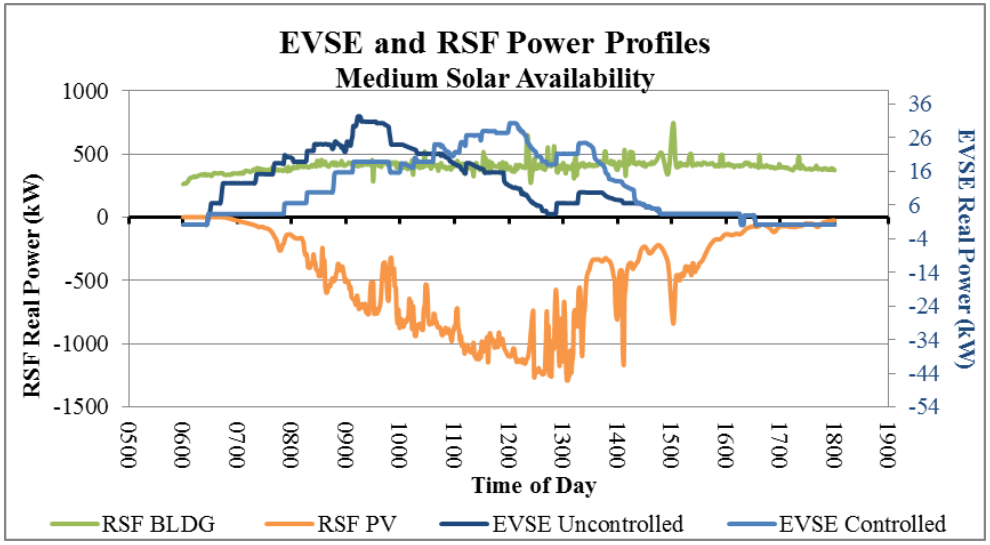
Planning for PEVs on a Highly Renewable Campus



Expanding Charging Data Streams and Interaction to Automate PEV Charge Management with Renewable Sources

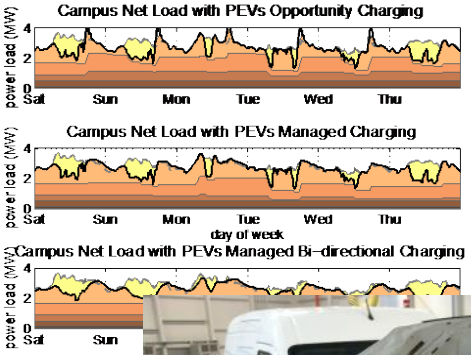


Provide simple interface with least information necessary to create managed individual and aggregate scenarios with status display



RSF = Research Support Facility

Laboratory Resources Applied to Tech Introduction



Scenario Simulation

Tech Development

Source: NREL, M. Simpson

Source: NREL, M. Simpson

System Confirmation

5x 60-kW Bi-directional Stations Integrated with Microgrid Operations

Source: Burns & McDonnell

VTIF

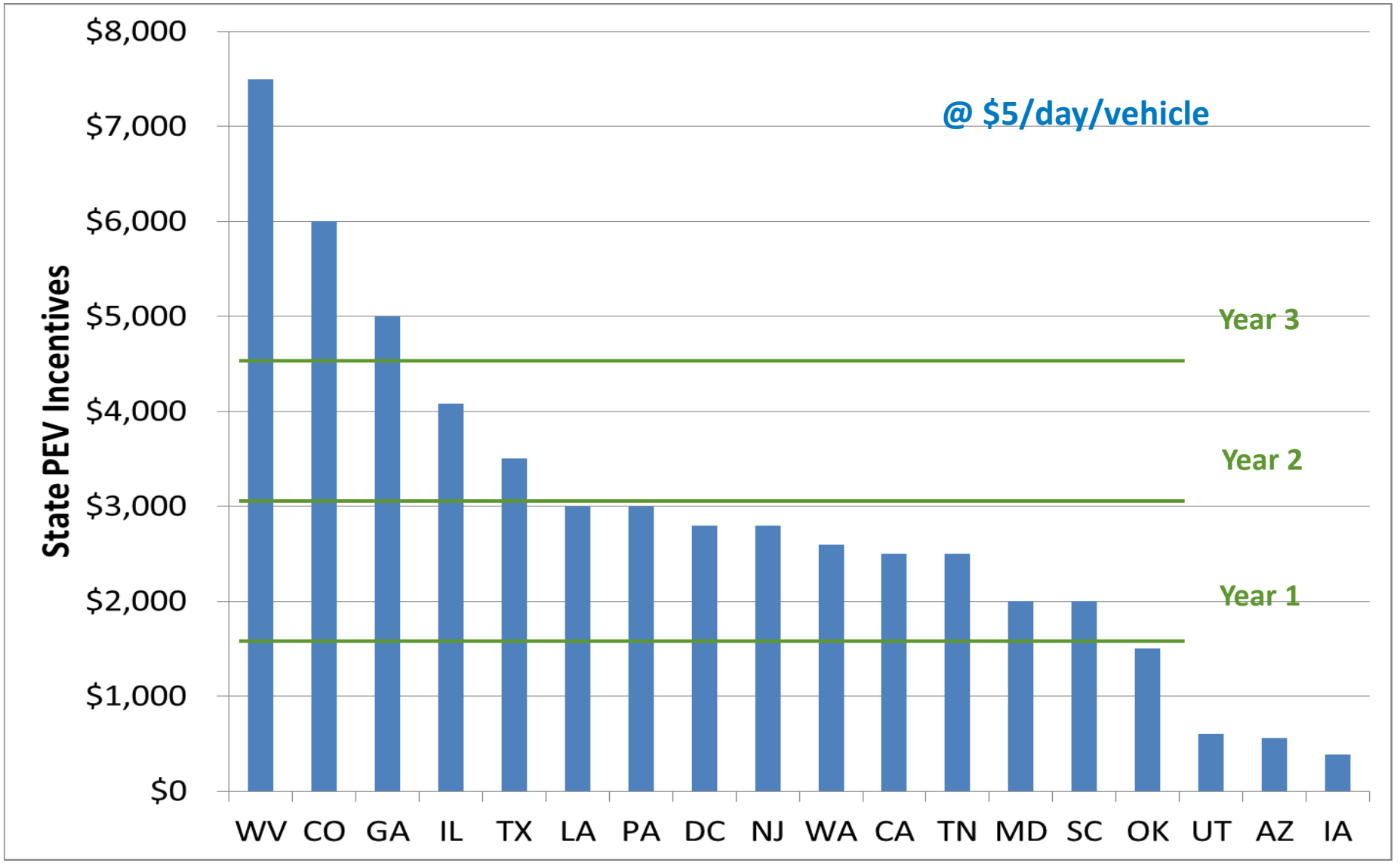
- Communications development and testing

ESIF

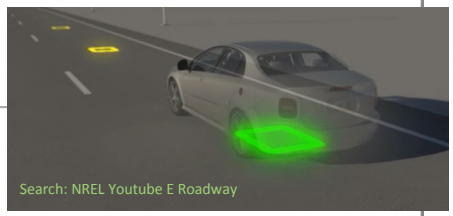
- Grid integration component verification

Relevance – Additional Value to Enhance Marketability

Can PEV Grid Services Provide Similar Value to Purchase Incentives?



E-roadway Loads Reduce RE Curtailment



Curtailment Reduction (%)

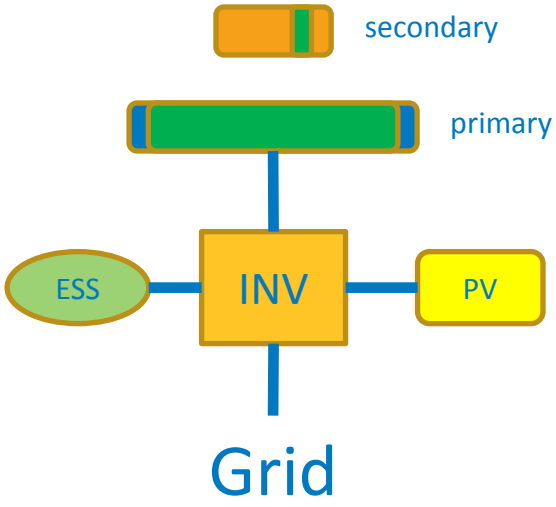
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%

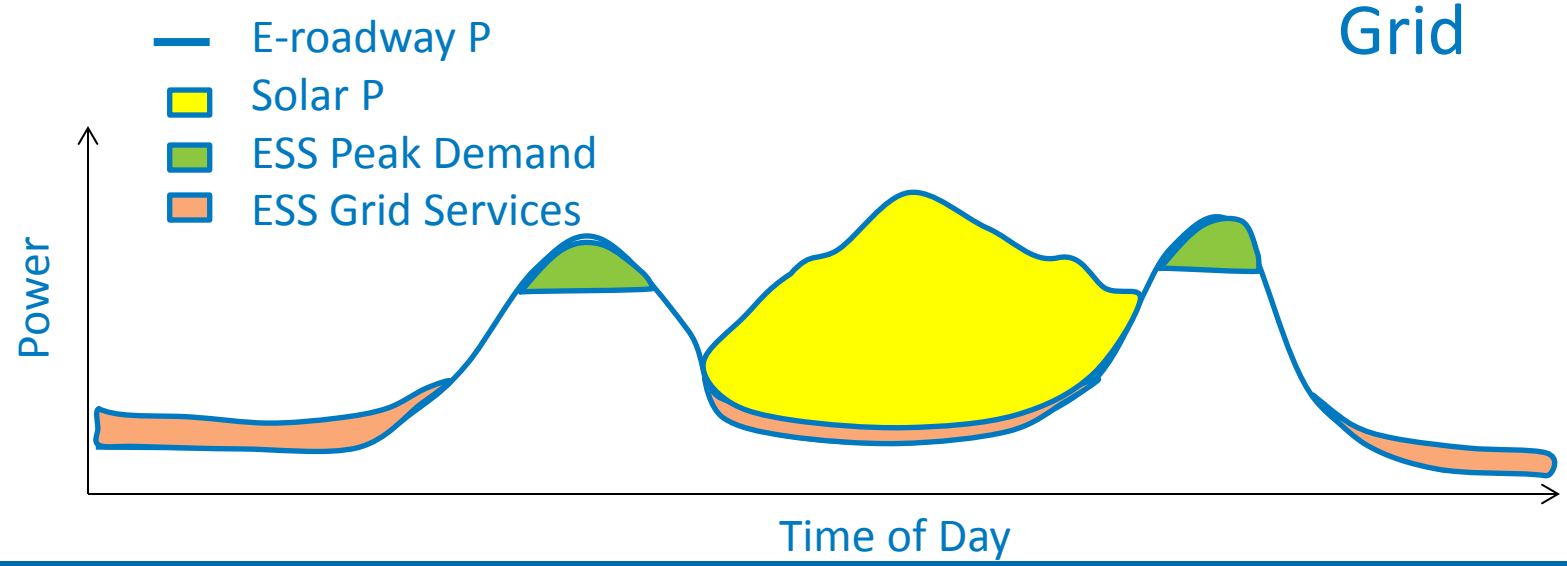
PV
Wind

2035 eHEV eRW
2050 eHEV 27 eRW
2050 eHEV 50 eRW
2050 eHEV 50 EV 50 eRW Opp
2050 eHEV 50 EV 50 eRW TOU
2050 EV 50 eRW Opp
2050 EV 50 eRW TOU
2050 EV 50 Opp
2050 EV 50 TOU

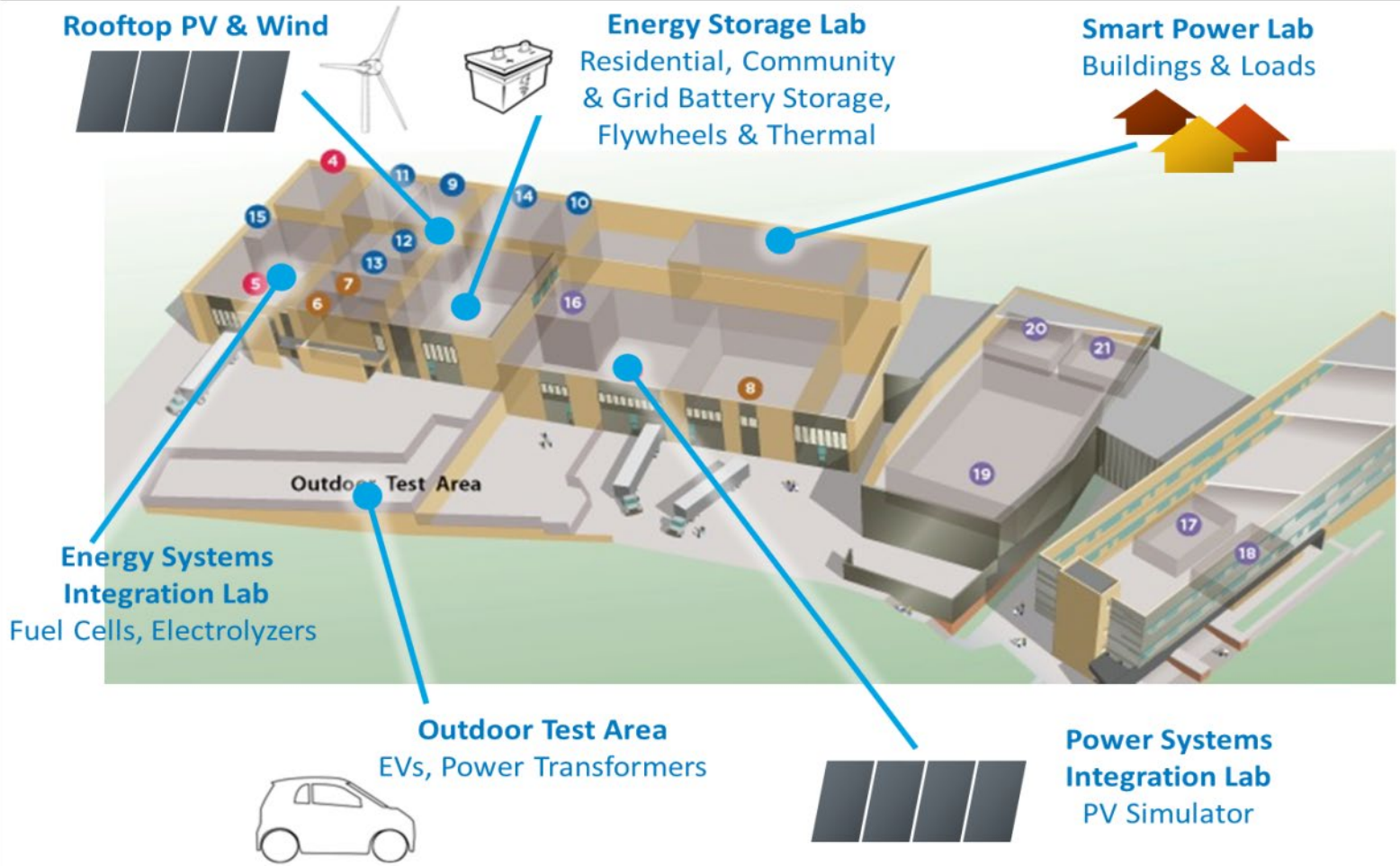
A Pathway to Inverter Enhanced Utilization

- **Driving patterns, road usage, system sizing, and mechanical layout**
  - Leads to E-roadway power profiles
  - Likely to be peaks and valleys
- **Grid modernization**
  - Driving toward renewables integration
  - Grid services from devices
- **Leverage multiport inverters for maximum value from infrastructure investment**





ESIF Resources for Vehicle Grid Integration Research



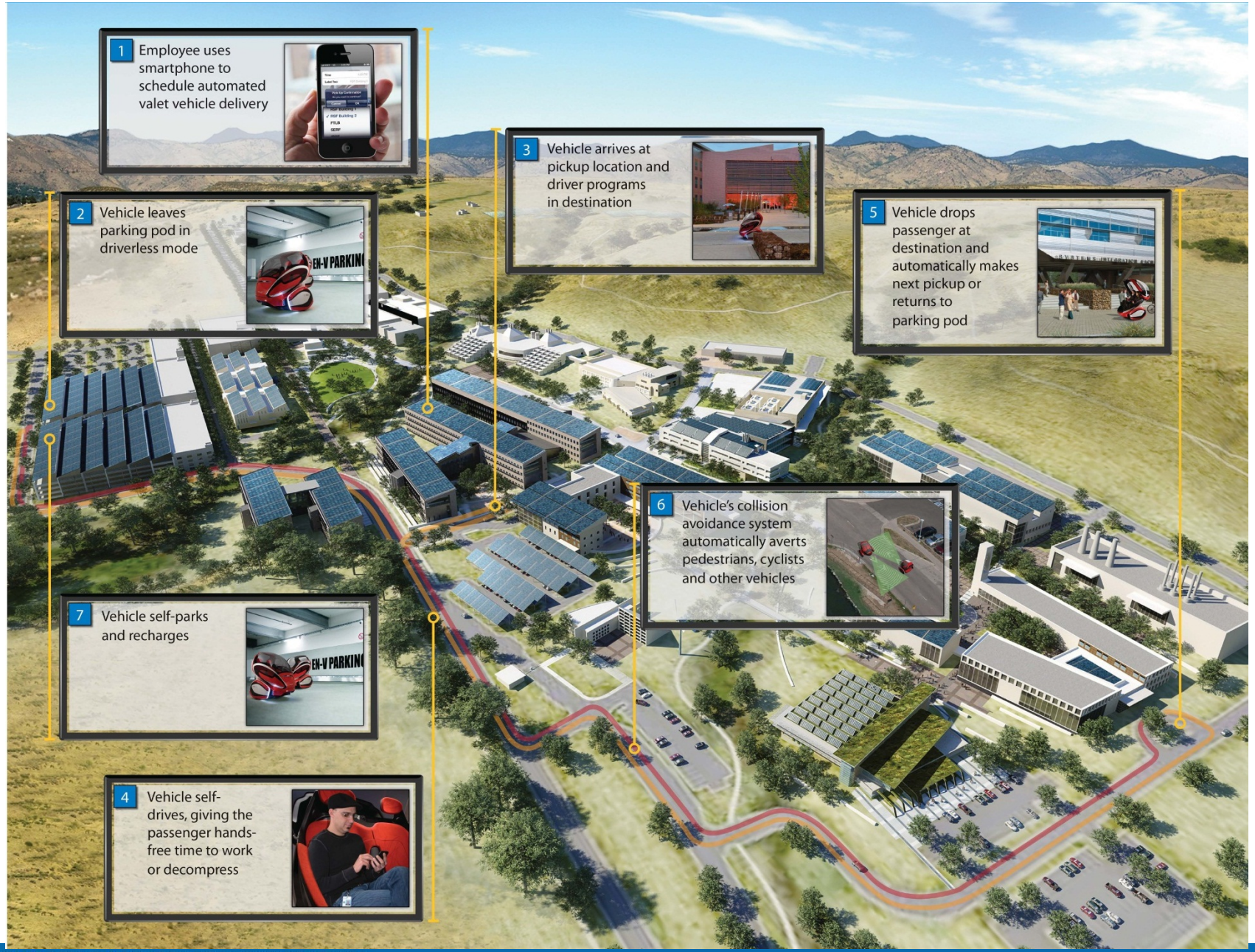
- More than 15 EVSEs accessible in lab spaces
- DC load bank to act as a programmable storage device
- Oscilloscopes for detail electrical system impacts analysis

ESIF=Energy Systems Integration Facility
EVSE=electric vehicle supply equipment

Thoughts on EV Integration Opportunities

- **EV charge management should first be focused on minimizing or eliminating the capacity costs and optimize around energy cost**
  - Adjust charge pattern such that no additional power capacity is needed at generation and distribution levels
- **The provision of ancillary services from EV charging has the potential to provide some additional value,**
  - Revenue opportunities are small relative to the benefits of reduced costs associated with controlled charging
- **The unknown path forward on Distributed Energy Resource participation in markets makes assessment challenging**

Campus Mobility of the Future



Acknowlegements

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