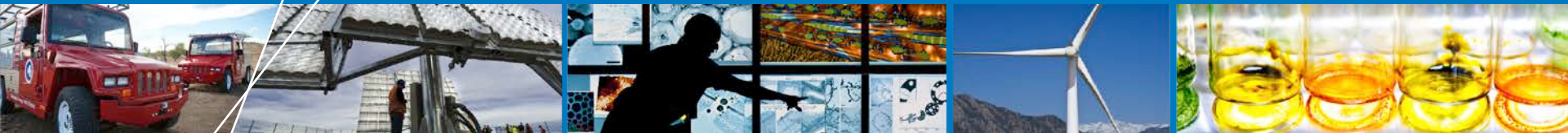


Islands and Our Renewable Energy Future



WREF 2012 Conference

May 16, 2012 Denver, CO

NREL/PR-7A40-55060

NREL Snapshot

Only US Laboratory Dedicated Solely to Energy Efficiency and Renewable Energy

- Leading clean-energy innovation for 34 years
- 1,740 employees working in a living model of sustainable energy
- Owned by the U.S. Department of Energy
- Operated by the Alliance for Sustainable Energy



Why Islands? *Motivation*



“Islanders”

- High *and variable* energy costs
- Excellent access to renewables
- Visible externalities
- Vulnerability to climate change



“Continental”

- Demonstration of high-penetration renewables
- Development of next-generation technologies
- Proof that energy transformation is possible

NREL's Island Work

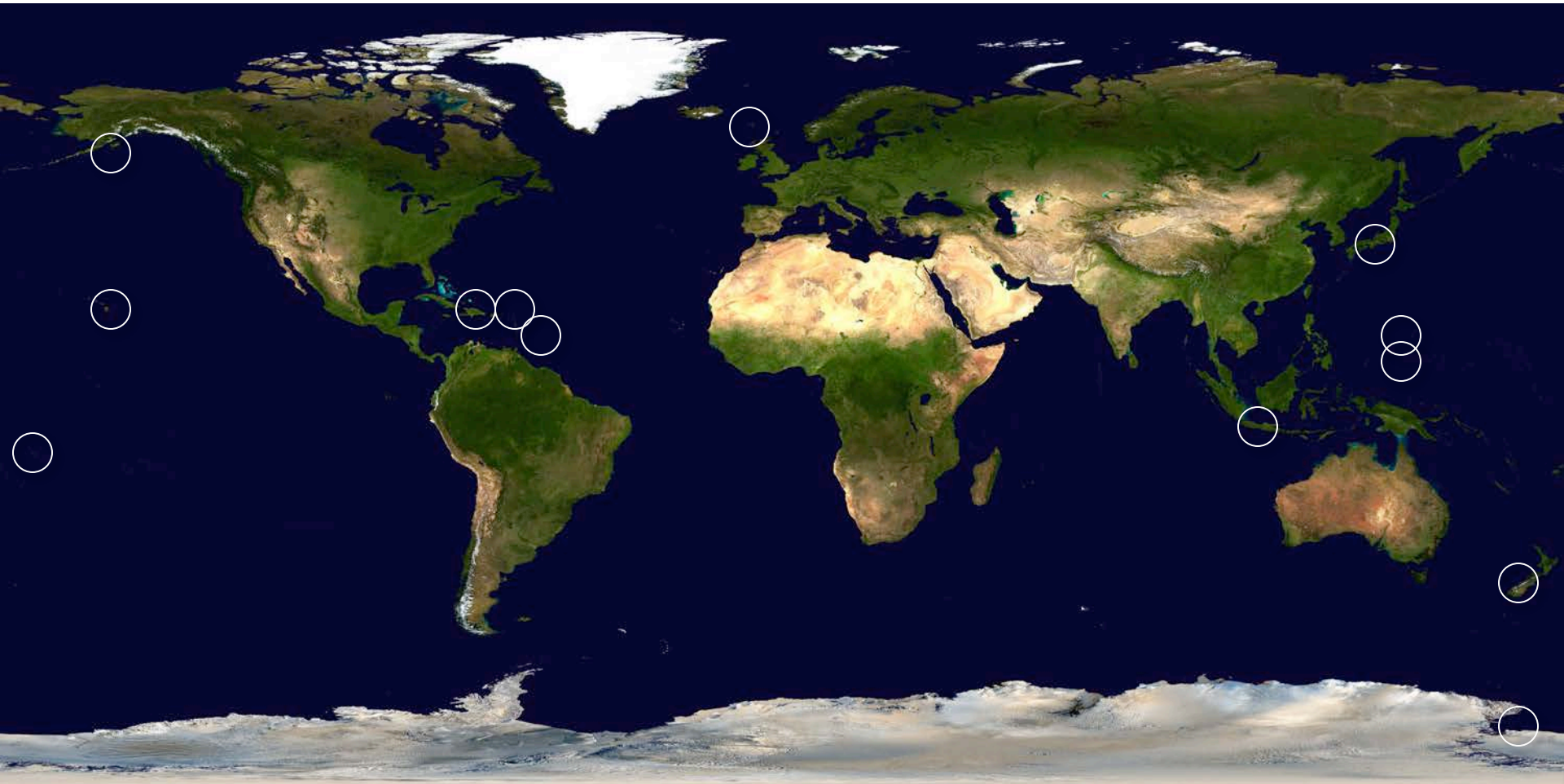


image courtesy NASA

NREL's Island Work - Panelists

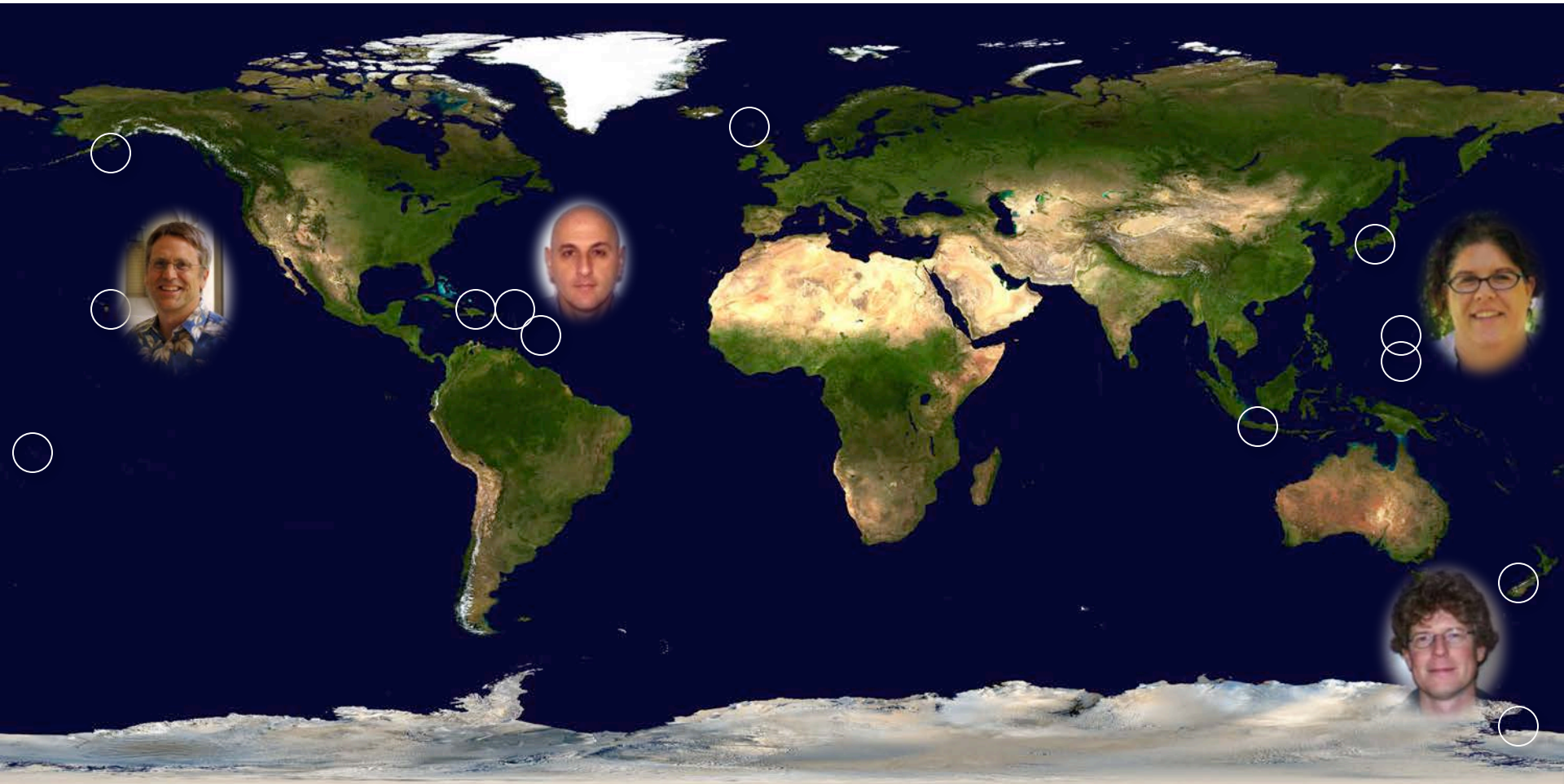


image courtesy NASA

Marketing Strategies for High Contribution Renewables in Islanded Power Systems



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E. Ian Baring-Gould, NREL

Wide Range of Power System Options

Renewable power system can be used to cover a wide range of needs, including:

- **Dedicated Use:** Power being used at point sources without regulation
- **Small or Simple Systems:** Power systems for individual buildings and dispersed generation where high level of reliability is not required
- **Community Power Systems:** Utility provided power to larger communities or group of buildings with larger loads.
- **Wind-Diesel Systems:** Large communities or facilities with large loads.
- **Integrated Systems:** Large islanded systems incorporating conventional and large scale renewable generation.

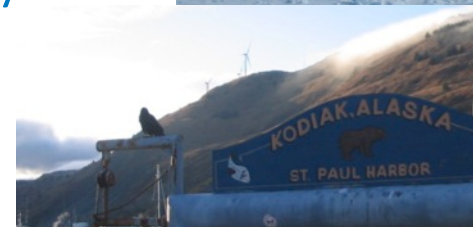
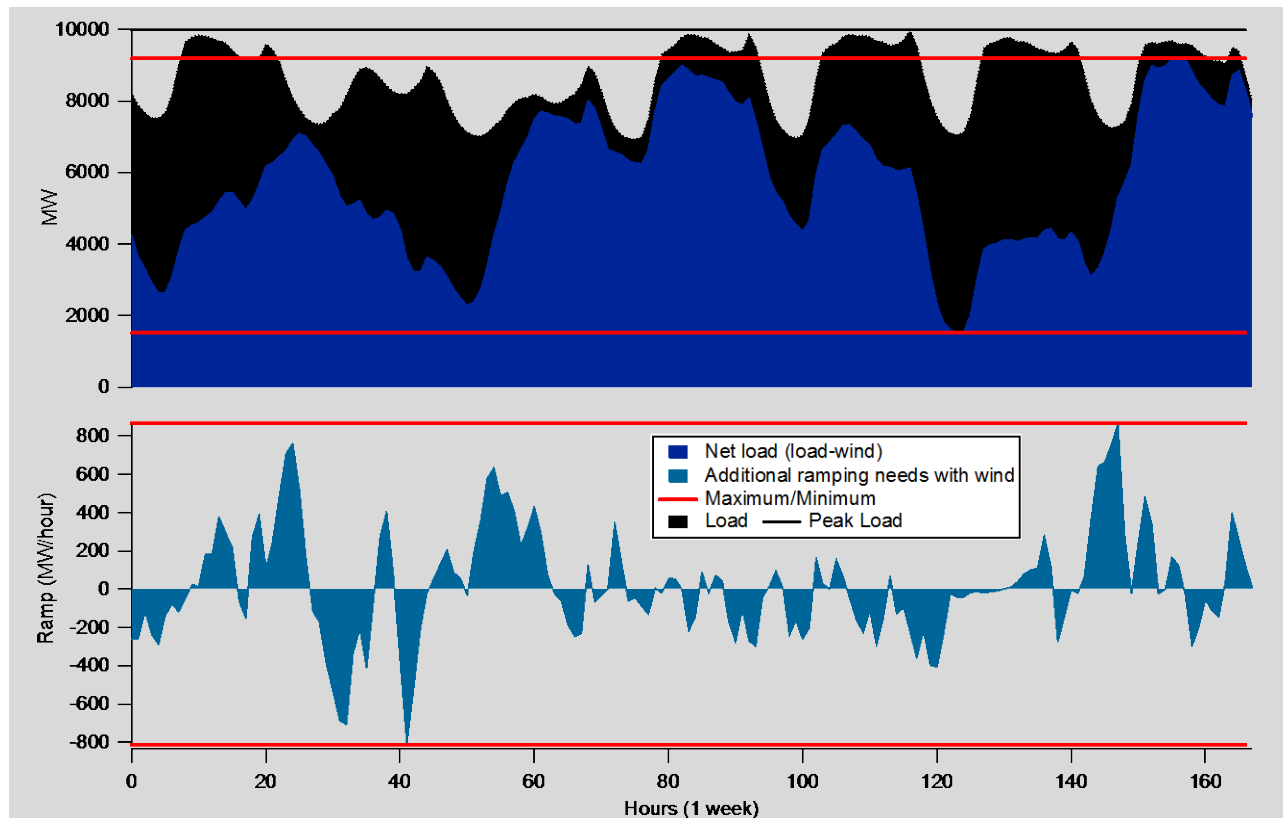


Photo Credit: Kent Bullard

High Contribution Renewables...

- *does not* require additional capacity
- *does* change the way that the balance of system capacity is utilized
- *does* require expanded system flexibility



- There are a number of ways from the demand and supply side to help support this flexibility, with expanded use of inelegant grids important

Current Status of High Contribution Renewable Tech

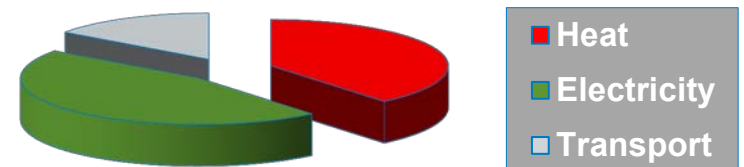
Recent oil cost variability has caused many nations, states, and organizations to look at options to reduce dependence on diesel fuel for power generation

Rapidly expanding market for large scale renewable-diesel systems:

- ~40 projects operating or in construction with additional projects being developed
- Operating projects in almost every region of the world
- Most projects are smaller in size (2 MW or less) with expanded interest in larger integrated island systems
- Interest growing worldwide but strong interest in US (Alaska), Australia, Canada, Caribbean, and Pacific Islands

But the challenges continue...

- Electricity is only part of the energy question
- High capital costs
- Lack of understanding of the technology
- Requires a rethinking of the grid and controls



% of energy usage in the rural community of Akutan, Alaska by sector

NREL's Energy Systems Integration Facilities

The existing and developing research facilities at NREL provides a unique international asset for energy systems integration R&D, testing, and analysis at a wide range of scales.

ESIF
1kW-2MW

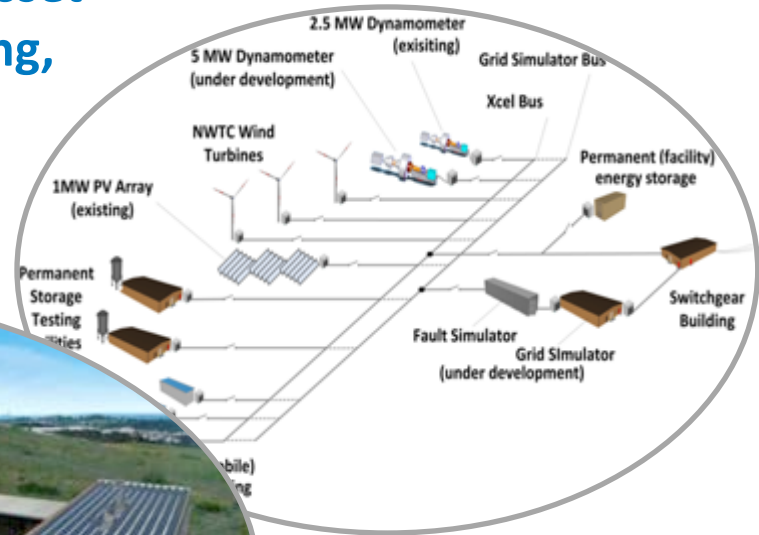


DERTF
1kW-200kW



TTF

NWTC – 2MW+



VTIF

- High, medium & Low voltage testing grids
- Indoor and outdoor test areas
- Dedicated control and product test capabilities
- High Performance computing
- Multi-system integration and testing capabilities

For More Information:

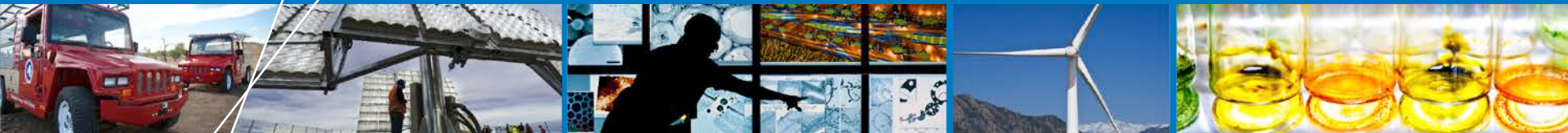
Energy Systems Integration Facility

http://www.nrel.gov/eis/facilities_esif.html

Wind / Diesel Overview

http://apps1.eere.energy.gov/tribalenergy/pdfs/wind_akwd04_basics.pdf

Inter-Island Transmission and Interconnection



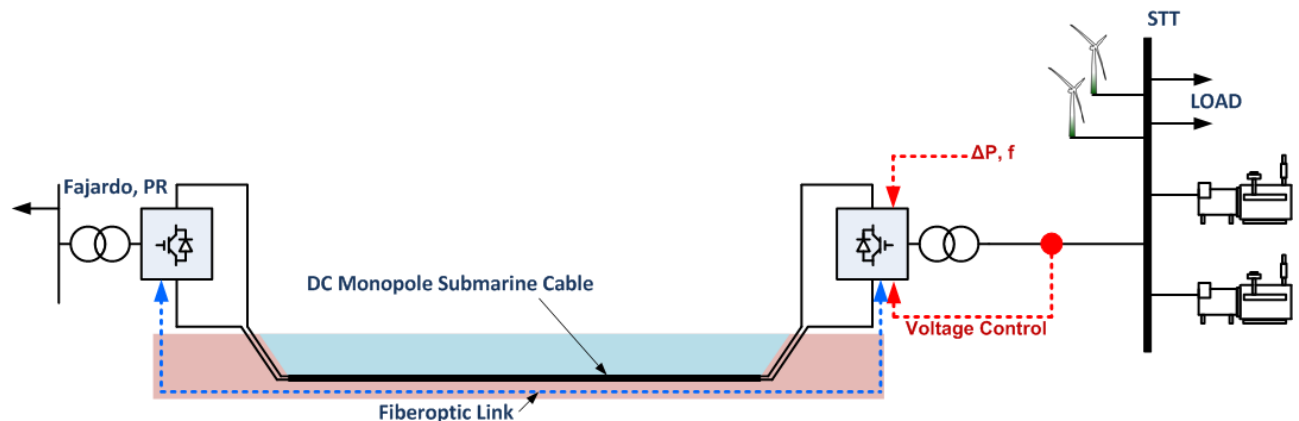
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Vahan Gevorgian, NREL

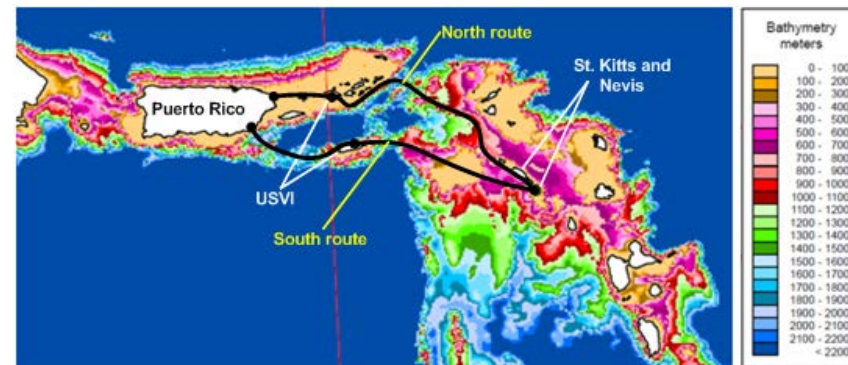
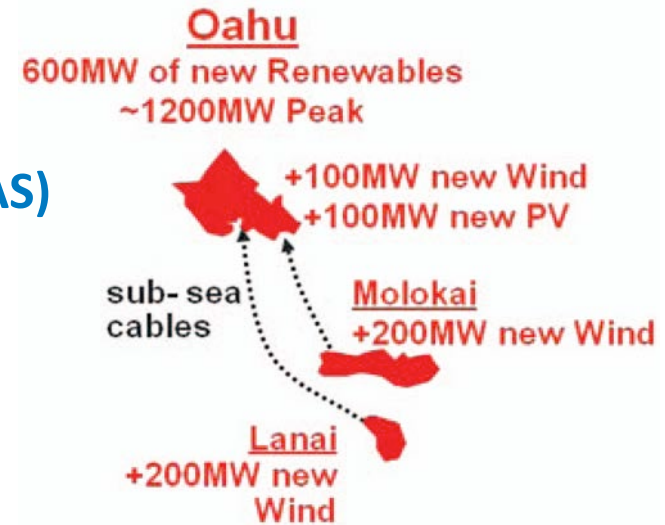
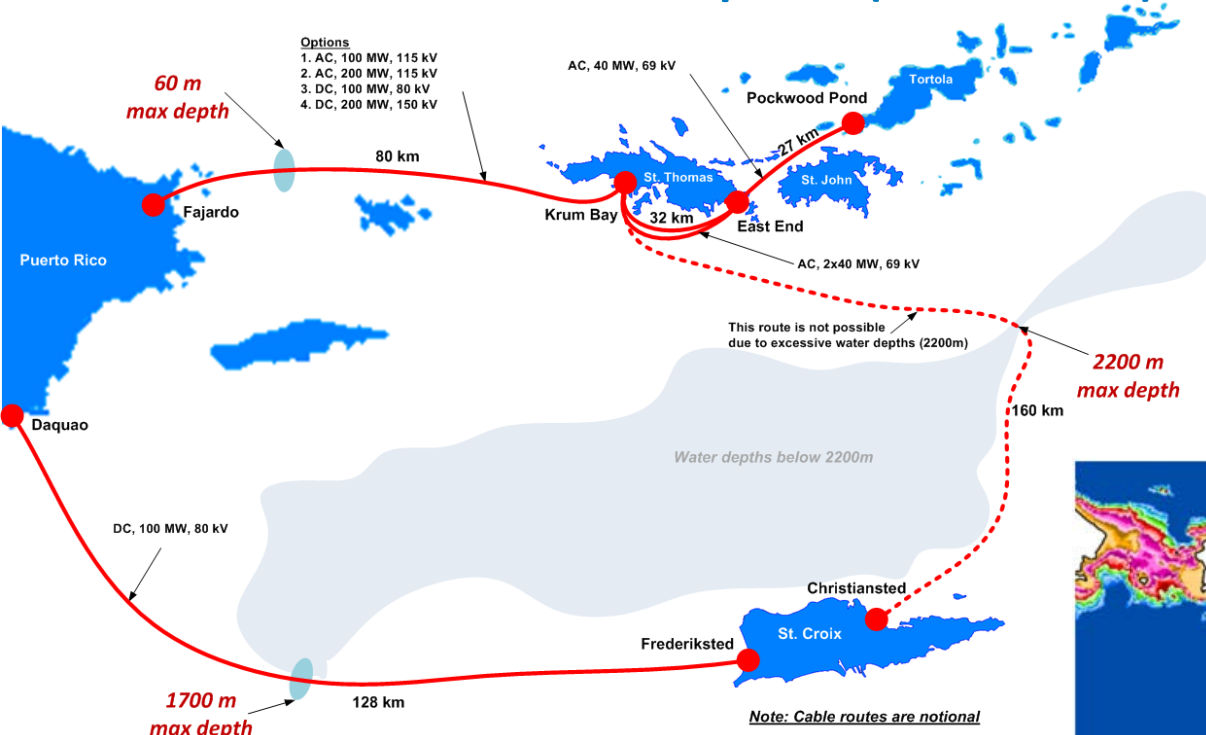
Benefits of Island Interconnections

- Deliver lower cost power from one island to another
- Transmit renewable generated energy to an island that otherwise does not have access to less expensive renewable power
- Increased reliability, better power quality, better hurricane resilience
- Reduced spinning reserve requirements, sharing frequency regulation without adding new generation, lower operating costs
- Integrated fiber-optic cables



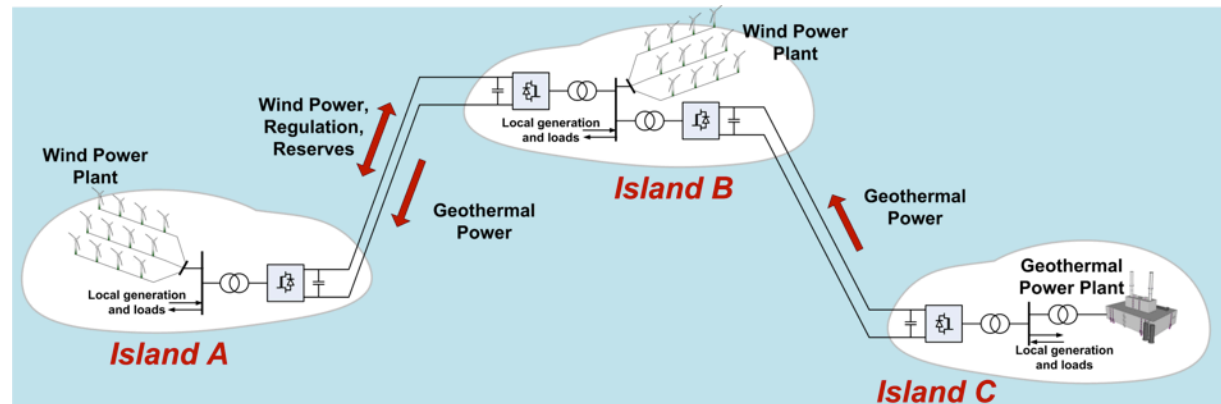
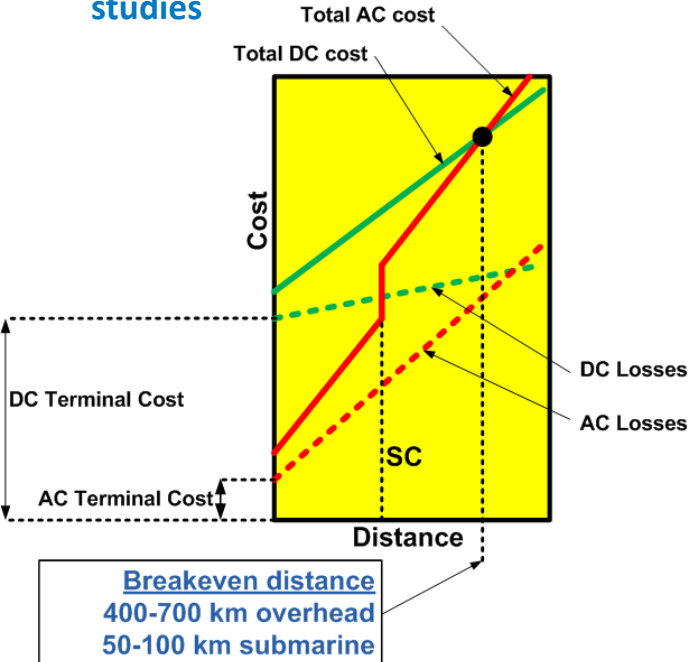
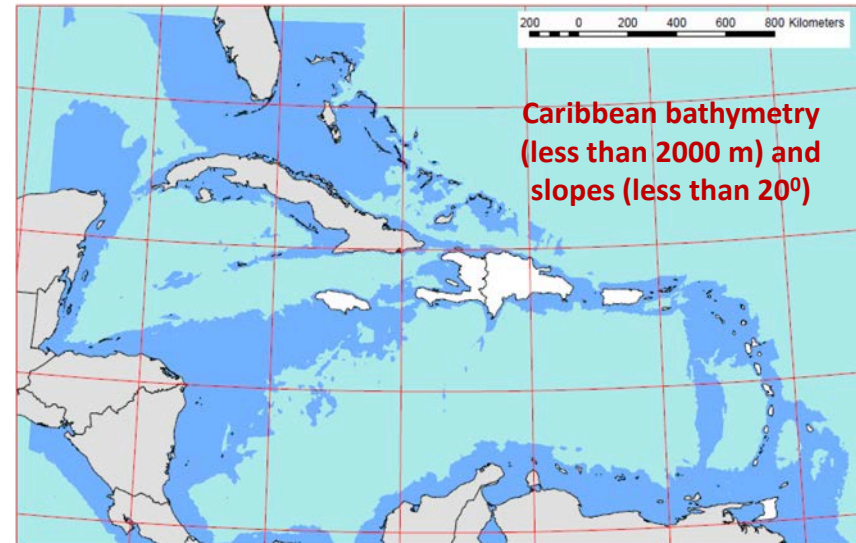
Examples of Case Studies

- OWITS (DOE/HECO/DBEDT)
- Caribbean Grid (World Bank)
- Puerto Rico – USVI - BVI (DOE)
- Nevis – USVI – Puerto Rico (U.S. Dept. of State / OAS)
- Puerto Rico – Dominican Republic (World Bank)



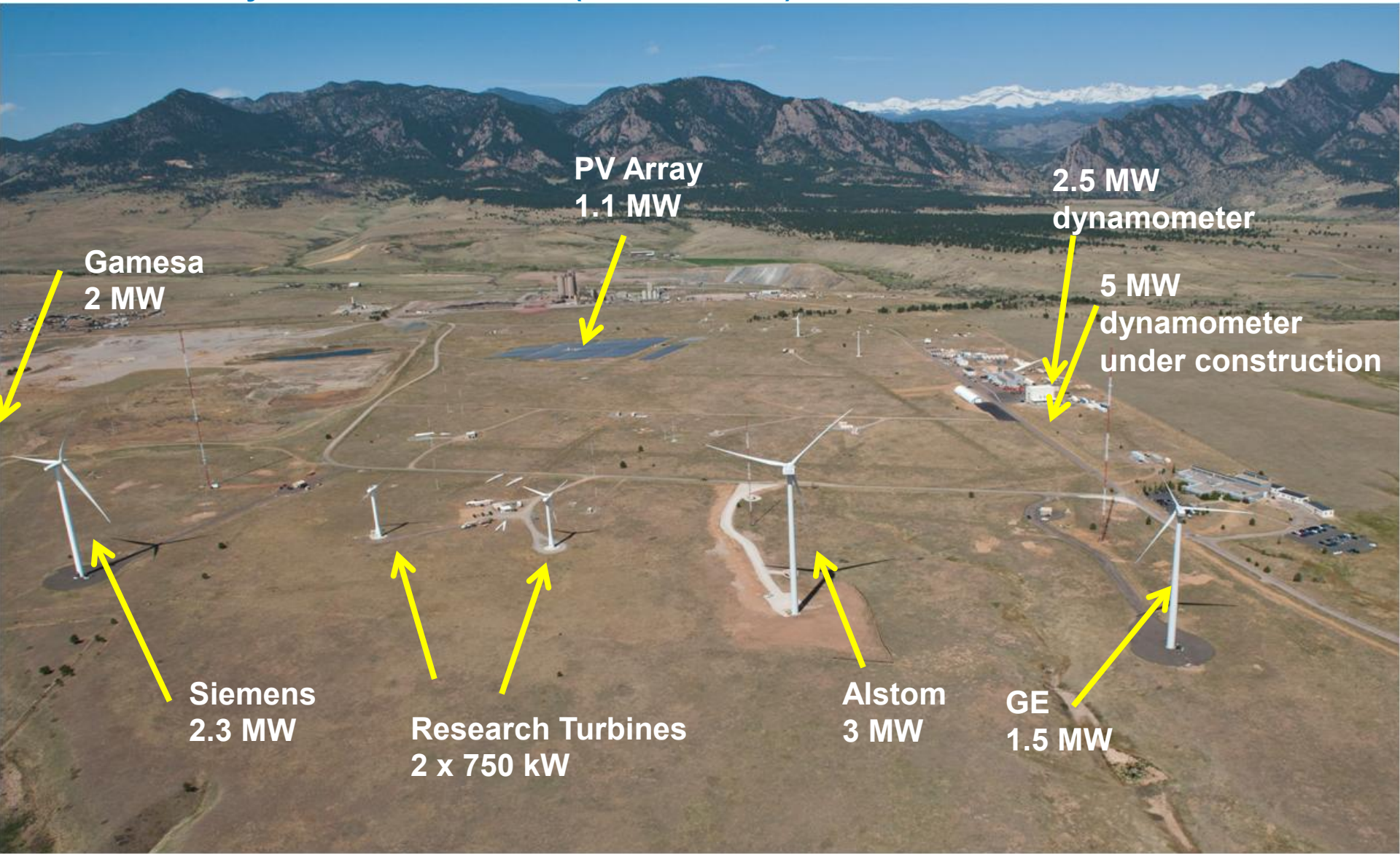
Technology Advances and Technical Barriers

- Submarine power transmission has been around for more than a century, significant offshore wind power experience
- Tradeoffs between HVDC vs. HVAC
 - Transmission capacity
 - Cable length
 - Water depths
- Deepest existing cable is only 1650m
- HVDC has many advantages over HVAC
- Multi-terminal HVDC is an existing technology
- Historically, geothermal power was the main driver for inter-island transmission
- Wind, PV, LNG generation can be drivers as well
- Environmental impacts and permitting require detailed studies

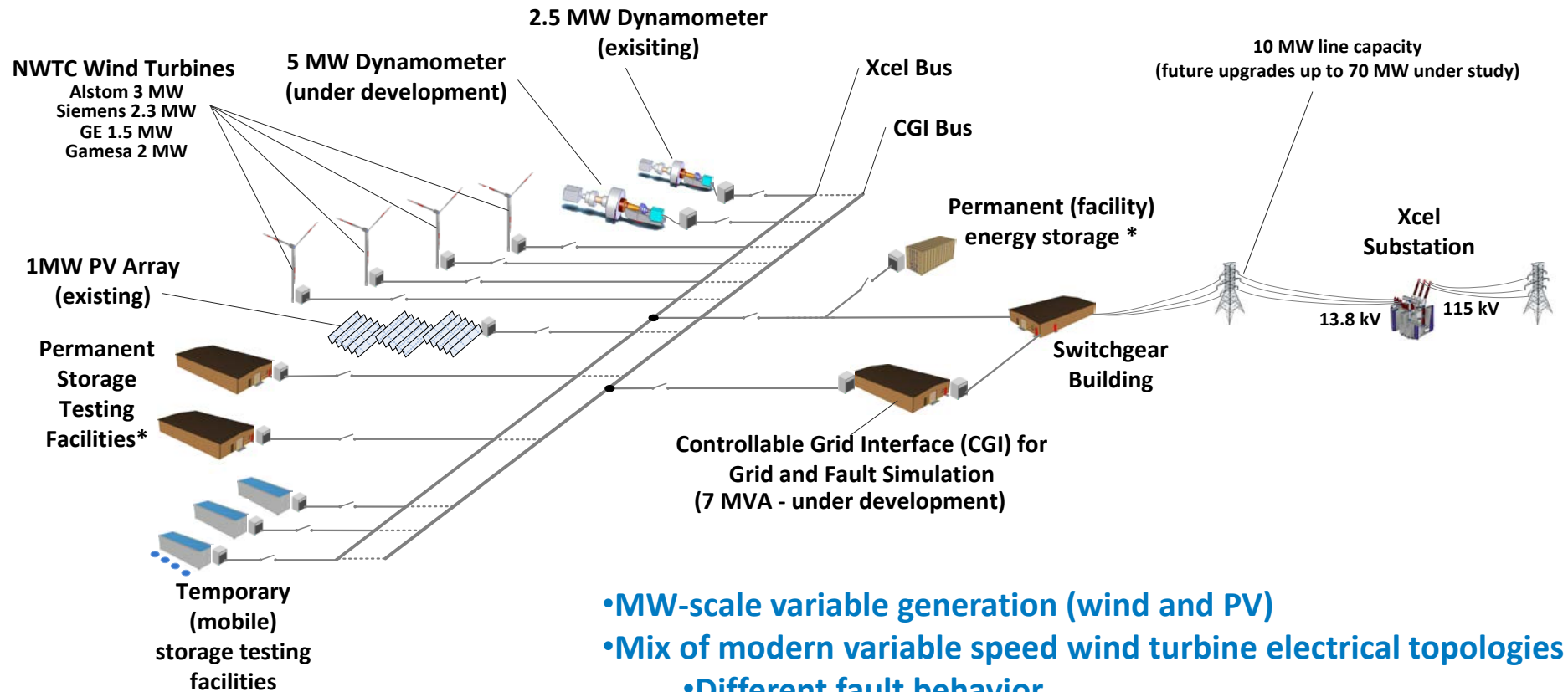


NWTC Test Site

- Total of 11 MW variable renewable generation currently at NWTC test site
- There are many small wind turbines (under 100 kW) installed as well



NWTC New Testing Capabilities – Dual Bus System



*Permanent storage facility concept is under evaluation

- MW-scale variable generation (wind and PV)
- Mix of modern variable speed wind turbine electrical topologies
 - Different fault behavior
 - Different voltage distortion spectrums
 - Different control architectures
 - Different mechanical inertia
- These conditions create unique opportunity for testing combinations of renewable technologies and energy storage

For More Information:

National Wind Technology Center (NWTC)

<http://www.nrel.gov/wind/>

Oahu Wind Integration and Transmission Study

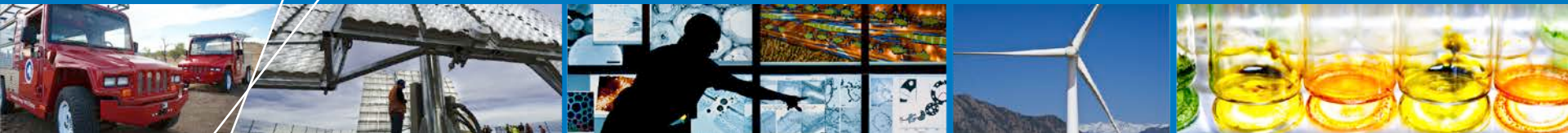
http://www.uwig.org/owits_summary_report.pdf

Puerto Rico / USVI Transmission

<http://www.edinenergy.org/pdfs/51294.pdf>

[http://www.viwapa.vi/AboutUs/Projects/ProjectDetails/11-08-02/USVI-BVI-Puerto Rico Interconnection.aspx](http://www.viwapa.vi/AboutUs/Projects/ProjectDetails/11-08-02/USVI-BVI-Puerto_Rico_Interconnection.aspx)

Hawaii Electric Vehicles



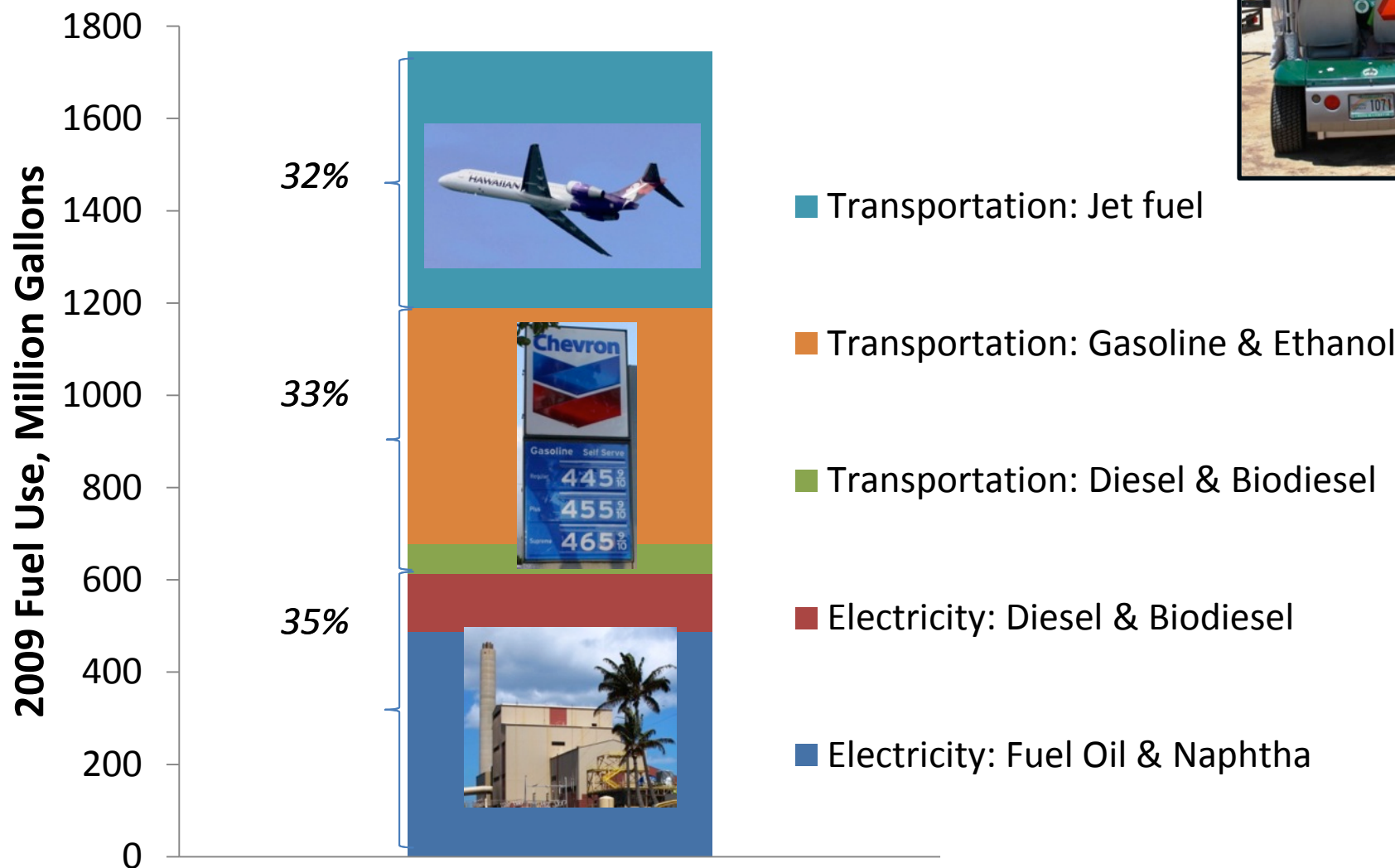
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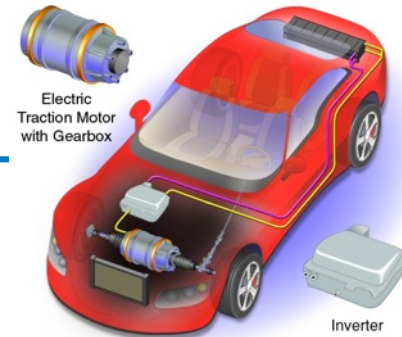
Ken Kelly, NREL

Hawaii Clean Energy Initiative

- Regional-focused Energy Strategies



Plug-in Electric Vehicles on Islands



Opportunities

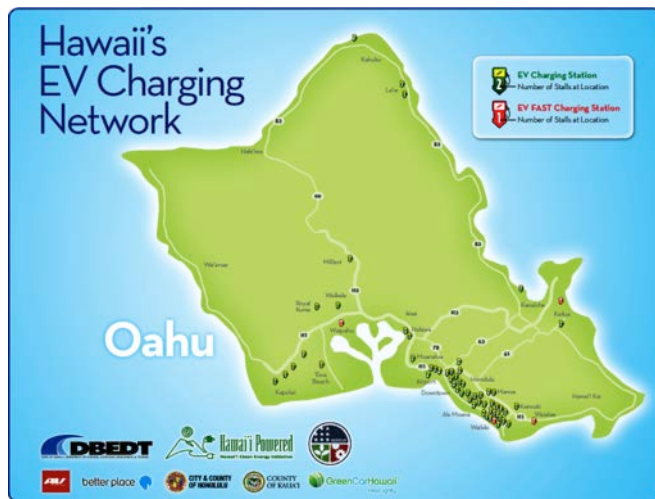
- Climate & driving limits
- Transportation fuel diversification
- Connection to smart grid and high-penetration renewables
 - Load demand management
 - Grid integration – peak shaving, energy storage
- Vehicle performance and efficiency
- Synergies with tourism industry



Potential challenges

- Market penetration – cost, availability, and vehicle turnover
- Establishing EVSE – home and public charging
- Grid impacts, control systems
- Education and outreach
- Range limitations (pure EV)

Hawaii's EV Programs



State EV-friendly policies

- ✓ EVs to park for free at state and county facilities,
- ✓ EVs access to Hawaii State HOV lanes
- ✓ Required EV Parking spaces set asides w/ chargers
- ✓ State and county agencies to Lead-by-Example in purchasing EVs
- ✓ Homeowner associations must not ban EVSE
- ✓ Active engagement with EV industry
- ✓ Utility off-peak EV charging rate demo

EV-Ready Grants & Rebates (*ARRA funded*)

- ✓ \$2.6M to establish state-wide charging infrastructure
- ✓ \$4500 EV and charger rebates

Expanding EV Charger (EVSE) Network

- ✓ Level 3 fast chargers

Smart Grid and Micro-grid demo projects

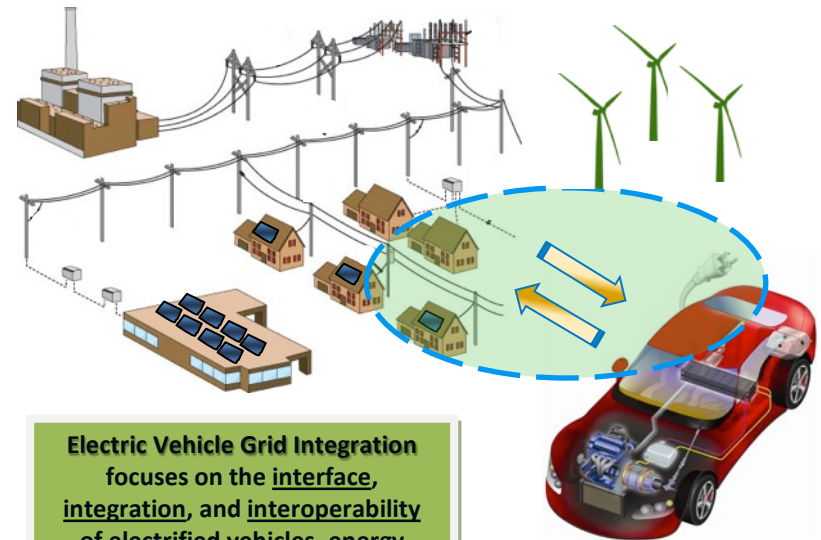
Hawaii's EV Grid Integration

US-Japan Maui Smart Grid

- integration of variable renewable energy resources on islanded grid with widespread adoption of electric vehicles
- International cooperation – public/private partnership
- Key features:
 - 200 EVs with home charging + public fast charger network
 - Smart meters and appliances
 - Integrated EMS, DMS, and μ DMS
 - EV Energy Control Center
 - RE intermittency / demand response
 - Excess renewable energy

Hawaii – Korea Smart Grid Proposal

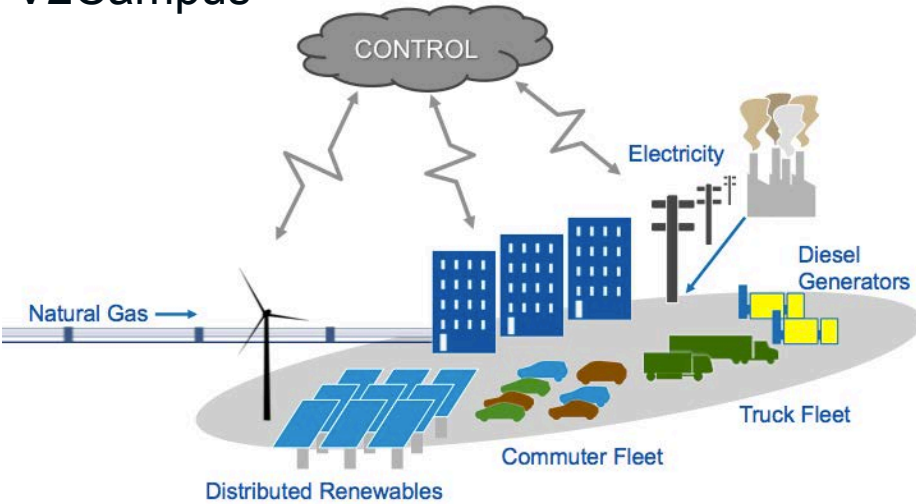
- Collaboration with hotel industry on Oahu
- focus on energy use in large commercial buildings with integrated renewable energy and electric vehicle charging



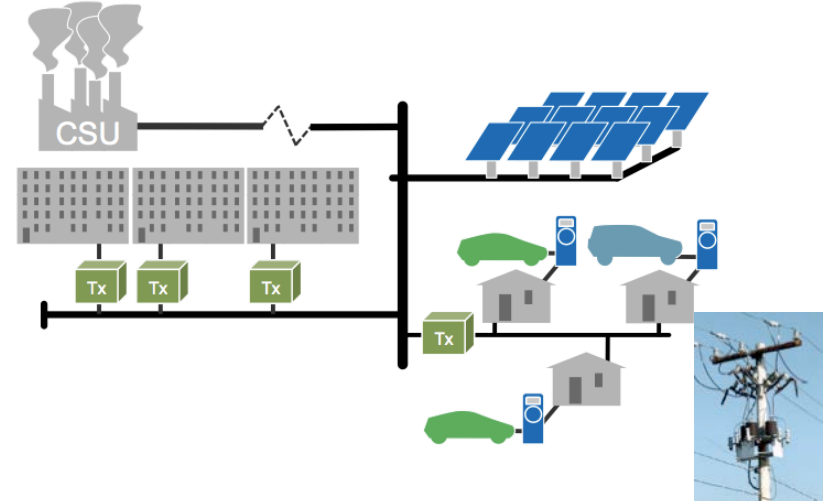
Electric Vehicle Grid Integration focuses on the interface, integration, and interoperability of electrified vehicles, energy storage systems, and the evolving smart, renewable grid.

NREL EV – Grid Integration Resources

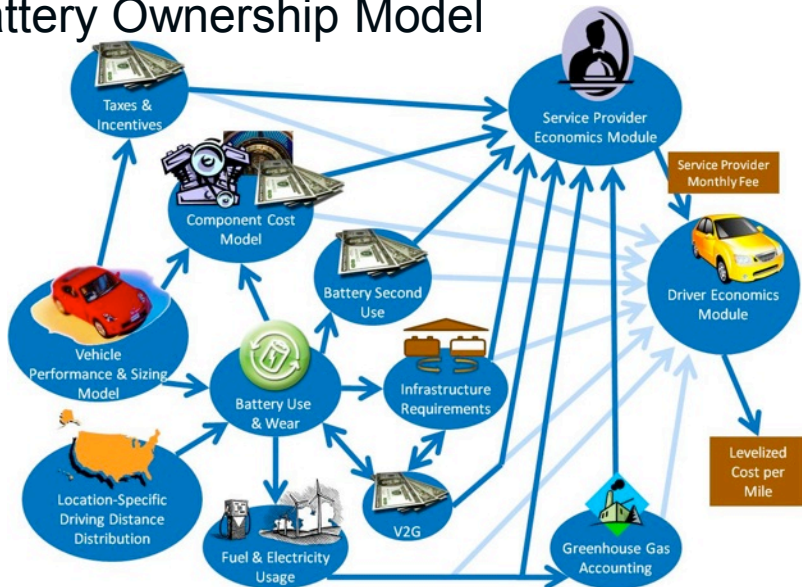
V2Campus



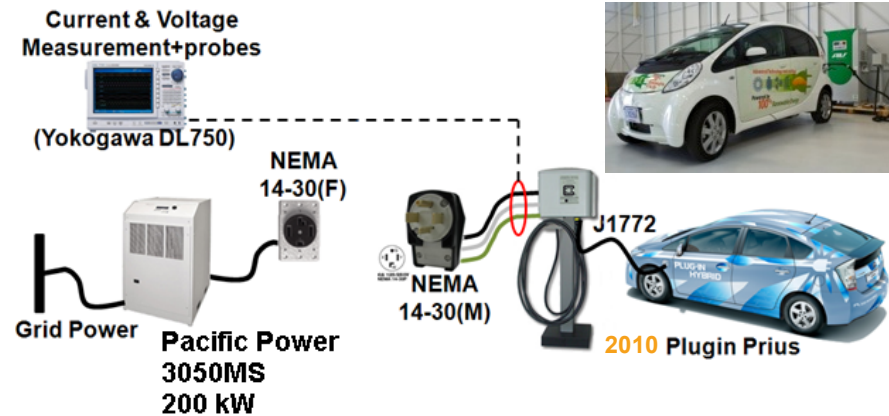
Distribution Electrical & Thermal Analysis



Battery Ownership Model



Hardware and Communications Testing



Mahalo nui loa!



Artist: Jean Charlot, Chief's Canoe (1956), Hawaii Convention Center

For More Information:

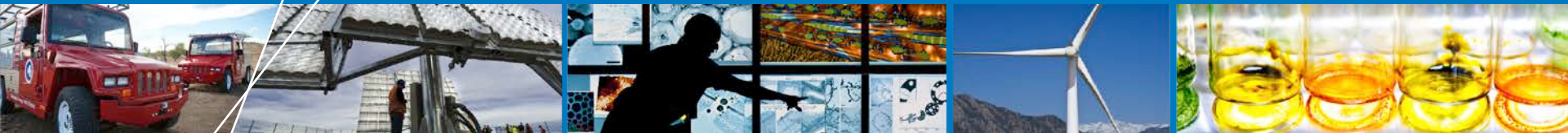
Hawaii Clean Energy Initiative

<http://www.hawaiicleanenergyinitiative.org/>

NREL Advanced Vehicles and Fuels

<http://www.nrel.gov/vehiclesandfuels/>

Integrated deployment



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Misty Conrad

Clean Energy Transformational Change

Develop an Approach That Provides:

- A comprehensive & aggressive method to address clean energy
- A focus on transformational, systemic change
- A multi-dimensional, multi-technology approach to energy sources, generation, and end-use
- An approach that addresses cross-technology linkages and gaps
- A model for the rest of the world to follow
- A vehicle to accelerate market adoption of clean energy solutions
- A way to integrate DOE's current deployment efforts

Integrated Deployment's mission is to accelerate market adoption of alternative energy solutions to power our homes, businesses and vehicles through a comprehensive and aggressive approach.

Combining Technology Solutions, Deployment Strategies & Leveraging Partnerships

Technologies

Deployment Strategies

Partnerships

Efficiency

- Residential
- Commercial
- Industrial

Renewable Generation

- Solar
- Wind
- Geothermal
- Hydro / Wave / OTEC

Renewable Fuels

- Biomass
- Hydrogen / Fuel Cells

Transportation

- Efficient Vehicles
- Electric Vehicles
- Alt. Fuel Vehicles

Grid System

- Transmission
- Distribution
- Controls

Situational Assessment

- Constituent Analysis
- Resource Assessment
- Barriers Assessment

Policy Opportunities

- Codes and Standards
- Utility Programs
- Legislation
- Utility Regulations

Economic Evaluations

- Financing Options
- Economic Development
- Business Case Development

Communication & Outreach

- Stakeholder Development
- Public Information
- Workforce Development

Leadership

- ▣ Vision & Goals
- ▣ Commitment & Dedication
- ▣ Strategy & Planning
- ▣ Political Commitment

Decision-making

- ▣ Drive policy change
- ▣ Drive regulatory change
- ▣ Reduce business risks

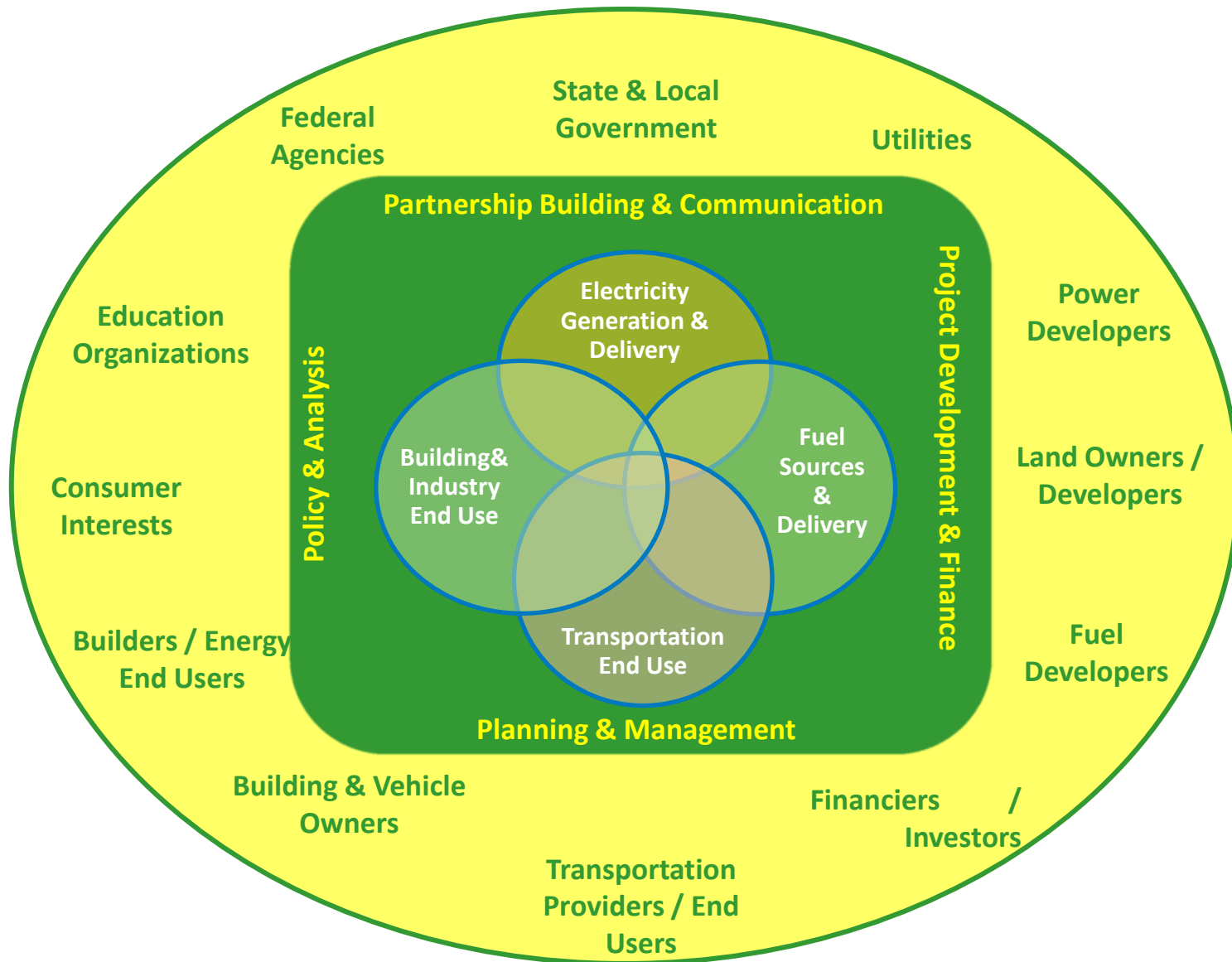
Funding

- ▣ Innovative
- ▣ Motivated

Will to Change

- ▣ Buy-in
- ▣ Engagement
- ▣ Adoption

Integrated Deployment Model



Implementation Approach & Value Proposition



Integrated Deployment's Unique Value Proposition:

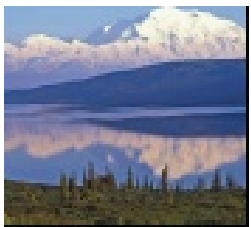
Integrated Deployment utilizes a **holistic approach** to inform energy communities who are **committed to implementing transformational energy system change** to achieve an affordable and sustainable **clean energy future**

An Aggressive Deployment Approach Can be Taken at various scales



Community/City

NREL is leading DOE support in rebuilding New Orleans and Greensburg, KS in the most energy efficient and renewable way possible



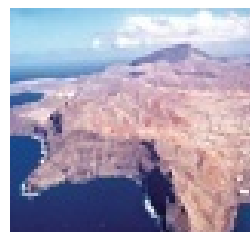
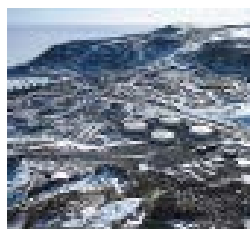
State

NREL is leading DOE efforts in Hawaii and Alaska in their pursuit for efficient and renewable solutions to reduce dependence on fossil fuel



Federal site

NREL is leading DOE support to the Department of Defense and National Science Foundation to pursue comprehensive solutions to energy independence on military installations and reduced emissions in our polar regions.



Nation

NREL is leading DOE efforts in support of the international partnership through Energy Development in Island Nations, providing comprehensive energy solutions to island nations.



For More Information:

Integrated Deployment Model Paper

<http://www.nrel.gov/docs/fy11osti/49230.pdf>

EERE's Deployment Website

<http://www1.eere.energy.gov/commercialization/deployment.html>

Thank you

Questions / Discussion

