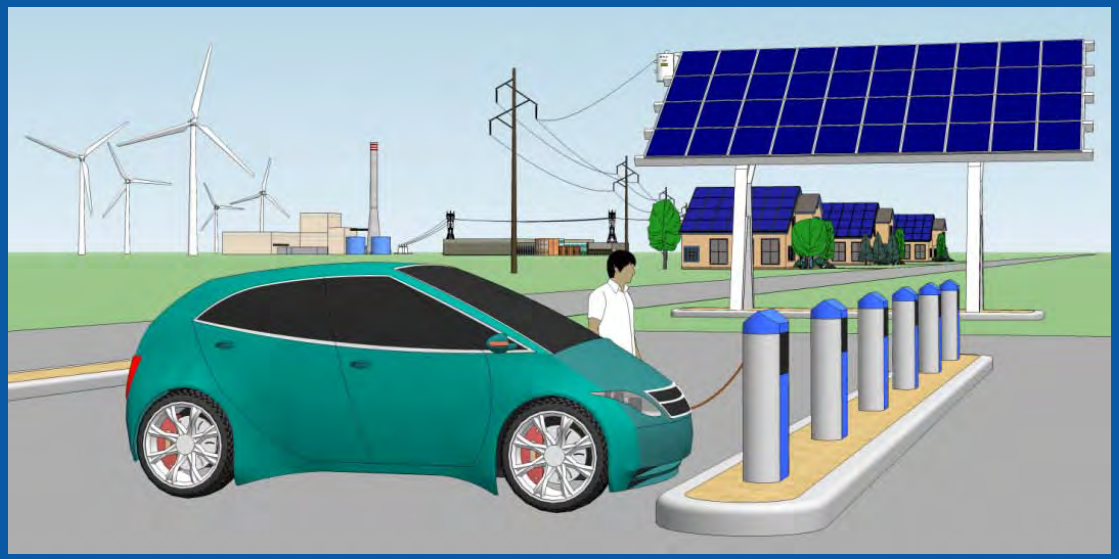
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Innovation for Our Energy Future

Plug-In Electric Vehicle Integration with Renewables



DOE Annual Merit Review

PI & Presenter: Tony Markel
Organization: NREL

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Project ID: VSS042

This presentation does not contain any proprietary, confidential or otherwise restricted information

Overview

Timeline

- Initiated FY10
  - Grid Interaction TT support
  - Review of Grid Integration studies
- FY11
  - “Green” Signal Development
  - V2G Comm. Standards
- End FY12 (proposed)
  - Systems testing with industry

Budget

- FY10
  - VT – $200K
- FY11
  - VT – $150K
  - DOE Office of Electricity - $75K (enhanced request)

Co-funding in FY11 supports cross program coordination on current and future communication scenarios and energy management features compatible with distributed systems and Smart Grid standards.

Barriers Addressed

- Risk Aversion
  - Scenario analysis to reduce uncertainty
- Technology Cost
  - Research and identify value streams
- Infrastructure
  - Standards, functions, and strategy

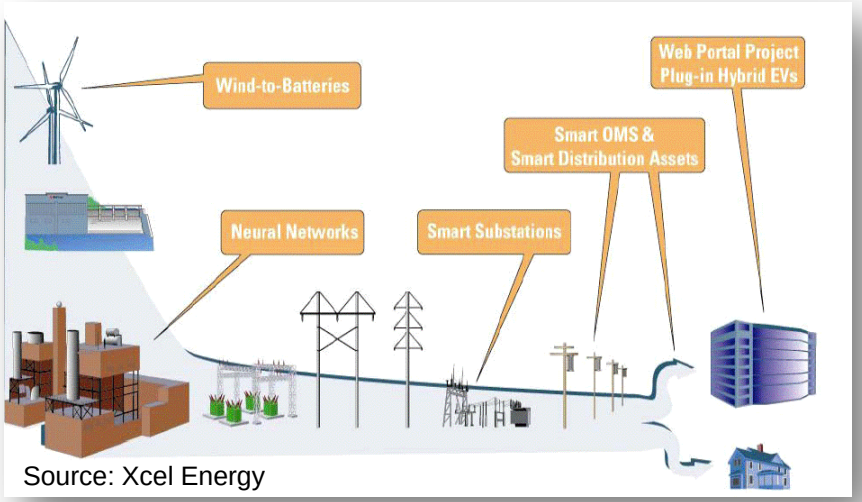
Project Partners

- Pacific Northwest National Laboratory (PNNL)
- NREL Strategic Energy Analysis and Distributed Energy Systems Integration Groups

Project Objective

PEV Integration with Renewables

- Identify opportunities for alternative value streams for plug-in electric vehicles through integration with renewables and support the definition of the infrastructure needed to enable these opportunities.



Source: Xcel Energy

Contributes to VT Program Milestones

- Development of smart charge components and infrastructure (2013)
- Creation of vehicle/grid bidirectional communications standards (2013)

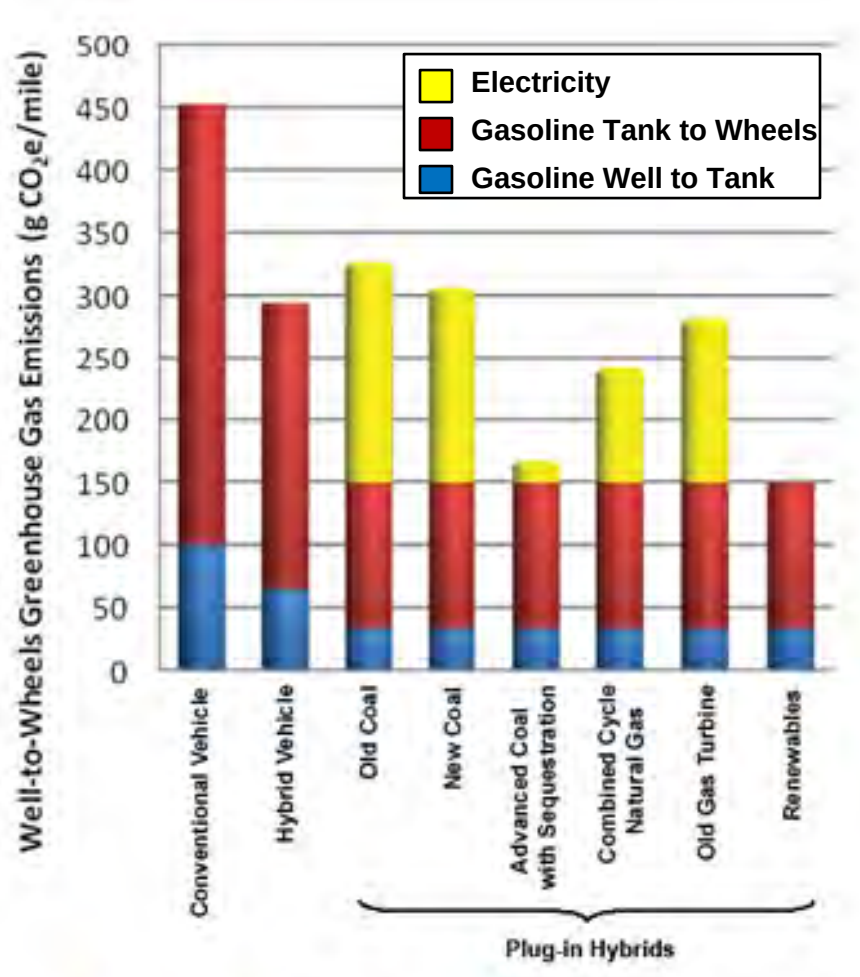
Approach

- Participate and contribute towards the development of plug-in electric vehicle communications standards development.
- Review renewable energy integration studies and grid support roles for energy storage.
- Analyze the coordination of vehicles supplying grid services.
- Summarize vehicle renewable energy integration.

Relevance

Vehicle Technologies Program Goals

- 2015, enable 50% reduction in petroleum consumption
  - Based on simulations, PHEVs will reduce per vehicle petroleum savings by 40-60%
    - Contributing to communications codes and standards enables tech intro and adoption
    - Infrastructure assessment and planning enables vehicle utility
- 2030, enable 80% of energy from non-carbon sources
  - PEVs powered by renewable resources achieves >80% reduction in CO_2 emissions
    - Smart Charge strategies and V2G enable connection between PEVs and Renewables
    - Demand for grid services increases with renewable growth – PEV value stream



Source: EPRI 2007 Report #1015325

Accomplishments

Integration of vehicles with the grid and the creation of alternative value streams to aid in PEV market expansion

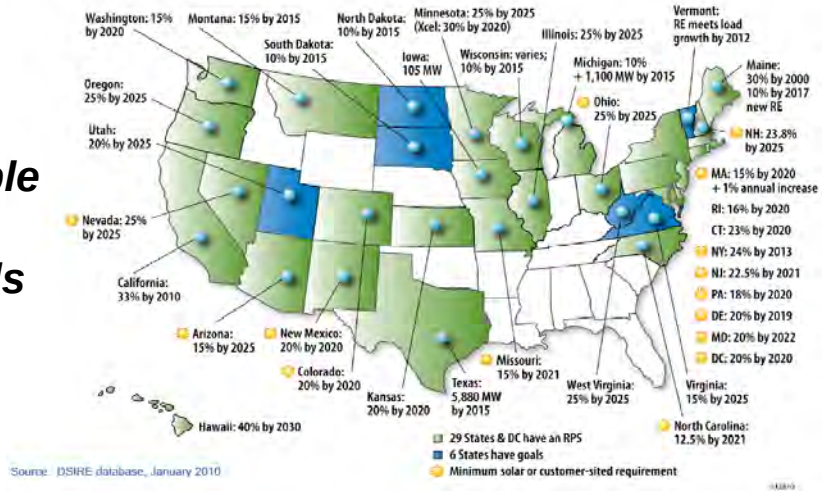
- Reviewed existing literature for renewable energy integration challenges and methods of addressing these challenges.
- Published results of vehicle communications analysis scenarios and infrastructure challenges and opportunities.
- Contributed to the communications standards development process.

Accomplishments
Literature Review

The Role of Energy Storage with Renewable Electricity Generation.
Denholm, P.; Ela, E.; Kirby, B.; Milligan, M.; January 2010.

- Think of renewables as a load reduction resource, not as dispatchable generation
- With high penetration renewables, the net load is more transient and system inertia is decreased
- Growth of wholesale markets increases opportunities for energy storage

Renewable Portfolio Standards

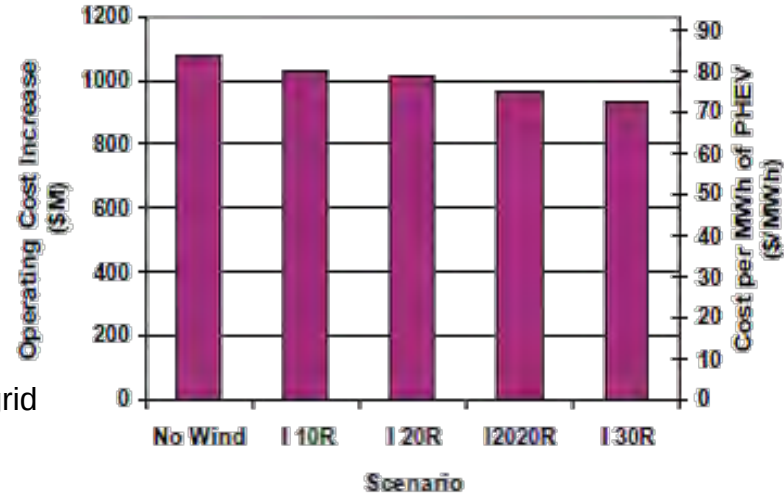


Assessment of Plug-in Electric Vehicle Integration with ISO/RTO Systems.
ISO/RTO Council. March 2010.

- Discusses current and future applications for vehicles managed through grid communications
- Highlights the value of standards development efforts in enabling markets
- One-way communication enables load shaping functions while two-way communication in future enables market participation of vehicles with aggregators

Western Wind and Solar Integration Study.
Law, D. GE Energy; May 2010.

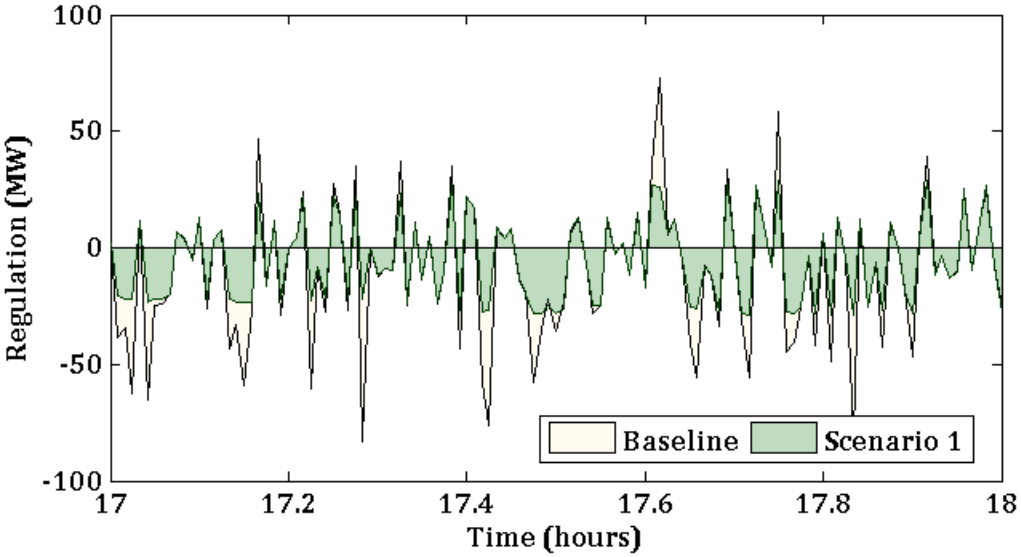
- Targeted 20-30% renewable energy integration in western region
- Included 5GW of nighttime electric vehicle load
- Increased evening loads due to PHEVs reduced the cost of RE generation by about 15% (see figure below)

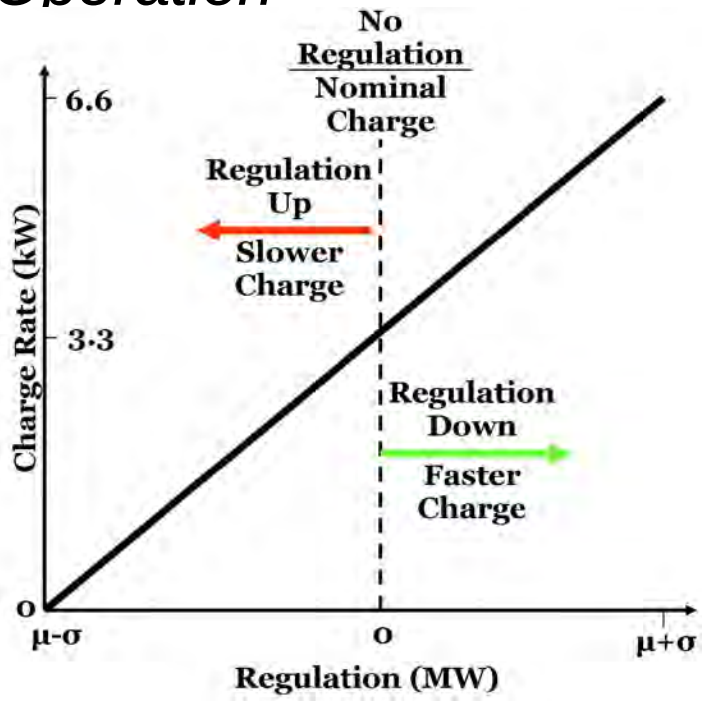


Accomplishments
Strategy/Planning Publications

"Value of Plug-in Vehicle Grid Support Operation"

- Analysis of Smart Charge linked to grid regulation signal (ACE*)
- Vehicles respond to ACE broadcast signal
  - Scaled to represent value between [-1,1]
- Charge rate is adjusted from nominal depending on ACE





- 1% fleet as PEVs provided 70% of grid regulation demand (Scenario 1)
- 5% fleet as PEVs provides 100% of regulation services (Scenario 2)

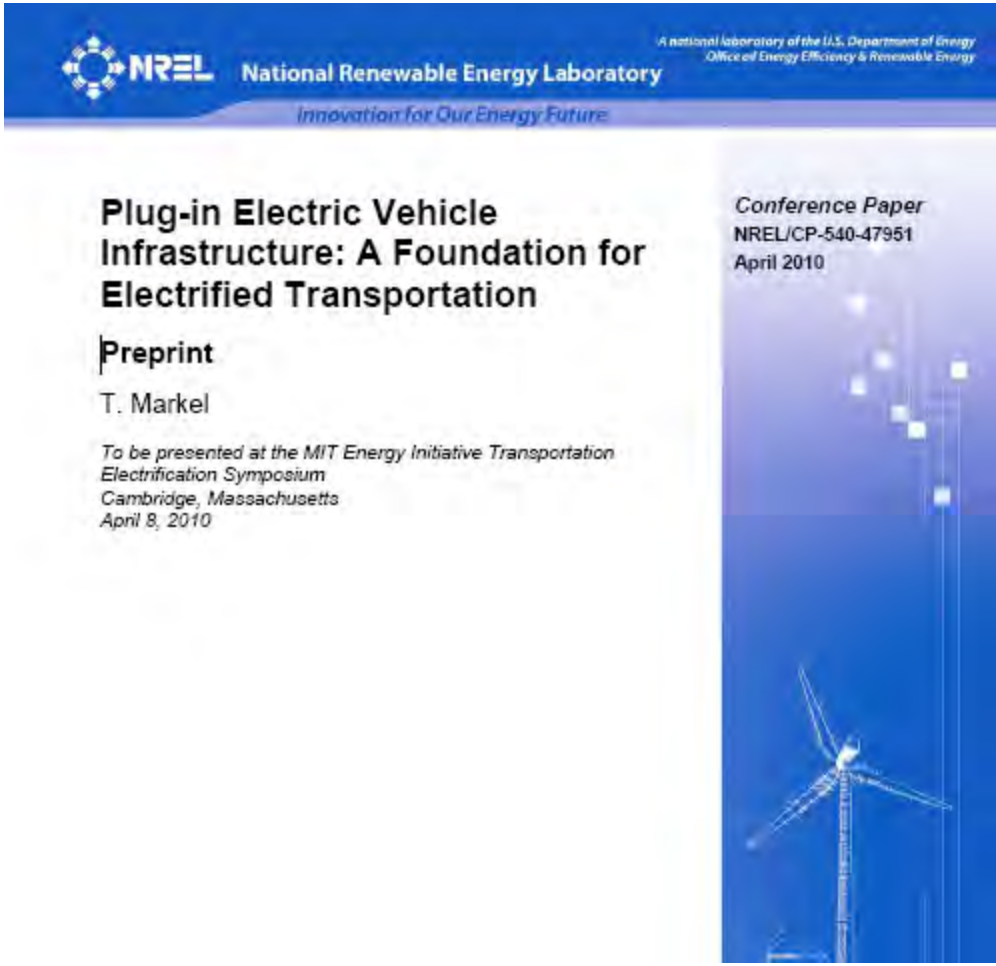
ACE – Area Control Error (indicator of difference between grid supply and demand)

Accomplishments
Strategy/Planning Publications

"Plug-in Hybrid Electric Vehicle Infrastructure – A Foundation for Electrified Transportation"

- Summarized the components of the PEV infrastructure, challenges and opportunities related to the design and deployment of the infrastructure, and the potential benefits.

- Presented at *MIT Transportation Electrification Symposium*



Accomplishments
Communications Standards

- **SAE J2836** - *Use Cases for Communication between PEVs and Grid Components*

- **SAE J2847** - *Communication Messages between PEVs and Grid Components*

- Review and comment on the development of these standards as they relate to smart grid and renewable resources.

Collaboration and Coordination

- Society of Automotive Engineers
- Pacific Northwest National Laboratory
- NREL Strategic Energy Analysis and Distributed Energy Integration Groups

Summary

Integration challenges of renewables include:

- Increased transients in net load
- Reduced system inertia to maintain stability
- Localized distribution system stability impact
- Data collection, analysis, and forecasting methods are under development.

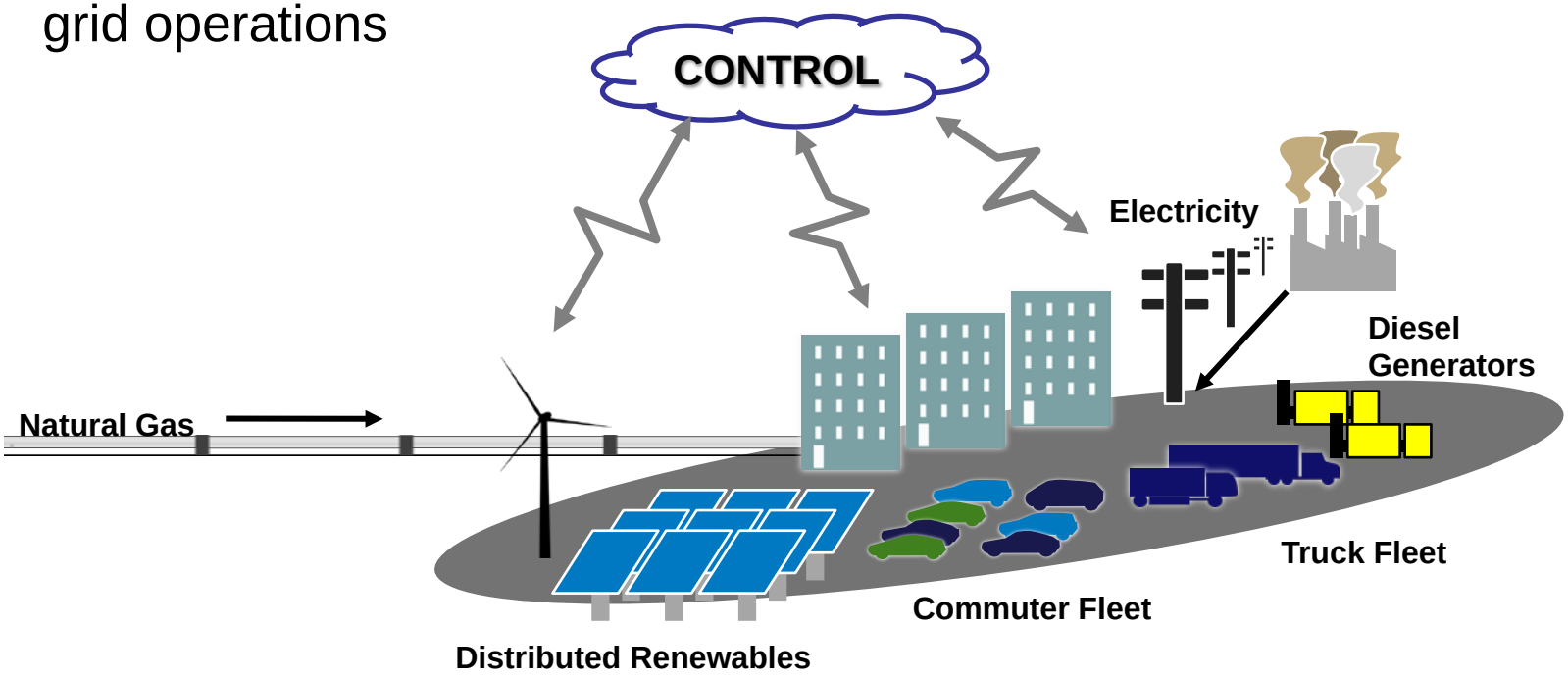
Plug-in vehicles can enable RE integration when,

- Charge and discharge events are planned and coordinated through communications
- Standards are defined that lead to consistent interfaces between vehicles and grid components
- Policies continue to support growth of renewables and PEVs in parallel and enable value stream accountability

Summary

FY11 Project Plans

- Define a “green” signal for charge and discharge management of plug-in vehicles that addresses both local and regional renewable energy and vehicle integration challenges
- Use industry-led communication standards definitions to evaluate and demonstrate vehicle energy management integrated with electricity grid operations



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Questions?