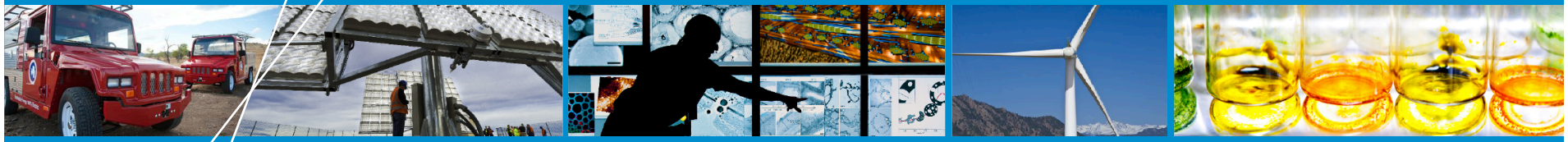
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

What's up in energy?

Current trends, activities, insights

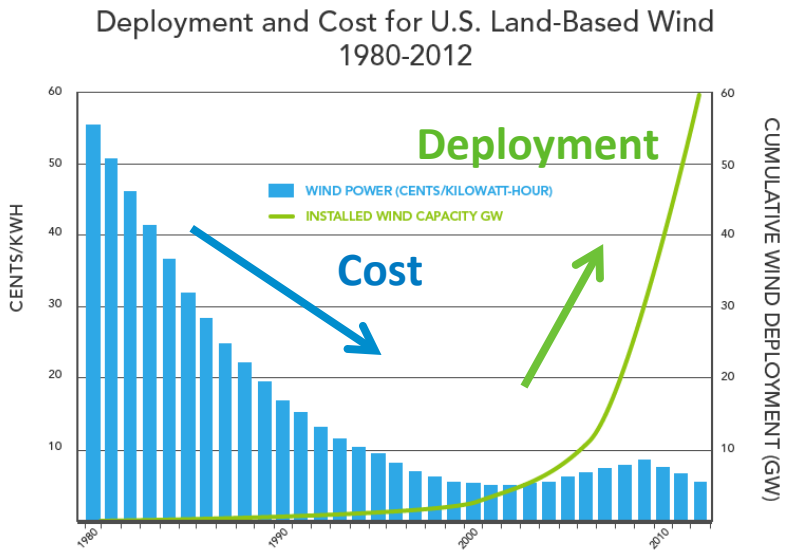


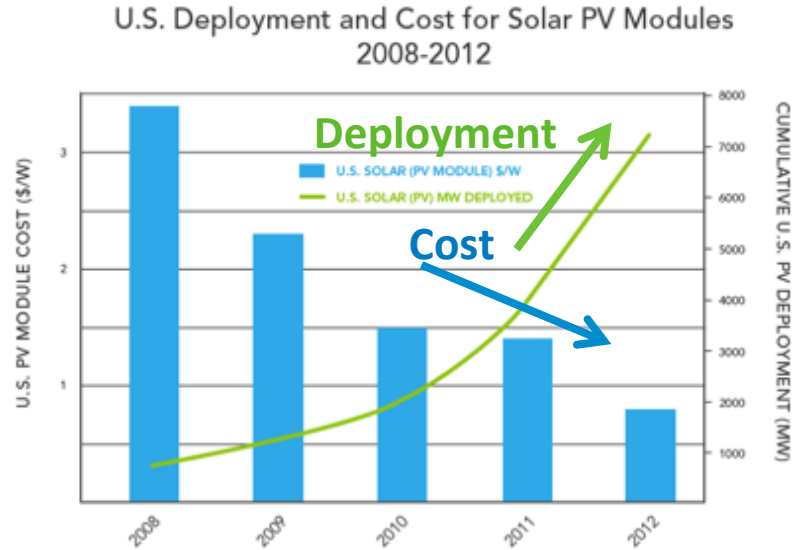
JISEA Annual Meeting

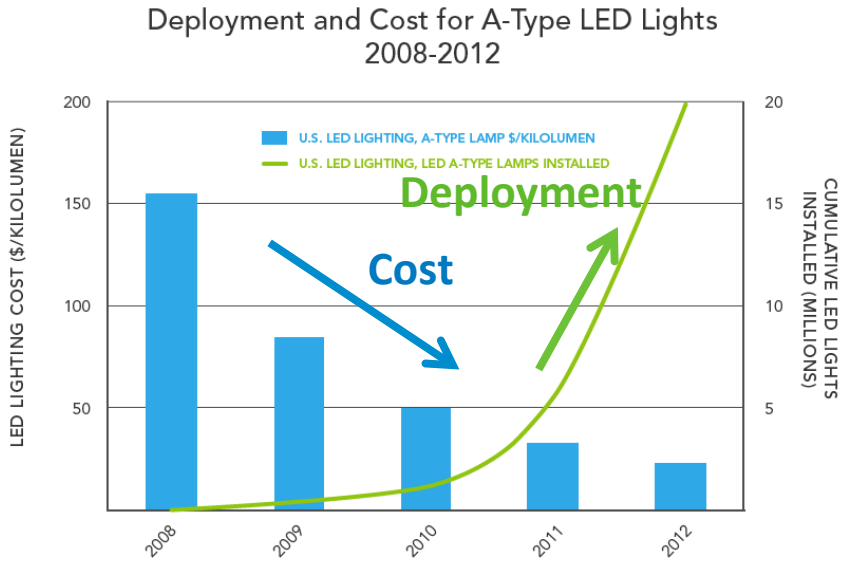
Robin L. Newmark
Energy Analysis and Decision Support
March 12, 2015

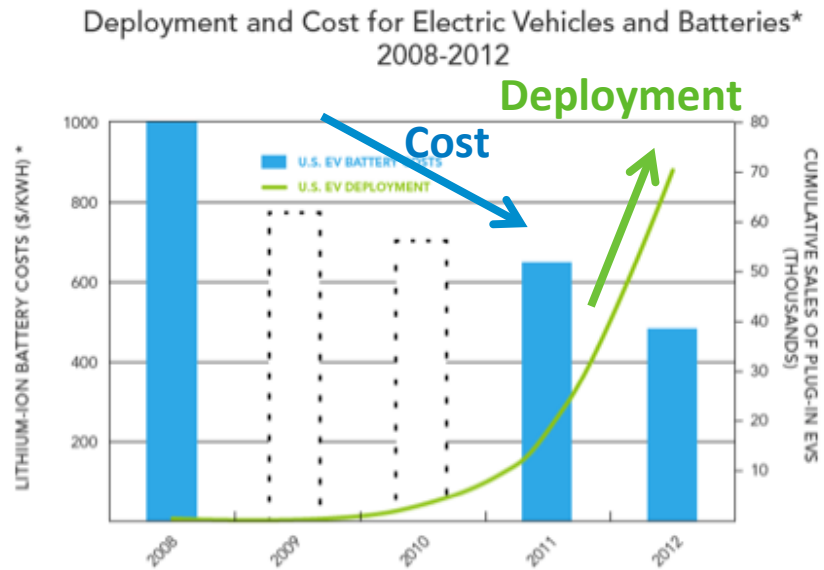
NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Future Energy Systems are Emerging …







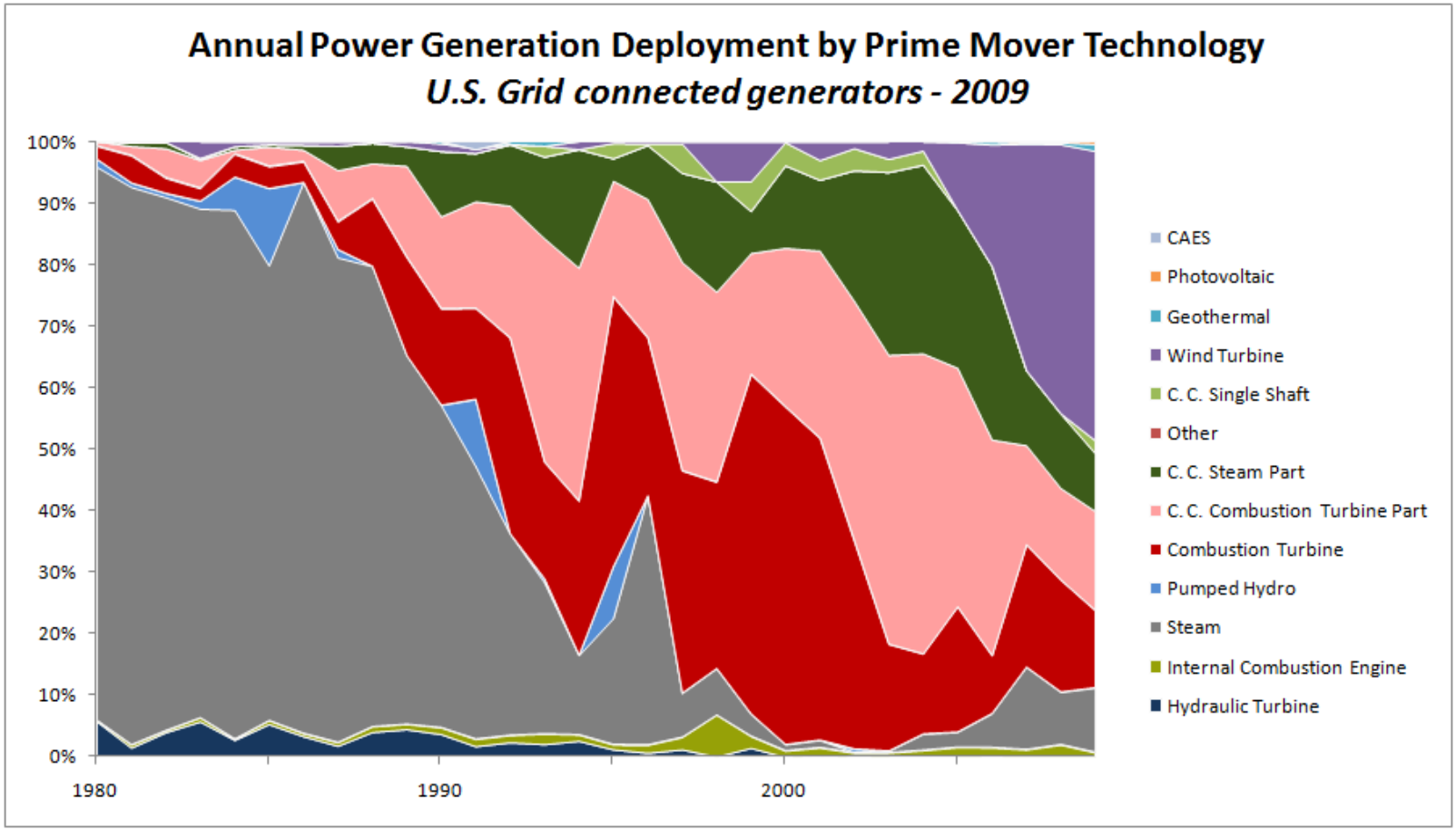


Source: "Revolution Now: The Future Arrives for Four Clean Energy Technologies", DOE, 2013

The system is becoming more complex

"Modernizing the grid requires advances on many fronts ranging from policy to information and security to physical infrastructure"

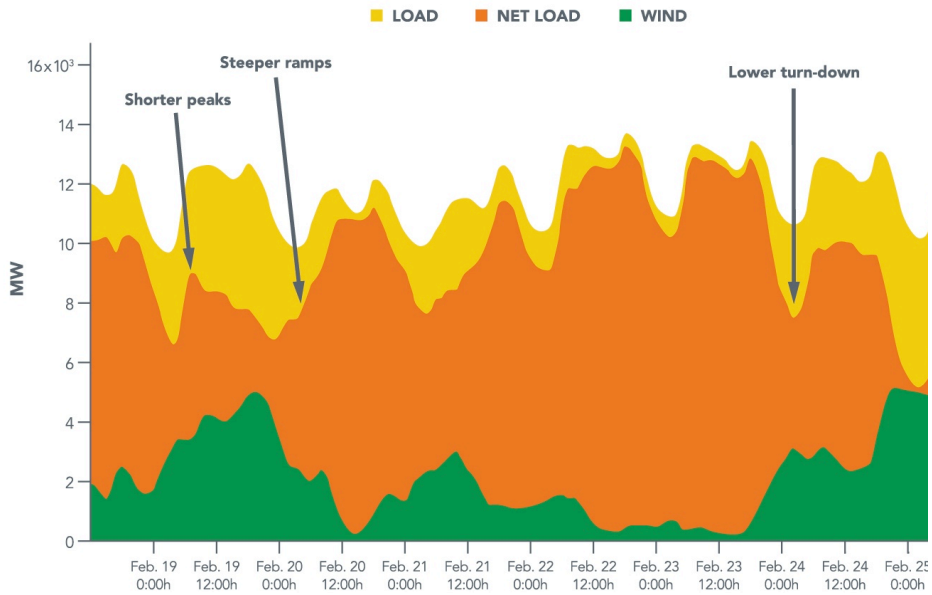
DOE Quadrennial Technology Review, 2011



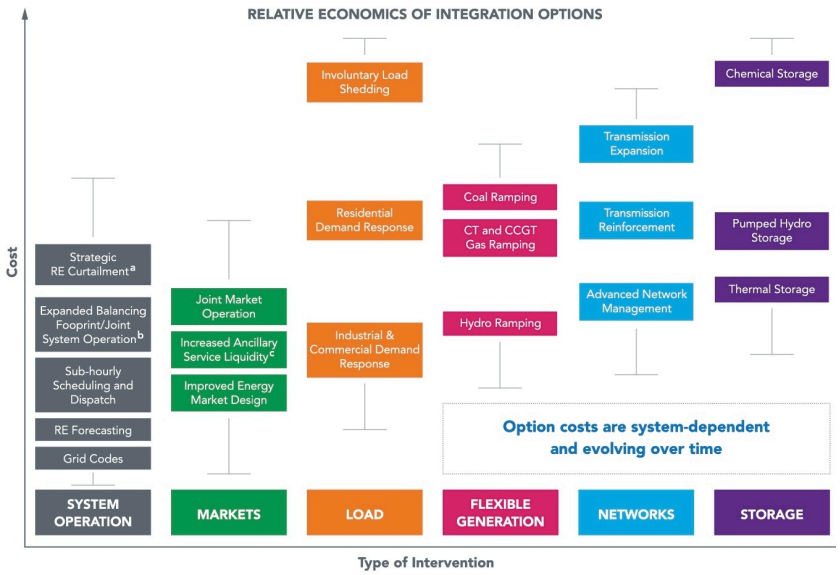
Source: Avi Gopstein, DOE, EIA

New dimensions in the power sector:
Increasing wind and solar can create a greater need for flexibility

Flexibility: The ability of a power system to respond to change in demand and supply



There are a wide range of options to increase flexibility…*each with different benefits and costs*



Ongoing studies explore different options, applied under different sets of conditions

Source: Cochran (2015)

http://www.nrel.gov/docs/fy14osti/61721.pdf

Where do we see things going?

Internet of things

Energy internet of things

- ***Always On - Always Connected***
- ***Systems intelligence, interaction and automation***

Smart grid

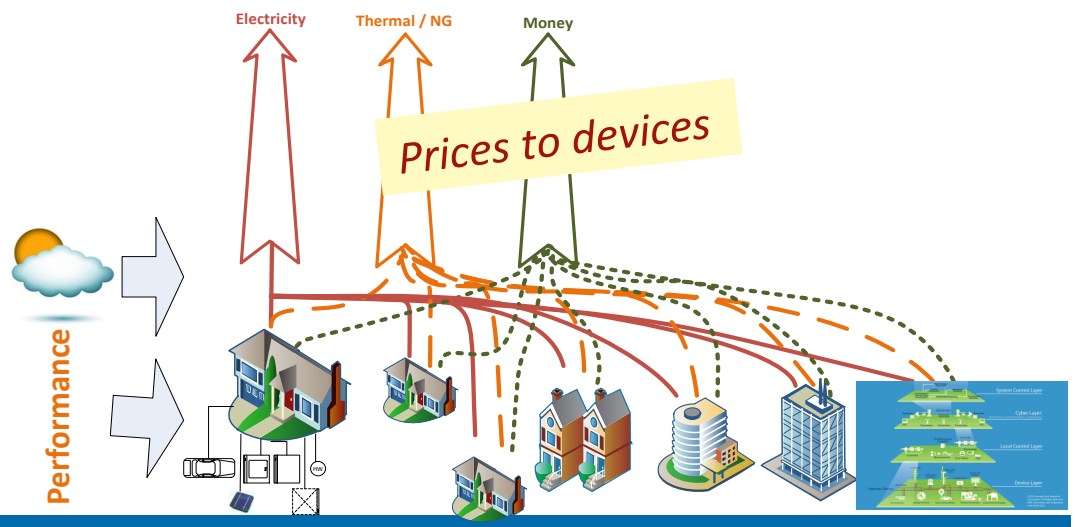
Smart homes

Smart appliances

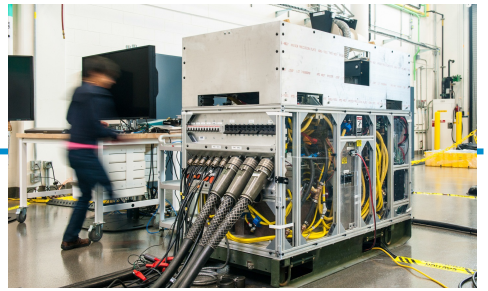
Smart devices

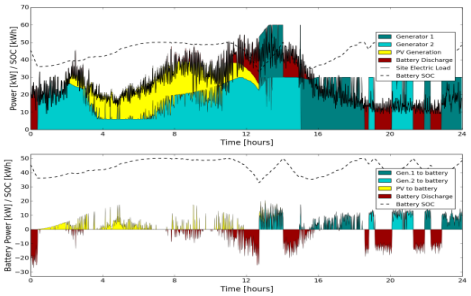
Increasing consumer involvement

Integrated energy system model (IESM) simulates the effects of retail market structures, coordination, and scheduling on energy use and production at buildings and campuses



Where do we see things going?





Resilience

Internet of things

Scalable Energy Sources and Storage –
from central plant to distributed and mobile to personal

New and evolving business models

- Transition from ***products*** to ***services***
- Public vs. private sector
- Partners & collaborators
- Increasing consumer involvement

Fairness: who pays?
Emerging structures?
Policies?

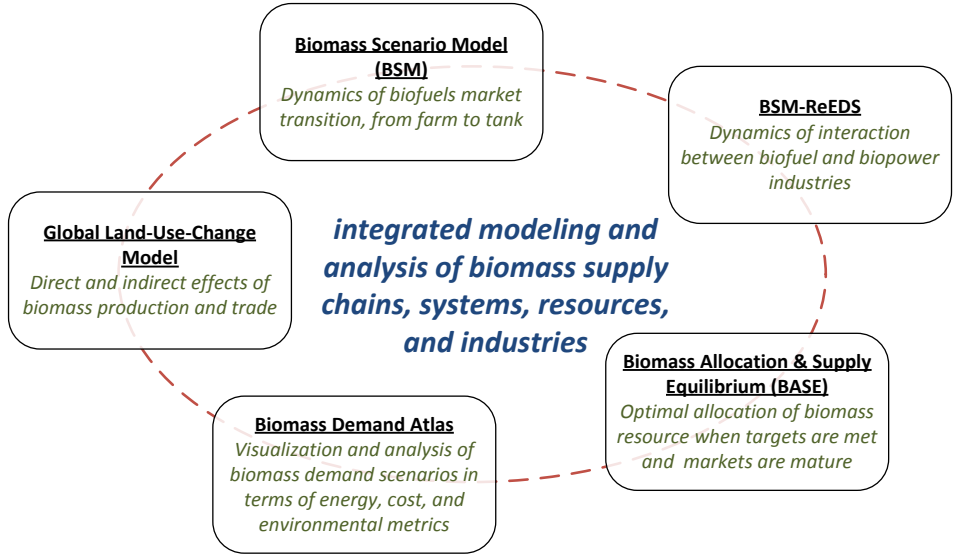
SolarCity

Exploring different energy futures

- **Business as usual**
- **Low-carbon, centralized generation**
- **Rapid growth of DER**
- **Interactivity: grid and demand**
- **Grid defection**

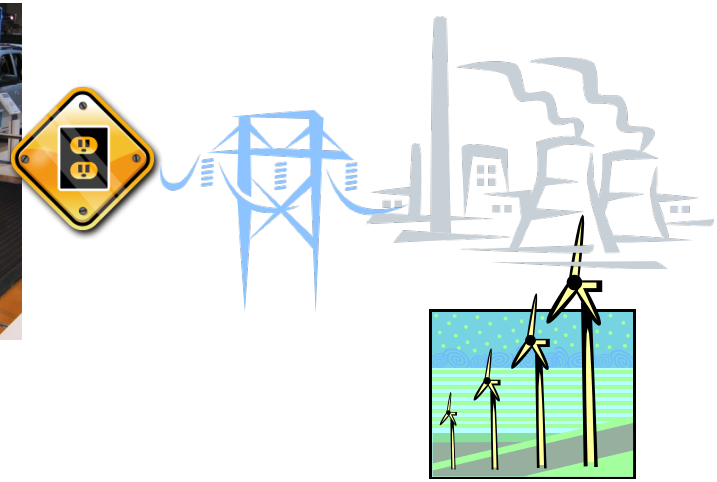
Where do we see things going?

Alternative fuels options



Biomass, Biofuel, and Biopower System Analysis

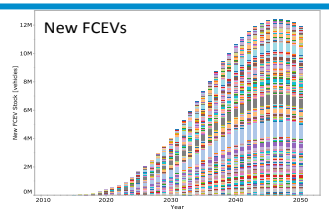
Electrification

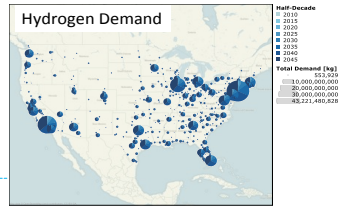


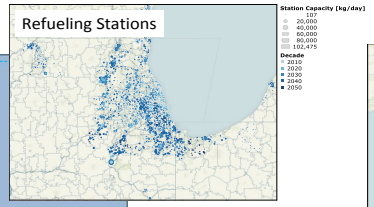
Adoption
Impacts
- on power system
- on emissions

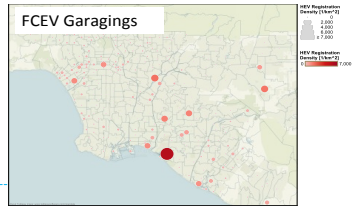
Where do we see things going?

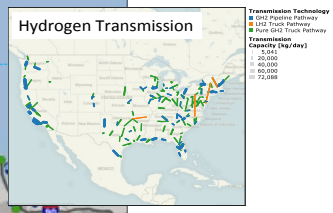
Alternative fuels options

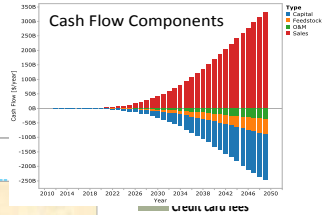


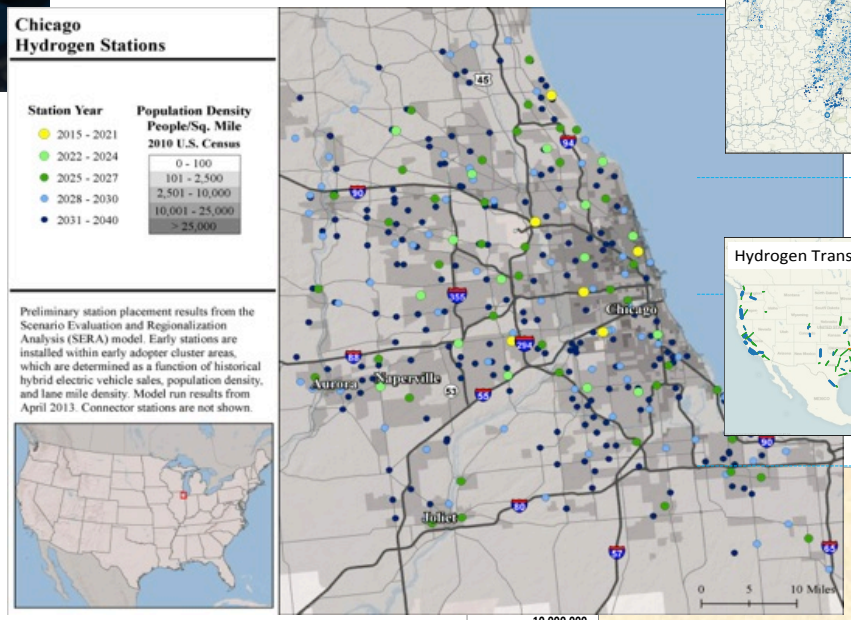




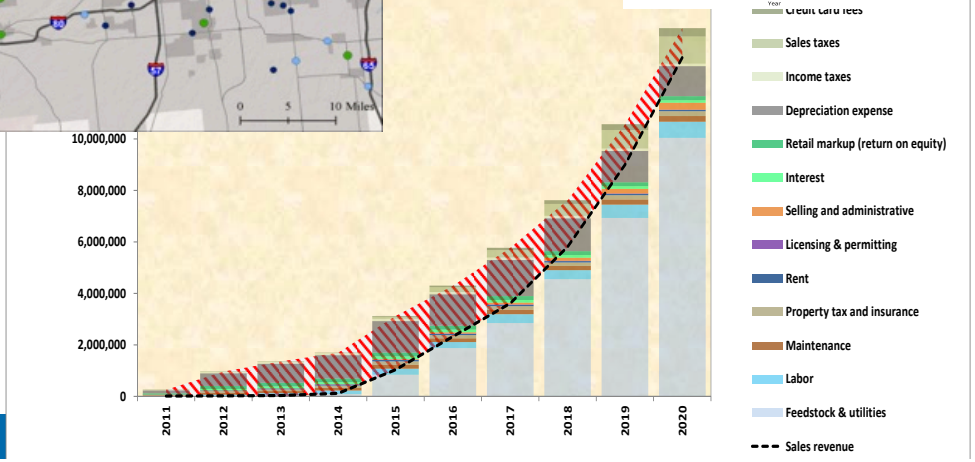






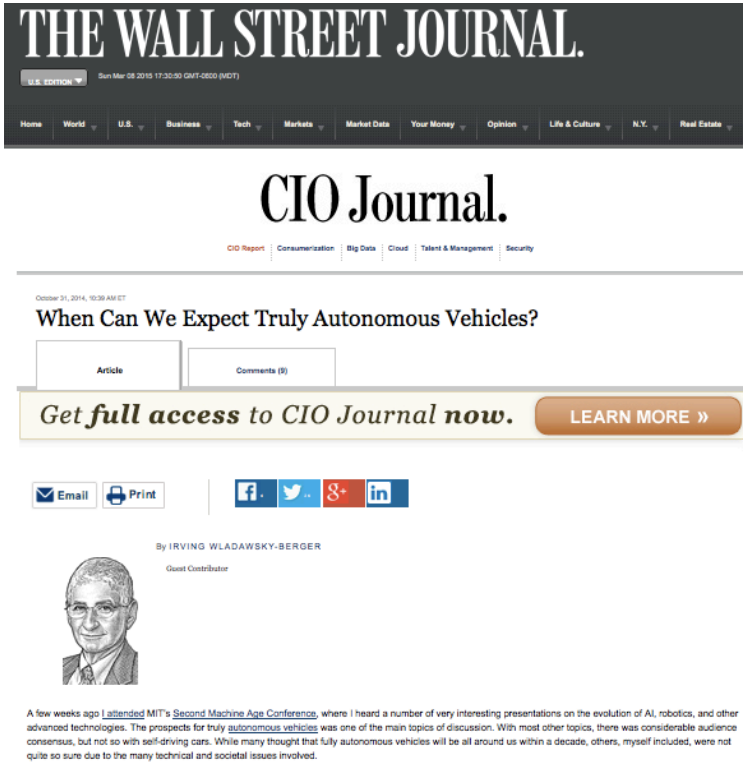


Infrastructure requirements and financials



Where do we see things going?

Automated and connected vehicles



THE WALL STREET JOURNAL.

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October 31, 2014, 10:39 AM ET

When Can We Expect Truly Autonomous Vehicles?

Article | Comments (9)

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By IRVING WLADAWSKY-BERGER

Guest Contributor

A few weeks ago I attended MIT's Second Machine Age Conference, where I heard a number of very interesting presentations on the evolution of AI, robotics, and other advanced technologies. The prospects for truly autonomous vehicles was one of the main topics of discussion. With most other topics, there was considerable audience consensus, but not so with self-driving cars. While many thought that fully autonomous vehicles will be all around us within a decade, others, myself included, were not quite so sure due to the many technical and societal issues involved.

New and evolving business models

- Consumer choice is key
  - ✓ Demographics have an influence

UBER

Where do we see things going?

Urbanization: *the ultimate systems integration opportunity?*

Cities Leading through Energy Analysis and Planning (C-LEAP):

Helping cities transition to a Clean Energy Economy

Urban Systems Science & Engineering

Toward zero emissions, zero energy waste, resilient cities

CO Resiliency Pilot Project: *focus on Energy and Water Security*

White House State, Local and Tribal Leaders Task Force on Climate Preparedness and Resiliency

Energy systems integration:
seeking efficiencies, increasing resilience

Systems thinking:

- ✓ Technologies
- ✓ Policies
- ✓ Institutions

The Electricity Journal
Volume 25, Issue 10, December 2012, Pages 38–48

Interactions, Complementarities and Tensions at the Nexus of Natural Gas and Renewable Energy

April Lee, Owen Zinaman, Jeffrey Logan, Morgan Bazilian, Douglas Arent, Robin L. Newmark

JISEA Joint Institute for Strategic Energy Analysis

Natural Gas and the Transformation of the U.S. Energy Sector: Electricity

Jeffrey Logan, Garvin Heath, and Jordan Macknick
National Renewable Energy Laboratory

Elizabeth Paranhos and William Boyd
University of Colorado Law School

Ken Carlson
Colorado State University

Energy Conversion and Management
Volume 78, February 2014, Pages 684–694

Nuclear-renewable hybrid energy systems: Opportunities, interconnections, and needs

Mark F. Ruth[a], Owen R. Zinaman[a], Mark Antkowiak[a], Richard D. Boardman[b], Robert S. Cherry[b], Morgan D. Bazilian[c]

Renewable Energy
Volume 74, February 2015, Pages 815–824

Thermodynamic evaluation of solar integration into a natural gas combined cycle power plant

Guangdong Zhu[a], Ty Neises[a], Craig Turchi[a], Robin Bedilion[b]

JISEA Joint Institute for Strategic Energy Analysis

Exploring the Potential Business Case for Synergies Between Natural Gas and Renewable Energy

Jaquelin Cochran, Owen Zinaman, Jeffrey Logan, and Doug Arent
National Renewable Energy Laboratory (NREL)

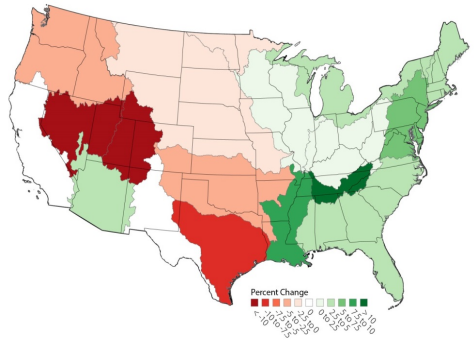
Energy systems integration:
seeking efficiencies, increasing resilience

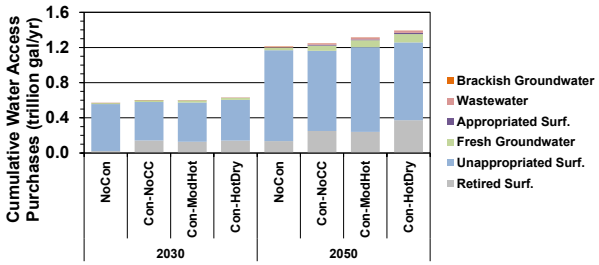
Systems thinking:

- ✓ **Technologies**
- ✓ **Policies**
- ✓ **Institutions**

Difference in 2050: Hotter, dryer climate (Hot-Dry climate - no Constraints)

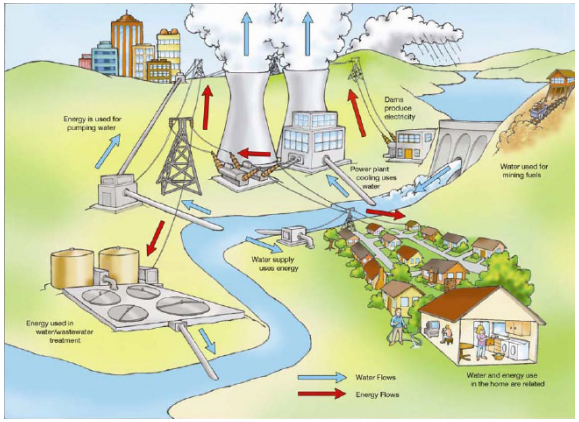
Δ Consumption





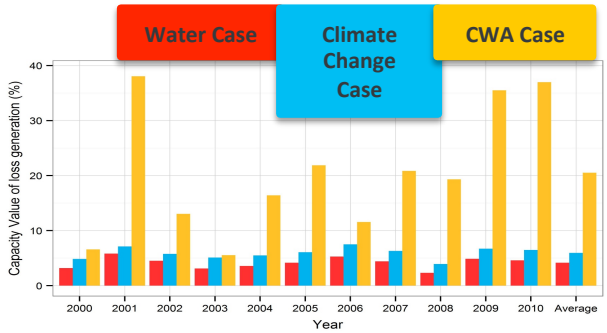
Source: Newmark et al., 2014

Energy-Water Land (or Food) Nexus



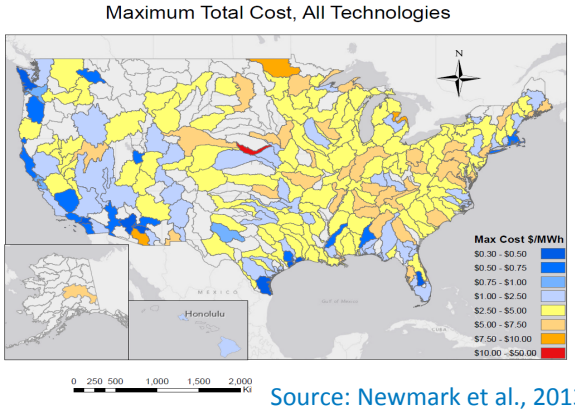
Source: The Water-Energy Nexus: Challenges and Opportunities, DOE, July, 2014

Linked models demonstrate water-related vulnerabilities and costs



Source: Macknick et al., 2014

Transition: zero freshwater withdrawal for thermoelectric generation: retrofit *ΔLCOE*



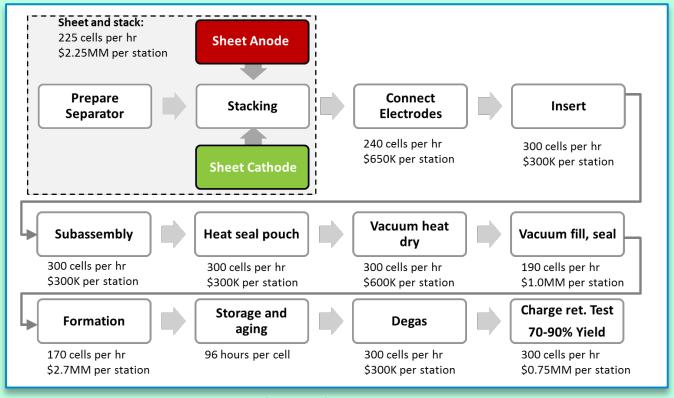
Source: Newmark et al., 2013

Clean Energy Manufacturing Analysis

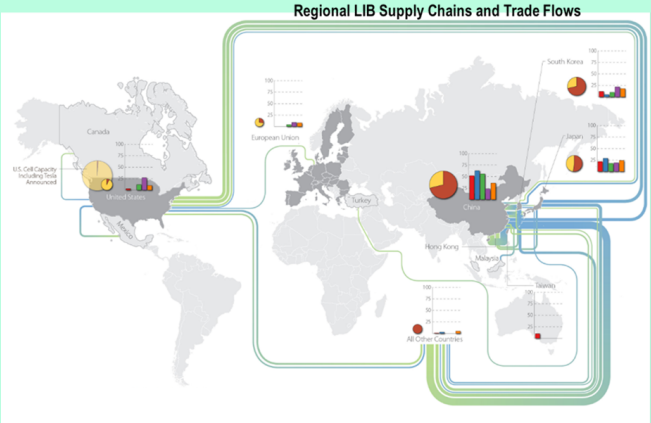
- insights to inform

CEMAP
Clean Energy Manufacturing Analysis Program

Technoeconomic Analysis – Detailed Cost Models: LIB Cell Production Process

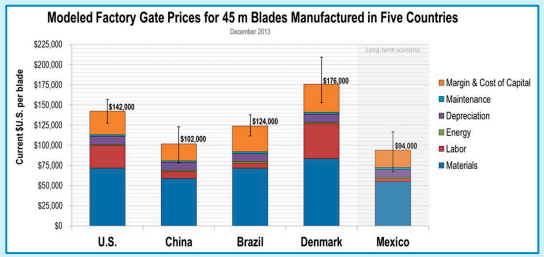


Global supply chain assessment



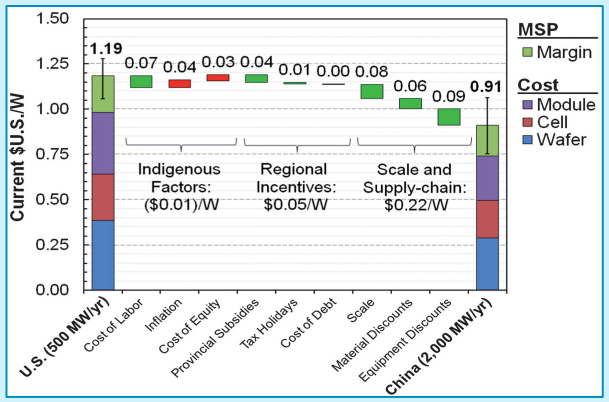
Chung, D.; Elgqvist, E. (2015). Automotive Lithium-ion Battery (LIB) Supply Chain and U.S. Competitiveness Considerations. NREL Report *in-press*.

Comparative cost analysis



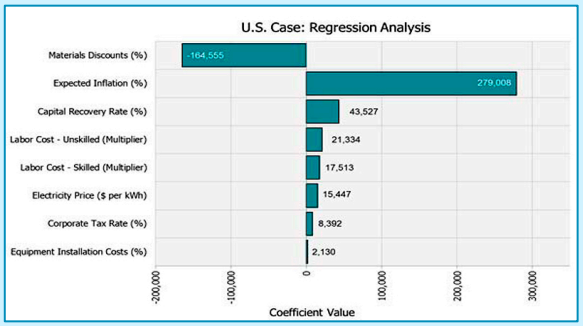
James, T.; Goodrich, A. (2013). Supply Chain and Blade Manufacturing Considerations in the Global Wind Industry (Presentation). NREL (National Renewable Energy Laboratory). 36 pp.; NREL Report No. PR-6A20-60063.

Analysis of the impact of qualitative factors



Goodrich, A. C.; Powell, D. M.; James, T. L.; Woodhouse, M.; Buonassisi, T. (2013). Assessing the Drivers of Regional Trends in Solar Photovoltaic Manufacturing. Energy and Environmental Science. Vol. 6(10), 1 October 2013; pp. 2811-2821; NREL Report No. JA-6A20-58652

Sensitivity analysis



James, T.; Goodrich, A. (2013). Supply Chain and Blade Manufacturing Considerations in the Global Wind Industry. NREL (National Renewable Energy Laboratory). 36 pp.; NREL Report No. PR-6A20-60063.

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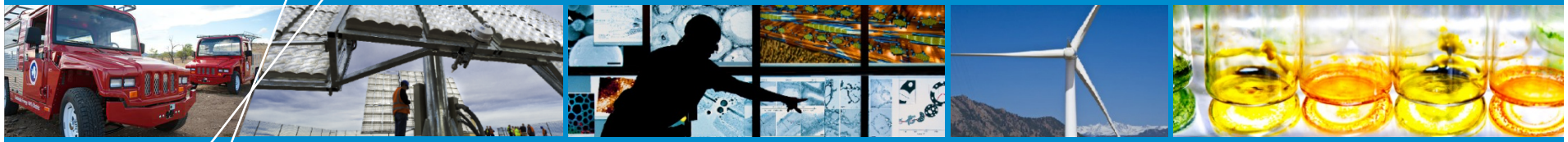
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