The Future of Sustainable Transportation Fuels

Coupling the Electric Power and Transportation Sectors:
Electric vehicles and beyond

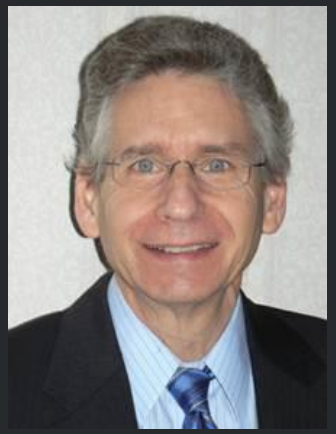
LightSpeed Solutions
Secure Energy • Sustainable Fuels

Introduction

Future of Sustainable Transportation Fuels

Ellen B Stechel, PhD
Deputy Director,
ASU LightWorks
Managing Director,
Light*Speed* Solutions

Light*Speed* Solutions, an initiative of Arizona State University LightWorks in partnership with the Security and Sustainability Forum is hosting **The Future of Sustainable Transportation Fuels Forum**, a free four webinar series to engage the range of fuels stakeholders in online conversations about the future of sustainable transportation fuel production and use.



Edward Saltzberg. PhD
Managing Director,
Security & Sustainability Forum

LightSpeed Solutions
Secure Energy • Sustainable Fuels

ASU LightWorks
ARIZONA STATE UNIVERSITY

SECURITY & SUSTAINABILITY FORUM
Convening Global Experts to Guide Decision Making

Webinar Details

Future of Sustainable Transportation Fuels Webinar Series

- Anchoring Themes (access video)
- Coupling the electric power and transportation sectors – June 30
- Recycling CO_2 to Liquid Hydrocarbon Fuels – July 28
- Challenges and Opportunities in Designing Good Metrics to Assess Promise - August

LightSpeedSolutions.org

LinkedIn

The Future of Sustainable Transportation Fuels Group

Promotional Partners

ENVIRONMENTAL LAW • INSTITUTE®

CAAFI® COMMERCIAL AVIATION ALTERNATIVE FUELS INITIATIVE

ASERTTI

SERC SOLAR ENERGY RESEARCH CENTER

SOFI Solar Fuels Institute

NASEO National Association of State Energy Officials

ACORE American Council On Renewable Energy

Agenda

1. Overview and Introductions: **Clark Miller, ASU**
2. Presentations
   a) **Robyn Beavers**, NRG Energy
   b) **Dawn Manley,** Sandia National Laboratories
   c) **Marc Melaina,** National Renewable Energy Laboratory
   d) **Levi Tillemann,** New America Foundation
3. Panel Discussion
4. Audience Questions *(submit through the side panel)*
5. *Panelist Summary*

(Please Take the Brief Exit Survey)

Moderator

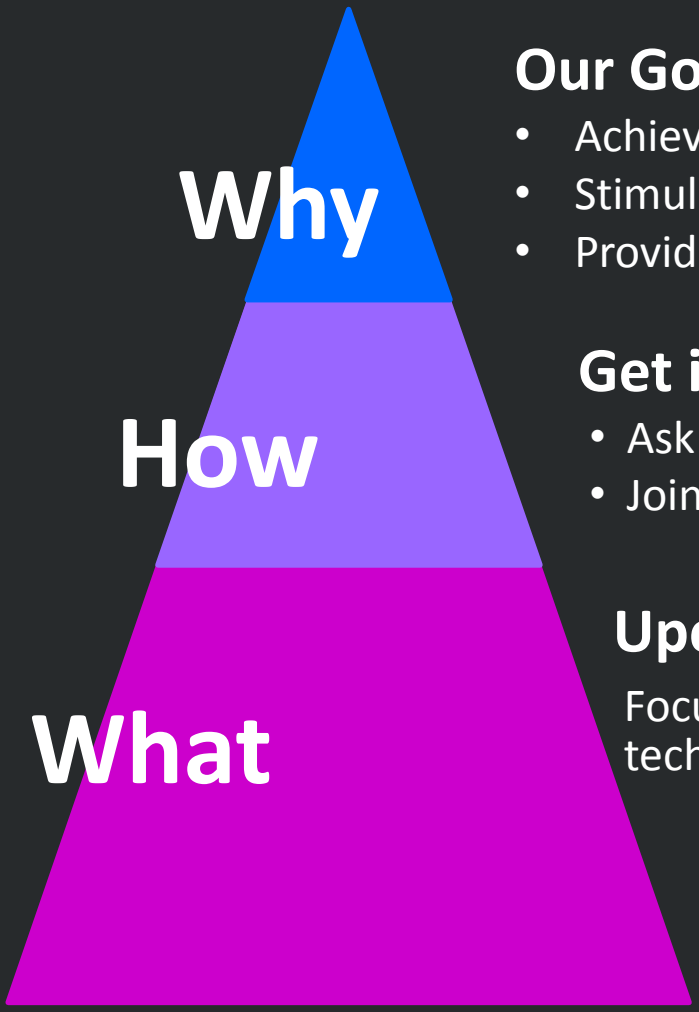
Clark Miller co-leads the energy and society initiative within LightWorks at Arizona State University, a group that employs social sciences, policy, and humanistic research to analyze and advance transitions toward sustainable energy futures.

Dr. Miller is Associate Director and Associate Professor of Science & Technology Studies in the Consortium for Science, Policy & Outcomes. An electrical engineer by training, his research focuses on the design of global environmental governance institutions, knowledge infrastructures that support public policy, and sustainable and socially responsible transformations of large-scale technological systems.

Forum introduction

Our ability to solve a problem is limited [only] by our conception of what is feasible

— Russell L. Ackoff, The Art of Problem Solving: Accompanied by Ackoff's Fables



Our Goal

- Achieve a sustainable low net carbon transportation future
- Stimulate conversation about a broad innovation space
- Provide useful input for policy and regulation

Get involved

- Ask questions for the panelists
- Join the associated LinkedIn discussion group

Upcoming monthly webinars

Focus on new innovation spaces and assess promise of early stage technologies

- **Recycling CO_2 to Liquid Hydrocarbon Fuels (July)**
- **Challenges and Opportunities in Designing Good Metrics to Assess Promise (August)**

Webinar series goals

To further the conversation on achieving a sustainable low net carbon transportation future

- To accelerate the transition and promote economic efficiency
- To convey that technical advances and better understanding are opening up opportunities to consider a broader range of options

To stimulate additional conversation and prove to be a starting point on exploring alternatives

- To offer a range of viewpoints, but won't be comprehensive and we are not going to provide "the answer" nor debate perspectives
- To further innovation and to further the conversation from a wide range of viewpoints and expertise
- To provide useful guidance for decision-makers, including policy makers and regulators

Webinar panelists

Robyn Beavers leads NRG Energy's internal innovation team focused on advancing its microgrid strategy. Previously she was a strategic advisor to the founders of Google and created and led Google's Green Business and Operations Strategy Group, the first business unit focused on sustainability strategy at the company.

Dawn Manley is a senior manager at Sandia National Laboratories and has been responsible for developing and leading programs in transportation energy analysis with government, industry, academic and international partners. She has provided testimony on fuels and transportation to the California State senate, supported an international congressional delegation of the Senate Energy and Natural Resources Committee on clean energy and served on the National Petroleum Council's Future Transportation Fuels and Technologies Committee. In these roles, Dr. Manley has analyzed technology options for future transportation energy pathways, including advanced efficiency, biofuels, hydrogen and electric vehicles.

Marc Melaina is a Senior Engineer with the National Renewable Energy Laboratory. His research involves modeling alternative fuel infrastructure development, market barriers, stakeholder decisions, and low-carbon transportation scenarios. Before joining NREL in 2007, Dr. Melaina served as a research track director within the Institute of Transportation Studies at the University of California at Davis.

Levi Tillemann is the Cal and Jeff Leonard Fellow at the New America Foundation and author of "The Great Race: The Global Quest For The Car Of The Future". Dr. Tillemann previously served as Special Advisor for Policy and International Affairs at the US Department of Energy. Prior to that, he was the CEO of IRIS Engines - a company he co-founded to develop a more efficient, and more powerful combustion engine.

STATION A

June 30, 2015

Electrification of Transportation

Presented by Robyn Beavers

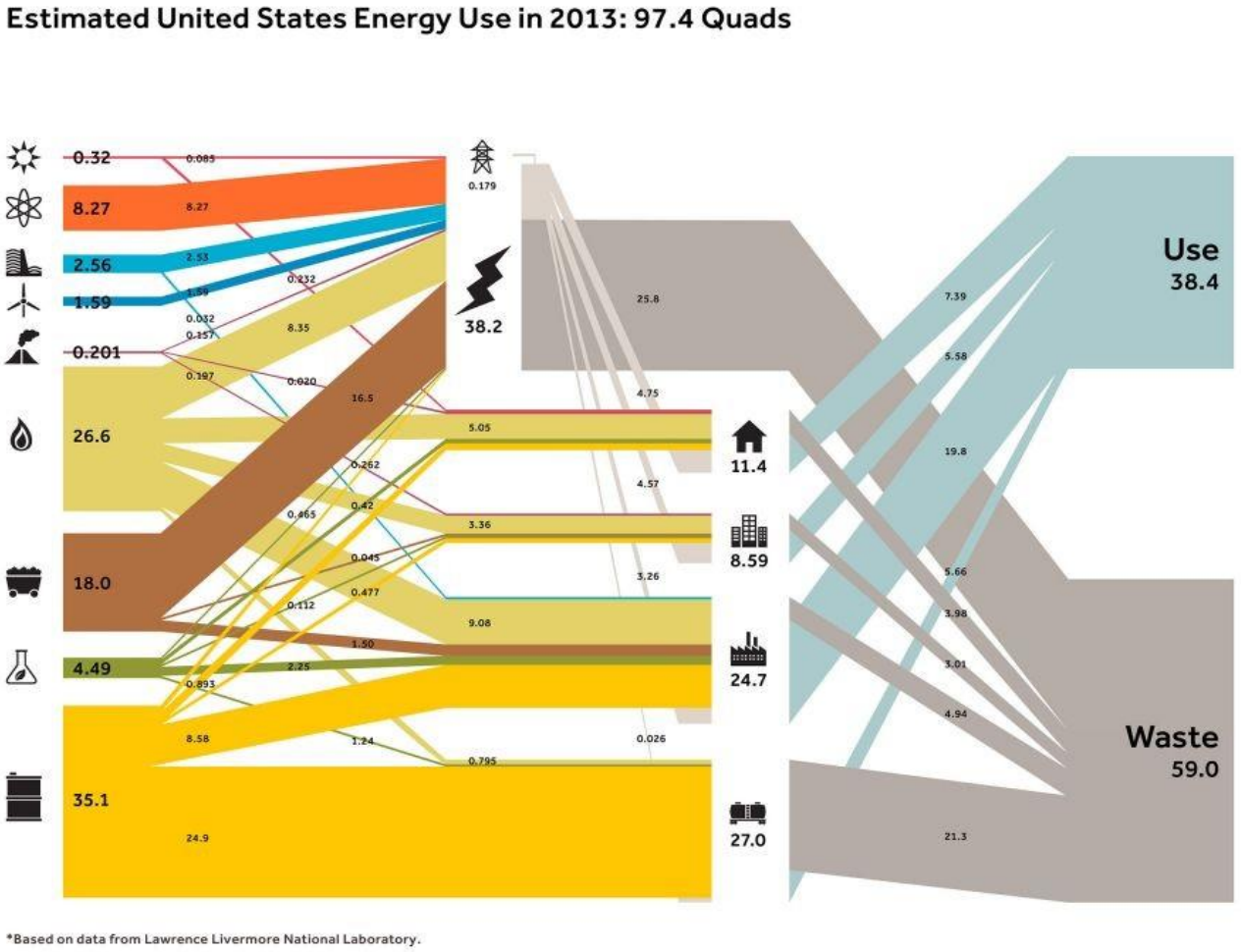
SVP of Innovation & Founder of the Station A Group

Current trends in (re)electrification in the US

Two current trends are self-reinforcing for a cleaner energy future

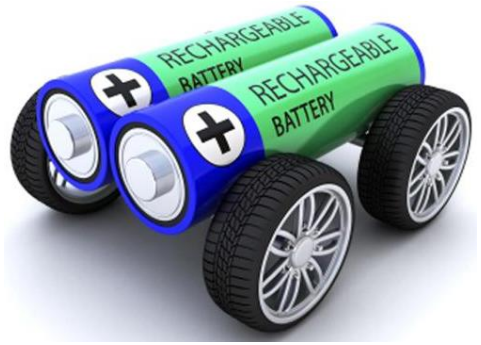
- Trend 1: Increasing adoption of electric vehicles
  - More options, longer ranges, growing charging networks and varying price points of electric vehicles
  - Energy industry sees shrinking demand overtime so should turn to vehicles for new growth opportunity
- Trend 2: Proliferation of distributed renewable generation
  - A shift towards more behind the meter generation with grid as a back up
  - Increased need for deferrable loads and stationary storage to help balance and optimize for our new type of energy lifestyle

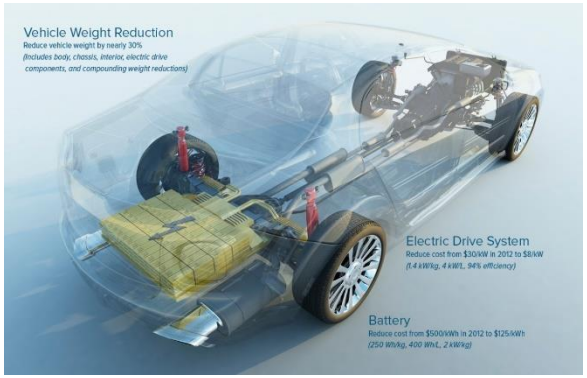
Trend 1: Electrification of Transportation



Trend 2:
Proliferation of clean distributed generation

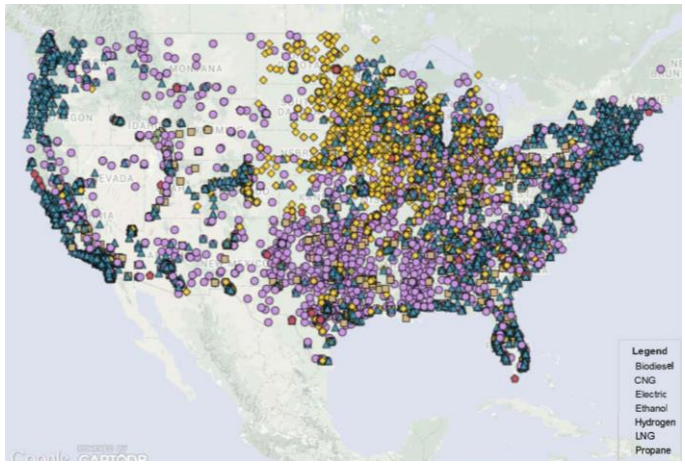
Factors that influence electric vehicle adoption and impact



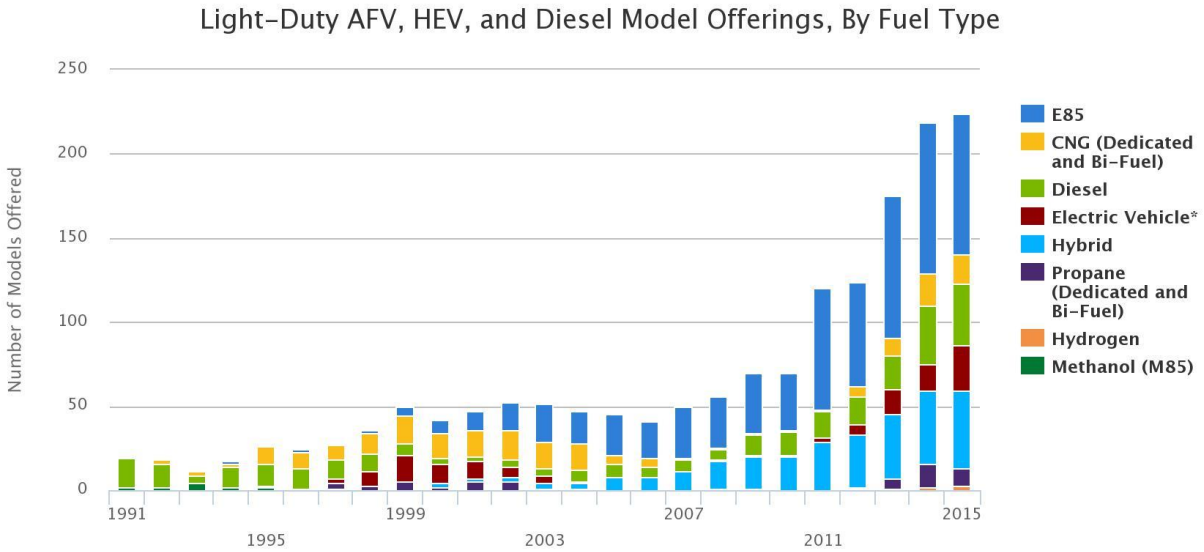


Dawn Manley, PhD
Sandia National Laboratories
The Future of Sustainable Transportation Fuels Forum
Arizona State University LightSpeed Solutions
June 30, 2015

US light duty vehicle market includes multiple alternative vehicles & fuels

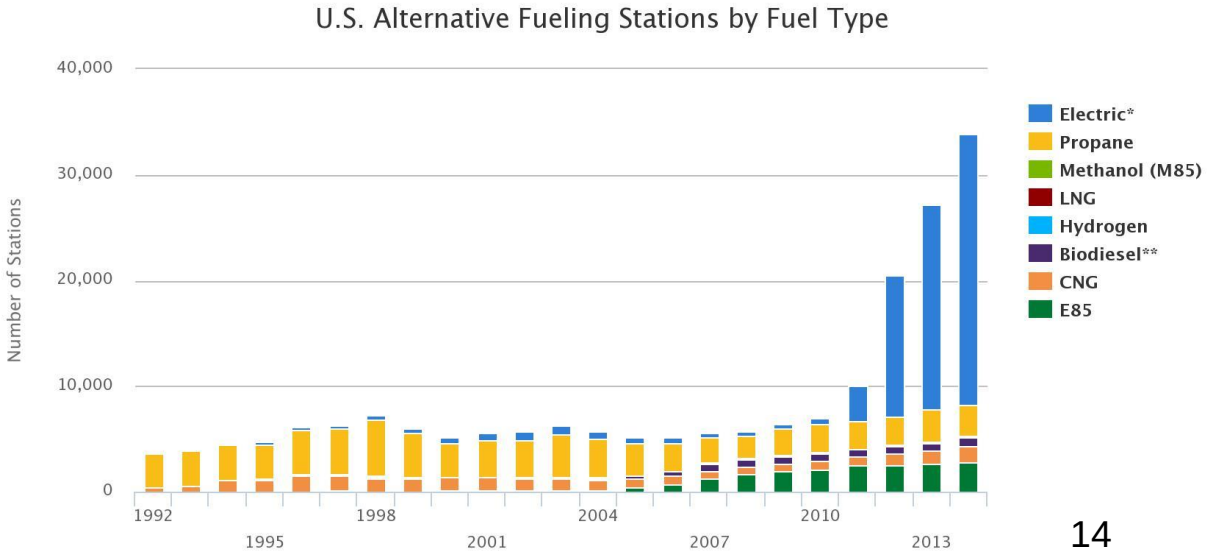


Source: http://www.afdc.energy.gov/locator/stations/



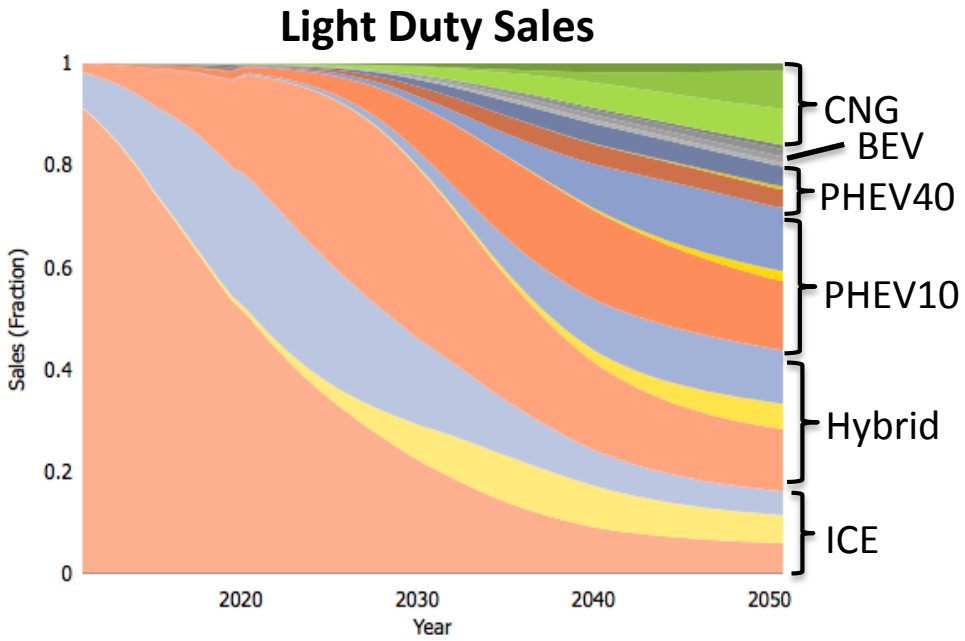
Source: National Renewable Energy Laboratory

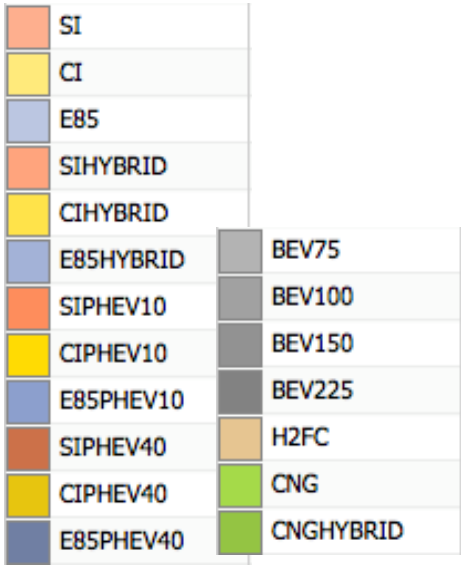
- 16,015 public alternative fuel stations
- Increasingly diverse model offerings



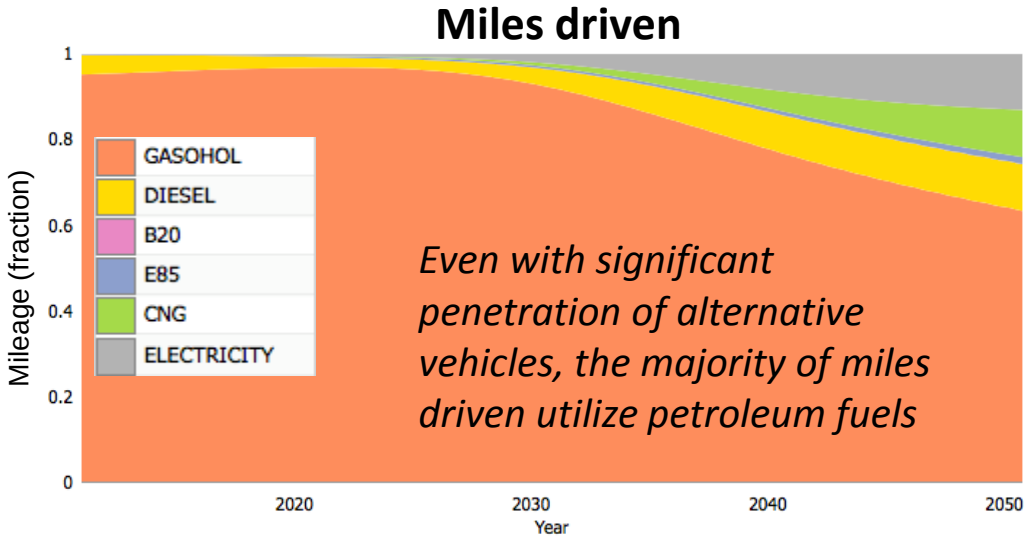
Source: DOE Alternative Fuels Data Center

Scenario analyses explore possible futures and pathways



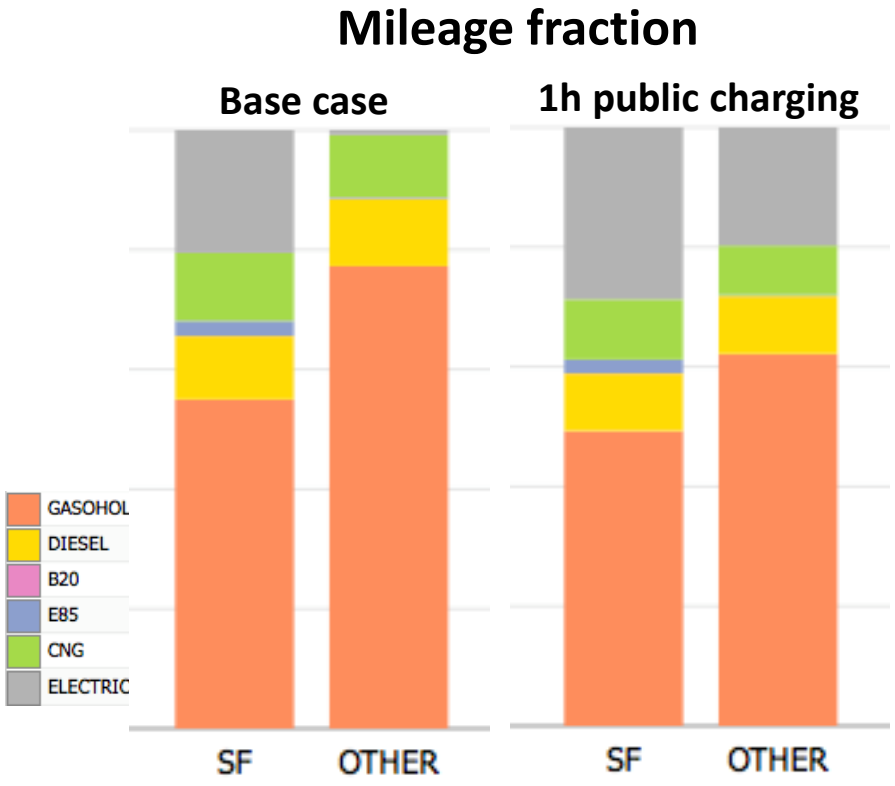


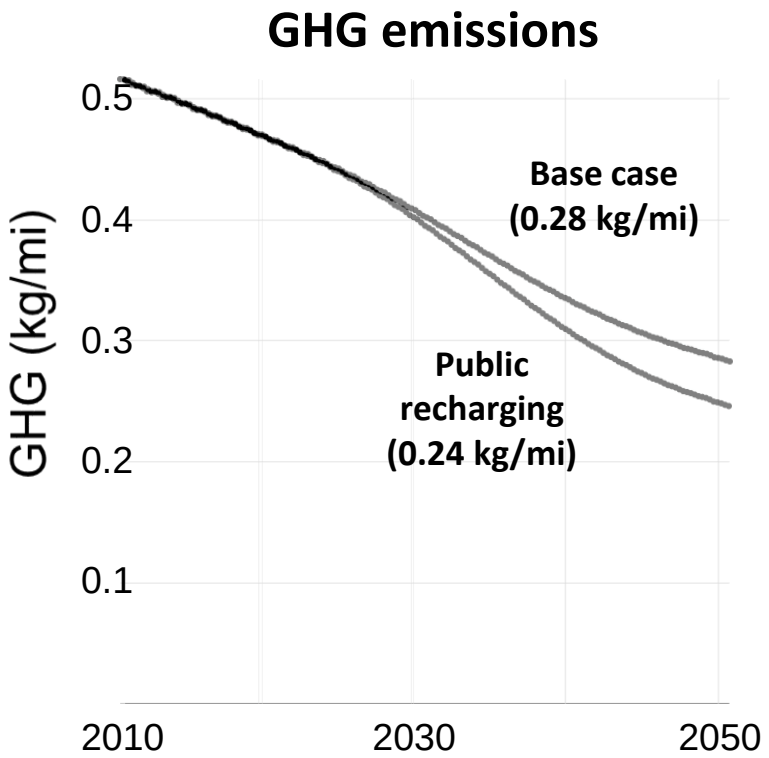
- How will the mix of technologies evolve over time?
- How can we achieve aggressive GHG reduction or fuel economy targets?



Manley, Levinson, Barter, and West, DOE Annual Merit Review 2015.

Probing across population segments can identify high impact markets





- Base case – BEVs and electrified miles driven are almost exclusively associated with single family (SF) homes where dedicated charging is available
- Public charging – Access to 1 hour of public charging significantly increases PHEV attractiveness and electric miles driven for residents of non-single family homes

Speed, scale, and segmentation matter

- Speed and scale
  - Target timeframes heavily influence technology options
  - US car mix takes 15-20 years to turn over
  - Hybrids first commercialized in 1997 – now still make up only about 5% of US sales
- Segmentation
  - Increasing divergence and fragmentation
  - Interdependencies of seemingly parallel technologies
  - How will regional issues and local consumer preferences influence the evolution of technology options?

Marc Melaina
National Renewable Energy Laboratory

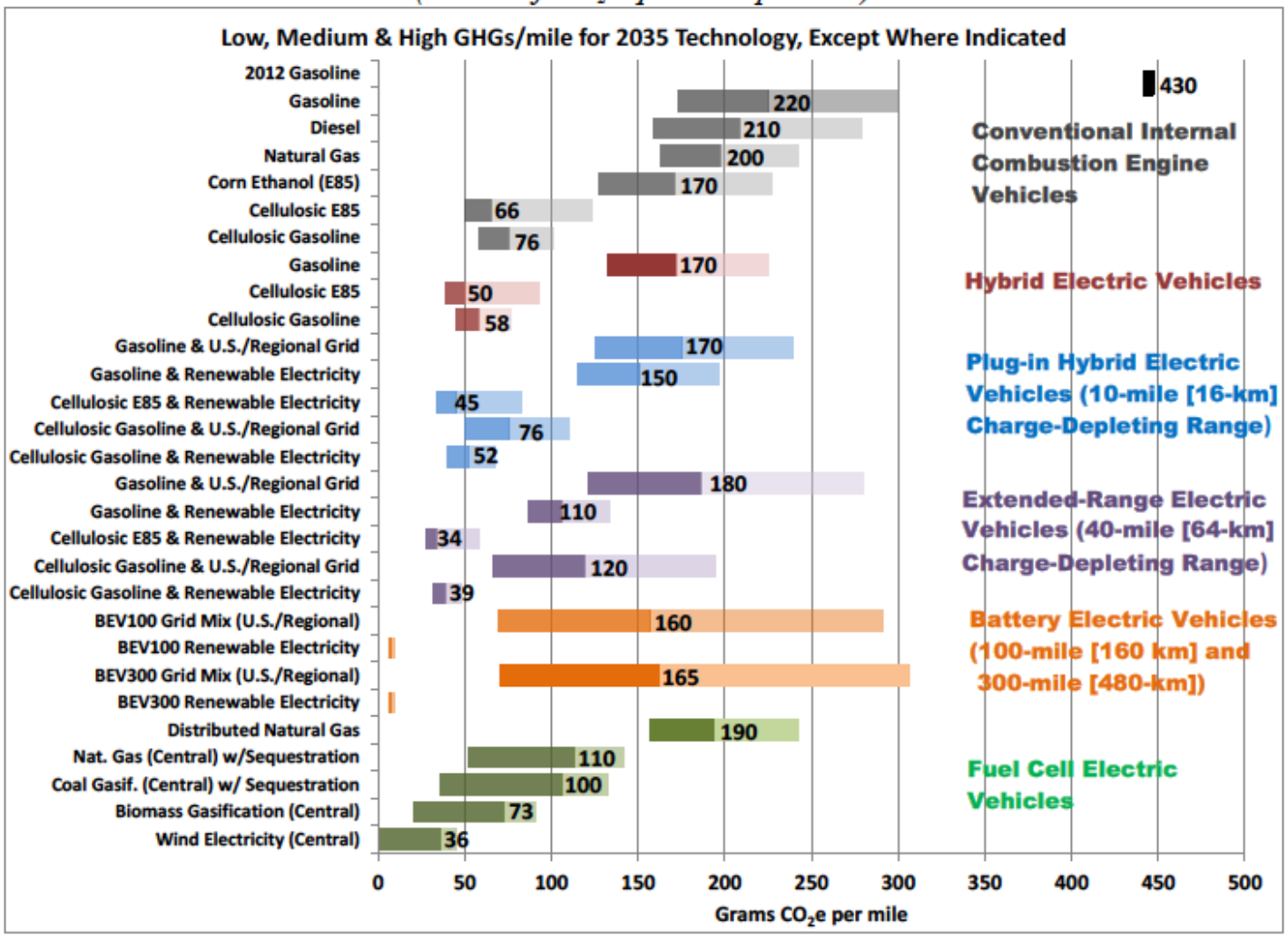
FUTURE OF SUSTAINABLE TRANSPORTATION FUELS

GREET lifecycle GHG emissions by vehicle-fuel

Low/medium/high: sensitivity to uncertainties associated with projected fuel economy of vehicles and selected attributes of fuels pathways, e.g., electricity credit for biofuels, electric generation mix, etc.

Potential for very low GHGs

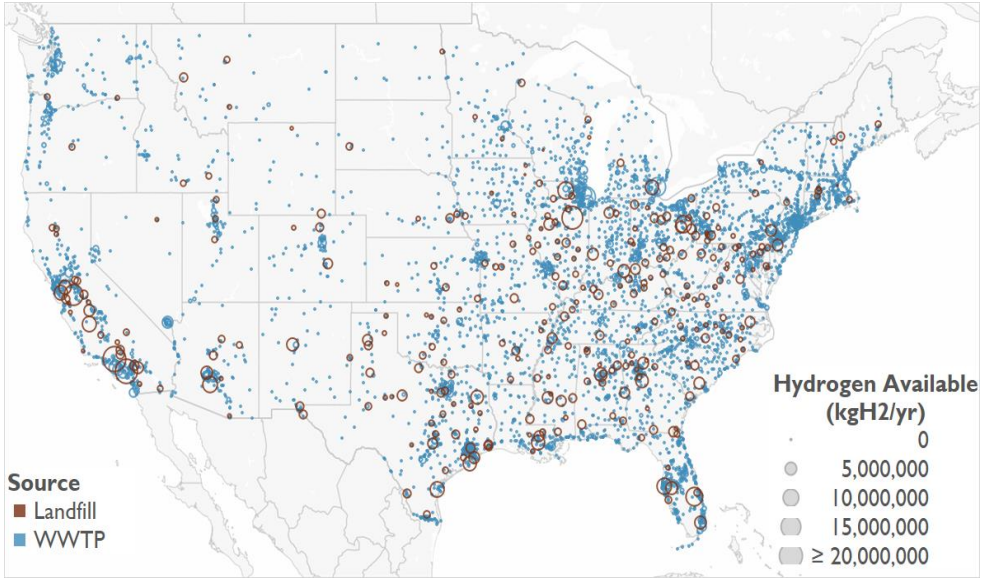
Figure 1. Well-to-Wheels Greenhouse Gases Emissions for 2035 Mid-Size Car
(Grams of CO_2-equivalent per mile)

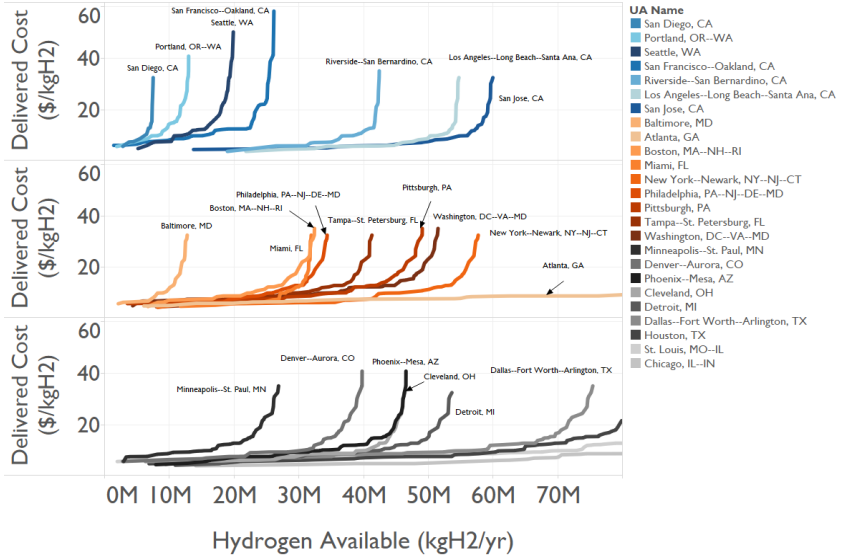


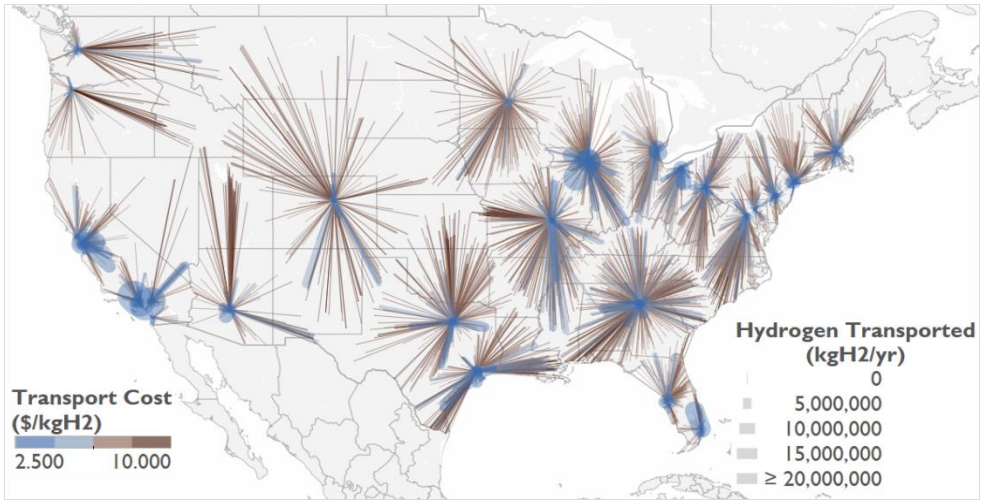
Nguyen, Ward, Johnson 2013. http://www.hydrogen.energy.gov/program_records.html

Supply curves for biogas to hydrogen

- **Delivery cost included for major urban areas**
- **Total delivered cost by city & region shown in graph below**
- **Significant variability by region**
- **Potential to increase economies of scale by combining multiple sources or direct pipeline injection**





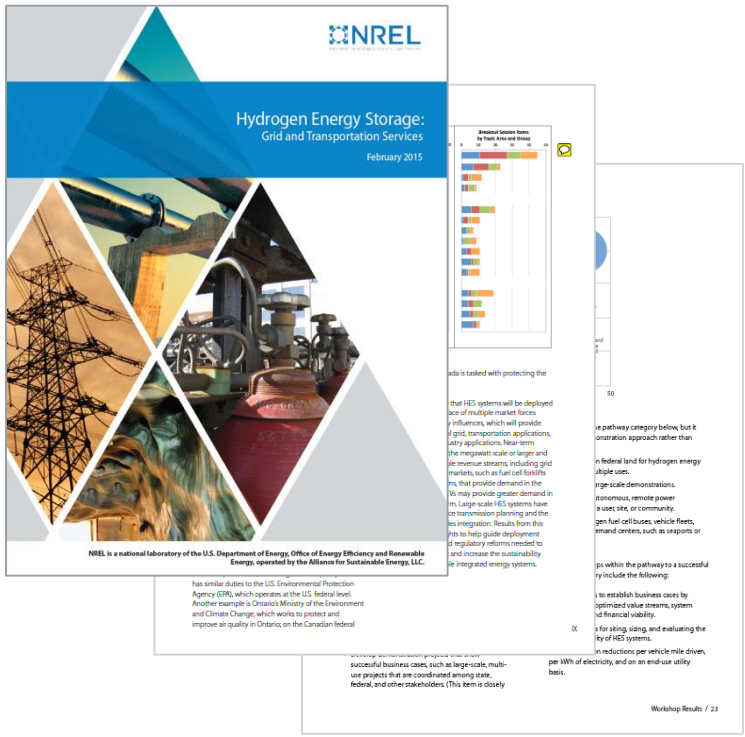


PRELIMINARY RESULTS (Milbrandt et al. 2015)

Hydrogen Energy Storage

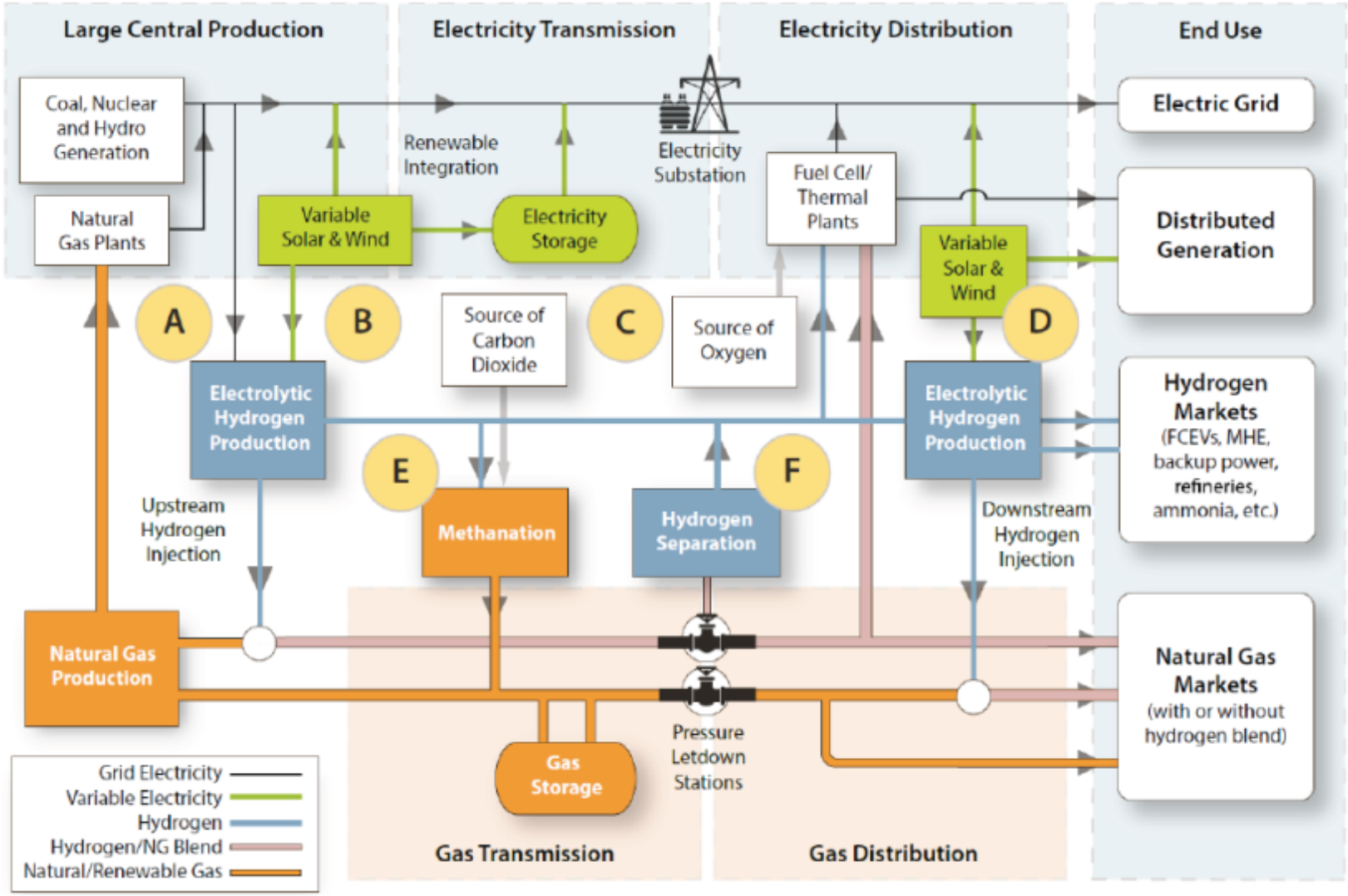
- **Hydrogen Energy Storage (HES) Workshop**
  - Held May, 2014 in Sacramento, CA and included a diversity of stakeholders
  - Explored barriers, policy and next steps for encouraging HES
  - Workshop proceedings are available

- **Example Findings**
  - Criteria and Barriers
    - Technical and Economic Viability
    - Multiple end uses
  - Policy
    - Equal treatment and credit in markets
  - Next Steps
    - Demonstration and pilot projects



Source: http://www.nrel.gov/docs/fy15osti/62518.pdf

Hydrogen energy storage pathways



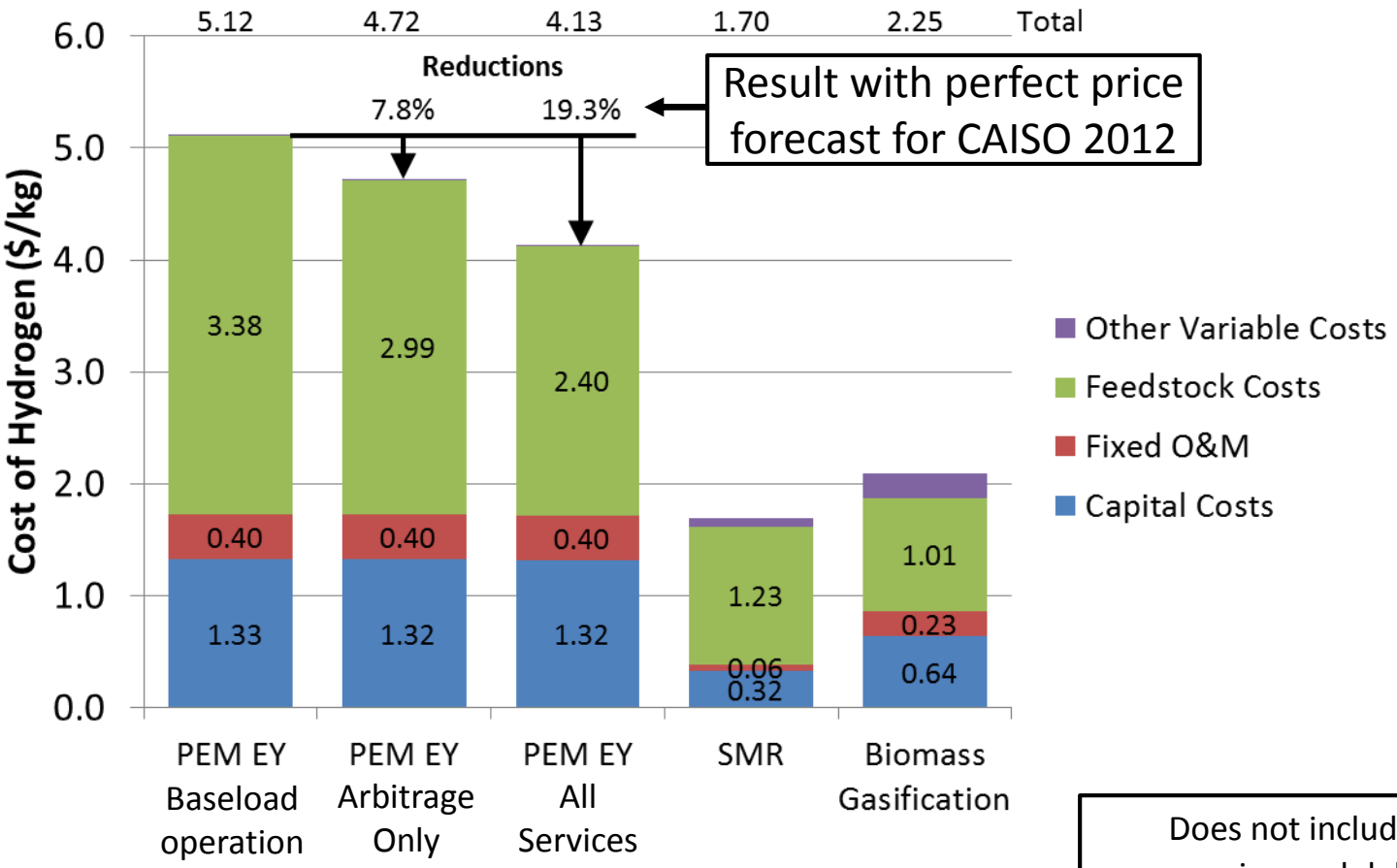
A. Electrolysis for Grid Support
B. Integration of large-scale central renewables
C. Conversion to grid electricity
D. Distributed production for variable resources
E. Methanation for renewable gas synthesis
F. Hydrogen Separation

Source: http://www.nrel.gov/docs/fy15osti/62518.pdf

Comparison to electrolysis production cost

Integration with the grid can lower feedstock costs and increase revenue

- **H2A Current Central Hydrogen Production**



Name	Technology
EY	Electrolyzer
SMR	Steam Methane Reformer

Name	Services
Baseload	"Flat" operation
All	Energy and Ancillary Service Markets

Does not include gas compression and delivery cost

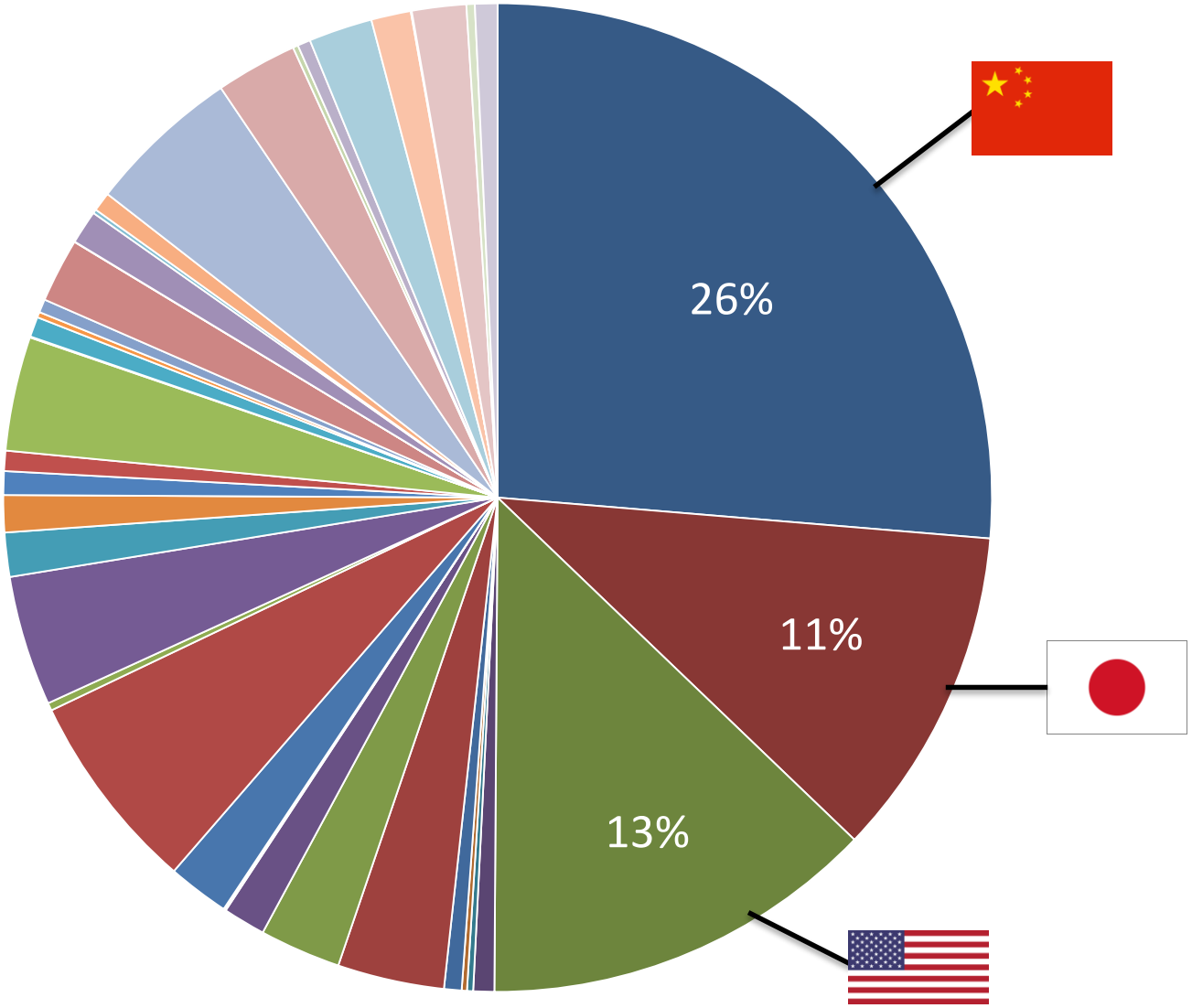
Source: http://www.hydrogen.energy.gov/h2a_prod_studies.html

The Great Race

The Global Quest for the Car of the Future

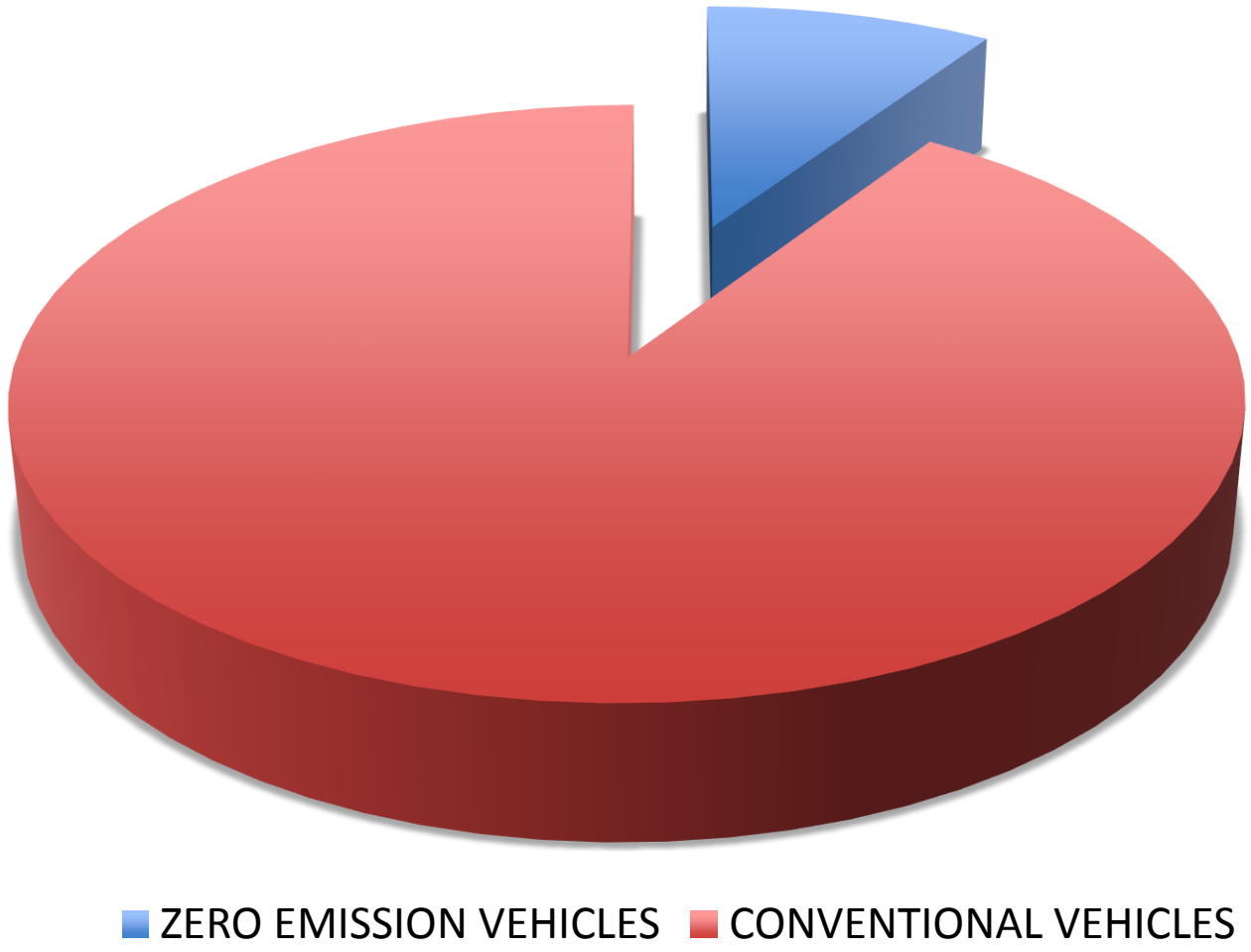
LEVI TILLEMANN

Global Auto Production in 2014




California Environmental Protection Agency
Air Resources Board

2003 ZEV Sales

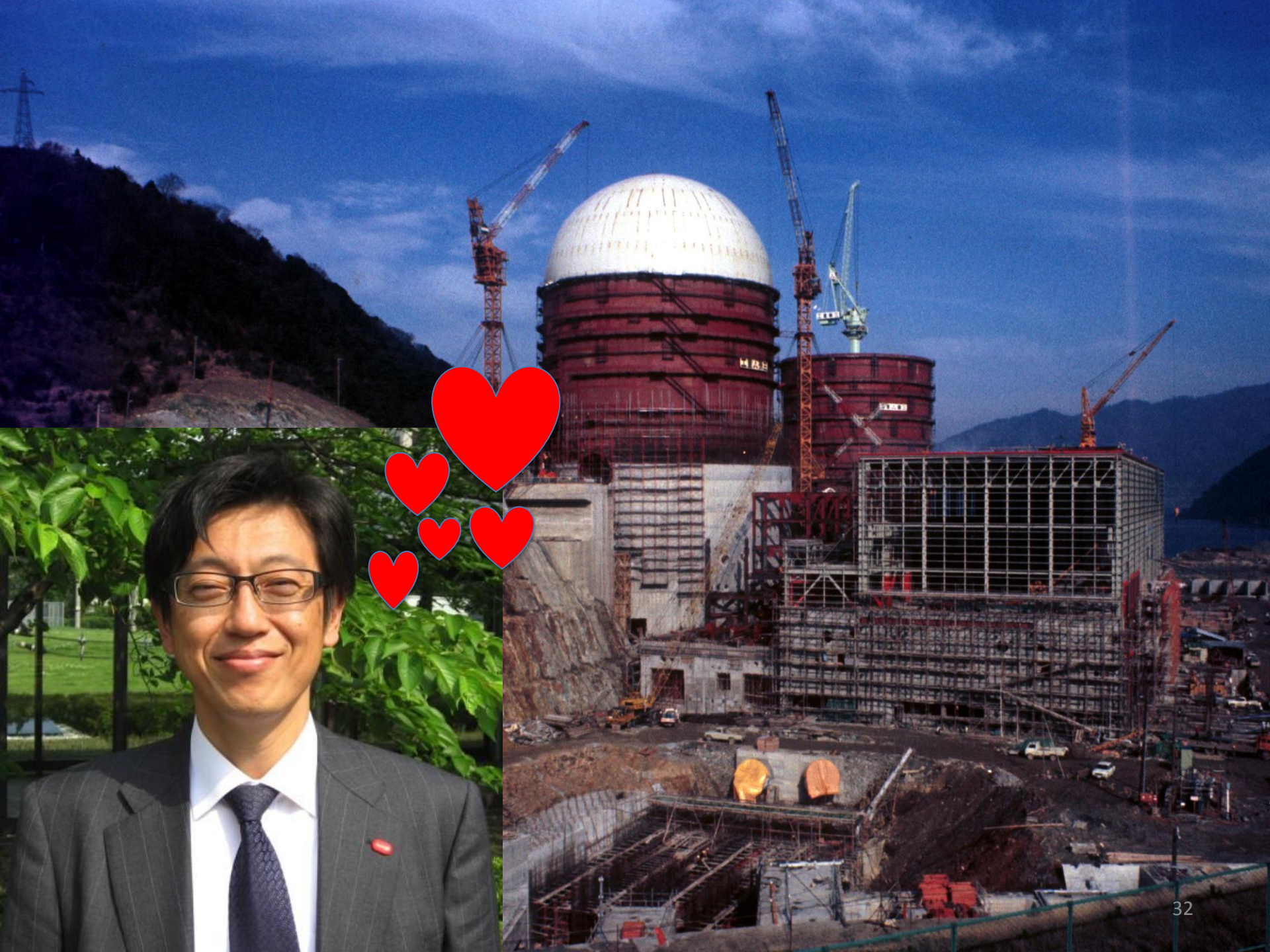


Why Is CARB Important/Effective?

- Generally regulates 20-30% of US auto market
- Strategic vision to stimulate global R&D
- EVs were the price of admissions to the CA auto market
- Market-based economic incentives used to stimulate innovation (ZEV credits market)

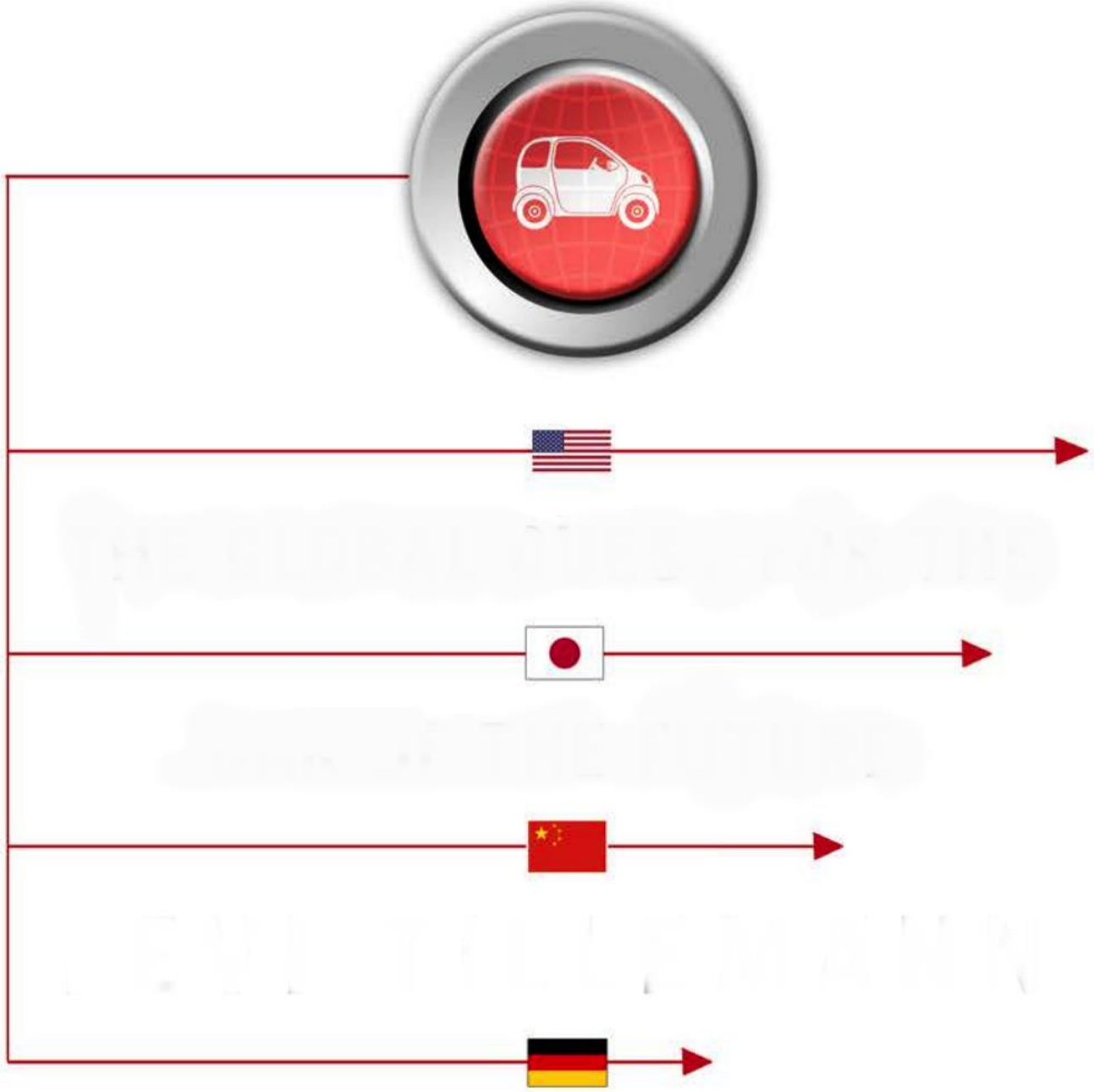
China's Strategy

- Leapfrog the West and Japan through electrification
- Employ intellectual property as the price of admission for foreigners (motors, inverters and batteries)
- Apply political pressure to domestic companies/governments to induce them to build/buy EVs
- Award rich consumer incentives for EVs (national+local ~$20,000)

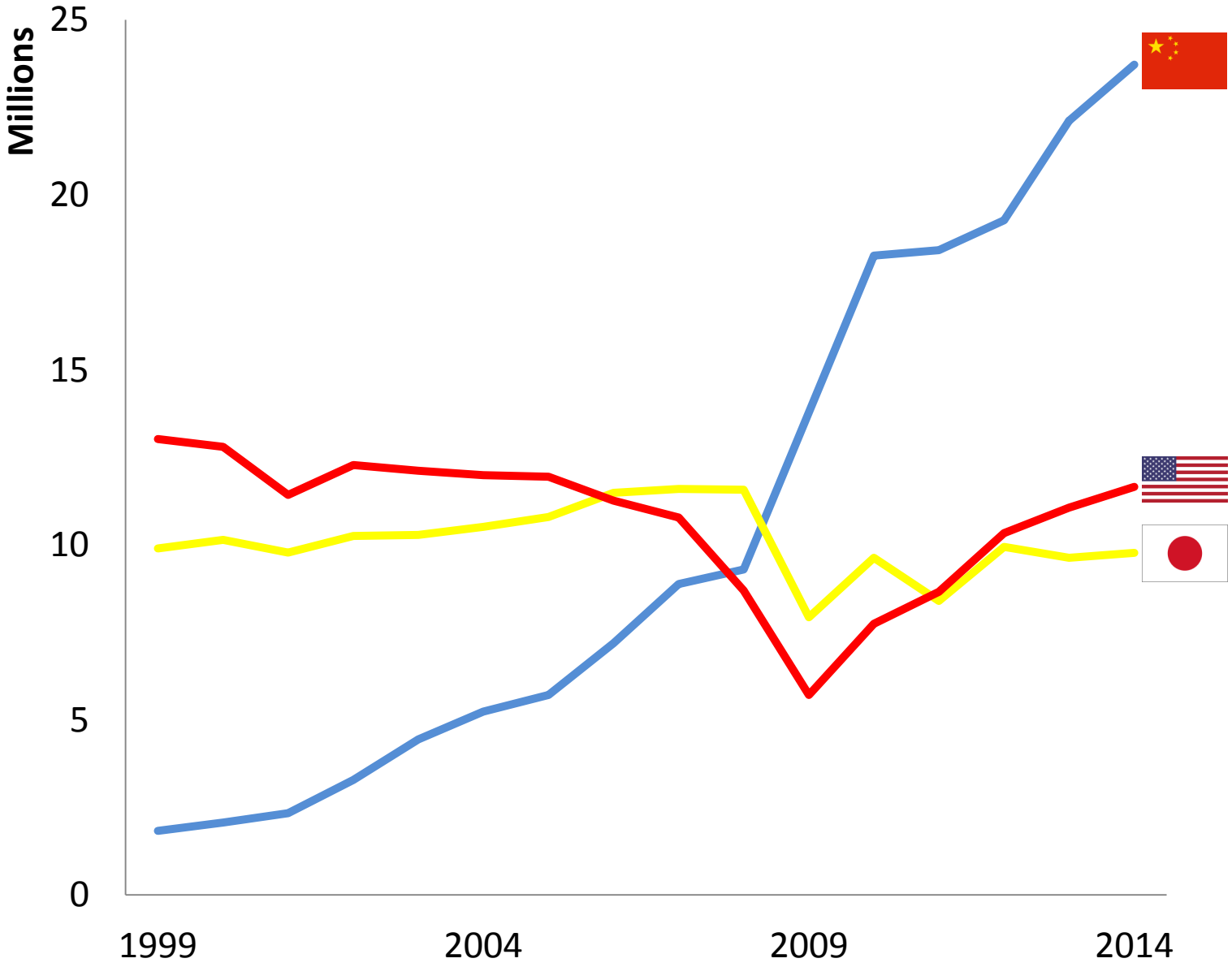


Japan's Industrial Plan

- Sprung from TEPCO's nuclear ambitions
- Sponsorship from METI was the critical milestone
- National incentives → Nissan's entry and revival of the electric car



U.S., Japan and China Auto Production



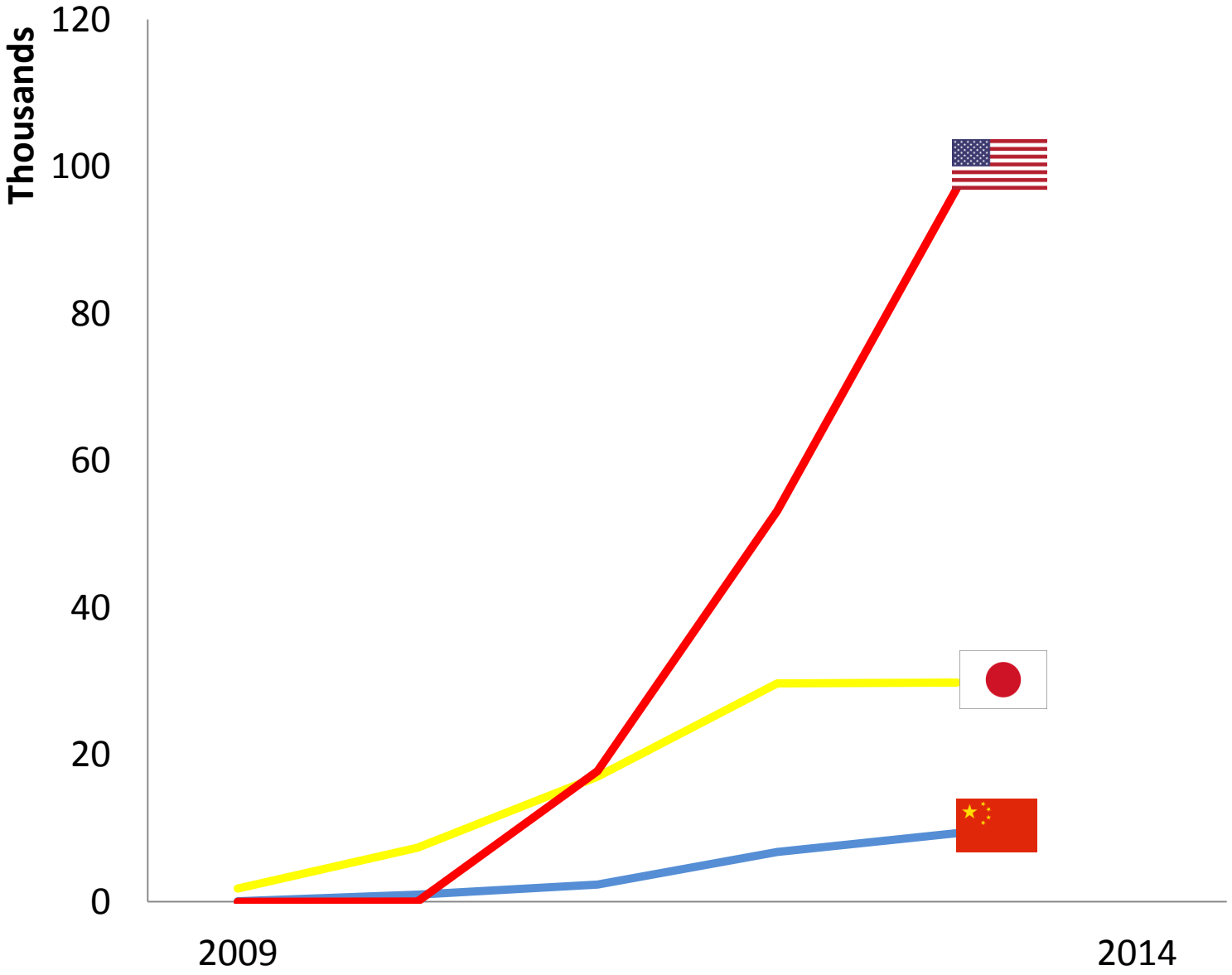
Goals and Subsidies by Policy System

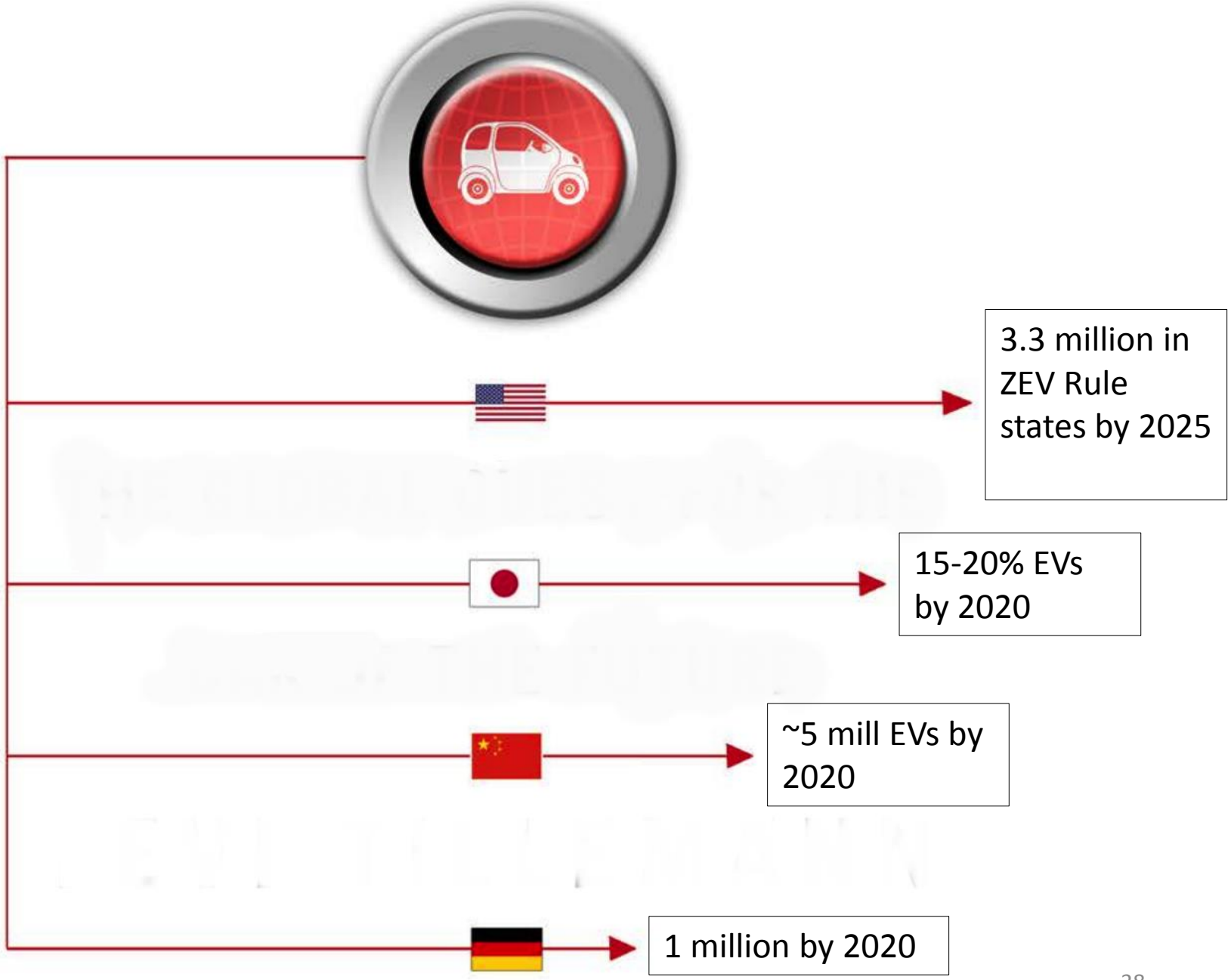
- China – 500,000 NEVs by 2011
- Japan – 15-20% EVs by 2020
- US Federal – 1 million PEVs by 2015
- California – 15% EVs by 2025

Country	National EV subsidy for a 24 kwh EV	Approximate Dollar value in spring of 2009
China	RMB 60,000	$9,000
Japan	Yen 780,000	$8,000
US	$7,500	$7,500

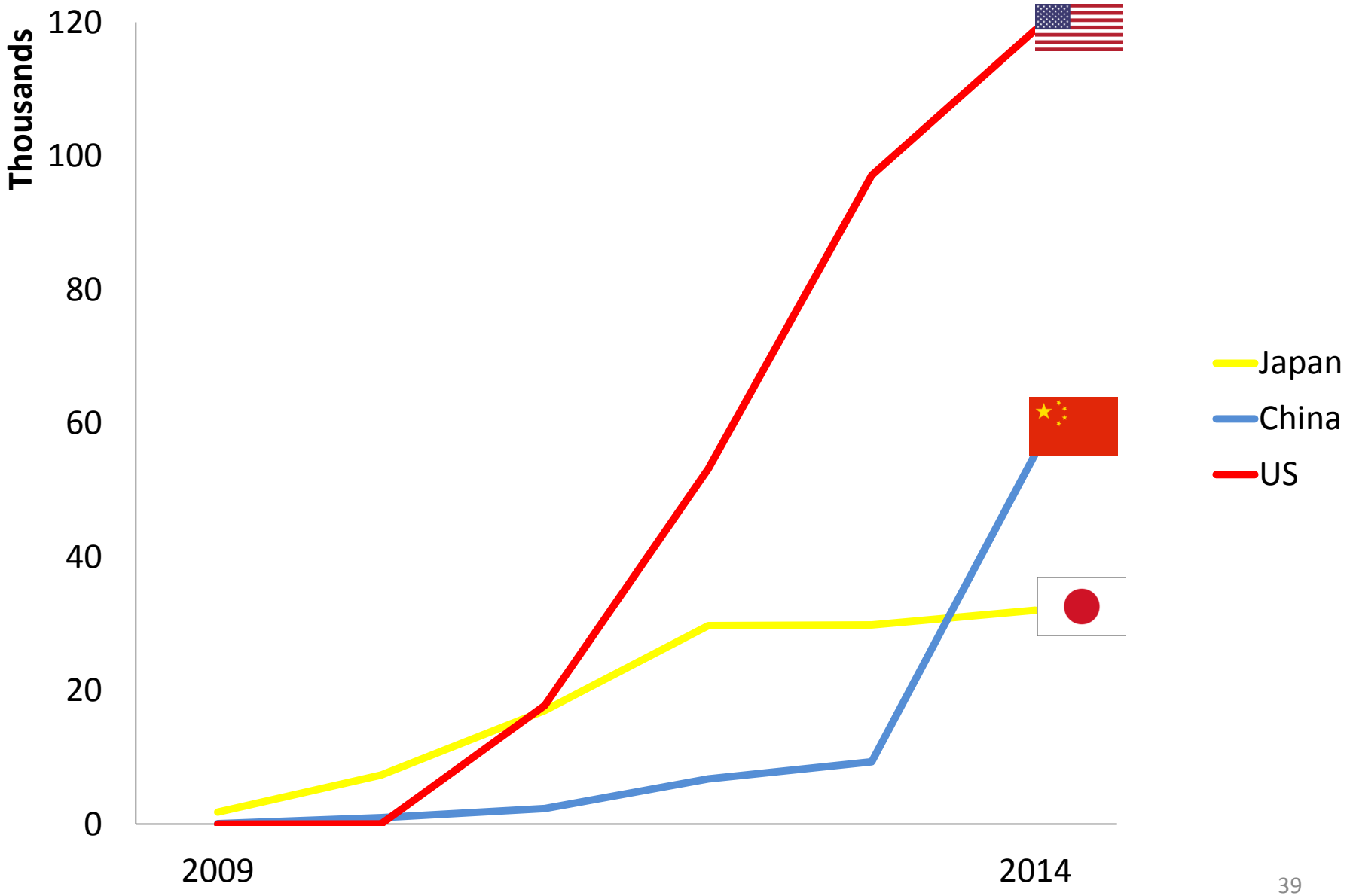
Sources: US DOE, METI, and MOST

U.S., Japan, and China EV Sales

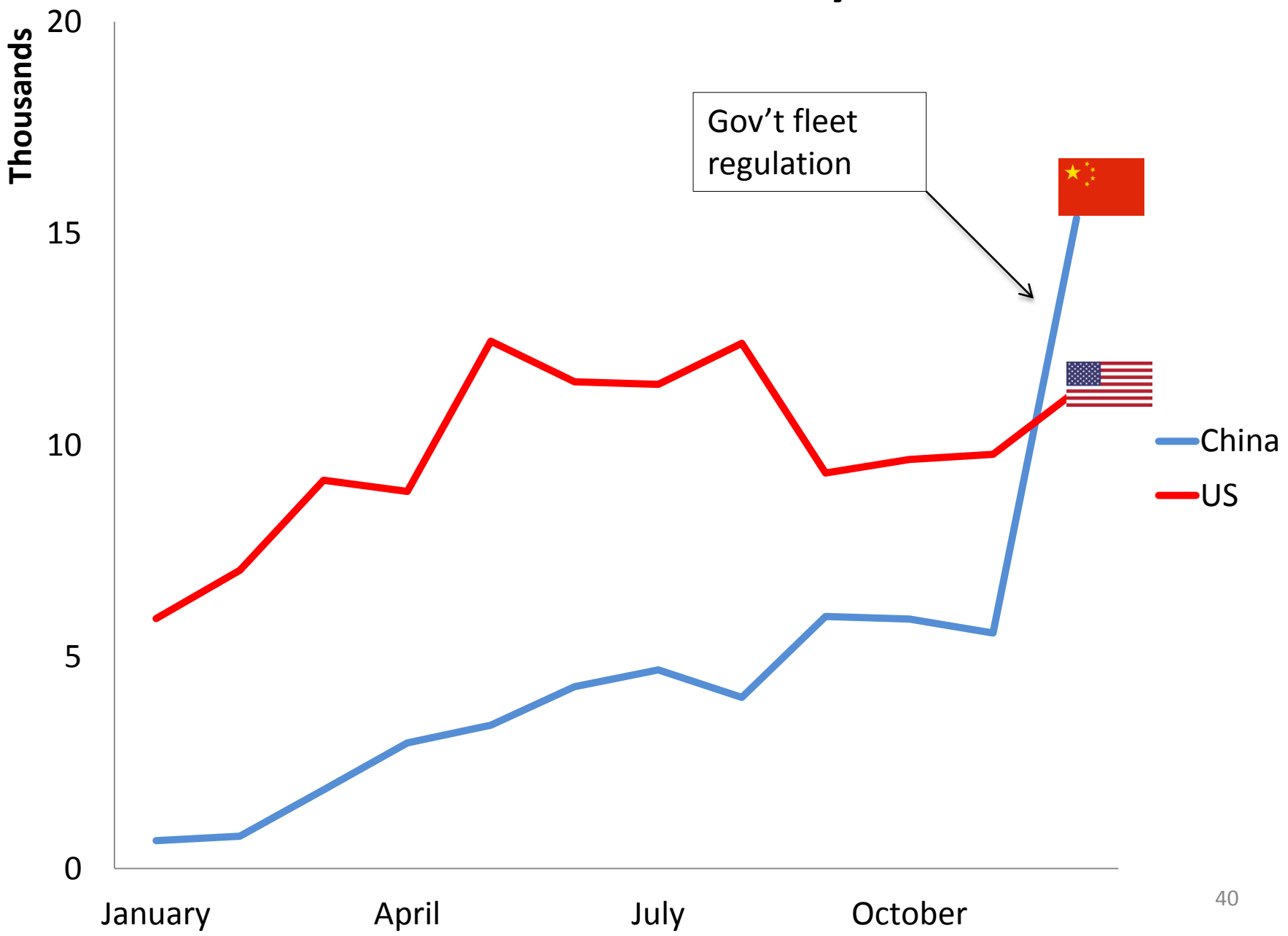



3.3 million in ZEV Rule states by 2025
15-20% EVs by 2020
~5 mill EVs by 2020
1 million by 2020

U.S., Japan, and China EV Sales



2014 US and China Monthly EV Sales



A Policy Framework for Automakers (and the rest of us…)

- Recognize that (for now) policy is the foundation for EV markets and deployment and integrate policy into your innovation strategy
- Advocate for government policies that are strategic (long time horizons), aggressive and tactically flexible.
- Nurture broad political coalitions
  - Clean air
  - Energy security
  - Industrial competitiveness

The Great Race

The Global Quest for the Car of the Future

LEVI TILLEMANN

Panel discussion

- Do current policy and business frameworks encourage and harness or impede arbitrage possibilities?
- Is there a need for policy support or will normal market forces suffice?
- Could increasing communication and awareness at the interfaces among stakeholder groups lead to greater responsiveness of the combined sectors?
- Are there more business and technology innovations at the intersection of the stationary power and transportation sectors that might add economic efficiency and accelerate the transition?
- Does envisioned policy actions support or impede such innovations?

The panelists

Robyn Beavers
Senior Vice President of Innovation, founder of Station A Group at NRG Energy.
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Dawn Manley
Deputy Program Director at Sandia National Laboratories.
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Marc Melaina
Senior Engineer, National Renewable Energy Laboratory, Golden, Colorado.
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Levi Tillemann
Jeff and Cal Leonard Fellow at New America Foundation.
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Clark Miller
Associate Director and Associate Professor of Science & Technology Studies, Consortium for Science, Policy & Outcomes
Arizona State University
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Upcoming webinars

Thank you for joining

Future of Sustainable Transportation Fuels webinars

- Recycling CO_2 to Liquid Hydrocarbon Fuels – **July 28**
- Challenges and Opportunities in Designing Good Metrics to Assess Promise - **August**

Webinar videos, registration information and more

Light*Speed*Solutions.org

Keep the conversation going!

The Future of Sustainable Transportation Fuels Group