Five Lessons for Sustainable Transportation

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and

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California Air Resources Board

Blue Planet Prize Commemorative Lecture
October 31, 2013
Thank You to Asahi Glass Foundation

“….supporting advanced research … and recognizing efforts to solve environmental issues that call for global solutions”
Thank You to ITS-Davis

• Founded: 1991
• 50 (brilliant and passionate) Professors and Researchers
• 130 (brilliant and passionate) Graduate Students
• Recently designated “National Center of Sustainable Transportation” by US Department of Transportation
• Centers within ITS-Davis:
  ▪ Plug-in & Hybrid Vehicle Center
  ▪ Energy Efficiency Center (1st in US)
  ▪ Urban Land Use and Transportation Research Center
  ▪ China Center on Energy and Transportation
  ▪ Sustainable Transportation Energy Pathways Program
ITS-Davis Team of Faculty, Staff, and Students
Thank You to California Air Resources Board

- World leaders in air quality and climate policy
- Pioneered Zero Emission Vehicle mandate, Low Carbon Fuel Standards, low emission vehicles, and much more
- Superb staff: technically sophisticated, engaged with stakeholders, passionate
- Visionary leadership with Mary Nichols and Richard Corey, with strong support from Governor Jerry Brown
World Population Is Expected to Increase by 3 Billion
More People + More Wealth = Many More Vehicles

Sperling and Gordon (2009), based on DOE, JAMA, other
Problem Is NOT Lack of Oil!
Real Problem is Environmental Impact of High-Carbon Unconventional Oil

Supply “Curve” of World Hydrocarbon Resources

- Already Produced
- OPEC Middle East
- Other Conventional
- Arctic
- EOR
- Heavy oil Bitumen
- Oil Shale

IEA, 2005
Energy Revolution Underway ... 
More (Unconventional) Oil and Gas Available Globally
Oil is Being \textit{Re-Carbonized} ... Heavy Oil, Oil Sands, Coal-to-Liquids

Photo of Canadian Oil Sands
Climate Change Is Arguably Greatest Threat

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<th>Global temperature change (relative to pre-industrial)</th>
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We Will Use Up Our Global Carbon Budget in 30-50 Years—and Then Zero (at current rates)

Carbon Released Since Industrial Revolution

- 530 billion tons

How Much More Can Be Released?

- 300 to 500 billion tons

Remaining Fossil Energy (Carbon) Reserves

- 2800+ billion tons

(800 billion tons emitted from burning known recoverable reserves with today’s energy prices and technology)

IPCC, 2013
Transportation accounts for 1/4 of global CO₂ emissions and 1/2 of oil in world.
Five Lessons and Conclusions

1. No single solution: Need to pursue many solutions

2. Focus on next steps (desirable pathways), not simplistic end-state visions

3. One size does not fit all.

4. Scientific community needs to engage in near-term decision-making—locally, nationally, globally

5. ???
Transforming Transportation

- Transforming mobility (*hardest*)
- Transforming fuels
- Transforming vehicles (*easiest*)
Starting in California, car-centric cities and lifestyles increasingly dominate cities around the world.

Public transport <20% of passenger kilometers traveled in all rich countries and shrinking almost everywhere.
Population Densities: Lowest in US, Highest in Asia

Comparative average population densities in built-up areas in 49 metropolitan areas


www.worldenergy.org/publications
Motor vehicles per 1,000 people, 2009

Sources: World Bank 2011. Motor vehicles include cars, buses, and freight vehicles, but do not include two-wheelers.
Travel Peaking in Rich (OECD) Countries

Figure 13.11: Passenger LDV travel for selected OECD countries, indexed to 2000

Key point: Vehicle travel began to flatten or even decline after 2000, suggesting “peak” travel may be occurring in the OECD.

Source: IEA, 2012 (ETP 2012)
Many Reasons to Reduce Vehicle Use (and Restrain Growth in Emerging Countries)

.... for Economy, Environment, and Health

- Reduced road and other infrastructure costs (water, wastewater, electricity)
- Reduced air pollution, GHG emissions and oil use
- Greater social equity and “livability” benefits
Not all vehicle trips are “high value”!
Key Strategy: Expand Traveler Choice

- Dynamic Ridesharing
- Smart Paratransit
- Carsharing
- Conventional Transit
- NEVs

NEW MOBILITY OPTIONS

Smarter, Cleaner, and Cheaper!
WE HAVE MET THE ENEMY AND HE IS US.
Second Leg: Transforming Fuels

BIOFUELS  HYDROGEN  ELECTRICITY
The Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil.

Sheikh Zaki Yamani, Saudi Arabian oil minister for 3 decades

• Today: Transport is 96% dependent on oil
• Future: Wide mix of fuels to power mobility

• Big challenges:
  1. How to keep most fossil energy below ground?
  2. How to stimulate innovation and support acceptance of low-carbon alternatives?
Many Promising Replacements
Some better than others…

-100 -50 0 50 100
Carbon Emissions Relative to Conventional Gasoline

Fuel Cells, hydrogen
Biofuel, wood
Battery Electric, natural gas
Hybrid Electric, full hybrid
Battery Electric, US power mix
Diesel
Ethanol, corn
Natural Gas
Gasoline, conventional
Battery Electric, new coal
Gasoline, tar sands
Gasoline, coal
Fuel du jour Phenomenon
Disruptive and wasteful

- 30 years ago – Synfuels (oil shale, coal)
- 25 years ago – Methanol
- 20 years ago – Electricity (Battery EVs)
- 10 years ago – Hydrogen (Fuel cells)
- 5 years ago – Ethanol
- Today – Electricity (Plug-in hybrid vehicles)
- What’s next?
California Leadership on Fuels Policy

• Low Carbon Fuel Standard (adopted 2009)
  ▪ Requires 10% reduction in carbon intensity of transport fuels by 2020
  ▪ Utilizes lifecycle analysis
  ▪ Harnesses market forces (via credit trading)
  ▪ Similar policy adopted by EU
Third Leg: Transforming Vehicles

Cars of future will be far more efficient and will be powered mostly by electric-drive

Success story for technology and policy!
Huge Success Story!
Vehicle Efficiency Improving Worldwide

ICCT, 2010 (updated 2012)
Moving Forward on Electrification

Disruptive process … will it continue?
Japan is Global Leader on Vehicle Electrification

- Highest sales of hybrid vehicles (19%)
- Most fast chargers for electric vehicles
- Strongest public-private partnerships with battery electric and fuel cell vehicles (and leading automotive companies)
Truck Efficiency and Technology Are Advancing Also, But More Slowly

Fuel Cell Truck

Electric Truck With Overhead Wires

Battery Electric Truck
Many Challenges--Clashing Interests and Priorities

Dysfunctional oil markets;
Conservative oil companies

Auto and oil industries

Muddled priorities
(oil prices, security, climate, regionalism)

Inelastic and conservative behavior

Consumers

Government
Policy Strategies to Transform Transportation

- **Performance standards for fuels/GHG**
  - Low carbon fuel standard, tighten vehicle standards

- **Market instruments to align regulations with market**
  - Fuel and carbon taxes
  - Feebates

- **Accelerate commercialization of advanced vehicles**
  - Require and reward electric and fuel cell vehicles

- **Restrain vehicle use**
  - Improve public transportation, expand mobility choices, increase the cost of driving, manage urban land use

- **Increased R&D investments (and training of next generation of scientists and engineers)**
  - Biofuels, batteries, fuel cells, lightweight materials, innovative mobility technologies
Five Lessons and Conclusions

1. No single solution: Need to pursue many solutions (which mostly exist already)

2. Focus on change (desirable pathways), not simplistic end-state visions

3. One size does not fit all. Tailor solutions to each situation (fuels, vehicles, mobility, infrastructure)

4. Scientific community needs to engage in near-term decision-making—locally, nationally, globally

5. .....
5. Take Action Now!
Domo arigatou gozaimasu

有難う 御座います