

Sustainable Transportation Energy Pathways (STEPS)

2017 Advisory Board Meeting

December 8, 2017

Joan Ogden, Director, Initiating Transitions Lead
Lew Fulton, Co-Director, Global Mobility Lead
Dan Sperling, Co-Director
Rosa Dominguez-Faus, Program Manager

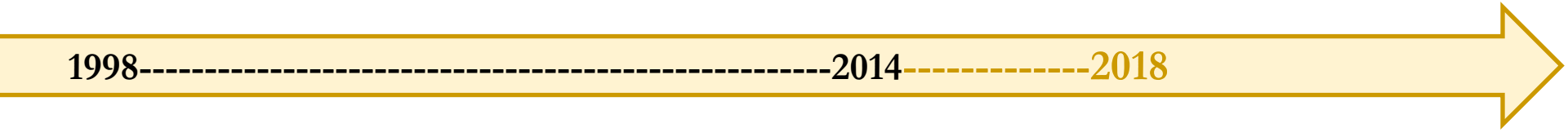
ITS UCDAVIS
INSTITUTE OF TRANSPORTATION STUDIES

www.steps.ucdavis.edu

STEPS is the leading global forum of low-carbon transportation stakeholders

Generate visions of fuel and vehicle futures grounded in technical and economic realities, a strong knowledge base for companies making long-term technology investments, and sophisticated analyses of future policies.

- Modeling and analyzing alternative fuel transitions
- Preparing scientific analysis and convening policy and business decision makers
- Training next generation leaders in transportation and energy



Fuel Cell Vehicle Modeling Program
1998-2002
FCV Technology

Hydrogen Pathways
2003-2006
FCVs & H2 Fuel Pathway

STEPS
2007-2010
Fuel/Vehicle Pathway Analyses & Comparisons

NextSTEPS
2011-2014
Scenarios & Transition Strategies

STEPS3
2015-2018
Critical Transition Dynamics

Goals for this meeting

1. Provide updates and discuss 2017 program, projects and impacts
2. Review slate of proposed projects for 2018
3. Ensure STEPS continues to provide useful, timely insights that inform your decision making

Introductions

Affiliations and Responsibilities

Directors' Report

STEPS 2017 Progress

STEPS 2017-18 Members

Welcome our newest members:

- Bosch
- Faurecia

STEPS Leadership and Management

Joan Ogden
Director
Professor, Env. Sci.& Pol

Lew Fulton
Co-Director
Global Mobility Lead

Rosa Dominguez-Faus
Program Manager

Daniel Sperling
Co-Director
Professor
ITS-Davis Founding

Beth Bourne
Assistant Manager

STEPS 2017 – Benefits for sponsors

Our Primary Goal:

Produce timely, science-based analysis, tools and insights to inform industry and gov't planning

Sponsor benefits:

Receive first access to preliminary research and experts in alt. fuels/vehicles/regulation

- Specific interactions and research update requests
- Interactions with consortium members
- White papers
- Invitation-only Symposia and topical workshops
- Webinars on timely topics
- Research insight emails
- Access to development of models and projects

STEPS 2015-2018 *(STEPS3)*: Understanding Critical Transition Dynamics for Sustainable Transportation

Key Research Themes :

1. **Initiating Transitions 2015-2030**
   What is required for early alternative fuel/ vehicle transitions to succeed?

2. **The Future of Fuels and the Oil and Gas Industry**
   How will changing geopolitical landscapes and disruptive technology in the oil and gas and clean technology industries impact future business models and the competition of fuels?

3. **The Future of Global Urban Sustainable Transport (GUSTO)**
   How will a rapidly urbanizing world affect transport and energy demand?

4. **Modeling Analysis, Verification, Regulatory and International Comparisons (MAVRIC)**
   What do improved and cross-compared energy/ economic/ environmental/ transportation models tell us about the future of transportation?

STEPS 2017 Program Stats

- 16 Research projects
- 25 publications and reports
- 20 PhD-level faculty and staff researchers
- 16 PhD and MS graduate students (5 new, 7 graduated)
- 7 graduate degrees granted in 2017 (4 Ph.D., 3 M.S.)
- 3 major STEPS events with industry, policymakers, NGOs, academics
- 5 webinars and briefings on STEPS research
- Research insights and blogs
- Numerous invited talks, meetings with sponsors and other expert stakeholders
- Research and expertise by STEPS team members and affiliates at UC Davis reported by state, national, and international media

STEPS3 continues to build robust set of models

- **CA-TIMES:** Energy System Model for California
- **CCPM:** CA Climate Policy Modeling dialogue project
- **GCAM:** Global Change Assessment Model
- **MoMo:** Global Transport Energy Model (IEA)
  - Assessing the Impacts of Rapid Uptake of Plug-in Vehicles in Nordic Countries
- **iTEM:** International Transport/Energy Model Comparison Project
- **GBSM:** Geospatial Biorefinery Siting
- **Natural Gas** Infrastructure model
- **Hydrogen** station siting and rollout models
- **EV charger siting & rollout** models
- **CCS system** model
- **LEM:** Life cycle emissions models
- **AVCEM:** Advanced Vehicle Cost & Energy Use Model
- **TOP-HDV**: California truck projection model
- **ADVISOR**: vehicle energy use simulation model
- **Water, land, materials & energy** modeling
- **MESSAGE**
- **Spatial Suite**

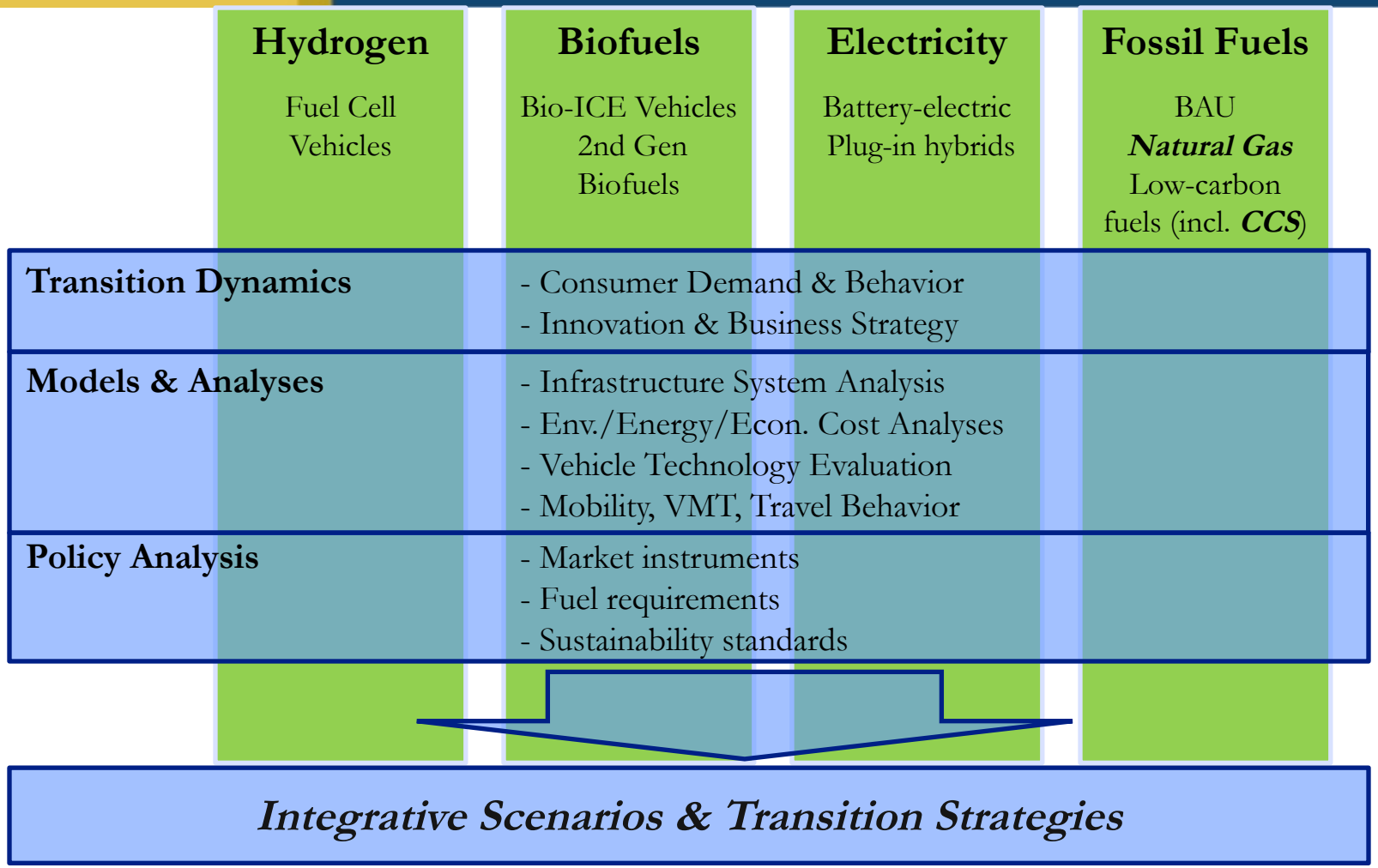
STEPS team member contracts with CEC, ARB and others

http://steps.ucdavis.edu/research/projects/

STEPS 2016

Research Updates

We use our STEPS research framework to analyze and compare alternative fuel and vehicle transitions



STEPS3 – Major Research Tracks

Understanding Critical Transition Dynamics for Sustainable Transportation

1. **Initiating Transitions 2015-2030**

   What is required for early alternative fuel/vehicle transitions to succeed?

2. **The Future of the Fuels Industry**

   How will changing geopolitical landscapes and disruptive technology in the oil and gas and clean tech industry impact future business models and the competition of fuels?

3. **The Future of Global Urban Sustainable Transport**

   How will a rapidly urbanizing world affect transport and energy demand?

4. **Modeling Analysis, Verification, Regulatory and International Comparisons**

   What do improved and cross-compared energy/economic/environmental/ transportation models tell us about the future of transportation?

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2017 Projects

Initiating Transitions 2015-2030 *What is required for early alternative fuel/vehicle transitions to succeed?*	
1	Transportation Transition Scenarios to Meet Climate Change Goals for CA and the US
4	Fuel cells and Hydrogen in Medium and Heavy Duty trucks and buses: A Technology Assessment
5	Truck Choice Decision Model to Evaluate the Penetration of New Technologies in the Trucking Sector
8	Hydrogen Energy Storage via Electrolysis from Curtailed Renewables in California: A Systems Analysis and Techno-economic Assessment
11	21st Century Rail Propulsion: 5 Case Study Analyses Examining Costs and Emissions across Motive Power Technologies
13	Regional Hydrogen Infrastructure Transition Strategies: From 100 to 1000 stations in California and Beyond
16	Which of 3 Revolutions in Highway Trucking? Comparative assessment of hydrogen/fuel cell, electric/catenary, electric/inductive charging systems in California
The Future of Fuels and the Oil and Gas Industry *How will changing geopolitical landscapes and disruptive technology in the oil and gas and clean technology industries impact future business models and the competition of fuels?*	
2	Peak Oil Demand: the Role of Policies after the Paris Agreement
6	Biofuel Costs: Supply Curve Update
12	LCFS Status Review: 2017 Annual Report
15	Impacts of Gasoline Prices on the New Car Market
The Future of Global Urban Sustainable Transport (GUSTO) *How will a rapidly urbanizing world affect transport and energy demand?*	
3	International Electric Vehicle Modeling and Scenarios
7	Shared Mobility in First/Last Mile Transit Access Programs: Impacts on Travel Demand, Energy and Emissions
10	Low-Speed Electric Vehicles (LSEVs) in China: Market Boom, Consumer Behaviors and Energy and Environmental Impacts.
14	Vehicle Ownership and Shared Mobility: Will driving for Lyft/Uber change the vehicle you buy?
Modeling Analysis, Verification, Regulatory and International Comparisons (MAVRIC) *What do improved and cross-compared energy/economic/environmental/ transportation models tell us about the future of transportation?*	
9	Near-term Transitions to AF Vehicles Using a Regional Consumer Choice and Fueling Infrastructure Model
	Others in previous sections

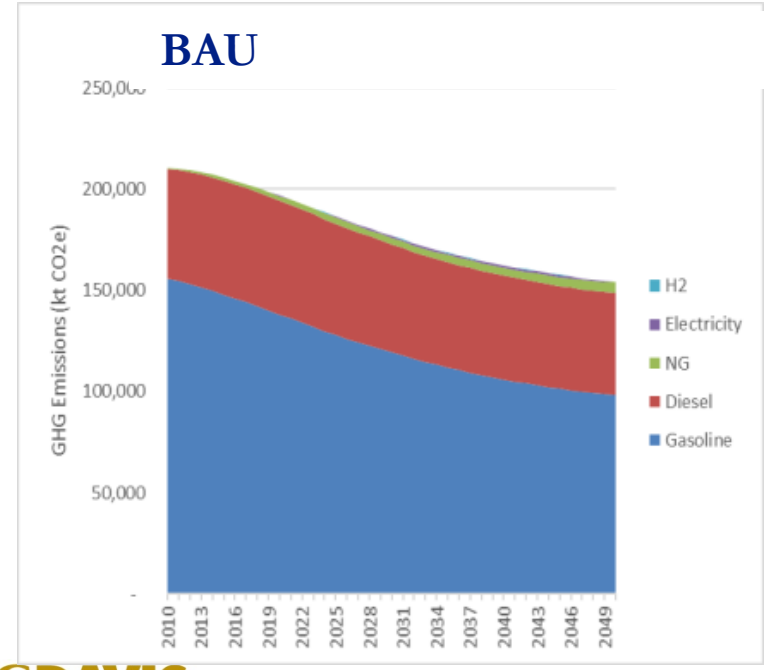
2017 STEPS RESEARCH INSIGHTS

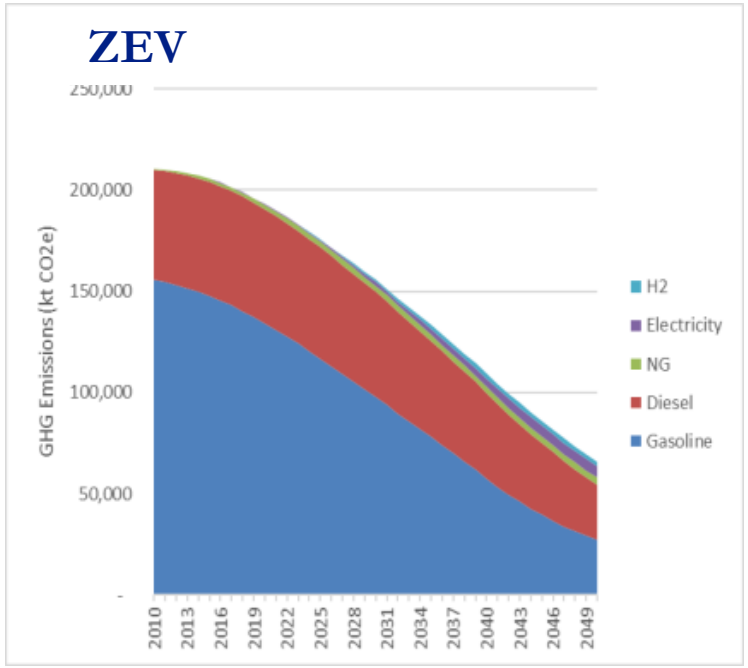
Revised Transition Scenarios for California (Miller et al.)

Develop scenarios for transportation to analyze future LD and HD vehicle market shares, fuel usage, emissions, transition costs

- Analyze 2010-2050, CA based
- Technology types (gasoline, diesel, hybrids, NG, BEV, fuel cell)
- Fuels types (diesel, gasoline, biofuels, NG, electricity, hydrogen)

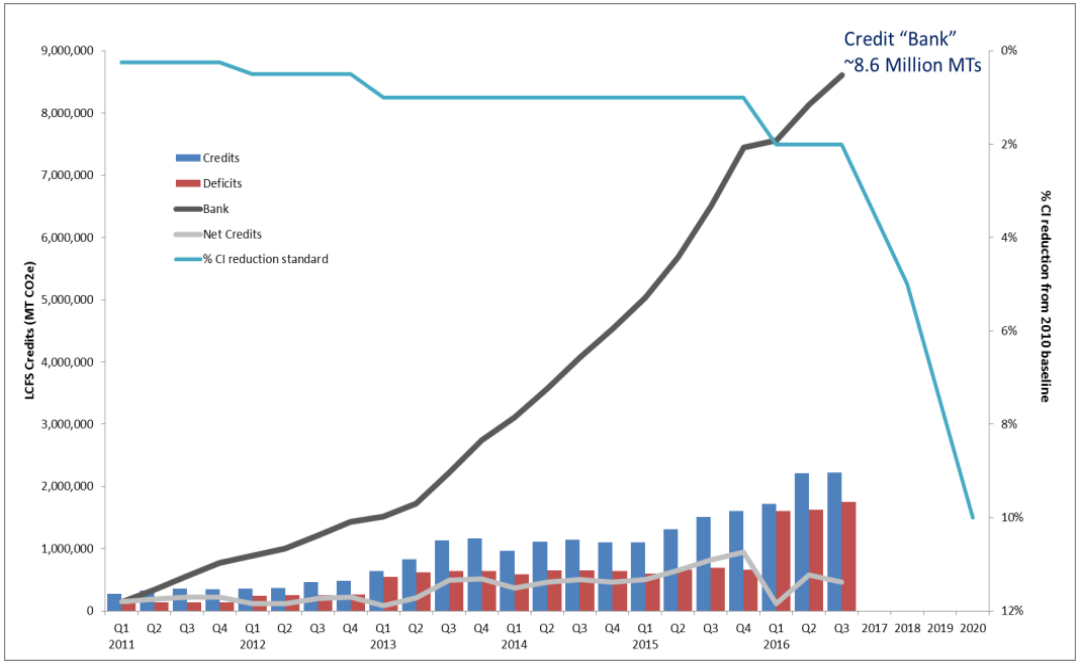
Truck + LDV GHG Emissions, BAU and ZEV Scenarios





2017 STEPS RESEARCH INSIGHTS : California Low Carbon Fuel Standard (LCFS) Status Review: (Witcover and Yeh):

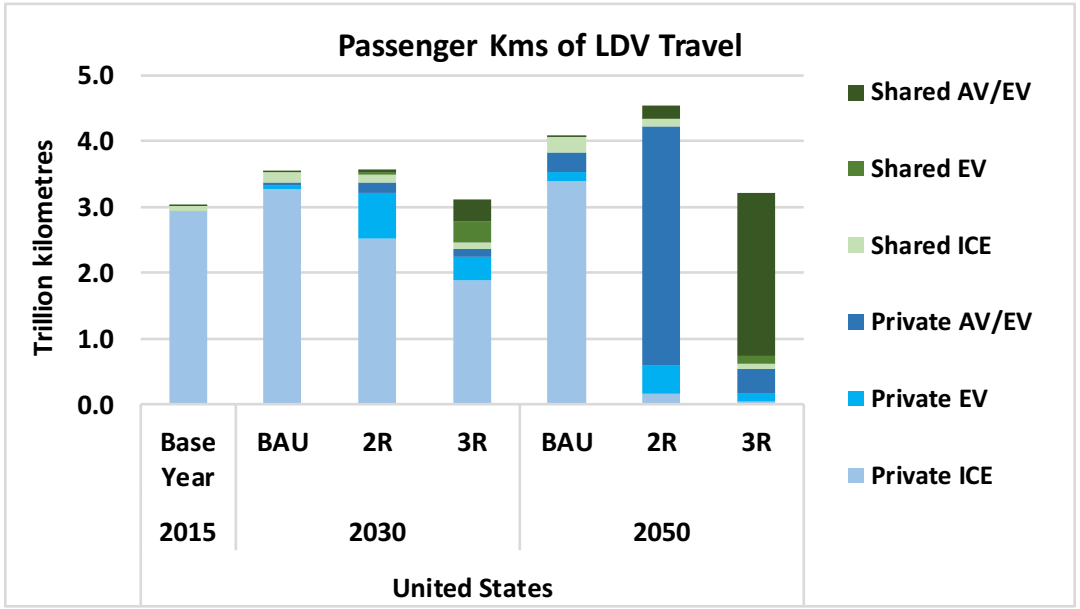
- LCFS standard required more stringent carbon intensity (CI) reductions in 2016 (2%, up from 1% in 2013-2015). The fuel pool continued to generate more credits than deficits, indicating over compliance, but the steepest program CI reductions still lie ahead.

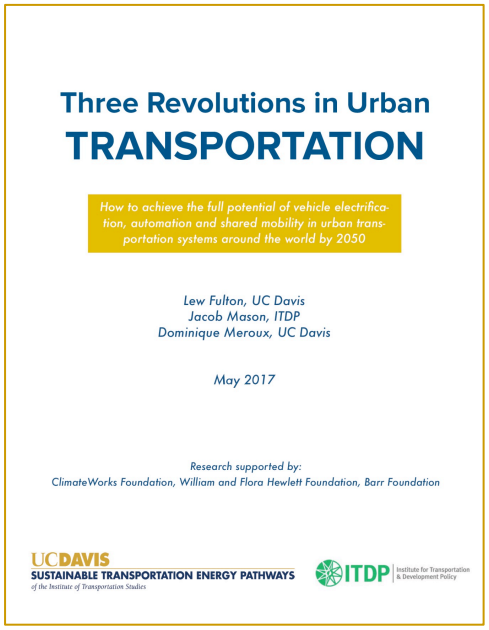


- There has been increased consumption in biomass-based diesel under the LCFS, with California's renewable diesel consumption in particular far exceeding the state's ~11% share of total US transportation fuel demand.

2017 STEPS RESEARCH INSIGHTS: **Three Revolutions in Urban Transportation (Fulton, Mason, Meroux)**

- Automation without electrification and shared mobility saves little energy or CO2
- Automation and electrification can cut CO2 but may still increase traffic
- 3 Revolutions, including more shared trips, active travel, transit use can save the most CO2 and would be the least expensive transportation system – but requires strong policies to achieve.





2017 STEPS RESEARCH INSIGHTS: **HD Truck Technology Transitions: Comparing an Energy Model with a Choice Model, C.Yang**

Attribute	Choice Model	Energy Optimization Model
Focus of Analysis	Vehicle adoption behavior	Energy system linkages – vehicle adoption coupled with upstream supply infrastructure and resources
Representation of decision-maker(s)	Consumer heterogeneity – many individuals maximizing utility	Global decision-maker - a single decision-maker designing the system
Decision factors	Utility, including non-monetary factors	Hybrid, primarily economic cost factors (coupled with implications in other sectors) with high discount rates are used to approximate non-monetary factors*
Results **Behavior** **Subsides** **Carbon Price/Tax**	**Probabilistic purchase behavior** **Very high subsidies req for C reduction.** Carbon price: extra economic costs associated with policies (may not include non-monetary factors)	**Often see "winner-take-all" behavior (one technology is the lowest cost)** **Modest cost C reduction** C price is policy instrument that can help to change behavior in the adoption of low-carbon technologies and fuels (should account for non-monetary factors)

Highlights a tension in modeling between results that are societally optimal and behaviorally realistic

STEPS 2018

Discussion of STEPS Projects for 2018

Project Selection Process for 2018

Goals for 2018 Projects:

Robust portfolio of projects selected have high research merit; match STEPS mission; collectively cover four "critical transition dynamics" tracks, fuel pathways, and cross comparative threads of the STEPS 2015-2018 program.

- Oct. 14: sent proposal solicitation and instructions to team.
  - *Title, team, 2016/2017 status, description, anticipated results, relevance to sponsors, deliverables, budget, additional research plans.*
- Nov. 1: collected proposals.
- Nov. 14: STEPS leadership reviewed proposals.
- Nov. 15: emailed STEPS sponsors list of 2018 proposed projects.
- Collected priority project lists from sponsors.
- Dec. 1: present and discuss proposed projects with STEPS board members.
- By Dec. 20: finalize budgets for projects; release final decisions on STEPS 2018 projects to team and sponsors.

Theme 1: Initiating Transitions 2018 Projects

What is required for early alternative fuel/vehicle transitions to succeed?

1	Long Term Study on Environmentally Compatible Transportation Technologies: A California Case Study (1,4)	Joan Ogden	Behdad Kiani, 1 GSR
5	Engaging Consumers in Transportation Energy Transitions (1)	Kenneth Kurani	1 GSR
10	Analysis of Hydrogen Infrastructure Requirements for Zero Emission Freight Applications in California (1,2)	Joan Ogden	Marshall Miller, Research engineer, Guozhen Li (GSR)
13	LCA of light duty Electric Vehicles – examining trends in vehicle efficiency, performance and battery capacity (1,4)	Alissa Kendall	Lew Fulton, 1 GSR
14	21st Century Rail Propulsion: Case Study Analyses Examining Costs and Emissions across Motive Power Technology Options (1,4)	Raphael Isaac	Lewis Fulton, Paul Erickson

Theme 2: Future of Fuels and the Oil and Gas Industry- 2018 Projects

How will changing geopolitical landscapes and disruptive technology in the oil and gas and clean tech industry impact future business models and the competition of fuels?

3	Comparing Impacts of Gasoline Prices and Government Policies on the New Car Market in Different Countries (2,3)	Dan Sperling	Tongxin Xu (GSR) Alan Jenn, Erich Muehlegger
2	STEPS Summary for Policymakers (1,2,3,4)	Austin Brown	1 GSR
4	LCFS Status Review -- California and beyond (1,2)	Julie Witcover	Lew Fulton
6	Technologies and Fuels to Reduce GHGs in MD/HD trucks and buses (1,2)	Andrew Burke	Marshall Miller, 1 GSR
12	Peak Oil Demand (2)	Lew Fulton	1 GSR

Theme 3: Global Urban Sustainable Transportation (GUSTo) 2018 Projects

How will a rapidly urbanizing world affect demand for transport and energy? How can we transition to sustainable transportation in a rapidly urbanizing world with ever-growing need for mobility?

8	4 Revolutions in Urban Freight: On-Demand Economy, Automation, Electrification, and Sharing (3,4)	Miguel Jaller	Lew Fulton, Marshall Miller, Giovanni Circella, GSR and Undergraduate Research Assistant
9	A multi-model approach to generate international electric vehicle future adoption scenarios (1,3,4)	Alan Jenn	Lew Fulton, 1 GSR
15	Panel Study of Emerging Transportation Technologies and Trends in California (PHASE TWO) (1,3)	Giovanni Circella	Lew Fulton, Susan Handy, Dan Sperling, 1 GSR
17	Present and Future Costs of Shared Mobility and Automated Vehicle Services, and Consumer Response to Policy Incentive Systems (1,3)	Lew fulton	Junia Compostella (GSR)

Theme 4: Modeling, Analysis, Verification, and Regional and International Comparisons (MAVRIC): 2016 Projects

What do improved and cross-compared energy/economic/environmental/ transportation models tell us about the future of transportation?

7	Expansion of the Trucking Transition Scenarios Model to the US (1, 4)	Marshall Miller	Lew Fulton, 1 GSR
11	Undertaking CCPM-2 CA Scenario Comparison Project (4)	Lew Fulton	Austin Brown, 1 GSR
16	Modeling the Spatial distribution of the PEV Market: Exploring neighborhood effects, incentives and infrastructure on PEV market penetration in California. (1,4)	Gil Tal	Jae Hyun Lee

Survey Questions

1. Which projects are of keen interest to you and your organization?
2. For which projects could you offer up expertise, data, or other relevant information?
3. What kind of dissemination products should we prioritize?

Wrapping up STEPS 3

Potential white papers during 2018

- Advanced biofuels – what role can they play by 2030, 2050 in CA and US?
- A low carbon transportation transition scenario for California/United States
- Can CA/US/World reach specific PEV sales/stock targets by 2030?
- What will it take to achieve ZEV truck targets by 2030?
- Global peak oil: if, when, and with what impacts?
- What do global models tell us about achieving Paris CO2 targets? What do CA models tell us about CA targets?
- Hydrogen infrastructure paper
- EV/renewables/Electric power paper

STEPS 4

Ideas

Potential Focus Areas for STEPS4

- Regional/spatial "deep dive" studies for CA, including light and heavy duty vehicle travel, pollutant as well as CO2 emissions, and energy production/distribution/infrastructure
- 3 Revolutions in passenger and freight travel: modeling the future in CA, US and internationally
- Future energy flows: where will energy feedstocks come from and where will they go, around the world (GCAM or Message type modeling)
- Optimizing the electricity system to 2050 with both large scale renewable generation and electric vehicle electricity demand
- Optimizing the low carbon future for heavy duty vehicles across liquid fuels, biogas, H2 and electricity

Thank you

Joan Ogden, Director and Initiating Transitions Lead jmogden@ucdavis.edu
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Rosa Dominguez-Faus, Program Manager rdominguezfaus@ucdavis.edu
Beth Bourne, Assistant Program Manager bybourne@ucdavis.edu

Appendix

STEPS – *Advisory Board*

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Jack Moore
Aramco

Uwe Higgen
BMW Group

Sean Waters
Daimler Trucks

John Viera
Ford

Chris Grundler
U.S. EPA

Kevin Womack
U.S. DOT

Frank Seyfried
Volkswagen

Britta Gross
GM

Karen Hamberg
Westport Fuel Systems

Alberto Ayala
CA Air Resources Board

Janea Scott
CA Energy Commission

Steven Cliff
Caltrans

Michael Hartrick
FCA

Debra Bakker
Hyundai

Robert Wimmer
Toyota

Lisa Browy
SEMPRA

Rodica Faucon
Renault

Avinash Pathak
Indian Oil

Greg Kamla
Shell

Jennifer Rumsey
Cummins

Rick Powell
Chevron

Sheila Watson
FIA Foundation

Matthew Miyasato
South Coast AQMD

Fred Joseck
U.S. DOE

Robert Bienenfeld
Honda

Chaomei Chen
Sinopec

Dawn Fenton
Volvo Group

Mallik Angalakudati
PG&E

STEPS – Sponsorship Benefits

- **Customized Engagement Plan –** Each year we coordinate a customized interaction schedule with your organization to ensure that you receive the maximum value from your contribution.
- **Research Symposia and Workshops -** Numerous invitation-only events are held each year on the latest research related to critical industry planning and government policy topics.
- **Advisory Board Membership -** The STEPS board meets several times each year to receive an update on the latest research and advise STEPS leadership on future research, events, and communications.
- **Focused Requests & Campus Visits -** STEPS is pleased to accommodate special sponsor requests for interaction on specific topics, and host visits to facilitate interactions related to these requests.
- **Briefings, Reports and Webinars -** STEPS researchers produce publications as one of their primary outputs. Monthly research briefings, periodic webinars, and quarterly reports are issued highlighting recent research results, events and upcoming activities.
- **Policy Engagement -** Special public process engagements are periodically held that include meetings, briefings and webinars with policy makers and their staff. STEPS sponsors are encouraged to attend these events.
- **Internships and Extended Visits -** STEPS is pleased to support student internships at sponsor locations, host extended visits by sponsors at ITS-Davis, and send research leaders to visit sponsors.

36 STEPS publications in 2016: 19 in peer reviewed journals (1)

Title	Author(s)
Energy Investing and Climate Change: Recommendations for the Next U.S. President	Bachher, Jagdeep Singh and Amy Myers Jaffe
Can We Achieve 100 Million Plug-in Cars by 2030?	Fulton, Lewis, Gil Tal, Thomas S. Turrentine
Status Review of California's Low Carbon Fuel Standard, 2011-2015: May 2016 Issue	Yeh, Sonia and Julie Witcover
War and the Oil Price Cycle	Jaffe, Amy Myers and Jareer Elass
Chapter 5 Update: Why History Won't Repeat Itself for OPEC This Time	Morse, Edward L. and Amy Myers Jaffe
Moving Beyond Alternative Fuel Hype to Decarbonize Transportation	Melton, Noel, Jonn Axsen, Daniel Sperling
Plug-In Electric Vehicle Multi-State Market and Charging Survey	Tal, Gil
Pollution: Three Steps to a Green Shipping Industry	Wan, Zheng, Mo Zhu, Shun Chen, Daniel Sperling
Exploring the Use of a Web Based Map Tool for Travel Behavior Data Collection: Lessons from Plug-in Vehicle Owner Surveys	Tal, Gil, Matthew Favetti, Michael A. Nicholas
Three Routes Forward for Biofuels: Incremental, Leapfrog, and Transitional	Morrison, Geoffrey M., Julie Witcover, Nathan C. Parker, Lewis Fulton

2016 STEPS publications (2)

Exploring the Longest Trip: A New Look on the Impact of Long Road Trips on VMT	Tal, Gil and Michael A. Nicholas
NCST Research Report: Bicyclist Behavior in San Francisco: A Before-and-After Study of the Impact of Infrastructure Investments	Fitch, Dillon T., Calvin Thigpen, Antonio Cruz, Susan L. Handy
A Comparison of Plug-in Electric Vehicle Markets Between China and the U.S. Based on Surveys	Xing, Yan, Gil Tal, Yunshi Wang, Ying Liu, Xiaohua Ding, Pinxi Wang, Wenjie Wang
Changing Oil Market Fundamentals and the Implications for OPEC Production Strategy	Scheitrum, Daniel, Lewis Fulton, Amy Myers Jaffe
New Car Buyers' Valuation of Zero-Emission Vehicles: California	Kurani, Kenneth S., Nicolette Caperello, Jennifer TyreeHageman
Effects of Battery Chemistry and Performance on the Life Cycle Greenhouse Gas Intensity of Electric Mobility	Ambrose, Hanjiro and Alissa Kendall
Equity Impacts of Fee Systems to Support Zero Emission Vehicle Sales in California	Fulton, Lewis, Julie Schiffman, Gil Tal
Merging Expert Perspectives to Site DC Fast Charging	Metcalf, Morgan Davis, Lucy McKenzie, Jonathan Donadee, Michael A. Nicholas, Gil Tal, Wei Ji, Ashley Horvat, Ray Jenks, Akhil Jariwala, Marc Wiseman, Sujith Kollamthodi, Sabrin Mohamed, Calder Silcox

2016 STEPS publications (3)

Rethinking the Role of Plug-In Hybrid Vehicles in the Transition to Low Carbon Transportation: Risks and Opportunities	Tal, Gil, Thomas S. Turrentine, Michael A. Nicholas
Exploring the Decision to Adopt a High-End Battery Electric Vehicle: Role of Financial and Nonfinancial Motivations	Hardman, Scott and Gil Tal
Exploring the Impact of the Federal Tax Credit on the Plug-in Vehicle Market	Tal, Gil and Michael A. Nicholas
Fuel Consumption Impacts of Auto Roof Racks	Chen, Yuche and Alan Meier
NCST Research Report: What Affects Millennials' Mobility? Part I: Investigating the Environmental Concerns, Lifestyles, Mobility-Related Attitudes and Adoption of Technology of Young Adults in California	Circella, Giovanni, Lewis Fulton, Farzad Alemi, Rosaria M. Berliner, Kate Tiedeman, Patricia L. Mokhtarian, Susan L. Handy
Optimal Allocation of Lane Space and Green Splits of Isolated Signalized Intersections with Short Left-Turn Lanes	Yao, Ronghan and Hongjun Michael Zhang
Simulation of Cumulative Annual Impact of Pavement Structural Response on Vehicle Fuel Economy for California Test Sections	Harvey, John T., Jeremy D. Lea, Changmo Kim, Erdem Coleri, Imen Zaabar, Arghavan Louhghalam, Karim Chatti, Jeffrey Buscheck, Ali Butt

2016 STEPS publications (4)

Status Review of California's Low Carbon Fuel Standard, 2011-2015: May 2016 Issue	Yeh, Sonia and Julie Witcover
PHEVLERs are the Zero CO2 Clean Green Machines of the Future	Frank, Andrew A., Bruce R. Thomas, Catherine J. DeMauro
Adaptive Planning for Sea Level Rise-threatened Transportation Corridors	Shilling, Fraser M., Justin Vandever, Kris May, Ina Gerhard, Robert Bregoff
Key Research Themes on Urban Space, Scale, and Sustainable Urban Mobility	van Wee, Bert and Susan L. Handy
EV Explorer: Evaluating a Vehicle Information Tool	Sanguinetti, Angela, Michael A. Nicholas, Gil Tal, Matthew Favetti
Integrating Renewable Energy with the Long Range Plug-in Hybrid Electric Vehicle Fleet	Frank, Andrew A. and Catherine J. DeMauro

2016 STEPS publications (5)

The Interactions between E-shopping and Store Shopping in the Shopping Process for Search Goods and Experience Goods	Zhai, Qing, Xinyu Cao, Patricia L. Mokhtarian, Feng Zhen
Using the Fleet of Long Range Plug-in Hybrid Electric Vehicles	DeMauro, Catherine J. and Andrew A. Frank
EVMT in the Household Fleet: Integrating Battery Electric Vehicles into Household Travel	Nicholas, Michael A. and Gil Tal
Can Commuters Combat the Duck Curve with Plug-in Electric Vehicles? Scenario Analysis of PHEVs and BEVs	Ji, Wei, Michael A. Nicholas, Gil Tal
Multimodal Travel Groups and Attitudes: A Latent Class Cluster Analysis of Dutch Travelers	Molin, Eric, Patricia L. Mokhtarian, Maarten Kroesen
The Rebound Effect and Energy Efficiency Policy	Gillingham, Kenneth, David Rapson, Gernot Wagner