

## STEPS3

### *Understanding Critical Transition Dynamics for Sustainable Transportation*

Technological innovations are transforming the energy and vehicle industries. The shale revolution is producing abundant oil and gas at relatively low cost, and oil prices have fallen dramatically; at the same time, conventional vehicles are becoming far more energy efficient and have the potential for even more efficiency gains. The net effect of these developments undermines the demand for alternative transportation fuels and vehicles. However, many studies conclude that market penetration of alternatives *must* be accelerated as part of a suite of mitigation options in order to stabilize the climate. Even with technical advances and early commercial activity in electric vehicles, natural gas, hydrogen, and advanced biofuels, none of these alternatives have reached mass-market scale. Successful, early transitions are critical for low-carbon transportation, but are challenging and poorly understood. What are the barriers to successful transitions, and how might they be overcome? How can the opportunities and benefits of transitions be realized in the most cost-effective manner?

The Sustainable Transportation Energy Pathways (STEPS) Program at the UC Davis Institute of Transportation Studies (ITS-Davis) is a four-year multidisciplinary research consortium that brings together the world's leading auto OEMs, energy companies and government agencies to understand sustainable vehicle and energy solutions. STEPS (2007–2010) and NextSTEPS (2011–2014) carried out a wide body of interdisciplinary research projects addressing four potential transportation energy pathways: electricity, hydrogen, biofuels, and fossil fuels. These pathways have been analyzed and compared across program areas including consumer demand and behavior; infrastructure system analysis; environmental, energy, and economic cost analysis; innovation and business strategy; vehicle technology evaluation; policy analysis; and integrative scenarios. Over the next four years, the STEPS3 2015–2018 research consortium (STEPS3) will focus on understanding these critical transition dynamics for sustainable transportation.

The STEPS3 consortium—consisting of 20+ Ph.D.-level faculty and researchers, 10+ Ph.D. and 10+ master's graduate students, and 25+ industry and governmental partners—will refine scenarios and better characterize the critical factors for successful sustainable transportation transitions. We will continue to explore the difficult technical, economic and behavioral questions required to inform industry planning and government policy during this transition period of competing claims to sustainable transportation. The following four research areas, which build on seventeen years of consortium-based research at ITS-Davis, will cover the increasingly complex landscape of alternative vehicles and fuels in California, the U.S. and internationally.

#### **1. Initiating Transitions 2015-2030**

##### *What is required for early alternative fuel and vehicle transitions to succeed?*

###### *Motivation & Value:*

Significant progress in alternative fuels and vehicles has been achieved over the past decades but none of the alternatives have reached mass-market scale. We appear to be on the cusp of an initial transition for several new sustainable transportation technologies. This research area aims to understand the potential and likely role of alternative fuels and vehicles over the next 15 years. We examine technology progress, stakeholder roles, transition dynamics, commercialization strategies, and the role of policy in driving and supporting transitions during this critical period.

*Key Research Questions:*

- What can we learn about the barriers and opportunities and the costs and benefits of introducing new fuels and vehicles?
- How are vehicle rollouts proceeding for electric vehicles, natural gas, biofuels and hydrogen? Which strategies are proving effective, and which are not?
- What have we learned about the policy landscape for sustainable transportation?
- How much public and private investment is needed to reach cost competitiveness with incumbents?
- What values, thresholds, limits, or other indicators signal the need for change to investments, policies, or other behavioral levers?
- What is required to develop a business case for new fuels and vehicles?
- How does adoption of alternative fuels up to 2030 impact the outlook for meeting longer-term sustainability goals and realizing different sustainable transportation futures?

## 2. The Future of Fuels and the Oil and Gas Industry

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

*Motivation & Value:*

Transformational technologies are changing the oil and gas industry, with dramatic impacts on the energy trade, competition of fuels, and the composition of future energy demand. This research area focuses on how the fuels industry will adapt to geopolitical and technology changes and climate concerns over time and how the industry will meet the challenges of rising demand for sustainable fuels.

*Key Research Questions:*

- In the absence of strong policies leading to sustainable transportation, what is the baseline outlook for future oil demand, and how might it change over time?
- How will the proliferation of big data analytics and the internet of things constrain growth in demand in the coming two decades?
- What role will changing automotive technologies and mobility services, e.g., car and ride sharing, have on oil demand?
- What are possible mixes of fuels and vehicles over time in a carbon-constrained world?
- What is the future role of liquid fuels versus gaseous fuels and electricity? How might biofuels penetrate liquid fuels markets?
- What do abundant, unconventional natural gas resources mean for the low carbon future?
- What are future technology and fuels options for the heavy duty, aviation and marine sectors?
- How will industry respond to regulatory and/or societal demands for reduced greenhouse gas (GHG) emissions and improved environmental quality for air, water, land use and materials?
- How might the oil industry transition to more sustainable fuels?

### 3. Global Urban Sustainable Transport (GUSTo)

*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?*

*Motivation & Value:*

The world's urban population is expected to rise from 3.5 billion today to 6 billion by 2050. This research area focuses on transitions to more sustainable urban transport and compares developed and developing cities, regions and countries. The role of information and communication technologies (ICT), big data, new mobility paradigms, integration of modes, and introduction of new fuel and vehicle technologies will be addressed holistically to describe likely future trends and identify forces and factors that might change VMT and system formats from an energy and GHG perspective.

*Key Research Questions:*

- What are the likely growth trends for urban travel around the world, taking into account shifts in land use, modal shares, new types of vehicles, and car ownership and use? What are the social, personal, political, economic, and technological constraints on the rates of change? Which of these tend to resist change, and which compel change?
- How will urbanization affect future transport and energy demand?
- What are the implications of growing and evolving cities for CO<sub>2</sub> emissions, transport and energy infrastructure requirements, and materials requirements?
- How might different types of policies play a role in improving alternative modes and deploying alternative fuels in this context? What are the possible impacts of greater use of ICT?
- How much and what kinds of investments and supporting policies will be needed to achieve more sustainable mobility? How does the picture differ around the world, and what trends appear likely to be global?

### 4. Modeling Analysis, Verification, Regulatory and International Comparisons (MAVRIC)

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

*Motivation & Value:*

STEPS3 will continue to develop a wide range of models and related tools to conduct research and create future scenarios. This research area will increase the focus on innovative tool development, validation—including a review of previous modeling results from today's perspectives to learn and improve models—and comparison with other existing methods. These activities will directly support priority research activities but also serve as an independent effort to assess the state of modeling and improve modeling practices in the area of sustainable transport, with a geographic scope that includes California, the U.S. and the world.

*Key Research Questions:*

- What do existing models at the California, U.S. and international levels tell us about different possible energy and transportation futures and the paths to those futures?
- How have the forecasts and models of market adoption of new vehicle and fuel technologies developed during the STEPS 2007–2010 and NextSTEPS 2011–2014 programs performed relative to their actual market penetration? What lessons can be learned and applied to improve our future models and forecasts?
- How do model projections and scenarios compare and what can we learn from each?

- How can a wide range of diverse and divergent scenarios/modeling outcomes be used to help inform decision-making and policy design in the face of significant uncertainty? Are there robust strategies that we can identify?
- What assumptions are being made and which ones matter most? What metrics of change over time are required to assess the comparative likelihood of alternative energy pathways, including one dominated by shale oil and gas, meeting sustainability goals and timelines?
- How can we improve our own scenario making and use our own models in a better fashion to help us assess policies?

### Sponsorship Benefits

**Interaction Plan** – At the beginning of each program year we coordinate a personalized conversation with your organization’s key contacts to ensure maximum value from your contribution. We also check in periodically throughout the year to understand your latest research interests and needs, and we host periodic meetings with you to discuss recent research insights.

**Research Symposia and Workshops** – Each year two to four invitation-only events are held on the latest research related to critical industry planning and government policy topics.

**Advisory Board Membership** – The advisory board meets once a year to receive an update on the latest research and to advise STEPS leadership on the program’s research and direction.

**Briefings, Reports and Webinars** – Researchers produce publications as a primary output, and issue working papers and reports over the course of the program. Sponsors get preliminary access to our research before it is published. Emailed research briefings, webinars, and quarterly reports highlight recent research results, events and upcoming activities.

**Public Process Activities** – Special public process events are periodically held, including briefings and webinars for policymakers, their staff, and the general public. STEPS sponsors are encouraged to attend and participate in these events.

**Focused Requests and Campus Visits** – STEPS is pleased to accommodate special sponsor requests for interaction on specific topics and to host visits that facilitate interactions related to these requests.

**Internships, Extended Sponsor Visits, and Employment** – STEPS is pleased to support student internships at sponsor locations, host extended visits by sponsors at ITS-Davis, send research leaders to visit sponsors, and help prepare STEPS students for careers with our sponsor and partner organizations.

### Outputs

STEPS3 program sponsors receive first access to preliminary research via our planned dissemination mechanisms, including Research Insights via email, webinar, blog and/or video, Quarterly Reports, and Symposia and Workshops. The set of anticipated deliverables each program (calendar) year includes:

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| Q1 | - Research insights via email, webinar, blog and/or video<br>- Quarterly Report                            |
| Q2 | - Research insights via email, webinar, blog and/or video<br>- Quarterly Report<br>- Workshop or Symposium |
| Q3 | - Research insights via email, webinar, blog and/or video<br>- Quarterly Report                            |
| Q4 | - Research insights via email, webinar, blog and/or video<br>- Quarterly Report<br>- Workshop or Symposium |

The STEPS3 team will also issue white papers on key topics related to the four new research themes.

## Members

During the NextSTEPS 2011–2014 program, we were proud to have 23 participants, including:

- Seven energy firms: Aramco, BP, Chevron, Centre for High Technology (India), San Diego Gas and Electric and Southern California Gas Company (Sempra Energy Utilities), Shell, Sinopec;
- Ten automotive OEMs: BMW, Chrysler, Ford, GM, Honda, Nissan, Renault, Toyota, Volkswagen, Westport; and
- Six government agencies: California Air Resources Board, California Energy Commission, Caltrans, South Coast Air Quality Management District, U.S. Department of Energy, U.S. Department of Transportation.



## Membership Fee and Responsibilities

The STEPS3 2015–2018 program fee is \$60,000 per program year (calendar year). We ask for a four-year commitment from each sponsor. Your contribution leverages, and grants you access to, \$2 million to \$3 million in research per year.

We ask that sponsors designate an *Advisory Board Member* to serve on the STEPS Advisory Board to provide research and strategic direction to the program leadership.

We also ask that sponsors designate at least one *Primary Contact*, to enable orchestration of STEPS3 research dissemination within the sponsor organization. STEPS3 research can be valuable to multiple functions within an organization, including strategic planning, government relations, and advanced vehicle, fuel and other technical divisions.

In recognition of the sponsor's participation, the sponsor's logo will be displayed on the STEPS website, in PowerPoint presentations, and in other materials.

## Leadership

The STEPS3 research team, directed by Joan Ogden and Lew Fulton, builds on eight years of STEPS research. Our highly skilled faculty and graduate students are affiliated with a range of UC Davis departments, including Agricultural and Resource Economics, Biological and Agricultural Engineering, Civil and Environmental Engineering, Economics, Environmental Science and Policy, the Graduate School of Management, and Mechanical and Aerospace Engineering. We engage over 70 faculty, staff, research leaders and graduate students at UC Davis, and maintain close ties with researchers in government, industry, national laboratories, other academic institutions, and societal organizations.

**Joan Ogden**, *Professor, Environmental Science and Policy; Director, STEPS Program, ITS-Davis*

**Lewis M. Fulton**, *Director, STEPS Program, ITS-Davis*

**Amy Myers Jaffe**, *Executive Director of Energy and Sustainability, STEPS Program, ITS-Davis*

**Daniel Sperling**, *Founding Director, ITS-Davis, Professor, Civil and Environmental Engineering, Professor, Environmental Science and Policy; Co-Director, STEPS Program*

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