VEHICLE TECHNOLOGIES OFFICE

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Analysis Program Overview

June 8, 2016

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VTO Analysis Program Goals, Objectives, and Strategy

goal

Plan, execute, and communicate technology, societal, economic, and interdisciplinary analyses for VTO, EERE, DOE, and external stakeholders

objective

Robust transportation energy analysis that speaks for itself

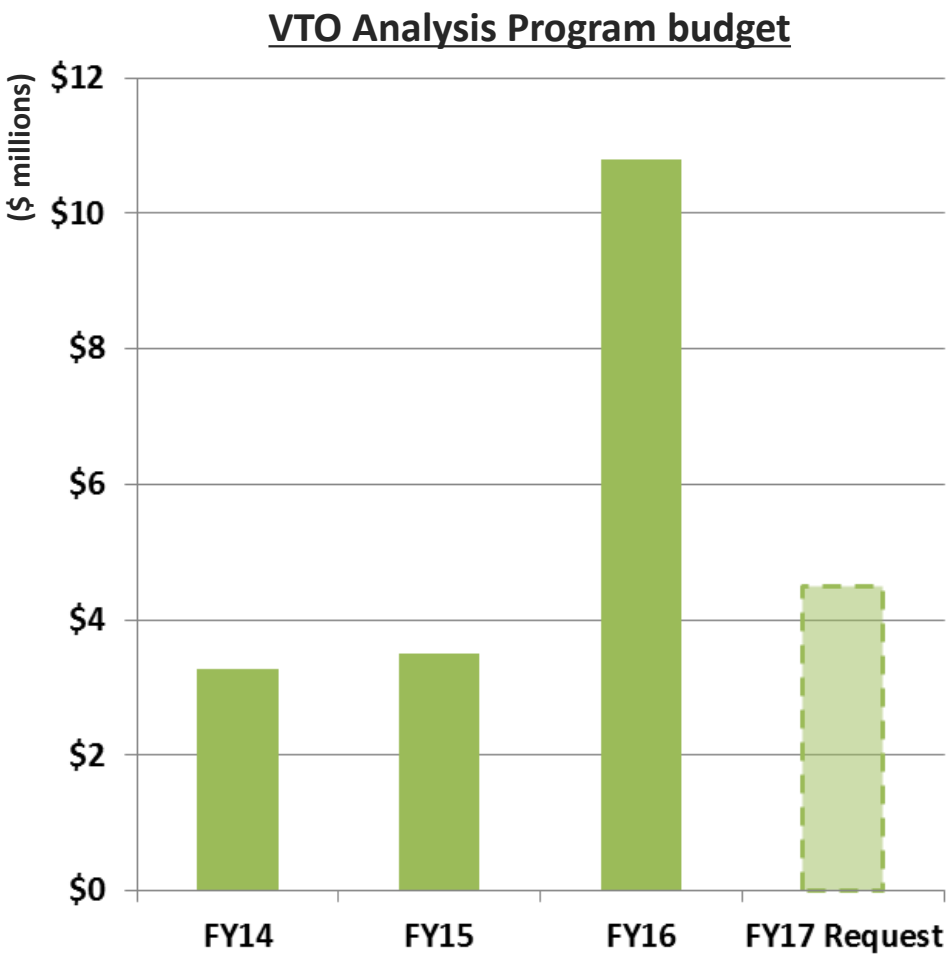
strategy

Support a strong foundation of data, build relevant analytical models, and execute insightful integrated analyses

VTO Analysis Program Budget

(all numbers in millions of dollars)

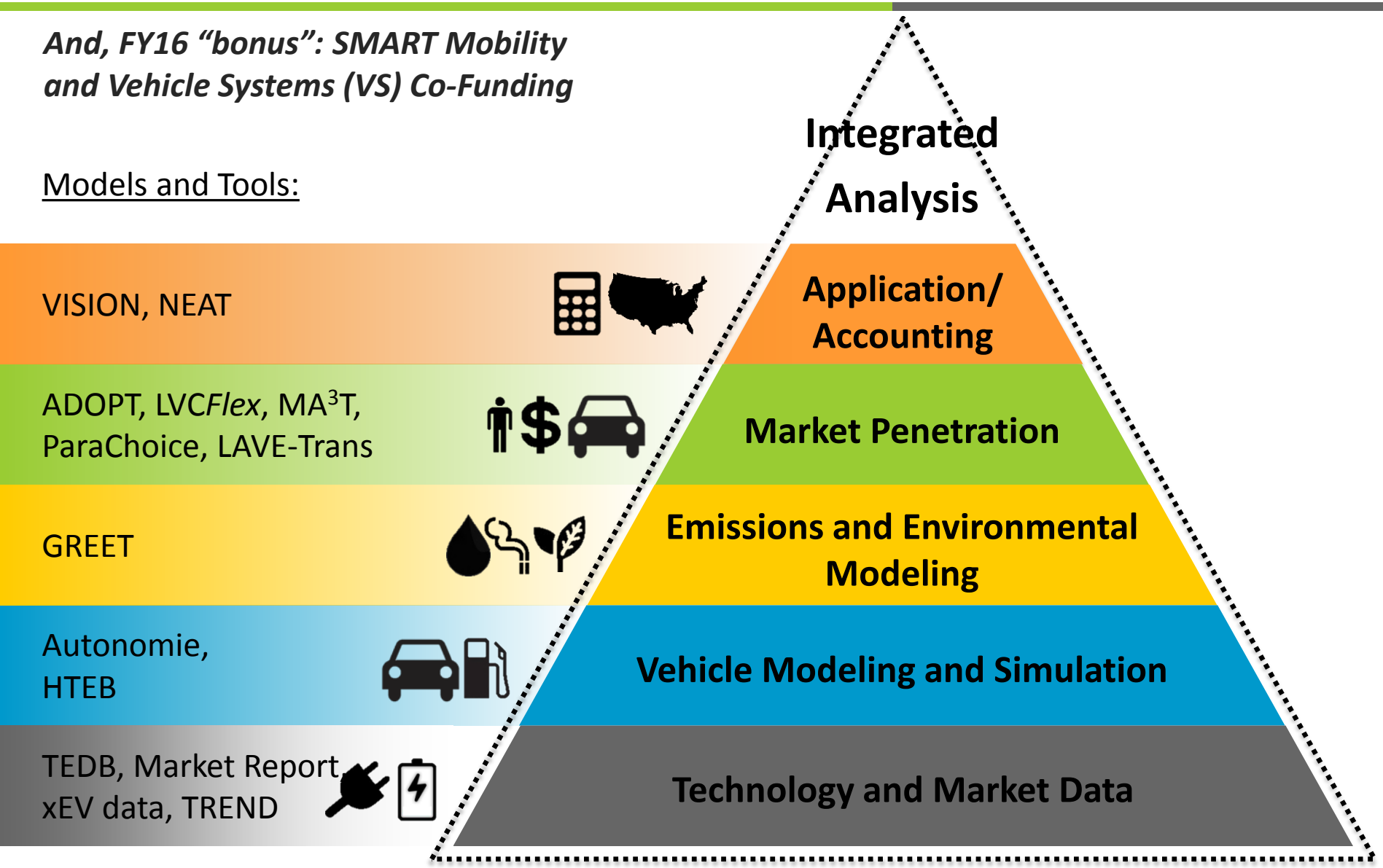
- FY16 budget restructure results in $10.8M Analysis budget; FY17 request aligned with historical levels at $4.5M
- Analysis core Program comprises data, modeling, and original analysis
- Analysis also includes Vehicle Systems (VS) co-funding and SMART Mobility foundational Analysis in FY16
- National Laboratory support from ANL, ORNL, LBNL, NREL, and Sandia



VTO Analysis (VAN) Core Program at a Glance

And, FY16 "bonus": SMART Mobility and Vehicle Systems (VS) Co-Funding

Models and Tools:



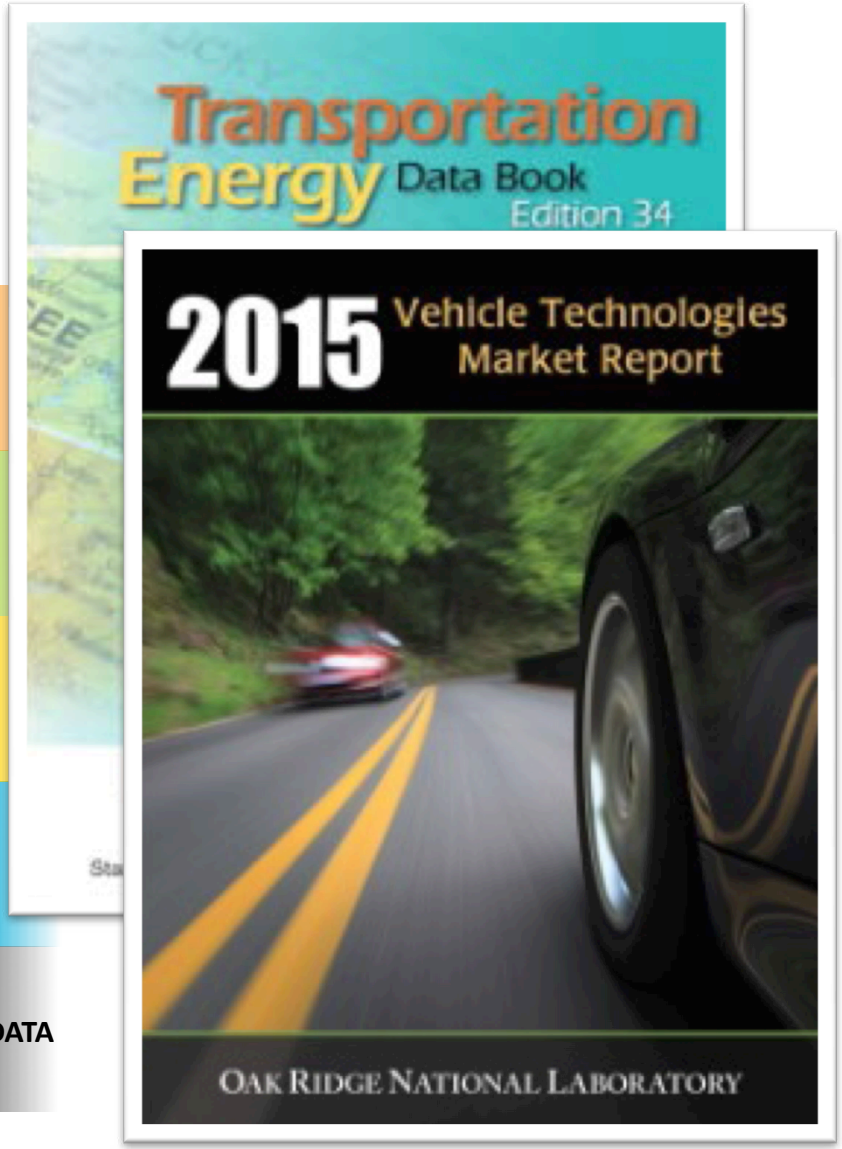
FY15-16 highlights

- **Published…**
  - Transportation Energy Data Book, edition 34
  - 2015 Market Report
- **Tracked…**
  - P/H/EV sales (U.S., international, and global)
  - Economic considerations, including public and/or private incentives and other potential correlations
- **and Reported…**
  - Historical data on consumer knowledge and perceptions
  - Extended or new time-series consumer preference data

future work

- Continue updating, disseminating, and expanding (where appropriate) data sources regularly
- Expand P/H/EV market knowledge with third-party data
- Extend relevant consumer preference time-series data, and conduct priority deep-dives supporting analysis efforts

Data: Trustworthy, Foundational, Public National Indicators



DATA

Useful, relevant information:

- **Energy systems** (petroleum, energy);
- **Vehicles** (characteristics and sales/markets of light-duty, medium-duty, heavy-duty, and non-highway modes, with special emphasis on all alternative fuel vehicles in all classes);
- **Economics** (consumers, households, manufacturing, jobs, and macroeconomic correlations);
- the **Environment** (emissions, air quality);
- and **Policy**.

With impact.

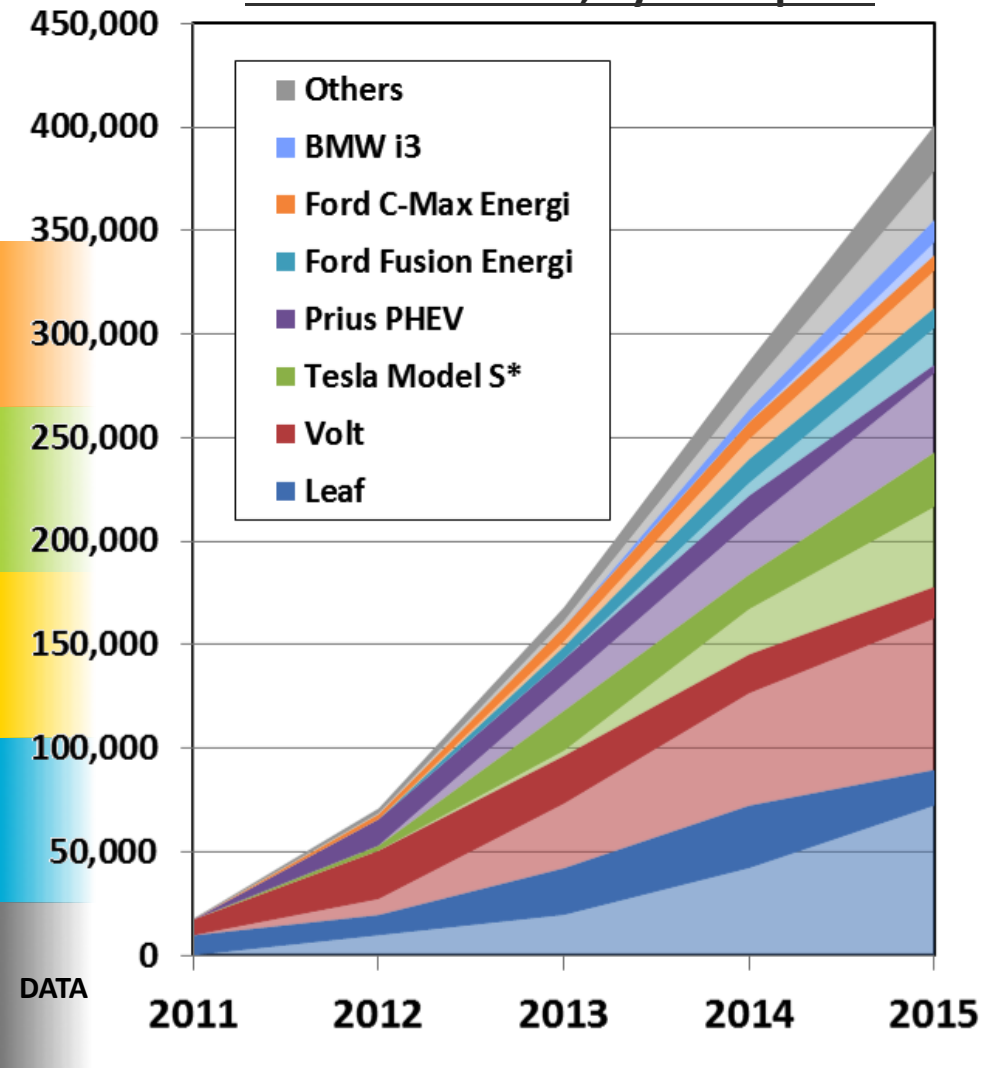
- The Transportation Data Energy Book website was *visited over 11,500 times each* month on average so far in FY16 (a 75% increase over FY15), and
- Google Scholar indicates the Data Book is *cited over 1,500 times in the academic literature*.

Resources:

- TEDB: cta.ornl.gov/data
- Market Report: cta.ornl.gov/vtmarketreport
- Fact of the Week: energy.gov/eere/vehicles/transportation-fact-week

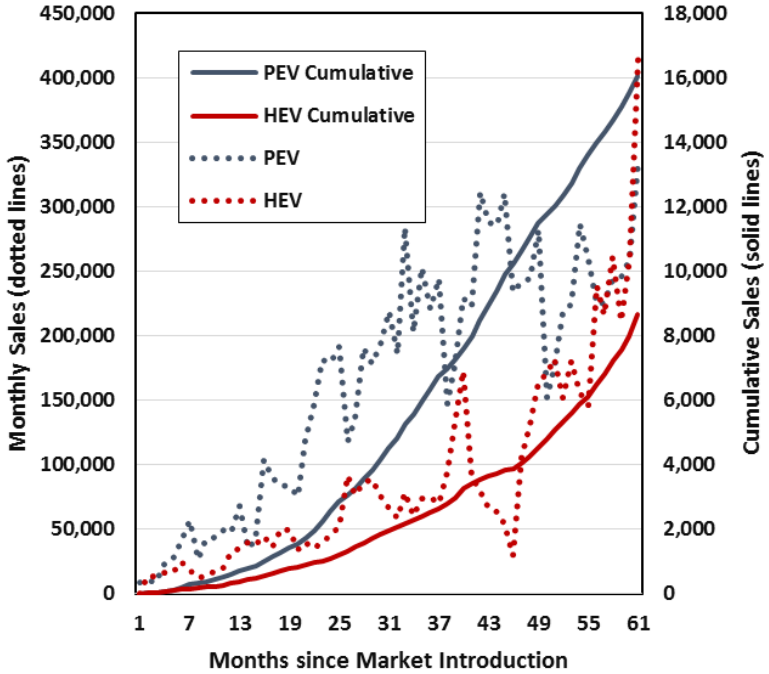
Data: P/H/EV Market Trends

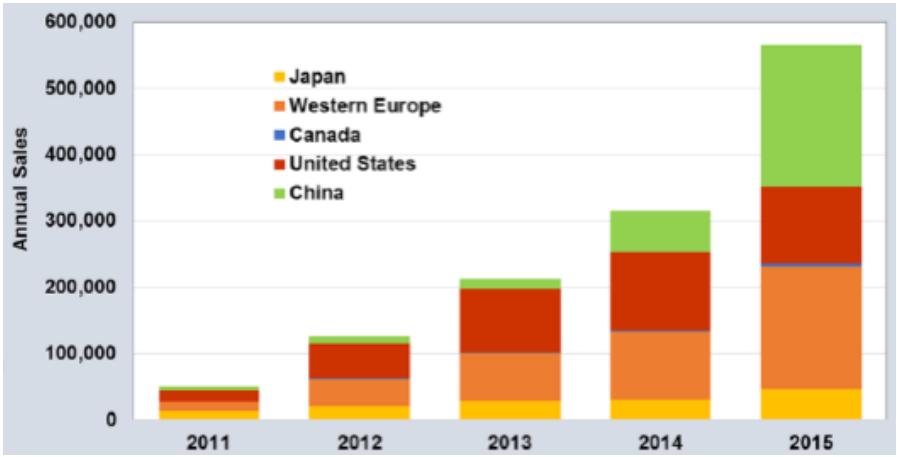
Cumulative sales, by nameplate



DATA

Historical and international context





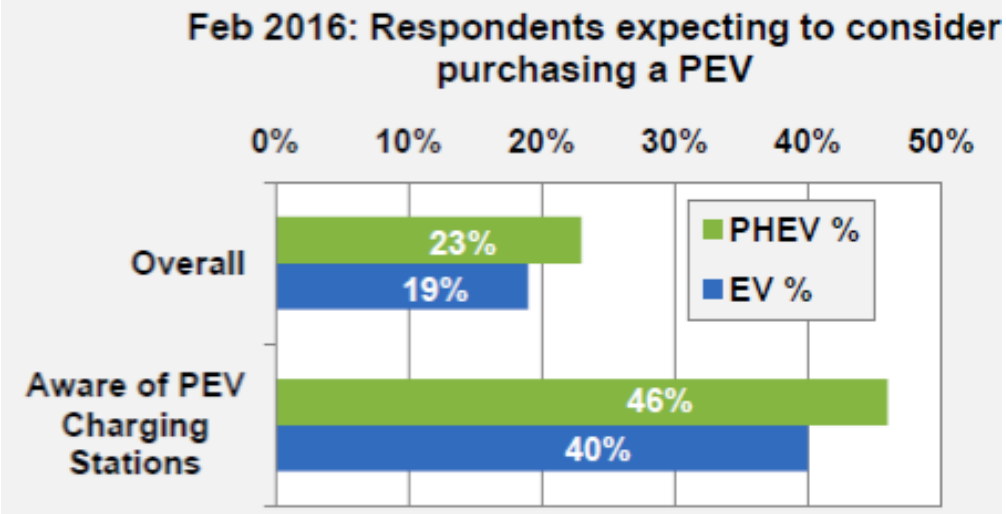
Data: Technology and Market Relevance Indicator(s)

Sample of Topic Areas	Time Series	Deep-Dives
PEV awareness	●	
PEV exposure	●	
BEV range	◒	FY15
Willingness to pay for fuel economy and PEV	◒	FY15
Alternative fuel preferences	●	
Fuel economy perceptions	◒	FY15; FY16

● - Tracked annually across multiple questions

◒ - Tracked annually at high level

- **Consumer data are tracked across VTO and Analysis topics of interest.**
- **As an example (data at right): awareness of existing charging stations is correlated with higher PEV purchase expectations.**



DATA

Vehicle Modeling and Simulation *(VTO/VS Co-Fund)*

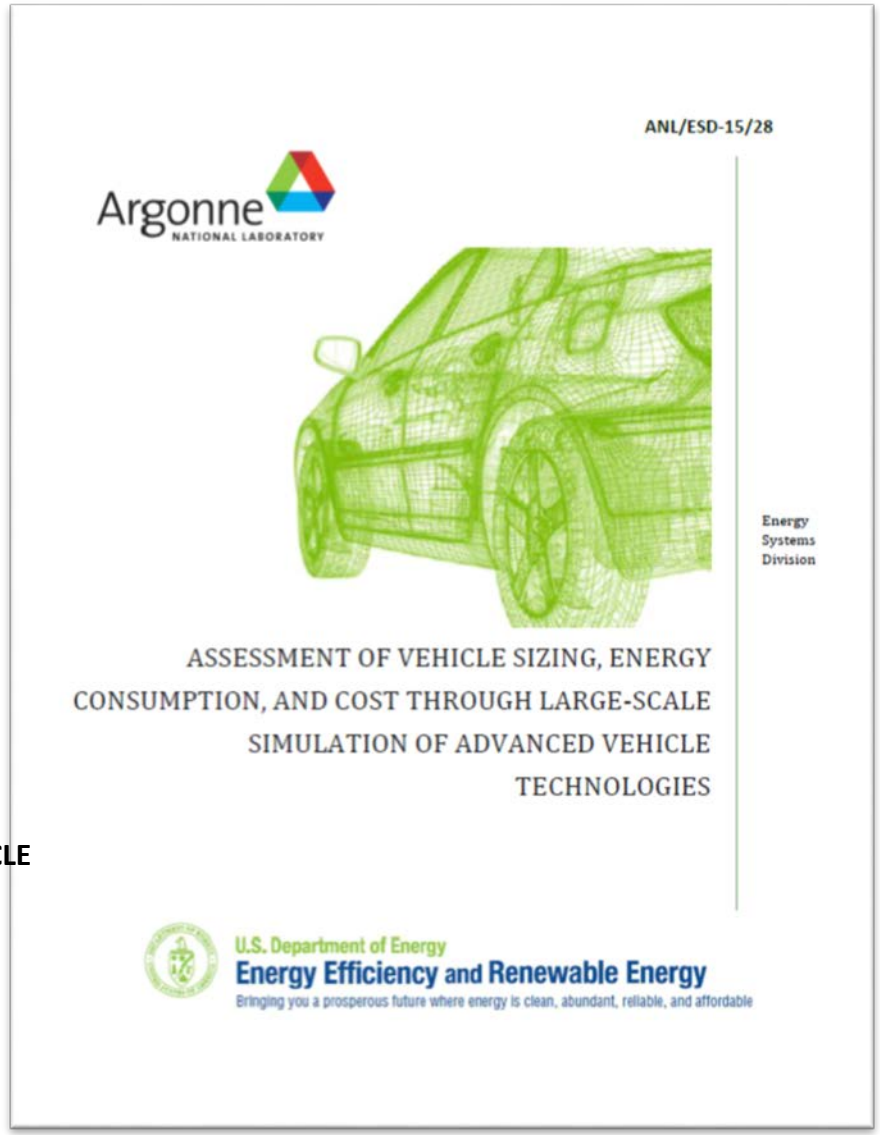
FY15-16 highlights

- **Updated Framework and Technology Outlook(s)…**
  - Underlying *Autonomie* software revised for VTO-specific needs (i.e. subcomponent models vetted against real-world vehicle and segment data)
  - VTO technology outlooks updated and formatted for *Autonomie* input
- **Modeled/Simulated Vehicle Meta-data…**
  - Virtual vehicle-level performance and cost(s) estimated for future technology ranges
- **and Quality-Assured (enormous improvement in FY15-16).**
  - Results diagnostics tools used for cross-walks to other models
  - Significant process and results examination, discussion, revision, and system redesign for future robustness

future work

- Continue modeling and simulation applied framework process improvement and quality control diagnostics and tools
- Leverage variation on this DOE process for U.S. DRIVE target-setting in FY16
- Update DOE meta-data in FY17 (and continue bi-annual process thereafter)

Vehicles: Applied Modeling and Simulation Report



VEHICLE

Methodology and results (for third-party use)

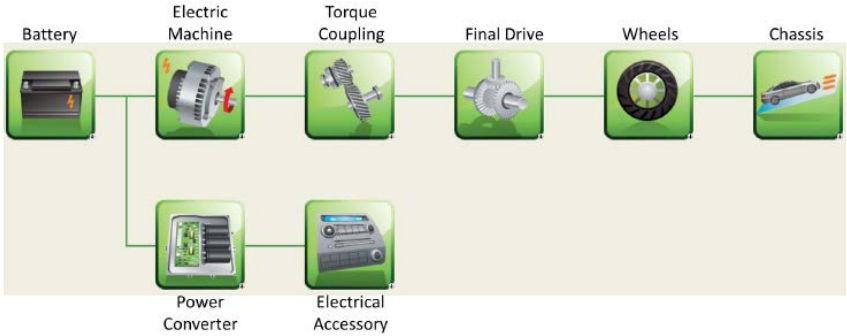


FIGURE 41 BEV configuration

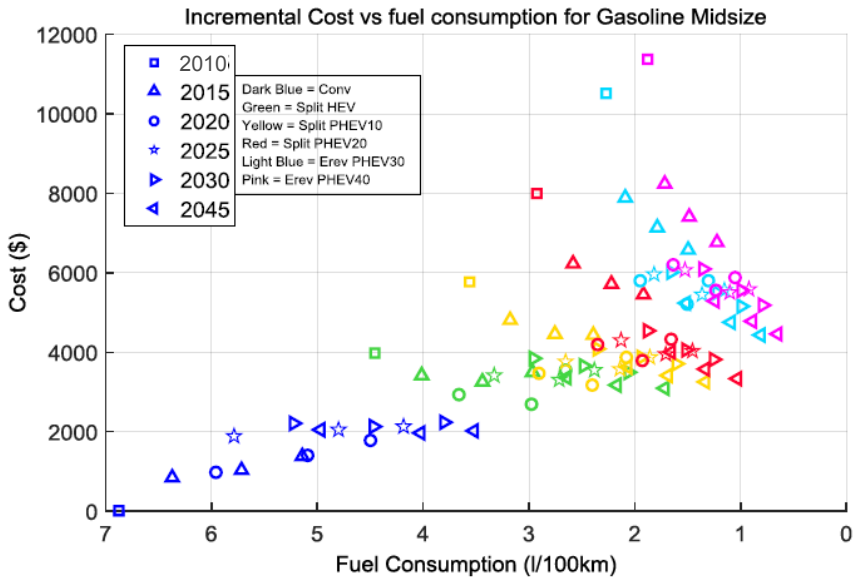


FIGURE 116 Incremental gasoline vehicle manufacturing costs compared with reference conventional gasoline vehicle manufacturing costs as a function of fuel consumption

Vehicles: Levelized Cost of Driving

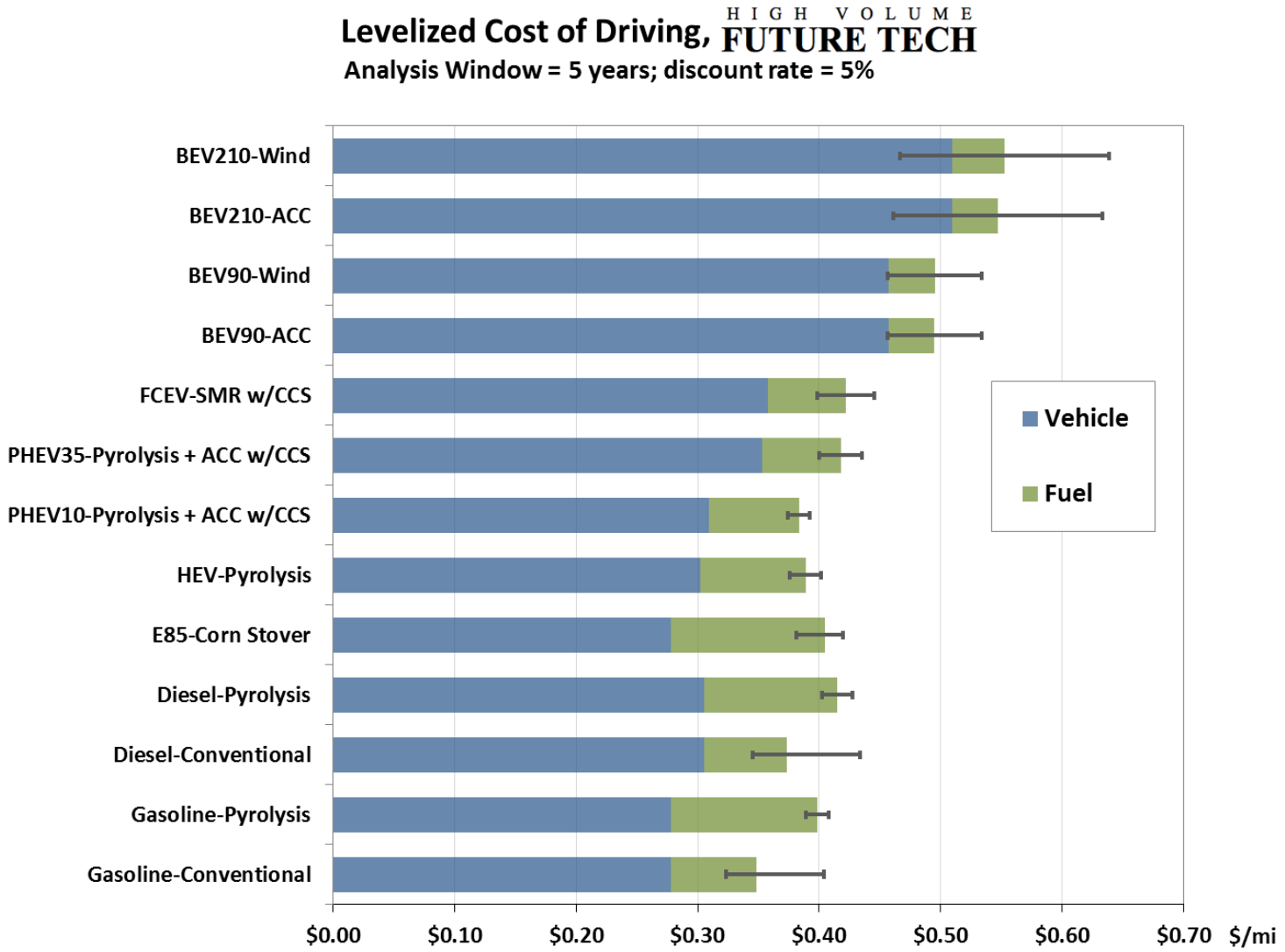


Figure 23, ANL (2016). Cradle to Grave Lifecycle Analysis of U.S. Light Duty Vehicle-Fuel Pathways: A Greenhouse Gas Emissions and Economic Assessment of Current (2015) and Future (2025–2030) Technologies

VEHICLE

FY15-16 highlights

- **Improve GREET…**
  - Collect, analyze water consumption data to develop consumption factors (including system boundary and regional considerations)
  - Analyze advanced material vehicle manufacturing data for vehicle lightweighting lifecycle considerations
  - Further develop GREET.net user-friendly visual interface platform
- **…and Apply GREET:**
  - Study emissions implications of technology improvement(s) and underlying model adjustments
  - High visibility model application for i.e. U.S. DRIVE strategic discussion(s)

future work

- Continue model improvement consistent with expert community state-of-the-art
- Continue to apply GREET for strategic and/or topical GHG and particulate emissions analyses, as needed

Emissions: "Cradle-to-Grave" gCO_2e/mile

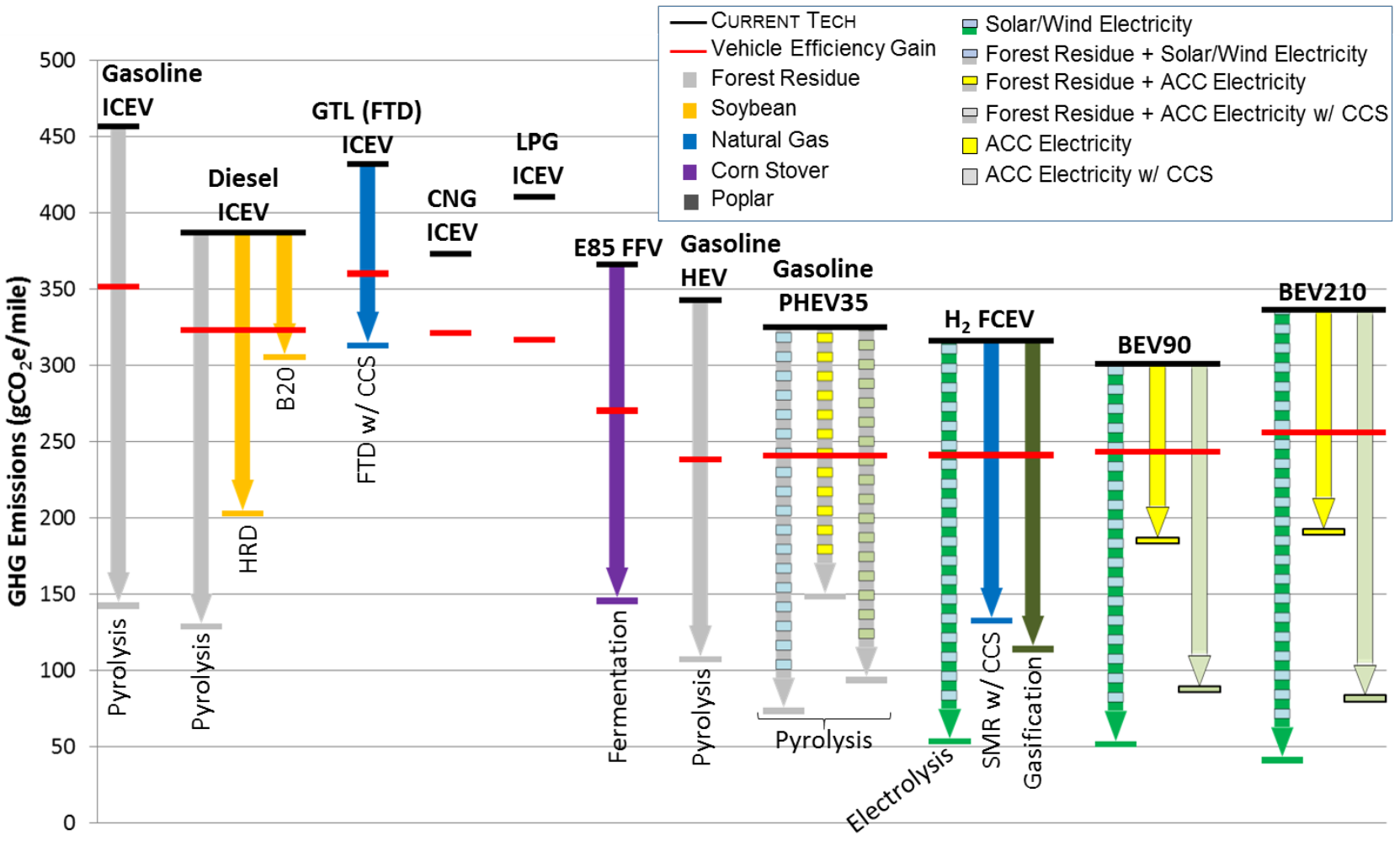


Figure 19, ANL (2016). Cradle to Grave Lifecycle Analysis of U.S. Light Duty Vehicle-Fuel Pathways: A Greenhouse Gas Emissions and Economic Assessment of Current (2015) and Future (2025–2030) Technologies

ECO

Market Penetration and Consumer Behavior

MARKET

FY15-16 highlights

- **Engage Expert Community…**
  - FY15 kickoff with Complex Choice Behaviors and Transportation Energy Policy (NSF) and International Transportation Energy Modeling (UC-Davis) workshops
  - Identify gap analysis and near-/long-term research priorities
- **Refine and Validate…**
  - Continue each model's strategic development (market segmentation, parametric sensitivity analysis, nameplate-based market evolution, etc.)
  - Discuss, develop, design and execute model-specific validation(s)
- **Apply and Analyze…**
  - Model and compare VTO-standard scenarios
  - Analyze comparison model, market, and model-market insights

future work

- Continue to evolve and validate models appropriately (according to each model's bases)
- Expand external expert engagement, comparing and refining models accordingly
- Incorporate additional model functionality, and examine novel market responses as modeled (for new insights on models and markets)

National Transportation Energy Accounting

APP/ACC

FY15-16 highlights

- **Maintain and Update…**
  - Standard scenarios, models, and tools to match historical and AEO-projected future data (which is updated ~annually)
  - Program-specific scenarios aligned with "VTO Program Success"
- **Improve and Expand…**
  - Models and tool sets according to new and evolving Program priorities (e.g., off-highway)
  - Crosswalks between/among models (given integrated analysis approach)
- **Integrate…**
  - Analysis models and tools in coherent vehicle-level-to-national analysis scenarios, examining and estimating VTO technology R&D benefits

future work

- Document and make publically available benefit metrics and methodology
- Repeat iterative analytical updates consistent with VTO goals, targets, and milestone updates and/or needs

Consumer/Markets: VTO Motivation/Context

Three important contextual caveats:

1. DOE's Energy Information Administration (EIA) is the *only* part of DOE responsible for future energy projections (through the Annual Energy Outlook, AEO)
2. Neither VTO nor EERE is in the business of market projection
3. VTO-supported market/consumer choice analysis models are tools for understanding how VTO R&D investment and complementary Federal policies can further VTO goals (reducing petroleum consumption, abating GHG emissions, and bolstering energy security)

MARKET

Primary use: VTO R&D portfolio benefits analysis

- VTO R&D lowers technology cost and improves performance
- Translating technology progress to national benefits requires market understanding

Secondary use: Federal policy analysis

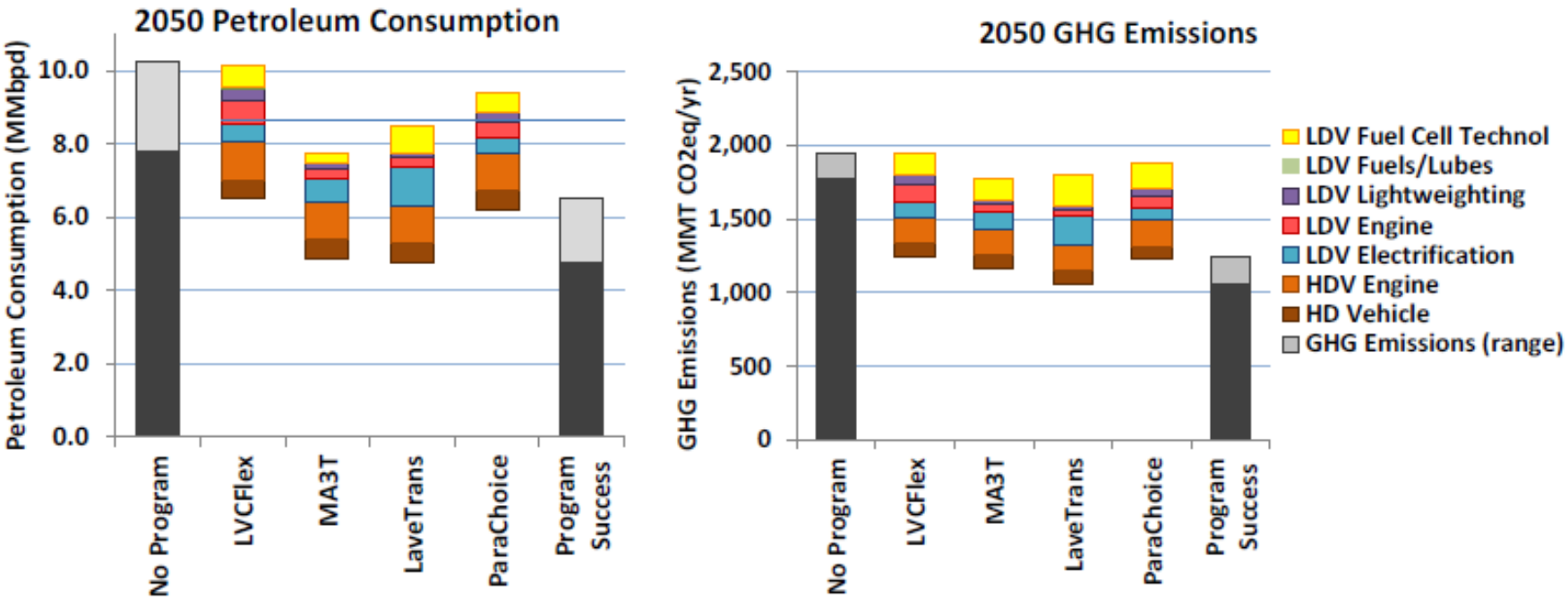
- Federal policies (subsidies, infrastructure investment) complement technology progress
- Interactions require market understanding

Ad hoc use: scenario analysis

- Full transportation transition scenarios require some investment (in technology and policy)
- Market understanding provides insight into such transitions

BaSce/GPRA Quantifies VTO Benefits

APP/ACC



Applied analysis aggregates subprograms (advanced combustion, electric-drive, energy storage, fuels, and materials programs) to estimate VTO program benefits.

For example, ***Program benefits in 2050 include:***

- ***Petroleum reduction: 2.9–3.7 mbpd (~26–31 billion barrels cumulatively)***
- ***GHG emissions abatement: ~600–750M tons CO_2eq/year (~14–15 billion tons cumulatively)***

Source: Stephens et al (2016). http://www.anl.gov/energy-systems/publication/vehicle-technologies-and-fuel-cell-technologies-program-prospective

SMART Mobility Foundational Analysis

U.S. DEPARTMENT OF ENERGY

SMARTMOBILITY

Systems and Modeling for Accelerated Research in Transportation

Focus Area	Lead	Future New Technologies/Models/Knowledge
Mobility Decision Science	LBNL	• New knowledge and applications of decision science to collect and analyze real-world data on transportation decision making
Connectivity & Automation	ANL	• An increased understanding of the potential impact of connected and automated vehicles (and relationship to vehicle technologies)
Multi-Modal	ORNL	• Dynamic passenger/freight modal energy-intensity modeling considering market preferences and energy implications
Urban Science	NREL	• Integrated city-scale models that explicitly consider energy impacts by collecting real-world data with local collaboration
Vehicles and Infrastructure	INL	• Integrated vehicle-fuel models to explore consumer and provider value propositions

SMART Mobility: Early Accomplishments

Future Mobility will have a HUGE energy impact…

…how do we start to make sense of it?

Early applied analysis and modeling/simulation research connects possible energy outcomes with potential VMT, connectivity/automation, shared mobility, travel behavior, and vehicle technology effects.

Possible connected and automated vehicle energy effects:

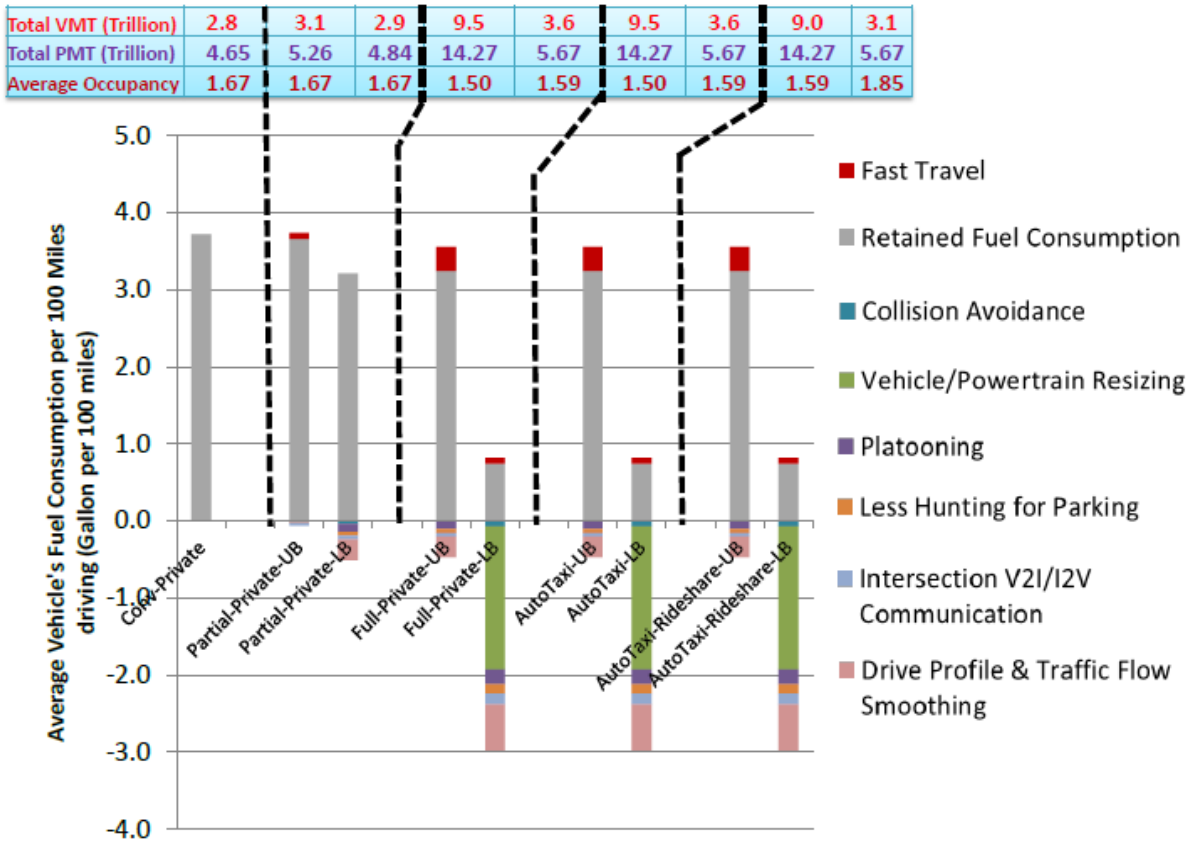
+200%

Potential Increase in Energy Consumption

2050 Baseline Energy Consumption

Potential Decrease in Energy Consumption

-90%



VTO Analysis Program and Integration, in Summary

Analysis Type: / Models:	DATA	VEHICLE	ECO	MARKET	APP/ACCT
TEDB					
xEV sales					
TREND database					
Autonomie					
HTEB					
GREET					
MA^{3}T					
ADOPT					
LVC *Flex*					
LAVE-Trans					
ParaChoice					
TRUCK					
VISION					
NEAT					

- The VTO analysis portfolio (left) satisfies VTO's priority analysis needs and includes some redundancies, where logical
- Some projects (e.g., BaSce/GPRA, below) span all categories for a truly integrated analysis

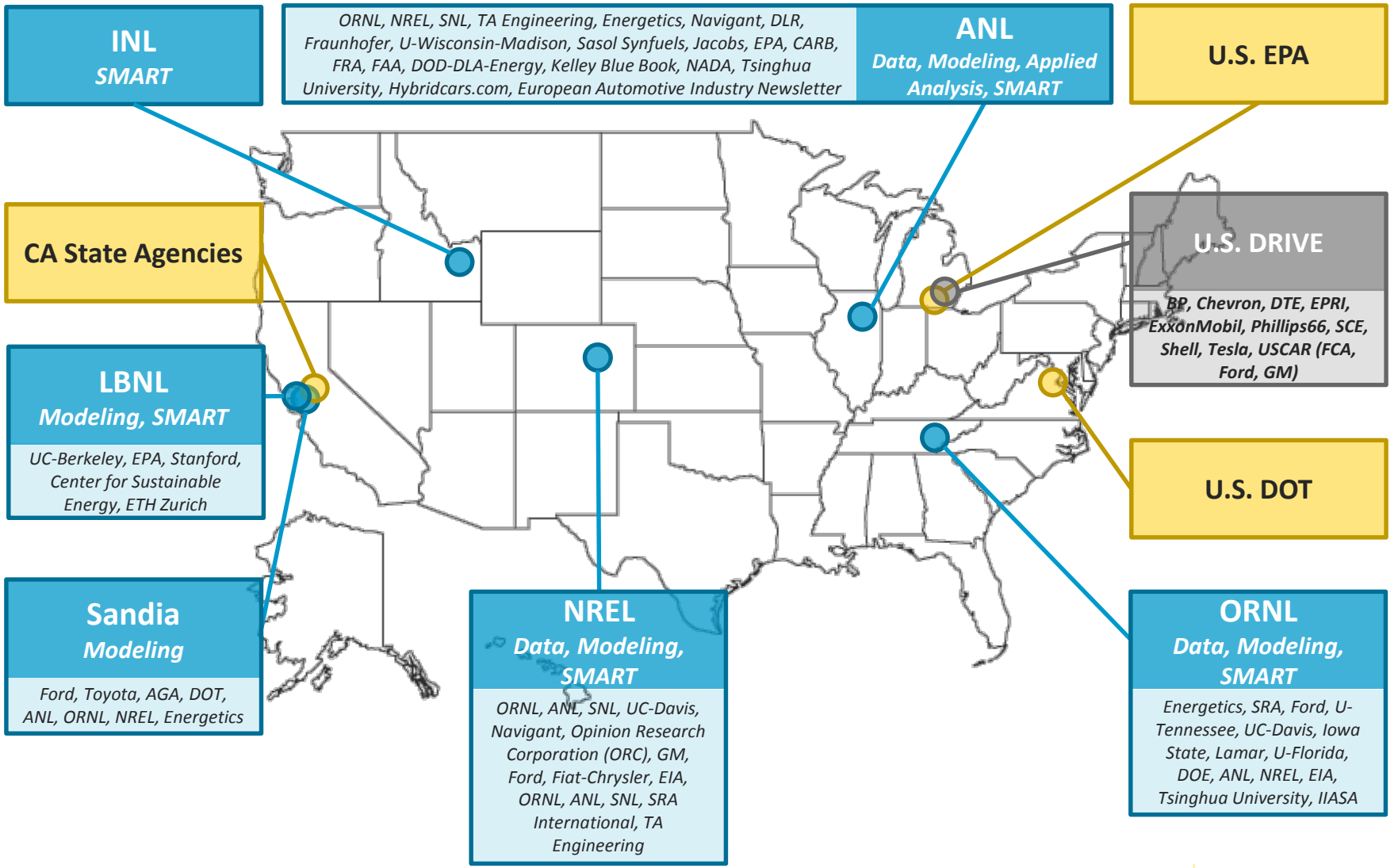
BaSce/GPRA integrated analysis	DATA	VEHICLE	ECO	MARKET	APP/ACCT
expert input					
Autonomie					
HTEB					
GREET					
MA^{3}T (et al)					
TRUCK					
VISION					

Collaboration

Co-Funders

U.S. DOE Projects

Other Partnerships



VTO Analysis (VAN) Presentations

Wednesday, June 8, Roosevelt 3

Time	Project ID	VAN Category	Principal Investigator	Project Title
2:15	VAN000/ VAN999	(Overview)	Jacob Ward, DOE	VTO Analysis Portfolio Overview
2:45	VAN016	DATA	Stacy Davis, ORNL	Transportation Data Program
3:15	VAN017	MODELING	Michael Wang, ANL	Vehicle Technologies Analysis Modeling Program
3:45	*Break*			
4:15	VAN018	APP/ACT	Tom Stephens, ANL	VTO Baseline and Scenario (BaSce) Activities
4:45	VAN023	VEHICLE	Aymeric Rousseau, ANL	Assessing Energy and Cost Impact of Advanced Technologies through Model-Based Design

VTO Analysis (VAN) Posters

Wednesday, June 8, 12:30p–1:45p

Project ID	VAN Category	Principal Investigator	Project Title
VAN019	MARKET	Rebecca Levinson, SNL	ParaChoice Model
VAN020	APP/ACCT	Tom Stephens, ANL	Applied Analysis of Connected and Automated Vehicles
VAN021	MARKET	Zhenhong Lin, ORNL	Transportation Energy Evolution Modeling (TEEM) Program
VAN022	APP/ACCT	Aymeric Rousseau, ANL	Applied Modeling and Simulation of Connected and Automated Vehicles

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Annual Merit Review
June 6-10, 2016