VEHICLE TECHNOLOGIES OFFICE

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

Overview of VTO Analysis Program

June 8, 2015

Jacob Ward

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

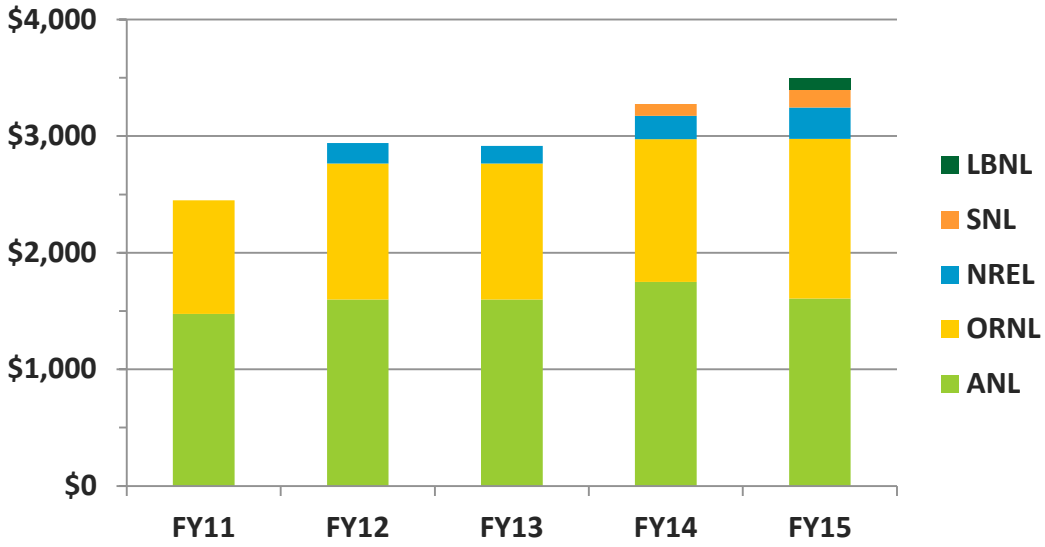
strategy

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

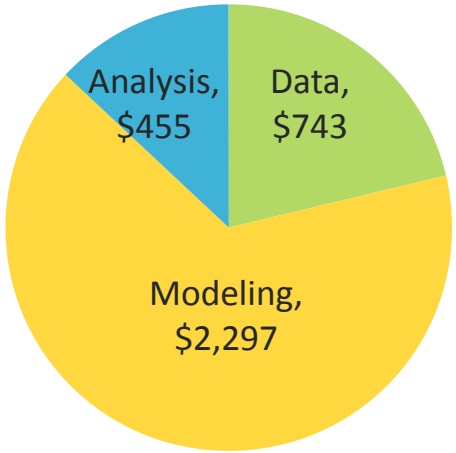
VTO Analysis Program Budget

(all numbers in thousands of dollars)

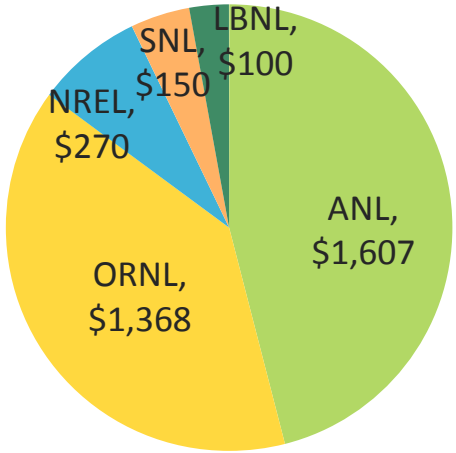
- Budget roughly steady at $3M
- Program supports data, modeling, and original analysis
- National Laboratory support from ANL, ORNL, NREL, SNL, and LBNL



FY15 by activity

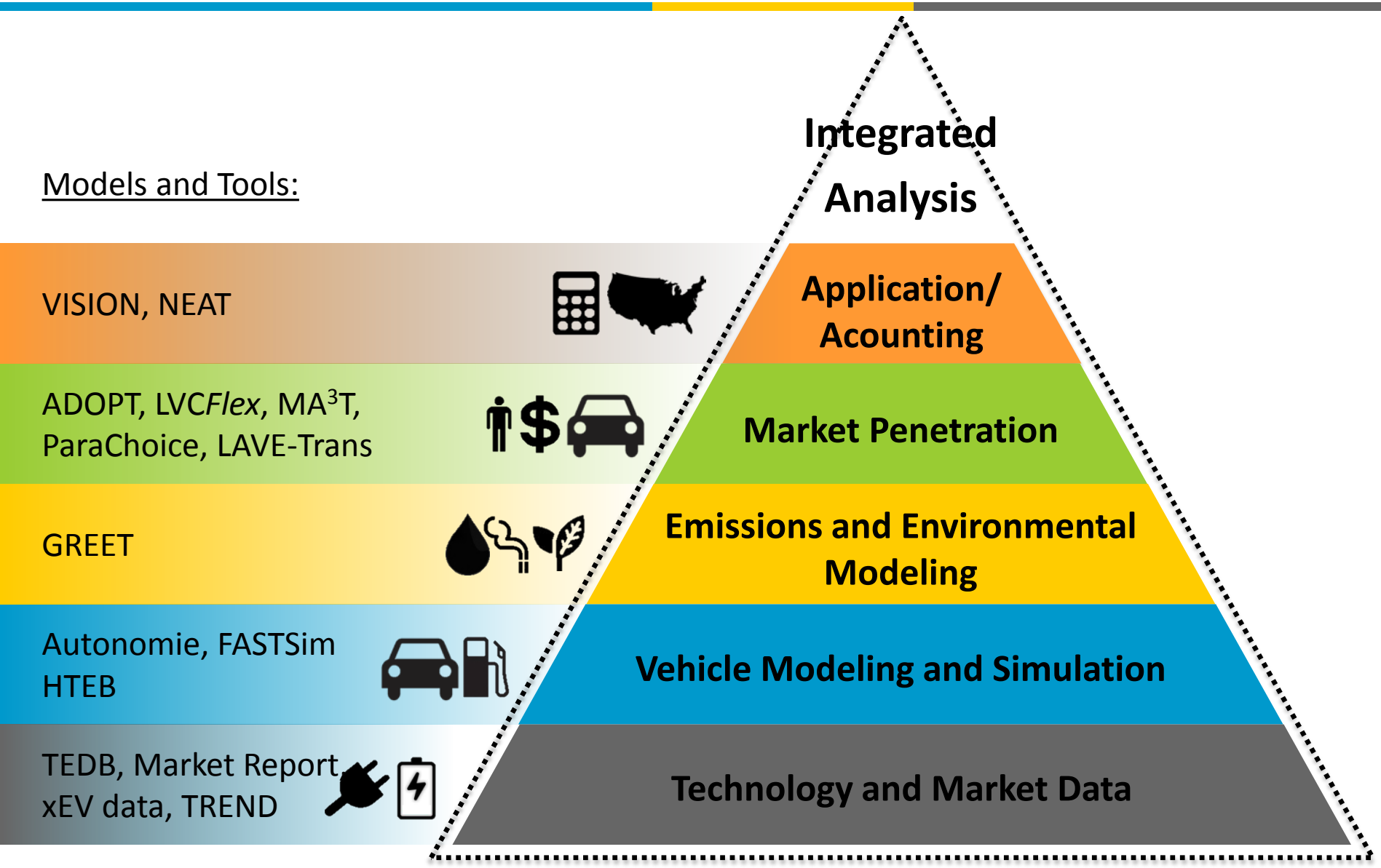


FY15 by source



VTO Analysis Program at a Glance

Models and Tools:



Technology and Market Data

FY14-15 highlights

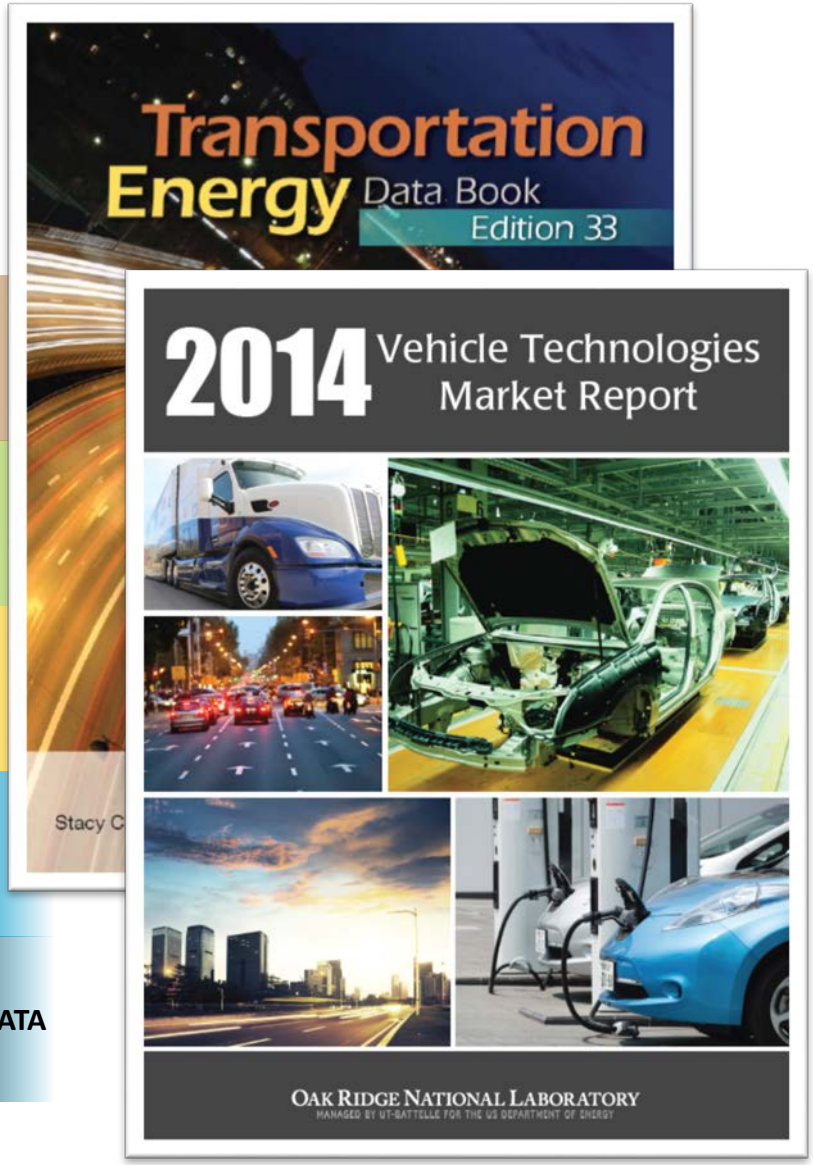
- **Published…**
  - Transportation Energy Data Book, edition 33
  - 2014 Market Report
- **Tracked…**
  - P/H/EV sales (U.S., international, and global)
  - Economic considerations, including public and/or private incentives and other potential correlations
- **and Reported…**
  - Historical data on 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

Data: trustworthy, foundational, public national indicators



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.

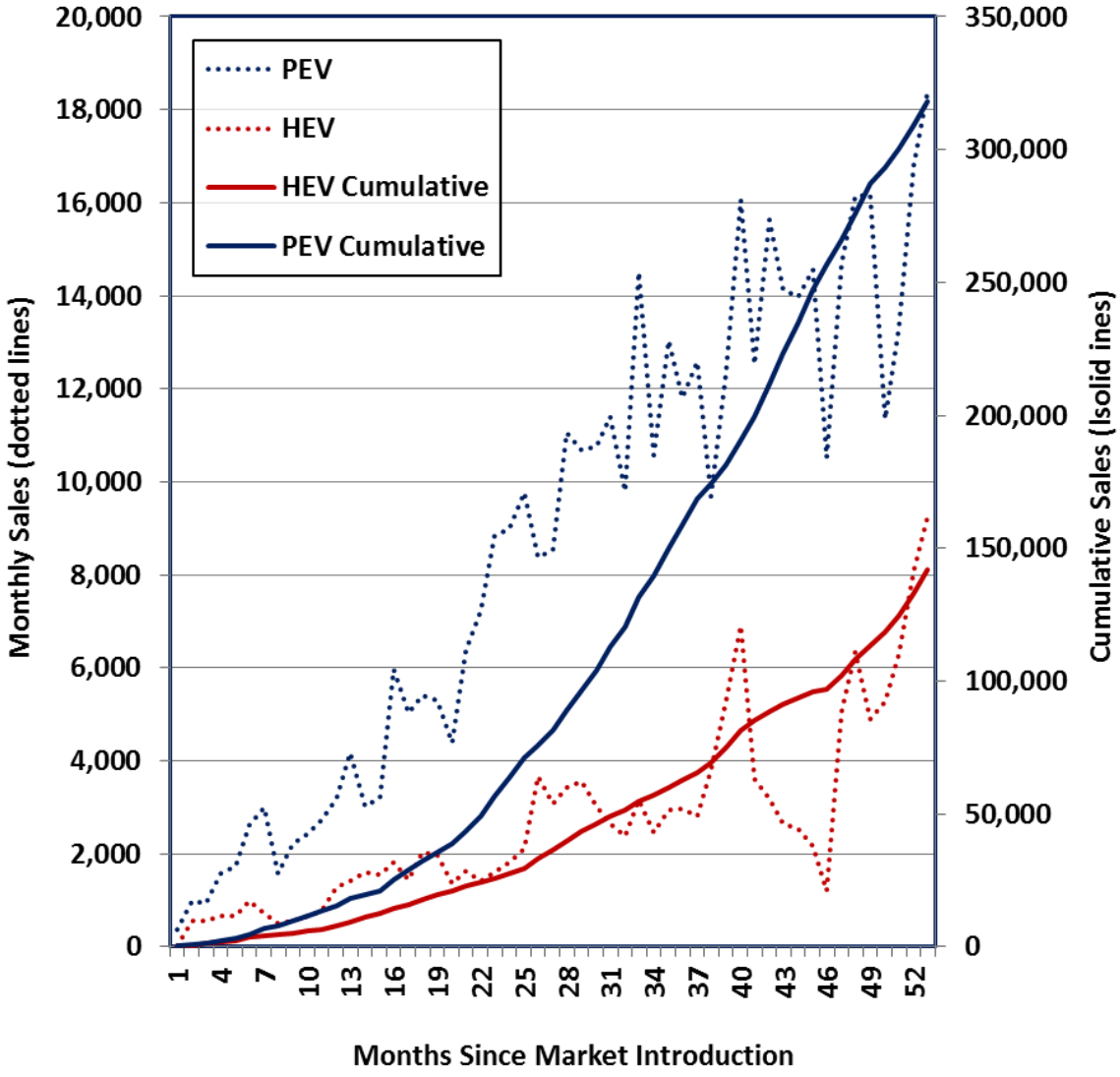
- The Transportation Data Energy Book website was *visited over 6,600 times each month in 2014*, and
- Google Scholar indicates the Data Book is *cited over 1,500 times in the academic literature*.

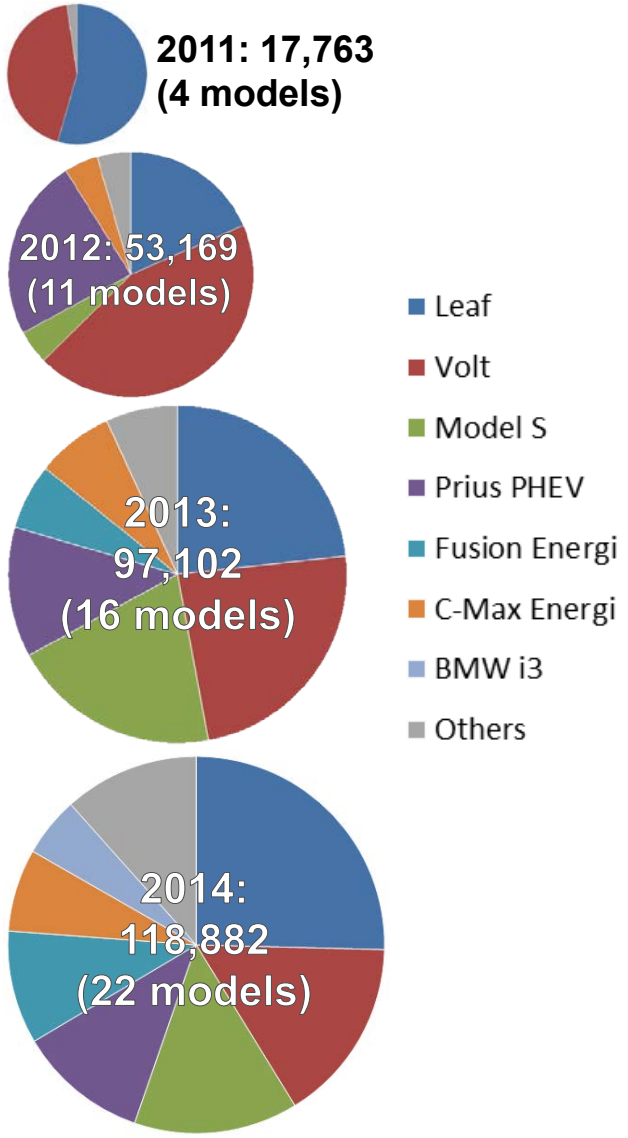
Resources:

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

DATA

Data: P/H/EV market trends





DATA

Data: technology and market relevance indicator(s)

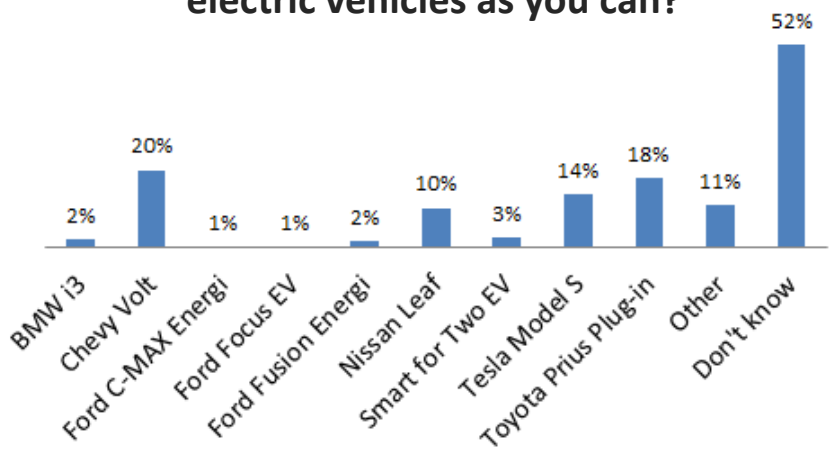
Consumer preference data collection informs VTO market barriers/opportunities and analysis deep-dives:			
FY15 Topics:	***Time-Series***	***Topical Interest***	***Deep-Dives***
PEV Awareness	●	●	--
PEV Exposure	●	●	--
BEV Range	○	●	●
Vehicle Preferences	○	○	◒
MPG Willingness to Pay	◒	◒	●
Fuel Type Preferences	●	--	--

● *Core*
◒ *Some*
○ *Emerging*
\- *No*

Of respondents in a February 2015 general population data collection…

- 58% cannot name a single plug-in vehicle *(data in 'illustrative example' at right)*
- 79% are not aware of any PEV charging stations in a typical day
  - And, fewer respondents indicate an ability to plug-in at home versus than 10 years ago (53% vs. 57%)
- 17-22% expect to consider a PEV, and 2% expect to buy

<u>Illustrative example</u>: Name as many plug-in electric vehicles as you can?



DATA

FY14-15 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…**
  - Results diagnostics tools used for cross-walks to other models
  - Significant process and results examination, discussion, revision, and system redesign for future robustness

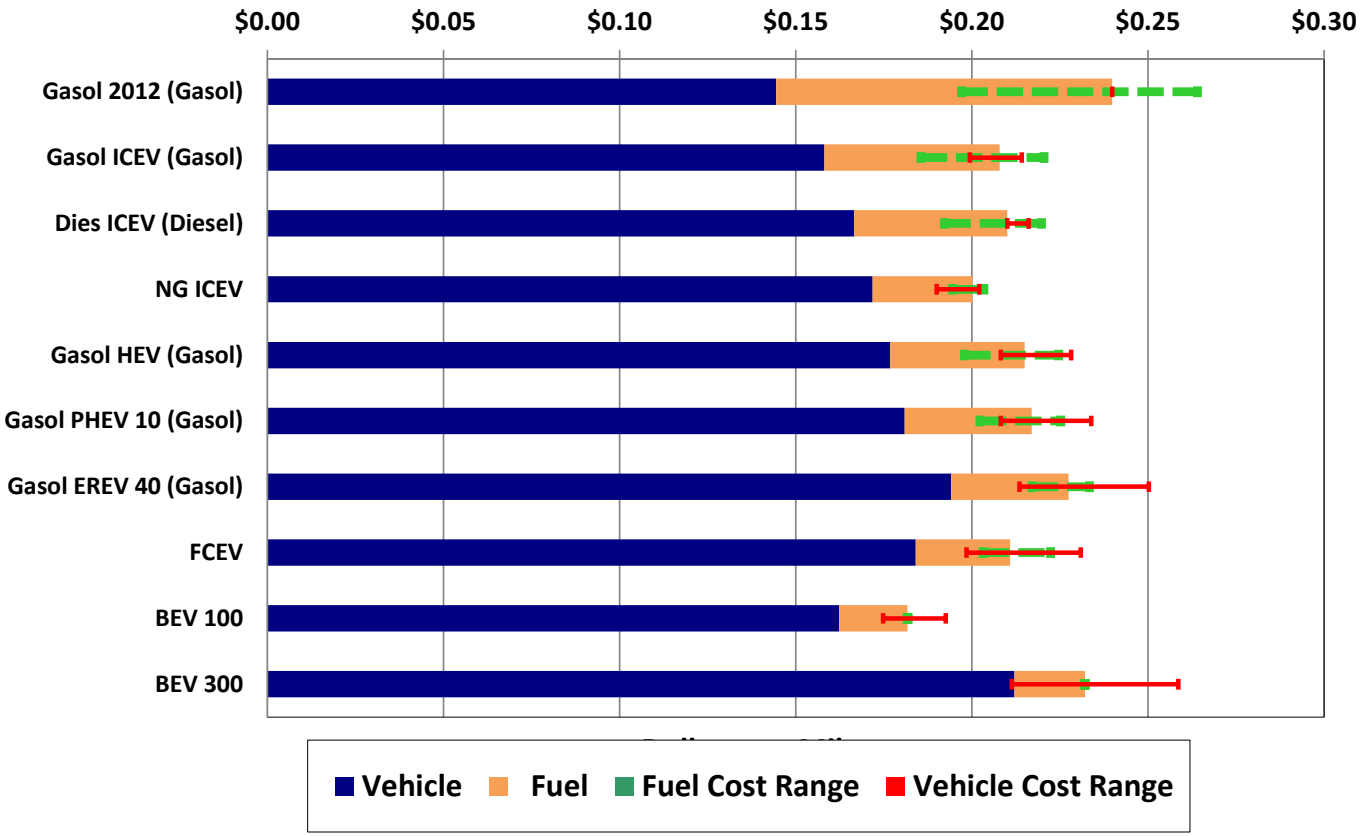
future work

- 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: Levelized Cost of Driving

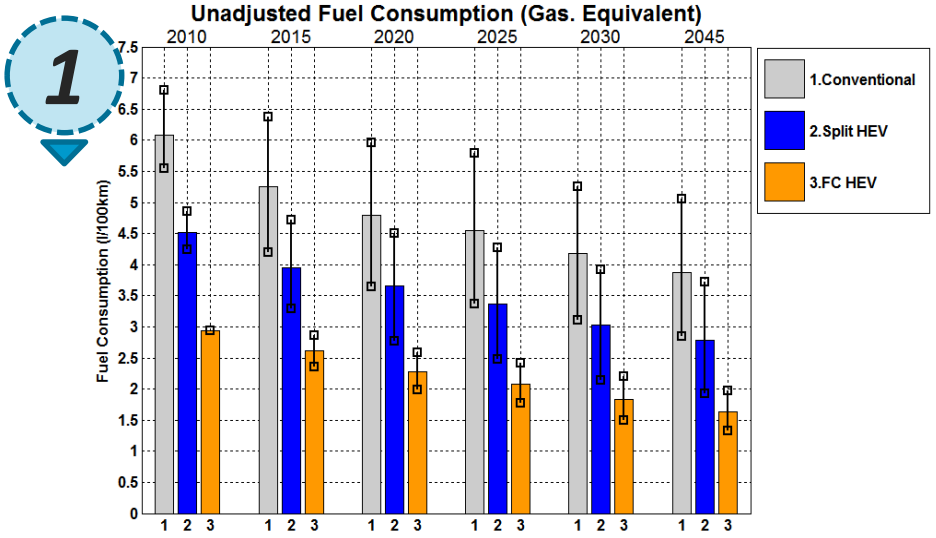
Societal View: 15-year vehicle life

Vehicle and Fuel Costs per Mile for Midsize Vehicles, 2035
(Vehicle purchase price estimated as 1.5 x manufacturing cost) (2010$)

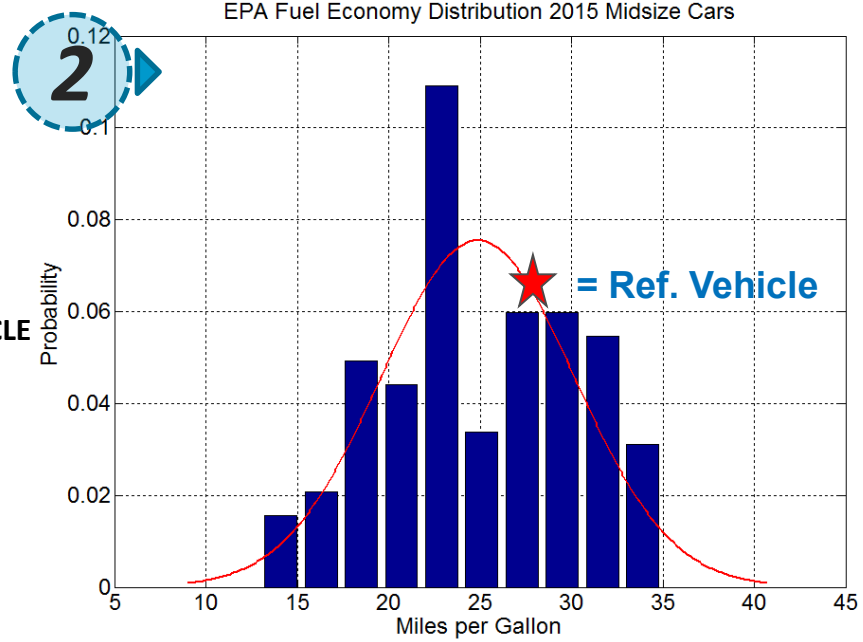


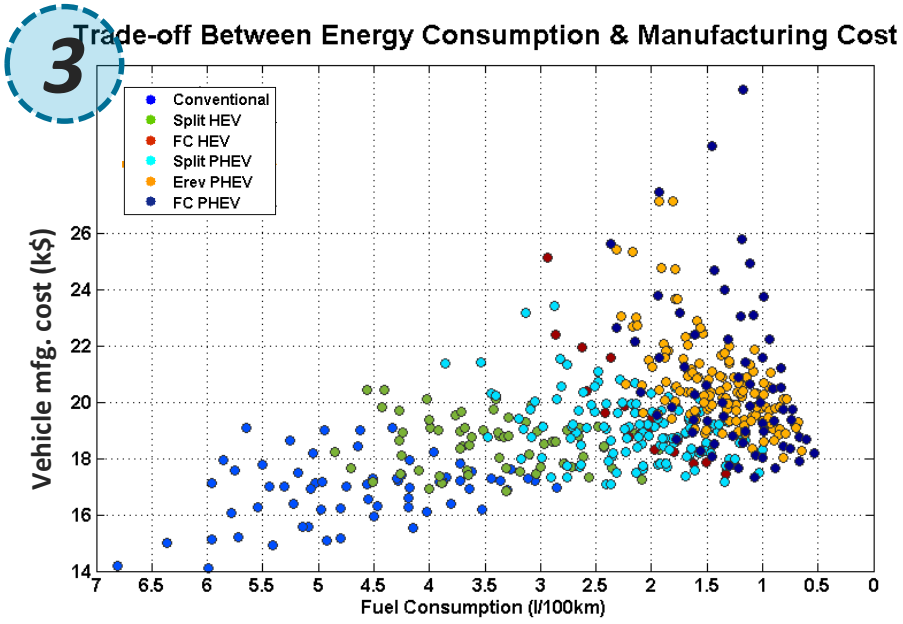
Notes: Average distance driven per car-year derived from USDOT/NHTSA analysis, Resale value at 25% of price, 7% net discount rate for future fuels expenditures, 2035 Results – 15-Year Ownership, 14,000 Miles, (22,500 km) per year (2010 Dollars)

Vehicles: step-wise applied modeling/simulation



1. Vehicle and subsystem modeling/simulation.
2. [Iterative] vehicle results validation.
3. Observational (and data for additional) analysis.





VEHICLE

Emissions and Environmental Modeling

FY14-15 highlights

- **Improve GREET…**
  - Re-align emissions coefficients with state(s)-of-the-art (e.g. CH_4 leakage)
  - Design and execute original research of i.e., oil sands and petroleum refineries, advanced materials/manufacturing,
  - Further develop GREET.net user-friendly visual interface platform
- **Expand GREET…**
  - Add metrics for water consumption and black carbon
  - Develop and deploy HDV module
- **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)

ECO

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

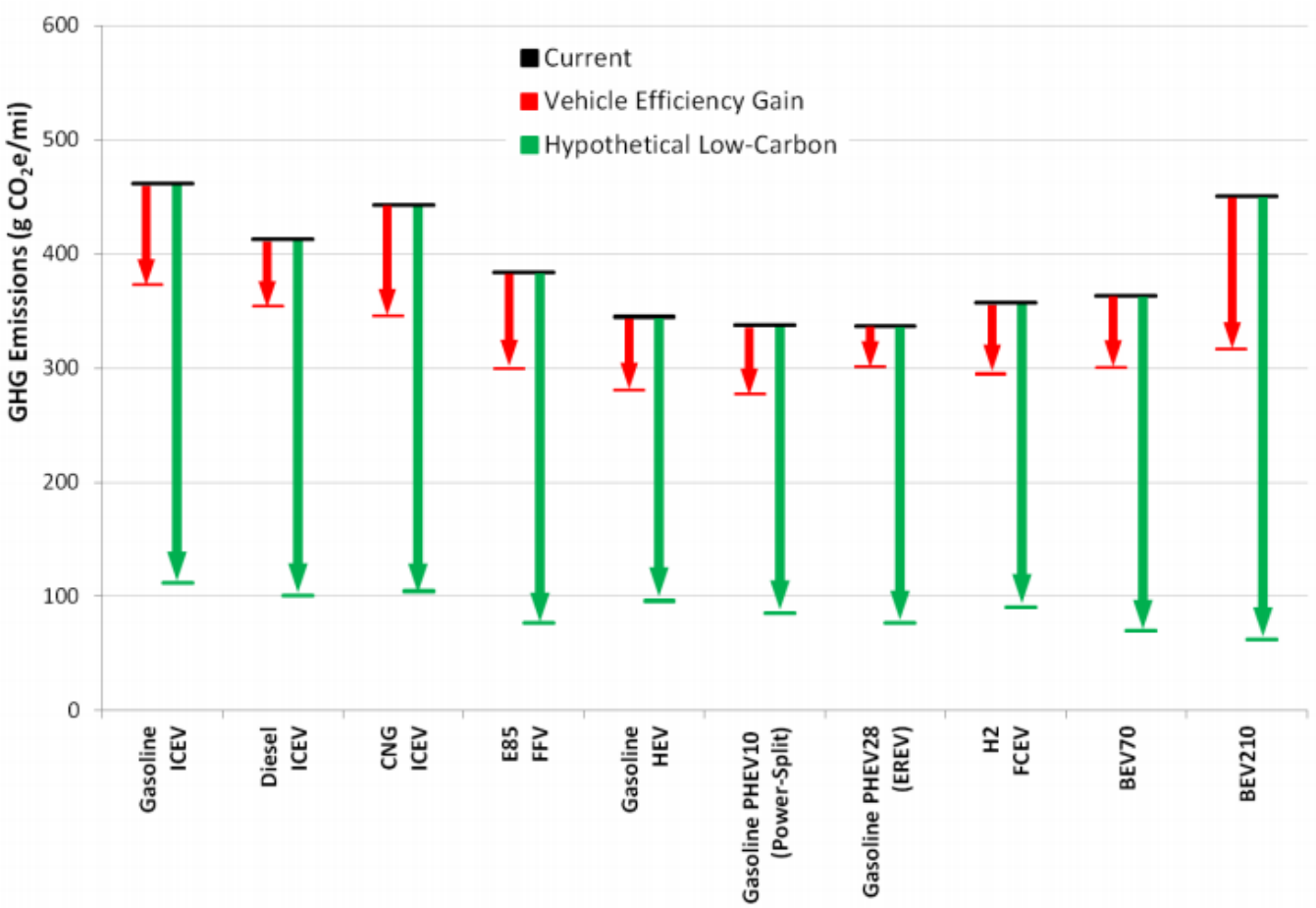


Figure 5. C2G GHG emissions for two bookends ("Current" and "Hypothetical low carbon"*) and the intermediate case ("Vehicle Efficiency Gains"). Contributions of vehicle cycle, fuel production and vehicle operations are shown in the appendix.

*100% biomass derived gasoline, diesel, natural gas, cellulosic ethanol and zero carbon based electricity for hydrogen and plug-in vehicles

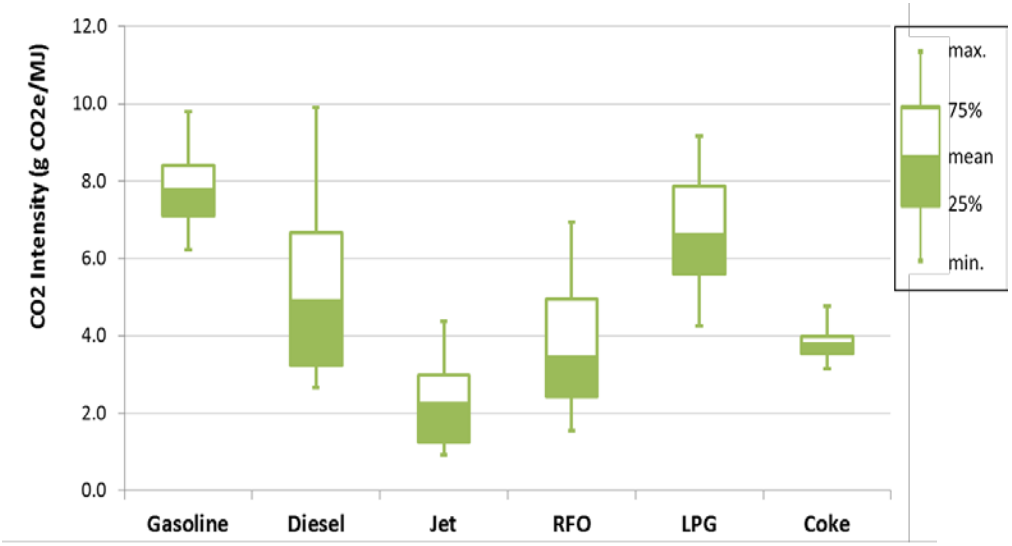
ECO

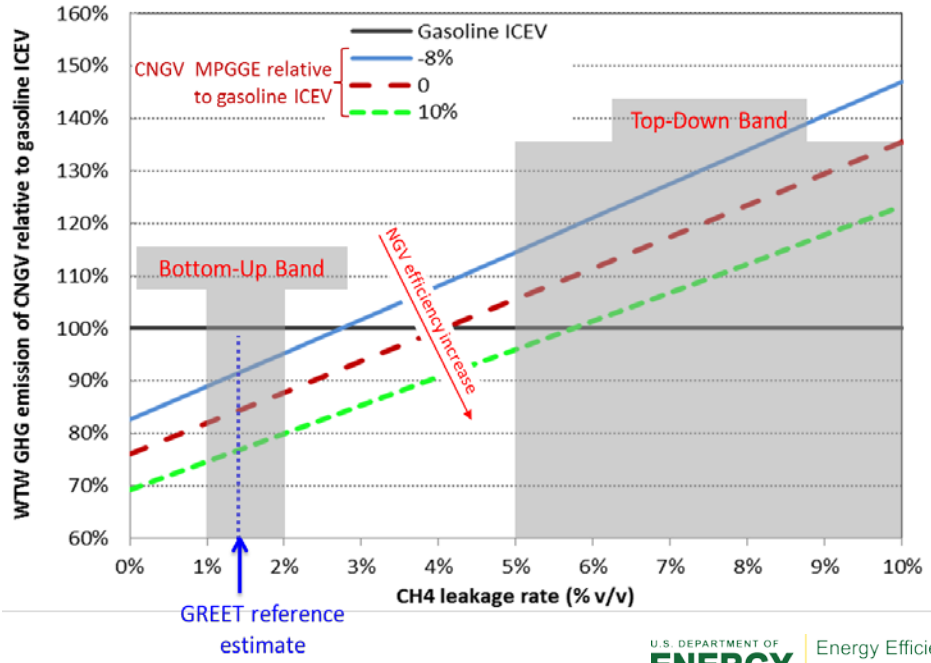
Emissions: deep-dive and applied analysis

Deep-dive example (at right): embedded carbon intensity of refined fuels.

Deep-dive analyses inform the GREET model, which, in turn, informs applied analyses.

Application example (at right): CH_4 leakage sensitivity analysis of CNGV vs. gasoline ICEV.





Market Penetration and Consumer Behavior

MARKET

FY14-15 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 VCMs 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)

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

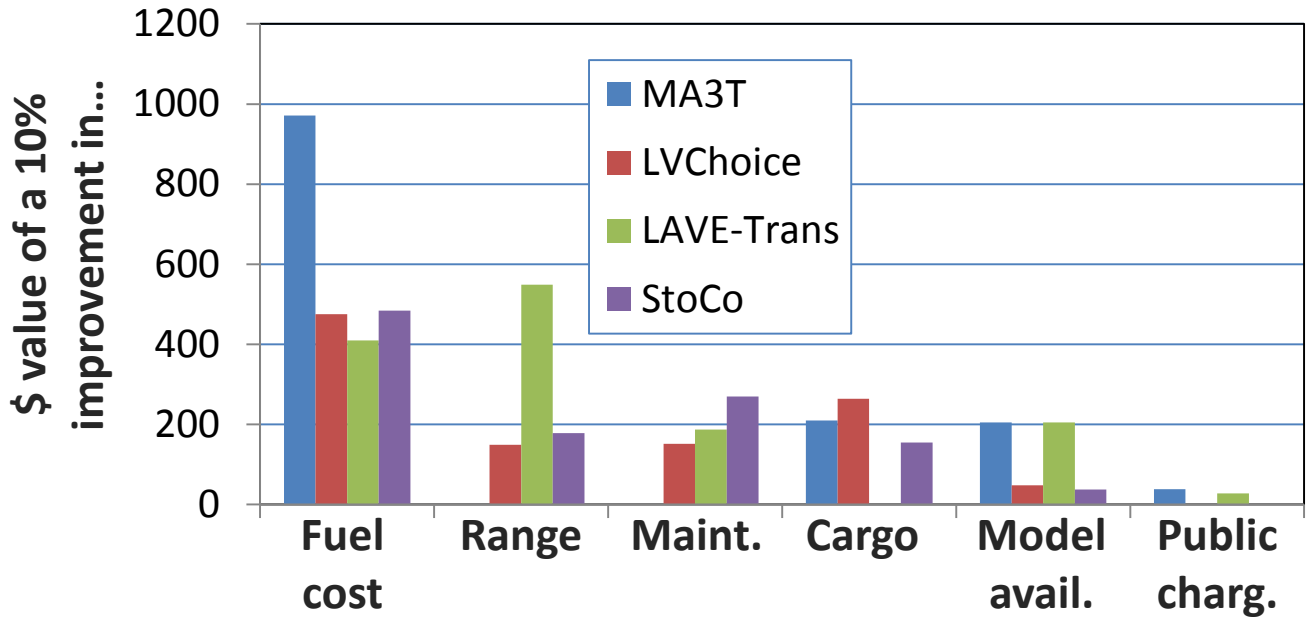
- Full transportation transition scenarios require some investment (in technology and policy)
- Market understanding provides insight into such transitions

Consumer/markets: strategic model alignment/nuance

Model Comparison: Strategic Alignment and Strategic Difference

	ADOPT	LAVE-Trans	LVC*Flex*	MA^{3}T	ParaChoice
Inputs :	*Autonomie* (vehicle), GREET (emissions), EIA (fuel)				
Outputs:	market share, energy use, GHG emissions				
Unique methods:	nameplate and ZIP code detail	benefit-cost calculation for energy transition	intentional NEMS mimicry	sophisticated consumer segmentation	stochastic simulation
Unique uses:	targeted, specific analysis	transition policy analysis	NEMS "light" simulation	P/H/EV, market segmentation	parametric analysis

MARKET



Consumer/markets: strategic model alignment/nuance

Illustrative [preliminary] results:

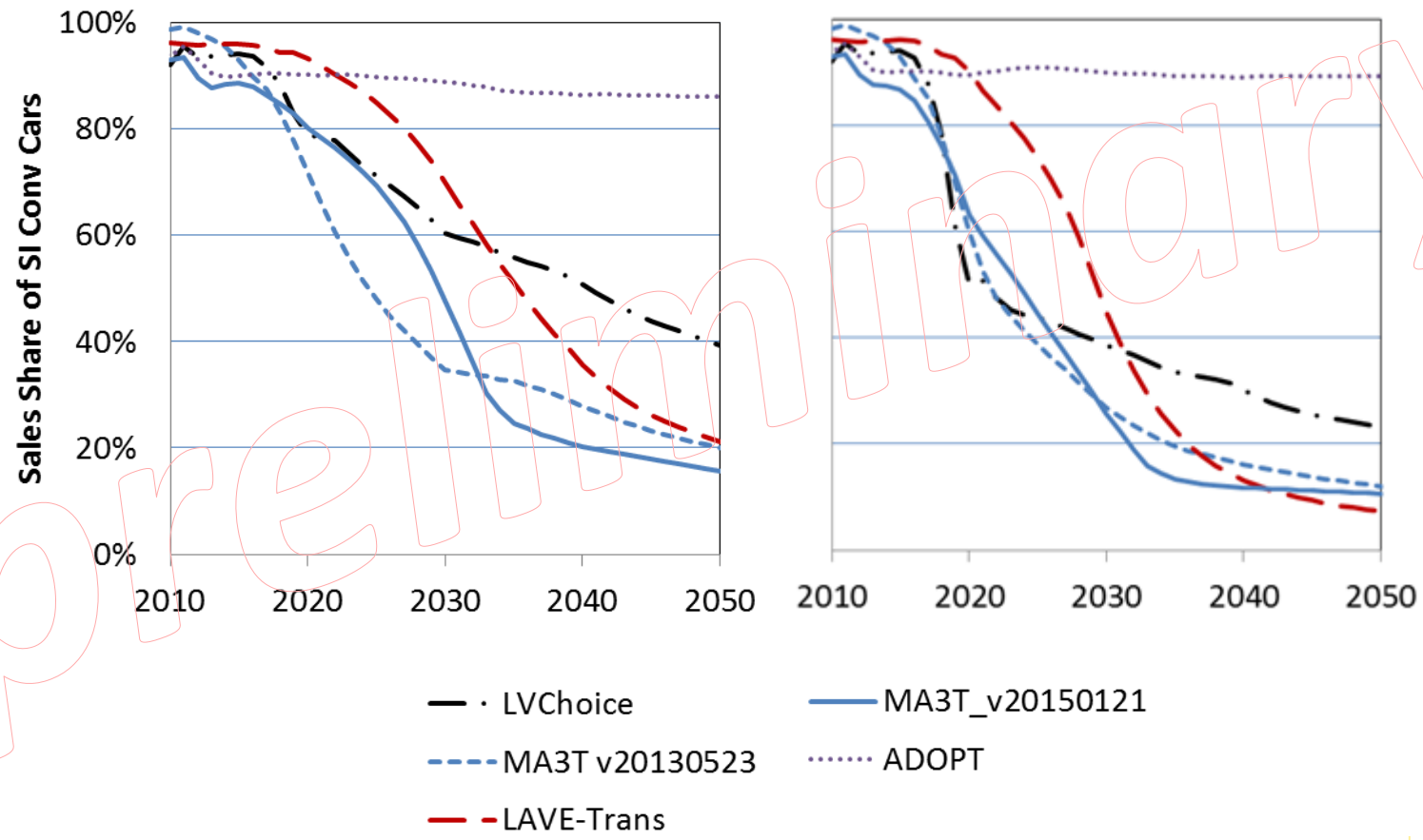
MARKET

No Program Case

(Lowest technology progress, with no VTO contribution)

Program Success Case

(Highest technology progress, with all VTO targets met)



National Transportation Energy Accounting

FY14-15 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

APP/ACC

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

BaSce/GPRA quantifies VTO benefits

APP/ACC

TABLE 12 Vehicle Technologies Program Benefits Metrics[a]

Impact	Metric	Year 2020	2030	2050
Energy security	Oil savings, cumulative (billion bbl)	1.0	7.7	31.1
	Oil savings, annual (million bpd)	0.9	2.4	3.5
	New vehicle mpg improvement (percent)[a]			
	LDVs	53	75	82
	HTs	25	39	43
	On-road mpg improvement (percent)			
	LDVs	9	44	87
	HTs	12	27	36
Environmental	CO_2 emissions reduction,[b] cumulative (million t $CO_{2\,eq}$)	450	3,500	14,000
	GHG emissions reduction, annual (million t $CO_{2\,eq}$/yr)			
	LDVs	85	259	350
	HTs	64	142	235
	Total	149	401	585
Economic	Primary energy savings,[b] cumulative (quads)	7	53	218
	Primary energy savings, annual (quads/yr)	2.2	6.2	9.0

[a] Improvement relative to baseline (No Program) fleet in the same year.

[b] "Reductions" and "savings" are calculated as the difference between the results from the baseline (No Program) case (i.e., in which there is no future DOE funding for this technology) and the results from the Target case (i.e., in which requested DOE funding for this technology is received and the program is successful). All cumulative metrics are based on results beginning in 2015.

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

For example, in 2050…

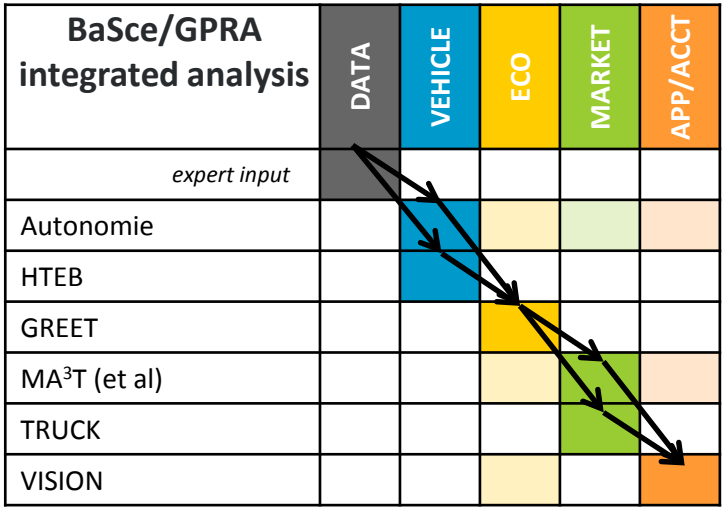
- ***Petroleum reduction: 30 billion barrels***
- ***GHG emissions abatement: 14 billion metric tonnes***

Source: http://www.transportation.anl.gov/pdfs/G/955.PDF

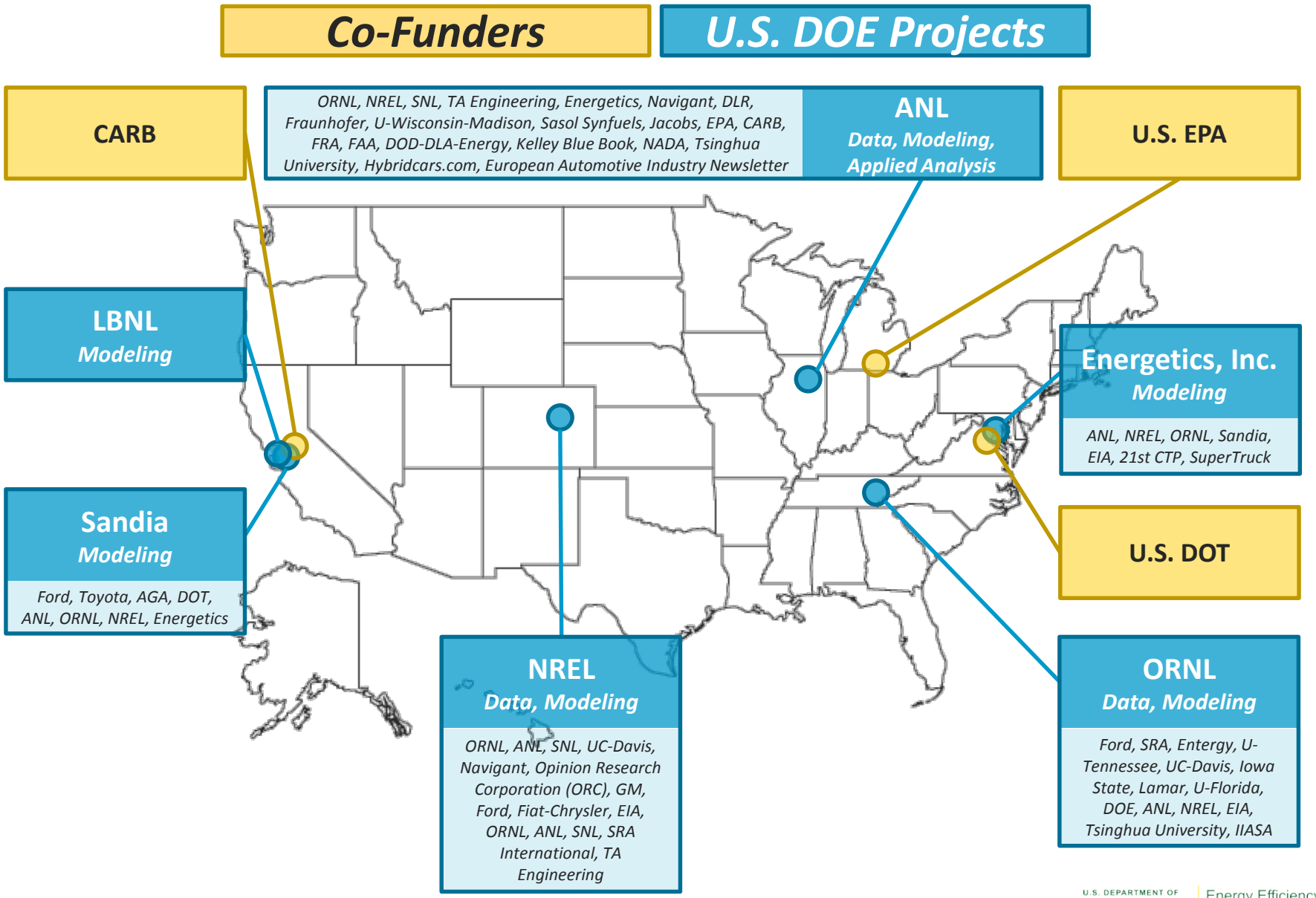
VTO Analysis Program and Integration, in Summary

Analysis Type: / Models:	DATA	VEHICLE	ECO	MARKET	APP/ACCT
TEDB					
xEV sales					
SRA database					
Autonomie					
FASTSim					
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



Collaboration



VTO Analysis (VAN) Presentations

Thursday, June 11, Crystal Gateway Salon H

Time	Project ID	VAN Category	Principal Investigator	Project Title
8:00	VAN000/ VAN999	(Overview)	Jacob Ward, DOE	VTO Analysis Portfolio Overview
8:30	VAN003	DATA	Mark Singer, NREL	Consumer Vehicle Technology Data
9:00	VAN004	MARKET	Aaron Brooker, NREL	Unified Modeling, Simulation, and Market Implications: FASTSim and ADOPT
9:30	VAN002	ECO	Michael Wang, ANL	GREET Life Cycle Analysis
10:00	VAN005	MARKET	Zhenhong Lin, ORNL	Consumer-Segmented Vehicle Choice Modeling: the MA3T Model
10:30	*Break*			
11:00	VAN014	MARKET	Dawn Manley, SNL	Parametric Vehicle Choice Modeling: ParaChoice
11:30	VAN001	APP/ACCT	Tom Stephens, ANL	VTO Baseline and Scenario (BaSce) Activities
12:00	VAN015	APP/ACCT	Michael Nicholas, UC-Davis	PEV Consumer Behavior in Practice (PCBIP)

VTO Analysis (VAN) Posters

Thursday, June 11, 6:30p–8:30p, Crystal Gateway

Project ID	VAN Category	Principal Investigator	Project Title
VAN009	DATA	Stacy Davis, ORNL	Transportation Energy Data Book, Market Report, and Fact of the Week
VAN011	DATA	Joann Zhou, ANL	E-drive Vehicle Sales Analyses
VAN008	VEHICLE	Aymeric Rousseau, ANL	Evaluation of VTO Benefits Using Large Scale Simulation
VAN012	MARKET	Alicia Birky, TA Engineering	Modeling for Light and Heavy Vehicle Market Analysis
VAN006	APP/ACCT	Joann Zhou, ANL	Development and Update of Long-Term Energy and GHG Emission Accounting Tool
VAN010	APP/ACCT	Changzheng Liu, ORNL	Reassessing the Outlook of U.S. Oil Dependence Using Oil Security Metrics Model (OSMM)
VAN013	MARKET	Changzheng Liu, ORNL	Transportation Energy Transition Modeling and Analysis: the LAVE-Trans Model

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Annual Merit Review
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