Development and Update of Models for Long-Term Energy and GHG Impact Evaluation

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U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Project ID: VAN006

Project Overview

Timeline	Barriers
Start Date: October 2012 End Date: Project continuation and direction determined annually by DOE	• Constant advances in technology • Computational models, design, and simulation methodologies • Lack of quick analysis tools and lack of comprehensive historical database
Budget	**Partners**
Total Project Funding (DOE) • $160,000	Interactions • NPC, ACEEE, Universities, NESCAUM, and other users • National Renewable Energy Lab • TA Engineering, Inc. • Energy Information Administration (EIA)

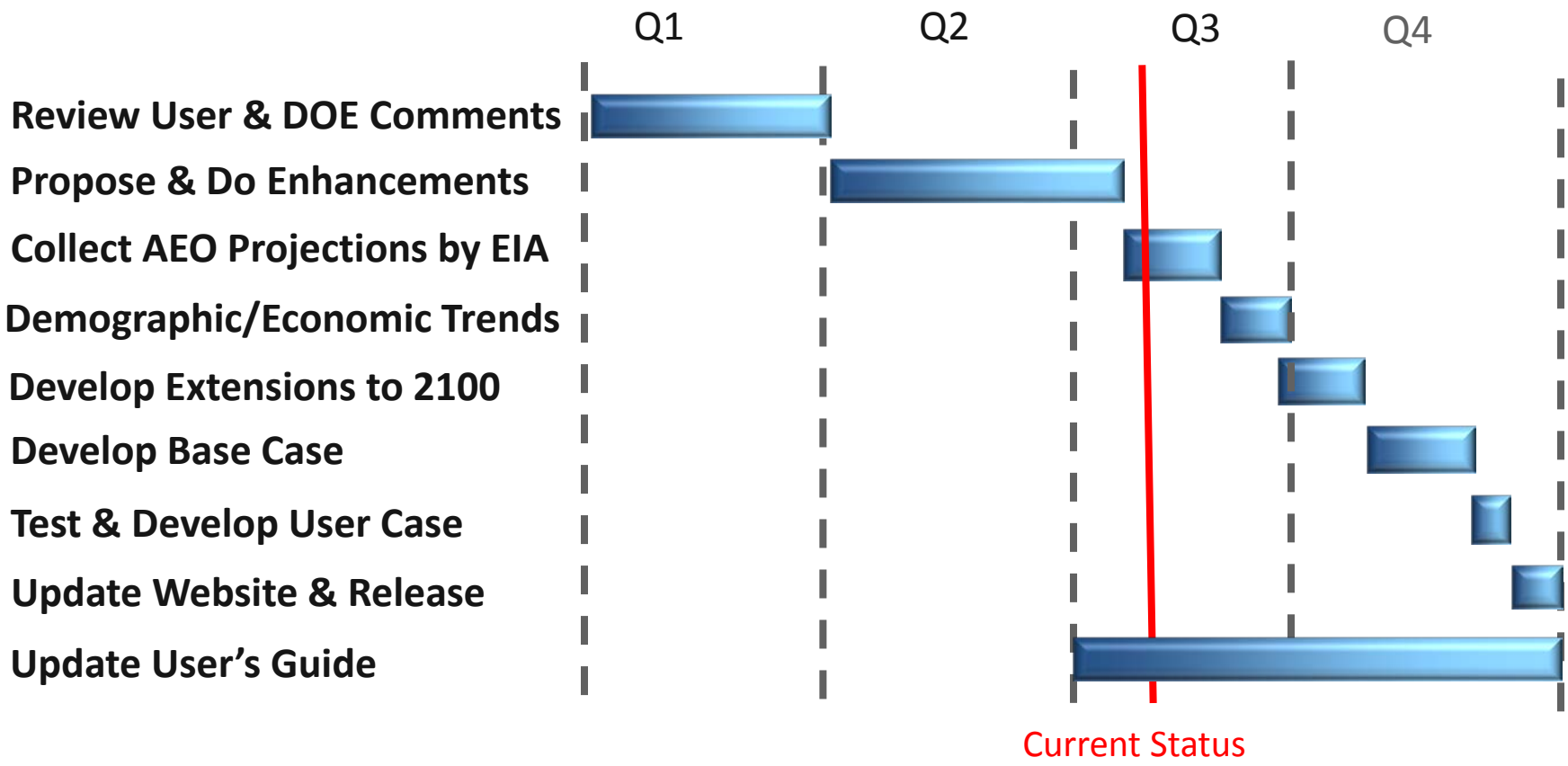
Relevance: Quick Energy & Emissions Analysis

- What are the long-term energy and GHG emissions impacts of DOE programs?
- How much energy is consumed in feedstock and fuel production?
- How much petroleum consumption reduction will result from an alternative scenario?
- How much alternative fuel consumption and GHG emissions change would be under an alternative scenario?
- How many vehicles of a technology will be on-road at a point in time?
- What GHG and upstream energy impacts would be from change in the mix of ethanol feedstock?
- What GHG and upstream energy impacts would be from change in the mix of hydrogen feedstock?

Objectives: Develop and Annually Update a Spreadsheet-Based Tool for Energy & GHG Impact Evaluation

- Create a transparent, flexible, and user friendly analytical tool (VISION) for evaluation of alternative scenarios relating to highway vehicle technologies and fuels
- Expand the analytical horizon to a long-term (2100)
- Construct the model to accommodate possible vehicle technologies and range of fuel economies
- Construct the model structure to accommodate multiple feedstock and fuel production pathways
- Develop a comprehensive database of historical vehicle sales, fuel economy, annual usage, and energy use
- Incorporate models on vehicle survival and age dependent usage, allowing estimation of annual estimates of vehicle stock, VMT, on-road fuel economy, and energy use
- Make the model available on the web

Milestones

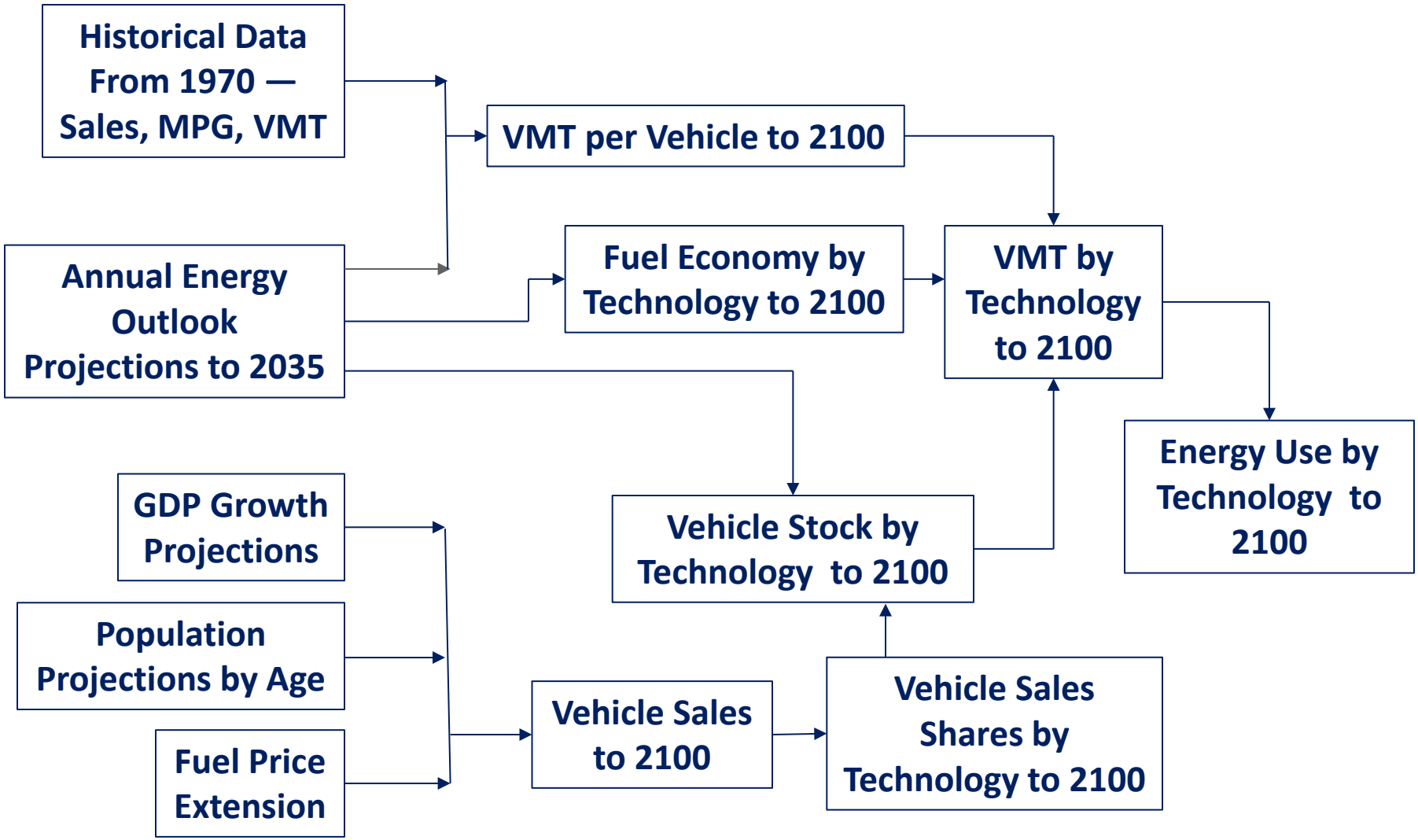


EIA = *Energy Information Administration*

Approach: Evaluate Highway Vehicle Technologies

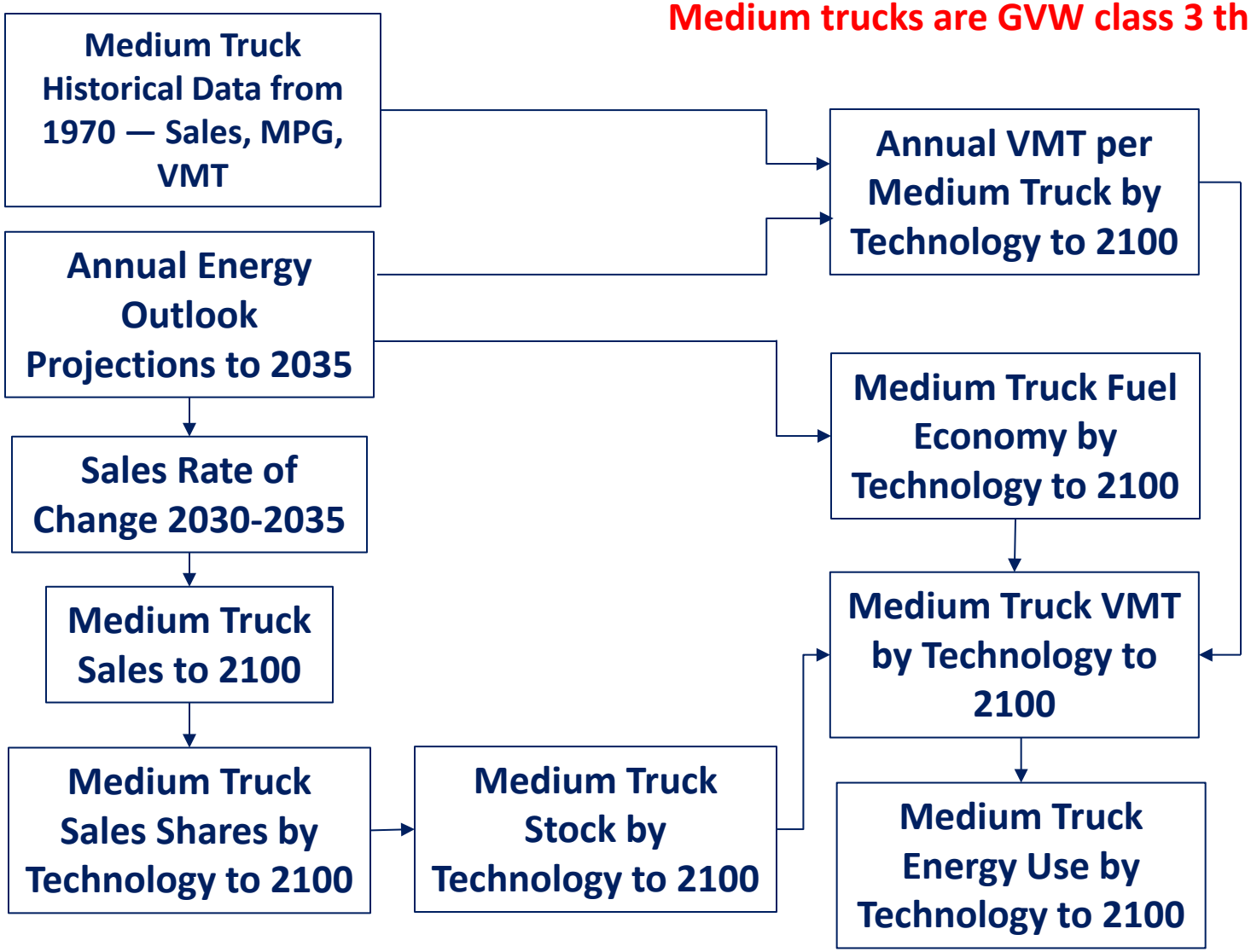
Vehicles	# Technology & Fuel	Technology Type
 Cars  Light Trucks	12 each	4 ICE (Gasoline, Diesel, Ethanol, CNG) 3 HEV (Gasoline, E85/H2, Dsl) 3 PHEV (2 Gasoline, 1 Diesel) 1 Electric Vehicle 1 Fuel Cell Vehicle
 Class 3-6 Trucks	4	Gasoline ICE, Diesel ICE, CNG ICE, Diesel HEV
 Class 7&8 Single Unit Trucks	3	Gasoline & Diesel ICE, CNG ICE, Diesel HEV
 Class 7&8 Combination Trucks	2	Diesel ICE and LNG ICE

Approach: Create a Light Duty Long Term Base Case

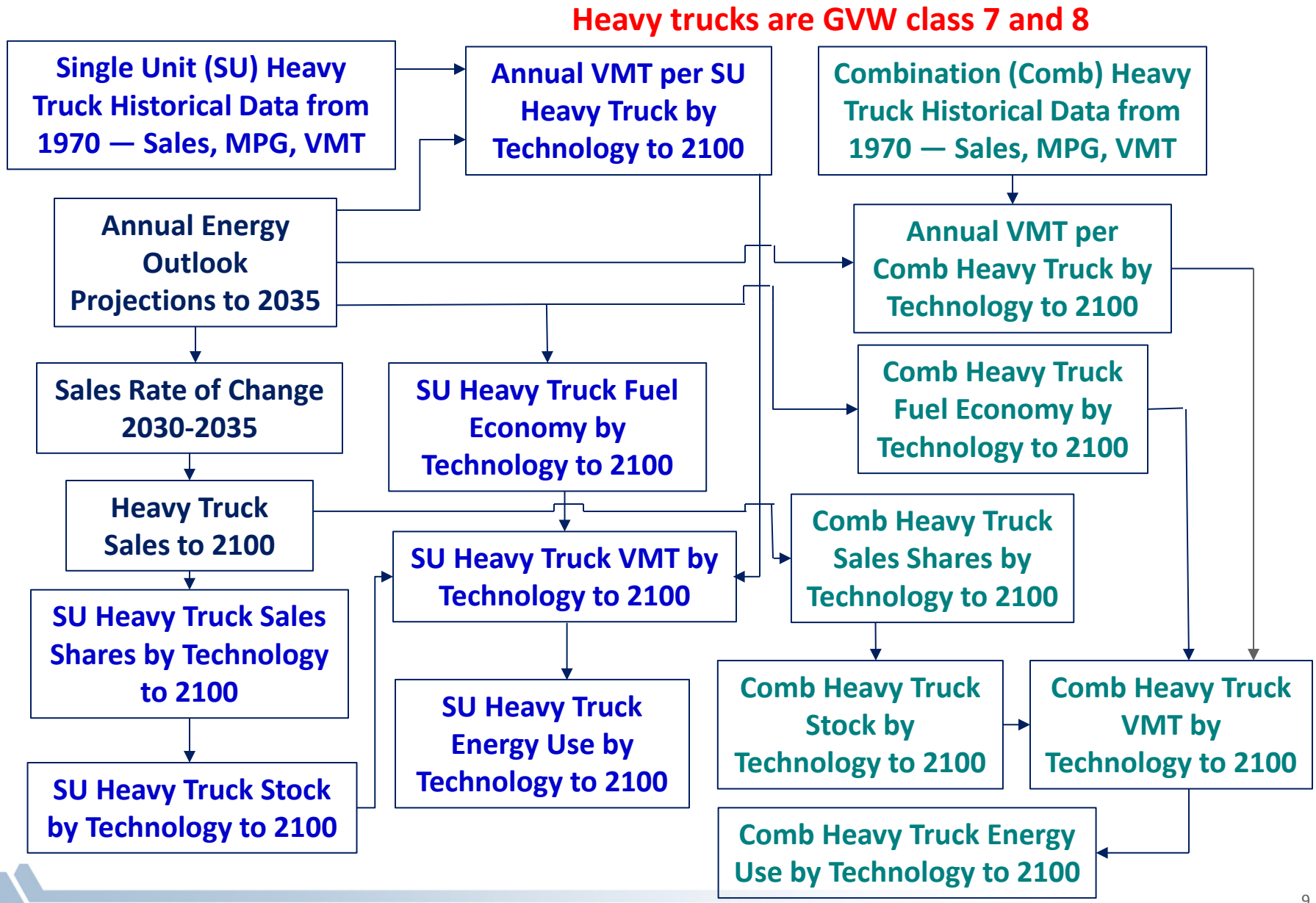


Approach: Create a Medium Truck Long Term Base Case

Medium trucks are GVW class 3 through 6



Approach: Create a Heavy Truck Long Term Base Case

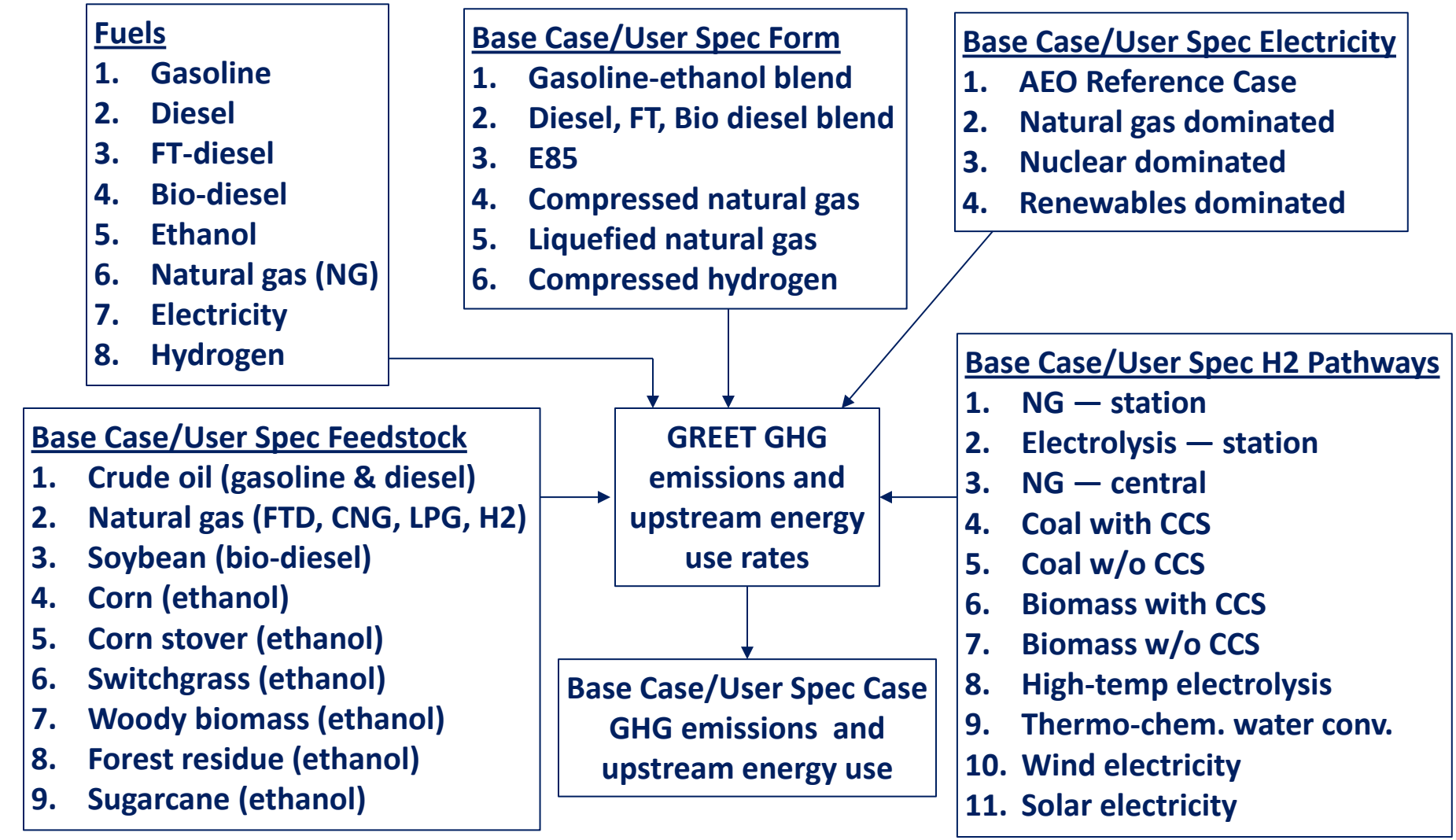


Approach: Incorporate Various Fuels and Fuel Blends

Fuel	Include As	Feedstock
Gasoline	Ethanol blend	Crude oil
Diesel	FT- and Bio-diesel blend	Crude oil
Fischer-Tropsch (FT) diesel	Diesel blend	Natural gas
Bio-diesel	Diesel blend	Soybeans
Fuel ethanol	Gasoline blend and E85	Corn, corn stover, switchgass, woody biomass, forest residue, sugarcane
Natural gas (NG)	Compressed and liquefied	Natural gas
Electricity	Four generation mix options	Coal, NG, Nuclear, Renewable
Hydrogen*	Compressed (fuel cell or HEV ICE)	NG, Coal, Biomass, Water (Electrolysis—low/high-temp, Thermo-chem conversion)

*Could be produced centrally and/or at station.

Approach: Incorporate Upstream Energy Use and GHG Emissions Rates from GREET Life Cycle Analysis



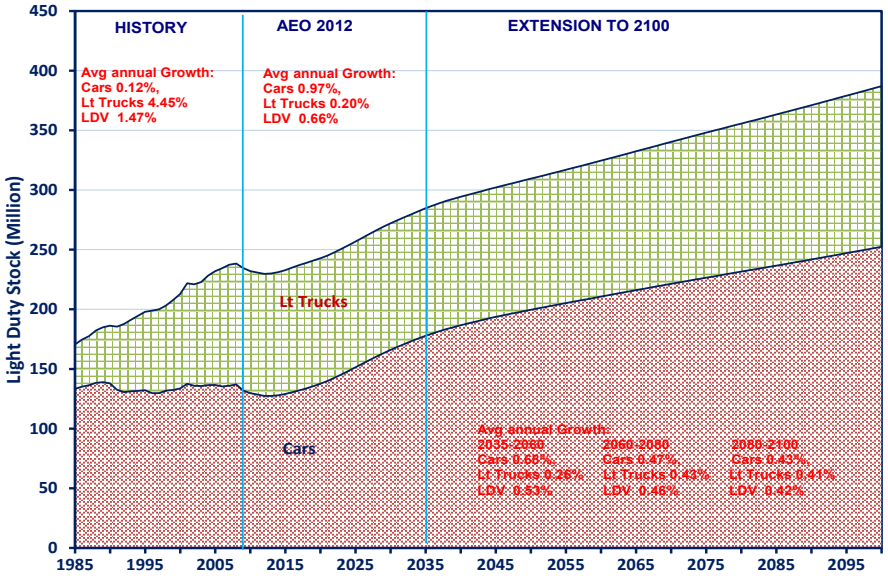
Approach: Allow User Specified Alternative Scenario

- **Fuels**
  1. **Fuel prices for all fuels**
  2. **Ethanol % in gasoline**
  3. **FT-diesel % in diesel**
  4. **Bio-diesel % in diesel**
  5. **Ethanol production share by feedstock**
  6. **Hydrogen production share by feedstock**
  7. **Electricity generation mix**

Approach: User Specified Alternative Scenario (Cont.)

- **Light Duty Vehicles**
  1. New vehicle market shares by technology
  2. New vehicle fuel economy by technology
  3. Light truck share of new sales
  4. Alternative fuel for AF HEV (E85 or H2)
  5. Fuel source for Fuel Cell (gasoline, diesel, NG, E100, H2)
  6. VMT share on E85 for flex-fuel vehicles
  7. All-electric range for plug-in HEV
  8. VMT elasticity to change in fuel cost per mile
- **Medium and Heavy Trucks**
  1. New truck fuel economy
  2. New truck market share by technology
  3. Pilot diesel fuel share of BTU used by natural gas trucks (CNG for class 3-6 medium and class 7&8 Single Unit heavy, and LNG for class 7&8 combination heavy trucks)

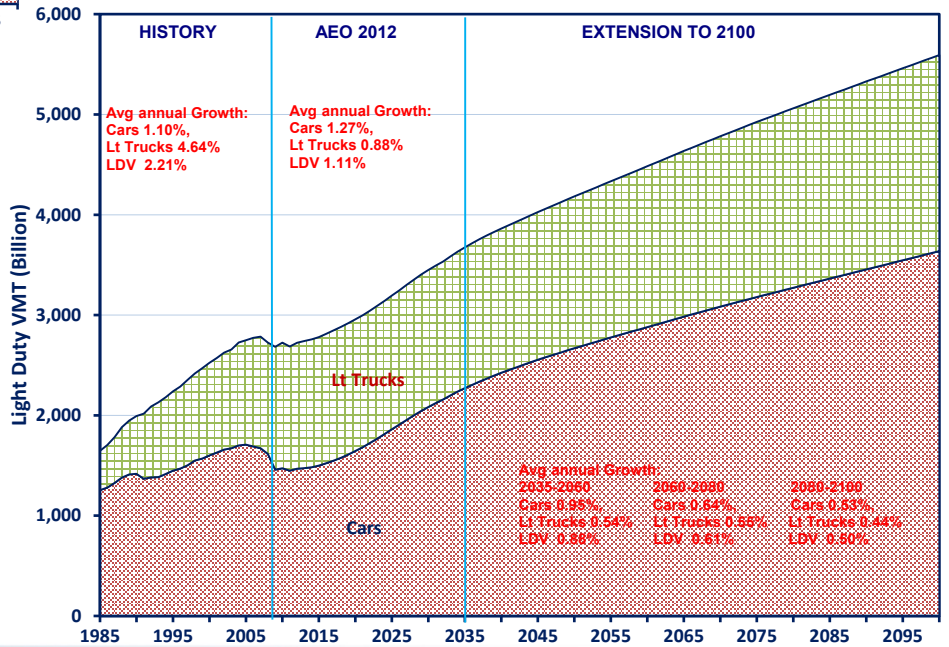
Accomplishment — Create a Long Term Base Case



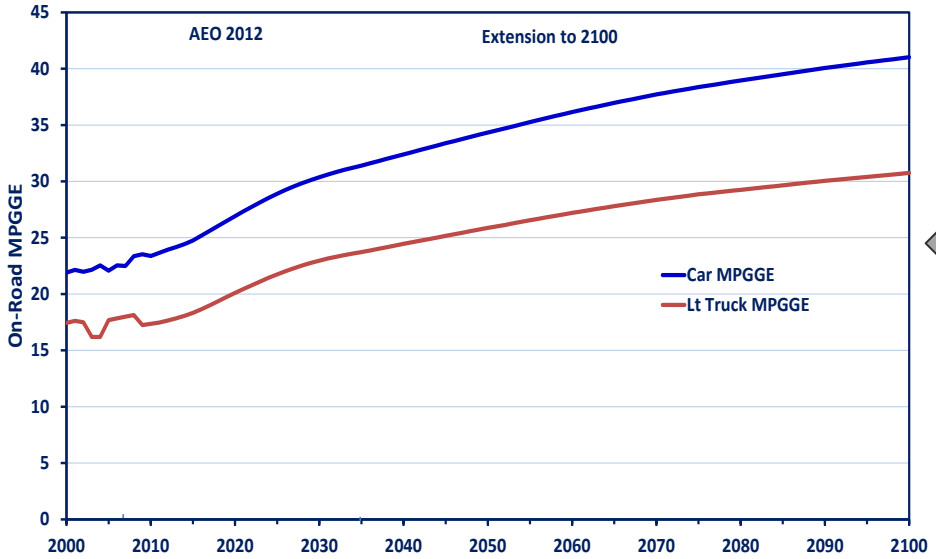
Use economic and demographic projections to expand light duty analysis horizon to 2100

Light duty vehicle stock

Light duty vehicle VMT



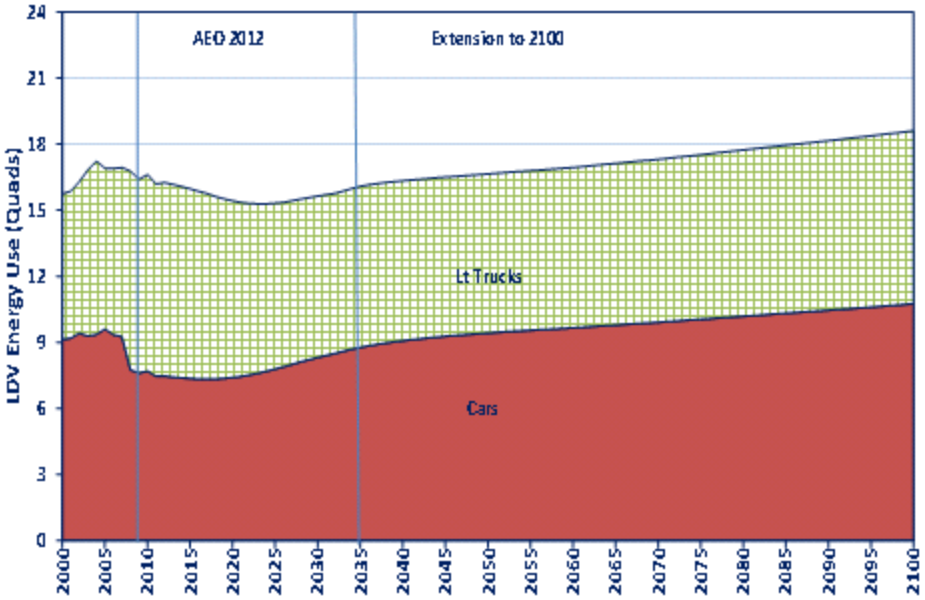
Accomplishment– Create a Long Term Base Case (Cont.)



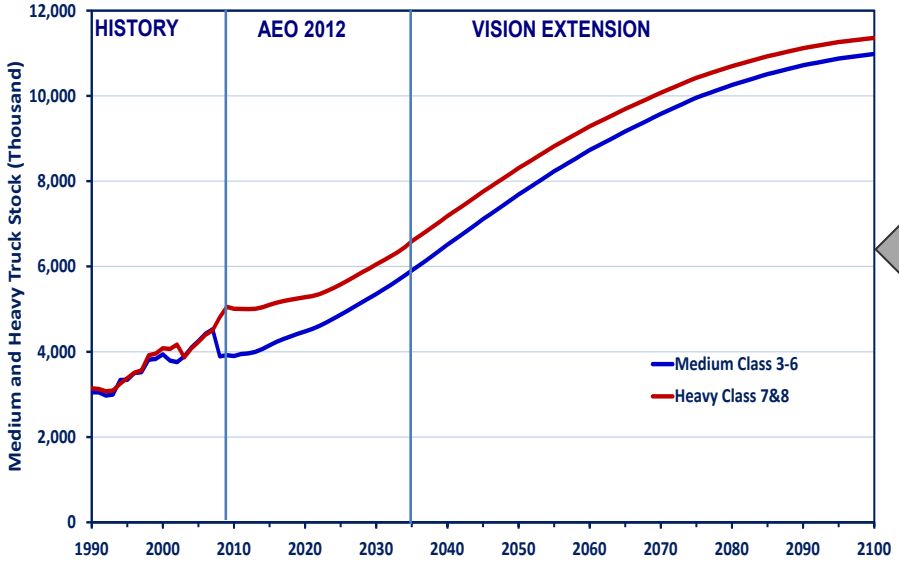
Expand light duty analysis horizon to 2100

Light duty vehicle on-road MPGGE

Resulting Light duty vehicle energy use



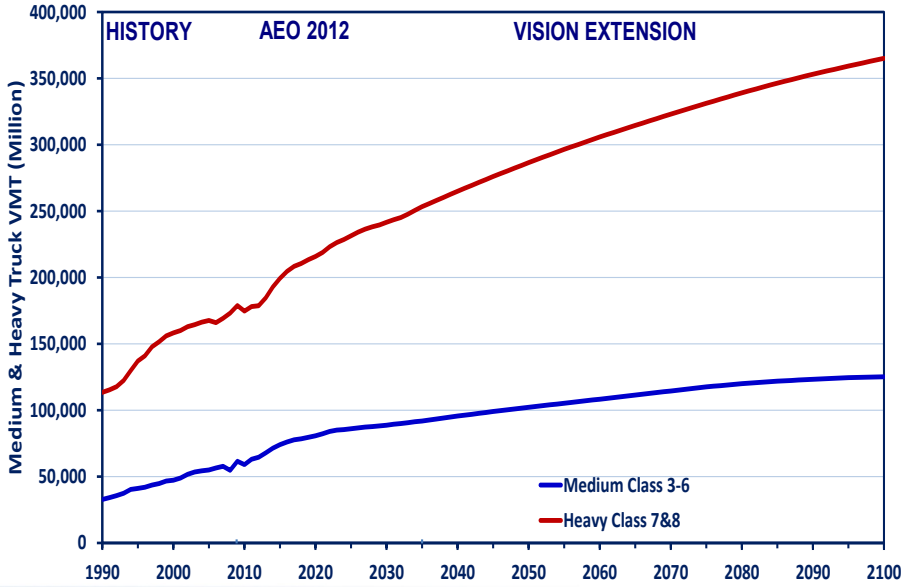
Accomplishment—Create a Long Term Base Case (Cont.)



Expand medium & heavy duty truck analysis horizon to 2100

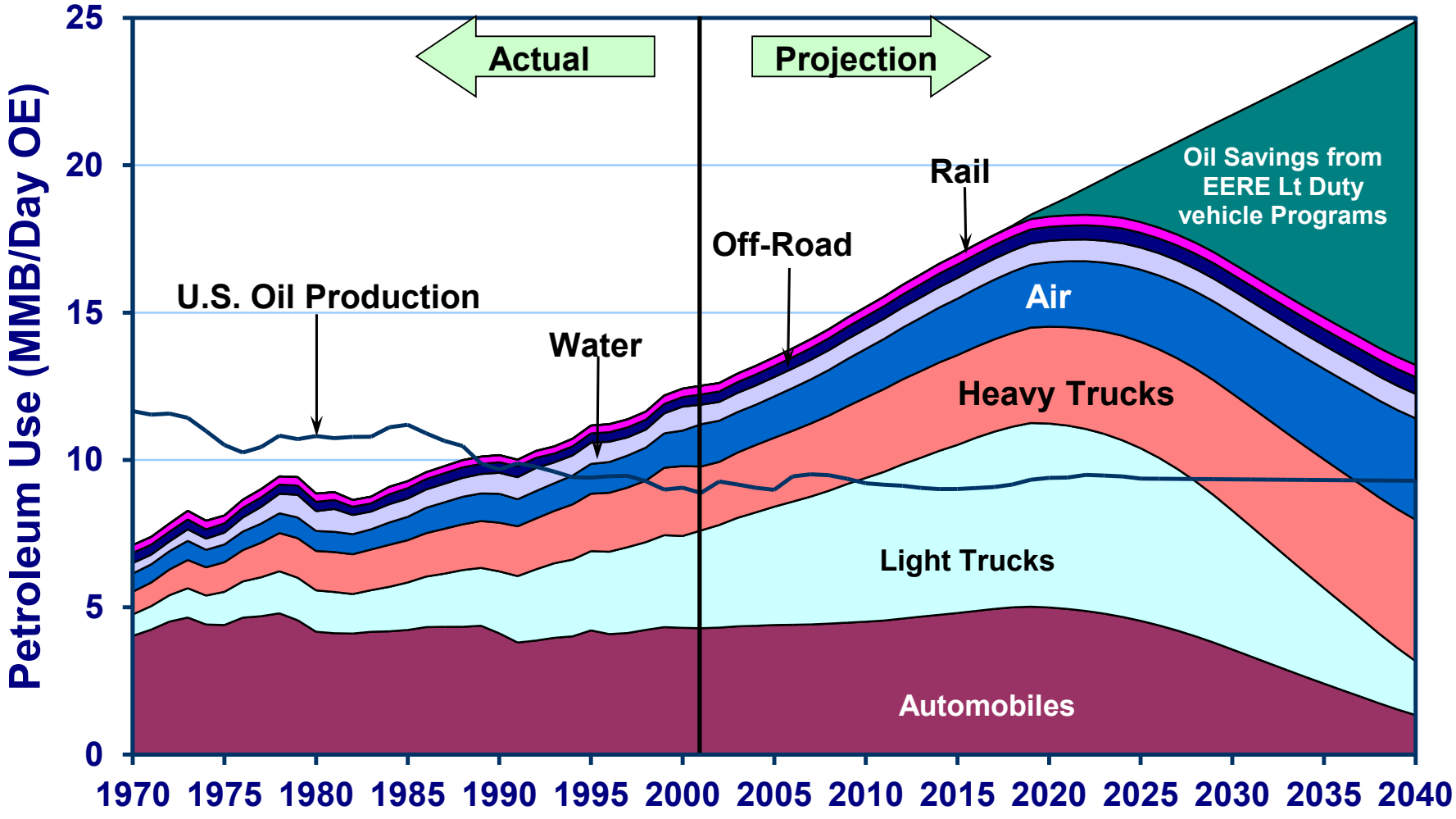
Medium and heavy truck stock

Medium and heavy truck VMT



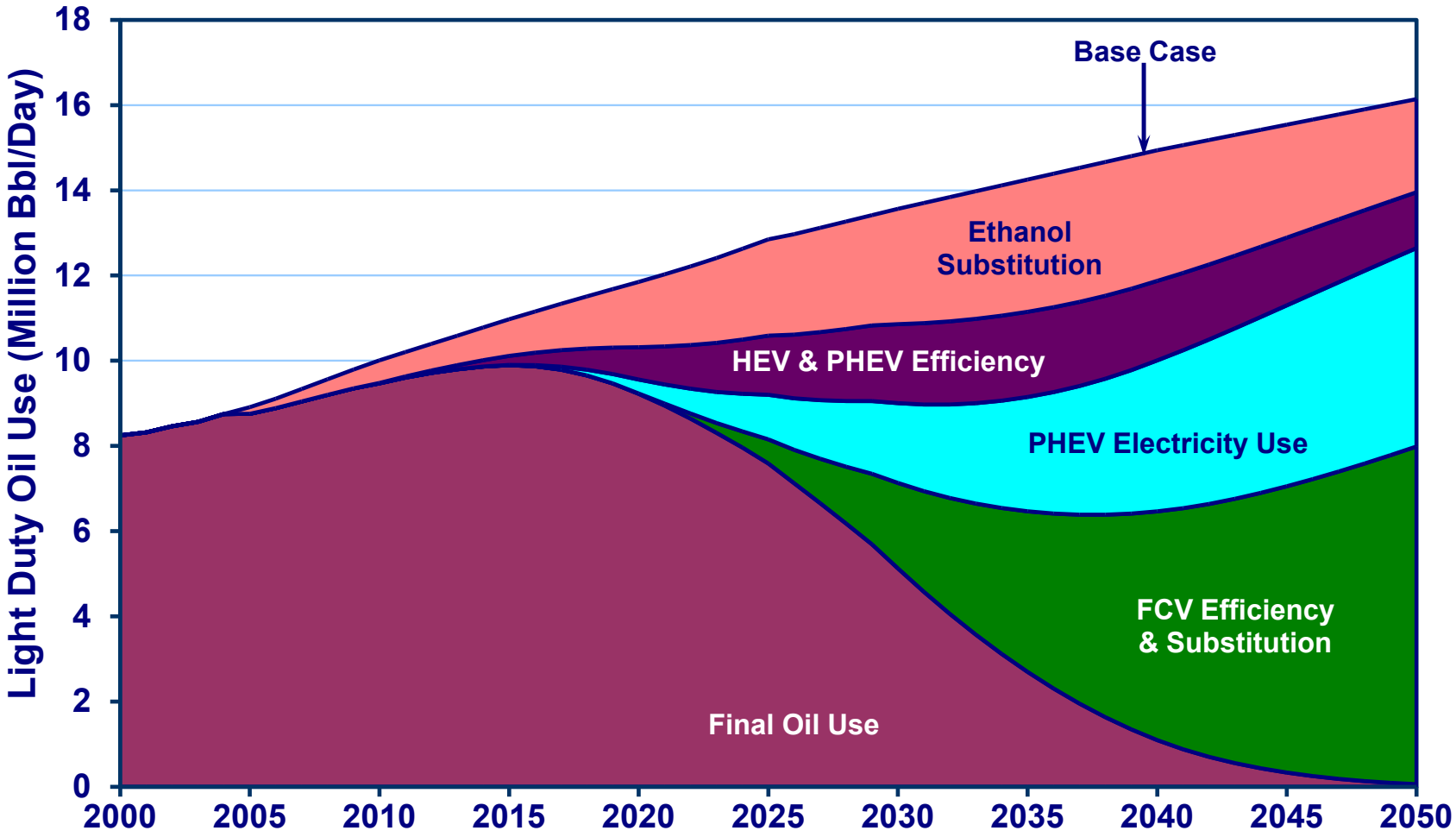
Technical Accomplishments

The VISION tool allows quick evaluation of alternative scenarios



Technical Accomplishments

Evaluation of a light duty energy efficiency and fuel substitution scenario



Collaboration and Coordination

Notable among (VISION) model's over 300 users:

- DOE – Vehicle Technologies Program, Hydrogen and Fuel Cells Program, Biofuels Program, Policy Office, Energy Information Administration
- DOT – NHTSA
- CBO
- White House – Economic Council and Technology Office
- GSA
- Others – General Motors, National Petroleum Council, ConocoPhillips, Booze Allen Hamilton, ACEEE, NESCAUM, Jack Faucett, Cambridge Systematics, TA Engineering, University of California, University of Maine, Iowa State University

Proposed Future Work

- **FY13 Ongoing Work**
  - **Update the VISION model with AEO 2013 projections and develop extensions to 2100**
  - **Develop a model for evaluating impacts of energy efficiency improvement and fuel substitution in freight transportation**
    - **Use commodity level ton-mile projections by USDOT**
    - **Use mode share projections by USDOT**
    - **Develop commodity level energy intensity estimate for each mode**
    - **Allow fuel substitution**
    - **Allow alternative scenario specification by users**
- **FY14 Activities**
  - **Update the VISION model with AEO 2014 projections and develop extensions to 2100**
  - **Expand the freight transportation model to include commercial aviation**

Summary

- The model for long-term energy and GHG impact evaluation (VISION) is updated annually with the latest Annual Energy Outlook projections, extending projections to 2100.
- The model can quickly evaluate alternative scenarios in terms of several metrics, notably petroleum use and GHG emissions changes.
- The model has over 300 users that include prominent government agencies, universities, industry, consultants, and non-governmental organizations.
- A model to evaluate impacts of energy intensity improvement and fuel substitution on freight transportation energy use and GHG emissions is being developed.

Technical Back-up Slides

FY13 Ongoing Work — Freight Transportation

A model to evaluate impacts of EI improvement and fuel substitution in freight transportation

- Covers five freight modes: (1) truck, (2) rail, (3) domestic marine, (4) air (cargo), and (5) pipeline.
- Covers 36 commodity groups.
- Allows commodity level specification of ton-miles.
- Allows specification of mode shares by commodity.
- Base case of the model represents FHWA's Freight Analysis Framework (FAF) ton-miles and mode shares.
- Allows specification of energy intensity by mode within commodity (Base Case represents EIA's Annual Energy Outlook, extended to 2050).
- Allows specification of fuel shares by fuel type.

FY13 Ongoing Work — Freight Transportation

The model would provide quick turnaround evaluations

- Analysis time horizon is 2050.
- Provides estimates of petroleum based fuel use, other energy use by type, and full fuel cycle carbon emissions for five freight modes: (1) trucks, (2) rail, (3) water, (4) air cargo, and (5) pipeline.
- Provides estimates of energy use in feedstock and fuel production of the end use fuels.
- Allows user to specify alternative scenarios and provides results for Base (FHWA's Freight Analysis Framework) and scenario cases.

FY13 Ongoing Work — Freight Mode Fuels

GHG rates from the latest GREET version are used

- **Truck**
  1. Petro-diesel
  2. Bio-diesel
  3. Renewable (FT) diesel
  4. Pyrolysis diesel
  5. Liquefied natural gas (LNG)
- **Rail**
  1. Petro-diesel
  2. Renewable (FT) diesel
  3. Pyrolysis diesel
- **Water**
  1. Petro-diesel
  2. Renewable (FT) diesel
  3. Pyrolysis diesel
  4. Residual fuel oil
- **Air**
  1. Petro-jet fuel
  2. HR/FT jet fuel
  3. Pyrolysis jet fuel
- **Pipeline**
  1. Natural gas
  2. Electricity