Sustainable TRANSPORTATION

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

Natural Gas for Transportation

Research Needs Workshop

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Legislative and Policy Drivers – House

FY17 HEWD Mark Guidance

Within available funds, the recommendation includes up to $15,000,000 for medium and heavy-duty on-road natural gas engine research and development, including energy efficiency improvements, emission after-treatment technologies, fuel system enhancements, and new engine development. Additionally, the Department is encouraged to address technical barriers to the increased use of alternative fuel vehicles, including the development of novel compression and liquefaction technologies, advanced materials, and improvements in processes for conditioning and dispensing natural gas.

No guidance in FY17 Conference Report

FY18 HEWD Mark Guidance

Within available funds, the recommendation includes up to $15,000,000 for medium and heavy-duty on-road natural gas engine research and development, including energy efficiency improvements, emission after-treatment technologies, fuel system enhancements, and new engine development.

Legislative and Policy Drivers – Senate

FY17 SEWD includes no guidance

FY18 SEWD Mark Guidance

The Committee encourages the Department to support research on natural gas storage, natural gas engines, and fueling infrastructure optimization. The Committee is also supportive of efforts to address technical barriers to the increased use of natural gas vehicles, including the development of novel compression and liquefaction technologies, advanced materials, and improvements in processes for conditioning, storing, and dispensing natural gas.

Legislative and Policy Drivers – Administration

Administration Guidance

“Focus on low-TRL”

- What’s that?

- TRL = Technology Readiness Level
  - Ranges from 1–10 (from basic science to product ready for the market)
  - “Low-TRL” = TRL 1–3
  - “EERE does not work on TRL 1” ← quote of unknown provenance (i.e., not Administration guidance)

- N.B.: the word “engineering” first shows-up in the definition of TRL 6

Workshop Objectives

What are we looking for today?

- Ideas that can lead to projects that will <u>advance the science base</u> underlying increased efficiency in natural gas engines and improved emissions control

What are we *not* looking for today?

- An additional engine product in the market
- Deployment activities

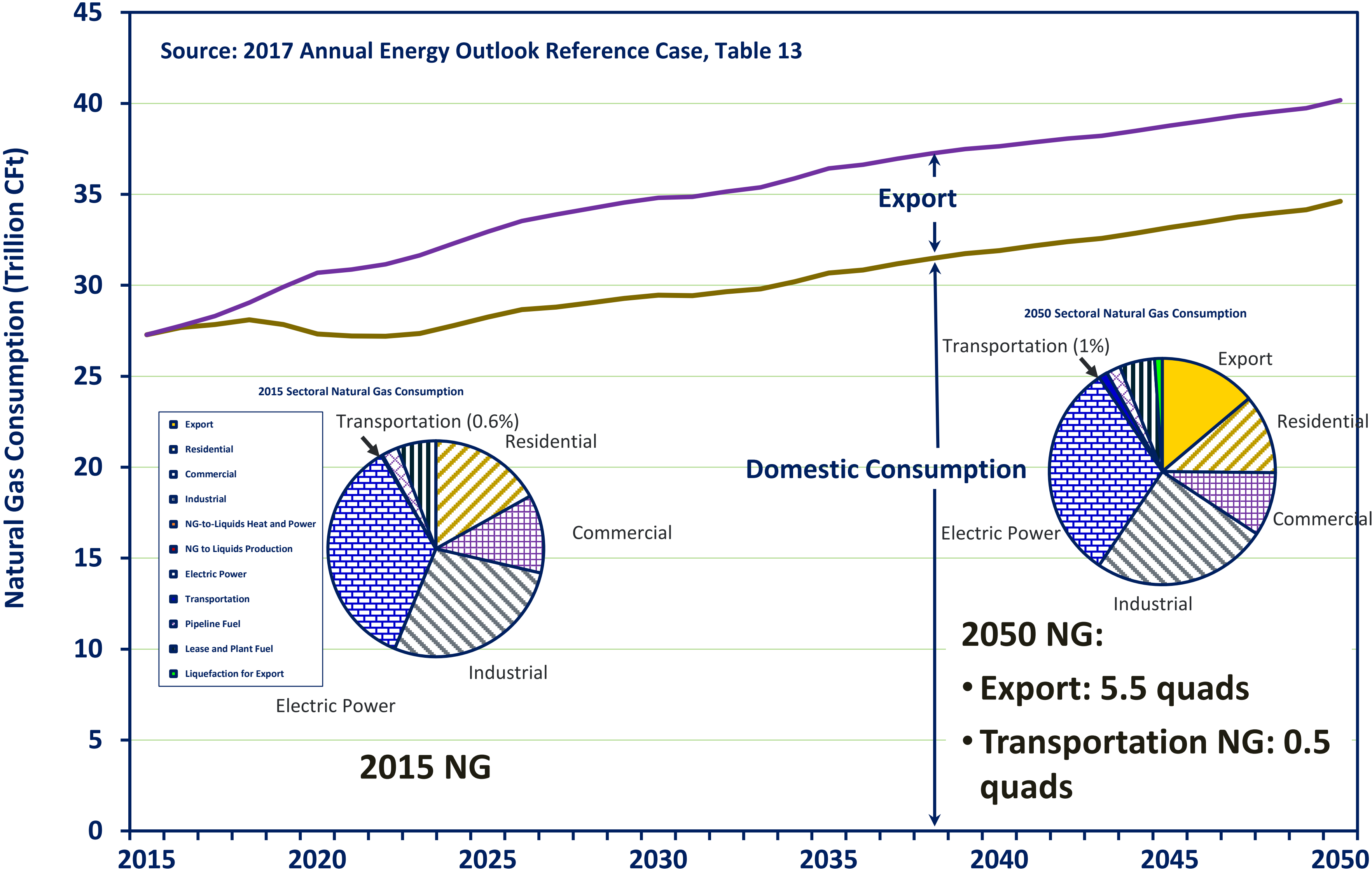
How do we plan to execute this activity?

- Multiple projects, balancing competitively-awarded, cost-shared cooperative agreements and projects at National Labs

Natural Gas Use in Transportation Offers Solutions

- New domestic NG proven reserves have increased exponentially in the past ten years and can be used to offset reliance on unstable oil sources
- By applying inexpensive domestic NG to vehicular transportation, reduction in the balance of trade and job creation can be envisioned along with long-term economic security
- The introduction of NG can be environmentally beneficial
  - Reduction in criteria emissions versus baseline fuel (i.e., gasoline for LD, diesel for HD)
  - GHG neutral or result in slight reduction versus baseline fuel

AEO 2017 NG US Supply and Demand Projection



NG Share of Transportation Fuel Demand by Sector/Mode

Sector/Mode	Fuel Type	2015	2040 AEO (ref)
Light-Duty Vehicle	NG	0.1%	0.2%
Commercial Light Truck	NG	0.0%	0.0%
Light Medium Freight Truck	NG	0.6%	2%
Medium Freight Truck	NG	0.8%	1%
Heavy Freight Truck	NG	0.4%	10%
Transit Bus	NG	18%	70%
Freight Rail	NG	0.0%	35%
Intercity Rail	NG	0.0%	0.0%
Air Transportation	GTL Jet	0.0%	0.0%
Heavy Freight Truck	GTL Diesel	0.0%	0.0%
Total transportation sector energy demand (Quad Btu)		26.7	25.5
Total NG share of transportation sector energy demand		0.2%	3.4%

Opportunities to Address Barriers to Large-Scale Turnover to NG for LD & MD/HD

Low TRL (early R&D)

High TRL (deployment)

Light Duty

- Conformable storage tanks
- Robust, low-cost home refueling

ARPA-E MOVE program

- Adopt NG to direct injection gasoline engine base designs

- Cost (tanks)
- External fueling infrastructure

Medium / Heavy Duty

- Ultra-low / near-zero NOx engine + aftertreatment systems
- High efficiency NG engine designs vs. baseline diesel
- NG engine durability improvements (ignition systems)
- Large-scale, fast full fill fueling infrastructure supporting Class 8 trucking
- Renewable NG gas standards (affects efficiency and emissions)

- Full displacement range, sustainable critical mass market for engine options
- Cost (tanks)

Major Studies Identify RD&D Advances Needed to Facilitate Efficient NG Use

- Engine operations
  - Direct-injection turbocharged CNG engines – downsized DI NG engines can approach torque output of diesel (NPC 2012)
  - Improved air handling, higher energy ignition (NRC 2013)
- Aftertreatment (NRC 2013)
  - Improved catalysts for oxidation and oxygen storage
  - Improved controls air/fuel ratio dithering, sensors
  - Crank case ventilation
- On board fuel storage – tradeoffs between storage volume, ease of packaging, mass, storage & dispensing pressures (NPC 2012)
- HD cryogenic fuel handling – static & dynamic seals, non-intrusive fuel level sensing, vapor pressure management (NPC 2012)
- Common gas specifications for RNG (beyond pipeline specs) – composition analysis & allowable levels of trace compounds (NPC 2012)
- LCA of GHG emissions during LNG refueling & use (ExxonMobil 2010)
  - LNG retail fueling & vehicle tank boil-off losses depends on fuel station utilization, station design, type of on-board fuel tank, vehicle utilization, etc.

Research Needs for Expanded NG Transportation Use

- Vehicle Research
  - Broader range of high efficiency NG engine technologies to cover wide variety of HD applications
  - NG technology development leveraging recent gasoline boosted direct injection engine improvements (+ higher compression ratio)
  - NGVs with fewer penalties (cost, cargo, performance, and maintenance vs. baseline; right sizing NG tanks for needed range)
  - Lean NG engine controls
  - Advanced ignition systems for NG engines
  - Aftertreatment tailored to NG applications
  - Advanced lubricants to improve NG engine efficiency, reliability, and durability

2014-present DAS-T Working Group: NG for Transportation

- Leader: Michael Wang (ANL); Co-Leaders: Brad Zigler (NREL) and Yarom Polsky (ORNL)
- **NG Distribution/Refueling: Yarom Polsky (ORNL)**, Marianne Mintz (ANL), Amgad Elgowainy (ANL), Martin Sulic (SRNL)
- **Liquid Fuels and LNG: Ted Krause (ANL),** Yarom Polsky (ORNL), Michael McKellar (INL), Tom Brouns (PNNL), Bryan Morreale (NETL), Vince Battaglia (LBL)
- **Storage: Don Anton (SRNL),** David Gotthold(PNNL), DJ Liu (ANL), Michael Kass (ORNL), Salvador Aceves (LLNL)
- **Vehicle End Use: Brad Zigler (NREL),** Dawn Manley* (SNL), Thomas Wallner (ANL), Tom Brouns (PNNL), Michael Kass (ORNL), Salvador Aceves (LLNL), Peter Therkelsen (LBL), Vi Rapp (LBL)
- **Impact Assessment: Michael Wang (ANL), Dawn Manley* (SNL),** David Tamburello (SRNL), Michael McKellar (INL), Marc Fischer (LBL), Anand Gogal (LBL)

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