Possible Pathways for Increasing Natural Gas Use for Transportation

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

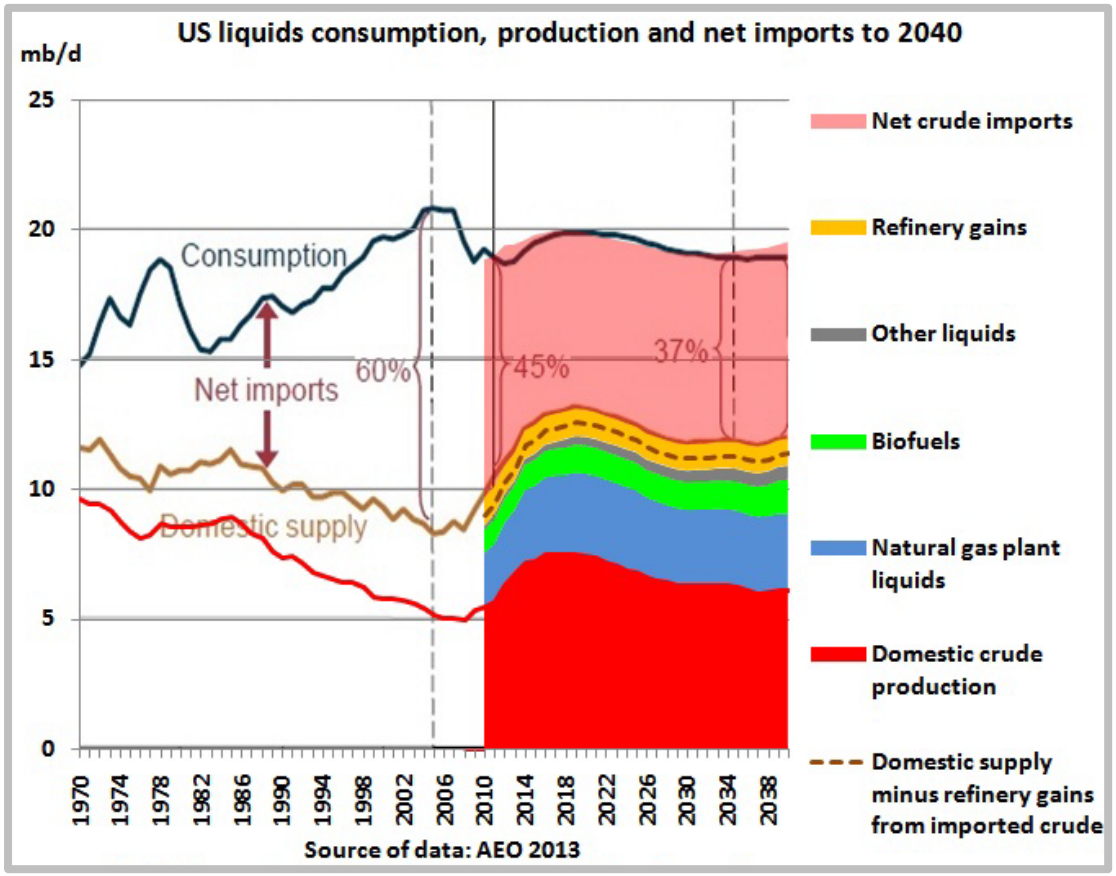
Background

A collaborative partnership of DOE national laboratories is working with DOE to identify critical RD&D needs to significantly increase the speed and breadth of NG uptake into the transportation sector.

How can DOE resources partner with industry, academia, and other stakeholders to address key technical barriers?

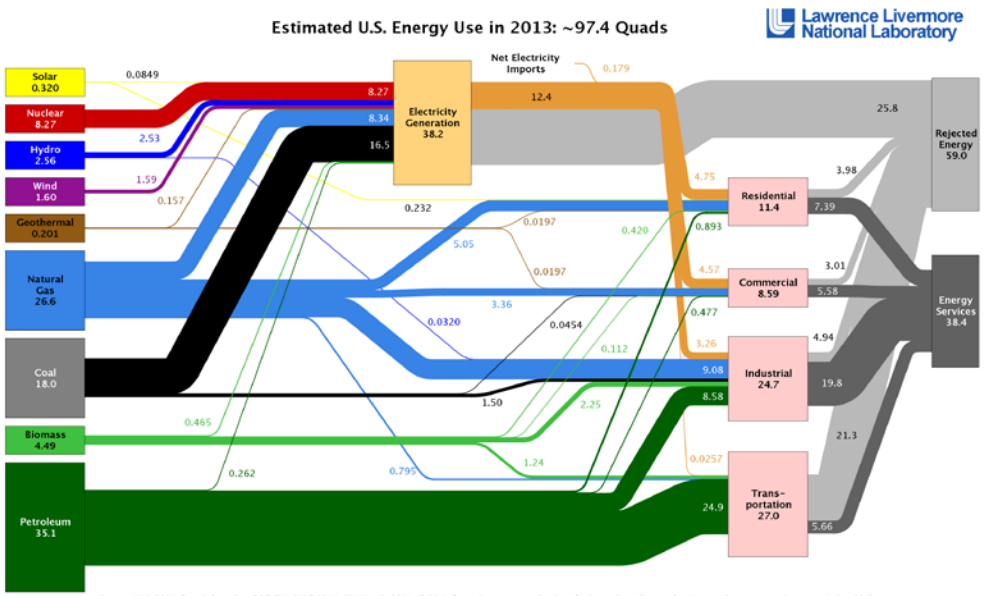
The Transportation Dilemma

- Foreign imports of petroleum and its products for transportation are currently $200B/year, accounting for 35% of the current U.S. trade deficit.
- Oil supply and price instability will persist because of political unrest and increased global consumption.



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, a significant reduction in the balance of trade can be envisioned along with long-term economic security.
- The introduction of NG can be environmentally beneficial, resulting in potential CO_2 emissions reduction.
- NG use can provide a pathway for future bio-based fuels (e.g., biogas and gas + biomass-to-liquids [GBTL]).



Source: LLNL 2014. Data is based on DOE/EIA-0035(2014-03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

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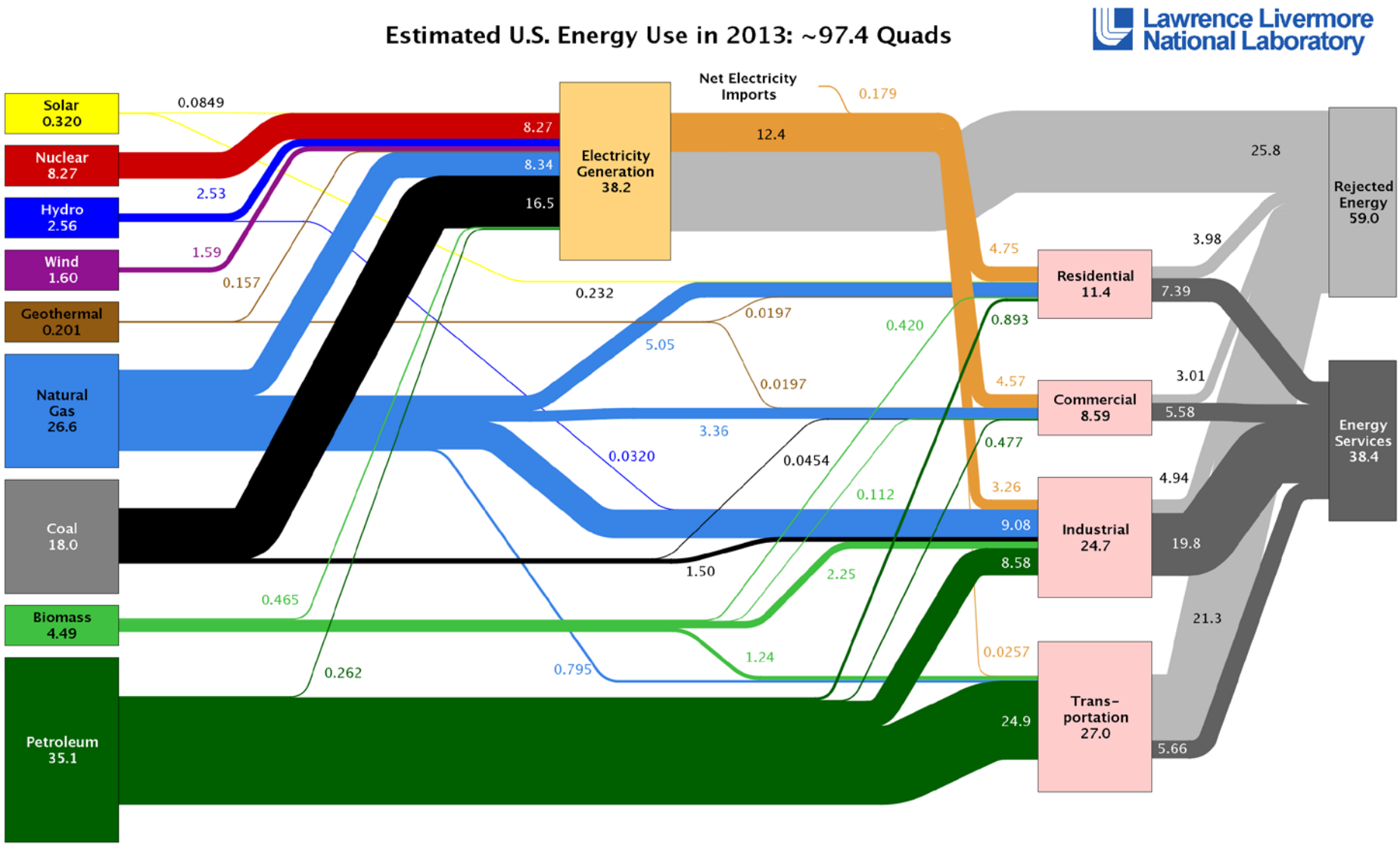

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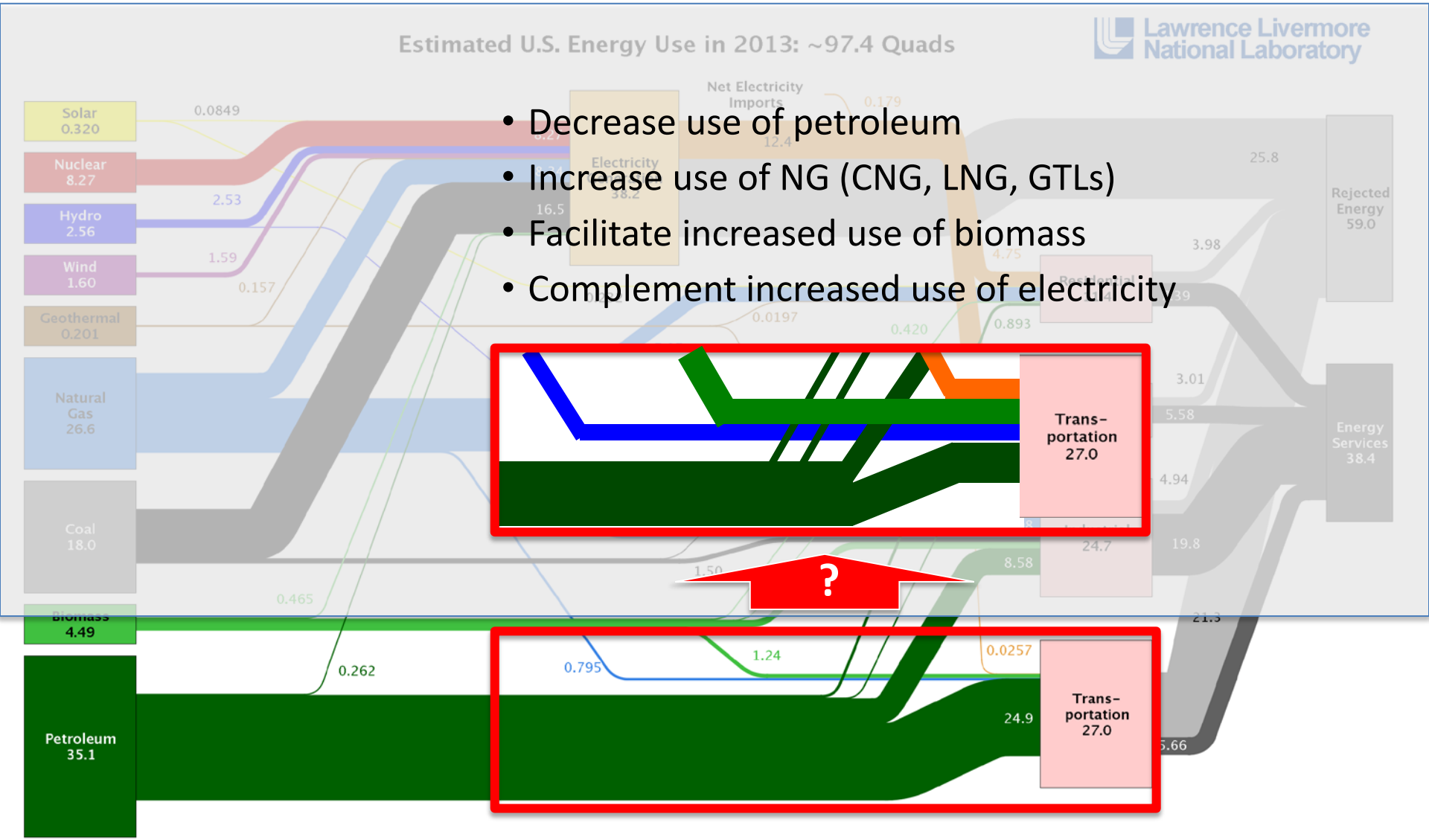

- Decrease use of petroleum
- Increase use of NG (CNG, LNG, GTLs)
- Facilitate increased use of biomass
- Complement increased use of electricity

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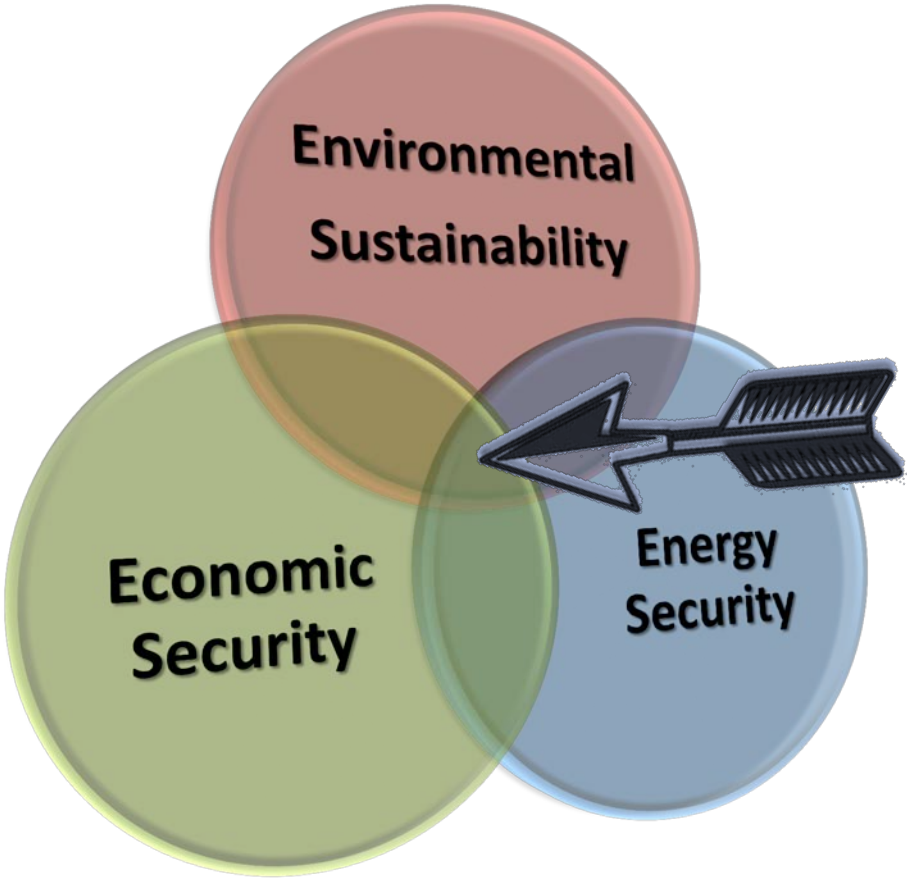
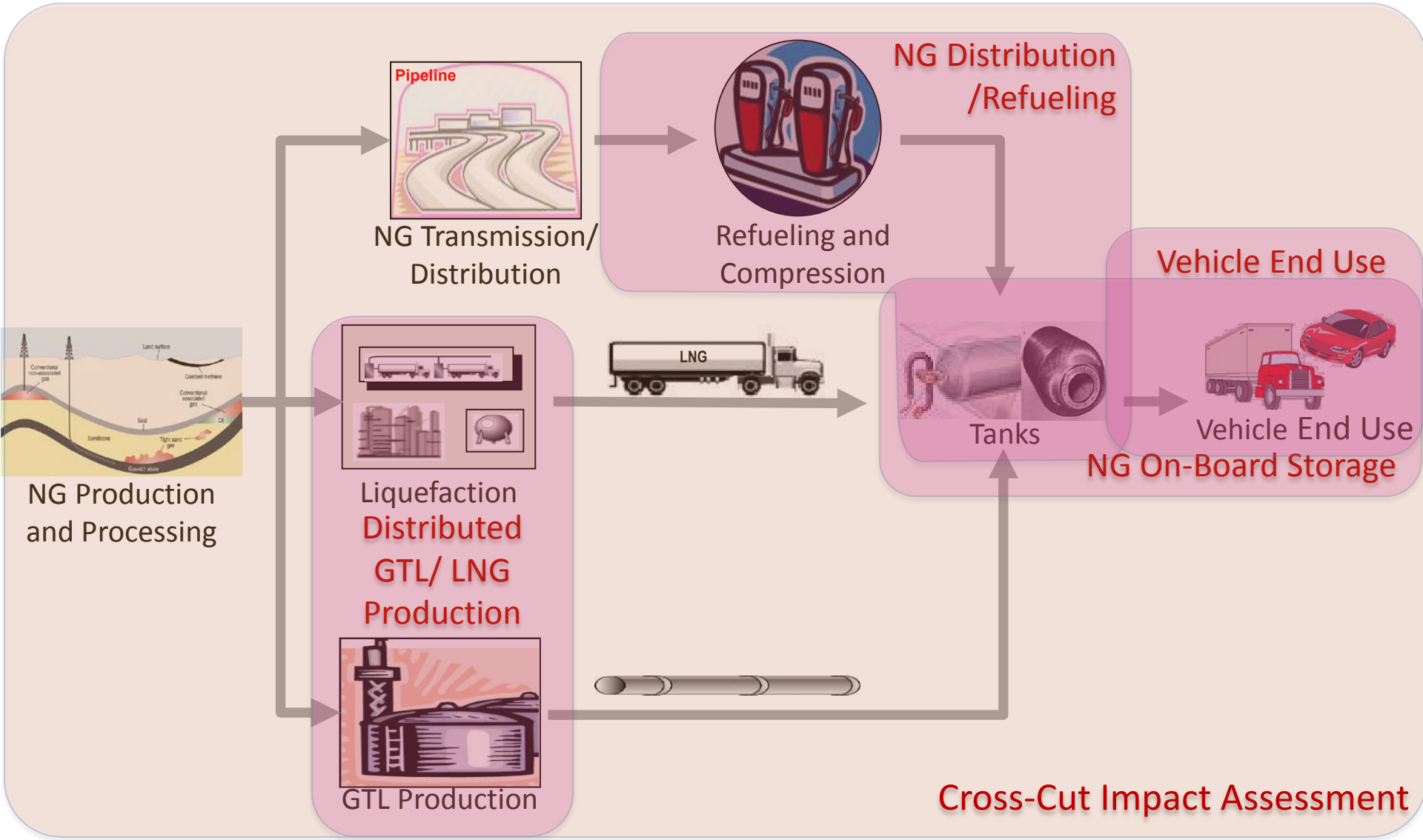
Goals and Rationale

- Significantly increase the use of natural gas in transportation to enable:
  - Cost savings to consumers and society
  - Improved energy security
  - Environmental sustainability with air pollutant and potential GHG emissions reductions
- U.S. economy and industry are adapting to utilize NG. However, without a coordinated effort by the federal government, disparate industry stakeholders will not optimize use of NG for the transportation sector.
- RD&D efforts are needed to overcome bottleneck issues for expanded NG use in transportation.



Key RD&D Areas Along the NG Supply Chain



Natural Gas RD&D Landscape

Current State of Research Examples

- Station and home compression research efforts
- Isolated, emissions-focused engine development projects
- Low-pressure adsorption systems and conformable tank storage R&D
- CH_4 leakage being measured and assessed

Examples of Gaps

- Holistic system modeling for fuel pathways (CNG/LNG/GTL)
- High-efficiency NG engine systems and aftertreatment RD&D
- Low-cost distributed LNG and GTL production processes
- No systematic cost models available for CNG/LNG and NG liquid fuels (and other vehicle/fuel systems)

Examples of Goals

- Address key barriers to enabling economic NG use in transportation
- Enable a diverse range of highly efficient, clean NGVs
- Demonstrate cost-competitive, environmentally friendly distributed mini LNG and GTL technologies for distributed liquid fuel production

Opportunity

- Enable <u>large-scale utilization</u> of natural gas as a domestic, clean transportation fuel
- <u>Holistic approach</u> ensures maximum economic and environmental benefits

Major RD&D Needs

Distribution/refueling

- Transportation dedicated distribution infrastructure
- Fueling infrastructure, codes/standards, and associated technologies including on-board vehicle storage
- Transportation specific methane leak detection / mitigation technologies and methods

GTL and LNG production

- Small-scale NG liquefaction
- Mini-scale GTLs and GBTL technology for distributed production

Vehicle end use

- Combustion concepts tailored to using CNG, LNG, rNG, dual-fuels, bi-fuels, NG/H_2 blends, and specific GBTLs
- Vehicle system integration (aftertreatment, hybridization, fuel storage) tailored for these fuels
- Deployment support, including standards, specifications, safety, and NGV end-of-life development

NG on-board storage

- Gaseous NG and H_2
- LNG

Impact assessment

- Analysis supporting NG use and impacts in transportation including consideration of influence of alternative NG uses
- Data supporting life-cycle and benefit analysis

Related needs

- NG production/recovery
- NG distribution infrastructure not specific to transportation
- R&D for improving large-scale, centralized LNG and GTL production; large-scale, centralized NG liquefaction for NG transmission
- Local LNG for large city fleets
- Fuel cell vehicles fueled with H_2 derived from NG

Possible Pathway to Address RD&D Needs

Set overarching goal of holistic NG use in transportation

- Focus on providing solutions to allow broad new fuel/vehicle deployment in the intermediate term
- Consider NG as an enabler for renewable resources such as biomass and biogas

Engage as a multi-stakeholder effort

- Accelerate and integrate activities complementary to DOE core programs
- Advance from early R&D (e.g., ARPA-E) to technology commercialization through the R&D "Valley of Death"

Interact with and complement other stakeholder programs (e.g., CEC, SCAQMD, CARB)

Identify and tackle key bottleneck issues that are currently not included in DOE's limited NG RD&D activities

RD&D Impact & Value Propositions

Focus efforts on maximizing value proposition to all key stakeholders for:

- Energy security
- Economic security
- Environmental sustainability

Society

- Reduce GDP drain / balance of trade issues
- Leverage the domestic NG resource as a hedge against global conflict
- Improve environmental sustainability (GHGs, H_2O use, regulated & unregulated air emissions)

Consumers

- Enable a diverse market of NG vehicle options, with fewer NGV "warts"
- Reduce vehicle operating cost
- Reduce fuel price fluctuations

Industry

- Allow companies to focus on issues under their control, through focus on coordination and key issues
- Enable NG for transportation to become a viable, self-sustaining sector
- Create new market opportunities for industries for NG in transportation

Agencies/ Policymakers

- Utilize domestic NG reserves in "smart" use with holistic consideration (not the "Wild West")
- Enable policies and standards based on unbiased technical foundation

Stakeholder Engagement

- National labs seek input from a wide range of stakeholders in furthering RD&D topics.
- Please let us know what technical barriers you consider to be most important. Colleagues from several DOE labs are at NGVTF and are happy to talk to you.

NGVTF
Natural Gas Vehicle Technology Forum

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Advanced Research Projects Agency • ENERGY

Thank you!

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Back-Up Material

NG for Transportation Cross-Lab Team

- 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 (LBNL)
- **Storage: Don Anton (SRNL),** DJ Liu (ANL), Michael Kass (ORNL), Salvador Aceves (LLNL), David Gotthold (PNNL)
- **Vehicle End Use: Brad Zigler (NREL),** Dawn Manley (SNL), Thomas Wallner (ANL), Tom Brouns (PNNL), Michael Kass (ORNL), Salvador Aceves (LLNL), Peter Therkelsen (LBNL), Vi Rapp (LBNL)
- **Impact Assessment: Michael Wang (ANL), Dawn Manley (SNL),** David Tamburello (SRNL), Michael McKellar (INL), Marc Fischer (LBNL), Anand Gogal (LBNL)