Future Transportation Fuels

Many Options, Each With Challenges and Opportunities…

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Outline

- Operating under a new Energy Equation
- Future fuel and vehicle options
- Energy scenarios
- Key R&D challenges and ways to overcome them

The New Energy Equation

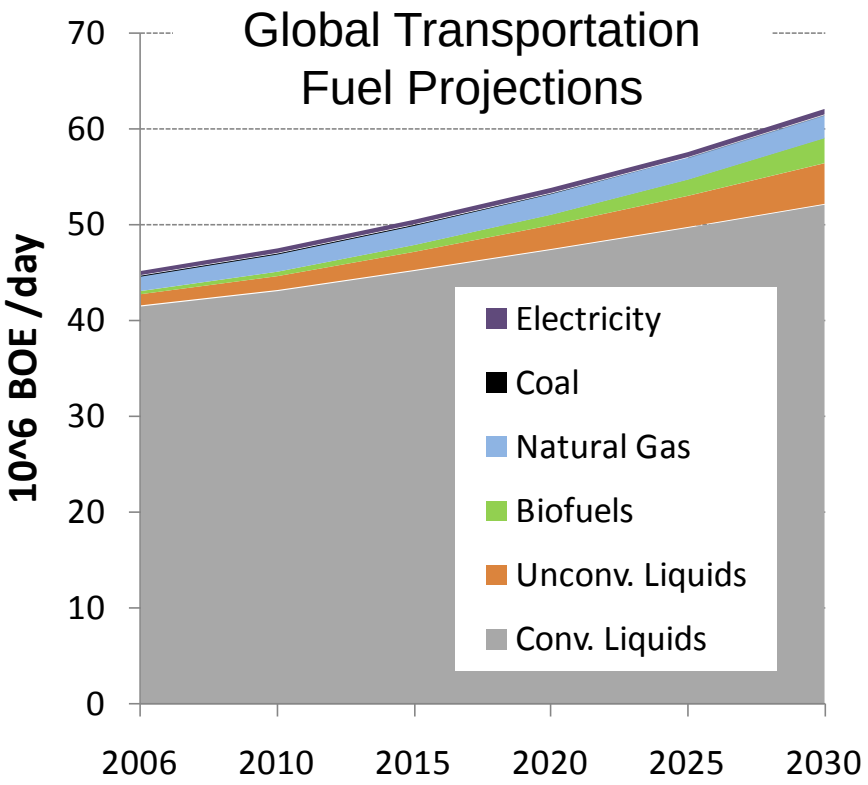
Operating in a More Complex World…

- Growing energy demand globally, especially in China, India, and Latin America
- Increasing competition and investments for resources
- Increasing price volatility
- Growing expectations to address climate change, environmental, social, and health impacts
- Tighter constraints on water availability and land impacts
- Improving energy efficiency
- Diversifying energy supply
- Developing and integrating sustainable energy resources and clean fuel technologies

Hydrocarbons Will Remain the Major Energy Provider

But Growing Share of Renewable and Lower Carbon Sources

- Through 2030
  - Total world energy consumption is expected to grow by over 40%
  - Global oil demand will increase 1% annually
  - Demand for natural gas is projected to rise almost 2% annually



Source: EIA International Energy Outlook 2009, reference case. Conventional liquids include crude oil, condensates, & NGLs. Unconventional liquids include extra-heavy oils, oil shale, bitumen, GTL, and CTL. Natural gas includes CNG and LNG. Assumed 5.8 MMBTU/BOE.

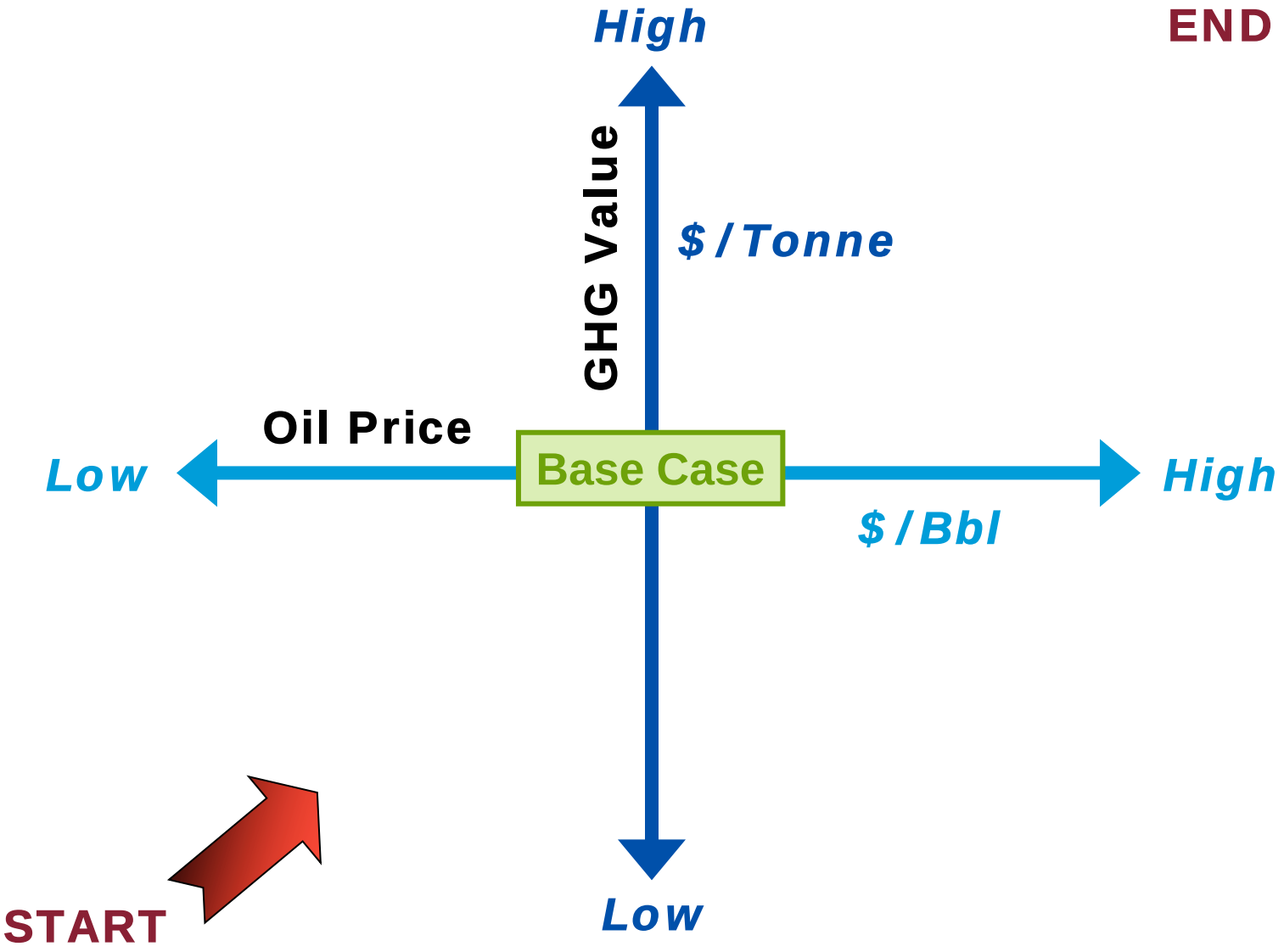
Switching to an Alternative Fuel Vehicle

Transition Criteria for the Customer

- To buy alternative fuel vehicles, customers want:
  - Equal or improved driving performance, safety, reliability, utility, and comfort
  - Equal or lower vehicle and fuel costs
  - Improved fuel economy and tangible environmental benefits
- Energy companies will strive to meet both customer demands and policy mandates

What will be the favored fuel and vehicle technologies of the future?

Which Scenarios Did We Consider?



Key Takeaways from Scenario Modeling

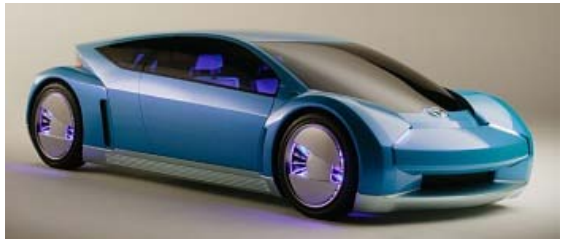
- As oil prices and CO_2 values increase to very high levels:
  - Advanced gasoline, diesels, hybrids, and (in higher cost scenarios) natural gas and biofuels show increasingly favorable customer economics
  - Plug-in hybrids, battery-electric vehicles, and fuel cell vehicles typically remain in a higher customer cost range
  - Each option has its own challenges

Key Technical R&D Challenges - Fuels

Fuel	Key Technical Issues and Challenges
Gasoline and Diesel	Challenged crude oil supplies (extra-heavy, sour, deep-water, Arctic), cleaner higher performing fuels, WTW GHGs
Biofuels	WTW GHGs, water and land use, impact on food, feedstock selection, biomass growth strategy, conversion processes, and fuel system compatibility (distribution, also on-board hardware issues with E10+, B5+)
CNG, LPG, LNG,	Supply, WTW GHGs, costs, distribution logistics
CTL	WTW GHGs, process efficiency, CCS, water use, land reclamation
GTL	Plant efficiency and costs, WTW GHGs, competition from LNG
Hydrogen	WTT GHGs, forecourt storage volume, costs, infrastructure requirements and distribution logistics, codes and standards
Electricity	GHGs, costs, charging infrastructure, energy storage

Key Technical R&D Challenges - Vehicles

Engine Technology	Key Technical Issues and Challenges
ICEs	Improved fuel economy at affordable cost and at scale; new combustion regimes (e.g., HCCI)
NGVs	On-board storage weight and volume, vehicle cost and range
PHEVs, EVs	Batteries: materials, power , energy density, reliability, lifetime, charge time, cost, and production scale-up.
FCVs	Fuel cell cost and longevity; on-board H_2 storage weight and volume (materials, H_2 packaging, water management, reliability, lifetime, cost, safety)



How Could Additional R&D Funds Impact Technological Barriers to Lower GHGs?

- Fuels (WTT)
  - Identifying and growing sustainable renewable feedstocks; selecting viable biomass conversion pathways
  - Generating low carbon hydrogen and steam
  - Further integrating efficiency upgrades into refineries and oil fields
  - Demonstrating and deploying Carbon Capture and Sequestration
- Vehicles (TTW)
  - Better understanding real-world performance and fuel economy (e.g., PHEVs in a wide range of applications)
  - Better illuminate pathways to help deploy leading edge technologies (e.g., batteries, HCCI)
  - Focus R&D to help bridge gaps (e.g., exhaust waste heat recovery)
  - Continued support for near-commercial technologies (e.g., advanced ICEs) with priority on those with clear potential for wide customer use

Keys to Successful Government Support for New Technologies

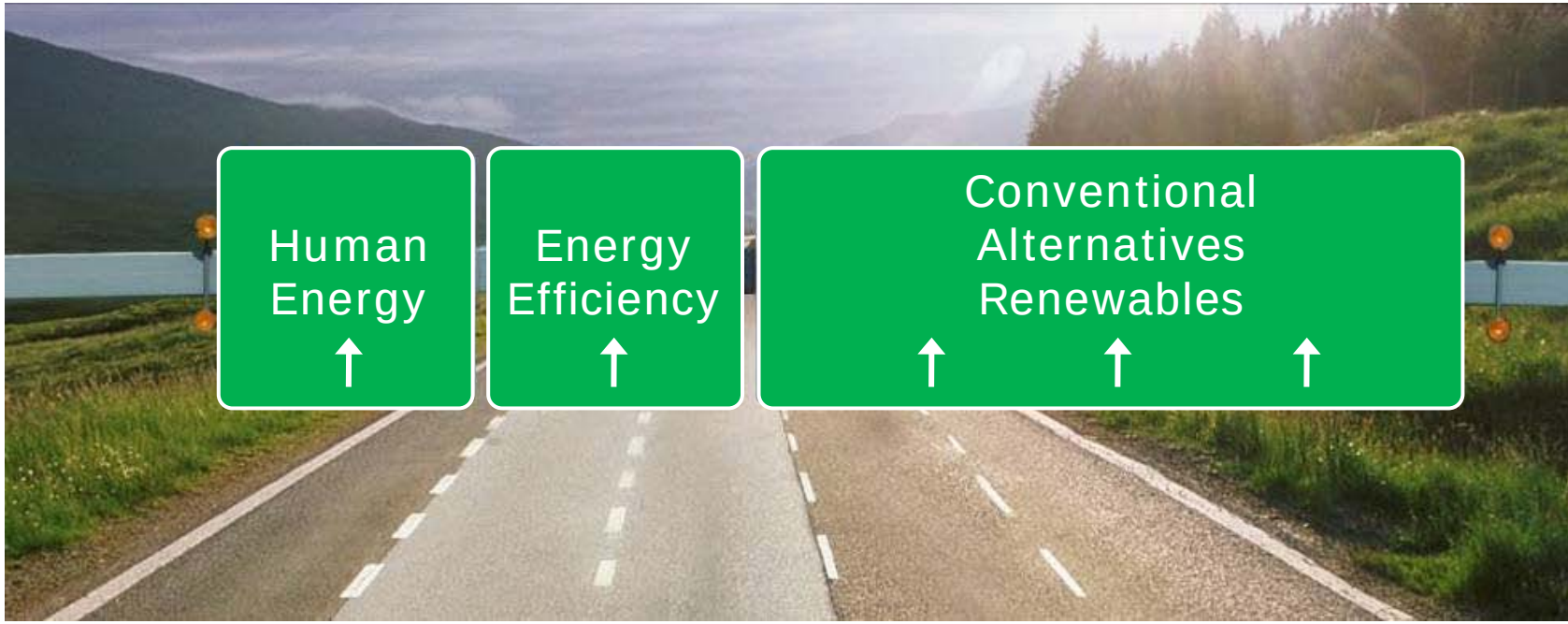
- Government support (e.g., policy, incentives, tax credits and direct funding of R&D) is needed, but
  - Collaboration between government, industry, NGO's, and the research community is critical to success
  - Support should be technology neutral, especially early on when technology and economic outcomes are uncertain
  - Need an unbiased, broad, and thorough analysis of options. A national lab could fulfill this role.
  - Need to align policy and R&D (e.g., government should fully understand the sustainability and lifecycle GHG implications of biomass demand when funding biofuel and bio-power programs)
  - Terms, conditions, and potential implications of support must be clearly understood and aligned with industry's strategic, technical and business objectives

Find and Encourage the Best Energy Options…

Enable the Winners … Don't Pick Them…

- Hydrocarbon fuels likely to supply most of primary energy for transportation and powergen past 2030, but use of renewables and low carbon sources will continue to grow
- There is no silver bullet
  - Issues of dependency, supply reliability, environmental footprint, cost, and sustainability apply to all fuels & vehicles
- Need all economic fuels and conservation to meet demand
  - Do not prematurely select "the winner" or establish policies to advantage one technology over another
  - Consumers respond to price signals and are using conservation options
- Allow time for technology to advance
  - New technologies must offer tangible benefits to consumers and real-world WTW benefits to the environment
- Need clear direction (cap and trade, regulations, taxes) on GHG issues

Questions Welcomed!



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