Integrating Biofuels into the Energy Industry

California Biomass Collaborative
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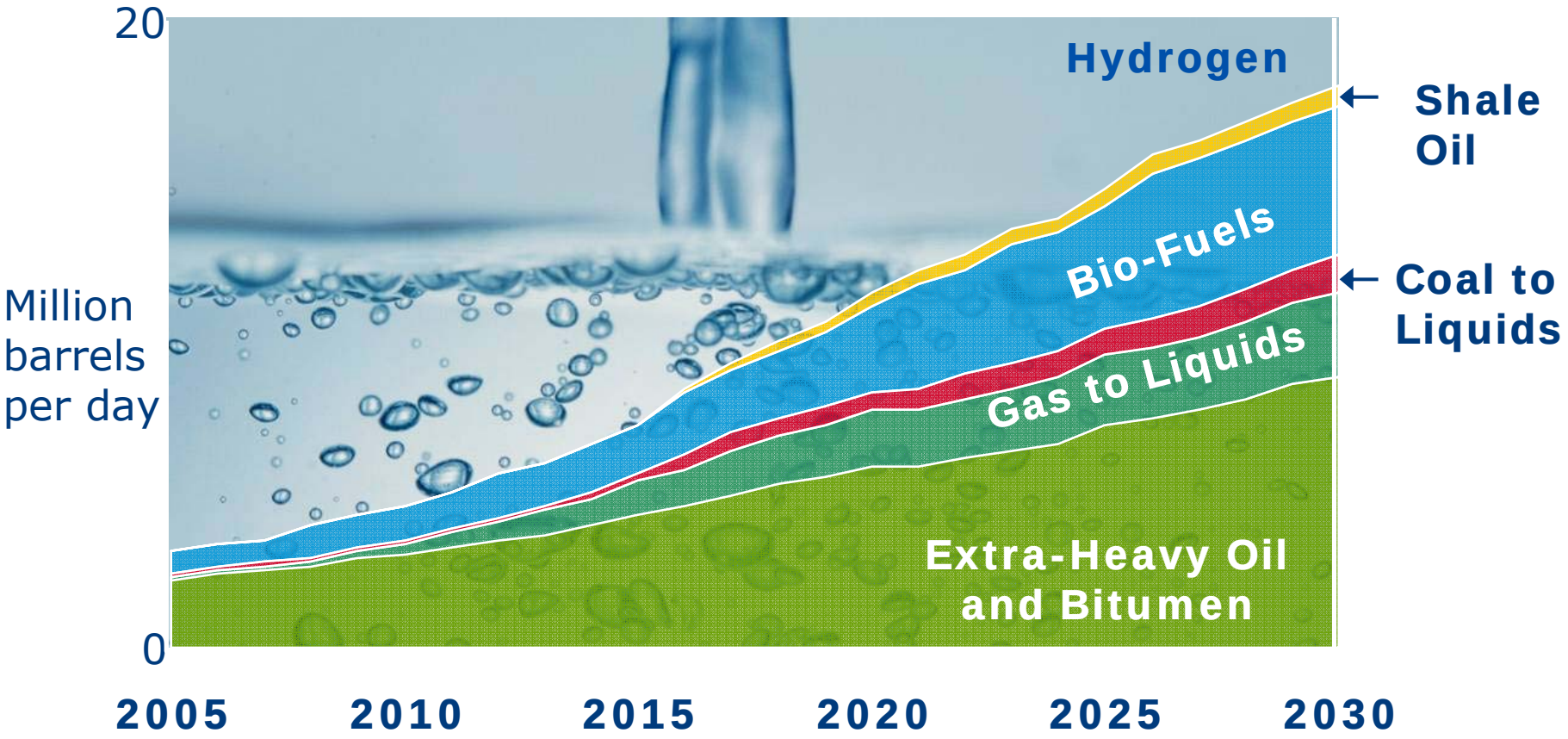
Global Energy Perspectives

- Grow energy demand globally, especially in China, India and Latin America
- Increase competition and investments for resources
- Develop cleaner fuels and technologies
- Improve energy efficiency
- Diversifying supply & integrating sustainable resources
- Increasing expectations surrounding climate change

Diversification of Feedstock and Fuel:

How big will it really be?
What will it be and by when?



Source Data: Chevron & Consultant Consensus

Customer Acceptance

- Energy companies will provide whatever fuels customers demand

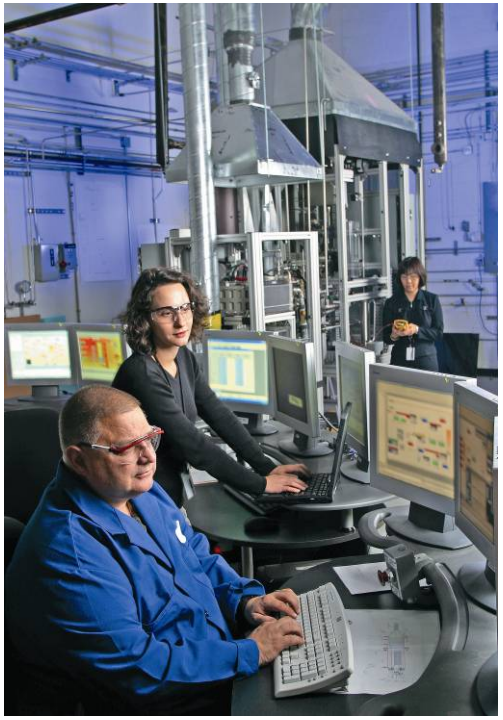
- ***For a customer to demand an alternative fuel, they want to see three criteria fulfilled:***

1. Equal or improved driving performance, safety, reliability and comfort
2. Equal or lower vehicle and fuel costs
3. Improved fuel economy and environmental benefits

Biofuels Success Factors

✓ **Industrial-scale infrastructure**

✓ **2nd generation production technology**



✓ **Large, concentrated supplies of feedstock**

***..plus*, sustainable business models**

Biomass-to-Fuel

- Bio-fuels
- Bio-products
- Bio-processing

- Feedstock supply development
- Molecular transformation
- Scalable, distributed manufacturing
- Fuel market and infrastructure evolution

The Fuel Supply System

- Capital intensive
- Technology intensive
- Highly-integrated systems

- Very long-lived assets
- Infrastructure characteristics
- Intersects global economics and politics

Fundamentals of Transport Fuels

Scale	Time	Capital
Global volumes: • World's largest supply chain • 40,000 gal/sec • 0.5 gal for every human, every day • 250 billion gal of fuel in transit in the U.S. alone	Infrastructure: • **Takes decades to develop at scale** • **Lasts decades to centuries** • **High levels of integration needed for efficiency and low cost**	All upfront investments: • $20,000+/daily BBL for fuel manufacturing • IEA estimates that $*trillions* needed over next 30 years

Deployment of New Fuel Technology at Scale

~ 10 years

Bench Top	Pilot Plant	Experimental Plant	World-scale Commercial Plant
$ Millions	$ 10's Millions	$ 100's Millions	$ Billions
			
<.01 B/D	~ 1 B/D	~1,000 B/D	~100,000 B/D

Illustrative example

Biofuels Quality Challenges

- Inconsistency in feedstock can lead to issues of quality
- For biodiesel, incomplete reactions in FAME process
  - Results from improper amount of catalyst or alcohol
  - Insufficient reaction time
  - Can lead to increased amounts of mono-, di-, and tri-glycerides
    - Will cause injector fouling, filter plugging and sediment formation
    - Poor shelf life which is not easy to measure or predict

Biodiesel Production - Challenges

- There are many possible production challenges
  - Soap formation
  - Emulsification
  - Insufficient catalyst removal
  - Poor separation of glycerin from methyl ester
  - High acid values
  - Insufficient alcohol removal
- All of the above can increase incidence of fuel filter clogging and gel formation
- *Consistent quality is important and necessary for customer acceptance*

Chevron's Objectives

- Build a focused biofuels organization that coordinates enterprise efforts while actively shaping and managing the emerging biofuels market segment
- Improve the performance of first-generation product quality assurance
- Develop next-generation processing technology to open up the choice of feedstocks, including cellulosic materials
- Improve small-scale distributed manufacturing

Biofuels – E85 project

- Demonstration program to learn more about E85 and how it works in practical applications
- Collaborative project with the state of California, General Motors and Pacific Ethanol Inc.
- Evaluate E85 performance, efficiency and environmental issues over a one-year period, using California-formulated fuel
- Two locations – Oakland and Marysville, CA
- Provide dispensing and storage capabilities

Biodiesel – U.S.

- Chevron invested in Galveston Bay Biodiesel
  - Texas-based biodiesel production facility
  - Potential production of 110 million gallons
  - One of 1st large-scale biodiesel facilities in North America

Current Research Alliances

Georgia Tech - Advanced distributed manufacturing technologies

- Chemical characterization of feedstocks; impact of pretreatment technologies on chemical structure and reactivity of biomass resources
- Analysis of chemical constituents impacting fermentation of enzyme hydrolyzed biomass to bioethanol
- Integration of chemical analysis into a systems model for biomass to bioethanol production.

UC Davis – Agricultural sciences, biotech, transportation policy

- California-based; biomass identification and development of technologies to grow, harvest and process into transportation fuels
- Potentially includes a demonstration facility

NREL – Only U.S. National Lab devoted to renewable energy

- Identification, evaluation and development of second-generation biofuels production from biologic pathways (e.g., algae)
- Identification, analysis and characterization of biomass and feedstock

Colorado Center for Biorefining and Biofuels

- The research focus of the center is on the identification and characterization of biomass energy crops and the development of advanced biofuel production technologies.
- Participating research institutions in C2B2 include the University of Colorado at Boulder, Colorado School of Mines, Colorado State University and NREL.

Several other strategic relationships being developed

- Feedstock, conversion technology and logistics

Finding and Encouraging the Best Options…Enabling the Winners

- There is no single solution
  - Issues of dependency, reliability of supply, environmental footprint and cost apply to all fuels to some degree
- All economic fuels, plus conservation, will be needed to meet future demand
  - Consumers have the means to conserve and are beginning to respond
  - Market-based competition among technologies and fuels should not be inhibited
- Allow time for technology to advance
  - New technologies must offer tangible benefits to consumers and real-world well-to-wheels benefits to the environment
  - Discussions like this are a good way to make progress