Quadrennial Technology Review-2015

Chapter 4: Cleaner and Safer Fuels Production

Public Webinar

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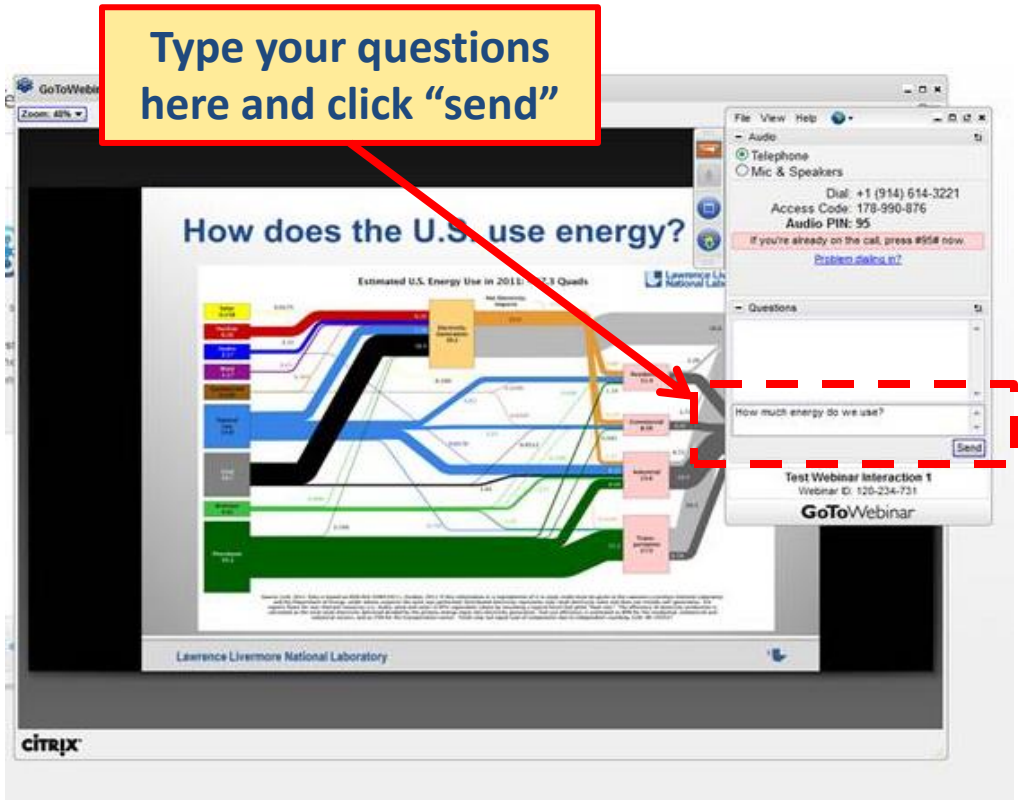
2015-02-18

Webinar Logistics

- Due to the large number of expected participants, the audio and video portions of this webinar will be a “one way” broadcast. Only the organizers and QTR authors will be allowed to speak.

- Submit clarifying questions using the GoToWebinar control panel. Moderators will respond to as many questions as time allows. Substantial input regarding chapter content should be submitted by email to: DOE-QTR2015@hq.doe.gov



QTR 2015 Chapter Outline

Introduction

1. Energy Challenges
2. What has changed since QTR 2011
3. Energy Systems and Strategies

Assessments

4. **Advancing Systems and Technologies to Produce Cleaner Fuels**
5. Enabling Modernization of Electric Power Systems
6. Advancing Clean Electric Power Technologies
7. Increasing Efficiency of Buildings Systems and Technologies
8. Increasing Efficiency and Effectiveness of Industry and Manufacturing
9. Advancing Clean Transportation and Vehicle Systems and Technologies
10. Enabling Capabilities for Science and Energy

Integrated Analysis

11. U.S. Competitiveness
12. Integrated Analysis
13. Accelerating Science and Energy RDD&D
14. Action Agenda and Conclusions; Web-Appendices

Web Appendices

Chapter Overview

- For the purposes of this QTR, a “fuel” is defined as a carrier of chemical energy that can practicably be released via reaction to produce work, heat or other energy services.
  - Fuels include oil, coal, natural gas, and biomass.
  - Nuclear fuels and other energy resources, such as geothermal, hydropower, solar, and wind energy, are treated separately in chapter 6
- Each fuel type has advantages and disadvantages with respect to our nation’s economy, security, and environmental sustainability (ESSE).
- The final use of these fuels is examined in subsequent chapters.
- Particular emphasis given on fuels for transportation (e.g., trucks, automobiles, ships).
  - Because the fuels are carried on board, the challenges for weight, energy density, and storage remain particularly difficult for new fuels to meet. Transportation fuels—oil—also represents significant challenges with regards to domestic energy security, balance of trade, and environmental controls.
- This chapter considers in depth three primary fuel pathways, their ESSE concerns and needs, and their associated technology and industrial ecosystems: fossil liquids and natural gas, biomass, and hydrogen.

Systems Approach

- In the oil and gas sector, the primary research needs are related to the resource's extraction.
- Biofuels research involves RD3 opportunities across the entire value chain, from resources through conversion to a variety of refined products.
- Hydrogen can be produced via a variety of industrially proven technologies; and its primary challenges are related to storage, transmission and distribution infrastructure, as well as economic scale-up of lower carbon production technologies that generate hydrogen from renewable resources.

Chapter Outline

1.0 Introduction

2.0 Oil and Gas

- Recent Technology Advancements
- Emerging Research Priorities

3.0 Bioenergy

- Bioenergy Overview
- Current Status and Accomplishments
- Feedstocks and Logistics
- Conversion Pathways
- Fuels and Fueling Infrastructure Technology

4.0 Hydrogen Production and Delivery

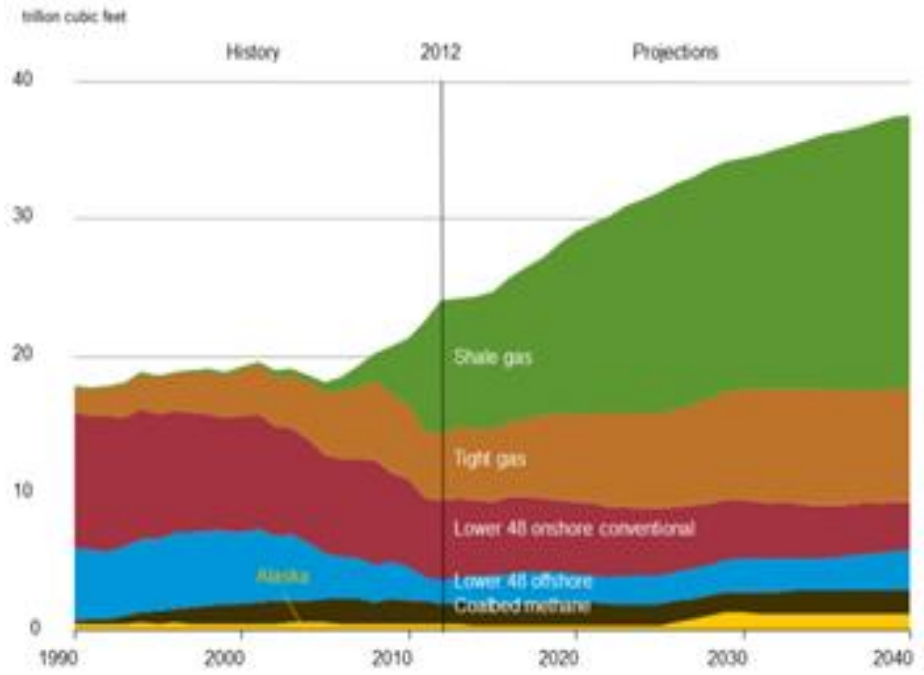
- Hydrogen Production and Delivery
- Current Status and Accomplishments
- R&D Needs and Priorities

5.0 Other alternative Transportation Fuels

Summary

2.0 Oil and Gas

- Recent Technology Advancements
  - Well Construction, Drilling, and Completion (onshore)
  - Well Construction, Drilling, and Completion (Offshore)
  - Enhanced Oil Recovery (including CO2-EOR)
  - Natural Gas Hydrates



Shale gas provides the largest source of growth in U.S. natural gas supply

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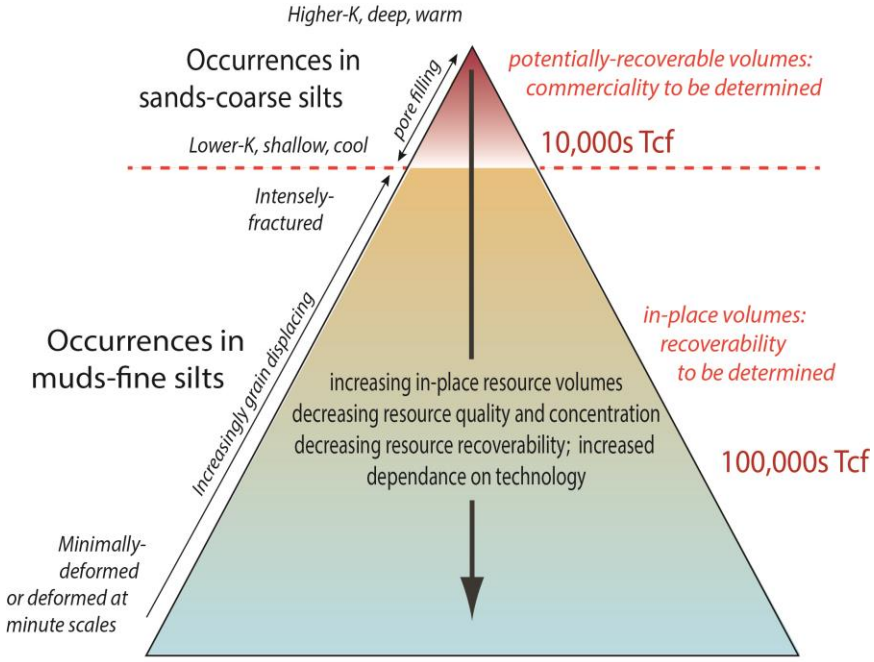
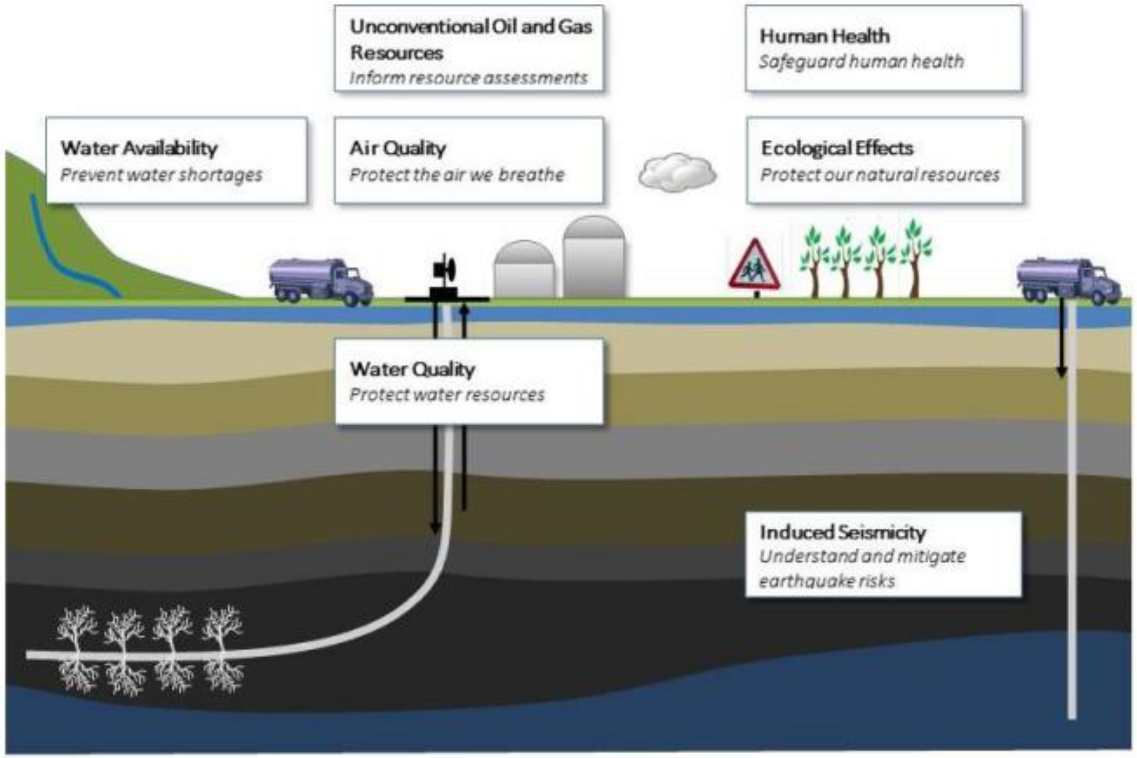


Gas Hydrate Resource Pyramid

2.0 Oil and Gas

- Emerging Research Priorities
  - Environmentally Sound Drilling and Completions
  - Other Environmental Challenges for Onshore Unconventionals
  - Offshore emerging needs
  - Gas hydrates: assessment, and safe and effective production



Key Findings – Oil and Gas

Research Priorities	Near Term (2-5 years)	Medium Term (5-10 years)	Long-term (>10 years)
Environmentally Sound Drilling and Completions	■		
Unconventional Oil and Gas Environmental Challenges	■	■	
Offshore and Artic	■	■	
Gas Hydrates			■

Emerging issues around hydrocarbon production. "Near Term", "Medium Term" and "Long Term" refer to potential outcomes with substantial impacts within the time frame.

3.0 Bioenergy

- Bioenergy Overview
  - Total Bioenergy Potential
  - Impact of Success: Growing the Bioeconomy
- Current Status and Accomplishments

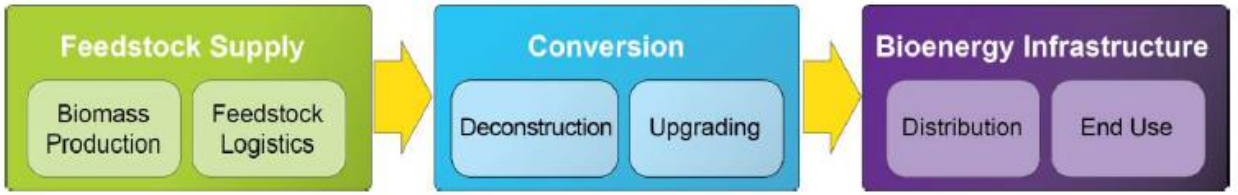
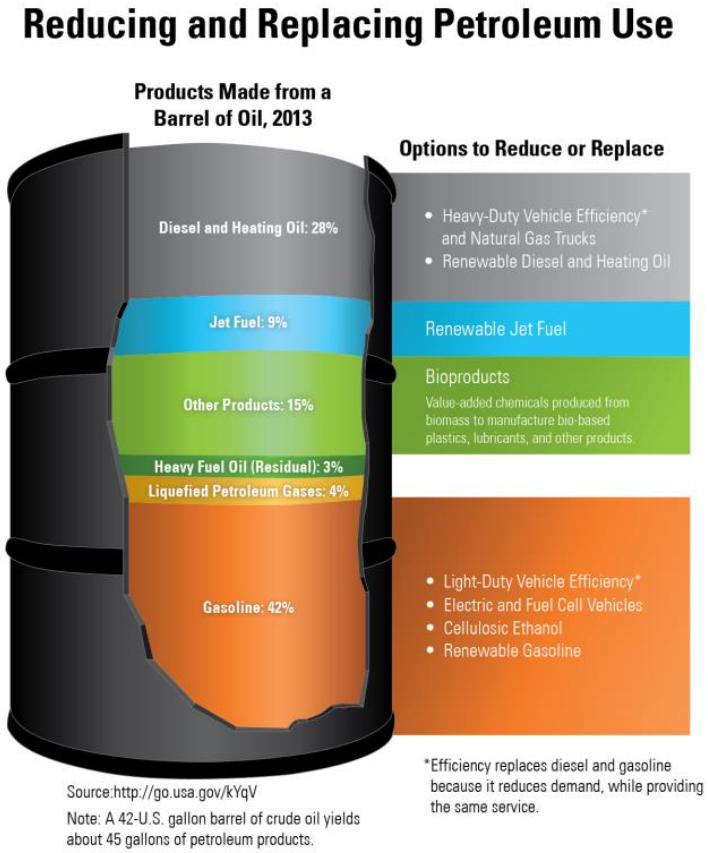


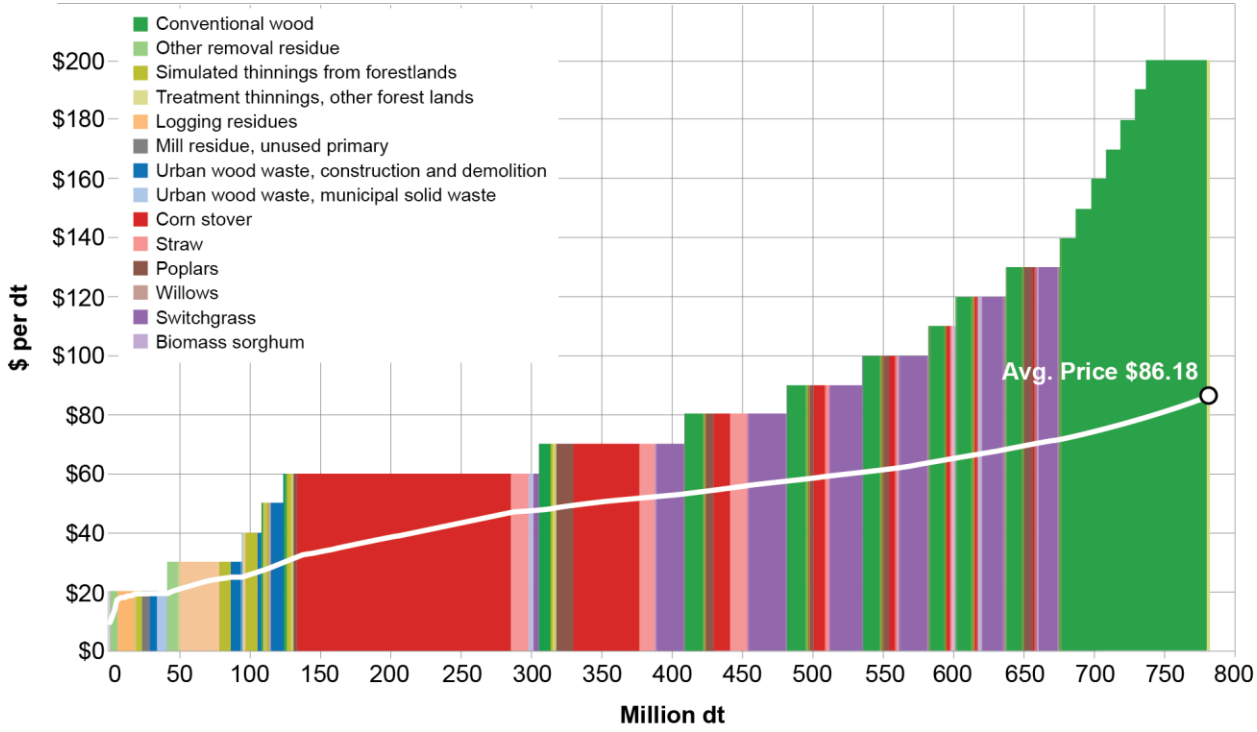
Figure A: Biomass-to-bioenergy supply chain

The overall pathway for production of fuels from biomass.



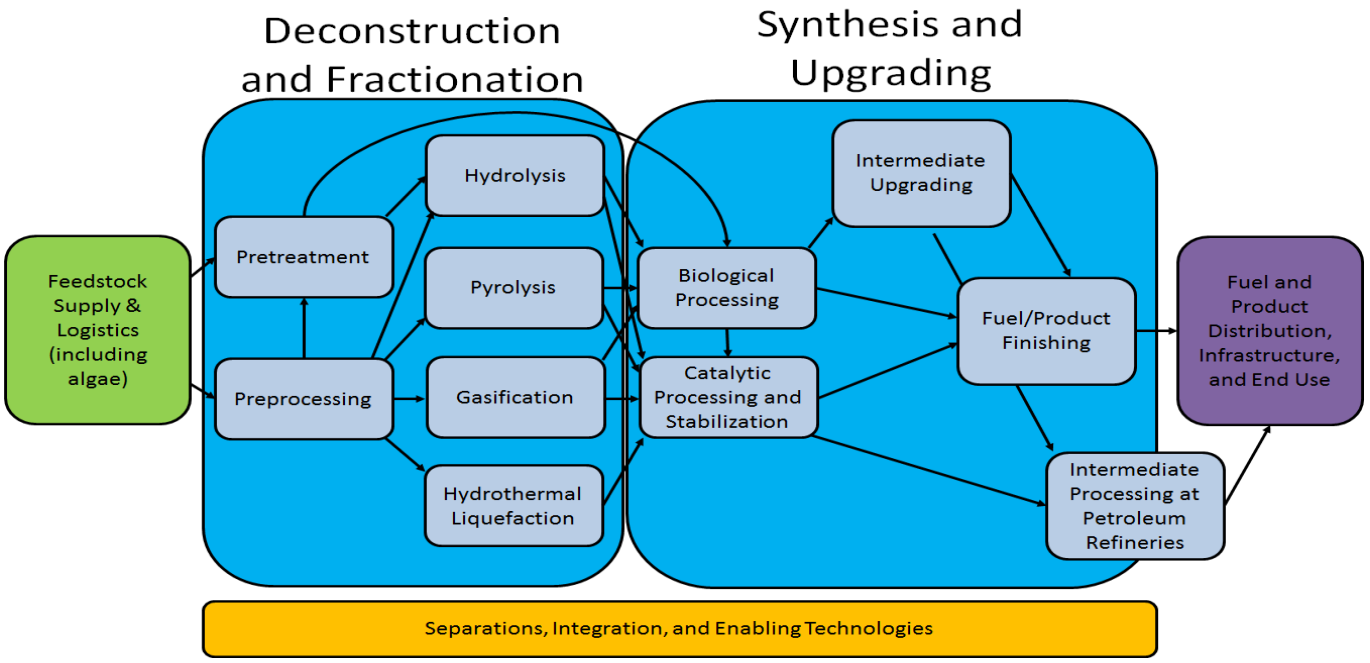
3.0 Bioenergy

- Feedstocks and Logistics
  - Lignocellulosic Feedstocks
  - Lignin
  - Algae
  - Waste to Fuels



3.0 Bioenergy

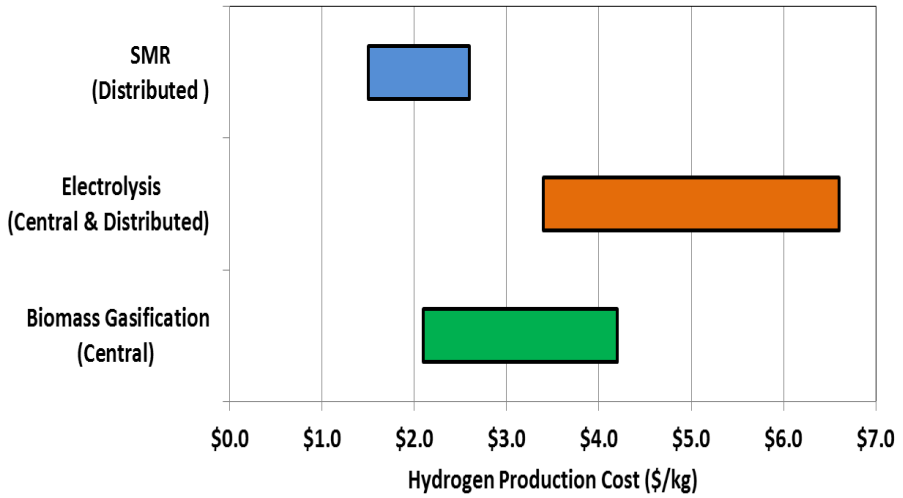
- Conversion Pathways
  - Conversion Process Steps
  - Deconstruction and Fractionation
  - Thermochemical Conversion: Fuels and PetroChemicals
  - Bioproducts
- Fuels and Fueling Infrastructure Technology



Conversion pathways from feedstock to products

4.0 Hydrogen Production and Delivery

- Hydrogen Production and Delivery
  - Thermal
  - Electrolytic
  - Photolytic
- Current Status and Accomplishments
- R&D Needs and Priorities



	Delivery Costs ($/kg H_2 delivered and dispensed)	
Dispensing pathways	**350 bar**	**700 bar**
Pipeline	4.44	4.84
Pipeline-tube trailer	3.16	3.21
Tube trailer	3.00	3.29
Pipeline – liquid tanker	N/A	3.73
Liquid tanker	N/A	3.23

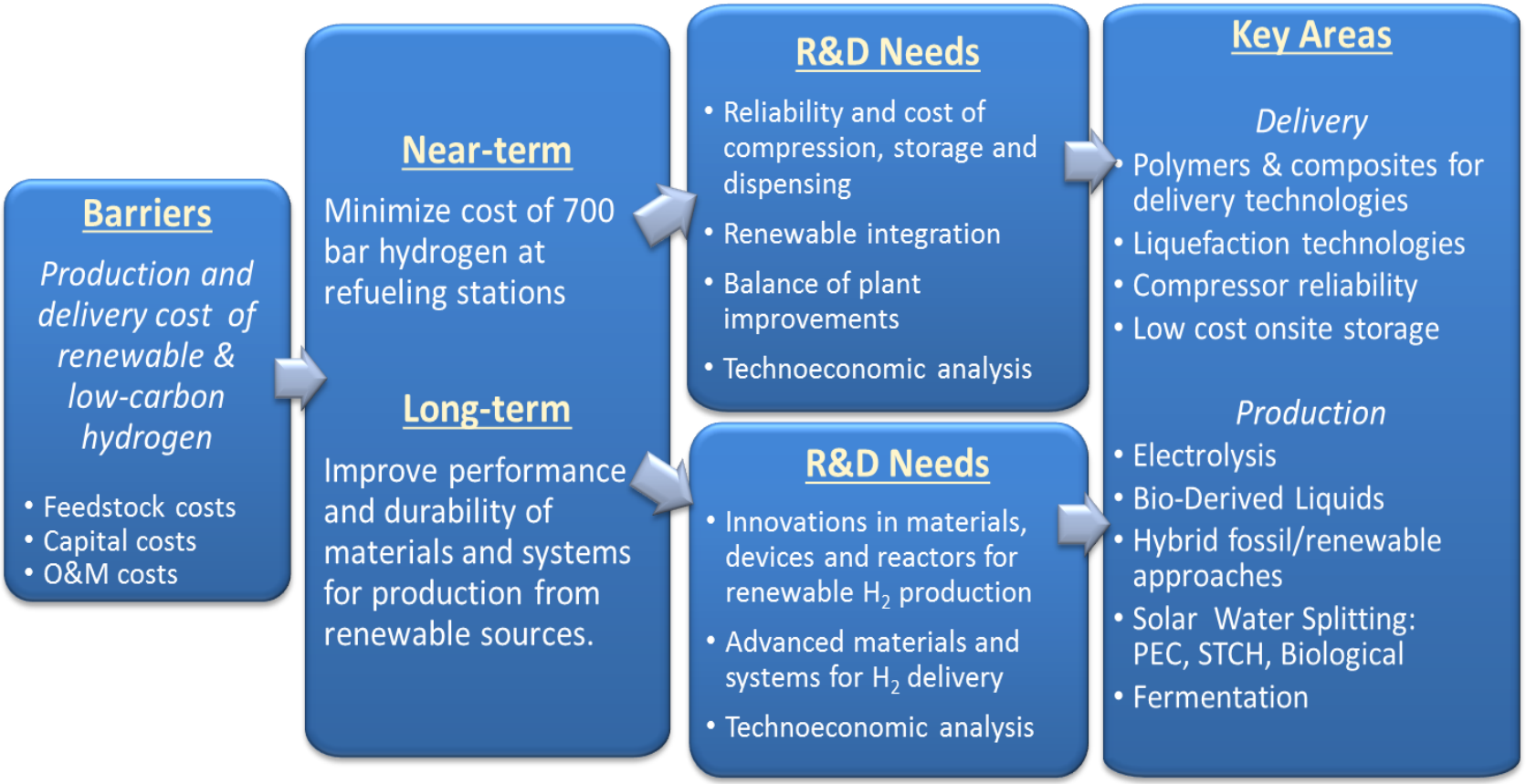
Key Findings – Bioenergy

- Bioenergy: The three major focus areas for R&D are aviation biofuels, refinery integration, and bio-products.

Research Priorities	Near Term (2 – 5 years)	Medium Term (5 – 10 years)	Long Term (>10 years)
Terrestrial feedstocks	■	■	
Algae			■
Biochemical conversion		■	■
Thermochemical conversion	■	■	
Bio-products	■		

Key Findings – Hydrogen

- Hydrogen: Cost reduction remains the key technological challenge in the production and delivery of hydrogen from low-carbon sources for use in fuel cell electric vehicles.



Public Input

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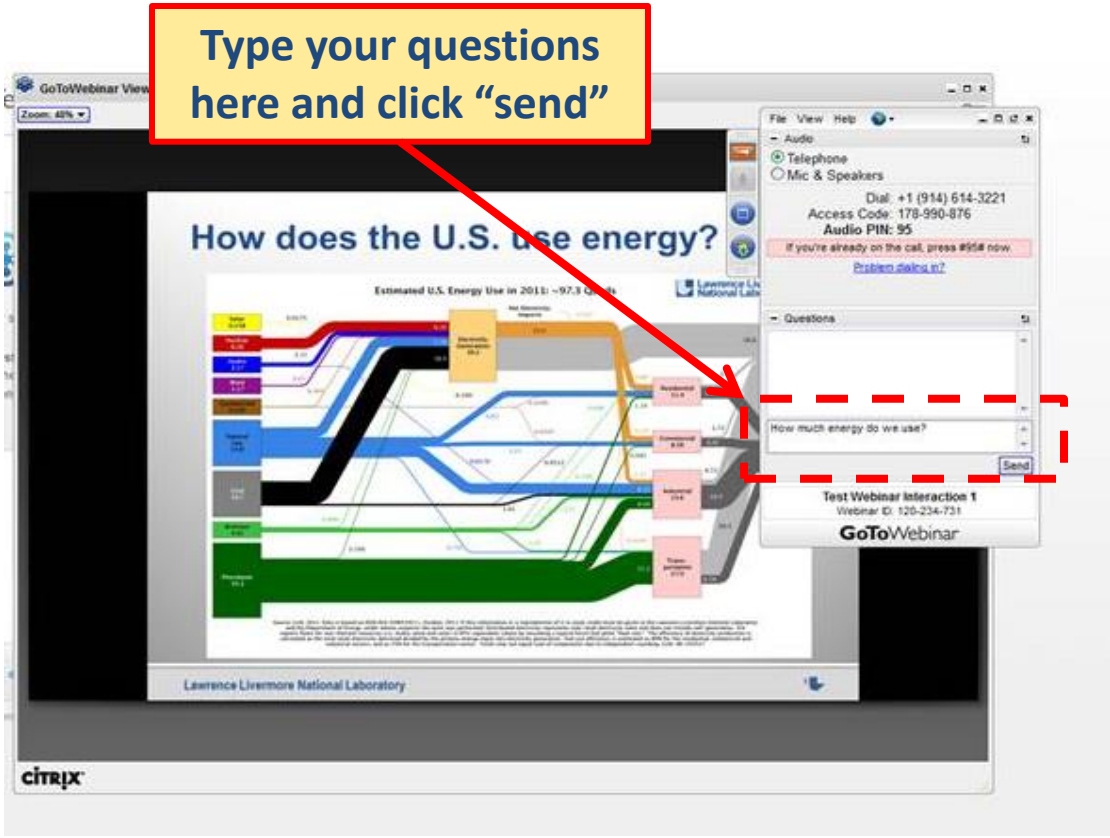

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Bioenergy and Hydrogen Highlights

Current Status of the bioenergy and hydrogen market	
Total Biofuel Production (2013)	13.3 billion gallons ethanol from 211 plants
Cellulosic biofuels expected (2014)	34 million gallons (of 1.75 billion in RFS)
Cellulosic projected modelled mature cost (2012)	$2.15 per gallon ($3.15 per gge)
US Investment in biofuels (BNEF) (2013)	$3 billion
E85 stations (current)	2,378 (of ~160,000 gas stations)
FFVs (2013)	17.4 million (862 thousand “in use”)
U.S. hydrogen production (2011)	9 million metric tons (1 quadrillion Btu)

System Highlights

- Current Status and Key Challenges
  - Addressed in QTR by showing importance of early deployment efforts as a component of an R&D strategy
  - Ethanol from starch is currently the major biofuel in the US, but is not expected to grow significantly from current production
  - DOE accomplished R&D goal for demonstrating cellulosic ethanol production from biochemical pathways
  - Actual cellulosic production is lagging behind RFS requirements (34 million gallons (of 1.75 billion in RFS)
  - Regulatory and financing uncertainty are key barriers

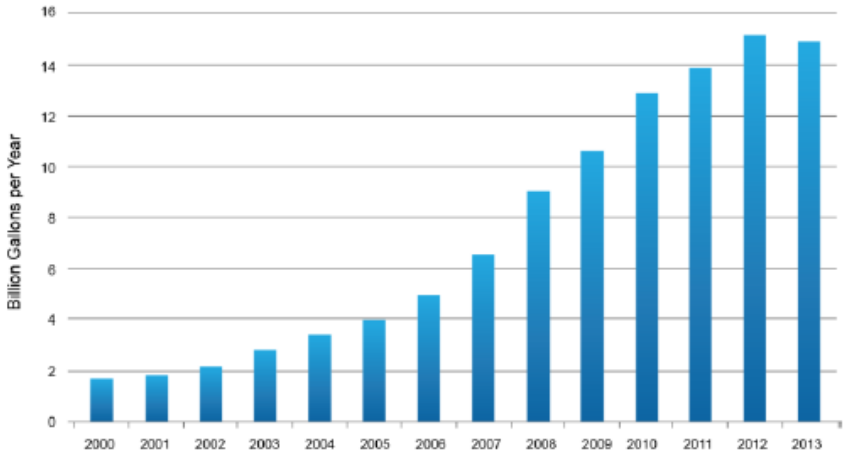


Figure 1-2: U.S. ethanol production capacity[9]

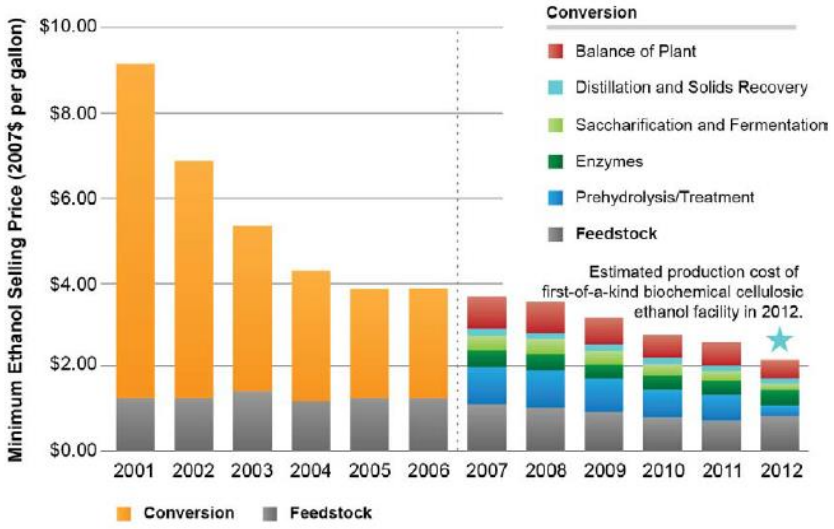
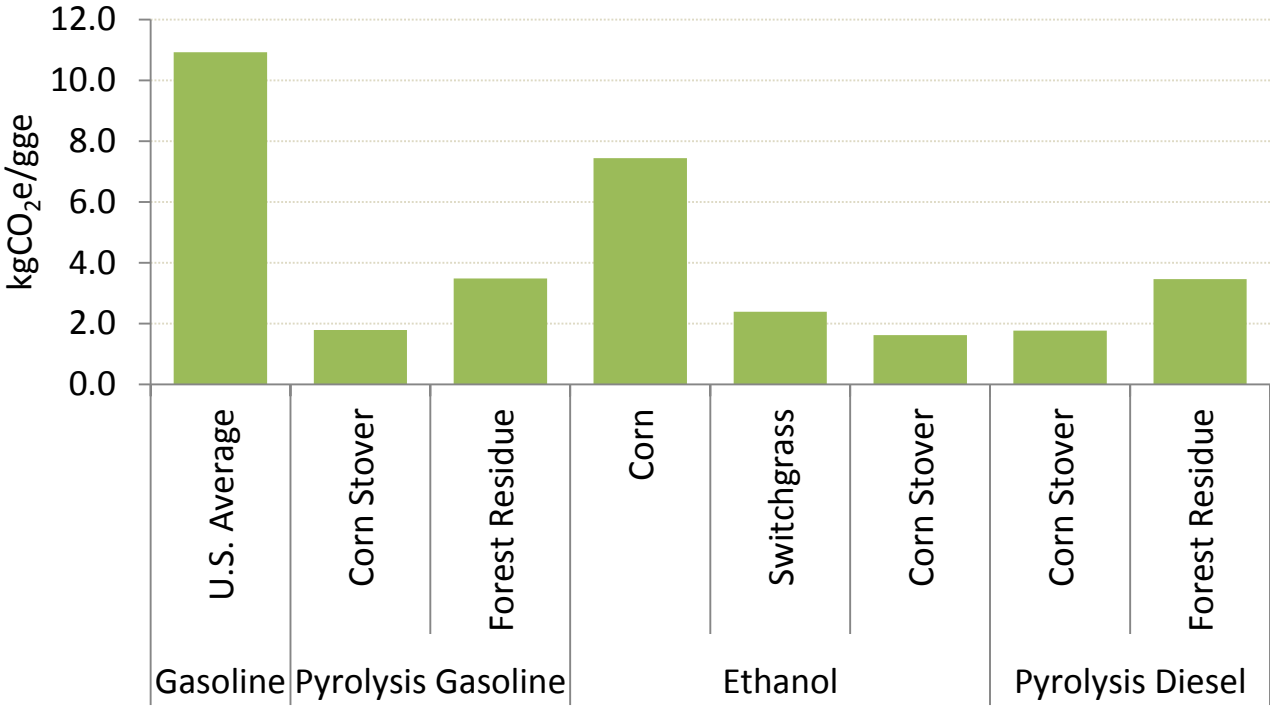


Figure D-1: Biochemical R&D impact on MESP from corn stover

System Highlights

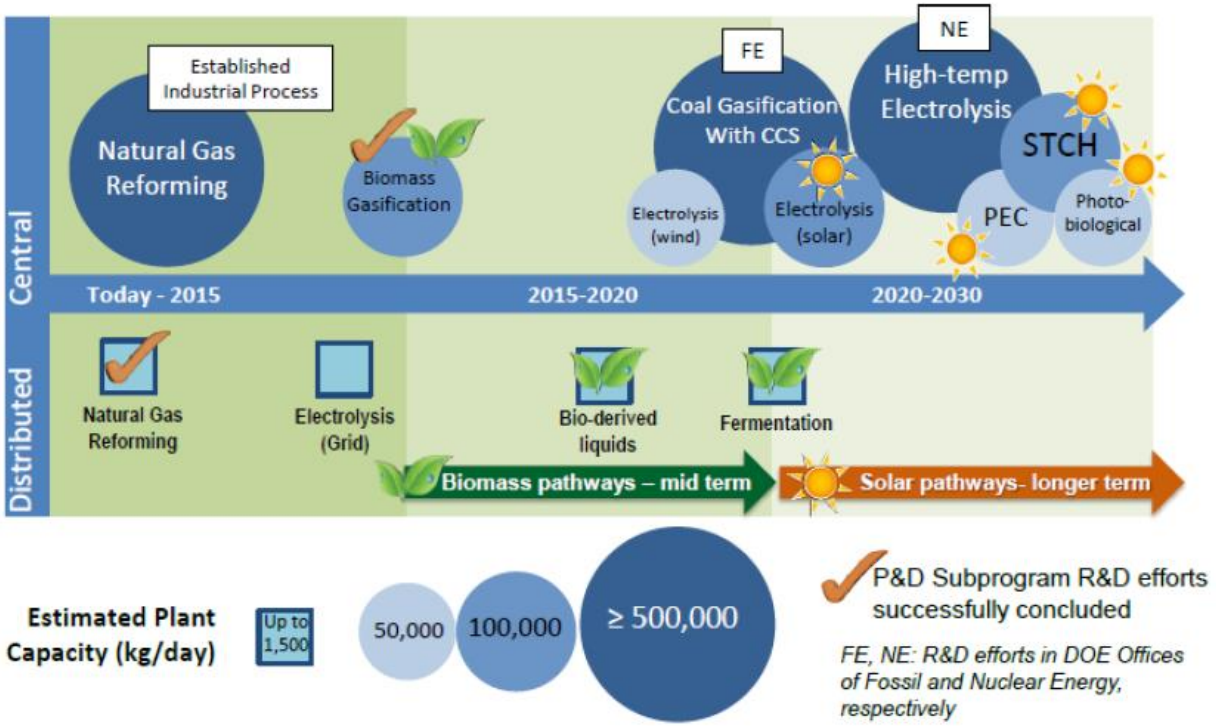
- **Impacts for fuels are estimated using lifecycle analysis**
  - **Reflects the full "well to tank" emissions and energy use and provides the most rigorous way to estimate energy and environmental benefits**
  - **Covers the whole bioenergy and hydrogen supply chain and can reflect the impact of technology improvements in sustainability**



Analysis from GREET1 2013 version

Technology Highlights

- **Technology: Hydrogen Production, Transport, and Storage**
  - **Hydrogen production is a significant industry, primarily service refinery and chemicals needs, and producing approximately 1 quad of H_2 annually**
  - **Most hydrogen production today is from natural gas**
  - **R&D includes production from coal gasification with CCS, biomass gasification, and electrolysis. Goals are for cost competitiveness of the fuel cell vehicle system on a cost-per-mile basis, integrated with vehicle improvement goals.**
  - **Distributed and central production options provide key flexibility**



Source: DOE, Fuel Cells Technology Office

Key Issues and Questions

- Key System Assessment/Analysis Issues and Questions
  - Climate Sensitivity of the Bioenergy System
    - R&D Options:
      - Drought resistance
  - Bioenergy and the economy
    - Feedstocks as a revenue stream for farms / forests
    - Investment required for industry creation
      - R&D's role in increasing the impact of investment
  - Interactions with the rest of the transportation system
    - Fueling technologies
    - Fuel / vehicle optimization (w/ chapter 9), including designer fuels
    - Fuel / vehicle system combined benefits (w/ chapter 9)

- Key Technology Assessment/Analysis Issues and Questions
  - Integrated Biorefineries
    - Why they are important
      - Nth plant, economies of scale
    - How they interact with R&D
  - Opportunities for CCS in Biofuel and Hydrogen Production
    - Pure-stream CO_2 and other process emissions, burying of char
  - Integrating fuel production with power generation (w/ chapter 5)
    - CSP / H_2
    - Trigen plants (power, hydrogen, and heat)