



What is the Future of Corn-based Ethanol and When Will Cellulosic Ethanol Become the Dominant Paradigm?



**IEA Bioenergy
ExCo67 Workshop**

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(with content adapted
from Jeff Passmore of
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Executive Summary

USA biofuels production levels continue to rise, dominated by conventional corn grain -based ethanol

- 13.2 billion gallons (50 B liters) of ethanol produced in calendar year 2010, up from 10.8 B gallons (41 B liters) in 2009.
- Rate of increase in conventional ethanol production is slowing as 15 B gal/yr cap is reached.
- Dozens of advanced cellulosic ethanol pilot and demonstration plants operating – many technology options moving forward – albeit combined production levels are well below RSF2 targets
- Accelerating cellulosic ethanol deployment requires an improved outlook for major investment; direction of future funding and policy (legislation and regulation) remain highly uncertain and is hindering financing of commercial projects

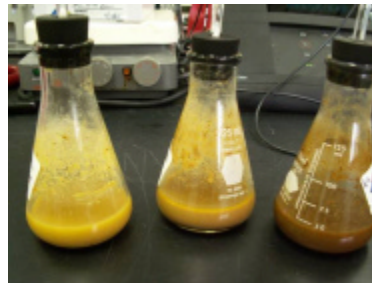
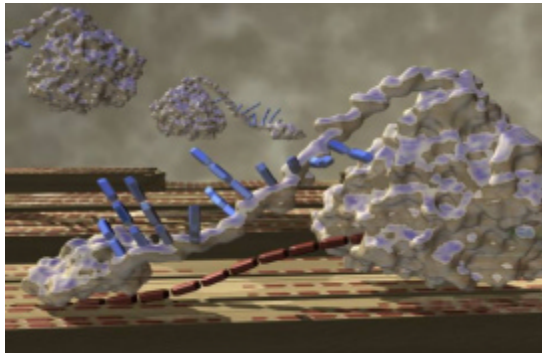
Outline

Current situation in the USA, conventional ethanol focus

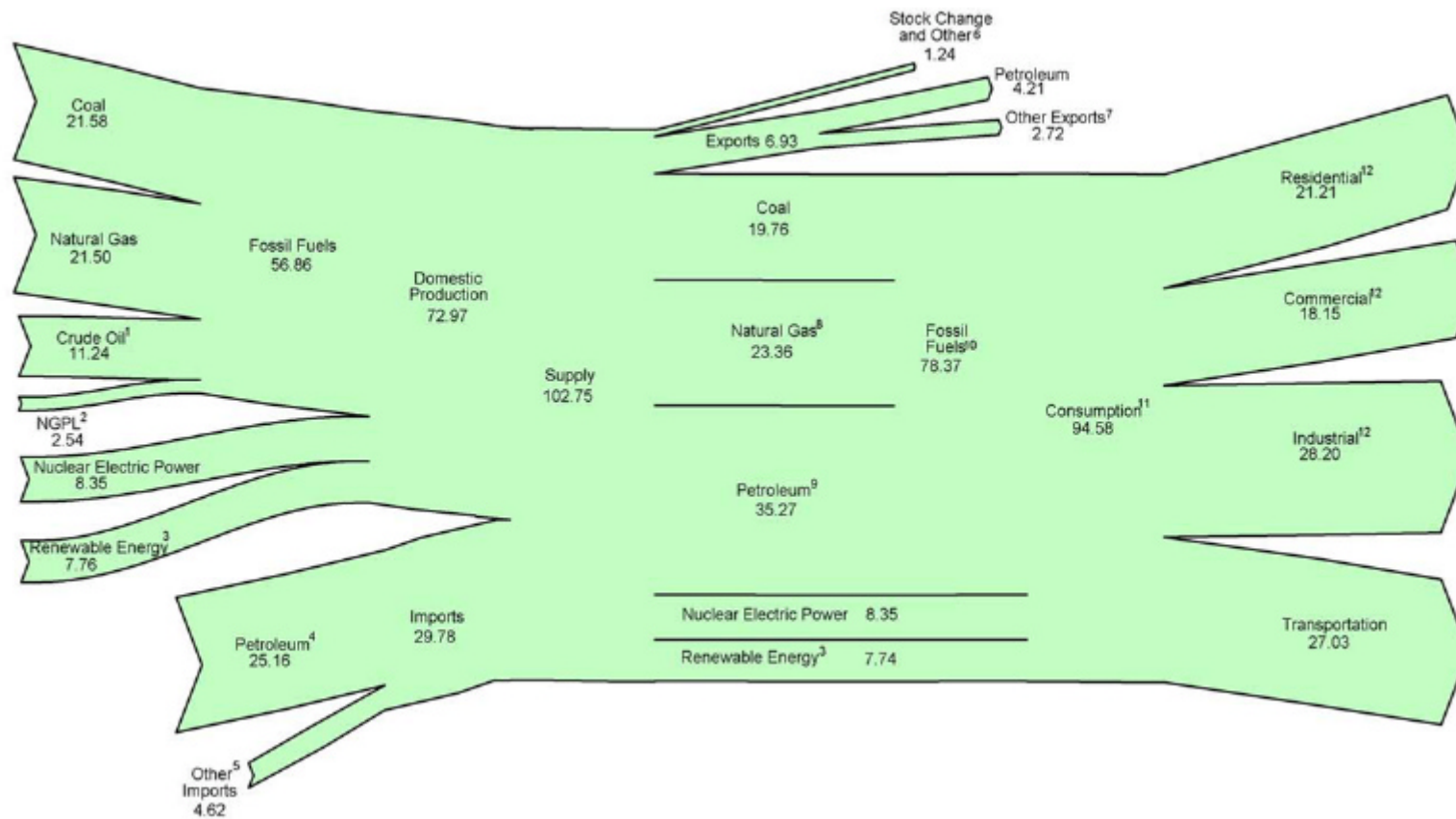
- Energy and petroleum flows
- Corn grain (starch based = conventional) ethanol production
- Energy Independence and Security Act (EISA) of 2007

Current situation in the USA, cellulosic ethanol focus

- Cellulosic ethanol production
- Commercialization status and outlook
- Challenges to achieving EISA 2007 targets



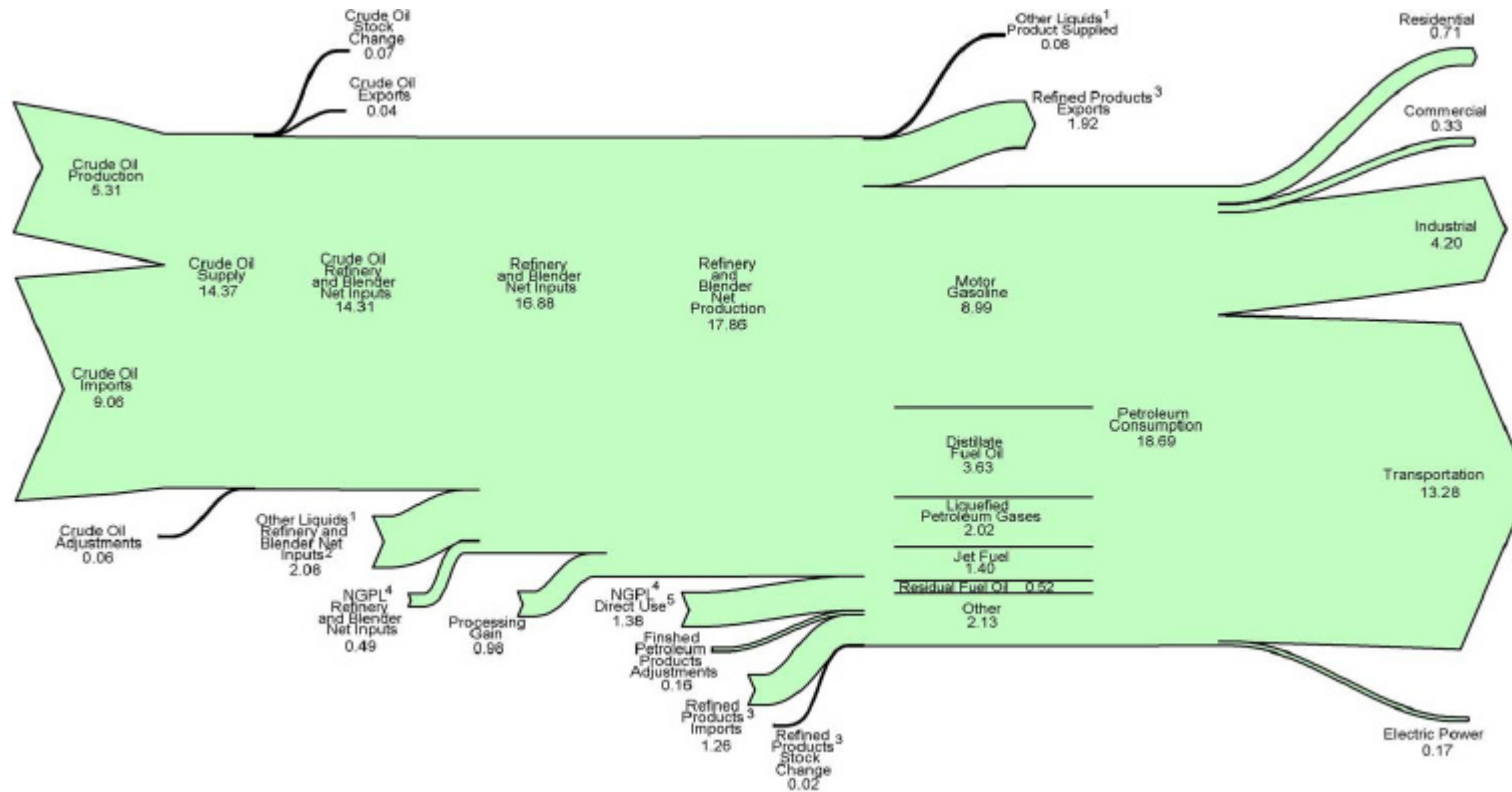
USA Energy Flow, 2009 (Quadrillion Btu)



Source: U. S. Energy Information Administration, Annual Energy Review 2009 (Figure 1.0)

USA Petroleum Flow, 2009

(Million Barrels per Day)



Source: U. S. Energy Information Administration, Annual Energy Review 2009 (Figure 5.0)

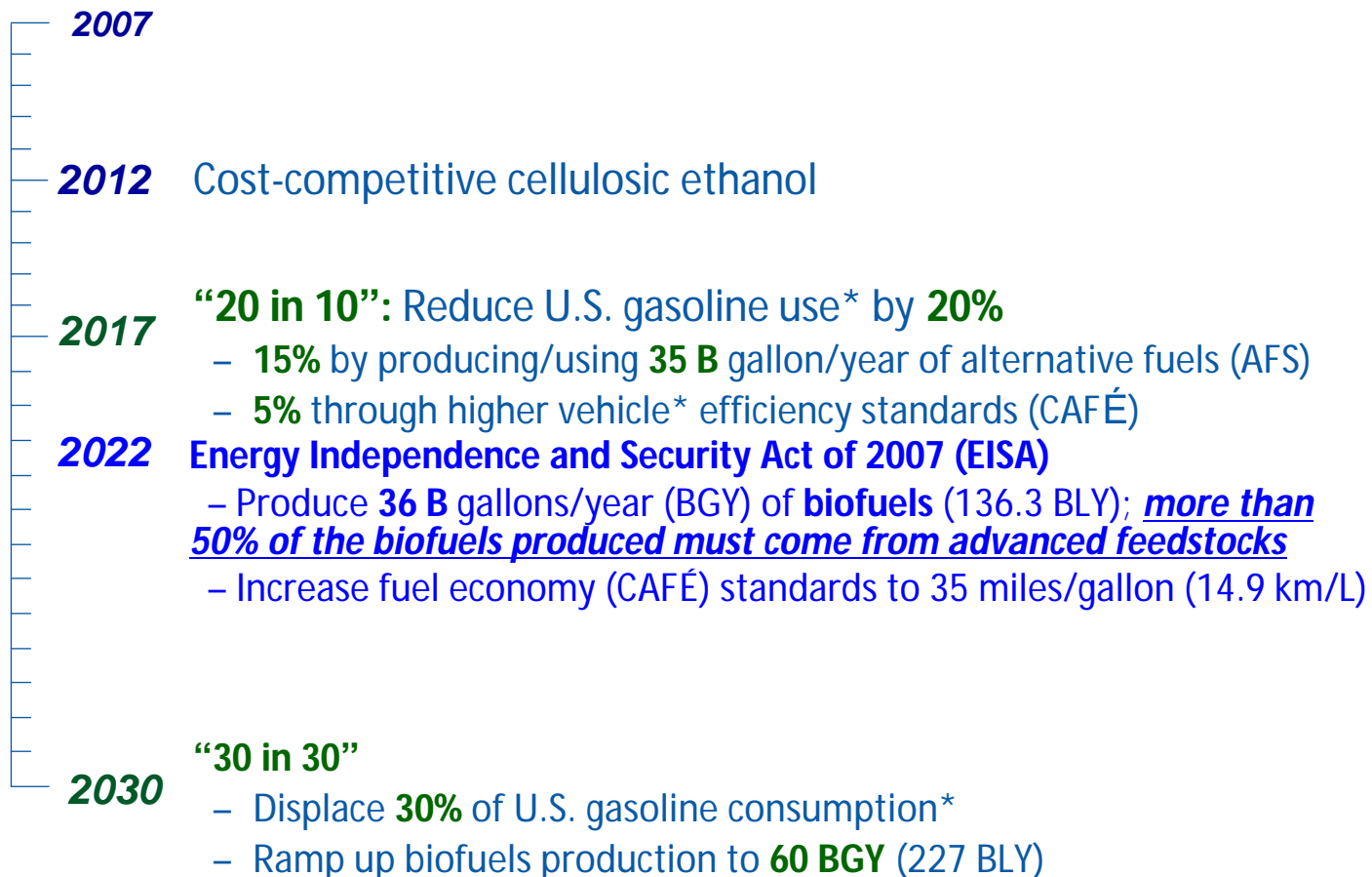
Current Status of Ethanol in USA

Levels of ethanol production continue to rise, dominated by conventional corn grain (starch)-based ethanol; cellulosic ethanol production occurring in many pilot and demonstration plants but amounts are quite small

- 13.2 billion gallons (50 B liters) of ethanol produced in 2010, up from 10.8 B gal (41 B L) in 2009.
- 211 active/idle production plants totaling 14.3 B gal (54 B L)/yr capacity
- Rate of increase expected to slow as 15 B gal/yr cap on conventional ethanol is reached, i.e., until cellulosic ethanol production ramps up.
- Continue to see only small amounts of ethanol imported / exported
 - 9.7 MM gal (35 MM L) imported in 2010, 193 MM gal (731 MM L) in 2009.
 - ~ 400 MM gal (1.5 B L) exported in 2010, ~ 4 times higher than in 2009; also 9 million tonnes of DDGs (livestock feed) were exported in 2010.

Source data: RFA (www.ethanolrfa.org) and EIA (www.eia.gov)

Ambitious Cellulosic Ethanol Goals

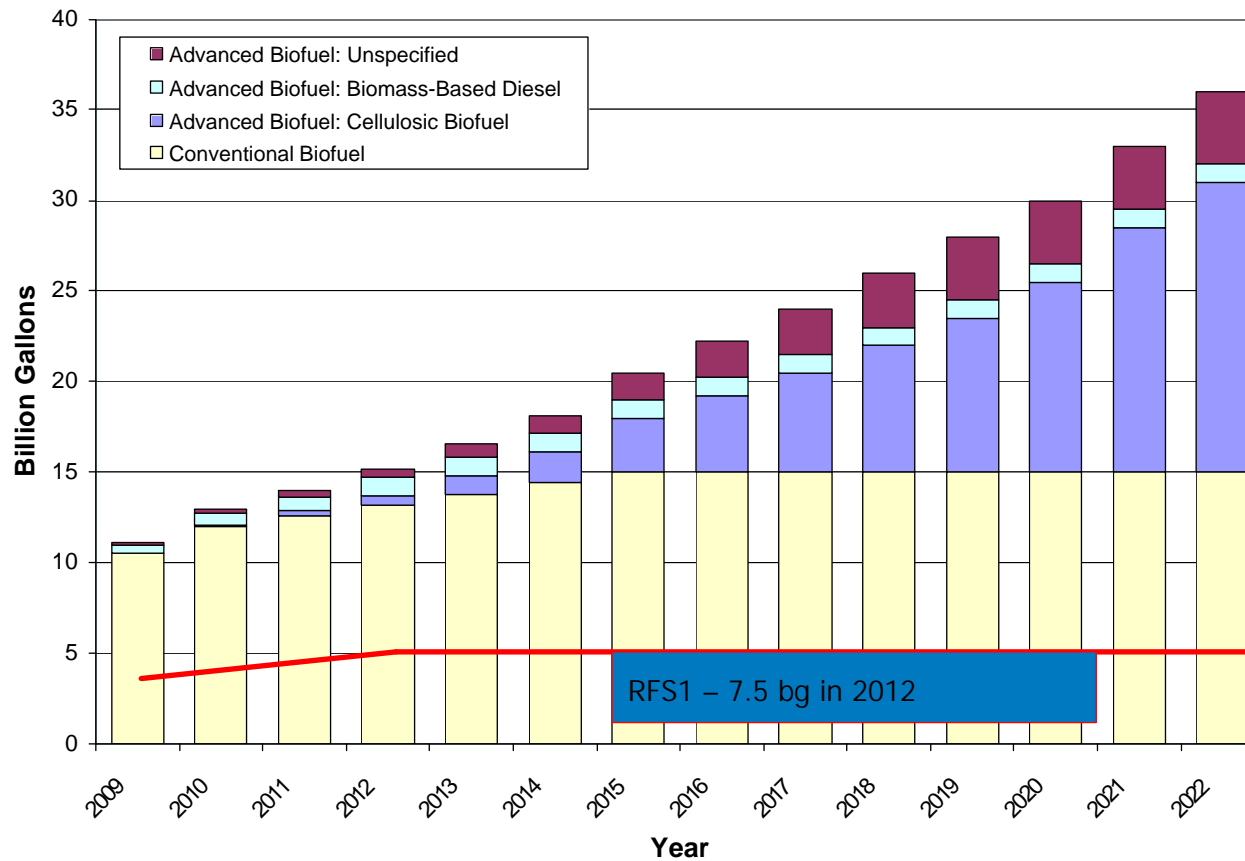


* light-duty vehicles only

1 Billion (B) = 1000 Million = 10⁹

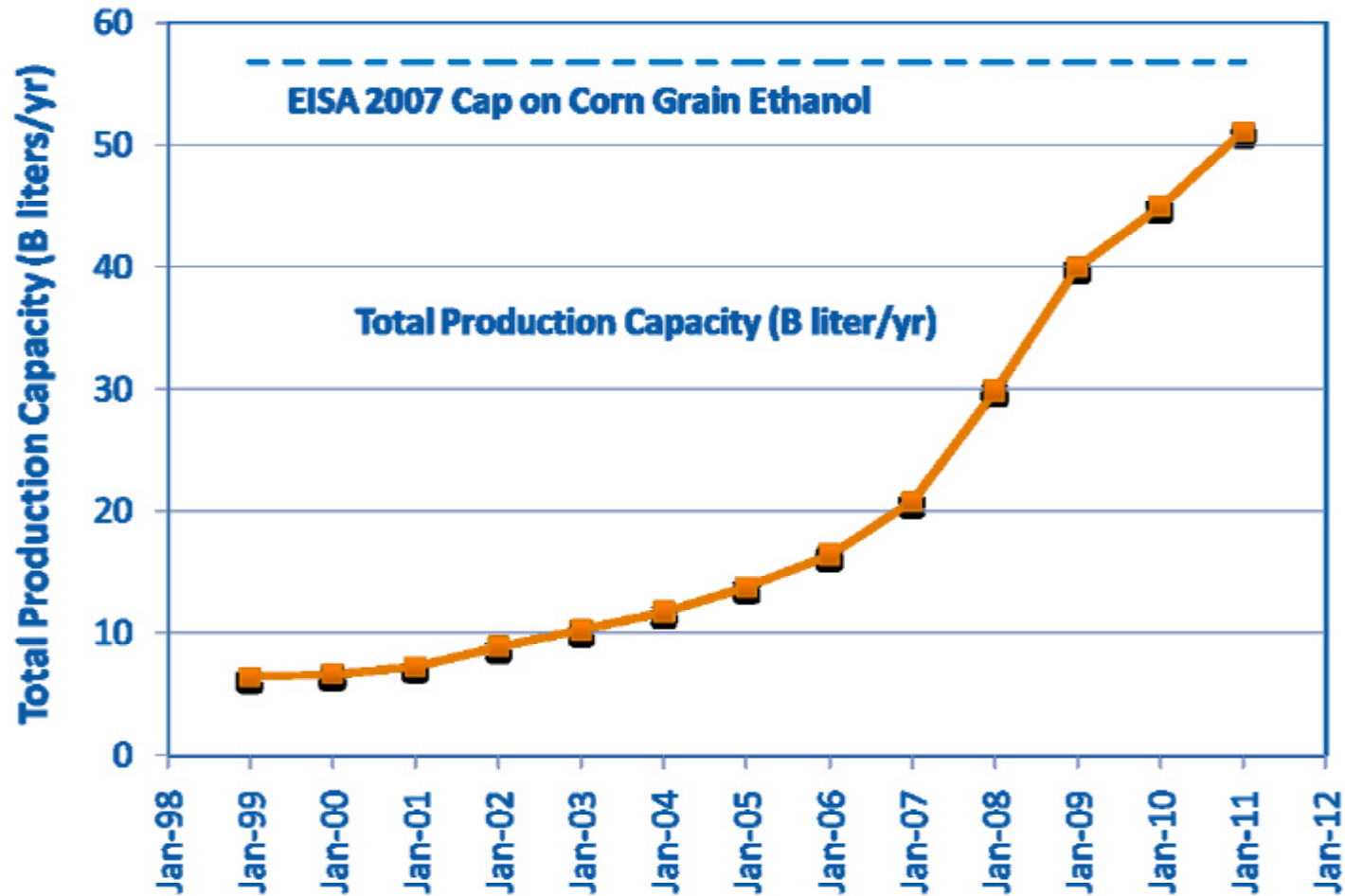
BGY = Billion Gallons per Year

2007 EISA Renewable Fuel Standard (RFS2)



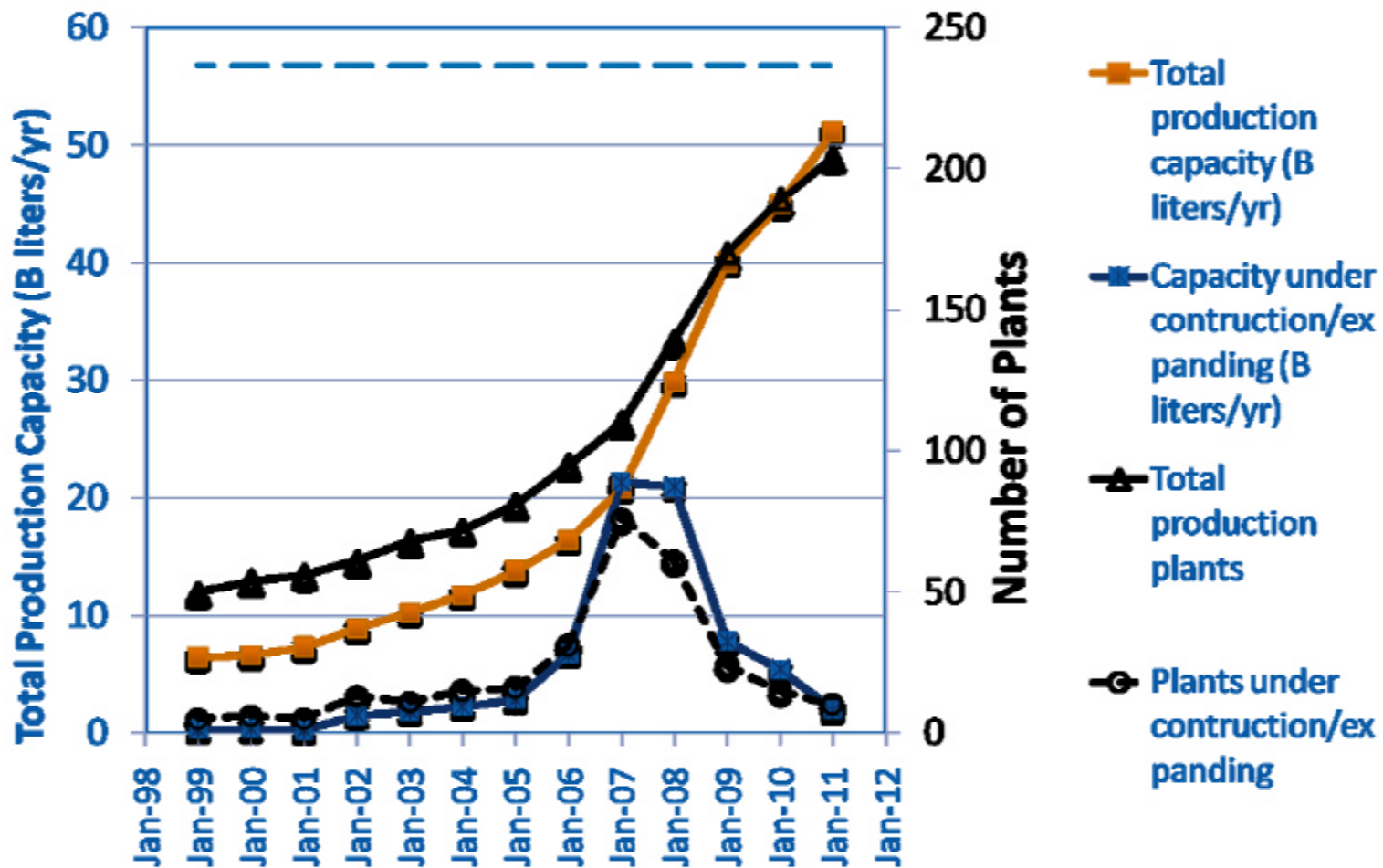
➔ Assumes cellulosic ethanol production starts ramping up in 2010, but near term target volumes reduced given slower than projected pace of demonstration and commercialization.

Grain Ethanol Production 1999 – 2010



Source data: Renewable Fuels Association (RFA, www.ethanolrfa.org)

Grain Ethanol Production 1999 – 2010



Source: Renewable Fuels Association (RFA, www.ethanolrfa.org)

Cellulosic Ethanol Developments

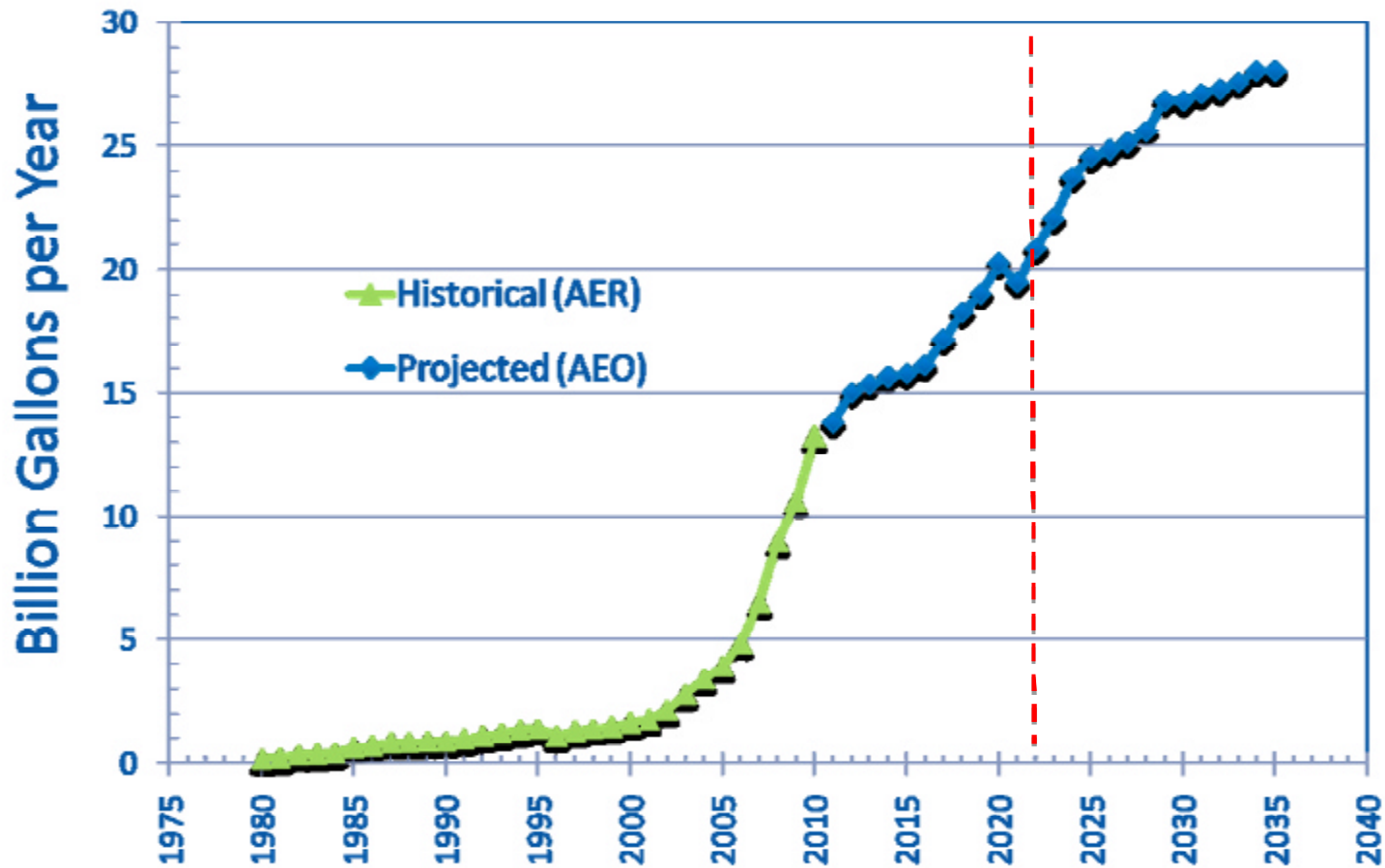
- DOE and RFA estimate over 3 dozen cellulosic biofuels pilot or demonstration plants being built or operating in USA
- Process technology has improved over past several years, with substantial progress in core technologies (e.g., hydrolytic enzymes, fermentation strains, integrated processing) and techno-economic assessment (e.g., 2011 update of NREL's biochemical design)
- Some larger scale cellulosic ethanol demonstrations occurring (Iogen, Inbicon, KL Energy, etc.) albeit rate of progress on commercial scale demonstration slower than previously projected; total production levels are well below RSF2 targets



Cellulosic Ethanol Commercialization Outlook

- Despite ambitious targets and substantially ramped up government funding, commercialization struggling
- Many large strategic investors (e.g., Abengoa, BP, DuPont, DSM, Poet, Shell, Total, etc.) are making substantial investments in **pre-commercial** RD&D but investment in commercial-scale production facilities lags
- Expect a few commercial-scale plants to be operating by 2012, but RFS2 volumetric targets unlikely to be met
- The USA's ambitious EISA 2007 cellulosic ethanol targets have been waived for the last two years (2010-2011) and the cellulosic biofuels credit will expire in December 2012
- Fragmented government policy and financial support has been insufficient to motivate large scale **commercial** investment

Historical and Projected Ethanol Production



Sources: RFA for historical and EIA for projected

Challenges to Major Private Investment

High capital costs (\$300-\$600 MM; = \$5 annual gal)

Technology still risky; not yet proven at large scale

- Processing solids, using new unit operations

No market pull/differentiation (same molecule/price)

No market push – no regulatory mandate or forcing mechanism

Market uncertainty – consistent long-term policy framework remains elusive (e.g., value on carbon)



Adapted from: Jeff Passmore, "Cellulosic Ethanol Commercialization: What's it Going to Take?," 33rd Symposium on Biotechnology for Fuels and Chemicals, May 4, 2011, Seattle, WA, USA.

Investors Want Policy Stability!

Ranking of the most problematic factors for doing business*

<u>Country</u>	<u>Access to financing</u>	<u>Policy instability</u>	Ranked # One
United States	1	8	
Spain	1	10	
Netherlands	1	8	
Ireland	1	5	
China	1	2	
Canada	2	8	Tax rates
United Kingdom	2	5	Tax rates
Italy	2	8	Inefficient gov't
Denmark	2	8	Tax rates
Russian Federation	2	11	Corruption
Malaysia	2	3	Inefficient gov't
Kenya	2	9	Corruption
Germany	3	7	Tax regulations
France	3	7	Restrictive labour regs
Czech Republic	3	4	Corruption
Mexico	3	10	Inefficient gov't
Sweden	4	6	Restrictive labour regs
Poland	4	10	Tax regulations
India	5	7	Inadequate infrastructure
Japan	7	1	#2 = Tax rates
Brazil	7	11	Tax regulations

*The Global Competitiveness Report 2010-2011, 2010 World Economic Forum (from a list of 15 factors)

Source: Jeff Passmore

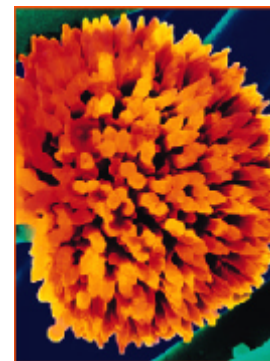
Other Factors Hindering Investment

Ability to invest impacted by economic downturn of 2008. However, this alone doesn't account for slow progress.

- "The problem is more fundamental." (Jeff Passmore)

Is feedstock availability a constraint? While feedstock and logistics are one challenge developers face, there is plenty of feedstock to supply the first billion gallons, i.e., at least a dozen full size commercial plants.

Has the technology been oversold? Yes, partially, at least initially (2006-2009) regarding market readiness. However, technology has now improved and demo plants are working. Still, big investors don't yet see a compelling value proposition.



Adapted from: Jeff Passmore, "Cellulosic Ethanol Commercialization: What's it Going to Take?," 33rd Symposium on Biotechnology for Fuels and Chemicals, May 4, 2011, Seattle, WA, USA.

Cellulosic Ethanol Commercialization Tool Box*

A Tax Component (motivate investment)

- Extend production tax credit (PTC) modeled on wind PTC, or create a CE blender's credit

An Infrastructure Component (enable increased demand and use)

- FFVs / E85 / Blender Pumps

A Policy Component (stimulate supply)

- Use existing RFS2 and properly allocate risks; focus on getting steel in the ground with clear market for those biofuels that get produced at acceptable cost



Danish fueling station pump dispensing E5 gasoline-ethanol blend containing wheat straw-derived cellulosic ethanol

photo courtesy of Claus Felby (Copenhagen U.)

*Adapted from: Jeff Passmore, "Cellulosic Ethanol Commercialization: What's it Going to Take?," 33rd Symposium on Biotechnology for Fuels and Chemicals, May 4, 2011, Seattle, WA, USA.

Spurring Investment in Cellulosic Ethanol

Investor situation:

- Many competing opportunities, prefers low risk options
- Evaluate options assuming worst case financial outcomes
- Willing to assume front-end risk if back-end market and price rewards are substantial enough

Cellulosic ethanol investors need market confidence

- Assurance that EISA RFS2 waivers won't be implemented
- Some type of 'contract' with Government to guarantee market, at least for the first billions gallons (4 B Liters)

Governments could enhance current policy

- Ask investors to assume technology and performance risks
- Create 'revenue confidence' that rewards those who succeed



Adapted from: Jeff Passmore, "Cellulosic Ethanol Commercialization: What's it Going to Take?," 33rd Symposium on Biotechnology for Fuels and Chemicals, May 4, 2011, Seattle, WA, USA.

A Major Strategic Investor Speaks



“There are things we know and things we don’t. Too often, we don’t know what the regulatory environment will be. **Certainties compel action...**

“Advanced biofuels will only reach significant commercial scale in 2020 and beyond, and it will take **significant investment** to get there. There’s been good work in the US and European governments on policy, but there’s a temptation to think that its enough. **But more must be done to stimulate market-driven innovation.**” [*emphasis added*]

- Marvin Odom, President, Shell Oil US, April 2011

Adapted from: Jeff Passmore, “Cellulosic Ethanol Commercialization: What’s it Going to Take?,” 33rd Symposium on Biotechnology for Fuels and Chemicals, May 4, 2011, Seattle, WA, USA.

Thank You. Questions?



Biomass

Information Links of Interest

Energy Information Administration: www.eia.gov

– Publishes Annual Energy Review and Annual Energy Outlook and with energy/fuels statistics and projections

Renewable Fuels Association: www.ethanolRFA.org

– USA corn ethanol production plants map and database

2011 Biomass Program Review: www.obpreview2011.govtools.us/

DOE's Biomass Program: www.eere.energy.gov/biomass/

DOE-USDA Biomass R&D Initiative: www.brdisolutions.com

Alternative Fuels: www.afdc.doe.gov

National Renewable Energy Laboratory: www.nrel.gov

– 2011 BC design: <http://www.nrel.gov/docs/fy11osti/47764.pdf>