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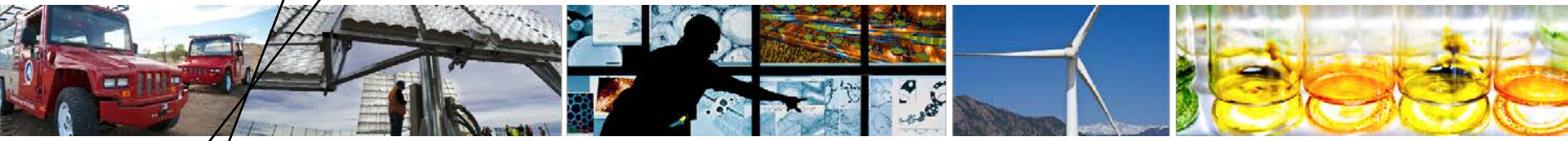
NATIONAL RENEWABLE ENERGY LABORATORY

United States of America Implementations Agendas Report Input Highlights



IEA Bioenergy Task 39 business meeting

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Beijing, China

April 7, 2018

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.

Summary

2016-2018: Challenging Times for Advanced Liquid Biofuels

Positive

- **US RFS2** and **CA LCFS** are strong drivers, have proven effective policy tools.
- US remains world's largest producer; 2017 production was ~ 59 B L ethanol, mostly from corn grain, and ~ 10 B L diesel biofuels (FAME + HVO/HEFA) from supply-limited oleaginous feedstocks.
- S&T advances continue; the efficiencies of many biofuels routes are improving; interest in new RE-enabled approaches like "electrons to molecules" building.
- Commercialization of cellulosic and CO/syngas ethanol still progressing.
  - Most activity on "Gen 1.5" corn fiber ethanol (Edeniq, QCCP, ICM, ADM, etc).
  - LanzaTech leading syngas ferm. RD&D
- Many cities/states more strongly committing to Paris agreement given federal government plan to withdraw.

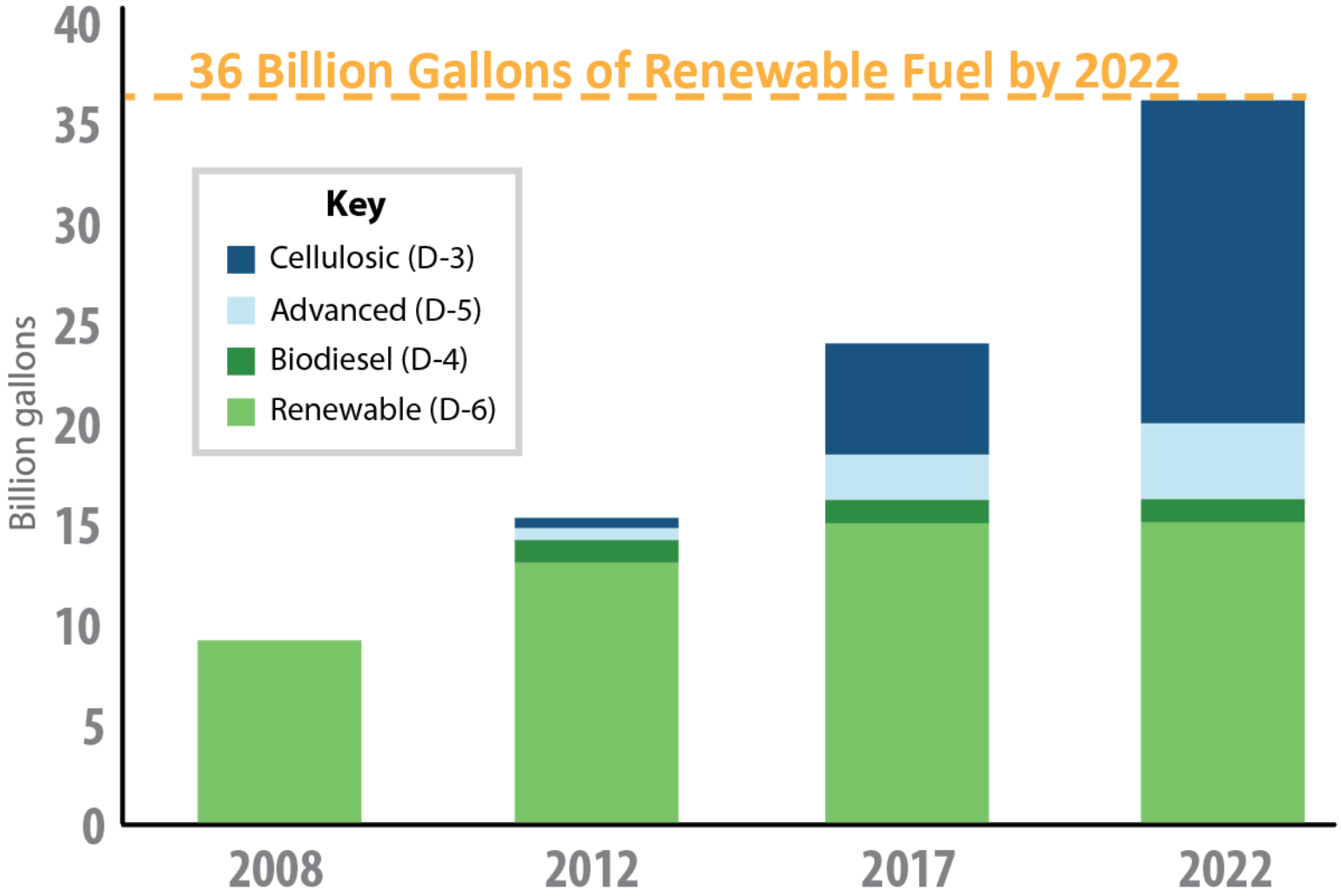
Negative

- US RFS2 and CAFÉ vehicle efficiency standards are under assault; administration and fossil fuel industry trying to roll them back.
- Petroleum prices too low for most advanced biofuels to be economically competitive, and policy uncertainty also remains very high.
  - Many companies have redirected RD&D & business strategy from fuels towards more profitable chemicals (e.g., Amyris)
  - Advanced biofuels producers also going slow, e.g., POET-DSM cellulosic ethanol production remains well below plant design (inferred from RIN generation data) even if good yields being achieved; similarly slow progress by Ensyn developing refinery coprocessing and Fulcrum for FT-based production
- US administration deemphasizing applied R&D funding for sustainable biofuels/reducing GHGs, even as impacts of climate disruption are mounting
- Urban e-mobility advancing, continues to have public's attention, shifting focus away from biofuels
- Bioenergy still held to a far higher standard than other technologies, e.g, concerns about:
  - Food vs. fuel and negative iLUC risks; carbon neutrality
  - Adv. biofuel production lagging RFS2 targets; obligated volumes for future years being revised down to reflect actual production; policy changes likely, but still unclear if they'll help or hurt biofuels

* RD&D = Research, Development and Demonstration

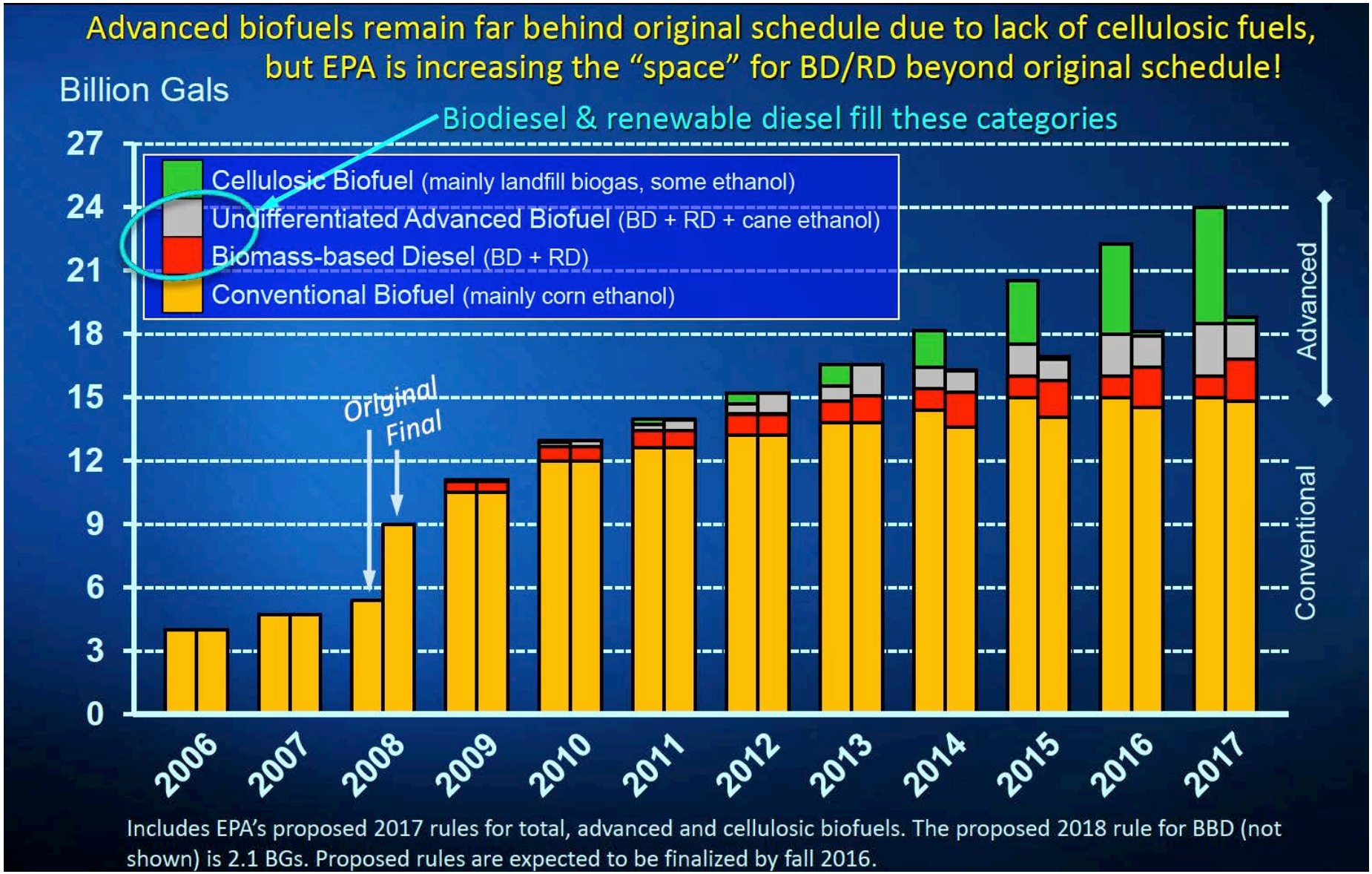
* RFS2 = Renewable Fuel Standard

Renewable Fuel Standard 2 (RFS2) Targets



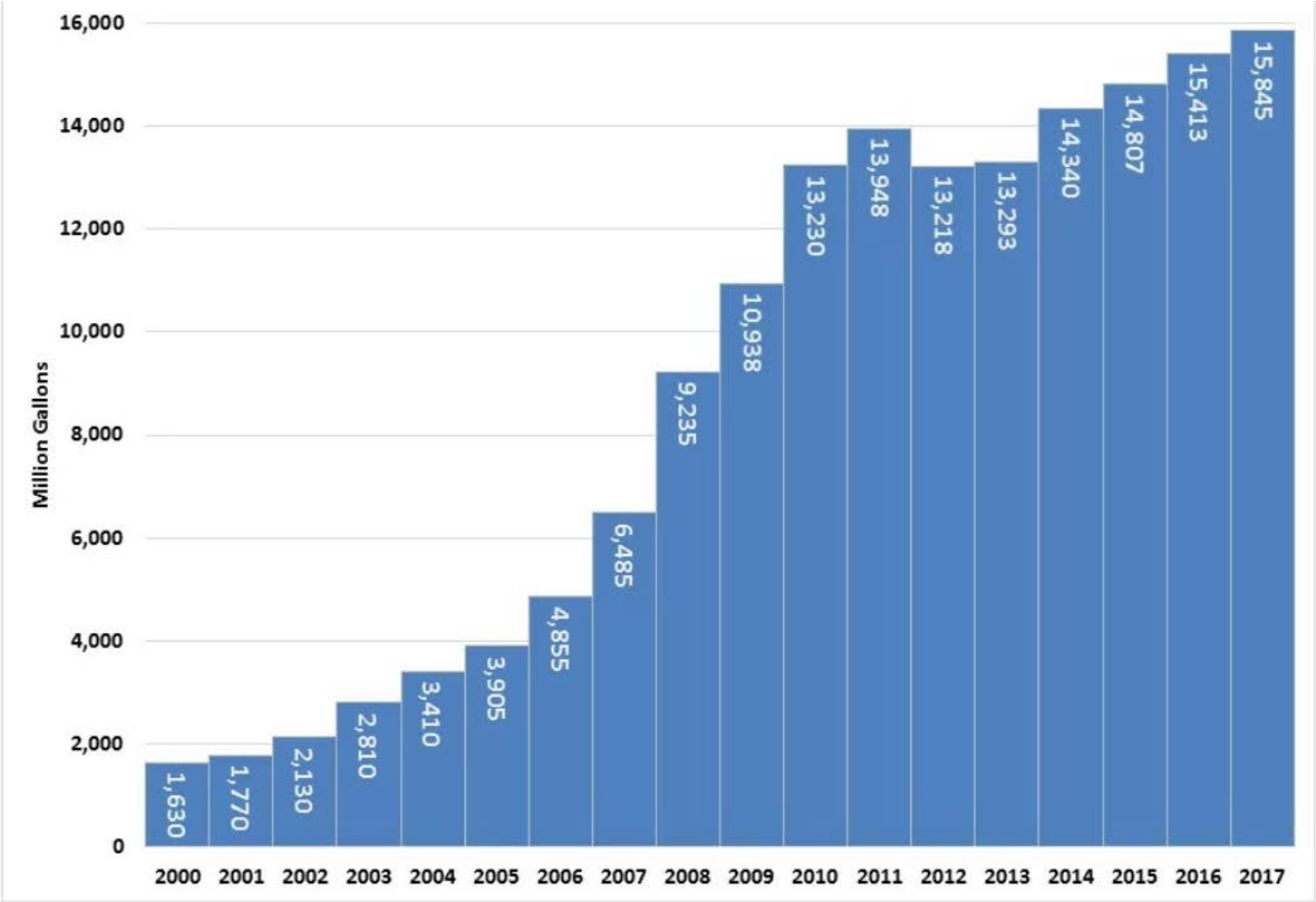
Source: USEPA, https://www.epa.gov/renewable-fuel-standard-program/overview-renewable-fuel-standard

RFS2 Biofuels Production History, 2006-2017



Source: Carter, 2016 (USDA). https://www.usda.gov/oce/energy/files/US_Biodiesel_RD_MarketJul2016.pdf

US Ethanol Production 2000 - 2017



Source: Renewable Fuels Association (RFA), 2017: http://www.ethanolrfa.org/resources/biorefinery-locations/

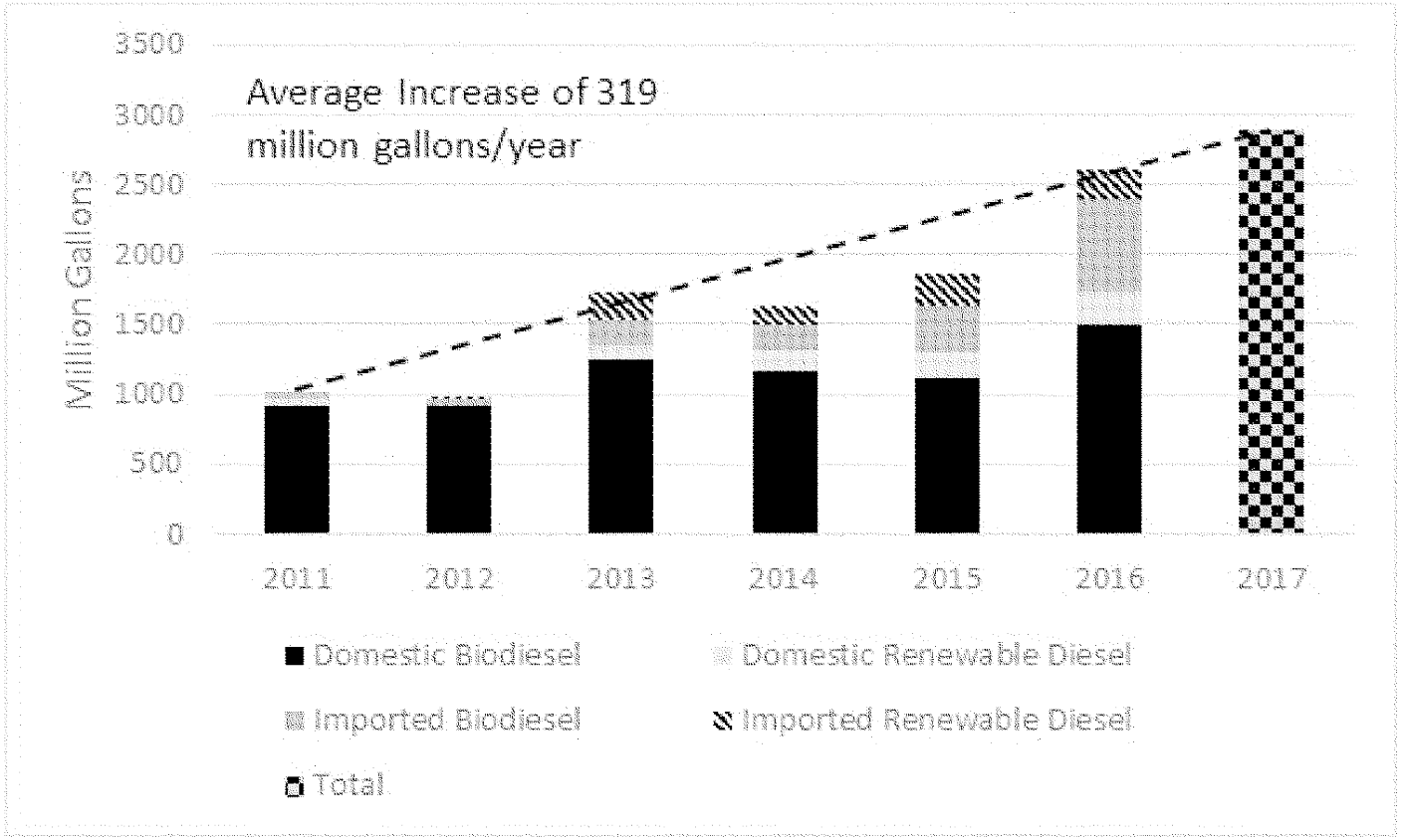
Ethanol Production from Corn Fiber Growing

- Multiple routes being commercialized to convert some or most of the corn kernel fiber present in dry mill ethanol facilities to cellulosic ethanol (CE).
- D3 RIN data shows 2016 CE production averaged ~ 1 million l/month, approx. doubling to 2 M L/month in 2017 and continuing to increase in 2018.

In-Situ	Separate		
Edeniq	ICM the energy of innovation™	Quad County Corn Processors	D3MAX
<2.5%	8-10%	5-6%	8-10%
cellulosic yield	cellulosic yield	cellulosic yield	cellulosic yield
4 plants operating Edeniq Pathway with D3 RIN approval	Successful 1.5G pilot; 1st plant in planning	1 plant operating Cellerate with D3 RIN approval	1 D3MAX pilot running

Source: K. Cagle (Novozmes). Bioeconomy 2017 conference, session 1E: Drawing a Roadmap to Cellulosic Biofuel Deployment, July 11, 2017 .

Biodiesel and RD Supply, 2011-2017[a]

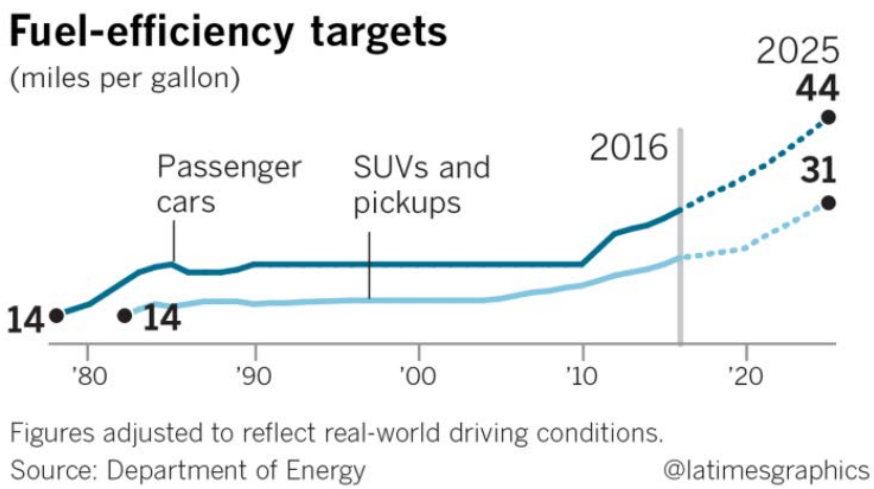


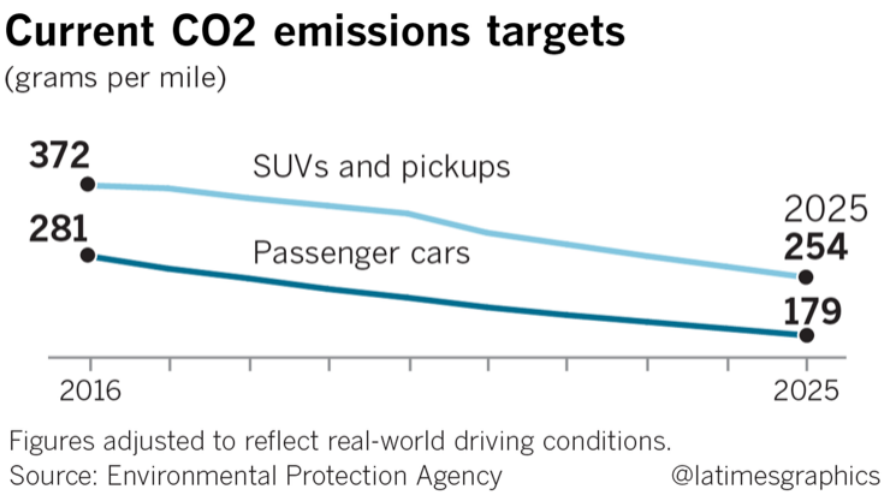
[a] Values represent current estimates of the net supply of biodiesel and renewable diesel (including conventional, advanced, and BBD biodiesel and renewable diesel) from EMTS, accounting for the production, import, and export of biodiesel and renewable diesel. 2017 supply is based on the projections for 2017 in the 2017 final rule

Source: US EPA 2017 RFS2, https://www.gpo.gov/fdsys/pkg/FR-2017-07-21/pdf/2017-14632.pdf

U.S. Vehicle Efficiency Standards (CAFÉ)

- Increasing CAFÉ standards have been highly effective in reducing demand for transport fuels.
- Phase II covering model years 2017-2025 proposed for roll back; some auto industry opposed (goes too far) and California says it will fight back. Could be an opportunity adding higher alcohol blends to RFS, i.e., afterCo-Optima recommendations.
- Stay tuned; changes coming, but what and when unclear.





Phase II as legislated reduces average emissions of new cars and light trucks to 163 g/mile in model year 2025, equivalent to 54.5 miles/ gallon if met only with fuel efficiency improvements.

Sources: http://www.latimes.com/politics/la-na-pol-mileage-epa-rule-20180329-story.html
https://www.ucsusa.org/clean-vehicles/fuel-efficiency/fuel-economy-basics.html#bf-toc-2

Co-Optimization of Fuels and Engines ("Co-optima")

Co-Optimization of Fuels and Engines

Draws on collaborative expertise of two DOE research offices, nine national laboratories, and numerous industry and academic partners.

Crosscutting initiative to co-innovate **fuels and engines** to **co-optimize performance** (max transport efficiency). Can contribute to future Task 39-AMF studies on Adv. Fuels in Adv. Engines.

Advancing R&D to:

- Bring **affordable, scalable advanced** biofuels and advanced engine solutions **to market more quickly**
- Improve fuel economy **15%–20% beyond targets** of BAU R&D efforts
- Reduce petroleum use, achieve **massive** cost savings annually via improved fuel economy
- **Dramatically decrease** transport sector pollutants and GHG emissions

Early finding: attractive option is higher ethanol (octane) blends in high compression engines.

http://energy.gov/eere/bioenergy/co-optimization-fuels-engines

Outlook

U.S. biofuels production being hampered by high policy uncertainty. Coupled with low petroleum prices, unclear / inconsistent policy signals are making it difficult to invest in advanced liquid biofuels development; economically viability remains a big challenge!

– High levels of ethanol production are expected to continue in corn dry mills (≥15 BGY), mostly conventionally from corn grain starch but increasing also from “Gen. 1.5” corn kernel fiber to produce cellulosic ethanol too.

- Biodiesel (FAME & HEFA) production are also expected to remain strong (≥12.5 BGY), with volumes constrained by feedstock availability and price.

- The single still-standing and operating large-scale POET-DSM cellulosic ethanol (CE) plant continues to improve production towards its design specification. We also expect increasing volumes of corn fiber-derived cellulosic ethanol (CE) to be produced in existing dry mills too; corn fiber-based CE production is expected to develop faster than more dedicated CE; additional commercial CE plants are unlikely until POET-DSM has proven out/established a history of reliable production.

Government funding for advanced biofuels will continue, but at what levels and with what priorities? RD&D strategies stalled/under consideration, awaiting clearer policy signals and actual revised policies.

Thanks for Your Attention!
Questions?

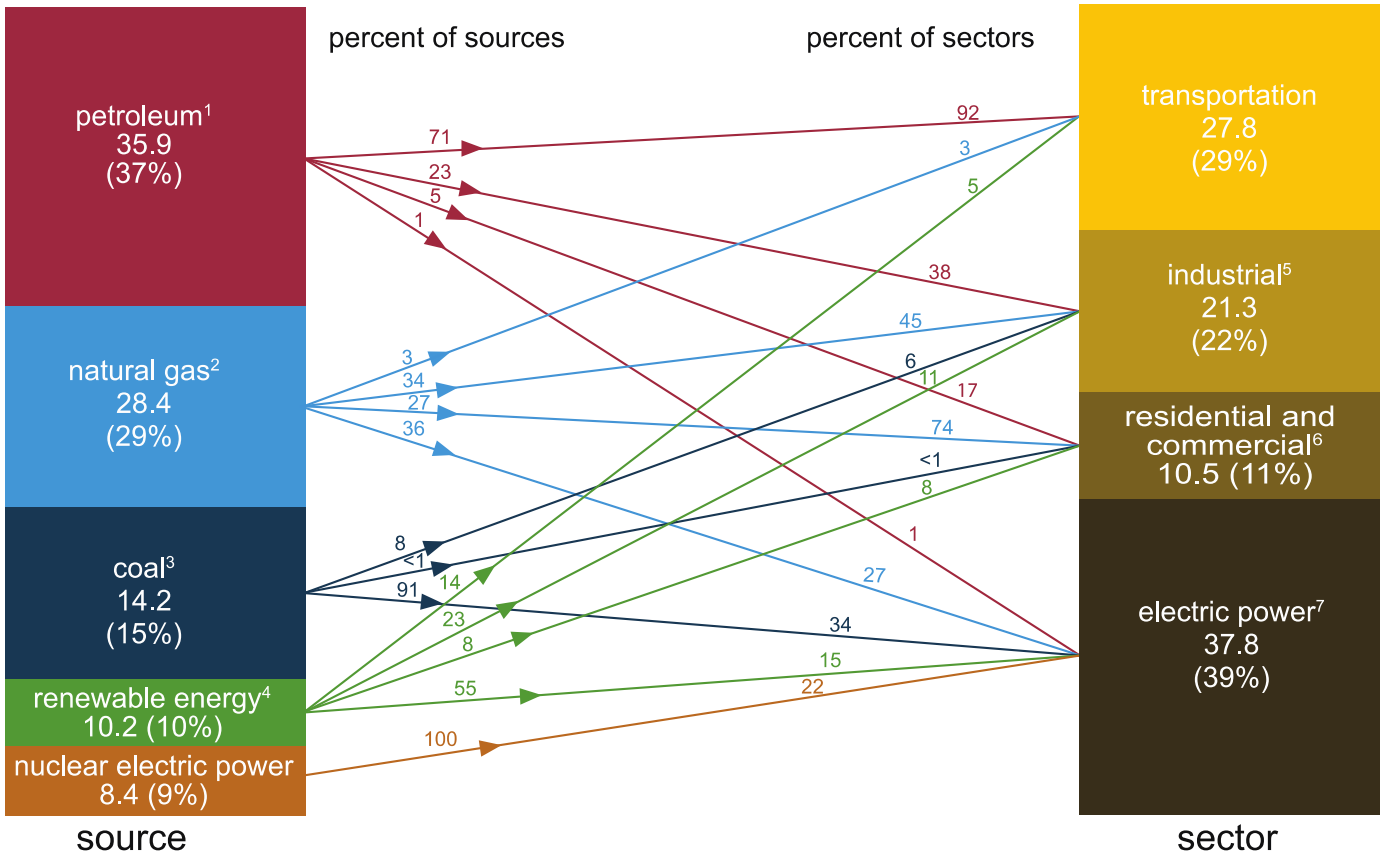
Acknowledgments

Funding from USDOE EERE Bioenergy Technologies Office (BETO) and IEA Bioenergy Task 39.

Additional Slides

USA Primary Energy Use in 2016

Total = 97.4 quadrillion British thermal units (Btu)



[1] Does not include biofuels that have been blended with petroleum—biofuels are included in "Renewable Energy."
[2] Excludes supplemental gaseous fuels.
[3] Includes -0.02 quadrillion Btu of coal coke net imports.
[4] Conventional hydroelectric power, geothermal, solar, wind, and biomass.
[5] Includes industrial combined-heat-and-power (CHP) and industrial electricity-only plants.
[6] Includes commercial combined-heat-and-power (CHP) and commercial electricity-only plants.
[7] Electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public. Includes 0.24 quadrillion Btu of electricity net imports not shown under "Source."

Notes: • Primary energy is energy in the form that it is accounted for in a statistical energy balance, before any transformation to secondary or tertiary forms of energy occurs (for example, coal before it is used to generate electricity). • The source total may not equal the sector total because of differences in the heat contents of total, end-use, and electric power sector consumption of natural gas. • Data are preliminary. • Values are derived from source data prior to rounding. • Sum of components may not equal total due to independent rounding.

Sources: U.S. Energy Information Administration, *Monthly Energy Review* (April 2017), Tables 1.3, 1.4a, 1.4b, and 2.1–2.6.

Source: US EIA. https://www.eia.gov/petroleum/ethanolcapacity/index.cfm