Written Testimony of:

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Subcommittee on Energy

THE NEXT MILE: TECHNOLOGY PATHWAYS TO ACCELERATE SUSTAINABILITY WITHIN THE TRANSPORTATION SECTOR

September 18, 2019

Good morning Chairman Lamb, Ranking Member Weber, and members of the Subcommittee. My name is Brooke Coleman. I am the Executive Director of the Advanced Biofuels Business Council.

The Advanced Biofuels Business Council (ABBC) represents worldwide leaders developing and commercializing next generation, advanced and cellulosic biofuels, ranging from cellulosic ethanol made from agricultural residues to advanced biofuels made from sustainable energy crops and municipal solid waste. Our members include those operating production facilities, those augmenting conventional biofuel plants with “bolt on” or efficiency technologies and those developing and deploying the technologies that make advanced biofuel production a commercial reality, including some of the largest cellulosic ethanol and advanced biofuel enzyme production facilities in the world.

Thank you for the opportunity to be here today to discuss future energy challenges and technology pathways to accelerate sustainability within the transportation sector. The United States must stay vigilant when it comes to developing next generation energy technologies. It is a matter of economic security. It is a matter of national security. And it is imperative for the protection of public health and the environment.

1. The importance of energy innovation to the U.S. economy

Energy innovation has helped drive U.S. economic growth for more than 200 years, and government support has been the catalyst for energy innovation for more than a century.[1] Governmental support drove investment in coal, timber, engine innovations, land settlement for resource extraction and other forms of innovation in the 19th and 20th centuries, and domestic energy consumption and GDP have tracked closely for at least 200 years.[2] Global energy demand rose 2.3 percent in 2018 – its fastest pace in the last decade.[3] From an opportunity perspective: (1) ongoing energy demand growth presents a massive and growing market opportunity for countries willing to seize it; (2) much of the U.S. competitive advantage over the last two centuries has come from our ability to innovate in the energy sector, and "technological innovation is linked to three-quarters of the Nation's post-WWII growth rate, with two innovation-linked factors – capital investment and increased efficiency – representing 2.5 percentage points of the 3.4% average annual growth rate achieved since the 1940's;" and, (3) other countries have made big commitments to energy innovation that are already drawing energy projects away from the United States.[4]

Government support has been critical in the fuel energy sector as well. For example, the shale boom has transformed the United States into one of the world's top oil and gas producers and a leading exporter of fossil fuels. And yet, one of the corporate leaders in the U.S. shale boom credited advantageous federal tax policy as a linchpin to developing the technology: "[w]ithout the current capital provisions in place, we would not have been able to fail over and over again, which is what it took to advance the technology needed to produce the Bakken and numerous other resource plays across America. And it is this technology that allows us to drill two miles down, turn right, go another two miles and hit a target the size of a lapel pin is the technology that has unlocked the resources that make energy independence a reality."[5] And

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[1] See http://www.dblpartners.vc/resource/what-would-jefferson-do/.
[2] *Id.*
[3] https://www.iea.org/newsroom/news/2019/march/global-energy-demand-rose-by-23-in-2018-its-fastest-pace-in-the-last-decade.html
[4] See http://waysandmeans.house.gov/uploadedfiles/colemantestimony922.pdf, referencing U.S. Department of Commerce, *Patent Reform: Unleashing Innovation, Promoting Economic Growth & Producing High-Paying Jobs* (2010).
[5] http://www.finance.senate.gov/imo/media/doc/Hamm%20Testimony1.pdf, p. 2.

much of the technological development occurred in partnership with federal energy agencies. According to the Congressional Research Service, [f]or the period from 1948 through 2012, 11.6% of federal energy agency R&D spending went to renewables, 9.7 % to efficiency, 25% to fossil energy, and 49.3% to nuclear.[6]

This is not just a matter of context. Cellulosic biofuel producers and "tight oil" producers have something in common; they are both endeavoring to supply the country and world markets with what the Energy Information Administration (EIA) terms "unconventional fuel." While facing similar technology risk, cellulosic biofuels (and many other renewable energy types) do not receive equitable federal support as fossil fuels (from the perspective of value or duration). In addition, global oil markets are price-controlled by OPEC and are extremely consolidated and vertically integrated domestically. While not the subject of this committee hearing, it is important to note that the absence of free market forces in the liquid fuel marketplace is a problem for the advanced biofuels industry (and other innovators) because non-competitive marketplaces do not properly facilitate and reward innovation. It is another reason why the federal government must stay engaged when it comes to supporting advanced biotechnologies.

2. The importance of energy innovation to national security

There is little question that the oil shale boom has impacted U.S. policy, causing a general shift in approach from a scarcity mindset to maximizing the economic and energy security benefits of producing and exporting more oil. Some have argued that we do not need renewable fuels in the wake of the shale boom and amidst declining gasoline demand. First and foremost, gasoline demand is increasing, not decreasing. We saw the highest gasoline consumption rate ever recorded in the United States in 2018.[7] Gasoline consumption also

[6] See http://www.fas.org/sgp/crs/misc/RS22858.pdf

[7] See https://www.eia.gov/petroleum/weekly/gasoline.php, June 20, 2018

reached a record high in 2016, breaking the previous record from 2007. Consumption is consistently matching that level and expected to reach another record high in 2019.[8]

Perhaps more importantly, producing more oil domestically should not be confused with eliminating the national security (and economic) problems associated with remaining dependent on foreign oil. The United States still imports more than 40 billion gallons of foreign oil from OPEC countries alone per year (or ~3M barrels per day).[9] The trade deficit impact of foreign oil imports is now partially recovered by U.S. oil exports – now allowed after the U.S. ban on crude oil exports was repealed in 2015 – but trade deficits do not tell the whole story. American consumers continue to inject OPEC countries with tens of billions of U.S. consumer dollars every year, global oil prices remain vulnerable to natural and human-made supply disruptions, and the U.S. economy is still exposed when it comes to oil price spikes. Just this week, Securing America's Future Energy (SAFE) called the drone attacks in Saudi Arabia "yet another wake-up call to the United States that a disruption in supply anywhere in the world impacts prices everywhere. We must not let our current high domestic production cause complacency in our energy policymaking." In addition, the American taxpayer spends about $81 billion a year to protect oil supplies around the world and keep fossil fuels flowing into U.S. gas stations, according to a 2018 analysis by SAFE.[10]

3. Where we stand in the development of advanced bioenergy systems and products

In 2013, the Department of Energy released the Transportation Energy Futures report – synthesizing the work of multiple national laboratories investigating what is technologically achievable to reduce (carbon) emissions from the transportation sector. The results were encouraging. Looking at the technologies available on the immediate and near horizon, they found that the U.S. could feasibly eliminate petroleum use in the transportation sector by 2050.

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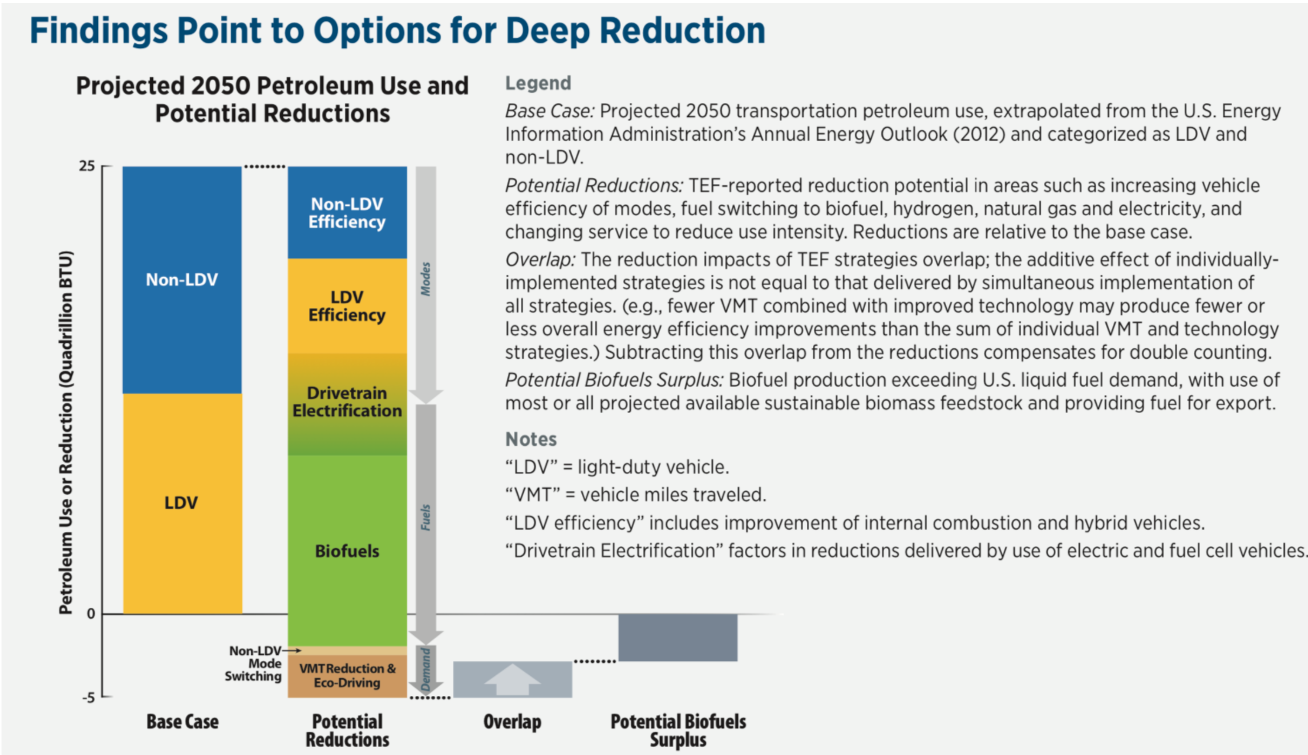
[8] See https://www.eia.gov/outlooks/steo/marketreview/petproducts.php; June 20, 2018.
[9] https://www.eia.gov/totalenergy/data/monthly/pdf/sec3_10.pdf
[10] https://www.cnbc.com/2018/09/21/us-spends-81-billion-a-year-to-protect-oil-supplies-report-estimates.html

And the labs detailed a scenario where we could meet our domestic liquid fuel needs and emerge as a net exporter of low-carbon biofuels.[11]



Crucially, this is not a theoretical scenario requiring the invention of a transformative technology or convincing millions of people to change their behavior. This is a "no-sacrifice" scenario – derived from a scientifically-derived picture of what we know can reasonably be achieved – that does not require Americans to give up flying or driving. It is also important to recognize that the biofuels projections are built from the ground up from the Department of Energy Billion Ton Report, which determined that the U.S. could produce one billion tons of biomass every year without adverse effects on either the environment or food markets.[12] Using this conservative production level as a baseline, biomass could replace about 30 percent of our current petroleum use without requiring significant shifts in production agriculture and land use. Even in the most optimistic scenarios, we will need low carbon liquid fuels for air travel,

[11] https://www.nrel.gov/docs/fy13osti/56269.pdf
[12] https://www.energy.gov/eere/bioenergy/2016-billion-ton-report

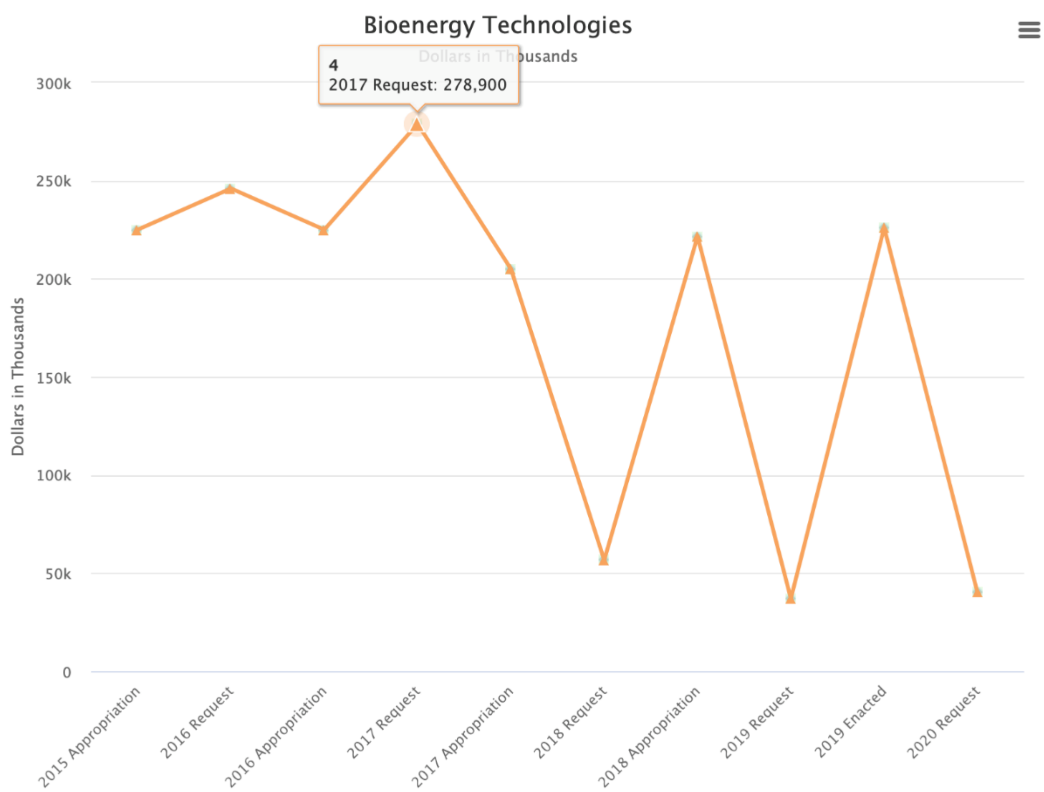
long haul trucking, and oceangoing transport. It is likely that we will need low carbon liquid fuels for light duty vehicles as well.

While it is encouraging to see what is achievable, we are not moving down this path aggressively enough to achieve the stated result of eliminating petroleum use by 2050.

The good news is the United States remains in position in to lead the world in the production of advanced bioenergy technologies. For example, a Bloomberg analysis looked at select regions in the world to assess the potential for next generation ethanol production.[13] The study found that eight regions – Argentina, Australia, Brazil, China, EU-27, India, Mexico and the United States – could displace up to 50 percent of their demand for gasoline by 2030 making cellulosic ethanol from a very small percentage of its each region's agricultural residue supply alone. The industry is embarking on the process of securing efficiencies that can only be achieved via commercialization (i.e. the "experience curve") and economies of scale. When the corn ethanol industry started building plants, their production costs exceeded their feedstock costs by a large margin. However, corn ethanol producers have reduced their production costs by roughly 60 percent since the first commercial plants were built in the 1980s. Likewise, some solar companies have seen a similar 60-70% production cost reduction in just the last ten years, as capacity has increased significantly. Advanced ethanol technology – particularly in the areas of agricultural residues (corn fiber, stover, wood waste, etc.) and municipal solid waste – are at this point. For example, in 2016-2017 EPA staff identified ethanol made from corn fiber as a cellulosic biofuel exceeding commercial expectations and forecasts. Every one of 200+ ethanol bio-refineries in the United States has a natural interest in taking advantage of an under-utilized cellulosic feedstock (corn residues) already at the plant feedstock door. Likewise, regions with high population densities have access to large amounts of municipal solid waste (MSW) – the large majority of which is cellulosic material (paper, cardboard and wood materials).

[13] See http://www.novozymes.com/en/sustainability/benefits-for-the-world/biobased-economy/white-papers-on-biofuels/Documents/Next-Generation%20Ethanol%20Economy_Executive%20Summary.pdf

The bad news is ongoing policy instability creates a ripple effect of investment uncertainty that is slowing down the deployment of advanced biotechnologies. There is tremendous political (and therefore outcome) uncertainty around advanced biotechnology tax provisions, farm bill programs, demand-side policies (e.g. the Renewable Fuel Standard/RFS) and R&D budgets. On the DOE budget side, Congress has pushed back admirably against efforts to de-fund critical advanced bioenergy programs. However, fiscal uncertainty is very difficult for companies to plan against and thereby dampens engagement in these vital programs.



Ironically, Department of Energy (DOE) programs also get ensnared in the policy uncertainty ripple effect. For example, the RFS is designed to break open a motor fuel supply chain largely controlled by the oil industry to provide demand opportunity for both conventional and advanced biofuels. Proper implementation of the RFS would help crack the commercial demand equation for emerging technologies, thereby facilitating success across the vast array of public/private partnerships (including DOE's Title 17 loan guarantee program) deployed by DOE over the years. Unfortunately, the RFS was not enforced in the 2014-2016 timeframe during a critical stage of cellulosic biofuel commercial deployment. The programs designed to facilitate the commercial deployment of advanced bioenergy then get bogged down in risk and politics. Today, many of the emerging RFS fuel pathways for cellulosic biofuels cannot get fuel eligibility registrations from EPA. And the nearly 400 percent increase in Small Refiner Exemptions (SREs) issued by EPA in the 2016-2018 timeframe has wiped out 4 billion gallons of biofuel demand across all biofuel categories (including advanced biofuels). While DOE cannot solve demand-side issues, it can provide more stability in developing technologies.

4. Recommendations

Support Biofuels and Department of Energy Laboratories. As you know, the work of the Department of Energy to advance research, development, demonstration, and commercial application is principally advanced through its Bioenergy Technologies Office (BETO) where it works to advance cost-competitive advanced biofuels from "non-food" biomass resources, including cellulosic biomass, algae, and wet waste. This work has been advanced by a number of the Department of Energy's laboratories including Oak Ridge, Argonne, and the National Renewable Energy Laboratory (NREL). For instance, the Center for Bioenergy Innovation (CBI), led by Oak Ridge National Laboratory, works to develop perennial nonfood crops that thrive in the harsh environment of marginal lands, require less fertilizer and pesticide, and are more easily broken down and converted to advanced biofuels and bioproducts. Argonne National Laboratory, in collaboration with NREL, has conducted valuable research on emerging biomass feedstocks through x-ray absorption spectroscopy that has the promise of delivering better catalyst technologies to the market. Argonne also developed the best carbon accounting model in the world (GREET) that is the model for the California Low Carbon Fuel Standard (LCFS). In an age of industry-funded, asymmetric information warfare – often involving manipulated carbon and land use modeling for bioenergy – it is absolutely critical to maintain independent and objective sources of information (e.g. Argonne, Oak Ridge, NREL, LL, etc.). While there are numerous other examples of biofuels work led by our national laboratories that are worth referencing, it is equally important to note that without a robust funding and direction for offices like the Office of Science and Bioenergy Technologies Office, progress will stagnate. I hope this Committee will continue to prioritize its work on accelerating a cleaner, greener, and more secure transportation future because the leadership you provide is vital.

Reorient the Bioenergy Technologies Office (BETO) with TEF and BT reports. The Transportation Energy Futures and Billion Ton reports concluded that in order to rapidly decarbonize transportation we must aggressively reduce petroleum's role in our economy with biomass as a key player in the effort. BETO would reorient (where necessary) and redouble its efforts (where existing) to produce analysis that supports using biomass to the maximum extent possible with existing infrastructure (and fleets) as well as researching the direct replacement of petroleum-derived products in fuels, chemicals, and products. For example, the current limitations on biofuel use – such E15 limits on pumps or guidelines on vehicles – are generally derived from historical practice rather than scientific analysis. National labs could play a valuable role in sorting out technical fact from fiction regarding how compatible higher blends are with refueling infrastructure and vehicles. However, this will only happen if the agencies are tasked with catalyzing maximum feasible petroleum displacement. National labs also have a key analytical role in the continual improvement of the GHG footprint of biofuels, in addition to correcting the record when necessary, by identifying the most economically efficient ways to widen the gap with fossil fuels throughout the production chain.

Increase funding for Low Carbon Bioenergy R&D. If we are going to take the IPCC report and the global competition to produce clean energy seriously, R&D funding must be commensurate with the scale of the challenge. Key pieces of the transportation economy have no other near-term, climate-friendly solution beyond biomass. R&D efforts should be of sufficient size and focus to deliver viable alternatives in all of these sectors within the next 5-10 years and early market support should be put in place to compete with other nations.

Focus Public-Private Partnerships on Integrated Bio-refining/Applied Research. Like many emerging industries, we have developed promising technologies at smaller scale. The critical next step is further developing these technologies and capturing efficiencies only achievable at larger scale. In addition to restoring funding for previous work on catalysts, feedstocks, and feedstock handling, R&D efforts should return to their emphasis on integrated biorefineries that can maximally extract value from biomass and displace the whole range of products currently produced from fossil fuels. While the 200+ ethanol plants and ~100 biodiesel plants located in the United States are often seen as single-product (i.e. ethanol or biodiesel) biorefineries ineligible for partnerships due to sometimes ineffectual program designations, the reality is these refineries have an eye for the future – in which biofuel producers are managing full-scale integrated biorefineries producing many types of biofuels, feed, biochemicals and materials for biodegradable plastics. The DOE program objective should work backwards from the billion ton report – maximizing displacement of oil in the economy with an ultimate goal of eliminating its use—rather than continuing to pit technologies such and ICE efficiency, electrification, fuel cells, and biofuels against each other for the same market niche. Creative use of existing loan programs, coupled with: (a) production and technical support; and, (b) dependable offtake like past partnerships with the Department of Defense will help break the current bottleneck for advanced (fuel) biotechnology. Public-private partnerships focused on demonstrating integrated biorefining technology would also reenergize many of the programs currently under review. There is no question that the Department of Energy can be a vital catalyst for major partnerships with the private sector with programs properly designed to leverage existing "in-ground" investment and assets.

Support Biofuel Analysis at the Energy Information Administration. While the Energy Information Administration (EIA) is under the purview of a different committee, it is worth noting how critical it is to have access to unbiased statistics. The data that EIA provides to lawmakers and the marketplace helps inform decision-making on a myriad of levels. As the biofuels/bioenergy industry grows, it is important that our primary market surveying agency has the funding and tools to track bioenergy utilization in real-time (and not just as a subset of gasoline/diesel consumption). Ensuring that EIA has the resources it needs is vital, because lag-time between its collection of data and its dissemination to the public can be critical when helping to inform public policy decisions.

Thank you for the opportunity to speak with you today, and I look forward to your questions.

See: Addendum A

ADDENDUM A: Carbon Impact of Bio-Based Fuels

When advanced bioenergy products become disruptive to the status quo – as renewable fuels have in the United States – it is common for incumbents to try to dampen enthusiasm by commissioning countervailing research. In these situations, it is critical to focus on independent research. As such, this addendum is based on analysis conducted by U.S. EPA, the California Air Resources Board (CARB), the U.S. Department of Energy, the U.S. Department of Agriculture and top energy labs such as Argonne and Oak Ridge National Laboratories.

Peer-reviewed analysis coming out of the U.S. Argonne National Laboratory shows that all types of ethanol – even the first-generation ethanol usually scrutinized for its GHG emissions – have significantly lower lifecycle greenhouse gas emissions than petroleum, even with penalties for indirect land use change. It is worth highlighting that the Argonne National Laboratory developed the GREET model, which remains the gold standard for modeling carbon lifecycle emissions from fuels (and is the analytical basis for the California Air Resources Board Low Carbon Fuel Standard as "CA-GREET"). Many of these biofuels are significantly more carbon reductive than technologies often regarded to be the most innovative in the world. Some cellulosic ethanol facilities can deliver fuel to market with more than a 90 percent greenhouse gas emissions reductions.

Well-to-Wheels Greenhouse Gas Emissions Reduction

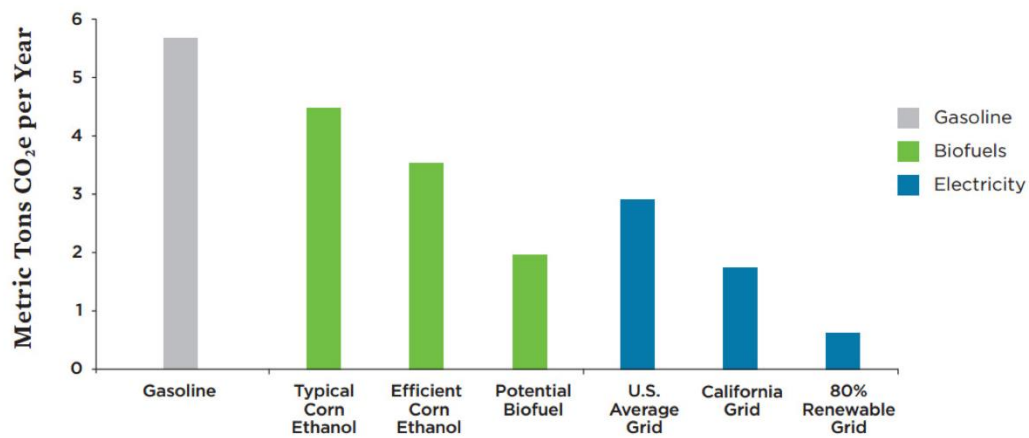
Relative to Average Petroleum Gasoline (including indirect land use change)

WTW GHG emission reductions	Corn	Sugarcane	Corn stover	Switchgrass	Miscanthus
Including LUC emissions	19–48% (34%)	40–62% (51%)	90–103% (96%)	77–97% (88%)	101–115% (108%)
Excluding LUC emissions	29–57% (44%)	66–71% (68%)	89–102% (94%)	79–98% (89%)	88–102% (95%)

Source: Argonne National Laboratory[14]

[14] See http://iopscience.iop.org/1748-9326/7/4/045905/pdf/1748-9326_7_4_045905.pdf

Compared with Gasoline, Alternatives Are Clean and Getting Cleaner



A typical car produces 6.7 metric tons of global warming pollution each year, once emissions from oil extraction and refining are added to tailpipe emissions. Biofuels and electricity are cleaner, and have the potential for dramatic improvements in the future.

Note: The global warming emissions of gasoline represents the metric tons of CO_2e associated with the production and consumption of fuel required to power a typical car (getting 25 miles per gallon, or mpg) for a year (driving 12,000 miles). This is compared with the energy equivalent amount of ethanol. For electricity the emissions represent the production of fuel (e.g., coal, natural gas) and consumption by power plants to generate a quantity of electricity needed for a similar vehicle traveling the same distance, adjusted for electric drive efficiency.

SOURCE: CARB 2015A; CARB 2015D; UCS ANALYSIS; NEALER, REICHMUTH, AND ANAIR 2015; HAND ET AL. 2012.

The carbon benefits of increasing the use of renewable fuels are even greater when you consider real world conditions – i.e. the fact that renewable fuels replace higher carbon marginal (rather than average) gallons of petroleum. To illustrate, Petrobras chief Jose Sergio Gabrielli has declared that "the era of cheap oil is over." This means that oil companies have shifted to an increasing reliance on more expensive and riskier "unconventional" fuels – including tight/shale oil (e.g. the Bakken), deep water (e.g. Gulf of Mexico, Deep Water Horizon) and Canadian tar sands (e.g. Keystone) – to meet the global demand for fuel energy.[15] Unconventional oil is harder to find and can result in serious ecological problems (earthquakes, drinking water contamination, ecosystem destruction in the case of the Gulf). These fuels are also more carbon intensive than the "average petroleum" often used to compare the carbon value of renewable fuels. There are many recent studies that have looked at the real world "marginal" impact of increasing the use of renewable fuels. One of the more extensive is a 2014 analysis conducted by Life Cycle Associates in California, which concluded that first-generation

[15] See http://www.eia.gov/forecasts/aeo/MT_liquidfuels.cfm#crude_oil

ethanol – assessed by EPA in 2010 to be 21 percent better than 2005 petroleum with regard to lifecycle GHG emissions – is 32 percent better than 2012 average petroleum and 37-40 percent better than petroleum derived from tar sands and fracking. The report recognizes that using less renewable fuel, as would be the case with the current proposal, will increase the use of these unconventional types of oil:

> The majority of unconventional fuel sources emit significantly more GHG emissions than both biofuels and conventional fossil fuel sources … [t]he biggest future impacts on the U.S. oil slate are expected to come from oil sands and fracking production … significant quantities of marginal oil would be fed into U.S. refineries, generating corresponding emissions penalties that would be further aggravated in the absence of renewable fuel alternatives." *Source: Life Cycle Associates, January 2014*

These findings are consistent with recent (lower resolution) assessments by federal agencies. For example, a recent report released by the Congressional Research Service (CRS) found that Canadian oil sands are 14-20 percent more carbon intensive than the 2005 EPA baseline.[16] As such, it is an inescapable reality that any proposal to increase renewable fuel blending is a proposal to reduce U.S. consumption of high carbon intensity, unconventional oil. If the high-carbon-intensity marginal gallon of oil is displaced by cellulosic ethanol, the carbon benefits are enormous.

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[16] See http://www.fas.org/sgp/crs/misc/R42537.pdf