THE EARTH'S BEST DEFENSE

NATURAL RESOURCES DEFENSE COUNCIL

Statement of

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Summary

- Sustainably produced biomass feedstocks, processed efficiently and used in efficient vehicles can reduce our dependence on oil for transportation, reduce emissions of heat-trapping carbon dioxide, and contribute significantly to a vibrant farm economy.
- Pursued without adequate guidelines, large scale biofuels production carries grave risk to our lands, forests, water, wildlife, public health and climate.
- The choice of feedstocks is just one of many factors that influence the environmental impacts of fuel production.
- If half of the alternative fuels mandate proposed by the administration were satisfied with coal-derived liquid fuels CO_2 emissions would be 175 million tons higher in 2017 than targeted by the administration. To offset this increase through automobile fuel efficiency standards would require an increase in CAFE standards of 8.6 percent per year, rather than 4% per year as suggested by the administration.
- A ton of coal used in a power plant employing carbon capture and storage (CCS) to generate electricity for a plug in hybrid vehicle will displace more than twice as much oil and emit one-tenth as much CO_2 per mile driven as using the same coal to make liquid fuels in a plant that uses CCS.
- Congress should cap total greenhouse gas emissions from transportation fuels and require progressive reductions in the average greenhouse gas emissions per gallon of transportation fuels sold, as California is planning to do.
- If the renewable fuels standard is expanded, conventional biofuels should be required to achieve at least a 20% reduction in lifecycle greenhouse gas emissions compared to conventional gasoline and advanced biofuels should achieve at least a 50% reduction.
- Biofuels should not qualify toward compliance with any renewable fuels standard if the biomass is obtained from old growth forests, wilderness study areas, roadless areas of national forests, native grasslands, important wildlife habitat, or other highly sensitive ecosystems.
- Congress should establish a straightforward no-backsliding requirement to protect air quality by directing EPA to adopt regulations requiring that the emissions of any air pollutant from vehicles using renewable fuel shall be no greater than the level of such emissions from vehicles when using conventional gasoline.

Introduction

Thank you for the opportunity to share my views regarding implementation of the Renewable Fuels Standard and possible modifications to achieve greater energy security and environmental benefits. My name is Daniel A. Lashof, and I am the science director of the Climate Center at the Natural Resources Defense Council (NRDC). NRDC is a national, nonprofit organization of scientists, lawyers and environmental specialists dedicated to protecting public health and the environment. Founded in 1970, NRDC has more than 1.2 million members and online activists nationwide, served from offices in New York, Washington, Los Angeles and San Francisco.

Mr. Chairman, as you know, U.S. energy policy must address three major challenges: reducing America's dangerous dependence on oil, reducing global warming pollution, and providing affordable energy services that sustain a robust economy. Biofuels have the potential to contribute significantly to all three of these goals. Sustainably produced biomass feedstocks, processed efficiently and used in efficient vehicles can reduce our dependence on oil for transportation, reduce emissions of heat-trapping carbon dioxide, and contribute significantly to a vibrant farm economy. Pursued without adequate guidelines, however, biofuels production carries grave risk to our lands, forests, water, wildlife, public health and climate. Any policy to expand the use of renewable transportation fuels should incorporate effective performance standards and incentives to ensure that biofuels are part of the solution, rather than part of the problem.

Accelerated corn cultivation for ethanol, for example, threatens to deplete water tables, magnify contamination by fertilizers, pesticides, and herbicides, and undermine vital conservation programs such as the Farm Bill's Conservation Reserve Program. Increased use of ethanol could also impair air quality depending on how it is blended and used. On farms and in forests across the country and abroad, imprudent biomass harvesting would cause soil erosion, water pollution, and habitat destruction, while also substantially reducing the carbon sequestered on land. Advancing a biofuels policy that leads to clearing forests for fuel production, at home or abroad, and hence increased emissions of carbon dioxide would be a particularly perverse result for a policy that is intended, at least in part, to reduce global warming pollution.

The Need for Performance Standards

In structuring an effective transportation fuels policy it is important to recognize that the choice of feedstocks is just one of many factors that influence the environmental impacts of fuel production. For biofuels, key factors to consider in addition to feedstock type are carbon emissions from converting land from other uses to feedstock production, tillage method, energy use for irrigation, fertilizer application rate, the source of thermal energy and electricity at the biorefinery, the overall efficiency of the biorefinery, and whether CO_2 produced during fermentation is sequestered or released into the atmosphere. Considering all of these factors it is possible to produce ethanol derived from corn in a way that produces less than half of the lifecycle greenhouse gas emissions of gasoline (per BTU of delivered fuel). Conversely it is possible to produce ethanol from cellulosic feedstocks in a manner that produces far more CO_2 than gasoline.

First consider a dry mill corn ethanol plant. Greenhouse gas emissions from corn production can be minimized by obtaining the corn from a farm that practices no-till cultivation. In addition, by collecting a portion of the corn stover along with the grain the ethanol plant can meet its thermal energy needs with this biomass energy source rather than fossil fuels. Finally, fermentation produces carbon dioxide in a pure stream that can be easily captured for geologic sequestration. Using Argonne National Laboratory's GREET model, we estimate that the lifecycle greenhouse gas emissions from ethanol produced at such a plant would be 7.5 pounds per gasoline gallon equivalent, or more than 70% lower than gasoline. NRDC has examined the greenhouse gas emissions from a wide variety of feedstock and conversion process combinations using the Argonne GREET model (see Figure 1 and Appendix). EPA conducted a similar analysis for a fact sheet released in conjunction with its final rule for implementing the Renewable Fuels Standard enacted in EPACT 2005.[1] EPA's results are shown in Figure 2 and are very similar to ours (note that EPA displays results relative to conventional gasoline, which is set to zero on their chart.)

[1] http://www.epa.gov/otaq/renewablefuels/420f07035.htm

Figure 1. NRDC Lifecycle Greenhouse Gas Analysis

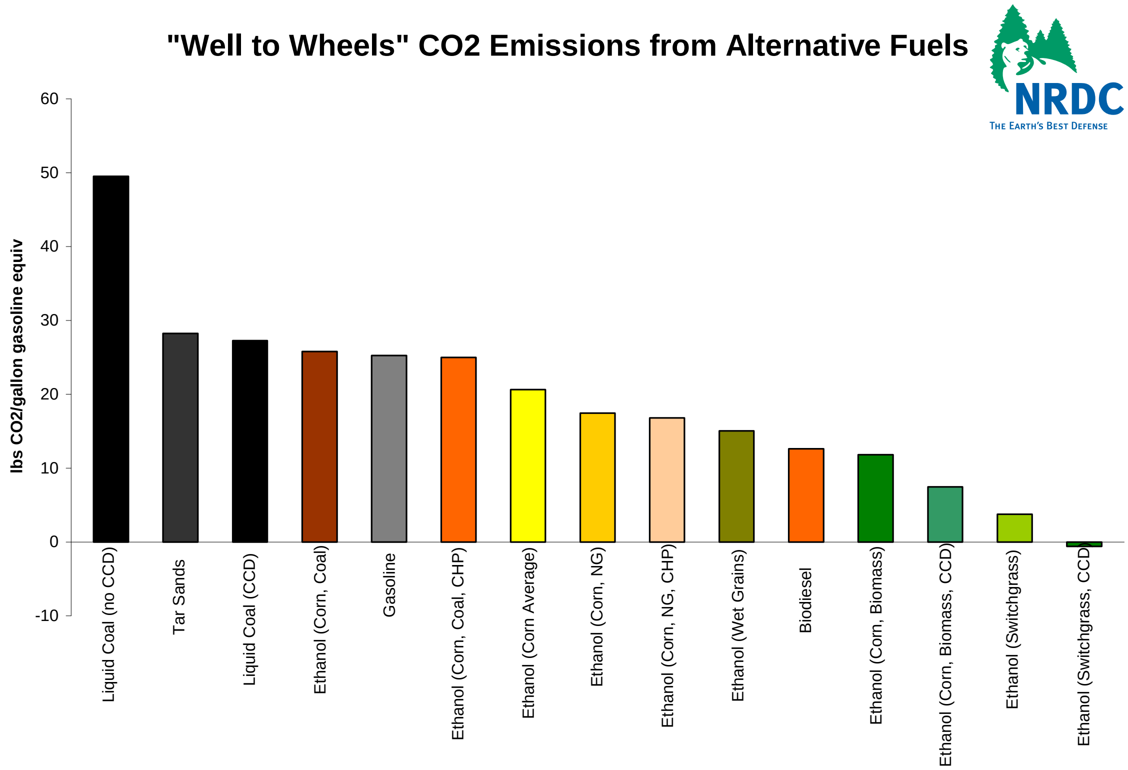
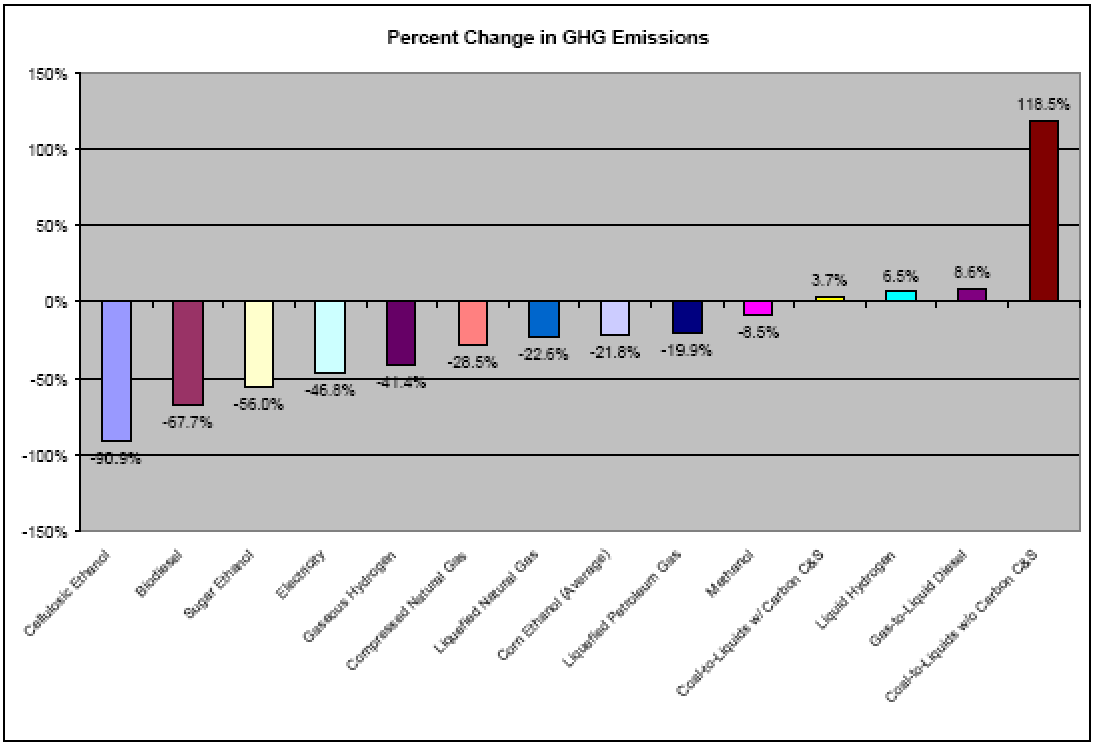


Figure 2. EPA Lifecycle Greenhouse Gas Analysis



Now consider a cellulosic ethanol plant. While such plants are often considered to be environmentally superior to corn ethanol plants, this is not necessarily the case, depending on how the cellulosic feedstock is produced. For example, if the biomass for the cellulosic ethanol plant is obtained by converting to biomass production land that had been enrolled in the conservation reserve program (CRP), then the forgone conservation benefits and carbon benefits must be accounted for. The CRP has enrolled more than 1 million acres in forest cover, including hardwoods, longleaf pine, and other softwoods. While these are secondary, rather than old growth, forests, they nonetheless provide important ecological services and sequester a substantial amount of carbon. Converting such lands to biofuels production would not only rapidly return to the atmosphere the carbon sequestered since the trees were planted, but would also forgo future carbon sequestration on this land. The net result would be CO_2 emissions to the atmosphere many times greater than the annual greenhouse gas benefits from cellulosic ethanol production on this land.

Land conversion need not be this direct to undermine the environmental benefits of biofuel production. Devoting an increased share of U.S. agricultural output to fuel production rather than grain exports will result in increased demand for animal feed from sources abroad. If any significant portion of this additional feed is obtained by converting mature forests into pasture or cropland the CO_2 emissions from this land use change could greatly exceed the emission reductions from the use of biofuels.

Some proposals distinguish between “conventional” biofuels and “advanced” biofuels based just on the type of feedstock from which the fuel is produced. For example, the bill reported by the Senate Energy Committee last week distinguish between “conventional biofuel,” defined as ethanol derived from corn starch, and “advanced biofuels,” which is essentially fuel derived from any other form of renewable biomass. In an important first step the Committee adopted a greenhouse gas performance standard for new biofuels facilities requiring at least a 20 percent reduction in global warming emissions over the fuel lifecycle from feedstock production through processing and use. The bill would also require that an increasing proportion of the overall renewable fuels standard come from advanced biofuels, but does not establish a higher performance standard for such fuels. Structuring the standard to ensure the diversification of feedstocks used for biofuels production is helpful, but is not an adequate substitute for stronger greenhouse gas performance standards and sustainable feedstock sourcing requirements, such as those included in the Advanced Clean Fuels Act of 2007, introduced last week by Senators Boxer, Collins, and Lieberman.

The Administration’s Proposal

The administration has proposed replacing the existing renewable fuels standard with an “alternative fuels” standard that increases to 35 billion gallons by 2017. The administration has asserted that this standard, in combination with their proposed changes to Corporate Average Fuel Economy standards, would return greenhouse gas emissions from light duty vehicles to current levels in 2017, a reduction of about 170 million metric tons below business-as-usual projections. Unfortunately, nothing in the Administration’s proposal would ensure this result. First, while the administration's analysis assumes that ethanol would be used to comply with the standard, their actual proposal opens the door to a variety of fossil fuels as well as renewable fuels, some of which could have lifecycle greenhouse gas emissions as much as twice as high as petroleum-derived fuel. Second, because of the very aggressive schedule for increasing the use of alternative fuels, the administration's proposal would create enormous pressure to convert forests and conservation reserve program lands to biofuels production, potentially contributing a pulse of carbon dioxide emissions that would take many decades to offset through reduced oil consumption. Third, the schedule is too rapid to allow potentially more beneficial processes for producing biofuels, such as cellulosic ethanol and biobutanol, to satisfy most of the alternative fuel mandate, as indicated by testimony of the president of the leading cellulosic ethanol company. Fourth, while the administration assumed a 4% per year increase in CAFE standards in their projections, the administration's CAFE proposal does not actually guarantee any increase.

These deficiencies in the administration proposal mean that it could lead to an increase, rather than a reduction, in global warming pollution compared with business as usual. For example, if half of the alternative fuels mandate proposed by the administration were satisfied with coal-derived liquid fuels (liquid coal synfuels) then CO_2 emissions would be 175 million tons higher in 2017 than targeted by the administration. To offset this increase through automobile fuel efficiency standards would require an increase of 8.6 percent per year, rather than 4% per year as suggested by the administration.

Liquids from Coal v. Electricity from Coal for Transportation

Even if liquid coal synfuels plants fully employ carbon capture and storage, full fuelcycle greenhouse gas emissions from using these fuels will be somewhat worse than conventional gasoline (see Figures 1 and 2). There is a straightforward reason for this. Liquid coal synfuels are hydrocarbon fuels with about the same carbon content per BTU as conventional gasoline or diesel fuel, so vehicle tailpipe CO_2 emissions from using liquid coal would be nearly identical to those from using conventional fuels. Any CO_2 emissions released from the synfuels production facility have to be added to the tailpipe emissions. The residual emissions from a liquid coal plant employing CCS are still somewhat higher than emissions from a petroleum refinery, hence lifecycle emissions are higher.

While I believe that there are better alternative, if coal is to be used to replace gasoline, generating electricity for use in plug-in hybrid vehicles (PHEVs) can be far more efficient and cleaner than making liquid fuels. In fact, a ton of coal used to generate electricity used in a PHEV will displace more than twice as much oil as using the same coal to make liquid fuels, even using optimistic assumptions about the conversion efficiency of liquid coal plants.[2] The difference in CO_2 emissions is even more dramatic. Liquid coal produced with CCS and used in a hybrid vehicle would still result in lifecycle greenhouse gas emissions of approximately 330 grams/mile, or **ten times** as much as the

[2] Assumes production of 84 gallons of liquid fuel per ton of coal, based on the National Coal Council report. Vehicle efficiency is assumed to be 37.1 miles/gallon on liquid fuel and 3.14 miles/kWh on electricity.

33 grams/mile that could be achieve by a PHEV operating on electricity generated in a coal-fired power plant equipped with CCS.[3]

Biofuels Environmental Performance Principles

The benefits of biofuels can be realized, and the potential pitfalls avoided, through carefully crafted policy. Here I outline key principles that should be incorporated into any expansion of the renewable fuels standard through a combination of robust performance standards, careful definitions of what qualifies as renewable fuel, and incentives to promote voluntary management practices that protect ecological values. These principles were endorsed by twelve leading environmental organizations in a letter sent to Congress on March 27th, which is attached to my testimony for the record.

- *The use of bioenergy must reduce greenhouse gas emissions.*

To assure benefits, new incentives and requirements for increased use of biofuels need to be tied to significant reductions in the greenhouse gas intensity of these fuels. As discussed above, this requires explicit greenhouse gas performance standards rather than an implicit assumption that certain feedstocks will produce greater benefits than others. The most effective approach is to cap total greenhouse gas emissions from transportation fuels and require progressive reductions in the average greenhouse gas emissions per gallon of transportation fuels sold, as California is planning to do. If the renewable fuels standard is expanded, conventional biofuels should be required to achieve at least a 20% reduction in lifecycle greenhouse gas emissions compared to conventional gasoline, as

[3] Assumes lifecycle greenhouse gas emission from liquid coal of 27.3 lbs/gallon and lifecycle greenhouse gas emissions from an IGCC power plant with CCS of 106 grams/kWh, based on R. Williams et al., paper presented to GHGT-8 Conference, June 2006.

adopted by the Senate Energy Committee. This level of performance can easily be achieved with efficient corn ethanol plants as shown in Figure 1. Advanced biofuels should achieve at least a 50% reduction in lifecycle greenhouse gas emissions, which can be accomplished through several different feedstock and conversion process combinations.

- *Biomass used for bioenergy has to be renewable.*

Biomass must be regrown on site, recapturing its released carbon, so that it is genuinely sustainable – unless it is the by-product of activity with independent, over-riding social utility (such as removal of vegetation immediately around wildland-interface homes). Greenhouse gas emissions from land-use change associated with biofuels production, both directly and indirectly, must be accounted for to ensure that biofuels are genuinely renewable and produce net environmental benefits. If wastes are used, care must be taken to prevent combustion of any toxic materials, such as pressure treated or painted wood products. In addition, material such as post-consumer waste paper should be recycled rather than converted to fuel in order to reduce the pressure on forests for virgin fibers.

- *Bioenergy feedstocks must not be grown on environmentally sensitive lands*.

Some areas should simply be off limits for biofuels production. Biofuels should not qualify toward compliance with any renewable fuels standard if the biomass is obtained from old growth forests, wilderness study areas, roadless areas of national forests, native grasslands, important wildlife habitat, or ecosystems that are intact, rare, high in species richness or endemism, or exhibit rare ecological phenomena.

- *Conversion of natural ecosystems must be avoided*.

Habitat loss from the conversion of natural ecosystems represents the primary driving force in the loss of biological diversity worldwide. Activities to be avoided include those that alter the native habitat to such an extent that it no longer supports most characteristic native species and ecological processes.

- *Exemptions and waivers from environmental rules must not be used to promote biomass production or utilization*.

Trading one serious environmental harm for another is poor policy. Our environmental laws and regulations act as a fundamental system of checks and balances to guard against just such collateral damage and the promotion of bioenergy production and utilization must in no way be exempted.

- *Conservation and Wetland Reserve Programs supported by the Farm Bill must be managed for their conservation benefits.*

These programs protect marginal lands, water quality, soil, and wildlife habitat. Enrolled lands need to be managed principally for these important values, not bioenergy feedstocks.

- *Independent certification, market incentives, and minimum performance requirements are necessary to ensure that bioenergy feedstocks are produced using sustainable practices.*

Certification standards for biomass from private lands should address key environmental and social objectives, such as protection of wildlife habitat, prevention of erosion, conservation of soil and water resources, nutrient management, selection of appropriate feedstock species, and biologically-integrated pest management. New policies are needed to ensure that producers, refiners and distributors adhere to minimum performance requirements and have incentives to maximize environmental performance at each step.

- *Stringent safeguards must be established for bioenergy production from feedstock derived from federal land.*

Federal lands, including wildlife refuges, national forests, and national grasslands, are held subject to the public's interest in their non-commodity values. They are not appropriate for large-scale, sustained biomass sourcing.

Implementation of the Renewable Fuels Standard

EPA recently issued its final rules to implement the renewable fuels standard (RFS) enacted as part of the 2005 Energy Policy Act. Congress appropriately assigned this responsibility to EPA as it has the authority to regulate transportation fuels under the Clean Air Act as well as experience with implementing credit trading programs. Any expansion of the RFS should similarly be implemented by EPA and should build on the system of Renewable Identification Numbers (RINs) established by EPA to implement the existing program.

EPA has also already explored how the RIN system could be expanded to track environmental practices in biofuel feedstock production as well as lifecycle greenhouse emissions. While some may argue that there is insufficient information available to implement a program based on lifecycle greenhouse gas emissions this is not the case. Statewide data on average yields, and energy and fertilizer use for different crops can be combined with specific information for individual biorefineries to arrive at reasonable estimates of lifecycle greenhouse gas emissions for each batch of biofuels. Indeed, although the administration ultimately rejected it, EPA proposed to label renewable fuels based on their lifecycle greenhouse gas emissions as well as the sustainability of feedstock production methods under the RFS. Hence EPA has already done most of the policy and methodological development needed to implement an expanded RFS that includes greenhouse gas performance standards and incentives for management practices that protect ecological values.

It is important to recognize that an effort to dramatically increase the use of biofuels must not ignore the potential adverse impacts such use may have on air quality. It is widely recognized that when ethanol, whether derived from corn or cellulosic biomass, is mixed with gasoline and burned in today's vehicles, some emissions go up and some go down. Further, it is understood that the magnitude of these emissions is significantly affected by both the parameters of the fuel in which the ethanol is used and the air pollution control and other equipment on the vehicles that burn the fuel. NRDC has focused most on the emissions that contribute to smog, but we must not ignore the potential for increases in particle pollution and toxic air pollutants. I would like to emphasize that the latest scientific research indicates that our current National Ambient Air Quality Standard for ozone (smog) does not provide an adequate level of safety. Therefore, it is critically important that we continue to reduce the emissions that contribute to smog even as we promote ways to transition our nation's transportation system to low-carbon biofuels.

EPA's Regulatory Impact Analysis that accompanied its recent renewable fuels standard (RFS) rulemaking found that, particularly in the areas that do not use gasoline with special limits to volatility, the use of the mandated levels in the current RFS will increase smog emissions 4-6 % (Table 4.1-12) with the possibility that NOx emissions might increase as much as 10% (Table 4.1-13). Clearly the prospect of adopting an RFS that more than quadruples the amount of ethanol mandated to be used in the nation's fuel supply demands an examination of such fuel use on smog impacts. Any such legislation should require serious analysis of the potential impact of a large ethanol increase on emissions, and a requirement that new volumes of ethanol be introduced in transportation fuel in ways that, at a minimum, do not increase the current levels of smog-forming pollutants in the nation's vehicle fleet. Further, the introduction of such fuels should also not increase toxic air pollutants or particle pollution.

To accomplish these sensible – and we believe uncontroversial – objectives, NRDC urges Congress to direct EPA to adopt regulations requiring that the emissions of any air pollutant from vehicles using renewable fuel shall be no greater than the level of such emissions from vehicles when using conventional gasoline. This is a straightforward no-backsliding requirement that will ensure that ethanol actually lives up to the name of being a cleaner fuel, delivering very real global warming benefits while not worsening air quality.

Moreover, Congressional action should address EPA's recent objectionable Clean Air Act rulemaking allowing new and upgraded ethanol plants to increase harmful emissions of smog and soot pollution by evading the need for air pollution controls that have always been required at these plants. Recently amended EPA rules now allow new biorefineries to more than double their emissions of harmful air pollution before they are required to install pollution controls, with the agency having increased the regulatory control threshold from 100 tons per year to 250 tons per year. Moreover, this rule will also allow existing ethanol plants to be even dirtier than allowed under pre-existing law, increasing smog and soot pollution and evading controls that the law has always required. The harm caused by this EPA rulemaking will be worsened by the recent disturbing trend of biorefineries resorting to coal to fuel ethanol production. Indeed, many observers believe that EPA's recent rulemaking was adopted precisely for the purpose of allowing these coal-burning biorefineries to be built and to avoid pollution control equipment that clean air rules required prior to EPA's rollback. EPA admits, as it must, that its recent rulemaking will create more air pollution from these facilities.

Congress should reject this indefensible EPA action that makes ethanol production dirtier at precisely the moment that there is a proliferation of these plants around the country. Moving forward with a new RFS to more than quadruple the amount of ethanol mandated in the nation's fuel supply *without* reversing EPA's harmful rulemaking will only ensure more air pollution, more hazy skies, and more health problems for the American people,

An expanded RFS should also be updated to accommodate renewable electricity used for transportation in emerging vehicles, such as Plug-in Hybrid Electric Vehicles (PHEVs). This can be accomplished by allowing electricity providers to opt into the program as fuel providers as long as they use smart meters to track separately renewable electricity supplied for transportation purposes. With the emergence of PHEVs and other electric vehicles, renewable electricity can be an important additional option to augment renewable biofuels to supply non-petroleum, low greenhouse gas fuels for transportation.

Conclusion

Renewable fuels hold great promise as a tool for reducing global warming pollution, breaking our dangerous oil addiction, and revitalizing rural economies, as long as appropriate standards and incentives are used to shape the nascent bioenergy industry to provide these benefits in a sound and truly sustainable fashion. I look forward to working with the Committee to accomplish this important goal.

Appendix. Basis for Figure 1.

Figure 1 compares the well-to-wheels (or full fuel cycle) emissions from alternative transportation fuels in pounds of CO2-equivalent per gallon of gasoline energy content equivalent. The basis for each bar is described briefly below:

Liquid Coal (no CCD): Fischer-Tropsch fuel produced from coal without carbon dioxide capture and disposal (CCD). Based on a stand-alone plant (R. Williams, Princeton University).

Tar Sands: Gasoline made from synthetic petroleum produced from Canadian tar sands. (Based on Oil Sands Fever, Pembina Institute, November 2005)

Ethanol (Corn, Coal): Ethanol produced from corn using coal for process energy at the ethanol plant. (Based GREET 1.7 beta as modified by Turner et al.)

Liquid Coal (CCD): Fischer-Tropsch fuel produced from coal with carbon dioxide capture and disposal (CCD) from the production plant and assuming a stand-alone plant. (R. Williams, Princeton University).

Gasoline: Conventional gasoline, including upstream emissions. (Based on GREET 1.7 beta)

Ethanol (Corn, Coal, CHP): Ethanol produced from corn using coal for process energy in a combined heat and power system at a new dry mill ethanol plant. (Based GREET 1.7 beta as modified by Turner et al.)

Ethanol (Corn Average): Estimate of the national average emissions rate from the current mix of fuel used for ethanol production and the current mix of dry and wet mills. (Based on GREET 1.7 beta as presented in Wang et al., "Life-Cycle Energy and Greenhouse Gas Emissions Impacts of Different Corn Ethanol Plant Types," presentation to 16th International Symposium on Alcohol Fuels, November 2006.)

Ethanol (Corn, NG): Ethanol produced from corn using natural gas for process energy at a dry mill ethanol plant. (Based GREET 1.7 beta as modified by Turner et al.)

Ethanol (Corn, NG, CHP): Ethanol produced from corn using natural gas for process energy in a combined heat and power system at a new dry mill ethanol plant. (Based on GREET 1.7 beta as presented in Wang et al., "Life-Cycle Energy and Greenhouse Gas Emissions Impacts of Different Corn Ethanol Plant Types," presentation to 16th International Symposium on Alcohol Fuels, November 2006.)

Ethanol (Wet Grains): Same as “Corn, NG,” except that plant sells wet distiller grains as a coproduct, saving the energy of drying the grains. (Based GREET 1.7 beta as modified by Turner et al.)

Biodiesel: Biodiesel derived from soy oil through fatty-acid methol-esterfication estimate including upstream emissions. (Based on GREET 1.7 beta)

Ethanol (Corn, Biomass): Same as Corn No Till, except that biomass is used for process energy. (Based GREET 1.7 beta as modified by Turner et al.)

Ethanol (Corn, Biomass, CCD): Ethanol produced from corn using biomass for process energy at a dry mill ethanol plant with capture and disposal of the CO2 produced from the fermentation process. Corn is grown with no-till practices and plant sells wet grains. (Based GREET 1.7 beta as modified by Turner et al. subtracting fermentation CO2 of 6.6 pounds of CO2 per gallon of ethanol per http://www.kgs.ku.edu/PRS/Poster/2002/2002-6/P2-05.html.)

Ethanol (Switchgrass): Ethanol produced from the cellulose in switchgrass using the lignin for process energy. (Based GREET 1.7 beta as modified by Turner et al.)

Ethanol (Switchgrass, CCD): Ethanol produced from the cellulose in switchgrass using the lignin for process energy with capture and disposal of the CO2 produced from the fermentation process. (Based GREET 1.7 beta as modified by Turner et al. subtracting fermentation CO2 of 6.6 pounds of CO2 per gallon of ethanol per http://www.kgs.ku.edu/PRS/Poster/2002/2002-6/P2-05.html.)

Sources:

The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model, GREET 1, Version 1.7, developed by the UChicago Argonne, LLC as Operator of Argonne National Laboratory under Contract No. DE-AC02-06CH11357 with the Department of Energy (DOE).

Turner et al., “Creating Markets for Green Biofuels, Measuring and Improving Environmental Performance,” UC Berkeley Transportation Sustainability Research Center, publication pending.