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Developing Low Carbon Ethanol For California

How to cut 10 percent global warming pollution from gasoline

The California Global Warming Solutions Act of 2006[i] (AB 32) calls for greenhouse gas reductions back to 1990 levels by the year 2020. E2 believes that this goal is achievable with available technology, and that the reductions will also spur a greater diversity of energy supplies and in some cases, lower costs for energy.

One important strategy is to displace gasoline with very low polluting biofuels made from feedstocks grown on California farms. Biofuels have the double benefit of both reducing greenhouse gases and keeping money that would otherwise buy crude oil overseas in California helping out own economy.

Making Ethanol – from corn to sugar to cellulosic feedstocks

Ethanol in the U.S. is almost entirely made from corn today with a moderate reduction in global warming pollution as compared to gasoline. California producers are the most efficient in the U.S. in part because they do not use coal nor do they need to dry the "distillers grain". Sugar feedstocks – sugar cane, sweet sorghum and sugar beets – are even more efficient and can produce ethanol with very little global warming pollution. In particular, sugar cane and sweet sorghum can produce both renewable ethanol and renewable electricity and are well suited to California agriculture. Cellulosic ethanol will be the lowest in greenhouse gases but production capacity is still in the future.

Global Warming Pollution From Gasoline

On average, about 25 pounds of CO2 are released for each gallon of gasoline (20 from the vehicle and 5 from the refinery process[ii]). California will use about 15 billion gallons of gasoline per year in 2020 for a total of 375 billion pounds of CO2. Converted to million metric tons (MMT), this would be 170 MMT. A ten percent reduction or 17 MMT would require replacing 1.5 billion gallons of gasoline with 2.5 billion gallons of ethanol. This assumes the ethanol is 90% free of carbon emissions and that it takes 1.5 gallons of ethanol to move a car the same distance as 1 gallon of gasoline. More ethanol is needed because it contains 33 percent less energy per volume than gasoline.

Producing 2.5 Billion Gallons of Low Carbon Ethanol

When ethanol is made from sugar crops such as sugar cane or sweet sorghum it produces significantly less global warming pollution than when it is produced from corn because the fiber from the plant can be used to produce substantial amounts of heat and renewable electricity which can both power the bio-refinery and produce excess power for the grid. Approximately 500 kilo-watt-hours of excess electricity can be produced from a ton of dry fiber (for sugar cane, dry fiber constitutes about 27% of the biomass of the fresh crop). In an ethanol optimized production facility, only about 35% of the total electricity produced is needed to convert the sugar cane to ethanol. Thus sugar crops can be a significant source of both low carbon ethanol and renewable electricity, as demonstrated in Brazil and elsewhere.

Sugar Cane and Sweet Sorghum Examples

California's Imperial Valley has excellent growing conditions for sugar cane – irrigated conditions that provide twice the yield per acre than achieved in Brazil. A University of California at Riverside study concluded that one acre of sugar cane can produce a minimum of about 1200 gallons of ethanol per season and a maximum of 2,100[iii]. Using the lower number, an acre produces:

1200 gallons of ethanol + 8.4 tons of fiber which can be converted into 4.2 Megawatt-hours electricity available to the grid (based on 50 tons/acre and 24 gallons ethanol/ton).

Sweet Sorghum can grow in many farming regions of California and produces a mature crop in only 4 months. In each 4 month cycle one acre of sweet sorghum produces:

600 gallons of ethanol + 8.4 tons of dry fiber which can be converted into 4.2 Megawatt-hours electricity.

Optimizing Energy Crops

In the timeframe of 2020, four significant improvements are likely for increasing the yield per acre of cane and sorghum. First, crops can be selected to maximize their sugar and fiber content. For example, existing species of high-fiber cane can produce 40% more sugar and 2.5 times the fiber per acre than traditional cane used for making crystalline sugar. Second, companies have proposed changes to the fermentation process from sugar to alcohol which improve the yield by more than 50%[iv]. Third, in a ten year time frame, it can be expected that cellulosic ethanol will be able to cost-effectively produce 80 gallons of ethanol per dry ton of biomass. Fourth, electricity from fiber can be produced by gasification instead of combustion providing a 50% increase in the amount of electricity produced per dry ton of fiber or biomass.

Using a hi-fiber cane and assuming an improved fermentation process and increasing yield from 50 to 65 tons per acre, Imperial Valley sugar cane would produce per acre:

3,276 gallons of ethanol + 27.3 tons of fiber which can be converted into 13.65 Megawatt-hours electricity.

With an improved fermentation process sweet sorghum would increase to 900 gallons of ethanol per acre + 8.4 tons of fiber which can be converted into 4.2 Megawatt-hours electricity.

2020 Potential for California Grown, Low Carbon Fuel

There may be up to 300,000 acres of land in California which can profitably grow sugar cane without an increase in water usage. We estimate that crops of sweet sorghum could be grown on 500,000 non-dedicated acres annually, throughout the state. In some cases, more than one crop of sweet sorghum would be grown per year but let us assume one crop. By 2020, 800,00 acres would annually produce:

1.43 billion gallons of ethanol + 6,195 Gigawatt-Hours of exportable, renewable electricity.

An additional 1.3 billion gallons of ethanol and 317 Gigawatt-Hours of power would come from conversion of 16 million dry tons of cellulosic material converted at the rate of 80 gallons/ton[v] and electricity at 24.4 Gigawatt-hour per 100M gallons.

Summary

Sugar crop can be expected to start producing low carbon fuel in 100 million gallon quantities within 5 years. Improvements in the fermentation process and optimized crops can be expected in 6 – 10 years to produce about 1.5 billion gallons per year. Cellulosic ethanol can be expected to begin volume production in 6 years and be at the billion gallon level within 10 – 15 years. It is reasonable that production could be at 2.5 billion gallons/year by 2020 and displace enough gasoline to reduce global warming pollution by 17 MMT. Electricity production of 6,195 Gigawatt-hours represents about 2% of total expected demand in 2020[vi] and a 20% increase above our current renewable generation of 31,000 Gigawatt-hours.

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[i] "California Solutions for Global Warming" - www.solutionsforglobalwarming.org/index.html
[ii] Joe Romm - autos.groups.yahoo.com/group/calcars-news/message/65
[iii] "An Overview of the Feasibility of Establishing a Sugar Cane to Ethanol Industry in the Imperial Valley of California", Paul Sebesta, et. Al, The University of California Desert Research and Extension Center.
[iv] Zeachem - www.zeachem.com/tech.html
[v] Growing Energy: - www.nrdc.org/air/energy/pump/contents.asp
[vi] California Energy Demand Forecast 2006-2016 - CEC-400-2005-034-SF-ED2, September 2005