

# Biomass

## Physics and Mathematics of Sustainable Energy

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1. In 2016 passenger cars in the US drove a total of 3.21 trillion miles<sup>1</sup> and the average fuel efficiency was 24.7 mpg<sup>2</sup>.
  - (a) How much fuel is used in the US by all cars in one year?
  - (b) Suppose we wanted to replace all of this gasoline<sup>3</sup> with ethanol derived from US corn? How much land would be required? Express this area in some way that makes sense.
  - (c) Suppose we wanted to replace all of this gasoline with ethanol derived from Brazilian sugar cane? How much land would be required? Express this area in some way that makes sense.

(Note, btw, that this doesn't include the fuel used for trucks and planes.)
2. To heat an average home in Maine requires approximately 540 gallons<sup>4</sup> of fuel oil per year
  - (a) How much thermal energy does this fuel oil produce? Answer in BTUs and kWh.
  - (b) What power does this correspond to?
  - (c) Suppose that you decide to heat your house with wood. Assume that the efficiency of your woodstove will be the same as the efficiency of your oil furnace.<sup>5</sup> How much land would you need to get this amount of power? Refer to Fig 18.1 from the textbook. (Let's use 0.5 W/m<sup>2</sup>.)
  - (d) There are very roughly half a million homes in Maine (<http://www.census-charts.com/HF/Maine.html>, accessed November 6, 2017.) How much land would be needed if all of Maine was to heat with wood? Put this number in perspective. Is this a little or a lot? What fraction of Maine is this?

Some useful info:

- Corn ethanol in the US produces 900 gallons per hectare.
- One hectare is 10,000 m<sup>2</sup>.
- Calorific value of ethanol: 75,600 BTU/gal.
- Calorific value of pure gasoline (petrol): 115,000 BTU/gal
- Burning one liter of oil releases 10.5 kWh of energy.
- Burning oil releases 260 grams of CO<sub>2</sub> per kWh.

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<sup>1</sup><https://afdc.energy.gov/data/10315>

<sup>2</sup><https://www.reuters.com/article/us-autos-emissions/u-s-vehicle-fuel-economy-rises-to-record-24-7-mpg-epa>

<sup>3</sup>The calorific value of ethanol is significantly less than that of gasoline, meaning that the "gas" mileage for a car running on pure ethanol will be perhaps as much as 40% less than using pure gas. But to simplify our calculation, let's pretend that their mileages are the same.

<sup>4</sup>[https://www1.maine.gov/energy/fuel\\_prices/heating-calculator.php](https://www1.maine.gov/energy/fuel_prices/heating-calculator.php), accessed November 6, 2017.

<sup>5</sup>This might not be a super assumption, but since in what follows we're interested in getting a very rough estimate, I think this assumption is ok.