An Introduction to Sustainable Energy

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Why Care about Energy?

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1. Climate change
2. Unreliable imports & national security
3. Fossil Fuels will run out
4. Supporting local economies
5.

Challenges when Thinking about Energy

1. The problem is enormous
2. It's depressing and makes me feel bad
3. It is hard to make sense of the numbers. What is big and what is small?
4.

My Goals for Today's Presentation

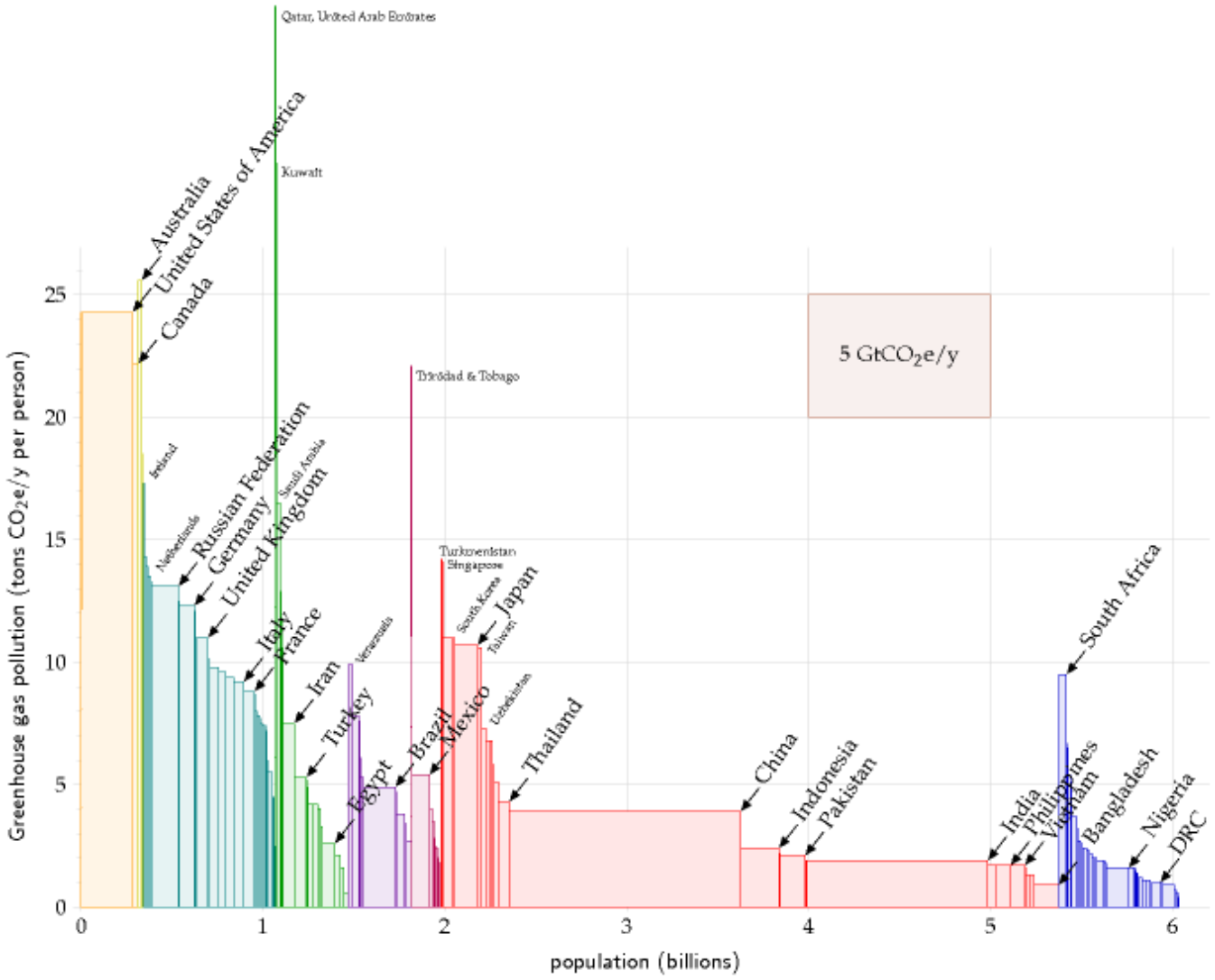
1. Present some numbers in a way that is easy to understand.
2. Give a sense of the scale of the problem.
3. Give a sense of the scale of some possible solutions.
4. Make the global issue of energy use seem a tiny bit more understandable.

- **Main Reference:** David MacKay's *Sustainable Energy—without the hot air*.
- Available free at `http://withouthotair.com/`!
- Except where noted, all figures and date are from this book.

Carbon Dioxide

- Total greenhouse gas emissions in one year: 34 Giga Tons of Carbon Dioxide Equivalent.
- Ummmmm.....
- Easier to think in terms of CO_2 per person.
- Average greenhouse gas emissions per person: **5.5 tons per year**.
- How much emissions do you think the average person in the U.S. is responsible for?
- How about China?

Carbon Emissions, by Country



The Carbon Problem is an Energy Problem

- Most scientists think that to have a reasonable chance of avoiding catastrophic climate change we to reduce the global emission of CO_2 to **One ton per person per year**.
- This means that we need to think in terms of reducing fossil fuel use by 90%.
- We thus must drastically increase renewable energy generation and/or decrease consumption.
- What would it take to do this?
- How much energy to we use, and where does it come from?
- Fossil fuel = coal, oil, natural gas.
- Renewable/Sustainable = wind, tidal, solar, biomass, wood, wave, nuclear(?)

Total US Energy Use, 2008

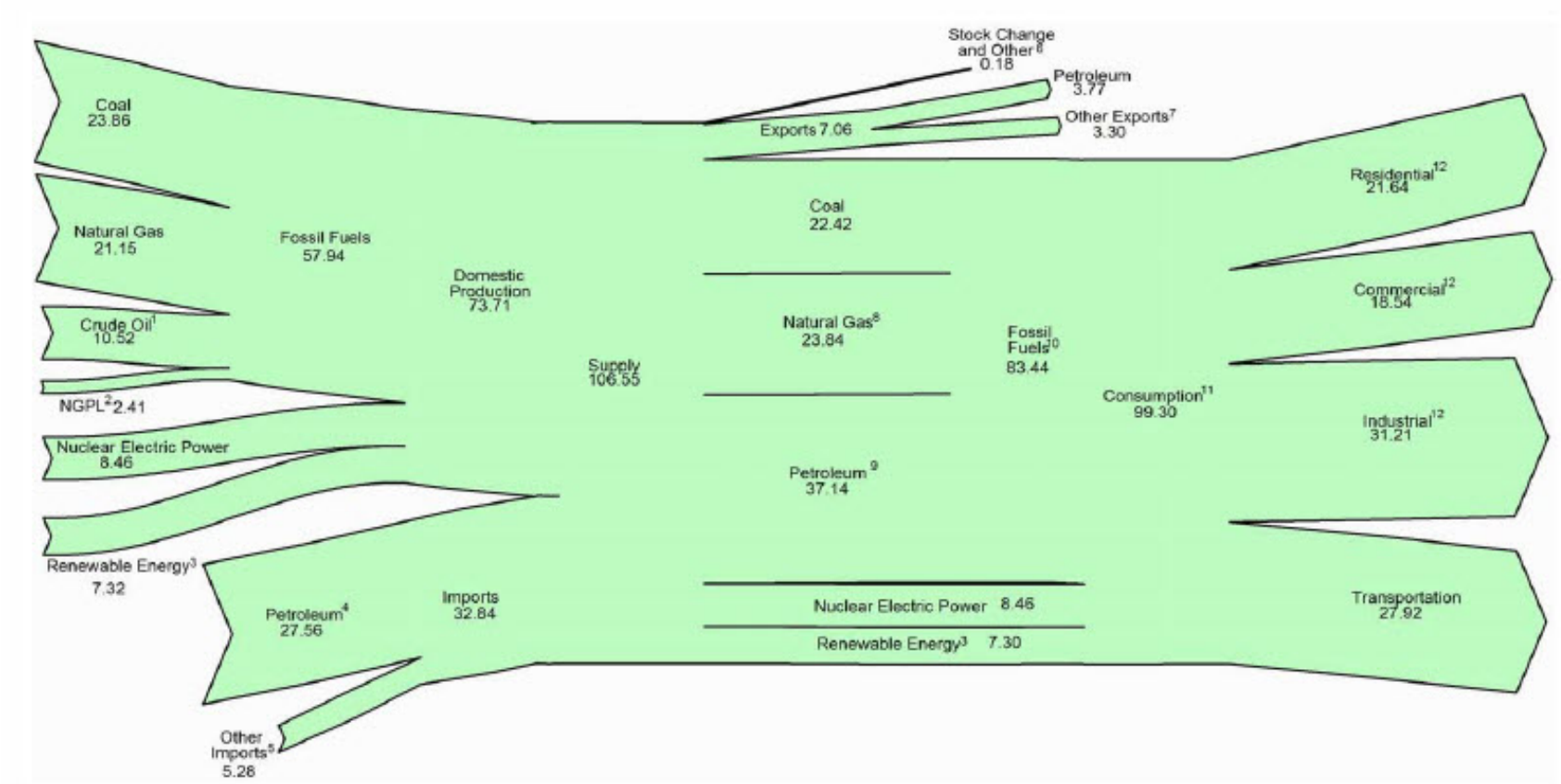


Figure Source: `http://www.eia.doe.gov/aer/diagram1.html`

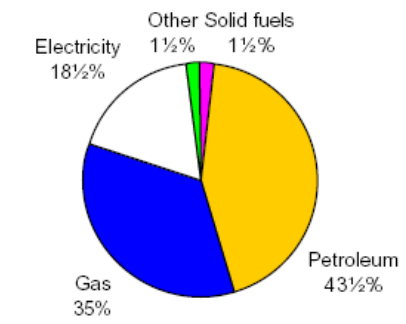
Units and Numbers

- Avoid millions and billions and trillions
- Numbers must be understandable and comparable
- Usually easier to think in terms of per person
- Energy Unit: kWh
- Power = kWh per day $\approx$ 40 W

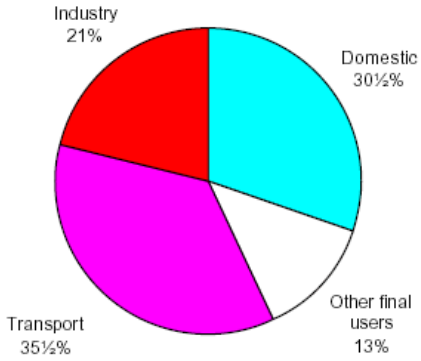
Examples

- 1 kWh = leaving one 40W light bulb on for 24 hours
- Driving 35 miles = 45 kWh
- Producing food for you for one day = 12 kWh
-

Average power consumption, UK: 125 kWh/d/p



2004



www.dti.gov.uk

125 kWh/day (Europe)
250 kWh/day (USA)

(Not including embodied energy in imports nor solar energy used by agriculture)

For CO_2 pollution, divide by 10:
100 kWh/day $\simeq$ 10 tonnes CO_2/y

Figure Source: David MacKay, `http://tinyurl.com/35ry89b`.

Energy Consumption: What is big, what is small???

Very Roughly:

- One round trip flight from London to Los Angeles: 26 kWh per day.
- One round trip flight from London to Los Angeles: Leaving your toaster on all day for an entire year.
- Driving 30 miles: 40 kWh
- Lights in your home: 4 kWh per day
- Heating your house in Maine: 120 kWh per day
- One day of charging your cell phone = one second of driving!
- Making the stuff you use (car, computer, etc): 40 kWh per day
- Typically half of the energy use associated with a car is from *making* it, not driving it.

Can We Meet Our Power Needs with Renewables?

- Renewables are diffuse—they require a lot of area.
- Let's consider wind as an example.
- A typical wind farm yields 2.5 W per square meter.
- So, if all of MDIHS's students got all their power from wind, this would require a wind farm around 2 km^2.
- This is 0.77 square miles, or 400 soccer fields.
- To power all of Maine solely with wind would require a wind farm roughly twice as large as Rhode island.

To Make a Difference, Renewables Must be Country-Sized

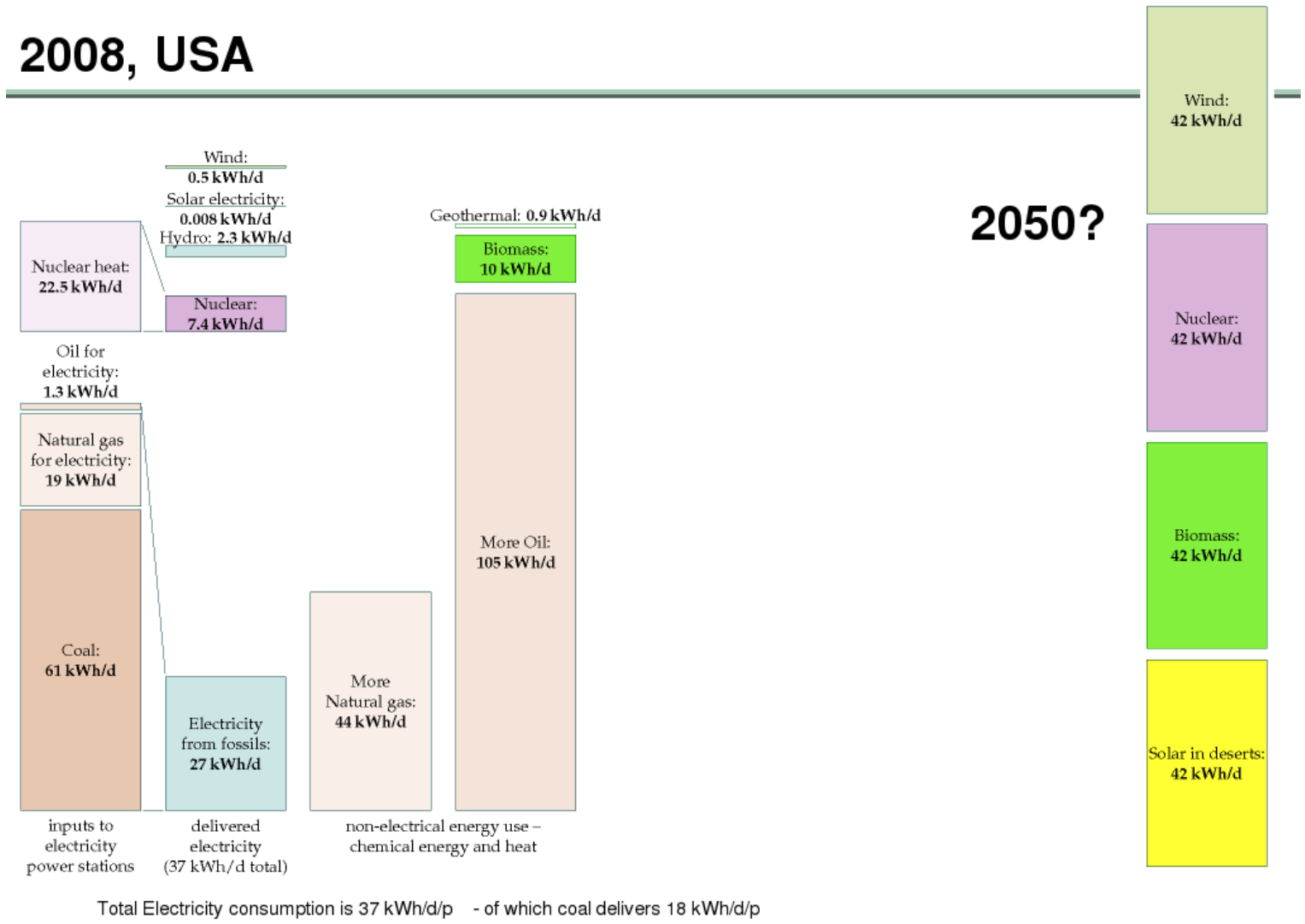
- A similar story holds for solar, tidal, biomass, and wave energies.
- Their potential is large, but it takes a lot of land.

What is to be done?

- If everybody does a little bit....

“Every-Little-Bit-itis”

- If everyone does a little bit, it will make a small difference.
- If everyone cuts their energy consumption by 2%, worldwide energy consumption will be cut by 2%.
- Small improvements, like using compact fluorescent light bulbs, are of course good things to do.
- But we need to think big.



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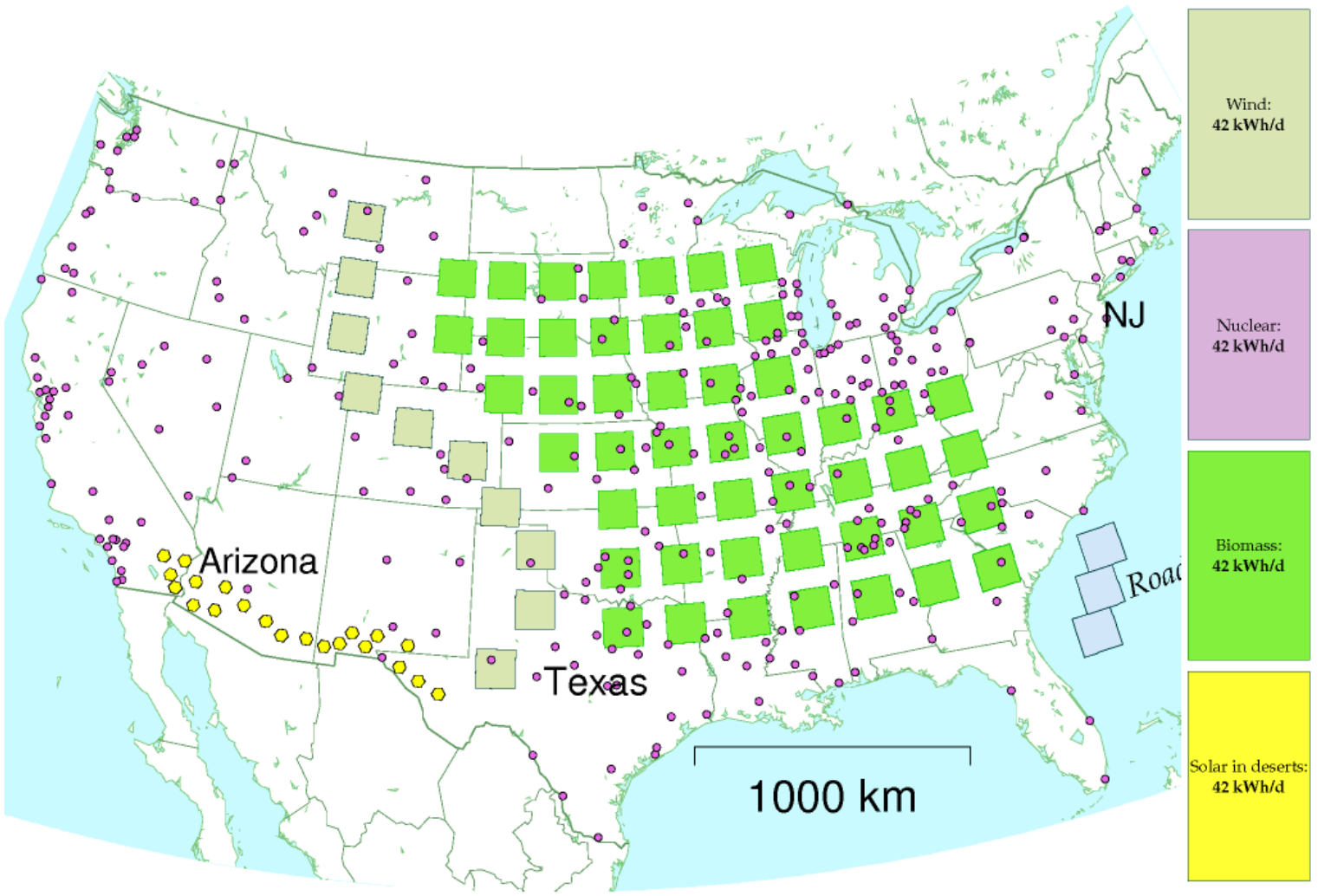


2100 GW of wind (60-fold increase)
525 one-gigawatt nuclear power stations (five-fold increase)

Figure Source: David MacKay, `http://tinyurl.com/35ry89b`.

Personalized

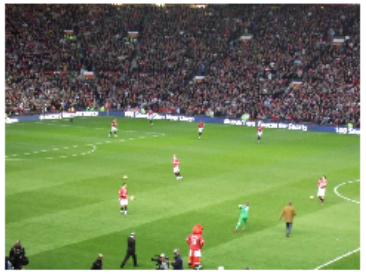
Wind:
42 kWh/d

One 2-MW turbine for every 300 people

Nuclear:
42 kWh/d

7 nukes for LA
5 nukes for Chicago
4 nukes for Houston
2 nukes for San Diego
1 nuke for Denver CO
1 nuke for Boston MA
1 nuke for Las Vegas NV
1 nuke for Portland OR...

Biomass:
42 kWh/d



4000 sq m per person

Solar in deserts:
42 kWh/d

30 eSolar mirrors per person; &
one tower for every 400 people

Figure Source: David MacKay, `http://tinyurl.com/35ry89b`.

Big Thoughts

In my opinion...

- No single energy source is the answer. We need multiple options.
- It is important to electrify the transportation system.
- A lot of energy consumption is “hidden.” It’s not light bulbs and refrigerators, but the cost of making and transporting our food and the stuff we buy.
- We need to buy less new stuff and eat a lot less meat.
- Energy needs to cost more.
- It is easy to say no to renewable energy options. We have to figure out how to say yes.
- We better get started. There is an enormous amount of work to do.

Some Non-tiny Individual Actions

Here are some things you can do. These numbers are very approximate.

- Turn your thermostat down several degrees: 20 kWh /day
- Stop flying: 35 kWh/day
- Drive less: 10 kWh/day
- Eat vegetarian, six days out of seven: 10 kWh/day
- Buy less clutter and junk: 20 kWh/day

But this is not enough.

Conclusions

- There are a lot of misleading and wrong numbers thrown around about energy.
- Practice translating numbers into understandable terms. MacKay's book (`http://withouthotair.com`) is fantastic at this.
- Energy is a big problem. It needs big solutions.
- I don't know how (or if) we will solve the energy problem. But I know that running from the facts won't help.
- Don't feel guilty. Don't get depressed. Get to work on big solutions and have fun while doing it.

Thanks for your Attention!

Questions, Comments, Rebuttals?

Thanks to:

- Anna Demeo
- Students in our sustainable energy at COA.
- Maine Space Grant Consortium Research and Higher Education Program.

If you want to continue the discussion or have questions later, please feel free to email me or call me at COA.