SP.721 (D-Lab) Fall 2004
Session #20 notes

Course administration preamble:

- Handout: "Distributed power modeling and life cycle assessment"
- Take-home quiz due today
- Homework "Distributed Power Modeling" handed out today – due next Wednesday (session #24).
- Worksheet Assignment on Energy Use handed out today, due next class (session #21). Reflect on this for a few minutes and fill it in…rough estimates are OK.

Energy Issues in Developing Countries

Lecturer: Kurt Kornbluth

This session will focus mostly on distributed power, will not be exhaustive on every possible technology. The last 20 min. will be a demonstration of a computer-based power simulation tool called HOMER.

Background Review of Electric Power concepts

What's the difference between AC and DC?

If you're running DC, what's a common voltage? 12 Vdc, like car battery.

If you're running AC, what's a common voltage? 110 V 60 Hz (US), 220 V 50 Hz (Europe), 230 V 50 Hz (Bangladesh).

Power = voltage x current, i.e. 12 V x 5 Amps = 60 watts.

Power over period of time = Energy, unit is kilowatt-hours. Using 60 watts for 5 hours = 300 watt-hours or 0.3 kwh (kilowatt-hour).

What does a battery store? Energy. How are batteries rated? A 12 V battery is rated at 30 amp-hour. How much energy does this hold? 12x30 = 360 watt-hours.

If you have a 60 watt TV, how long can you watch TV with this 360 W battery? Less than 6 hours, due to inefficiencies; you need a charge-controller device between battery and TV, can't draw ALL the energy out of a battery…

What's a renewable energy source? Solar, wind, hydro, geothermal. What about wood? Can be renewable if you plant enough trees to replenish what's cut down.

[Slides were shown for the following, but are not available.]

Sources of Power and Applications

1. TV in a "wealthy poor" household in Bangladesh, run on batteries.

2. Lighting, with a charge controller + switches. $250 gives them about 5 yrs worth of lighting/energy.
3. Cooking. How do you cook w/ cow dung? Form into disk, dry it and it burns. Creates lots of smoke.
4. Biogas for cooking. Biogas is also made from cow dung.
5. Pumping/grinding.
6. Several slides on solar and thermal energy applications.

Discussion/Context

7. Why generate electricity? More reliable. Easy to transport. Enough light to study by (not good w/ kerosene). Multiple uses, common resource.
   (Q: what's the most efficient way to store energy? A: that depends on how quickly you discharge or use it, how long you store it, manufacture/recycling options…)
8. Electrical Use (table). US usage is not uniform; Wyoming uses 20 kwh per capita, due to heating needs, whereas California is about 7 kwh (same as Japan).
   (Discussion about why the spread? Extremes of climate have big impact. Also, where electricity is sporadic, lifestyle doesn't expect it and is less built around it)
9. Bangladesh electrification project. Assuming 5 people for household, at current rate (2M people per yr going on grid) it will take 40 years assuming no population growth!
10. Picture of rural electrification – wires everywhere. Note that demand outstrips generation capacity, and people keep going on grid due to UN initiative. This motivates distributed power, local generators…
11. Small Scale Distributed electricity generation. This slide lists sources that can be used for distributed power schemes.

Distributed power solutions

12. Diesel generators
13. Micro-hydro. Can be really small, i.e. 1 kwh
14. Wind turbines. Upper right Nepal, this group travels and sets up its own turbine. The other two images are from China.
15. Distributed power considerations. These criteria will be considered in doing our modeling project. Load is the sum of power requirements of the electrical devices you're trying to serve. If you have a 50W generator and need to supply 100 W peak load for 4 hours, run the generator for 8+ hours and store the surplus to be delivered later.

HOMER modeling

HOMER is an optimization model for distributed power, developed by NREL, the National Renewable Energy Laboratory. The software tool is available as free download at http://www.nrel.gov/homer/.

Walk through Kurt's sample files. Example "Gasoline" to learn the tool. Equipment Add/Remove, Economic Inputs…then create a load profile. Walk through example "PV."

Note that generators like to run at full load – so if the actual demand is less, you should have a way to store the extra power generated. See the DView tool to compare plots over time of generator power, storage, and loads.)

The class discusses the HOMER homework assignment. Hybrid system means a combination of some renewable source plus other source or storage subsystem. Each group should include a half-page discussion on their conclusion. Use an informal lab report format.