Project notes for GEOS24705
EJM 5/14/2012

This handout provides some guidance on final class projects, since it is time to begin thinking about them very seriously. Problem set size will decrease from now on to allow people to focus time on projects instead. There are 4 weeks left before finals week.

The purpose of a project is to give you a chance to dive into one topic in depth and have a chance to explore with great independent responsibility, rather than doing canned problem sets. That is, it's a chance to do something more like you'd do in the working world or graduate school. In choosing topics, above all the topic should be something that you are interested in. You may also want to choose an area you're weak in, to give yourself a new educational experience you can't get otherwise (e.g. policy people learning to build something, or science types learning to do business calculations). Conversely if you're closer to graduation you may want to choose something more directly related to your career, to give you more practice in the most relevant areas. Both are OK strategies.

The usual schedule for projects is

- Identify your project group (usually with a tentative project topic in mind)
- Explore your tentative topic or topics, come up with a draft question to address and some thoughts on how to approach it, and set up a meeting with prof & TA to discuss
- Get approval or your project group and proposed project
- Make a division of initial work & set a schedule of meetings for when to convene
- Begin final write-ups before reading period – document as you go.
- Presentations during exam time during finals week
- Turn in report by the end of finals week

Guidelines follow:

Project groups should be 4-6 people and integrated. Integrated means that they should comprise people with diverse backgrounds and should not be all-male or all-female. The reason to require different backgrounds of group participants is to let you look at a topic in different ways - for example, if the project was on adoption of a new energy technology, you'd look at not only the engineering but also at the economics of its use and at policy means of promoting adoption.

Every project topic must be a question, that ends with an actual question mark. Not a general subject, but a specific question. ("Would proposed wind turbines in Lake Michigan off Evanston be profitable?" "Will the Illinois Renewable Portfolio Standard law achieve its stated goals?"). Even a build project should be phrased as a question so that you have a target for your design. ("Can I build a bicycle-powered generator that is cheaper than commercial systems?" "Can I build a wind turbine that produces a useful amount of power for typical Hyde Park wind conditions?"). *Don't pick a project for which you think you know the answer already.* The purpose is exploration, not advocacy.

Project questions should be interesting to someone other than yourself. At minimum, remember that your project will be read and graded by someone else (me), so if your particular topic has no interest to anyone besides yourself, it will be a very boring effort for the person grading it.

Projects should be rooted in reality. No studies of idealized cases ("imagine that technology X exists..") or generalized global estimates that don't depend on particulars. Since the project goal is to getting you grappling with real problems, make it as real as possible. The best projects also get you out of paper and screens and involve your having to pick up the phone and call someone (a facilities manager, an industrial energy user, a city planner).

Project questions should be of a scale that you could make progress in a few weeks. They aren't book reports where you do nothing other than summarize other reports. On the other hand, they also shouldn't be thesis-size questions on which you can make no progress at all. Think of a question whose answer you'd be interested in, and which you could go some distance towards answering in a few weeks of group reading and calculating. That being said, in one case a student project was eventually turned into a scientific paper (after another year of work). So extension is possible, but you want to have something that can feel satisfying by finals week.

Projects should be quantitative and involve an original calculation. To serve this goal, there is a requirement that every project must involve some graph that you make yourself. (A table is not enough - it should be a visual display of information). For some projects, it might be OK if the data that you graph are only compiled with no separate processing involved, but check with me if that looks like it will be the case for your group. I'm not looking for a level of calculation beyond that of the problem sets, but am looking for some ownership of the research - you have asked a question and you're going to make the calculations needed to answer it. If you can't think of a graph that's relevant to your project question, you're probably not asking a good question.

Project types:

The most common projects in the past have been **analyses of particular proposed energy systems** (technical and economic feasibility, or the implications of existing or proposed legislation). For this kind of project, the more specificity the better - you can analyze an actual proposal, or a plausible proposal on a real location, so that you have to grapple with the minutiae of real-life concerns that actually affect a project's success (land prices, zoning laws, market competition from other local providers, local regulations, energy markets, local regulatory landscapes). Specificity is your friend - it makes a project richer and more real (and more fun).

Some students have opted to do "**build projects**" that involve making something. Building something for educational demonstrations that can be used in future labs is especially encouraged. Build projects can be a great educational experience, but if you want to do a build project, think through the logistics carefully. Where will you get materials, where will you assemble and test, do you have the requisite skills in the group, do you have access to the necessary test equipment? Do you have enough time? Build projects always, always take longer than you expect and always involve some setback to fight through. (That's what makes them educational). We can reimburse expenses up to a few $100. Check in with a proposed budget before proceeding.

No one has yet opted to do **historical projects** but those would be very possible as well.

Projects that worked well in the past include

- Evaluation of trade-offs between closing Fisk and Crawford coal plants: increase in price of electricity vs. health effects. Students did a good job of really understanding the "dispatch stack" in the PJM market and the "shadow price" of electricity.
- Evaluation of the likelihood of fulfillment of the Illinois RPS standard. This evolved over two successive projects and then became a paper (see http://geosci.uchicago.edu/~moyer/GEOS24705/Readings/RPS.pdf).
- Evaluation of a proposed wind farm off of Evanston.
- Estimation of the cost of various carbon sequestration options, including bio-sequestration: cutting down trees and sinking them into anoxic lakes. This could have been a silly or over-general project but the students got very serious and specific about estimating actual costs and I learned something from it.
- Wind turbine build project. It was overambitious and students turned out to be better at building than at analyzing what they built (or designing to spec in the first place), but they learned a lot in doing it, and I learned something about how students think.

Projects that were almost there and could have been great include

- Building a Stirling-cycle engine – should be totally do-able from online models. Students just didn't have enough people in the group / building experience / time to complete.
- Analysis of German renewables mandates

Project ideas include the following… these are some miscellaneous things I've been curious about. Some may be done already to the point that they are not good projects but simply would be book reports – always important to check that out before getting too wedded to a question.

NON-BUILD RESEARCH QUESTIONS

- Size of the energy sector: What is the total infrastructure cost of the existing U.S. energy system? (Broken down by turnover time, i.e. things that turn over in 5-20 year, in 20-40 years, in 40+ years..) This is bookkeeping but incredibly useful bookkeeping, and something that people seem not to have actually done, not even the Dept. of Energy. This is something that the center I'm involved with (RDCEP) does want to see as a published paper.

- RPS feasibility in non-Illinois states. Former class students helped develop a framework for looking at the costs of renewable portfolios, a common mechanism for promoting renewables, and we used it to examine Illinois. Which states besides Illinois have unreasonable targets that cannot be met under cost caps? Again, something we'd like to become a real paper.

- Natural tendency of carbon intensity ($/GDP) to evolve with the size of the economy. Most developed countries are showing decreases in carbon intensity over time - but how much of that is due to what we'd consider physical efficiency improvements, and how much is just due to the fact that an increasing fraction of the economy is in the service sector, which uses less energy? That is, what is the "natural" relationship of carbon intensity to GDP, so that we could normalize by it and determine whether countries are more or less carbon intensity than expected for the size of their economies.

- History of the Industrial Revolution: what were capital costs for manufacturing industries in the 19th century? Was the rise of electrification really a factor in bringing capital costs down?

- Limitations on scale-up of alternative energy: what are mineral resources required for scaling up commercial solar PV cells? That is, given their current composition, what would a forecast in price and in trade be as the world scaled up? What countries control the limiting minerals; how big are reserves; how does price respond to demand; when do limitations kick in?

- Carbon sequestration in Illinois. Illinois is frequently mentioned as a geologically favorable site for carbon sequestration. If carbon were priced, how would a sequestration market in Illinois evolve? (That means considering the regulatory landscape as well as well as geology, local sources, costs of capture and shipping etc.). There is one active sequestration project in the state.

- Do energy use and GDP follow the same trajectory in developing countries regardless of when industrialization happened? What about income inequality? It would be very interesting to see not just comparisons across countries for GDP but for each country over time as each country evolved.

- Possibility / probability distributions for technological improvements in various energy technologies. This might be a bit book-report-y but surely could also turn into a quantitative calculation as well.

BUILD PROJECTS

- Wind turbine demonstration for lab
- Stirling cycle engine demonstration for lab (Students tried last year, did not succeed, but there are abundant examples documented in YouTube videos.
- Lightweight anemometer for making wind measurements from a weather balloon. Requires a bit of electronics and some fun with motors but very do-able from kit electronics. For a big project, could involve testing/demo-ing with wind measurements in various locations in the Chicago area, or just calibrate by driving around with it on the car roof.
- *Basically anything fun and educational that would make a lab demo that you'd like to see …*