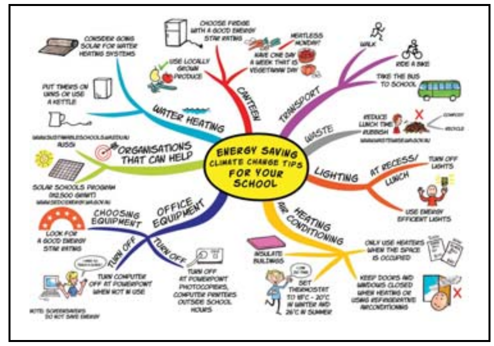
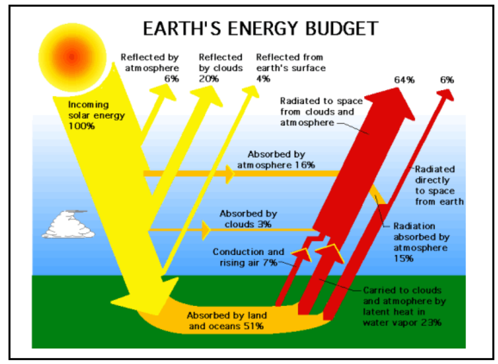
SEED 2A: Scientific and Sociological Literacy for Sustainability—Problem-Solving the Energy Conundrum

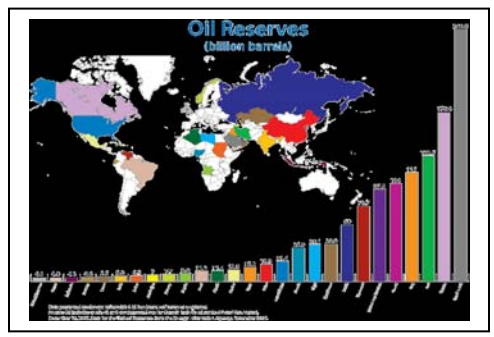


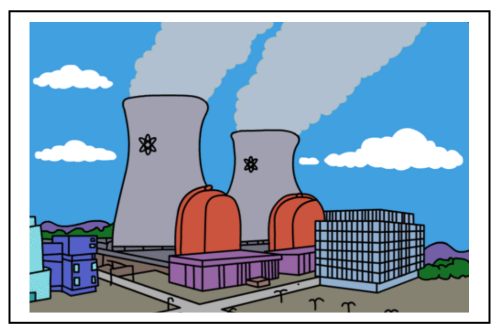
This is a 5-unit course designed to introduce students to and train them in technological and sociological literacy as a prelude to more in-depth study of issues related to sustainability. The focus of the course is problem solving energy. Assignments consist of a number of problem sets and several short papers.



Energy is ubiquitous. Energy is used by everyone. But what is it, exactly? From where does it come? How much energy is there, of what kinds and where? How do we use energy? Why does it cost so much? And could we use less and not suffer a lowering of our standard of living?

The course provides an overview the technical-scientific, quantitative and social aspects of energy production and consumption through a problem-solving approach. It will introduce concepts associated with energy, such as the Three Laws of Thermo-dynamics, quantitative and qualitative measurements and indicators (what's the difference between an erg and a watt, and which energy source is of greatest quality), how to calculate and transform energy stocks and flows, and other matters. The course will also address political, sociological and economic understandings of energy, its uses, flows and conservation: determining the costs of various types of energy; energy as a social project; conservation; pollution; greenhouse gas emissions, etc. At the end of the tutorial, you should have sufficient working knowledge and skills to be able to do straightforward calculations, discuss why we are so dependent on oil and explain what would be required to deploy a fully-renewable energy system.





Texts & resources: The Web is rife with useful source material on energy. As a basic text, we will use:

Encyclopedia of Energy Engineering and Technology (*EEET*), http://www.crcnetbase.com/doi/book/10.1201/9780849338960

Other readings are listed and hyperlinked.

Week 1: Energy as a social project

The goal of this class is to investigate and understand "energy as a social project." That is, energy is a foundational constituent of the universe and our ability to extract and use it, both biologically and mechanically, is fundamental to life and how we live. At the same time, however, energy is not an end; we don't light fires simply to break carbon bonds, liberate heat, and contribute to entropy. What is critical are the uses and benefits we receive from energy.

What this points to is that *how* we use energy, what *forms* of energy we use, and the *ways* we "produce" it for our needs is the result of *social* decisions and actions. Sometimes, all three of these elements are a consequence of decisions and actions by particular entities who stand to benefit—and that is also a social process—as are the invention of new forms of energy production and new uses for energy.

In other words, while we tend to focus on "how much" energy there is in the world, or "how much is left," the important point is why we need and want energy, why it arrives in specific forms, and how we might change those patterns of production and use to benefit society and the earth.

Here are questions to be addressed in this class:

- **Energy:** What is it? Why do we "need" it?
- **Quantities & supplies**: units of measurement; forms of energy (biological & physical); how much is there & where is it found; can we ever "run out" and when?
- **Energy flows:** How energy moves (conduction, convection, radiation); how energy is moved (tankers, pipelines, solar, electricity); relevant units of flows; stocks and flows
- **Physics & chemistry**: how energy is "liberated" from stuff
- **Laws of Thermodynamics:** all three!
- **Profit & loss**: What factors determine the cost of various energy sources and what will be produced?
- **Politics & geopolitics**: What do decisionmakers, energy executives, utilities, consumers take into account when deciding on energy production, transmission, consumption?
- **U.S. energy spaghetti diagram**: forms of energy production and end uses

Required reading:

John Byrne and Noah Toly, "Energy as a Social Project: Recovering a Discourse,"
http://www.ceep.udel.edu/energy/publications/2006_es_energy_as_a_social_project.pdf

EEET, "Energy: Global & Historical Background," ch. 73,
http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch73

Matthew T. Huber, "The Use of Gasoline: Value, Oil, and the "American way of life," *Antipode* 41, #3 (2009): 465-86, at: http://www3.interscience.wiley.com/cgi-bin/fulltext/122401269/PDFSTART

EEET, "Energy Accounting," ch. 54,
http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch54

EEET, "Thermodynamics," ch. 164,
http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch164

EEET, "Heat Transfer," ch. 18,
http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch18

Problem for group analysis & discussion: Assume that new energy sources cost an average of $3,500/GW (or equivalent in liquids) and the present system must be wholly-replaced over the coming 20 years. How would you go about designing and costing such a project? Please take into account both technical and social factors.

Week 2: Demand-side energy supply: how much is enough?

Most of the time, we think of energy in terms of how much there is and how much it costs. Can we provide sufficient energy, in necessary forms, to support the patterns of behavior to which we are accustomed, at an affordable price? What is the relationship between supply, demand and price, and what does a "high price" actually mean? If we produced less energy, what would happen? How would people respond in terms of behavior? What would be the effect on "lifestyles?" To what degree is our energy consumption "subsistence" and "luxury?"

A focus on the "demand side" of the energy question means looking closely at end uses, and whether there are ways to provide the same ends with less energy input. One approach is increasing the efficiency with which energy is produced and consumed, usually via technological changes and fixes. A second is to alter lifestyles by changing practices, e.g., biking instead of driving. A third is to change attitudes regarding expectations in life, e.g., less opportunity for global travel. All of these force us to question how our society has come to its current energy circumstances and what is involved in modifying the social conditions that shape and maintain those circumstances.

Here are questions to be addressed in this class:

- **Energy as service**: We need energy not for itself but for what we can do with it, that is, what are the services we require?
- **How do we use energy for services?** What is the distribution of energy use on the demand side, and what forms does it take? How much energy, and what kind, is used annually? How much energy do various devices use (car, computer, refrigerator, building, etc.).
- **How could we use less?** Changes in use patterns include: at the generation site (e.g., cogeneration), in transmission, distribution, technology, behavioral, urban redesign, energy efficiency
- **Efficiency & conservation considerations**: Focus on a house, to determine how much energy it uses, in what forms, for what purposes; how much energy could be provided by PVs on the roof; heat pumps, etc.
- **Why is energy conservation unpopular?** Associated with discomfort, requires interaction with devices, building, etc.; people don't like to change habits; utilities have a difficult time making money.

Required reading:

D. Pimental, et al, "Energy efficiency and conservation for individual Americans," *Environment, Development and Sustainability* 11, #3 (2009): 523-46, http://dx.doi.org/10.1007/s10668-007-9128-x

EEET, "Life Cycle Costing: Energy Projects," ch. 18, http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch18

EEET, "Energy Conservation," ch. 18, http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch18

EEET, "Energy Conversion," ch. 60, http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch60

Problem for group analysis & discussion: Using data available on the internet, determine the balance of "subsistence" vs. "luxury" energy use in the United States. You will have to decide what to put in each category. Which would be less costly, demand side conservation or new supply side technologies?

Week 3: Peak oil, cheap oil, excess oil: what is to be done?

There is growing discussion of the possibility that the world has reached, or is about to reach, peak oil production, the point after which global oil supplies will begin to decline and real scarcity will set in. This has led to various (lurid) predictions of resource wars and skyrocketing prices. It is odd to note, therefore, that there might even be large, undiscovered oilfields in many parts of the world, which will not be tapped until the price of oil rises. Many people believe that oil, and gasoline, are much too expensive and that greater reliance on domestic sources could increase supplies and lower prices. Finally, it is entirely possible that there is too much oil and that it is too cheap; the Shah of Iran once opined that oil was too noble a substance to be burned for heat. And, if fossil fuels were less available, we would almost certainly have a civilization based on other, cleaner and more efficient energy sources.

But there is a problem here: if oil were priced at its "true" value, taking into account not only the costs of production, transportation, refining and distribution but also social and environmental effects and the military costs associated with guarding sources, it might be well above its current market price, as high as $150 or $200 per barrel or more. But at those prices, demand would drop sharply, leading to a fall in oil prices—which would then encourage growing consumption, etc. etc. So, is oil running out or not? Where does it come from? How is it priced? What should we do about oil?

- **Advantages of oil**: energy density, transportability, fungibility
- **Global oil supplies & their locations:** how much has been used, how much is there estimated to be, where is it, who owns or controls it? tar sands, shale oil, synthetic oil
- **Oil geology & chemistry:** how oil was created in the first place, geological formations and extraction, chemical structure of oil and its derivatives, energy in carbon bonds and process whereby it is liberated, conversion efficiency
- **Hubbert Curve:** shape, meaning, integrals and derivatives of bell curves
- **Oil pricing**: costs of extraction, transportation, refining, distribution; relative costs from different sources; futures markets and their role in prices; taxes
- **Too little oil or too much?** How much does the world use? How much will it use, and at what price? Why there is excessive oil in the world and whether the world will "run out"
- **Economic consequences of reducing consumption**: vested interests, employment, supply-price-demand relationship, taxes and redistribution.

Required reading:

Energy Conversion, "Fossil Fuels," ch. 2, http://www.crcnetbase.com/doi/pdfplus/10.1201/9781420044324.ch2

Larry Hughes and Jacinda Rudolph, "Future world oil production: Growth, plateau, or peak?" Energy Research Group, Dalhousie University, June 30, 2010, http://dclh.electricalandcomputerengineering.dal.ca/enen/2010/ERG201005.pdf

Carlos Pascual & Evie Zambetakis, "The Geopolitics of Energy: From Security to Survival," pp. 9-36, in: *Energy Security Economics, Politics, Strategies, and Implications* (Brookings, 2009), http://www.brookings.edu/~/media/Files/Press/Books/2008/energysecurity/energysecurity_chapter.pdf

James L. Smith, "World Oil: Markets or Mayhem?" MIT Center for Energy & Environmental Policy Research, September 2008, http://dspace.mit.edu/bitstream/handle/1721.1/45659/2008-015.pdf

Problem for group analysis & discussion: The supply and price of oil are highly volatile, as a result of oil shocks, speculation and variable demand. At the same time, high dependence on imports exposes various consuming countries to potentially-disastrous supply reductions. What would be the geopolitical consequences were consuming countries to reduce imports by 50%? What would be the effect on consumption and oil price if a tax of $100/barrel were imposed? How much longer would oil "last" if the industrialized world cut its oil consumption by half?

Week 4: Delivering electricity

Electricity is pictured as a clean and efficient form of energy, but there is much that happens between cup and lip. Electricity can be understood as a "second- or third-order" form of energy. Electricity can be produced by using the kinetic energy in water, wind, waves and geothermal steam to turn a turbine. Alternatively, the liberation of chemical energy in fossil fuels or nuclear energy in fissile fuels can be used to raise steam from boiling water, which can then drive a turbine. In either case, a considerable amount of primary energy is lost in conversion. It is also the case that electricity, a high quality and costly form of energy, is often used for low quality purposes that could be provided more cheaply with fossil fuels, for example, hot water and space heating and cooking. This, too, is quite inefficient.

The incentives to conserve electrical energy are, for the most part, limited. Electric utilities are in the business of selling their product, not saving it. Many of their power plants must be operated constantly (baseload) and every bit that is dumped due to low demand—for example, at night—is money lost. Not all utilities are in the business of selling both electricity and natural gas, so fuel shifting also means a loss of sales. And, if consumers conserve rigorously, that also reduces revenues. Finally, does it make sense to use electricity to power automobiles? Depending on the source of the electricity, pollution will be shifted and conversion efficiencies can drop to very low levels.

- **What do we use/need electricity for?** Appliances, electronics, hot water, space heating, lighting, electrified rail
- **Forms of centralized & decentralized generation:** coal, oil, natural gas, water, geothermal, nuclear, solar thermal, wind farms, waves, fuel cells, hydrogen
- **How electricity is made**: electrons from spinning magnets; electrons from hydrogen; photoelectric effect
- **Conversion efficiencies**: energy content of original source and life cycle energy investment vs. conversion steps and final use
- **Public vs. private power**: why the difference?
- **Utility regulation:** monopoly, rate of return, rate hikes, avoided cost
- **Costing electricity (inc. discount rates):** capital cost of plant; O & M; fuel costs; cost of borrowed funds; interest rates; revenue generation and loan repayments; components of electricity costs

Required reading:

EEET, "Electric Supply System," ch. 49, http://www.crcnetbase.com/doi/pdf/10.1201/9780849338960.ch49

EEET, "Public Policy for Improving Energy Sector Performance," ch. 138, http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch138

"Electricity 101," http://www.centerpointenergy.com/staticfiles/CNP/Common/SiteAssets/doc/EEI%20Electricity_101.pdf

"Electric circuits and fields," http://www.practicalphysics.org/go/Topic_8.html

Electropedia, "Energy Efficiency," http://www.mpoweruk.com/energy_efficiency.htm

Robert J. Michaels, "The Regulation and Restructuring of Electricity," Aug. 18, 2004, at: http://www.business.fullerton.edu/economics/rmichaels/workingPapers/040818%20Keating.pdf

Browse *The Electropedia*, http://www.mpoweruk.com/index.htm

Problem for group analysis & discussion: Electric utilities are in the business of producing and selling electricity (although some have simply become distributors), and they realize their profits by minimizing the cost of generation (or purchased electricity) and selling a kilowatt-hour for as much as is permitted by law. At the same time, electricity demand is rising and so is the cost of building new generating capacity. By contrast, the cost of conserving power by reducing demand is considerably lower and every kilowatt of demand reduction makes a kilowatt available for some other use (Amory Lovins calls this for of generation "negawatts"), But utilities have been reluctant to invest heavily in demand-side conservation. Why?

Week 5: The nuclear revival: fact or fantasy?

The promise of nuclear energy has been touted in the United States for more than 50 years; today, there are roughly 100 large power reactors in operation in the U.S., and some 400 throughout the world, with plans in some countries to build more. But, overall, nuclear has failed to live up to its billing during the 1960s, when the Atomic Energy Commission predicted 1,000 reactors in operation in the United States by the year 2000. Why has this happened? Can nuclear energy be revived? How much uranium is there? What have other countries done and why are some so committed to nuclear power? And what about radioactive waste.

Nuclear power is merely a complex and somewhat hazardous way to boil water, raise steam and turn generating turbines. Its primary energy source derives from the particles and radiation emitted as the bonds found in the nucleus of fissile materials—uranium-235, plutonium-239 and others—are broken. As those fragments slow down, their kinetic energy is transformed into heat which boils the water. But the temperatures at which fission occurs are very high, and the nuclear fuel must be cooled in order to ensure that it does not overheat and melt. And, when the fuel has been "used up," it must be carefully removed from the reactor core and stored in swimming pools and other devices that are shielded so that people will not be exposed to radiation. Nevertheless, the operating and safety record of nuclear plants has been relatively good—with a few notable exceptions—and a new generation of reactors is promised to be much safer than its predecessor.

- **How nuclear fission works**: U-235 & 238; Pu-239; thorium; fission chain; fission products; how fusion works
- **Reactor designs & safety issues**: boiling and pressurized water reactors; breeder reactors; graphite reactor (Chernobyl); CANDU; new designs
- **Clean or dirty?** Limited greenhouse gas emissions; relatively small waste volumes; leakage potential; waste disposal; liquids & solids
- **Uranium supplies & plutonium breeding:** how much uranium is there and how many reactors could be fuelled? Thorium supplies and energy potential. Breeder reactors, reprocessing, plutonium economy
- **Financing, regulation, construction & opposition**: who pays, how much, and when? How nuclear power is regulated (NRC & DOE in U.S.). safety surveillance, reactor vulnerability; not in my backyard.
- **Cost of nuclear electricity:** capital costs, fuel costs, O & M, disposal costs, cost of money, rate of return

Required reading:

EEET, "Nuclear Energy: Technology," ch. 131, http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch131

EEET, "Nuclear Energy: Fuel Cycles," ch. 129, http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch129

EEET, "Nuclear Energy: Economics," ch. 128, http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch128

MIT, "The Future of Nuclear Power," 2005 & update, http://web.mit.edu/nuclearpower/

Paul Joskow & John Parsons, "The Economic Future of Nuclear Power," *Dædalus* 138, #4 (Fall 2009): 45-59, http://www.mitpressjournals.org/doi/abs/10.1162/daed.2009.138.4.45

Joseph Romm, "The Self-Limiting Future of Nuclear Power," Center for American Progress, June, 2008, http://www.americanprogressaction.com/issues/2008/pdf/nuclear_report.pdf

Russell Ayres, "Policing Plutonium," *Harvard CL-CR Law Review* 10 (1975): 369–443 http://www.ccnr.org/harvard_on_mox.html

Problem for group analysis & discussion: A revival of nuclear power generation will require ample supplies of fissile materials. Potential limits to world uranium supplies could be addressed through breeder reactors and fuel reprocessing (as opposed to the current once-through cycle in the United States). In a breeder economy, large quantities of plutonium would be in circulation. Consider the economic, political and social implications of this strategy.

Week 6: Centralized vs. decentralized solar & wind

The Earth is awash in energy. Everyday, the sun pours enormous quantities through the atmosphere, with much being absorbed in the generation of weather systems and climate. Both solar and wind energy can be captured and turned into electricity or, with some additional effort, into fuels such as hydrogen, without the environmental or geopolitical problems associated with fossil fuels. But these forms of renewable energy also lack some of the advantages of non-renewables: lower energy intensity per "unit" of fuel; diurnal or intermittent availability, often far from points of consumption; still relatively expensive (although the cost of wind-generated electricity is now competitive with most non-renewables); and dependent on major changes in some energy-consuming systems, especially transportation.

In addition to cost and intermittent generation, renewables are often subject to the same kinds of siting disputes that affect other energy sources, especially, it would seem, when centralized facilities are proposed for construction in deserts. These matters could be settled through decentralization, that is, siting PV and wind close to or on/at the consumption site, but the upfront capital cost is usually too great. Utilities dislike having to compensate decentralized electricity generators for power pumped into the grid, since it means lower sales (and also causes electricity meters to run in reverse). There have been some experiments with "build and lease" systems, in which a company both installs and owns the PV installation, and rents it to the building owner. Finally, living with renewables may require major changes in one's relationship to an energy system, especially for those who decide to "go it alone."

- **Renewable energy potentials:** What is "renewable," in what form does it come, and how much is there in sun, wind, water and biomass? Where is it located and how can such things be estimated and/or measured?
- **Technologies (PV, thermal, wind):** photovoltaics vs. solar thermal power generation; small wind vs. large; types, experience, new designs
- **Efficiency, space, storage, transmission**: how much can be converted into useful energy? How much space do renewables take up, and what are their effects on the environment? How much energy is invested in their manufacture, and how does this compare with other energy sources?
- **Cost of electricity:** What are the delivered costs of energy from renewable sources, and how and why do they vary according to the specific technology? What about minimizing electricity and energy use in order to decrease system size and cost?
- **Siting and transmission issues:** How do we decide whether to centralize or decentralize? What kinds of social and technical issues arise and what obstacles often exist to each approach?
- **Financing strategies:** How can renewables, either centralized or decentralized, be financed? Who has money and who can get it? How does the cost of money matter? What can building owners do?

Required reading:

EEET, "Photovoltaic Systems," ch. 134,
    http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch134

EEET, "Solar Thermal Energy," ch. 154,
    http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch154

EEET, "Wind Power," ch. 184, http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch184

EEET, "Alternative Energy Technologies: Price Effects," ch. 5, http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch5

Problem for group analysis & discussion: Even as utilities and energy companies seek to build centralized solar facilities, there is growing social resistance to both plants and transmission plans. And, while electricity is a high-value energy source, delivery to the final use is quite inefficient. At the same time, the conversion efficiencies of solar PV are quite low (which is why PV electricity is so costly). Consider the costs and impacts of providing 10 GW of solar power generating capacity to California, comparing centralized and decentralized solar, and taking into consideration end-use efficiency.

Week 7: Sustainable urban landscapes

The "crystallization" of the energy problematic can be found in cities, aka "urban landscapes." Inasmuch as more than half of the world's population lives in cities, that is where most of the world's energy is consumed. Cities and their sprawls are sites of the energetic transformation of landscapes, the site of a great deal of embodied and embedded energy (in buildings, streets and infrastructure), and the locus of considerable current energy expenditure (transportation, distribution, heating and cooling, electricity, etc.). At the same time, energy is consumed with greater efficiency and effect in cities as compared to suburbs and the countryside. Preserving urban landscapes can reduce the energy inputs associated with new construction, reduce the need for long-distance commutes, and encourage energy-efficient planning. Moreover, cities can also be the site of energy generation, given large areas of solar exposure on the roofs and sides of buildings.

At the same time, the "ecology" of the urban landscape is somewhat obscure. Even "planned cities" rarely develop as the designers intended. What then, are the possibilities of creating truly sustainable cities?

- **Energy use: city vs. country**: How much energy is consumed in different landscapes, in what form and for what purposes? How does the "ecology" of an urban landscape affect energy use? How do different cities compare in terms of energy use?
- **How cities are "designed"**: Some basic principles of urban planning and design, and how cities have come to acquire their current "shape."
- **Distribution of gas & electricity**: How does energy get into a city? What determines which forms are distributed? How do cities get locked into particular energy sources and uses?
- **Costs of urban mobility:** How much energy does it take to get around cities and how much does it cost? How much time (and energy) is required to achieve "urban mobility" and how could urban planning and design reduce mobility and energy costs?
- **Changing living patterns and practices**: What kinds of behavioral changes reduce energy use, and how difficult are these to achieve? Successes and failures in inducing behavioral changes.
- **Sustainable cities: strategies & successes**: Are there any "sustainable cities?" What are they doing? How far have they gotten? Is "sustainability" anything more than an urban buzzword?

Required reading:

Eric Andersson, "Urban Landscapes and Sustainable Cities," *Ecology and Society* 11, #1(2006): 34-40, at: http://www.ecologyandsociety.org/vol11/iss1/art34/ES-2006-1639.pdf

Peter W. G. Newman, "Sustainability and Cities: Extending the Metabolism Model," *Landscape and Urban Planning* 44, #4 (September 1999):219-26, at: http://dx.doi.org/10.1016/S0169-2046(99)00009-2
Patrick Troy, et al, "Embodied and Operational Energy Consumption in the City," *Urban Policy and Research* 21, #1 (2003): 9-44, http://pdfserve.informaworld.com/545212_918976451_713701536.pdf
Marina Alberti, "Measuring Urban Sustainability," *Environmental Impact Assessment Review* 16, #4-6 (July-Nov. 1996):381-424, http://dx.doi.org/10.1016/S0195-9255(96)00083-2

Problem for group analysis & discussion: Imagine you are a member of an urban planning commission tasked with restructuring your U.S. city of 500,000 so that its energy consumption is reduced by 50% over the next three decades. Discuss the following: (i) how much energy is consumed in each urban sector (you can make up the sectoral composition of your city, but please used reasonably realistic data): (ii) where can the lowest cost reductions be made and how should they be sequenced?; and (iii) how could such a project be financed?

Week 8: Transportation strategies: is automobility necessary?

"Freedom of mobility" is a deeply-held value in the United States, and it becoming more widespread in many parts of the world, as automobiles proliferate. The growth of automobility also leads to growth in energy consumption and pollution, even if cars are electrified, and traffic congestion is almost inevitable, leading to considerable wasted time. In some circumstances, personal transport is required to get to places but, as the case of Europe and Japan illustrate, rail and mass transit can substitute very effectively for cars and trucks. The costs of constructing new transit infrastructures are considerable, and such systems are rarely able to generate sufficient revenues to cover construction and operating costs; they must be subsidized through taxes, which enrages those who believe they should not have to pay for something they do not use.

If, however, personal mobility became much more costly and transit were easier to rely on and less expensive, many people could be induced to leave their cars garaged, or even give them up. How might transit systems facilitate such mobility, and what would it cost? Do electric cars necessarily address the automobility problem? What else could be done to control automobility?

- **Automobility as a social project, a "right," and problem**: The car is more than a technological device; it is also an assemblage and a "way of life." How many cars are there in the world, and how many could there be? Why is automobility so highly valued? Is there a "right" to a car?
- **Economic & environmental costs of automobility**: How much energy does automobility consume and how much does the assemblage cost? What kinds of social costs are involved and can these be quantified? Can social and environmental costs be internalized into the cost of automobility, and what effect might this have?
- **Comparative drive systems**: How do different automotive propulsion systems affect the numbers and social costs associated with automobility.
- **The decline of air travel**: As the economic and ecological costs of air travel, especially short-hops, rise, and companies lose business and money, such trips could become subject to high taxes, normative disapproval and prohibitively expensive. It seems quite likely that, within a decade or so, the era of cheap and easy air travel will come to an end. Are replacements possible? What would be the consequences of shifting to other forms of long-distance travel?
- **Reviving mass transit and developing high-speed rail travel:** Transit in cities and high speed rail between cities, are growing in attractiveness although, in the U.S., the latter seems more a pipe dream than a realistic possibility. Still, foreign countries and

manufacturers have expressed interest in constructing and even financing such systems? What would be the effects of an increase in transit and rail, and the consequences of turning such systems over to "foreign" owners?

- **Getting out of the car**: Are there ways to end the love affair with automobility? What would it take, and how long might it take? What sorts of inducements and compulsions could work?

Required reading:

Todd Litman & David Burwell, "Issues in Sustainable* Transportation," *Int. J. Global Environmental Issues* 6. # 4,(2006): 331-47, at: http://vtpi.org/sus_iss.pdf

David Hess, "What is a Clean Bus? Object Conflict in the Greening of Global Transit," *Sustainability: Science, Practice & Policy* 3, #1 (Spring 2007):45-58, at: http://ejournal.nbii.org/archives/vol3iss1/0608-027.hess.pdf

Peter Freund and George Martin, "Hyperautomobility: The Social Organization of Space and Health," *Mobilities* 2, #1:37-49, at: http://www.informaworld.com/smpp/ftinterface~content=a771144817~fulltext=713240930

L Bailey, PL Mokhtarian, A Little, The broader connection between public transportation, energy conservation and greenhouse gas reduction, ICF International ,2008, http://publictransportation.org/pdf/reports/land_use.pdf

EEET, "Transportation: Location Efficiency," ch. 167, http://www.crcnetbase.com/doi/pdfplus/10.1201/9780849338960.ch167

Problem for group analysis & discussion: As part of the urban planning commission's mandate, you have been tasked with "getting people out of their cars." This means finding the appropriate inducements (economic and otherwise) to get automobilers not only to think about alternative modes of transportation but also to make a habit of using them. It also means developing strategies for (i) increasing automobile occupancy; (ii) reducing the number of short-range trips; (iii) devising transit strategies that make sense, using already existing-infrastructure where possible; and (iv) transforming people's *habitus* (i.e., their normalized habits, in this case, getting them not always to jump in the car). Devise a plan.

Week 9: Calculating the green lifestyle

As public concern about the environment and health has grown, so have the attractions of "going green." One of the central assumptions is that a green lifestyle means reducing energy consumption. To what extent is this the case? Are green choices and green consumption really more energy efficient? How can the energy costs be calculated? What about life-cycle costs? What are the tradeoffs between consuming green and consuming less? If millions of people decide to "go green," what will be the effects on the rest of society? Will the market respond and "fix" the energy problem? And what about people in developing countries?

A great deal of energy consumption is associated with the production, transportation and preparation of food and disposal of food wastes (not to mention the energy we extract from food in order to live). What are the energy costs of organic vs. industrial agriculture, of local vs. distant food production, of fast vs. slow food? How can it make economic or energy sense to fly apples from Chile to the United States? What if we did not demand fruits and vegetables year around? And how would this effect people in developing countries? Can the world be fed? What are the energy costs?

- **What is a "green lifestyle?"** What are the elements involved in going green? Are there concrete cases of such a lifestyle, and what does it involve, especially with respect to energy use. Is generating your own electricity greener than buying it from a utility or from a company selling electricity "from renewables?"

- **Mapping energy use & consumption decisions**: How does the choice of what to consume affect how much energy we use? How can an individual make intelligent decisions if information is not readily available? How reliable is such information, where available? Calculating and mapping individual energy use.
- **Cause, commitment & the Green Leviathan**: Some people choose green products without fully committing to a green lifestyle, while others turn it into a life cause. Is there a role for government compulsion in all of this or is it better to be offered opportunities to reduce energy use?
- **Costs & benefits of going green**; To what extent to individual choices to go green lead to individual and social benefits? Does it make sense to go green when no one else does?
- **Thinking about food and energy:** How does eating affect energy use? Can different eating strategies and practices change individual and social demands and expectations?
- **Lifestyle designs for less energy**: Are there systematic, deliberate and fairly straightforward ways to change to a less energy-consuming lifestyle? What would it cost? Does it make any sense for the poor?

Required reading:

Blake Alcott, 'The Sufficiency Strategy: Would Rich-World Frugality Lower Environmental Impact?' *Ecological Economics* 64 (2008): 770-86, at: http://dx.doi.org/10.1016/j.ecolecon.2007.04.015

Fiona Allon & Zoë Sofoulis, "Everyday Water: Cultures in Transition," *Australian Geographies* 37, #1 (March 2006): 45-55, at: http://www.informaworld.com/smpp/ftinterface~content=a741482964~fulltext=713240930

Elizabeth Shove & Mika Pantzar, 'Consumers, Producers and Practices', *Journal of Consumer Culture* 5 (2005): 43-64, at: http://joc.sagepub.com/cgi/reprint/5/1/43

Jesper Ole Jensen, Measuring consumption in households: Interpretations and strategies, Ecological Economics Volume 68, Issues 1-2, 1 December 2008, Pages 353-361 http://dx.doi.org/10.1016/j.ecolecon.2008.03.016

Problem for group analysis & discussion: Can a "green lifestyle" reduce both individual and aggregate energy use? What is the relationship between goods and services offered in the market and the needs and practices of consumers? How do consumers "know" what they need? Can technologies alone facilitate green consumption? Consider here the behaviors and *habitus* of consumers and what would be required to go beyond green lifestyle to the internalization of new energy-efficient ones. Keep in mind how people relate to those things and practices that consume energy and those things in which energy is embedded—cost is not the only factor that motivates people's behaviors.

Week 10: Global energy strategies and practices

The world and its many societies need a new energy strategy for the 21st century. There are many possibilities and alternatives on order, and we are regularly admonished to "let the market choose," but markets don't make choices, people do. Furthermore, virtually all energy production and consumption is strongly influenced by public policies, state subsidies and intense regulation. While it is probably impossible to conceive of, let alone implement, a globally-coherent energy strategy, the exercise is a useful one, especially if different scenarios are compared.

For example, could a nuclear-centered energy strategy be successfully implemented? What would it cost, and what social adaptations would be required? And might a hydrogen-based system be feasible? What about one that relied, to the extent possible, on a declining mix of fossil fuels and a growing reliance on locally-available renewables, with long-distance transmission, where possible? What about the hundreds of millions who are "off the grid?" Can they/should they be brought into the global energy system? At what cost and to what end?

Finally, what are the limits of conservation, and does it necessarily imply hardship and hairshirts? Amory Lovins once pointed out that, in 1950, the 150 million people in the United States used less than half as much energy as the much more numerous population used in the mid-1970s. Yet, the U.S. in the 1950s was not less than half as civilized as the U.S. of the 1970s. In many ways, our energy "needs" are constructed ones, and have little to do with basic comfort and survival.

- **Global energy needs for the 21st century:** How much energy does the world need? How do different societies compare today? Who is best able to make a transition and who should pay the costs of such a strategy?
- **How are energy "needs" determined?** What social and technological forces drive energy consumption and how might we differentiate "subsistence" from "luxury" consumption? Should those who consume more also pay more, and how? What is the role of capitalism and advertising in driving energy use?
- **How could energy use be reduced?** What might be the required combination of inducements and compulsion necessary to make energy consumption not only more efficient but also reduce it? Could we find ways to monetize the social and environmental costs of energy use and incorporate them into direct energy costs? Is the law necessary or sufficient in driving reductions?
- **How does social change happen?** A new energy strategy cannot be implemented overnight, but only over a matter of decades. People's habits and practices also change only over a span of decades? Is it possible to imagine programs of "social engineering" that would change desires and practices in the direction of fewer luxury "needs" and lower energy consumption? Would this be a form of totalitarianism or could it be achieved in a democratic and participatory fashion?

Required reading:

Vaclav Smil, "Energy in the 20th Century," *Annual Review of Energy and the Environment* 25 (2000): 21-51, at http://arjournals.annualreviews.org/doi/pdf/10.1146/annurev.energy.25.1.21

Nathan S. Lewis, "Powering the Planet," *MRS Bulletin* 32 (Oct. 2007): 808-20, at: http://www.mrs.org/s_mrs/bin.asp?CID=11285&DID=202372&DOC=FILE.PDF

Matti Parikka, "Global Biomass Fuel Resources," *Biomass and Bioenergy* 27 (2004) 613–620, http://dx.doi.org/10.1016/j.biombioe.2003.07.005

Richard L. Ottinger and Rebecca Williams, "Renewable Energy Sources for Development," *Pace University School of Law* (2002), at: http://digitalcommons.pace.edu/cgi/viewcontent.cgi?article=1253&context=lawfaculty

Problem for group analysis & discussion: Provision of energy to the 21st century world is subject to at least three critical considerations: (1) providing adequate supplies to the world's poor without increasing the burden on the world's environment; (ii) reining in and restructuring energy consumption (especially fossil fuels) among the world's rich populations; and (iii) transitioning to a sustainable energy system only minimally dependent on depletable sources and does not wholly bankrupt the world (this could include uranium, plutonium and breeder reactors, if you are so inclined; fusion, as the saying goes, is always 50 years in the future, so don't count on it). Your task is to plan such a system, with a target date of 2075 and an annual outlay of no more than one trillion dollars ($2010, so you'll have to take inflation into account).