This assignment requires you to begin focusing on the paper due the following week. Hand in the results of the following.

1. Choose a paper topic, either from the Paper Topic list or one of your own. If you want to pick one of your own, please send me an email with your idea first to check that it’s OK.

2. Find 5 sources related to your topic, either books, articles or websites. Tell me what these are. For websites, say what it is (not just the URL). **One website can be a Wikipedia entry, but not more than one.**

3. List 3 questions that you plan to address in your paper. These should be more detailed than the ones in the Paper Topic list.
After noting the skepticism of delegates from other countries…

John Ashton, a special adviser on climate change to the British foreign secretary, called voluntary measures ineffective. Dozens of nations had agreed to nonbinding goals for emissions cuts in 1992, he said, then watched the pollutants linked to global warming rise at a double-digit percentile rate over the next decade.

“A voluntary approach to reducing greenhouse gases is hardly likely to be more effective than voluntary speed limits on the roads,” he said.
Ethanol’s Boom Stalling as Glut Depresses Price

By CLIFFORD KRAUSS

NEVADA, Iowa, Sept. 24 — The ethanol boom of recent years — which spurred a frenzy of distillery construction, record corn prices, rising food prices and hopes of a new future for rural America — may be fading.

Only last year, farmers here spoke of a biofuel gold rush, and they rejoiced as prices for ethanol and the corn used to produce it set records.

But companies and farm cooperatives have built so many distilleries so quickly that the ethanol market is suddenly plagued by a glut, in part because the means to distribute it have not kept pace. The average national ethanol price on the spot market has plunged 30 percent since May, with the decline escalating sharply in the last few weeks.

Because ethanol is corrosive and soaks up water and impurities, it cannot be shipped through the country’s fuel pipeline network. So it must be transported by train, truck and barge, a more expensive transportation network that is suddenly finding it hard to keep up with the surge in ethanol production.

There is a long backlog in orders for specialized ethanol rail cars to ship the surplus production. Many rail terminals at the ethanol plants do not have spurs large enough to accommodate the long trains that ethanol promoters like to call “virtual pipelines.” And pumps from the storage tanks to the rail cars at the terminals often do not have sufficient capacity to load trains quickly and efficiently.

Phillip C. Baumel, economics professor emeritus at Iowa State University, said that in many cases ethanol producers ramped up their production so rapidly that they gave “inadequate attention to meeting transportation and distribution needs.”
Massachusetts Universities and Colleges Commit to Renewable Energy

Boston, Massachusetts [RenewableEnergyAccess.com]

Massachusetts Energy and Environmental Affairs Secretary Ian Bowles last week congratulated 41 Massachusetts campuses -- including all 29 public colleges and universities -- for joining a national campaign to make college campuses climate neutral by embracing clean energy technologies and reducing greenhouse gas emissions.

Of the more than 400 campuses in 47 states that have signed onto the American College & University Presidents Climate Commitment since it was launched earlier this year, 10 percent are Massachusetts institutions of higher education. The only other state that approaches Massachusetts's allegiance to the campaign is California—also with 41 campuses signed on, but with a population six times larger than Massachusetts.

"Massachusetts campuses have clearly stepped up to the plate in a big way," Secretary Bowles said. "Several schools have significant expansion plans on the table. That makes their pledge to pursue clean energy and reduce greenhouse gas emissions especially significant."

By signing the American College & University Presidents Climate Commitment, presidents and chancellors pledge to eliminate greenhouse gas emissions from their campuses within a "reasonable period of time."

Clean energy programs already under way on Massachusetts's public campuses include:

- At Massachusetts Maritime Academy, a 660 kilowatt (KW) wind turbine that provides, on average, over 28 percent of campus electricity needs—plus a solar photovoltaic system on one Academy dorm, campus-wide energy efficiency measures, and a program to explore use of biodiesel for campus vehicles;
- At Mt. Wachusett Community College, a wood chip-fired biomass plant that supplies all heat for the entire campus, plans to install a 100-KW solar array, and a feasibility study for a large wind turbine (the campus has already reduced its greenhouse gas emissions by approximately 20 percent over the past five years);
- At UMass-Amherst, work on installing a state-of-the-art co-generation natural gas power plant that will eliminate a university-owned coal plant which, alone, is responsible for 5 percent of state government greenhouse gas emissions;
Campuses that sign the “climate commitment” agree to:

1. Initiate the development of a comprehensive plan to achieve climate neutrality as soon as possible.
   a. Within two months of signing this document, create institutional structures to guide the development and implementation of the plan.
   b. Within one year of signing this document, complete a comprehensive inventory of all greenhouse gas emissions (including emissions from electricity, heating, commuting, and air travel) and update the inventory every other year thereafter.
   c. Within two years of signing this document, develop an institutional action plan for becoming climate neutral, which will include:
      i. A target date for achieving climate neutrality as soon as possible.
      ii. Interim targets for goals and actions that will lead to climate neutrality.
      iii. Actions to make climate neutrality and sustainability a part of the curriculum and other educational experience for all students.
      iv. Actions to expand research or other efforts necessary to achieve climate neutrality.
      v. Mechanisms for tracking progress on goals and actions.

2. Initiate two or more of the following tangible actions to reduce greenhouse gases while the more comprehensive plan is being developed.
   a. Establish a policy that all new campus construction will be built to at least the U.S. Green Building Council’s LEED Silver standard or equivalent.
   b. Adopt an energy-efficient appliance purchasing policy requiring purchase of ENERGY STAR certified products in all areas for which such ratings exist.
   c. Establish a policy of offsetting all greenhouse gas emissions generated by air travel paid for by our institution.
   d. Encourage use of and provide access to public transportation for all faculty, staff, students and visitors at our institution
   e. Within one year of signing this document, begin purchasing or producing at least 15% of our institution’s electricity consumption from renewable sources.
   f. Establish a policy or a committee that supports climate and sustainability shareholder proposals at companies where our institution’s endowment is invested.
   g. Participate in the Waste Minimization component of the national RecycleMania competition, and adopt 3 or more associated measures to reduce waste.

3. Make the action plan, inventory, and periodic progress reports publicly available by providing them to the Association for the Advancement of Sustainability in Higher Education (AASHE) for posting and dissemination.

Umass President Jack Wilson is amongst the 407 signatories of the “climate commitment”. It would be very interesting to know what kinds of structures have been put in place to achieve these goals?

We’ll talk a bit later about the new UMass Central Heating Plant, which will provide most of the campus’s electricity and steam heat starting in 2008…

Only Umass, Dartmouth appears to have joined the Association for the Advancement of Sustainability in Higher Education (www.aashe.org) where progress reports are to be posted.

http://www.facil.umass.edu/~utildept/html/utilproj.html
Oil is refined via fractional distillation.
• The crude oil is heated and vaporized in the furnace.
• The vapor is fed into the fractionating column and cools as it rises.
• Different hydrocarbon “fractions” of the vaporized crude oil condense at different temperatures. These correspond to different heights in the column.
• Generally the heavier fractions condense at higher temperatures.

• **Petroleum gas** (small alkanes with 1-4 carbon atoms, i.e. methane, ethane, propane & butane) have a boiling point above 40C and condense at the top of the column.

• **Gasoline** is a mixture of alkanes and cycloalkanes with 5-12 carbon atoms that condenses in the range 40C to 205C.

Source: [http://science.howstuffworks.com/oil-refining2.htm](http://science.howstuffworks.com/oil-refining2.htm)
• **Kerosene** - fuel for jet engines and tractors; mix of alkanes (10 to 18 carbons) and aromatics, condenses between 175°C and 325°C.

• **Diesel oil** - used for diesel fuel and heating oil; alkanes containing 12 or more carbon atoms which condense between 250°C and 350°C.

• **Lubricating oil** - used for motor oil, grease, other lubricants; long chain (20 to 50 carbon atoms) alkanes, cycloalkanes, aromatics that condense in the range 300°C to 370°C.

• **Fuel oil** - used for industrial fuel; long chain (20 to 70 carbon atoms) alkanes, cycloalkanes, aromatics that condense between 370°C and 600°C.

• **Residuals** - coke, asphalt, tar, waxes; multiple-ringed compounds with 70 or more carbon atoms that condense at more than 600°C.
Usually it’s the case that the refiner would like to have more of one of the fractions, usually gasoline, than naturally results from the refining process. Fractions can be transformed into each other using three chemical processes.

- **Cracking** - breaks large hydrocarbon chains into smaller pieces.
- **Unification** - assemble shorter pieces into longer ones.
- **Alteration** - rearranging pieces to produce a different hydrocarbon.

### What a barrel of crude oil makes.

<table>
<thead>
<tr>
<th>Product</th>
<th>Gallons per Barrel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>19.4</td>
</tr>
<tr>
<td>Distillate Fuel Oil</td>
<td>10.5</td>
</tr>
<tr>
<td>Kerosene-Type Jet Fuel</td>
<td>4.1</td>
</tr>
<tr>
<td>Coke</td>
<td>2.2</td>
</tr>
<tr>
<td>Residual Fuel Oil</td>
<td>1.7</td>
</tr>
<tr>
<td>Liquefied Refinery Gases</td>
<td>1.5</td>
</tr>
<tr>
<td>Still Gas</td>
<td>1.8</td>
</tr>
<tr>
<td>Asphalt and Road Oil</td>
<td>1.4</td>
</tr>
<tr>
<td>Raw Material for Petrochemicals</td>
<td>1.1</td>
</tr>
<tr>
<td>Lubricants</td>
<td>0.4</td>
</tr>
<tr>
<td>Kerosene</td>
<td>0.2</td>
</tr>
<tr>
<td>Other</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Figures are based on average yields for U.S. refineries in 2005. One barrel contains 42 gallons of crude oil. The total volume of products made is 2.7 gallons greater than the original 42 gallons of crude oil. This represents “processing gain.”
There are now 149 oil refineries in the U.S. with capacities ranging from 10,000 bbl/day up to roughly 500,000 bbl/day. This number is down sharply from 301 in 1982.

There are concentrations of refineries around ports in the Gulf Coast region, California, New Jersey and Seattle. There are none in New England.
The largest oil refinery in the U.S. is Exxon-Mobil’s Baytown Refinery in Baytown, Texas. Baytown Refinery covers 2400 acres adjacent to the Houston Ship Channel and has a capacity of 557,000 bbl/day.

It originally opened in 1919 under the ownership of the (ironically named?) Humble Oil company.

Like many oil refineries, Baytown has various environmental issues. In 2001 the Texas environmental group SEED (Sustainable Energy and Economic Development Coalition) released the results of a study of problems at Baytown Refinery.

According to SEED, “An exhaustive study of the ExxonMobil Baytown refinery has found a history of persistent pollution problems at the plant, including repeated violations of state and federal law as well as repeated failures by the Texas environmental agency to address even ongoing problems. …..This report is the first of its kind in the United States - an in-depth investigation of the operations of a single, massive refinery in Texas. Focused on the largest refinery in the United States (based on crude oil capacity) ExxonMobil's Baytown refinery, this analysis exposes how Texas industrial polluters can repeatedly flout the law, contaminate the air and threaten public health, while the Texas Natural Resource Conservation Commission sits back and lets them do it.
According to the organization Environmental Defense, “Anything that goes into a refinery and does not come out as a product such as gasoline or diesel ends up as pollution. According to a landmark study, 99.7 percent by weight of crude oil arriving at Amoco's Yorktown, Virginia refinery was converted to product or fuel for the refinery; and only 0.3 percent of the oil was released to the environment as pollution in one form or another. Since an average-size refinery processes over 90,000 barrels of oil daily, that 0.3 percent can result in the release of more than 11,000 gallons of oil to air, land, or water every day -- and that does not count releases of any of the other chemicals used in refineries.

According to federal right-to-know data, in 1997 alone, over 100 million pounds of toxic substances from U.S. refineries were reported released to the environment or transferred to other facilities for recycling, treatment, or disposal.”

Following Hurricane Katrina in 2005, which shut down 20% of the nation’s oil refining capacity in a single day, there was a great deal of focus on the shortage of refining capacity in the U.S. and the fact that no major oil refineries have been built in the U.S. since 1976.

The reason for this and also for the steep decline in the number of U.S. oil refineries over this same period is a matter of some debate.
The oil industry claims this is the result of too stringent environmental regulation and calls for “streamlining” of the permitting process.

Industry critics note that profit margins in oil refining have been slim through this period, and the reason for no new plants has been the lack of economic incentive to build them. Moreover, they claim that the industry has purposefully kept refining capacity down to keep prices up.
What does all this oil get used for….

- In the U.S. 68% of petroleum ends up being used for transportation, while 97% of the energy used for transportation comes from petroleum.
- The U.S. consumes 20.8 million bbl/day of petroleum - out of this we get 9.2 million bbl/day of gasoline (385 million gallons/day)

A natural thing to focus on is fuel efficiency….  
The Environmental Protection Agency (EPA) recently released the report - **Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2007**

Light-duty vehicles(cars, pick-ups, vans & SUV’s) account for approximately 40 percent of all U.S. oil consumption and about 20% of CO₂ emissions.

Source: [http://www.epa.gov/otaq/fetrends.htm#1](http://www.epa.gov/otaq/fetrends.htm#1)
Basic findings….

“Since 1975, the fuel economy of the combined car and light truck fleet has moved through several phases: (1) a rapid increase from 1975 to the early 1980s, (2) a slow increase extending to the fuel economy peak of 22.0 mpg in 1987, (3) a gradual decline from the peak to 19.3 mpg in 2004, and (4) consecutive annual increases in 2005 and 2006, growing to 20.2 mpg in 2006, with the same value projected for 2007.”

Adjusted Fuel Economy by Model Year
(Annual Data)
An important ingredient is the increase in “light truck” sales, including vans and SUV’s as well as pick-ups. This now corresponds to 1/2 the market…

Shift to less powerful, lighter cars. Note maximum acceleration rates continued to increase…

<table>
<thead>
<tr>
<th>Characteristics of Light Duty Vehicles for Four Model Years</th>
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</thead>
<tbody>
<tr>
<td>Adjusted Fuel Economy (mpg)</td>
</tr>
<tr>
<td>Weight (lbs.)</td>
</tr>
<tr>
<td>Horsepower</td>
</tr>
<tr>
<td>0 to 60 Time (sec.)</td>
</tr>
<tr>
<td>Percent Truck Sales</td>
</tr>
</tbody>
</table>
Because of their poor gas mileage, SUV’s are a target for conservationists…

According to an anti-SUV website (www.suvsuck)…

Switching from an average new car to a 13 mpg SUV for a year would waste more energy than leaving a refrigerator door open for six years, a bathroom light burning for 30 years, or a color TV turned on for 28 years.

It would be an interesting exercise to try to check this

Attitudes towards fuel efficiency are very polarizing in American politics….  

Give Vice-President Dick Cheney credit; he says what he thinks. In his Apr. 30 speech in Toronto previewing the Bush Administration's energy policy, he bluntly rejected conservation as a major part of the solution to the current energy crisis. His plans focus almost exclusively on boosting domestic oil sources, building refineries, and laying natural-gas pipelines. Conservation, Cheney said, "is not a sufficient basis, all by itself, for a sound, comprehensive energy policy." Moreover, he added, the government shouldn't "step in to force Americans to consume less energy."

Source: Business Week, May 14th (2001)

We’ll talk about ways to improving fuel efficiency, electric cars, hybrid cars, etc. later on.
Let’s recall that we’re talking about fossil fuels and move on to natural gas….. Let’s start by recalling how its role in overall world energy consumption.

Natural gas consumption is similar (in terms of total energy content) to coal. We see from EIA projections, that coal consumption is projected to increase slightly faster than natural gas in the coming decades.

In 2004, total world energy consumption was 447 Quads \((10^{15} \text{ BTU})\) coming from…

- Oil \(167.7\) Quads = 37%
- Natural gas \(103.8\) Quads = 23%
- Coal \(114.5\) Quads = 25%
- Nuclear \(27.5\) Quads = 6%
- Renewables \(37.7\) Quads = 9%
Quantities of natural gas are measured in two ways….

• by volume - in units of cubic ft (ft$^3$) in the U.S.
  - in units of cubic meters (m$^3$) in Europe
• in terms of energy - 1 ft$^3$ of natural gas releases about 1030 BTU’s of energy when it is burned

On the last slide, we saw that in 2004 the world used 103.8 Quads = 103.8 x $10^{15}$ BTU. How many cubic feet is this?

$$V = 103.8 \times 10^{15} \text{ BTU} \times \frac{1 \text{ ft}^3}{1030 \text{ BTU}} = 1.01 \times 10^{14} \text{ ft}^3 = (101 \text{ trillion}) \text{ ft}^3 = 101 \text{ TCF}$$

Recall ….  

$10^3$ = thousand
$10^6$ = million
$10^9$ = billion
$10^{12}$ = trillion
$10^{15}$ = quadrillion

World & U.S. natural gas usage is measured in trillions of cubic feet (TCF).
How big is a TFC (trillion cubic feet)?

1 mile = 5280 ft
1 (mile)$^3$ = (5280 ft)$^3$ = $1.5 \times 10^{11}$ ft$^3$
1 TFC = $10^{12}$ ft$^3$ = 6.8 (mile)$^3$

101TFC = 686 (mile)$^3$ = (8.8 miles)$^3$

The natural gas used by the whole world in 2004 would fill a cube 8.8 miles on a side.

For comparison, in 2006 the world produced 1.02 (mile)$^3$ of oil....

One thing we see from this is that natural gas takes up a lot of space. Even though the world got about 1.6 times more energy from oil than from natural gas, the natural gas takes up almost 700 times as much space.

Transporting natural gas is a big issue.

Physics 190E: Energy & Society
Fall 2007
What is natural gas?

When it is used in the home (heating, cooking, etc.) or burned in a power plant to make electricity, natural gas is almost pure methane - CH$_4$. However when it comes out of the ground, it is mixed with other hydrocarbons and impurities. These vary from location to location...

Natural gas needs to be refined to separate these components and produce “pipeline quality” dry natural gas.

Dry in this context means pure methane

Source: www.naturalgas.org
2006 figures for natural gas in the U.S.

Source: Energy Information Administration

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<table>
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<tbody>
<tr>
<td>Consumption</td>
<td>21.9 Tfc</td>
</tr>
<tr>
<td>Production</td>
<td>18.5 Tfc</td>
</tr>
<tr>
<td>Imports</td>
<td>4.2 Tfc</td>
</tr>
<tr>
<td>Exports</td>
<td>0.8 Tfc</td>
</tr>
</tbody>
</table>

**Top Natural Gas Producing States 2005,**
(Million Cubic Feet)

1 Texas 5,254,974
2 Oklahoma 1,670,137
3 New Mexico 1,645,166
4 Wyoming 1,639,317
5 Louisiana 1,296,048
6 Colorado 1,133,086
7 Alaska 487,282
8 Kansas 377,229
9 California 317,637
10 Utah 301,223
Natural gas makes its way from regions of production to regions of consumption by way of an elaborate network of pipelines…
What do we use natural gas for?

- 22% of the energy we use in the U.S. comes from natural gas.
- More than 50% of homes in the U.S. have heating systems that run on natural gas.
- 19% of electricity in the U.S. comes from natural gas (about the same as nuclear). Because natural gas burns very cleanly compared to coal, it has been the fuel of choice for new power plants in recent years.
Can natural gas production keep up with consumption?

<table>
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<tbody>
<tr>
<td>U.S. 204 Tfc</td>
<td>US 22.2 Tfc</td>
</tr>
<tr>
<td>World 6227 Tfc</td>
<td>World 101 Tfc</td>
</tr>
</tbody>
</table>

A simple linear estimate gives about a 9 year domestic supply and a 60 year world supply at current consumption rates.

But… Consumption rates are projected to rise and people talk about **peak natural gas** coming about 10 years down the road from peak oil.

EIA estimates that U.S. demand for natural gas will grow at a modest rate of 0.7% per year over the period (2005-2030), with a slowly increasing fraction coming from imports.

Natural gas imports come in two forms - as a gas through pipelines (from Canada & Mexico) and as liquefied natural gas (LNG) via ship.
EIA projects that overall natural gas imports will rise at a rate of 1.7%/year.
• Pipeline imports are projected to decrease at a rate of - 4.6%/year
• LNG imports are projected to increase at a rate of 8.7%/year

This is interesting because LNG imports are quite a controversial issue because of safety and environmental issues.

Natural gas is liquefied by cooling it to -163°C, which reduces its volume to about 1/600 of its gaseous state.

LNG is transported in cryogenic tanker ships and trucks

LNG is extremely explosive… There is some disagreement over how to describe the effects of the explosion of an LNG tanker - with the high end comparing it to a small nuclear explosion.
Currently, there are 5 LNG terminals in the U.S. The terminal in Alaska is for export purposes…

Many proposals for new LNG terminals are currently under consideration… mostly with opposition from nearby communities.
LNG tankers going to the Everett, MA terminal on the Mystic River pass through Boston Harbor. Coast guard and State Police escort ships ensure that all other water traffic stays at least 1 mile away from LNG tankers in the harbor.

Since 9/11/2001

The Everett terminal, owned by SUEZ Energy North America opened in 1971 and provides 20% of New England’s natural gas supplies.
SUEZ has proposed building an offshore LNG terminal, 10 miles out from Gloucester, MA.

The Neptune terminal would be connected by pipeline to the mainland and have a capacity of 400 cubic feet of natural gas per day.
A variety of local groups, including the Gloucester Fisherman’s Wives Association (GFWA) are opposed to the offshore terminal. The GFWA website notes the following concerns….

Source: http://www.gfwa.org/aboutUs/about.html

A: There are three primary concerns:

1. Human safety
2. Environmental safety
3. Disruption of fishing and other marine and recreational activities

Human Safety:
- Too close to population centers (the other US offshore facility is 116 miles off the coast of Louisiana)
- Technology is untested
- Released LNG can create a flammable vapor that could travel 2.5 to 7 miles before dispersing. It could be ignited at any point engulfing population centers, boats, or another tanker. Gloucester is ten miles from the proposed site. The proposed site is also less than one mile from the major channel used for shipping off the North Shore
- Accidents: while tanker hulls are constructed for maximum safety, accidents or attacks are possible at many potential points: rupture to line, misfit of connection, collision of boats, buoy opening to pipeline, terrorist attack

Environmental Safety:
- Huge amounts of air pollution from tankers (over 100 tons per year per vessel)
- Intake of more than 100 million gallons of sea water each day sucking in hundreds of millions of fish eggs and marine life
- Disruption of vital and fertile fishing grounds, such as Stellwagen Bank
- Leaks from storage compartment while open to facilitate transfer
- Increase in water temperature.

Disruption of Fishing and Other Marine and Recreational Activities:
- More fishing ground closures within the “safety” zone (one-fourth of a mile)
- No vessels with underwater gear can operate within two-thirds of a mile
- No traffic out to nearly one and one-half miles when the tanker is approaching
- Security zone of six miles for all commercial and recreational vessels when a tanker is present
- Represents important feeding grounds for endangered Northern Right, Humpback, and Fin whales.