ME 251

PROJECT

ASSESSMENT OF CURRENT AND FUTURE ENERGY SOURCES

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Final report due on 12/19/2013
REPORT GUIDELINES

Submit the report as a .pdf file. Include pictures and references within the sections listed below:

Section 1: Describe the source of power generation. Sketch layouts of power plants and other power generation systems.

Section 2: Show thermodynamic cycles related to the particular power generation system (if applicable)

Section 3: Provide details of your cost estimates for power generation (capital costs, operational costs and fuel costs). Assess economic viability and attractiveness.

Section 4: Provide brief description of climate change issues (general)

Section 5: Provide assessment of environmental impact. Comments on the effects on climate change

Section 6: Current usage and forecasts for future usage

Section 7: Comments on strategic and geo-political issues related to the particular energy source.

USEFUL REFERENCES:

Overview and Summary of America's Energy Future, National Academy of Sciences, National Academy of Engineering, National Research Council (2010)


The Environmental Protection Agency, http://www.epa.gov/
WIND POWER (Groups W1-W3)

Introduction from http://en.wikipedia.org/wiki/Wind_power. Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electrical power, windmills for mechanical power, wind pumps for water pumping or drainage, or sails to propel ships. Large wind farms consist of hundreds of individual wind turbines which are connected to the electric power transmission network. For new constructions, onshore wind is an inexpensive source of electricity, competitive with or in many places cheaper than fossil fuel plants. Small onshore wind farms provide electricity to isolated locations. Utility companies increasingly buy surplus electricity produced by small domestic wind turbines. Offshore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher.

Wind power, as an alternative to fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation and uses little land. The effects on the environment are generally less problematic than those from other power sources. As of 2011, Denmark is generating more than a quarter of its electricity from wind and 83 countries around the world are using wind power to supply the electricity grid. In 2010 wind energy production was over 2.5% of total worldwide electricity usage, and growing rapidly at more than 25% per annum. Wind power is very consistent from year to year but has significant variation over shorter time scales. As the proportion of windpower in a region increases, a need to upgrade the grid, and a lowered ability to supplant conventional production can occur. Power management techniques such as having excess capacity storage, geographically distributed turbines, dispatchable backing sources, storage such as pumped-storage hydroelectricity, exporting and importing power to neighboring areas or reducing demand when wind production is low, can greatly mitigate these problems. In addition, weather forecasting permits the electricity network to be readied for the predictable variations in production that occur.

1. Describe the technical aspects of all forms of wind power
2. Determine the total electricity produced for a model land area and then calculate the total electricity produced for a larger area by extrapolation
3. Compare the total electricity produced using variables such as wind direction, topography, and number and design of the wind turbines
4. Determine the cost of electricity from wind and develop a projection to assess the cost of electricity from wind within the next 3-4 decades
5. Determine the environmental impact of wind power
6. Determine the prospects for wind energy as base load versus peaking power
7. Describe and assess all the relevant issues you can identify regarding wind power such as energy storage, optimal locations, and compatibility with the current electrical grid, economic attractiveness, and environmental benefits/issues.

**SOLAR POWER (Groups S1-S3)**

Introduction from http://en.wikipedia.org/wiki/Solar_power. Solar power is the conversion of sunlight into electricity, either directly using photovoltaics (PV), or indirectly using concentrated solar power (CSP). Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaics convert light into electric current using the photoelectric effect.

Photovoltaics were initially, and still are, used to power small and medium-sized applications, from the calculator powered by a single solar cell to off-grid homes powered by a photovoltaic array. They are an important and relatively inexpensive source of electrical energy where grid power is inconvenient, unreasonably expensive to connect, or simply unavailable. However, as the cost of solar electricity is falling, solar power is also increasingly being used even in grid-connected situations as a way to feed low-carbon energy into the grid.

Commercial concentrated solar power plants were first developed in the 1980s. The 354 MW SEGS CSP installation is the largest solar power plant in the world, located in the Mojave Desert of California. Other large CSP plants include the Solnova Solar Power Station (150 MW) and the Andasol solar power station (150 MW), both in Spain. The 250+ MW Agua Caliente Solar Project in the United States, and the 221 MW Charanka Solar Park in India, are the world’s largest photovoltaic power stations.

1. Describe the technical aspects of all forms of solar power (sketch the power system, describe the components, determine the efficiency)

2. Determine the total electricity produced for a model land area and then calculate the total electricity produced for a larger area by extrapolation

3. Determine the connection between weather variables and the changes in available solar energy

4. Determine the current cost of electricity from solar and develop a projection to assess the cost of electricity from solar within the next 3-4 decades. Include the impact of federal subsidies on the current cost of electricity from solar.

5. Determine the environmental impact of solar power

6. Determine the prospects for solar energy as base load versus peaking power
7. Describe and assess all the relevant issues you can identify regarding solar power such as energy storage, optimal locations, and compatibility with the current electrical grid, economic attractiveness, and environmental benefits/issues.

**BIOFUELS (Groups B1-B3)**


Biofuels are produced from biomass. Biomass includes living organisms such as plants, trees and crops, as well as half of all trash. The major potential of biomass is for production of liquid transportation fuels. These fuels include ethanol and methanol, two alcohol fuels made from corn, wheat and other crops, and methane, a colorless, odorless and flammable gas made from waste. Ethanol, methanol and methane offer an attractive alternative to petroleum-based gasoline and diesel fuels. There are more than 185 million vehicles in the U.S., and these vehicles are responsible for two thirds of the nation's total oil consumption. The quantity of biomass currently available could produce enough liquid transportation fuel to replace all the gasoline we currently use in these vehicles. By the end of the decade, technological advancements will make these fuels as affordable and easy to use as today's petroleum-based gasoline and diesel fuels.

1. Describe the technical aspects of biofuels for power production and for transportation (sketch the power system, describe the components, determine the efficiency).
2. Determine the cost of fuel from biofuels and compare with conventional fuels used in the transportation sector (petroleum-based gasoline and diesel fuels).
3. Determine the environmental impact of biofuels.
4. Currently biofuels are used in the transportation sector. Assess the viability of biofuels for power production (base load versus peaking power).
5. Describe and assess all the relevant issues you can identify regarding biofuels such as optimal locations, economic attractiveness, environmental benefits/issues. Include considerations with regard to the impact of biofuels on climate change.
6. Research the usage of biofuels (inside and outside the US) and evaluate its economic impact on the local economies.

**NUCLEAR POWER (Groups N1-N3)**

Introduction from [http://en.wikipedia.org/wiki/Nuclear_power](http://en.wikipedia.org/wiki/Nuclear_power). Nuclear power is the use of exothermic nuclear processes, to generate useful heat and electricity. The term includes nuclear fission, nuclear decay and nuclear fusion. Presently the nuclear fission of elements in the actinide series of the periodic table produce the vast majority of nuclear energy in the direct service of humankind, with nuclear decay processes, primarily in the form of geothermal energy, and
radioisotope thermoelectric generators, in niche uses making up the rest. Nuclear (fission) power stations, excluding the contribution from naval nuclear fission reactors, provided about 5.7% of the world's energy and 13% of the world's electricity in 2012. In 2013, the IAEA report that there are 437 operational nuclear power reactors, in 31 countries, although not every reactor is producing electricity. In addition, there are approximately 140 naval vessels using nuclear propulsion in operation, powered by some 180 reactors. As of 2013, attaining a net energy gain from sustained nuclear fusion reactions, excluding natural fusion power sources such as the Sun, remains an ongoing area of international physics and engineering research. More than 60 years after the first attempts, commercial fusion power production remains unlikely before 2050.

There is an ongoing debate about nuclear power. Proponents, such as the World Nuclear Association, the IAEA and Environmentalists for Nuclear Energy contend that nuclear power is a safe, sustainable energy source that reduces carbon emissions. Opponents, such as Greenpeace International and NIRS, contend that nuclear power poses many threats to people and the environment.

1. Describe the technical aspects of nuclear power production (sketch the power system, describe the components, determine the efficiency).

2. Determine the cost of electricity from nuclear power (capital costs, operational costs and fuel costs). Develop a projection to assess the cost of electricity from nuclear within the next 3-4 decades.

3. Determine the environmental impact of nuclear power.

4. Determine the current usage of nuclear power in the US and worldwide.

5. Describe and assess all the relevant issues you can identify regarding nuclear power such as optimal locations, compatibility with the current electrical grid, economic attractiveness, environmental benefits/issues including the effects on climate change, availability of fuel, strategic importance.

6. Research the current usage of nuclear power in the US and worldwide, and evaluate its economic impact on the local economies.


NATURAL GAS (Groups G1-G4)

Introduction from http://en.wikipedia.org/wiki/Natural_gas. Natural gas is a major source of electricity generation through the use of cogeneration, gas turbines and steam turbines. Natural gas is also well suited for a combined use in association with renewable energy sources such as wind or solar and for alimenting peak-load power stations functioning in tandem with hydroelectric plants. Most grid peaking power plants and some off-grid engine-generators use natural gas. Particularly high efficiencies can be achieved through combining gas turbines with a
steam turbine in combined cycle mode. Natural gas burns more cleanly than other hydrocarbon fuels, such as oil and coal, and produces less carbon dioxide per unit of energy released. For an equivalent amount of heat, burning natural gas produces about 30 per cent less carbon dioxide than burning petroleum and about 45 per cent less than burning coal.

Coal-fired electric power generation emits around 2,000 pounds of carbon dioxide for every megawatt hour generated, which is almost double the carbon dioxide released by a natural gas-fired electric plant per megawatt hour generated. Because of this higher carbon efficiency of natural gas generation, as the fuel mix in the United States has changed to reduce coal and increase natural gas generation, carbon dioxide emissions have unexpectedly fallen. Those measured in the first quarter of 2012 were the lowest of any recorded for the first quarter of any year since 1992.

Combined cycle power generation using natural gas is currently the cleanest available source of power using hydrocarbon fuels, and this technology is widely and increasingly used as natural gas can be obtained at increasingly reasonable costs. Fuel cell technology may eventually provide cleaner options for converting natural gas into electricity, but as yet it is not price-competitive. Locally produced electricity and heat using natural gas powered Combined Heat and Power plant (CHP or Cogeneration plant) is considered energy efficient and a rapid way to cut carbon emissions

1. Describe the technical aspects of natural gas power production (sketch the power system, describe the components, determine the efficiency).

2. Determine the cost of electricity from natural gas (capital costs, operational costs and fuel costs). Develop a projection to assess the cost of electricity from natural gas within the next 3-4 decades

3. Determine the environmental impact of natural gas mining and power production

4. Determine the current usage of natural gas in the US and worldwide (base load versus peaking power production)

5. Describe and assess all the relevant issues you can identify regarding natural gas such as compatibility with the current electrical grid, economic attractiveness, environmental benefits/issues including the effects on climate change, availability of fuel, strategic importance.

6. Research the current usage of natural gas in the US and worldwide, and evaluate its economic impact on the local economies

7. Assess the future prospects for natural gas in the US and worldwide
COAL POWER AND CLEAN COAL TECHNOLOGIES (Groups C1-C3)

Introduction from http://en.wikipedia.org/wiki/Coal_power_in_the_United_States. Coal power in the United States accounted for 42% of the country's electricity production in 2011. Utilities buy more than 90 percent of the coal mined in the United States. In 2009, there were 1436 coal-powered units at the electrical utilities across the US, with the total nominal capacity of 338.732 GW (compared to 1024 units at nominal 278 GW in 2000). The actual average generated power from coal in 2006 was 227.1 GW (1.991 trillion kilowatt-hours per year), the highest in the world and still slightly ahead of China (1.95 trillion kilowatt-hours per year) at that time. In 2000, the US average production of electricity from coal was 224.3 GW (1.966 trillion kilowatt-hours for the year). In 2006, US electrical generation consumed 1,026,636,000 short tons (931,349,000 metric tons) or 92.3% of the coal mined in the US.

From http://en.wikipedia.org/wiki/Clean_coal_technology. Clean coal technology is a collection of technologies being developed to mitigate the environmental impact of coal energy generation. When coal is used as a fuel source, the gaseous emissions generated by the thermal decomposition of the coal include sulphur dioxide, nitrogen dioxide, carbon dioxide, and other chemical byproducts that vary depending of the type of the coal being used. These emissions have been established to have a negative impact on the environment, contributing to acid rain and climate change. As a result, clean coal technologies are being developed to remove or reduce pollutant emissions to the atmosphere. Some of the techniques that would be used to accomplish this include chemically washing minerals and impurities from the coal, gasification, treating the flue gases with steam to remove sulfur dioxide, carbon capture and storage technologies to capture the carbon dioxide from the flue gas and dewatering lower rank coals (brown coals) to improve the calorific value, and thus the efficiency of the conversion into electricity.

Clean coal technology usually addresses atmospheric problems resulting from burning coal. Historically, the primary focus was on sulfur dioxide and particulates, since it is the most important gas in the causation of acid rain. More recent focus has been on carbon dioxide (due to its impact on global warming) as well as other pollutants. Concerns exist regarding the economic viability of these technologies and the timeframe of delivery, potentially high hidden economic costs in terms of social and environmental damage, and the costs and viability of disposing of removed carbon and other toxic matter.

1. Describe the technical aspects of power production using coal (sketch the power system, describe the components, and determine the efficiency).

2. Determine the cost of electricity from coal (capital costs, operational costs and fuel costs). Develop a projection to assess the cost of electricity from coal within the next 3-4 decades

3. Determine the environmental impact of coal mining and power production

4. Determine the current usage of coal in the US and worldwide

5. Describe and assess all the relevant issues you can identify regarding power generation from coal such as compatibility with the current electrical grid, economic attractiveness,
environmental benefits/issues including the effects on climate change, availability of fuel, strategic importance.

6. Research the current usage of coal in the US and worldwide, and evaluate its economic impact on the local economies

7. Assess the future prospects for coal in the US and worldwide

8. If implemented, determine the impact of clean coal technologies on the cost of electricity from coal. Assess the prospects for electricity production with clean coal.