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The Upcoming Energy Crisis

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by

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Abstract

There are many misconceptions surrounding the current state of national energy. Media propaganda has portrayed the coming years as a crisis, both from a production and environmental standpoint. The government view regarding these problems lies in the national energy policy. But what sort of impact will the current policy have, and whose interest does it take? By outlining the truth about energy sources this project critiques the current policy and also commits some changes.

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Executive Summary

In today's world, energy is required in every aspect of a person's life. People have grown dependent on energy since it is needed so often. Since the public is accustomed to having what seems an endless supply of fuels that are used to produce energy, most people are not aware of the upcoming energy crisis. It is a crisis that is very real, and it is one which could force us to change our ways concerning energy use unless new methods of producing energy are introduced in the near future.

One method of producing energy that is becoming more profitable is the use of solar energy using photovoltaic cells. This method works by using energy from the sun, an almost endless resource, and converting it to energy using solar cells made of semiconductors. This method of producing energy is promising because it is clean and somewhat cheap. Its efficiency, however, is only between 15-25%, which must be improved greatly before widespread use can occur.

Like solar energy, wind energy is a renewable method of producing energy that has promise. A wind farm, which consists of a large number of wind turbines, can generate good amounts of energy. With the improvements in wind turbine technology that has resulted recently, wind farms are becoming more and more useful as a means of producing energy.

Nuclear fission is another method that has a lot of promise. Energy is produced using this method when two hydrogen atoms are combined to form a new helium atom. If this technology is developed fully, it will be able to generate endless amounts of energy. It has not entered widespread use because of several factors, including the fact that millions of degrees of heat are needed to facilitate fusion reactions.

With improvements in new technologies coming along slowly, improvements in a current method of energy production, Natural gas, have been dramatic. It is much easier now for people to find large deposits of Natural gas. That, along with the amazing method of transporting gas from one place to another in the country, makes natural gas a very important source.

Along with producing high amounts of energy, it is also hoped that new methods being developed are also more environmentally-friendly than their predecessors. Coal gasification is one method that accomplishes both of these goals. Coal gasification has been in use for decades now, but recent improvements are making it a more feasible method. Unfortunately, its efficiency is not yet that of a similar coal combustion plant, so more improvements are needed before gasification becomes a cost-effective method.

When looking at nuclear fusion as a potential method of producing energy in the future, we must also look at nuclear fission, a current method that produces close to 20% of today's energy in this country. Fission is a technology that has not been used to its potential due to public concern about accidents that could happen. However, nuclear plants are much safer today then plants were when major accidents did happen, so this concern is not as important as is once was.

Chapter 1: Proposal

1.1 Purpose

The purpose of this project is to inform the reader of the current US energy policy and its impact on society. After analyzing a wide variety of sources we will submit our own energy policy that we feel better reflects the US's interests.

Goals:

- To outline and analyze the current research status of: fusion power, nuclear power, natural gas, wind power, solar power, and coal gasification.
- Research how the listed resources are currently implemented in the US.
- Research and analyze the current potential uses and impacts for listed power supplies in the US.
- Formulate a new national energy policy based on our findings.
- Explain the difference between the impact current energy policy and new energy policy will have on the US.
- Look at global energy policies to see if they face some of the same problems as the US.

1.2 Introduction

Most people put very little though into how much electricity they use. They usually have very little choice on a provider, so the only way to alleviate their cost is to slightly change their lifestyle. Things like remembering to shut off all the lights in your house before bed can make a large difference in electricity usage. So aside from the small price fluctuations and the occasional brown-out, the average US citizen has little or no contact with the complex world that keeps the national energy grid flowing. The only knowledge most people gather is from news propaganda which creates a buzz by using phrases like "national energy crisis". Questions arise regarding the amount of fuel we have left and if we're going to run out. Then the environmentalists chime in saying that the US is creating too many pollutants with our power plants and clear cutting forests to get at oil. The government outlines its answer to the all these questions in the national energy policy. However, is the government making the best choices for the people or for itself? The only way to answer that question is by laying all the information about all the sources and then making a decision.

Chapter 2: Energy Sources

2.1 Solar Energy

2.1.1 Introduction

The idea of harnessing the sun's energy is not a recent phenomenon. The Indian Pueblos of the American southwest were designed using the concept of thermal mass. This technique uses the thick adobe mud and rock walls to gain the sun's energy in the winter, passing this energy to the interior at night. In addition these structures were placed and built to be shaded in the summer and allow heat in the form of sunlight to enter in the winter. Again the thick walls provided year round thermal comfort. The Greeks also built structures to maximize the natural energy of the sun. Xenophon wrote in 400 BC of how to design the openings and placement of a given structure to allow for the natural heating and cooling of the building. The Roman architect Vitruvius wrote about solar architecture in detail in The Ten Books on Architecture (before 30 BC).

The basic principles behind the development and practical use of solar energy are for the most part very simple. The sun's energy is radiated through space, filtered by our atmosphere and strikes the surface of the earth in a predictable and quantifiable manner. For most design purposes BTU[1] per square foot or some measurement of energy over a given area is the first starting point. Thermal design applications require the basic needs of heat energy or work to be done. Once the desired result is known the proper materials are formulated into a design. One of the most simple thermal design systems utilized direct thermal transfer. Direct thermal transfer uses the basic principles of radiation, conduction and convection to heat systems such as a solar pool[2] or home water heating. Overall, all thermal systems are governed by the law of Thermodynamics which generally states that temperature always disperses from hot to cold.

Solar energy can be use in many ways to generate electricity: for heating water, lighting, and any other basic household needs. Devices which capture light directly and turn it into energy are generally called photovoltaic solar cells. Traditionally prices for these systems have been very high in the past. However, as the price of these systems continues to drop as the efficiency increases, the solar cells are becoming more and more economically feasible for large scale "solar farm" implementation and also on the personal level.

2.1.2 Functioning

Photovoltaic (PV) cells perform this conversion without any moving parts, noise, pollution, radiation, or maintenance. PV cells are made of a semiconductor material, typically silicon (from beach sand, an abundant resource), which is treated chemically to create a positive charge layer and a negative charge layer. Most PV modules are made with around 36 or 72 silicon cells, each producing about 1/2 volt. When sunlight strikes a PV cell, an electron is dislodged. These loose electrons are gathered by wires attached to the cell, forming an electrical current. The more cells ranged, the greater the current and voltage. A number of PV cells laid side-by-side form a rectangular module; several modules together form an array. (See Figure 1) PV modules sold commercially range in power output from about 5 watts to 300 watts, and produce a direct current (DC) like the current from a car's battery.

[1] A unit of heat equal to the amount of heat required to raise one pound of water one degree Fahrenheit at one atmosphere pressure; equivalent to 251.997 calories.
[2] A method of using a solar collector for heating indoor or outdoor pool, same deal for home water heating.

Figure 1: 720 Wp Array, **ETAPUMP** HR14, max. Vertical lift 42m pumping into two tanks: 1 x 1.1km, 2,000 ImpG/day , 30m vertical lift, 1 x 1.5km, 4,000 ImpG/day, 42m vertical lift . Picture Courtesy by [BW Solar, Australia]

2.1.3 Economics of a PV System vs. Electric Utility

The development and usage of solar energy system for home use has become a promising prospect in the future. During a speech to the United Nations' Session on Environment and Development, June 26, 1997, President Clinton announced a national program to install solar energy systems on 1 million roofs by 2010. This paved the way for states and communities to commit to environmentally- sound energy development. The program, known as the Million Solar Roofs Initiative, includes two types of technologies: photovoltaic systems that produce electricity from sunlight, and solar thermal collectors that produce heat for domestic hot water, space heating and swimming pools.

The initiative, sponsored by the U.S. Department of Energy (DOE), will help increase the market for solar energy and encourage increased development and production of solar energy systems. At the same time, it will give consumers an affordable, clean-energy option and create new U.S. high-technology jobs.

To attain this goal, DOE is working with numerous state and local government agencies and commercial businesses to remove market barriers to solar energy use and develop and strengthen the demand for solar energy products and applications.

To be included in the MSRI (Million Solar Roofs Initiative), a building's solar energy system must comply with all relevant parts of the National Electrical Code, Underwriters Laboratories Standards, and the Solar Rating and Certification Corporation Standards. The system must also be located on or immediately adjacent to the building and meet minimum standards of that particular system established by the MSRI.

There are over 25,000 homes in California today that are off-grid and powered primarily by photovoltaic. It is easy to install and has increased incentive due to tax credits[3] available in California. Such electricity is produced without oil, coal, natural gas or any other limited resources that create any emissions or pollution. In addition, these homeowners are protected against future rate increases for the next 25-30 years.

2.1.3.1 Example 1: Reducing a businesses annual electrical expense

From 1970 to 2000, annual retail electric rates increase averaged 5.1%. Take a look at the following example. A Corporation with taxable income of $100,000,000 per year that is spending $10,000 on electricity; can turn a $6,019 annual expense (the net cost after tax) into a $1,156 net profit in the first year of ownership just by installing a solar energy system as shown in Table 1.

Table 1: Net savings of given company with 10,000 annual electric bill.

	Before Purchase	After Purchase	Saving
Electric bill	-$10,000	-$2,371	$7,633
Tax Savings(Utility Bills)	$3,985	$944	-$3,041
Payment on loan	0	-$7,472	-$7,472
Tax Savings(loan interests)	0	$2,598	$2,598
Tax savings (depreciation)	0	$7,456	$7,456
Total Cash Flow	-$6,019	$1,156	$ 7,175

[3] **20/20 Energy Rebate:** Residential, commercial, and industrial customers are eligible for this voluntary program which will provide rebates to customers who reduce their summer 2001 electricity usage. Customers will receive a 20% rebate on their summer electric bill if they cut back their electricity use by 20% over last summer's level. (Direct access customers are not eligible.)

Low-energy usage building materials: California's commercial buildings account for 36% of the state's annual electricity use. *During peak times, commercial buildings use 11% of the state's* electricity for lighting and 15% for air conditioning. Funds will be used to identify and buy-down the cost of energy measures, such as "white roofs," used to retrofit commercial buildings for energy efficiency.

System is 34 kW with net purchase price of $93,592 after incentives. Assumes net purchase amount financed with 30-year term at 7.00%. Even in the absence of any future utility rate increase (which, based upon past history, is highly unlikely), the firm in the example achieves a $35,000 positive contribution over the first five years of implementation. As the loan gets paid down and the interest tax credit diminishes, much of the gains are given back. Nonetheless, the overall contribution over the life of the system is still positive.

Table 2 (and charts 1 & 2) has examined the annual costs and savings before and after solar energy system installation. Please note that because it is extremely unlikely that utility rates will remain at their current levels until 2031, therefore the "No Utility Rate Increase" column is included. In addition to all, Figure 2 has provided a reasonable formula to calculate for electricity Bill savings for a PV System.

Table 2: Projected Annual Costs and Savings Before and After Solar Energy System Installation

	5.1% Annual Utility Rate Increase *same as trend 1970-2000*				**No Annual Utility Rate Increase**			
	Cost After System Purchase	Cost Before System Purchase	Annual Savings	***Cumulative Savings***	Cost After System Purchase	Cost Before System Purchase	Annual Savings	***Cumulative Savings***
2002	$1,155	($6,019)	$7,174	***$7,174***	$1,155	($6,019)	$7,174	***$7,174***
2003	$5,499	($6,326)	$11,825	***$18,999***	$5,601	($6,019)	$11,620	***$18,794***
2004	$590	($6,649)	$7,239	***$26,238***	$800	($6,019)	$6,819	***$25,613***
2005	($2,418)	($6,988)	$4,570	***$30,808***	($2,094)	($6,019)	$3,925	***$29,538***
2006	($2,572)	($7,344)	$4,772	***$35,579***	($2,128)	($6,019)	$3,891	***$33,429***
2007	($4,883)	($7,719)	$2,835	***$38,415***	($4,312)	($6,019)	$1,707	***$35,136***
2008	($7,203)	($8,112)	$909	***$39,324***	($6,498)	($6,019)	($479)	***$34,657***
2009	($7,387)	($8,526)	$1,139	***$40,462***	($6,540)	($6,019)	($521)	***$34,136***
2010	($7,581)	($8,961)	$1,380	***$41,842***	($6,584)	($6,019)	($565)	***$33,571***
2011	($7,787)	($9,418)	$1,631	***$43,473***	($6,632)	($6,019)	($613)	***$32,958***
2012	($8,005)	($9,898)	$1,893	***$45,366***	($6,684)	($6,019)	($665)	***$32,293***
2013	($8,236)	($10,403)	$2,167	***$47,533***	($6,739)	($6,019)	($720)	***$31,573***
2014	($8,481)	($10,933)	$2,453	***$49,986***	($6,798)	($6,019)	($779)	***$30,794***
2015	($8,739)	($11,491)	$2,752	***$52,737***	($6,861)	($6,019)	($842)	***$29,952***
2016	($9,014)	($12,077)	$3,063	***$55,801***	($6,929)	($6,019)	($910)	***$29,042***
2017	($9,304)	($12,693)	$3,389	***$59,190***	($7,001)	($6,019)	($982)	***$28,060***
2018	($9,611)	($13,340)	$3,729	***$62,919***	($7,079)	($6,019)	($1,060)	***$27,000***
2019	($9,937)	($14,021)	$4,084	***$67,003***	($7,163)	($6,019)	($1,144)	***$25,856***
2020	($10,282)	($14,736)	$4,453	***$71,456***	($7,253)	($6,019)	($1,234)	***$24,622***
2021	($10,648)	($15,487)	$4,840	***$76,296***	($7,349)	($6,019)	($1,330)	***$23,292***
2022	($11,034)	($16,277)	$5,243	***$81,539***	($7,452)	($6,019)	($1,433)	***$21,859***
2023	($11,444)	($17,107)	$5,663	***$87,202***	($7,563)	($6,019)	($1,544)	***$20,315***
2024	($11,877)	($17,980)	$6,103	***$93,305***	($7,681)	($6,019)	($1,662)	***$18,653***
2025	($12,336)	($18,897)	$6,561	***$99,865***	($7,808)	($6,019)	($1,789)	***$16,864***

2026	($12,823)	($19,860)	$7,037	***$106,903***	($7,945)	($6,019)	($1,926)	***$14,938***
2027	($13,338)	($20,873)	$7,536	***$114,438***	($8,091)	($6,019)	($2,072)	***$12,866***
2028	($13,883)	($21,938)	$8,055	***$122,493***	($8,248)	($6,019)	($2,229)	***$10,637***
2029	($14,460)	($23,057)	$8,597	***$131,090***	($8,416)	($6,019)	($2,397)	***$8,240***
2030	($15,071)	($24,233)	$9,161	***$140,251***	($8,596)	($6,019)	($2,577)	***$5,663***
2031	($15,718)	($25,468)	$9,750	***$150,002***	($8,789)	($6,019)	($2,770)	***$2,893***

Chart 1: No Annual Utility Rate Increase

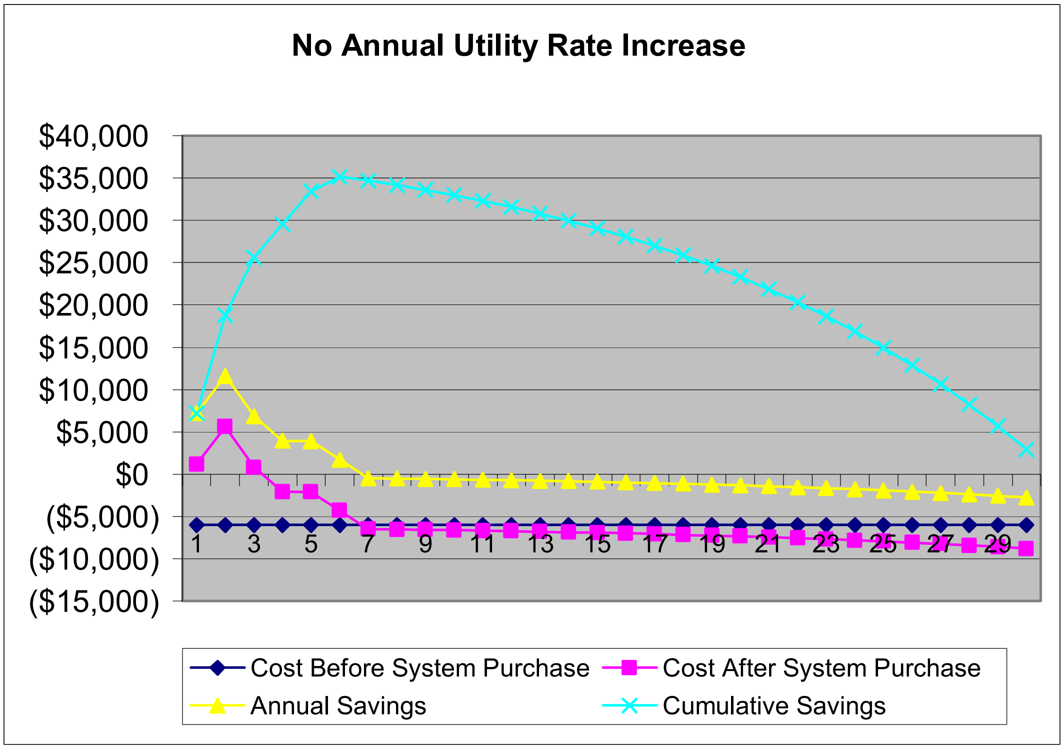


Chart 2: Cost and Savings before and after PV systems

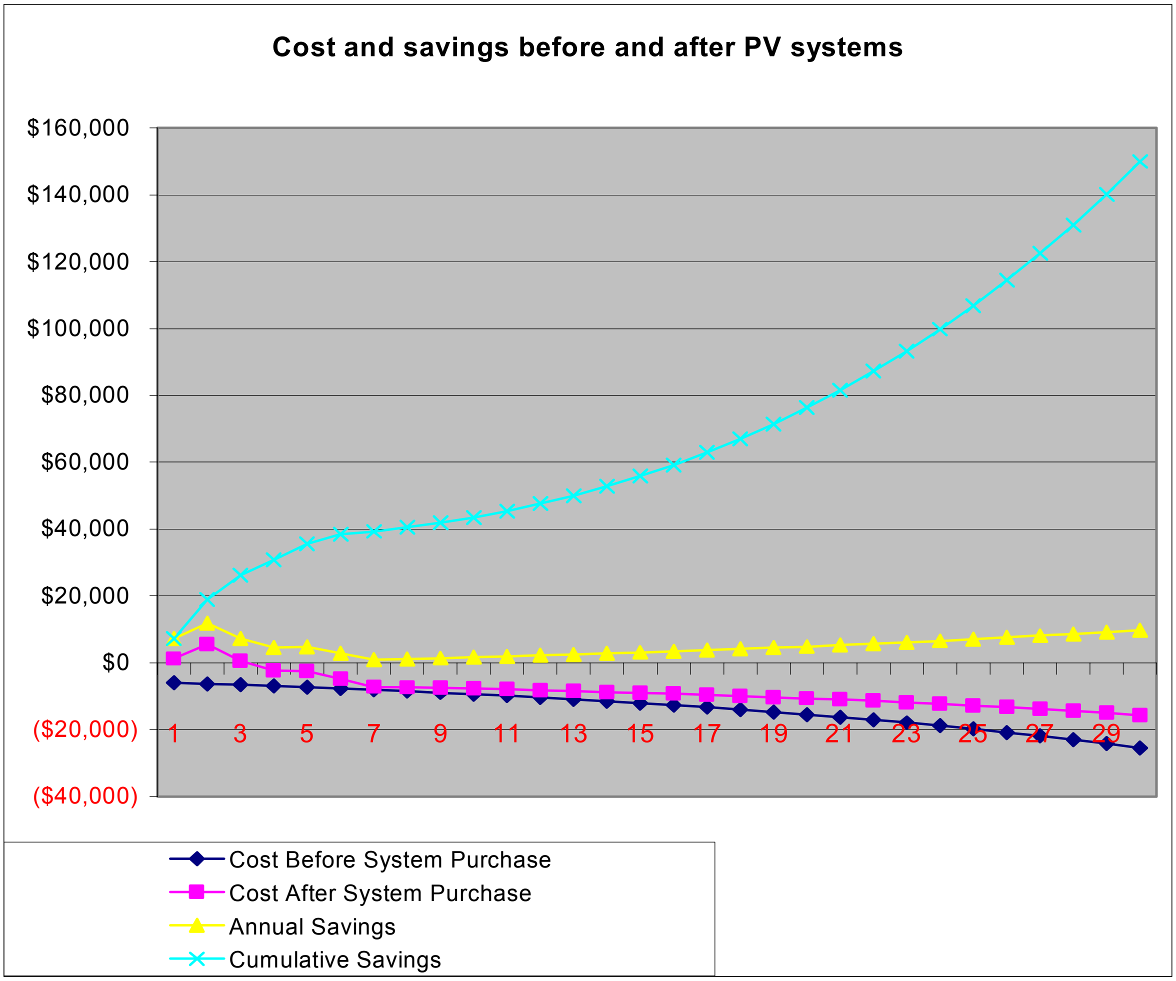


Figure 2: Calculating Electricity Bill Savings for a Net-Metered PV system

Calculating Electricity Bill Savings for a Net-Metered PV System

- Determine the system's size in kilowatts (kW). A reasonable range is 1 to 5 kW. This value is the "kW of PV" input for the equations below.
- Based on your geographic location, select the energy production factor from the map below for the "kWh/kW-year" input for the equations.

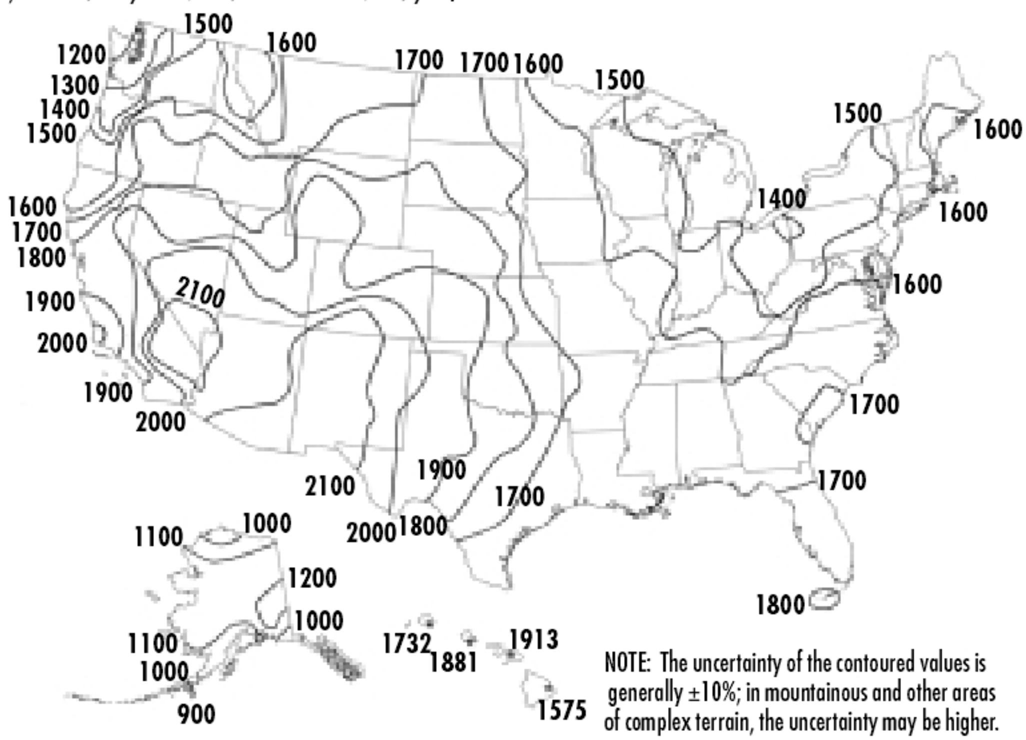
Energy from the PV system = (kW of PV) x (kWh/kW-year) = kWh/year

Divide this number by twelve if you want to determine your monthly energy reduction.

Energy bills savings = (kWh/year) x (Residential Rate)/100 = $/year saved

(Residential Rate in this above equation should be in dollars per kWh; for example, a rate of 10 cents per kWh is input as $0.10/kWh.)

For example, a 2-kW system in Denver, CO, at a residential energy rate of $0.07/kWh will save about $266 per year (1,900 kWh/kW-year x $0.07/kWh x 2 kW = $266/year).



NOTE: The uncertainty of the contoured values is generally ±10%; in mountainous and other areas of complex terrain, the uncertainty may be higher.

2.1.3.2 Example 2: Economics of the personal solar power system

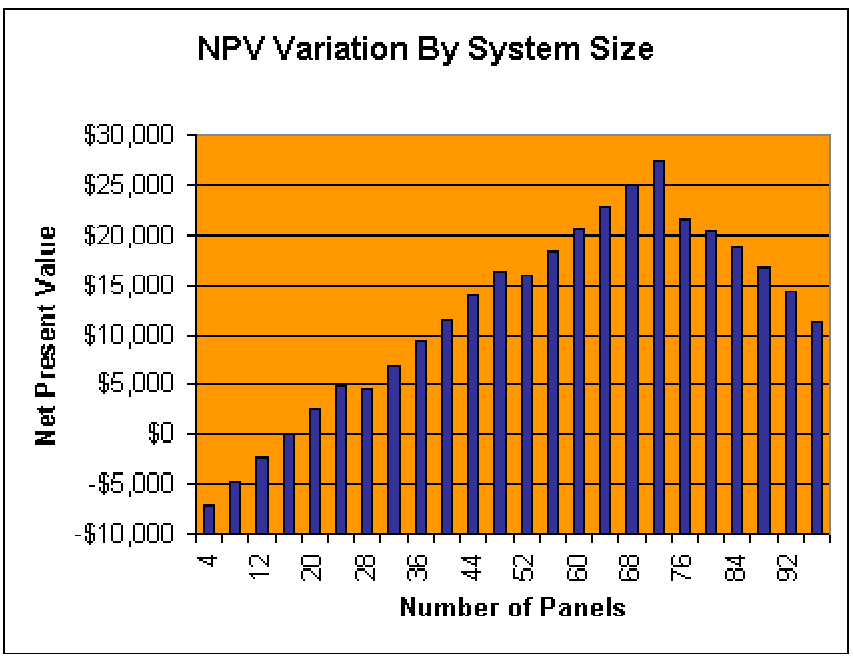
When dealing with personal systems, the *size* of the system may be the most significant factor in any equation measuring costs vs. benefits. Small, single PV-panel systems with built-in inverters that produce meanly 75 watts may cost around $900 installed, or $12 per watt. These small systems will offset only a small fraction of your electricity bill. A 2-kilowatt system that will offset the needs of a very energy-efficient home may cost $16,000 to $20,000 installed, or $8 to $10 per watt. At the high end, a 5-kilowatt system that will completely offset the energy needs of many conventional homes may cost $30,000 to $40,000 installed, or $6 to $8 per watt. These prices, of course, are just rough estimates, and individual costs will depend on the system's configuration, equipment options, and other factors.

Based on PV Module Efficiency and PV Capacity Ratting; below (Table 3) is an estimate of roof area needed in square feet for installing panels, as well as Figure 3 that illustrated how installing more PV capacity may not always save more money, but instead, more PV capacity increases the overall value of the system.

Table 3: PV Efficiency vs. Capacity Rating (http://www.rerc-vt.org)

PV Module Efficiency	PV CAPACITY RATING, watts (in bold)							
	100	**250**	**500**	**1,000**	**2,000**	**4,000**	**10,000**	**100,000**
4	30	75	150	300	600	1,200	3,000	30,000
8	15	38	75	150	300	600	1,500	15,000
12	10	25	50	100	200	400	1,000	10,000
16	8	20	40	80	160	320	800	8,000

Figure 3: NPV Variation by System Size (http://www.akeena.com)



In addition to that, please note that to install enough generating capacity will completely eliminate one's electric bill. For example, if you have a monthly bill of 1,100 kWh, the first 51 kWh your PV system generates will generate a credit on your bill at the rate of $0.235 per kWh, the next 350 kWh will be worth $0.213 per kWh, the next 245 kWh will be worth $0.174 per kWh, the next 105 kWh will be worth $0.129 per kWh, and the next 350 kWh will be worth $0.113 per kWh. Under the current Net Metering laws, PG&E (Pacific Gas & Electric Company) must give you credit for any net power that you produce. However, that credit will initially apply to the lowest (cheapest) rate tier. To avoid over sizing your PV system it is necessary to analyze the impact of the energy your PV system generates on each rate tier on your bill.

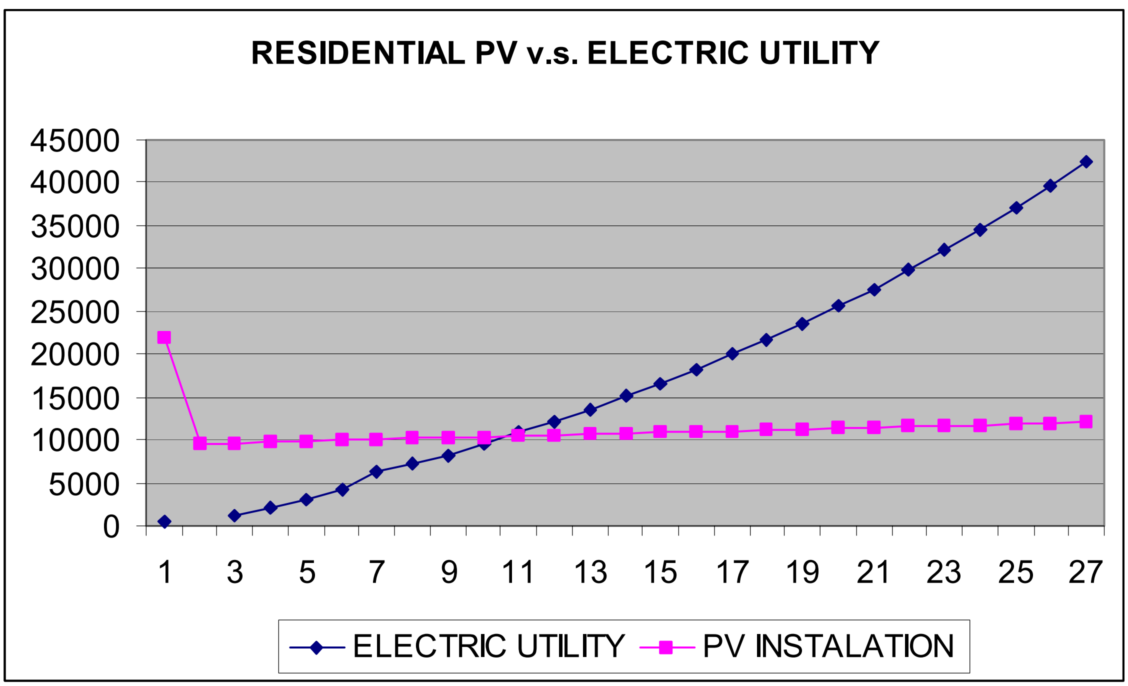
Here is an example of a typical 4-family household with Residential PV system. (See table5 and Chat 3 below) Estimating 850 kWh/mo., $0.084/kWh at first year and assuming a 5% annual rise in electric utility, over 25 years of range, the cost for electricity will go up enormously. The cost for the PV system, in another hand, as the curve had shown, besides the rebate and tax credit the government had provided that deducted the installation cost almost half of the amount, there is only a faction of maintaining fee applied. Thus that over a 10-year period, the system will be able to pay for itself and save big.

Table 5: 5% annual increasing on electricity (over a 25 years range)

856.8	1094	1396	1782	2274
900	1149	1466	1871	2388
945	1206	1540	1965	2508
992	1267	1616	2063	2633
1042	1330	1697	2166	2765

Chart 3: Residential PV vs. Electric utility

Note: The first dot was the cost when purchasing the system, and the second dot and after was price after the rebate.

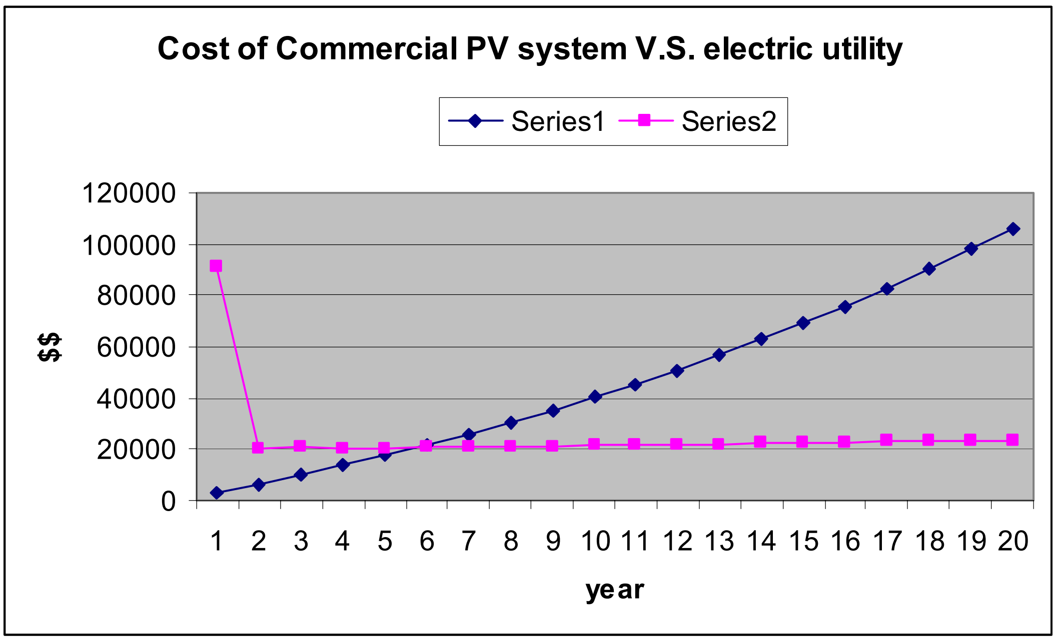


Commercial PV systems qualify for a Federal 10% tax credit and corporate accelerated 6-year depreciation. At most, one can reduce installed costs in the first year by 78% and create a return on investment in less than 6 years. Financial incentives from the State of

California include rebates of $4500/kw or 50% of installed cost (whichever is less), and a 15% income tax credit.

A small covalence shop, 1000 ft^2, usually has an electric utility reading of around 2500 kWh/month. The PV system cost is around $ 91,000 (using a PV build in calculator from web), 78% rebates at most, it will cost less than $20,000. It makes more sense to installing a Commercial PV system with such deduction. As chart 4 below has shown, if the electric utility is $0.107 the first year and increase 5% every year, over the 20 years of period, the cost for electric utility is enormous. A PV system usually has a lifetime over 20 years, but before that, it is already paying for itself after the 6th year. (Save at least $80,000 in the long run).

Chart 4: cost of Commercial PV system vs. electricity utility
Note: The first dot was the cost when purchasing the system, and the second dot and after was price after rebate the rebate.

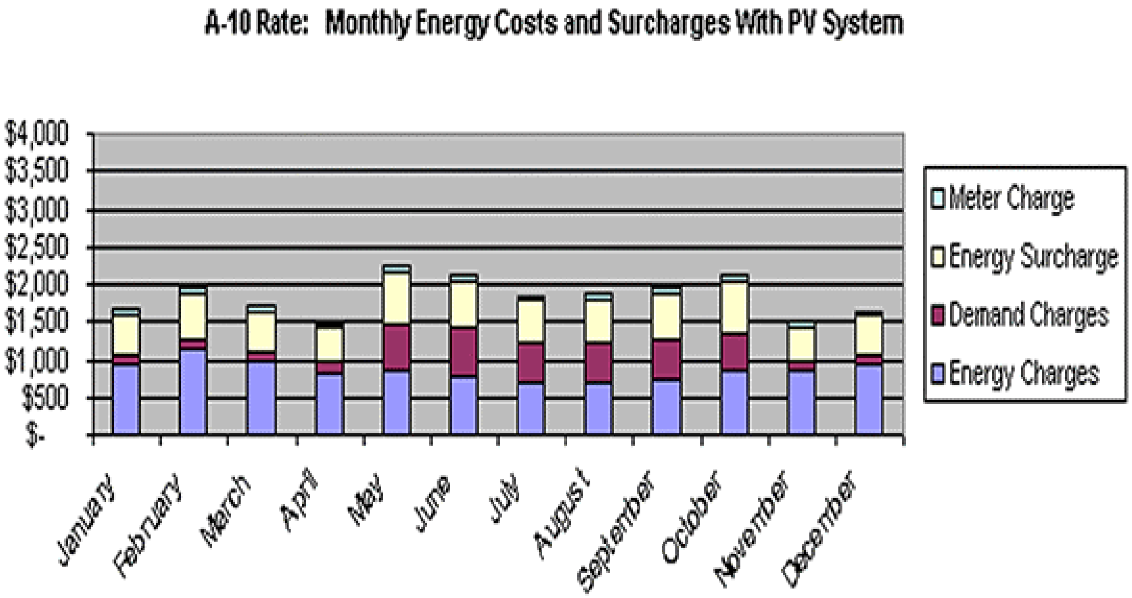


There is a commercial case study in San Jose area (http://www.akeena.com): A photovoltaic system was designed for a 20,000 square two-story building. It included:

- Three hundred *165-watt solar panels* installed on the flat roof facing south at a 10-degree tilt.
- *49,500 watts of peak* power generating capability is provided.
- Provides about 195 kWh of energy per day or about *71,000 kWh per year*.

As shown below, once the system was installed the business's monthly electrical charges were dramatically reduced.

Figure 4: Energy Costs and Surcharges with PV System



Total costs of the system were $443,370, including all equipment and installation. The customer received the following rebates and tax credits:

- $184,533 California Energy Commission Rebate
- $38, 826 California State Tax Credit
- $22,001 Federal Investment Tax Credit
- $16,633 Accelerated Depreciation for the first five years of operations.

Net costs to the business were therefore $198,010.

Based on current commercial A-10 electric rates, a 7% discount rate, 30 year system lifetime, 5% annual electrical rate increases (top electric rates in California have actually increased at an average of 5.5% per year), and 42% combined California and Federal tax rates, this system will save the business $10,626 in the first year with a Net Present Value of $17,577. The table below shows the annual cash flows as a result of the system (the purchase price is not shown but occurs in year zero).
Figure 5:

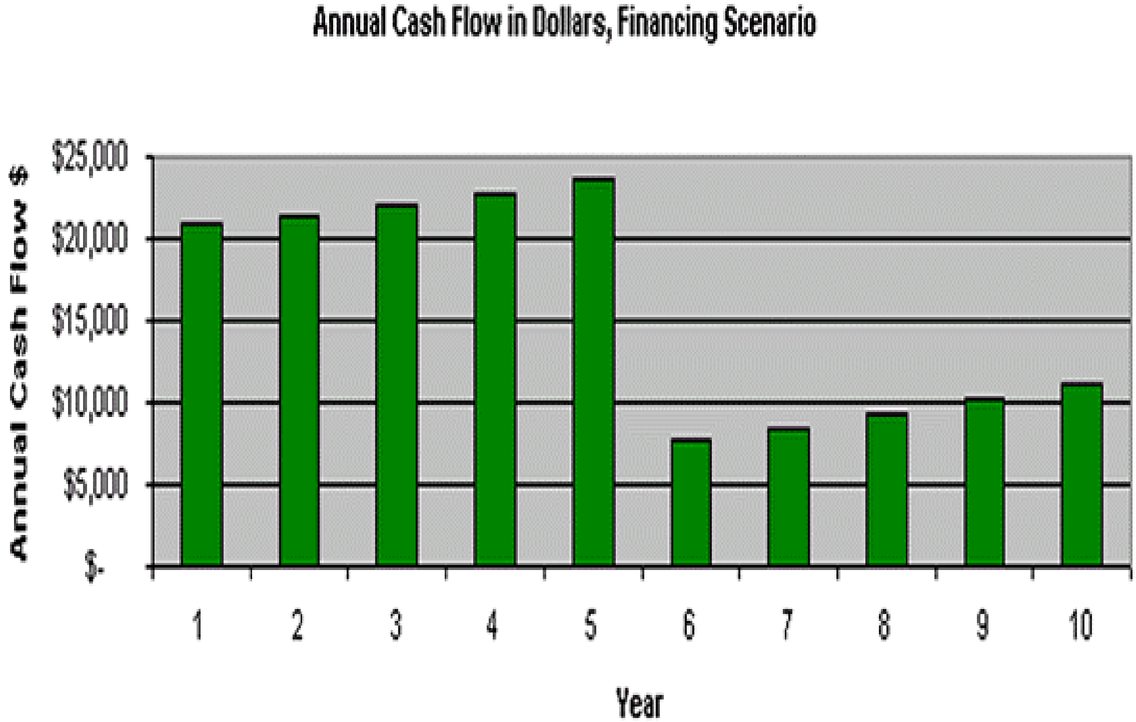


Figure 5: Annual Cash Scenario

Moreover, by financing the purchase of the system at an interest rate of 6.5%, the Net Present Value of the system increased to $163,460. This improvement results from the fact that he return on the investment from the PV system when it is financed exceeds the cost of the financing itself. Their monthly positive cash flow improvement as a result of the installation of the system averages over $18,000 per year in the first five years. The table below shows how dramatically these cash flows improve, particularly in the first five years as a result of the accelerated depreciation of the system.

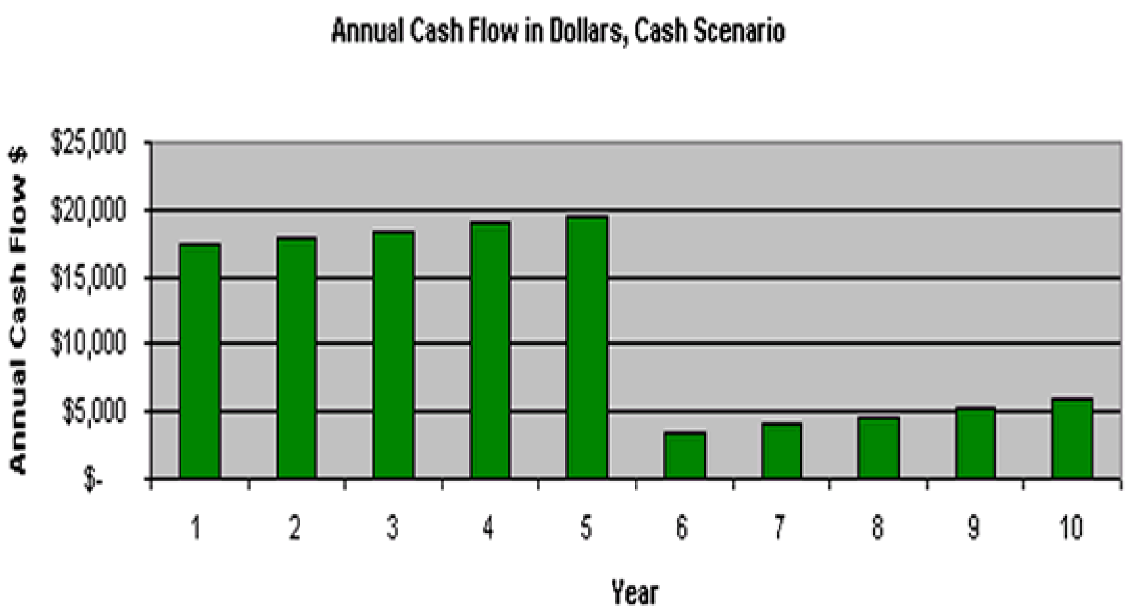


Figure 6: Annual Financing Scenario

2.1.4 Drawbacks of a PV System

When something sounds too good to be true, then there is a great chance that it is. Despite the fact that the during the operation of the PV system, its panels required a frequently turning to catch the sun energy, which results in certain maintaining fee, as well as a result to lower the efficiency of the PV cells; the PV system required a very large amount of areas to occupied. Therefore, improvement on both the PV cells efficiency and its sizing become the mean issues in the future developments.

2.1.5 Future Applications of PV Cell Efficiency

Typical photovoltaic cells use layers of chemically treated metals that produce electric current when struck by sunlight. The basic problem has always been the quantity of current produced per unit cost of the materials used to produce it. Most photovoltaic cells are only about 15% efficient and produce energy for around $1 per kilowatt hour.

The maximum efficiency a solar cell made from a single material can achieve in converting light to electrical power is about 30 percent; the best efficiency actually achieved is about 25 percent. Dozens of different layers could be stacked to catch photons at all energies, reaching efficiencies better than 70 percent, but too many problems intervene. When crystal lattices differ too much, for example, strain damages the crystals. The most efficient multi-junction solar cell yet made - 30 percent, out of a possible 50 percent efficiency - has just two layers. (Indium nitride)

Quantum dots are nanoscopic metallic or semiconductor devices which can hold a well defined number of electrons. Quantum dots have been built which can hold an excess charge of just a single electron. Today these devices are typically 30 nanometres across. In the future they are likely to be made even smaller.

Quantum-dot Cellular (QCA) follows the well established rules of Boolean logic and at the same time offers the potential of extreme increases in circuit density and speed as well as reduced power usage. For dots of size 10nm, a circuit that would conventionally require 30 transistors occupies an area of less than $1.5\mu m^2$.

In August 1999, researchers in Germany and California built an array of quantum dots, which relied on the use of magnetic fields. These were the smallest semiconductor rings ever to support a measurable electric current. The rings were only 50nm across and could contain only one or two electrons. A perpendicular magnetic field was applied so as to confine the electrons to moving around the wire in only one direction.

A major factor limiting the conversion efficiency in single-bandgap cells to 31% is that the absorbed photon energy above the semiconductor bandgap is lost as heat through electron-phonon scattering and subsequent phonon emission, as the hot photogenerated carriers relax to their respective band edges. The main approach to reduce this loss in efficiency has been to use a stack of cascaded multiple p-n junctions with bandgaps better matched to the solar spectrum. In the limit of an infinite stack of bandgaps perfectly matched to the solar spectrum, the ultimate conversion efficiency at one-sun intensity can increase to about 66%.

In a quiet research laboratory here, Alvin M. Marks, the founder of Phototherm Inc. in Amherst, NH, is developing solar power devices designed to operate four or five times more efficiently than the best photovoltaic cells now in use, and at a small fraction of the cost. He says that solar panels made with *Lepcon* or *Lumeloid*[4], the materials he patented, could turn 70~80% of the energy from sunlight they receive into electricity. The electricity would cost 3 or 4 cents per kilowatt hour, as against about 10 cents a kilowatt hour for commercially generated electric power**.**

Chart 5 demonstrates the deduced cost with the increase of efficiency with new photovoltaic cell materials. Please make a note that its installation cost is relevant in ratio with the cost of PV system as of today. However, the different curves shown that with the improvement of photovoltaic cells' efficiency, the cost of PV system in the future has a clear marked downslide trend, which means that the cost for PV system is going to be much cheaper and cleaning way for generating electricity.

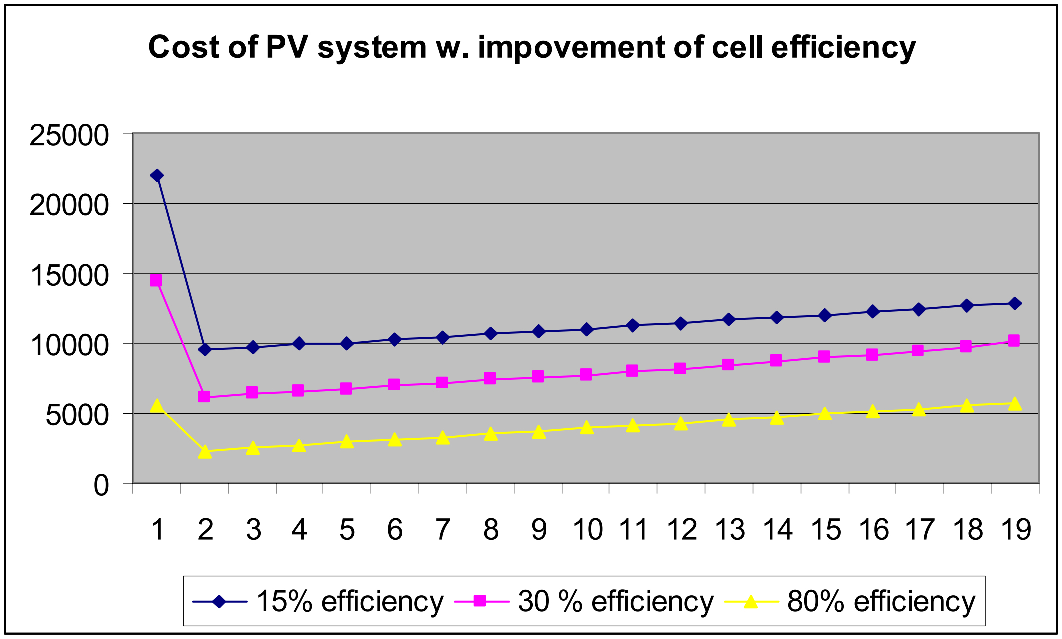


Chart 5: Cost of PV system with improvement of cell efficiency

2.1.6 Conclusion

One major goal for building a photovoltaic farm is to generate power, such as electricity, with lowest cost possible—both for installation fee and price per unit (i.e. cents per kilowatt hour). Upon achieving this goal, it also reduced the crises of pollution. Currently, there are but a few PV farms built in the Untied States due to the limited low efficiency of PV cell (15 ~ 25%), which result high cost for installation. Even through the U.S. Department of Energy had provided programs to reduce the burden of installing

[4] *Lepcon*, which was a preliminary design, consists of glass panels covered with a vast array of millions of aluminum or copper strips, each less than a micron or thousandth of a millimeter wide. As sunlight hits the metal strips, the energy in the light is transferred to electrons in the metal, which escape at one end in the form of electricity.

Lumeloid uses a similar approach. But substitutes cheaper, filmlike sheets of plastic for the glass panels and covers the plastic with conductive polymers, long chains of molecular plastic units. Lumeloid is easier to manufacture and handle than Lepcon. The company declines, for competitive reasons, to identify the chemicals it uses to produce Lumeloid polymers.

PV system with Rebates and Tax Credits to 50%. It still takes a long time to recover the charge.

With the development of PV Cells, it is predicable that within the next 50 years, the possibility of increasing the efficiency to at least 70%. As the last chart had illustrated, its cost will have a downward trend respectfully.

2.2 Wind Power

2.2.1 Introduction: Wind Energy

Wind energy, like solar, is powered by the sun. As the sun heats regions of the world creating differing pressure zones, wind is created. As wind flows past the propeller blades a high pressure zone is produced on one side of the blade and a low pressure zone is produced on the other side. As these two zones are produced the energy in the wind is transferred to the blades forcing them to spin. The propellers are connected to a shaft that enters into a gear box. This gear box increases the speed of another shaft, which goes to a generator. This generator is connected to a power grid and when enough energy is produced, it is sent to a battery that stores the energy. On top of the casing is an anemometer which measures wind speed and direction. This anemometer is connected to a computer, which analyses the data and rotates the propellers to best accommodate for the wind direction. This computer also controls the pitch of the blades, which can effect how fast they spin in different wind conditions. For extreme winds the computer will turn the pitch enough to slow the propeller down and eventually a disk brake will be applied so the propellers won't undergo too much stress.

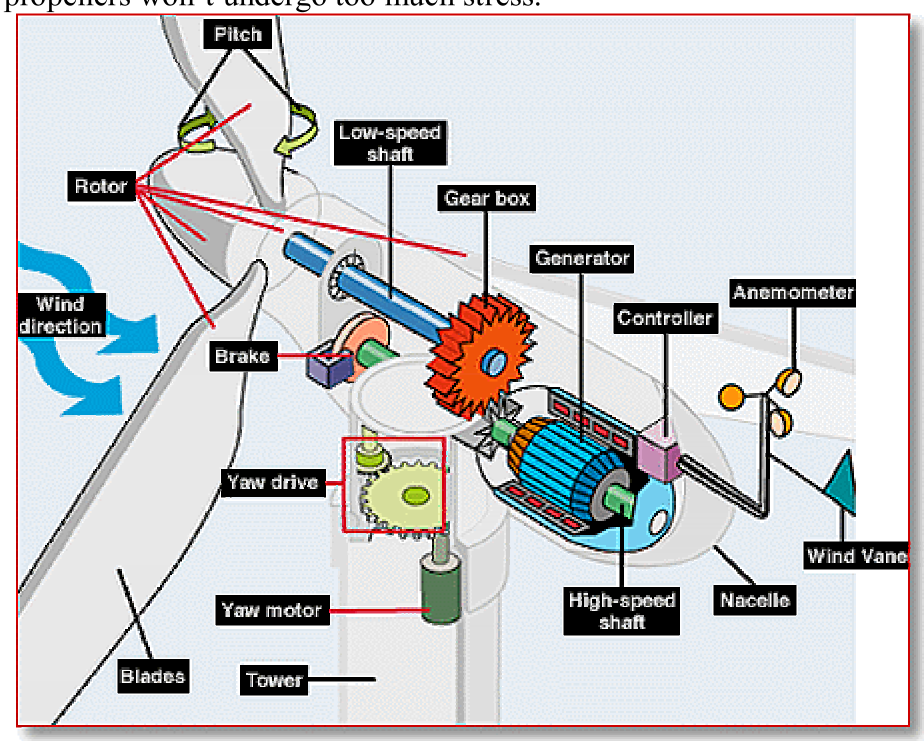


Figure 7: Internal view of a wind turbine

Wind turbines can be implemented into the overall energy scheme in four different ways. The first type of wind power plant is a remote plant. These are best for rural areas because they can be left unattended for long periods of time. Since the turbines used are usually small in diameter, they can run in very harsh conditions, which allows for these power plants to power the entire rural community. The second type of wind power plant is a hybrid plant. The idea behind these plants is not to produce all the energy but to have at least two types of energy working for the same goal. Wind and solar energy work well together in a plant like this. A third type of wind energy plant is one that is grid connected. Since a single wind turbine usually only produces energy about 25% of the time, it can't be solely relied on for a full time energy producer. The fourth type of wind energy plant is a utility plant. These plants consist of many wind turbines connected to each other. With these different types of plants it allows wind energy to be used in many different locations.

2.2.2 Wind Sources

A study last examined in September 1993 by D.L. Elliott and M.N. Schwartz shows, by utilizing the windy areas of the United States (about 6% of U.S. territory) 150% of the 1990 U.S. energy consumption could be generated. In examining the U.S., researchers divided the territory into 7 different classes. These classes are ranges of wind speeds. Shown below are the different classes and the values that they fall between.

Table 6. Classes of Wind Power Density

Wind Power Class	**Wind Power Density, W/m^2**	**Speed^b, m/s (mph)**	**Wind Power Density, W/m^2**	**Speed^b, m/s (mph)**	**Wind Power Density, W/m^2**	**Speed^b, m/s (mph)**
	0	0	0	0	0	0
1						
	100	4.4 (9.8)	160	5.1 (11.4)	200	5.6 (12.5)
2						
	150	5.1 (11.5)	240	5.9 (13.2)	300	6.4 (14.3)
3						
	200	5.6 (12.5)	320	6.5 (14.6)	400	7.0 (15.7)
4						
	250	6.0 (13.4)	400	7.0 (15.7)	500	7.5 (16.8)
5						
	300	6.4 (14.3)	480	74.4 (16.6)	600	8.0 (17.9)
6						
	400	7.0 (15.7)	640	8.2 (18.3)	800	8.8 (19.7)

7						
	1000	9.4 (21.1)	1600	11.0 (24.7)	2000	11.9 (26.6)

Figure 8 is a "wind energy resource atlas of the United States". These atlases show the different classes of wind present throughout the United States.

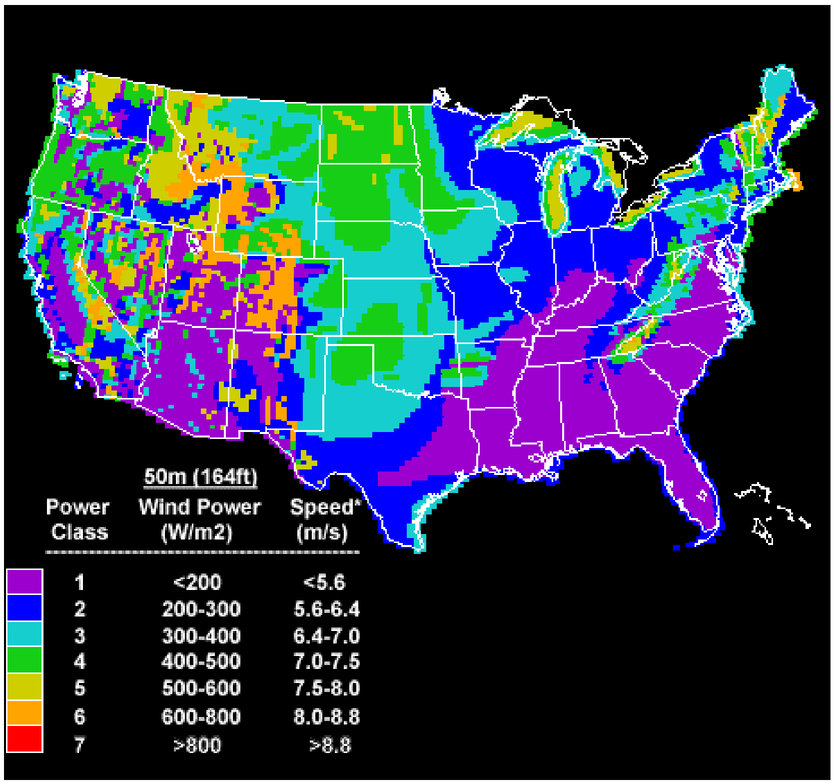


Figure 8. U.S. Annual Wind Power Resource

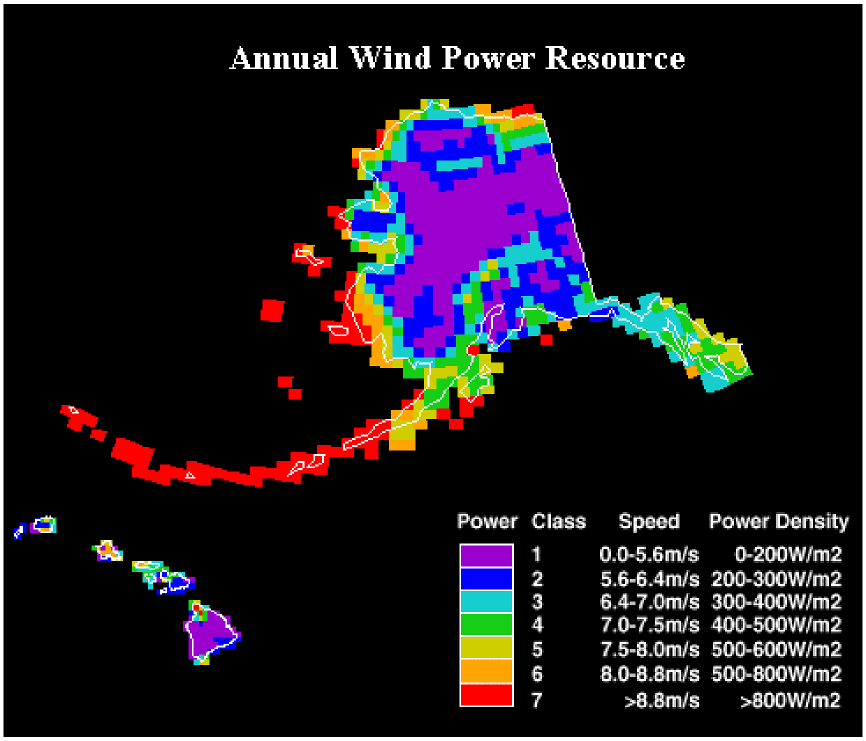


Figure 9: Annual Wind Power Resource Alaska and Hawaii

As shown in Figure 9, the wind in the United States is strong enough in selected areas to allow for further analysis. The strong winds are not the only factor in the Wind Electric Potential. Another large factor will be the availability of the terrain. Shown below is an atlas of the percent land availability in the United States.

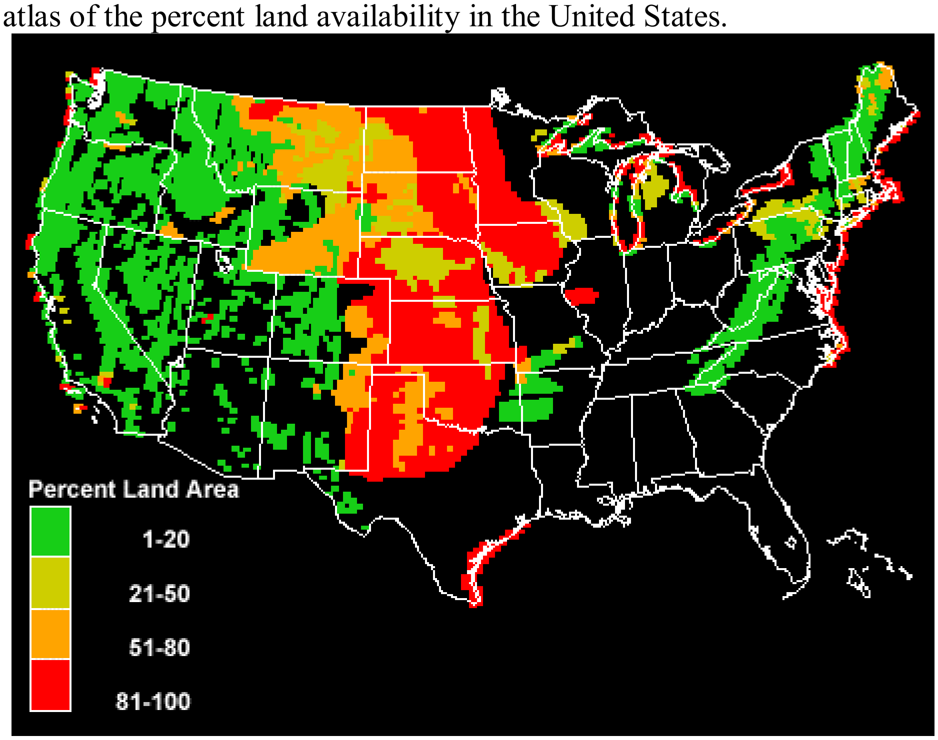


Figure 10: Percentage of used land area across the US

"Even under the most restrictive (severe) land exclusion scenario, the wind energy potential for areas with power class 3 and above is greater than total U.S. electricity consumption in 1990. Figure 10 shows the contribution that the wind energy of each state could make to meet the total electrical needs of the nation, assuming a moderate land exclusion scenario. North Dakota alone has enough potential energy from windy areas of class 4 and higher to supply 36% of the total 1990 electricity consumption of the 48 contiguous states."

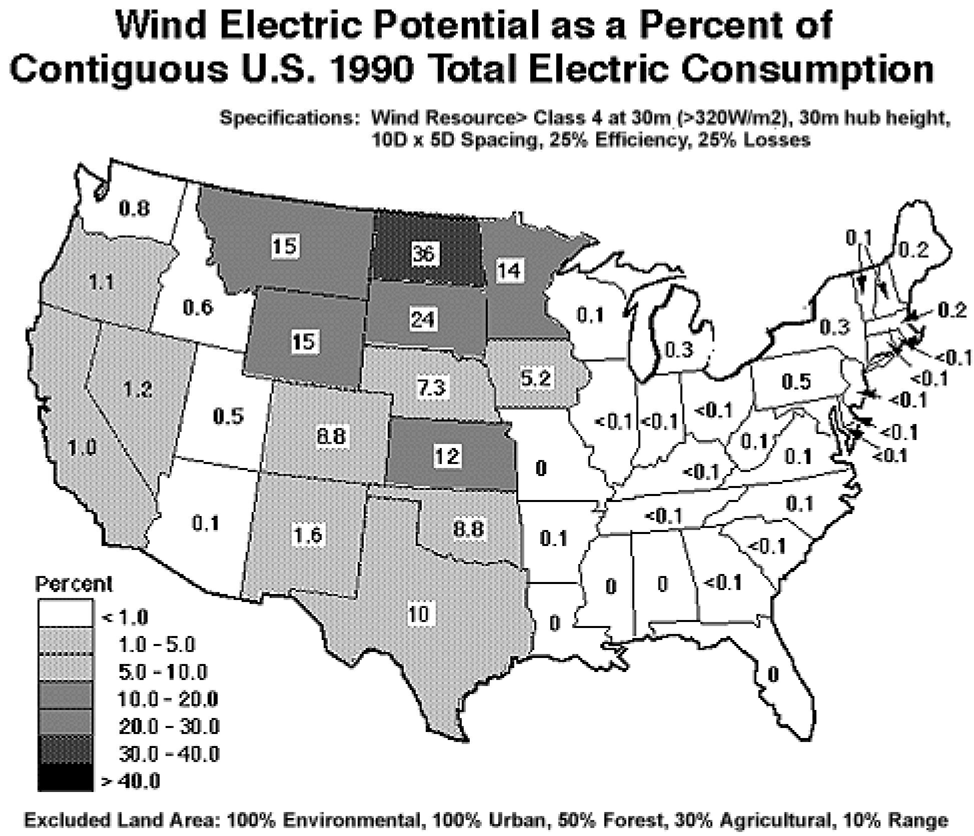


Figure 11: Wind Electric Potential

This data only shows the potential for wind energy and doesn't reflect the costs of building these turbine farms.

2.2.3 Analysis

Consider utilizing half the area of North Dakota at rated wind power class 4. North Dakota (70704 sq or 183,123.36 sq meters) as being 91561.68 sq meters. Using the information on Table 6, we find that this system could attribute approximately 1/7 of the total 1,066,693,527 kWh (1998 Figure) the US consumes.

This information proves that we do have the substantial land and the resources required for wind energy to reserve a place and be a factor in the United States energy policy. The problem then remains is, how much will this cost?

Using the annual energy production of 1,066,693,572 kWh (1998 Figure) data from Table 6 shows that 2200 wind-turbines will be needed to accomplish this. At a price of $650,000 for production and installation of a single turbine, plus an extra $13,000 for maintenance brings the cost to $663,000 per turbine. Overall, this comes to a total cost of $1,458,600,000. Since the life expectancy for a wind turbine is designed to be, at least, 20 years, it would cost $72,930,000 per year for 1/7 of the 1998 US energy consumption.

2.2.4 Case Study

Why does Cape Wind want to invest in an offshore wind farm and how will they make their money? Cape Wind is proposing a 170-turbine wind farm to be built of the coast of Cape Cod. This wind farm will be used to supply energy to the Cape and its surrounding islands.

Overestimating the cost of each wind-turbine, all the necessary utilities, and maintenance for 20 years to be $1 million each, Cape Wind would be investing $170 million into this wind farm.

The way Cape Wind will make their money is by the process of how the cost of electricity is established. Electricity is sold on what is called the energy spot market. The energy spot market works through a bidding process. The market administrator finds out how much energy is in demand in each hour time slot. Once this is found he replies to the electric companies and each company sends how much energy they can supply and at what price they can supply it for. In a simplified example, the market administrator demands 1,000 MW of electricity for a certain hour. The electric companies then send in their bids, like shown below:

Company A: can generate 400 MW at $25/MWh
Company B: can generate 500 MW at $30/MWh
Company C: can generate 350 MW at $40/MWh
Company D: can generate 200 MW at $35/MWh

The market administrator then organizes the companies by $/MWh:

Company C: can generate 350 MW at $40/MWh
Company D: can generate 200 MW at $35/MWh
Company B: can generate 500 MW at $30/MWh
Company A: can generate 400 MW at $25/MWh

Since 1,000 MW are needed the market administrator will use company D, B, and A, but instead of paying each company for their bid price he will pay them all, the highest bid price (being $35/MWh). This is where Cape Wind can make money. By Cape Wind entering the market the new bidding would look as fallows:

Company C: can generate 350 MW at $40/MWh
Company D: can generate 200 MW at $35/MWh
Company B: can generate 500 MW at $30/MWh
Company A: can generate 400 MW at $25/MWh
Cape Wind: can generate 100MW at $20/MWh

Now instead of having to use company D, the electric company can save money (only pay the highest bid of $30/MWh) and only use company B, A, and Cape Wind. Since the fuel cost and maintenance cost for Cape Wind is almost $0, Cape Wind is making all profit (past their initial investment). This means for that hour, Cape Wind would be making a profit of $3,000.

Shown on the Cape Wind website, they claim they will save the New England Energy Market $0.20/MWh. Over the course of the year this would add up to:

$0.20/MWh X 124,886,000 MWh/year = $25 million/year
If Cape wind makes a profit of $3,000 per hour, they will make $26,280,000/year. Since Cape Wind's turbine are supposed to have a lifetime of 20 years, they should make $525,600,000 total. Cape Wind's net profit would be $355,600,000 over 20 years. This would make it a 310% return over 20 years.

Cape Wind presents a strong argument toward the building of this wind farm but what are some of the drawback? A large problem that arises is the varying wind speed. Cape Wind will have trouble in forecasting the energy production over long periods of time. Another problem is without enough wind on a given day (below 8m/s) the turbines will not achieve enough force to break the friction in the wind turbine. On the other hand if the wind turbine experiences higher wind speeds a break will be applied to slow it down to reduce the risk of breaking the gears of having structural failure on the mounting shaft. The cost of a wind farm can be expensive but more than 70% of this cost comes from the construction of the wind turbines. This makes it hard to find investors before any further steps can be taken. Cape Wind is also feeling pressure from people who live on the Cape, wondering such questions about noise pollution and unsightly surroundings. The noise produced by a wind turbine is around 35-45 db at 350m away. The average office environment is about 60 db. The turbines are also painted to match the surrounding environment and are matted to reduce reflections from the sun.

2.2.5 Conclusion

Wind energy is a slowly increasing energy source and should not be overlooked. Wind energy offers us the ability to produce a useful amount of energy without any emissions. This form of energy could be used by the United States government if willing to put forth an initial investment. By implementing wind farms across the United States the trouble with varying wind speeds will be reduced. If used correctly, wind energy could produce enough energy to make an impact on the United States energy consumption.

2.3 Fusion Power

2.3.1 Introduction

Fusion like fission is based on releasing the stored energies of atoms. However, unlike fission, which is based on shattering the bonds in an atom by hitting them; fusion allows two smaller atoms to create a larger one. The first assumption that most people make, which is wrong, is that there isn't any energy produced in a fusion reaction because it is natural to think that joining things together takes more energy. However, it turns out that the binding energy of the new atom being produce is actually less than the sum of the two atoms coming together. It is this left over binding energy that is released in a fusion reaction

The actual particles involved in a fusion reaction are Tritium and Deuterium. These are both isotopes of hydrogen. Tritium contains two neutrons and one proton, and deuterium contains one neutron and one proton. When they are combined at very high temperature the fusion reaction occurs and a Helium-3 (two protons, one neutron) atom and a free neutron is the result. Additionally, a fusion reaction can occur between two deuterium atoms. However, reactions between two deuterium atoms are slightly less reactive than a deuterium atom and a tritium atom.

Tritium and deuterium aren't as dangerous as the fuel used in fission reactions; however, there are a number of problems with them. First of all, they are both gasses. This makes it harder to store since it takes up a huge amount of space at room temp. The second is that tritium is relatively rare; it has a half-life of 12 years in addition to releasing a weak beta radiation. More specifically, tritium undergoes beta decay. This decay happens when a neutron in the nucleus turns into a proton, an electron, and an antineutrino. The atom ejects the electron and turns into Helium-3. The tritium must be isolated because this beta radiation can cause biological effects. You might notice that the result of the fusion reaction is also Helium-3, without the beta radiation. Needless to say the goal of a fusion reactor is to get enough of the tritium to combine with the deuterium before it decays into Helium-3.

The second problem with fusion is that in order to get the two particles to fuse together the kinetic energy must be strong enough to overcome the repelling charges. All these isotopes are positively charged so they naturally repel each other. In order to increase the kinetic energy the temperature must be raised. Once the temperature is high enough, the "strong force" (the force that holds atoms together) will be strong enough to overcome the electromagnetic force; however, this temperature can be upwards of a few million degrees. These extremely high temperatures are required because it has to be enough energy to totally release the electrons from the particles and create an ionized gas, or plasma. In this plasma state the particles have the extremely high kinetic energy required for a fusion reaction.

Conditions for a fusion reaction to take place seem like an almost impossible situation to create on earth. With statistics of millions of degrees and extremely high pressure it all hardly seems possible. However, scientists are just starting to create generators that will be able to achieve some of these goals.

2.3.2 Fusion Generators

In the 1960s the Soviet Union was the first country to conceive the tokamak fusion concept. The technology was originally intended to be used for a weapon by the Soviets, however, after it was apparent that controlled fusion was not weapon related the research was declassified. By 1972, 17 tokamak generators were operating safely around the world. That 1972 number has since increased to near 100 individual tokamaks.

The tokamak gains its acclaim from being able to contain a fusion reaction. It does this by using a vacuum chamber surrounded by magnets producing an extremely powerful electromagnetic field. The magnetic field is used to imitate the extreme gravitational conditions native to natural fusion reactions, such as the one in our sun. The chamber itself is toroidal making the contained fusion reaction a ring shape. The trick to focusing the reaction into a ring is to get it to stick in one place. A fusion reaction, as you can imagine, is not very uniform. The energy density of the reaction varies quickly around the ring. The field generators must be able to control these changes while using a minimum amount of energy to contain the reaction. The obvious reason for the magnetic field to be as small as possible is to increase the overall gain for the reactor. The generator must not just produce enough energy to maintain a reaction, it must produce excess that can be used for other purposes.

The generator has to be able to produce enough energy to sustain itself, and produce enough energy to balance out the power used in the initial reaction. Needless to say it isn't easy to get a fusion reaction started. As discussed earlier extremely high temperatures are required. To remedy this problem scientists have started the fusion reaction using lasers to heat up a small portion of gas extremely quickly. The resulting heat given off by the resulting reaction should spur more molecules into the plasma state.

The point where the energy produced equals the energy required to ignite and create a fusion reaction is called the "energy breakeven equivalent". This statistic was achieved by a Japanese reactor called the JT-60.

Usable energy produced by the fusion reaction comes from the neutrons emitted in each of the combinations. The neutrons pass through the chamber walls and are absorbed by a lithium shield, along with there 14MeV of energy. The energy is extracted from the neutrons by their collisions with the lithium atoms which creates heat. The heat is extracted from the lithium using a technique common to a conventional steam electric plant. The neutrons themselves end up in reactions with the lithium atoms and return to being tritium and are fed back into the reactor as fuel.

2.3.4 Future of Fusion

The United States has had a varying stance on the possibility of adding fusion power to its wide arsenal of energy sources. Like most up and coming technologies fusion has always shown great promise, it is just a matter of creating a working generator. The problem has been that the fusion project has been around so long that positive interest in the technology has wavered dramatically. In the 1980s the government deemed that the energy crisis was over and that new energy developments should be left to the private sector. Needless to say this cut the governments funding for the ITER project to near 0 and took the US out of the running for any new fusion technology. To worsen matters for the US fusion program, "only 8 out of 1300 physicists in 25 leading university research departments were experts in plasma physics." (Popular mechanics)

However, that was back in the 80s and the turn of the century has rekindled the US's interest in fusion technology. The DOE promised researches $225 million-a-year budget until 2006. Regarding this increase Miklos Porkolab, director of the Massachusetts Institute of Technology's Plasma Science and Fusion Center in Cambridge states that, "… With adequate federal funding, a prototype nuclear fusion reactor could be tested within 30 to 40 years. A commercial reactor could be deployed by the middle of the century." (Popular mechanics)

The numbers produced in predicting how much potential energy fusion generators will produce seem to be filled with too much speculation. At a point when our current generators are simply at a break even state it seems too much for the scientist to start pricing wares that haven't even been tested, scientist aren't even sure how efficient of a fusion reaction they can produce, which is one of the greatest factors in determining the power output and waste output of a given generator. The one point that can be taken seriously is the fact that there will be comparatively very little waste created by these machines. In addition fusion avoids all the controversy over radioactive waste and meltdowns that fission plants face. After scaring the fission use out of the American people it is no surprise that government is interested in its non radioactive counterpart.

If there is one thing that you can tell from fusion research in the past, it's that you can't count of fusion power to arrive at any particular time. For decades in the 20th century scientists strung the government's funding along on hope alone and little scientific backing. They still sing the same tune today and the government will continue to hear it for the next century. There is no truly objective source when talking about the potential of fusion power. No plasma scientist in his right mind will say it is possible simply to further his career, and unfortunately they are the ones with the answers. The government seems content to play there game now that they have finally produced some results.

Luckily for the United States the US energy policy doesn't hinge on the discovery of fusion power in the slightest. It is simply a pet project that the government has been running the last century with very little results. However, the government is not about to pass by a technology that could have a serious impact on some of today's energy problems; it also seems that they in a sense "won't get their hopes up."

2.3.5 Impact of Fusion

It is hard to predict what the world is going to be like in 40 years. Considering 40 years ago things like the internet and the PC weren't even invented yet, it is hard to imagine what our energy needs might be let alone how much energy will cost. The irony of the situation is also the fact that the dream of fusion started over 40 years ago yet it will not even be realized until 40 more years.

When and if fusion reactors start working they will most likely face some of the same problems facing fission reactors. The fusion generators obvious advantage will be to not produce a radioactive waste material. However, it will be like a fission reactor in the sense that it will be essential to keep the reaction going for as long as possible. Ideally a fusion reactor would be started once in its lifetime, and then continuously fed fuel straight into the chamber, while also having a way of removing waste from the reactor. Also like a fission reactor, a fusion will most likely have an inefficient water flow technique collecting heat coming out of the core.

Fusion will not have a remarkable affect on energy prices right away. The plants are immensely complicated and expensive, in addition to the hassle of processing and storing fuel. What fusion will be good for is keeping the energy supply constant when things like oil, coal, and natural gas are reaching there respective ends. Fusion is by no means a limitless energy supply, but it diversify the kinds of energy produced in the US.

Overall fusion will someday be a staple of the US energy grid, but there is no way to tell how much of an effect it might have. Environmentally it will have very little affect, which could be a huge concern in 40 years. Also economically it has the potential of competing with other forms of energy, which will allow US to produce more of it's own energy.

2.4 Natural Gas Power

2.4.1 Introduction: Natural Gas

Millions of years ago organisms died and were buried beneath the earth. With pressure and heat this layer of organic material became coal, oil, and natural gas. This natural gas is tasteless, odorless, and colorless. In 1785 this natural gas was used to light lanterns in streetlamps. The use of natural gas eventually became a very popular method for boiling water, heating rooms, and as a source of light. The problems with natural gas were the method of transportation, efficient uses, and the exploration (methods in which to locate natural gas). Now in the 21^{st} century, these methods have become less costly, more efficient, and more necessary.

2.4.2 Background

There are many steps in the process of bringing energy produced from natural gas to our homes and businesses. The first step is finding where natural gas exists and evaluating whether it is worthwhile to drill for the fossil fuels. Finding natural gas was previously done by searching for signs on the surface and it was very difficult to tell exactly how much fossil fuel was buried beneath the surface. The technology used to today is a large factor in the growth of the natural gas industry. A geologist surveys the land for the most probable area of natural gas to have formed. Then a research team tests the area using the latest seismic technologies. With the help of computer generated seismic imaging, geologists have the ability to better analyze the different layers of rock beneath the earth's crust as they change over time. Once a likely location for the existence of natural gas is found the company needs to drill through the layers of rock and extract the natural gas. There are three types of wells. The first is called an oil well that extracts mostly oil with some natural gas. A natural gas well extracts only natural gas with little or no oil. The third type is called a condensate well. These wells extract a liquid hydrocarbon that needs to be processed to separate the natural gas. Since natural gas is lighter than air, most wells don't require pumps to extract the natural gas. Once the natural gas is extracted it must be processed before sent to consumers. Raw natural gas is mostly Methane but contains other gases that need to be removed. Below is a table showing the composition of raw natural gas.

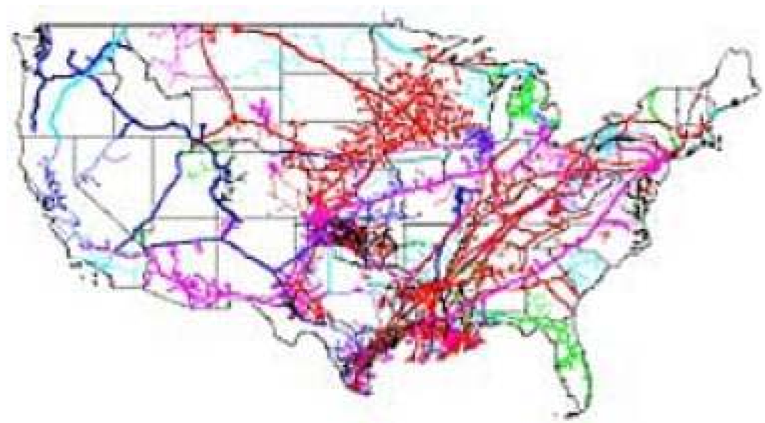
Typical Composition of Natural Gas

Methane	CH_4	70-90%
Ethane	C_2H_6	0-20%
Propane	C_3H_8	
Butane	C_4H_{10}	
Carbon Dioxide	CO_2	0-8%
Oxygen	O_2	0-0.2%
Nitrogen	N_2	0-5%
Hydrogen sulphide	H_2S	0-5%
Rare gases	A, He, Ne, Xe	trace

Table 7: Typical Composition of Natural Gas

There are four steps in the purifying of the raw natural gas; oil and condensate removal, water removal, separation of natural gas liquids, and sulfur and carbon dioxide removal. Even though all these other gases are removed they are not wasted. These other gases known as natural gas liquids are sold separately for other uses. Once the natural gas is purified it is sent to the consumers through a system of pipelines or is sent to storage. The United States has around 36,100 miles of pipeline for the transportation of these gases (Figure 12).

Figure 12: Natural gas pipelines



Since some of the gas is not needed right away it is sent to underground storage facilities. These storage facilities play a large role in the distribution of natural gas. Since natural gas is a seasonal fuel source (higher demand in winter), the gas needs to be stored until demand exceeds the production, when the stored gas is used to meet the difference. The next and final step is to distribute the natural gas to the end users. This is the mostly costly step because small distribution piping is needed to run small volumes of gas to each user, some being far from the distribution plant. Figure 11 show a break down of the costs associated with natural gas.

2.4.3 Supply and Demand of Natural Gas

The National Petroleum Council estimates the amount of recoverable natural gas in the United States is around 1,779 Trillion cubic feet, which is enough to meet the United States natural gas demand for over 93 years, excluding the increase of natural gas consumption each year. Over 83% of the natural gas consumed in 2000 was produced in the United States, primarily in 5 states (Chart 6).

Chart 6: Components of Residential Natural Gas Prices (http://www.eia.doe.gov)

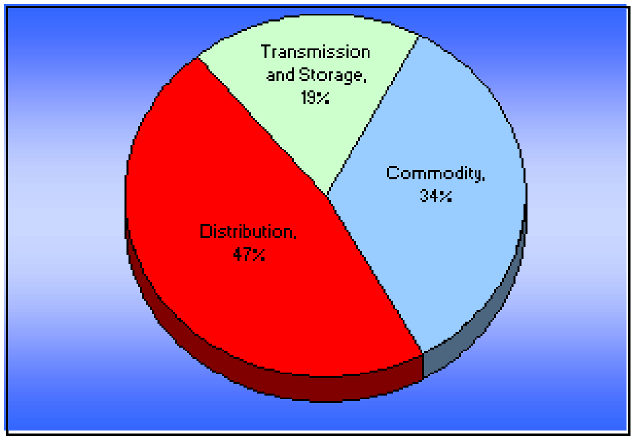
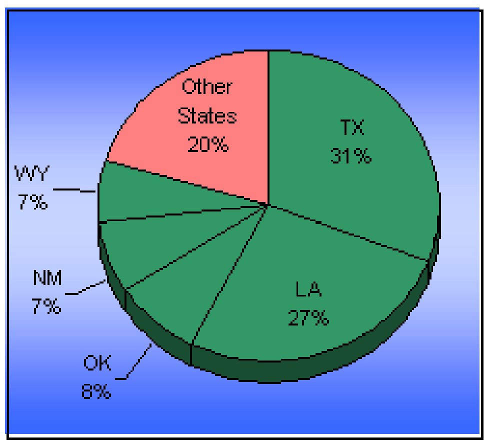


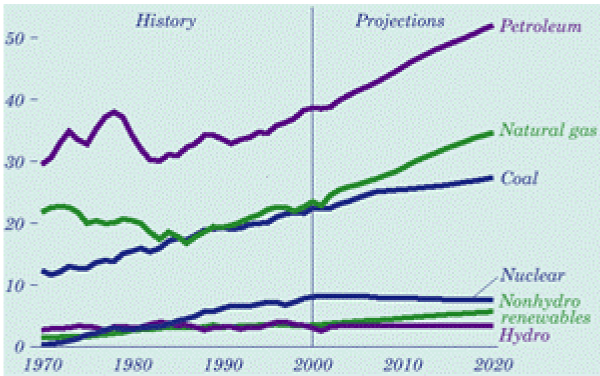
Chart 7: Percent of Domestic Production by State (http://www.eia.doe.gov)



This is outstanding compared to only 39% of the crude oil consumption being produced in the United States. Of the entire imported Natural Gas 94% is imported from Canada. This reduces the cost of transportation of the Natural Gas. Even though the estimate for total recoverable Natural Gas is high, there are factors that restrict increases of production. There are four main short term factors; the availability of skilled workers, the availability of equipment, permitting and well development, and weather and delivery disruptions. These short term factors can build up forcing the drilling to be delayed for several months. The three primary barriers for increasing supply are accessibility to the land, the pipeline infrastructure, and the financial environment. The United States government owns more the 29% of the land and has many restrictions on where drill can occur. When a location has been found for drilling, the company has to find a method of attaching the pipeline. Since the equipment, research and labor is so expensive, companies need to invest large quantities of money into constructing a well that has potential of not pumping any fossil fuels.

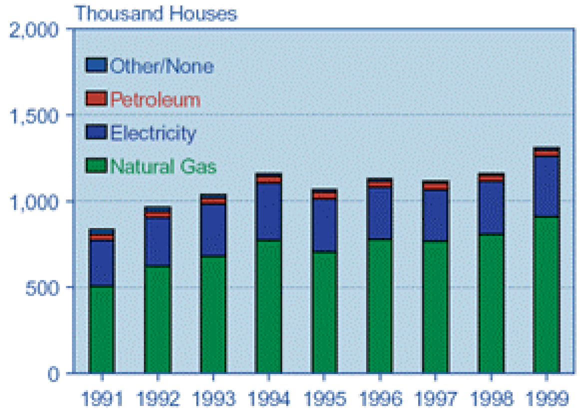
The EIA estimates that by the year 2020 the Natural gas demand will rise to 32 Trillion cubic feet from 22.8 Trillion cubic feet in the year 2000. Of all energy sources, the EIA predicts Natural Gas to have the highest increase in demand over the next 20 years (Figure 12).

Figure 13: Energy Consumption by Fuel 1970-2020 (Quadrillion Btu) (Reference EIA – Annual Energy Outlook 2002 with projections to 2020)



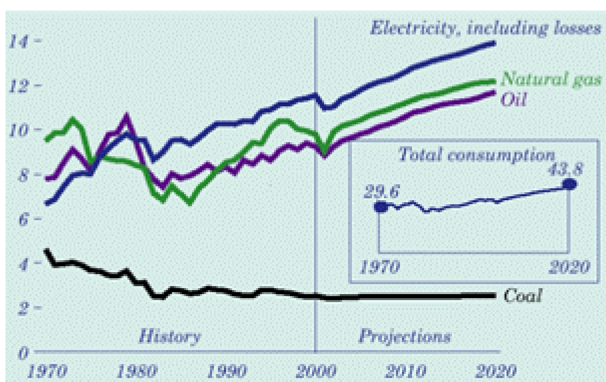
In the past Natural Gas demand has been cyclical, meaning it changes throughout the year. The demand is higher in the colder months due to the Natural Gas being used to heat homes and businesses, but with the increase use of Natural Gas to provide electrical energy, the demand in the warmer months has been increasing. The three main factors that influence the short term natural gas demand are the weather, fuel switching, and the United States economy. Since a primary use for Natural Gas is to cool and heat homes, when the weather is mild neither is necessary, which brings down demand. Fuel switching is an option some larger companies have. When gas prices become too high, a company might switch there energy source to coal because it is cheaper. In the growing economy, more energy is being consumed making the demand increase. In the residential sector, the largest factor of demand is number of gas furnaces/generators being installed. Another way to look at it is the number of homes being built. Figure 13 is a graph of the number of houses built with the energy source.

Figure 14: New Houses by Heating Fuel Type 1991 – 1999 (EIA – U.S. Natural Gas markets: Mid-Term Prospects for Natural Gas Supply – 2001)



The EIA estimates a 1% annual increase in the residential energy demand with a Natural Gas annual consumption increase of 0.9%. In the industrial sector the EIA predicts a 1.1% annual increase in demand, which is very low compared to the other sectors. This is due to the decrease of energy-intensive machining, increase in efficiency, and the increase in on-site generators. Figure X is the Industrial Primary Energy consumption.

Figure 15: Industrial Primary Energy Consumption by Fuel 1970-2020 (Quadrillion Btu) (Source: EIA – Annual Energy Outlook 2002 with Projections to 2020)



Even as the demand in natural gas is rising, so is the efficiency of the machines, which makes the amount of natural gas consumed by a particular company decrease but sparks interest in other companies to switch to natural gas.

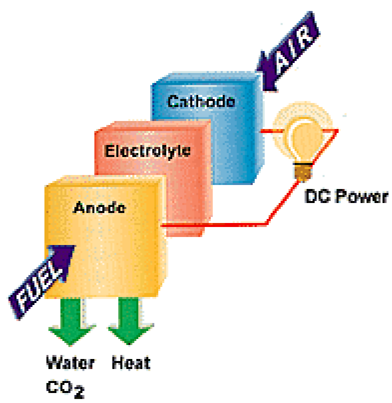
2.4.4 The Technology of Natural Gas

The Natural Gas industry has become one of the most technologically advanced industries in the United States. Some of the leading advances in the Natural Gas industry are the advances being made in the exploration and production sector. Since 1985 the well efficiencies have increased by 100%. The amount of drilling waste has decreased due to the well productivity. The drilling footprint has decreased 70%, which if no improvements had been made would have left a total of 17,000 acres of marked land. The weight of the equipment has decreased making it easier to reach certain drilling locations and reduces the effect of surface impact. The new 3-D and 4-D seismic imaging has lead to the increased efficiency of find Natural Gas and has reduced the number of explosives used in extraction. Some of the other improvements that help increase efficiency and reduce costs are CO2-Sand Fracturing, Coiled Tubing, Measurements while drilling, Slimhole Drilling and offshore drilling technology.

Liquefied Natural Gas is becoming a more reasonable option for the transportation and storage of natural Gas. Cooling natural gas to -260°F in normal pressure results in a condensate to be formed. This liquefied natural gas is less combustible and takes up one sixth of the room that gaseous natural gas does. This is still a growing technology because the cost of transforming the natural gas to and from a liquid is still expensive.

Natural Gas Fuel Cells are showing a lot of promise in the field. Fuels cells use electrochemical reactions instead of combustion to generate electricity. Figure 15 is a diagram of how a fuel cell works.

Figure 16: How a Fuel Cell Works (DOE – Office of Fossil Energy)



The benefits of fuel cells are: they produce clean electricity, distributed generation, meaning they can be used in all sectors due to their extremely compact size, they are dependable because of the few moving parts, and they convert the fuel into energy more efficiently than combustion reactions.

2.4.5 Natural Gas and the Environment

Natural gas is the cleanest of all fossil fuels. The combustion of natural gas produces mostly carbon dioxide and water vapor. By using natural gas, main composed of methane, it reduces the amount of nitrogen oxides and sulfur dioxide, which would be emitted from other fossil fuels. The burning of coal and oil releases ash into the atmosphere that adds to the pollution. With natural gas there is virtually no ash or particle matter being emitted into the atmosphere. Table 9 shows Fossil Fuel Emission Levels.

Table 8: Fossil Fuel Emission Levels (EIA – Natural Gas Issues and Trends 1998)

Fossil Fuel Emission Levels - Pounds per Billion Btu of Energy Input

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016

The use of natural gas is hoping to reduce the fallowing problems pertaining to the environment: greenhouse gas emissions, smog, air quality and acid rain, industrial and electric generation emissions, and the pollution from the transportation sector through the use of natural gas vehicles.

2.4.6 Conclusion

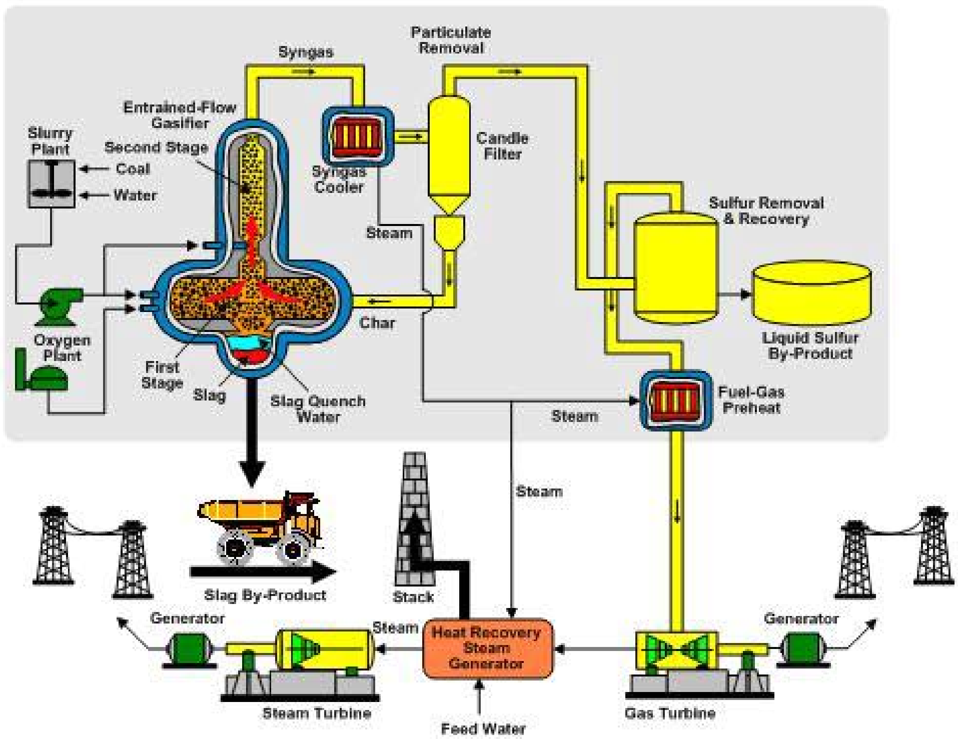
Natural Gas has potential to become the leading source of energy in the United States. Because of the existence of large quantities of recoverable natural gas in the United States and Canada, the cost for transporting this fuel will be lower than that of crude oil. With the growing technology of extracting natural gas, drilling companies are able to drill in places unimaginable before. Increases in efficiencies have lead more companies to switch their energy source to natural gas and have reduced costs of electricity. Natural gas has a bright future and will be in the United States energy policy for years to come.

2.5 Coal Gasification Power

2.5.1 Introduction: The Coal Gasification Process

The coal gasification process is a very complicated one. The process begins when coal and water are mixed and put into a grinder. Oxygen is then added to that mixture in the burner, operating at 2600 degrees Fahrenheit, which forms gas and also removes ash. The gas is then cooled in another chamber known as the syngas cooler. The cooling process produces highly pressurized steam. The resulting gas is put through scrubbers, which are filters that remove pollutants from the gas. That "clean" gas is then sent to a turbine, which goes on to produce energy from the gas. A detailed diagram of the process is shown in Figure 16.

Figure 17: Diagram of a Coal Gasification Plant
(http://www.lanl.gov/projects/cctc/factsheets/wabsh/wabashrdemo.html)



Coal gasification is a very promising method of producing power, but before it can develop into a viable option, the technology must approach the efficiency of another method of converting coal into energy, coal combustion. It is predicted that one day this may occur, but as of right now combustion is still the more efficient way to use coal.

2.5.2 Coal Gasification vs. Coal Combustion

Combustion of coal has been in use for hundreds of years, but it is being challenged by gasification and biomass, among other new technologies, for one main reason: pollutants. Many unwanted gases are released into the atmosphere as a result of combustion, including Sulfur Oxides and Nitrous Oxides, which lead to acid rain, smog, and poor air quality. This is why coal fired combustion plants are becoming frowned upon, and technology is being developed that will allow these plants to be replaced by much cleaner gasification plants, although combustion plants are still used widely around the world.

Coal production is the largest in China and the United States, which combine to account for 55% of all coal production in the world (in 1997, www.eia.doe.gov). These numbers lead one to believe that one of those two countries will be the first to make a significant breakthrough in gasification technology, possibly one that will begin a major transition from combustion plants to gasification plants.

There are still some problems that will be encountered in the future, however. With the production of coal in a position to grow even more, the price of coal will probably go up. This will occur for several reasons. One of these reasons is that coal miners are beginning to mine in more difficult geological conditions, which will increase overhead costs to companies that buy the mined coal. This price increase will be carried out from miners to individual households that use coal. Another reason is that coal is being mined very far away from the countries that consume it. This increase in distance between the producing and the consuming countries will add to the cost of coal as well.

When it comes down to it, efficiency is the factor that will make or break the future of coal gasification. The best gasification plants in the world, while being able to reduce the amount of pollutants released into the atmosphere significantly is between 43 and 45 percent efficient. Today's most advanced coal combustion power plant operates at 50 percent efficiency.

Looking to the future, there are two new ideas that will further expand the usage of coal gasification. The first new idea is being developed in the Pinon Pine Demonstration Plant in Reno, Nevada. This plant uses high-temperature sulfur removal with high-temperature ceramic filters that will eliminate 99% of the sulfur that results from the gasification process. The second new idea, being studied in the United Kingdom, is known as the Air-Blown gasifier. This process has the potential of being close to 50% efficient, as steam resulting from the hot gas cleanup is recovered and reused, producing more energy.

2.5.3 Coal Gasification Concepts and Projections

In 1995, the Department of Energy funded the modification and repowering of an old coal-fired power plant in Terre Haute, Indiana. Instead of burning coal as this plant did in the 1950's, a new coal gasification system was integrated into this plant. This plant operated from 1995 to 1999. During this time, 1.5 million tons of coal were processed to produce 4.1 MWh of power. As a byproduct of this process, 33,000 tons of pure sulfur were produced. The efficiency of this plant was much better than that of the older plant that was in its place decades before. In fact, the resulting efficiency was even better than the predicted goal. When the design was made, the goal was for the process to be 37.8% efficient. By 1999, the process was over 40% efficient. For the most part, this plant was a success. There were minor problems that arose during the years, such as small parts that needed to be replaced and minor modifications that needed to be made. In 1999, there was significant damage to several rows of the gas compressor, which shut down the plant for 3 months. After repairing the damages, the plant continued to run smoothly.

It is easy to see that the Department of Energy is very interested in coal gasification technology. Other than their goals for 2008, they have come up with other goals for further down the road. By the year 2040, it is estimated that goal gasification will produce 130 gigawatts of energy per year, which will be able to power almost 50 million homes. The money has already been pledged to further development of coal gasification, now it is up to companies to use that money wisely and successfully.

There is a fundamental imbalance in how the world utilizes today's fuel reserves. According to reports, when all fossil fuel reserves are put together, 76% of these fossil fuel reserves are coal, while 14% are oil reserves and 10% are natural gas reserves. The consumption of these fuels is quite different; 44% of fuel consumed is oil, 33% is coal, and 23% is natural gas. This shows that the while the world's supply of coal is nowhere near exhausted, the supplies of oil and gas are much closer to being exhausted. The common assumption is that as the cost of fossil fuels increase when supplies run low, coal gasification will become a much more economical option.

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2.5.4 Cleanliness of Coal Gasification

The main reason coal gasification technology is gaining more and more support is that the amount of pollutants released into the atmosphere is greatly reduced when compared to the emissions of an older coal-fired combustion plant. That, along with new, stringent emissions limits that are currently being implemented by the US government, will force gasification to become the main vehicle for converting coal into energy in the near future. With the efficiency of gasification plants continuing to climb and almost reaching the efficiency of combustion plants, the time is now for gasification plants to become more common.

The Department of Energy recently carried out a study on the current and future emissions of several gasification plants in the US, including the Wabash River power plant, located in Terre Haute, Indiana, and the Tampa Polk power plant, located in Polk County, Florida. Their study shows that these plants are capable of eliminating emissions to a point that is far better than federal regulations require. The main byproducts of the gasification and combustion process that are being focused on in this study are SO_2, NO, NO_2, CO, and HG.

All of these byproducts are harmful for the environment, but some are harmful for different reasons. The most prevalent harmful side effect is acid rain, which is formed when certain gases dissolve in rain water. The two most common gases that cause acid rain are SO_2, which causes 70 percent of acid rain, and different forms of NO, which cause the other 30 percent. The damage caused to trees, buildings, lakes, and rivers by acid rain is immense, and therefore any process that limits the emission of harmful byproducts should be developed.

Before looking at actual data, the projections for the future emission levels show how well a gasification plant eliminates emissions compared to the current federal standards issued for coal-powered plants. For SO_2, the projected emission level is 0.08 lb/10^6 Btu. This is compared to a federal standard, which required SO_2 emissions to be below 1.2 lb/10^6 Btu. For NOx, a combination of NO and NO_2, the projected emission level is 0.09 lb/10^6 Btu, compared to the standard of 0.15 lb/10^6 Btu. As the data shows, the projections show that the coal gasification process reduces emissions even further than federal standards require. The gasification process also does a great job in reducing carbon dioxide.

Although there is currently no federal standard regulating its emission, the gasification process effectively reduces up to 75% of the CO_2, while only losing 2-3% efficiency in doing so. Implementing CO_2 collection is much easier and much cheaper to do in a gasification system than is it in an old coal-fired system. When the cost of CO_2 cleanup is included, the cost to produce 1 kWh of electricity from the gasification plant is about 6.3 cents. This is cheaper than the 7.9 cents that it costs to produce the same electricity with the same CO_2 cleanup using a coal-fired plant.

Today's gasification plants do not reduce emissions as much as the projections, but they show a decent performance that may one day reach projected levels. The Wabash River plant and the Tampa Polk power plant will be the two focused on in this study, because their numbers are very similar to one another. Both plants are approximately 38% efficient, and both have been active for between 20,000 and 26,000 hours. Both plants remove over 97% of the sulfur present in coal. Both plants only produce about 1 lb of SO_2 and 1 lb of NOx for each MWh of energy produced. One remarkable piece of data regarding these two plants is the reduction in mercury that takes place. The Wabash River power plant eliminates 67% of mercury that is sent into the process and produces 6.1 x 10^5 lbs of mercury per MWh, while the Polk power plant eliminates 59% of the mercury and produces even less, at 4.8 x 10^5 lbs of mercury per MWh. The two plants eliminate different amounts of mercury because different types of coal are used at each plant.

The Wabash River plant's 2001 performance is a good sign that emission controls are going in the right direction. The plant produced SO2 at the same rate as the projections allow: 0.08 lb/10^6 Btu. NOx was produced at a rate of 0.15 lb/10^6 Btu, which is a good rate compared to the projection of 0.09 lb/10^6 Btu.

With environmentalists both in the government and across the world appealing for cleaner power plants to come about, this data seems to lead me to believe that as long as the technology continues to improve and grow, a gasification plant will be one of the cleanest ways to produce power in the future.

2.5.5 Conclusion

The process of coal gasification is one that has a very bright future. As mentioned before, this process is more efficient than today's typical combustion plants, and it will continue to become more efficient as newer, more improved technologies are developed.

The US Department of Energy has set targets that it hopes are reached by the year 2008. By that year, it is hoped that coal gasification plants are greater than 52% efficient, a goal that can be reached. Furthermore, the government wants the emissions of harmful gases to be less than 0.07 lb / Million BTU's, and it wants the cost of producing electricity to be as cheap as today's production methods.

As for furthering the development and research of coal gasification, President Bush has pledged two billion dollars over the next ten years, which will be used for researching methods of clean coal power, including coal gasification. Already $150 million has been put into the FY 2001 energy budget, and in March 2002, the Department of Energy has been given $320 million to use for more research. There is unbounded optimism for the further development and usage of coal gasification, and one can only hope that one day the full potential of the technology can be reached.

2.6 Nuclear Power

2.6.1 Nuclear Fuel Processing

Uranium, like most any other metals can be extracted in conventional open pit or tunnel mining procedures. Miners can also use a leeching technique where the natural ore is brought through a series of regularly spaced wells then recovered later on from the solution. Uranium ores in the United States “range from about .05 to .4 percent uranium oxide ($U3O8$). (http://eia.doe.gov/cneaf/nuclear/page/intro.html) Once the ore reaches the surface it is subjected to machines that wear the pieces of ore into uniform sizes. Then the pieces are subjected to chemicals that separate the usable uranium oxide from the ore. The natural uranium oxide, which is called “yellowcake”, is sold on the uranium market to uranium conversion facilities.

These conversion facilities convert the uranium oxide to uranium hexafluoride (UF6). UF6 is the conventional form required by commercial uranium enrichment facilities. This uranium must be sent to an enrichment facility because it only contains about 0.71 percent fissionable uranium (U235). The remaining 99.28% is comprised of U238. The U235 isotope will almost always split apart when hit with a neutron. However, the U238 isotope usually absorbs this neutron and turns into U239. Luckily, the U239 undergoes decay and turns into Pu-239. Pu-239 is also an atom that will split when hit with a neutron. The problem that arises is that pure U238 isn’t reactive enough to keep the fission going. There has to be enough U235 in the core to produce enough free neutrons to push the U238 into Pu-239. In the end, there is no way to get all the U238 to change into Pu-239, so there is always some left over U238 or U239 when the reaction stops.

The object of an enrichment facility is to increase the density of the fissionable isotope of uranium in the pure UF6. To do this they first convert the UF6 into a gas by increasing its temperature. Once it is in gas form the molecules are channeled through a serious of “diffusion barriers”. The fissionable isotopes of uranium, U235, are slightly lighter than the non-fissionable isotopes such as U238. The diffusion barriers use this property to slowly remove the U238 atoms from the mix until the density of U235 atoms reaches a desired point. For instance, a standard light water reactor, which will be described later, requires that the uranium contain 4% of the fissionable U235. All in all the enriching process simply removes a portion of non-fissionable isotopes, like U238, so that there are more U235 isotopes in the mix.

The gas diffusion method is by no means efficient. It takes many, many, stages to reach the require densities. This makes the gas diffusion method time consuming, space consuming, and in turn expensive. Another option to separate the isotopes is to use a centrifuge. A centrifuge separates the U238 and U235 based on there slightly different atomic masses. However, like gas diffusion the centrifuge itself is also very expensive to build and to operate. Currently gas diffusion and gas centrifuge are the only operational enriching technologies that we have available. There are new technologies that use lasers to separate the isotopes called AVLIS (atomic vapor laser isotope separation) and MLIS (molecular laser isotope separation). Technologies like these will help nuclear plants operate more efficiently.

The final stage of fuel processing is when the UF6 is transformed into uranium dioxide (UO2). The UO2 is processed into ceramic pellets and then placed into tubes called “fuel rods”. These rods, which are especially designed for each individual reactor, distribute the uranium into the core during the reaction. And naturally they are removed once the uranium has been depleted.

2.6.2 Nuclear Generators

The United States currently has two different forms of nuclear reactors in operation: there are 69 versions of the pressurized water reactor, and 35 boiling water reactors. As mentioned in the national energy policy overview, there are no plans to build any more reactors of any variety.

In the pressurized water reactor the nuclear fission reaction is used to superheat water running through the reactor core. The water absorbs the heat being given off by the reaction and carries it out of the reactor housing. It is then used to create steam, which is in turn forced through an electric turbine generator. The boiling water reactor is much like the pressurized water reactor; however, it has a reservoir above the reactor's core which creates steam directly. Once again the steam is lead through an electric turbine generator to produce electricity. These types of reactors are generally referred to as "light-water reactors" referencing there use of ordinary water to transfer heat away from the reaction.

One of the problems with "light-water" reactors is the waters natural ability to absorb the free neutrons coming off the reactor. This slows the fission process which inherently needs the free neutrons as bodies to create new reactions. In order to remedy this problem the ordinary 345U is enriched until it is concentrated enough to produce an efficient reaction.

In addition to the water slowing the reactions, the fission reaction also has to deal with poisons. "Poison" is a term used to refer to the neutron absorbing byproducts of the diminishing 345U. Needless to say there is a point where the density of available 345U nuclei is low enough to not produce a useful reaction. When this occurs the nuclear rector must be shut down and restocked with the proper concentration of 345U. In general one-fourth of the core must be replace in each refuel for a boiling water reactor, and one-third of the core must be replaced in a water pressure reactor.

The amount of time a nuclear reactor can last on a "refuel" is measured in "full power days". This refers to the number of 24-hour periods in which the reactor will be operating at full capacity. The number of "full power days" a generator can produce is directly proportional to how concentrated the 345U fuel is at the start of the reaction. The amount of energy produced by the reactor is referred to "burn up". "Burn up" measures the ratio from MW of energy produced to initial weight of the fuel. This gives reactor controller an idea as to how efficient the reaction was.

2.6.3 Nuclear Waste

Nuclear waste has to be one of the most widely misunderstood topics in recent history. Most people just know that it is harmful if you get near it, but have no idea why or what the physical effects actually are. This controversy has stunted the growth of nuclear energy for years, mainly because people don't want this dangerous material traveling or being stored in or around their towns.

The first topic to clear up is how nuclear waste actually affects people. Nuclear waste, like all radioactive materials, releases a variety of radiation. Some of these radiations are: alpha decay, beta decay, gamma rays, cosmic rays, and neutron radiation. Generally they are also referred to as ionizing radiation. Ionizing radiation is dangerous because like its name suggests it carries enough power to remove electrons from atoms, thus turning them into ions. When atoms in the human body get ionized “en masse”, the radiation can mutate, sometimes causing cancer, or kill the cell completely.

Unfortunately, although most of the radiation causes the same sort of effect, it cannot all be blocked in a similar fashion. Alpha and beta decay usually can’t make it that far into matter. They can be blocked using most materials. Gamma rays can be blocked by lead shielding. Neutron radiation is more difficult to block. Since neutrons have no charge the only way of blocking them is to set up enough mass for them to pass through so that they are blocked. Huge layers of concrete are traditionally used for this purpose.

Currently once the fuel rods have been depleted they are removed and then cooled down. The rods are placed into a pool full of boric acid to not only reduce the temperature of the rods, but also absorb the radiation coming of them. To further increase safety measures control rods, much like the ones to keep the reactor core under control, are put into the pool. The problem is that not all reactors have access to permanent waste disposal centers. This causes dangerous overcrowding of the pools and simply delays the inevitable final disposal. The fuel rods were originally only supposed to stay in the pool for six months; however, due to the waste disposal problems they now stay in there for years at a time. A secondary storage device called dry cask is built at some sites to relieve overcrowding in the pools. Instead of using acid the casks use large layers of concrete and lead to block the escaping radiation.

The permanent solution for the disposal of toxic waste was a topic of much controversy for a while. Scientist wanted to put it deep underground, or at the bottom of the ocean, or even up in space. However, it was found that that the best way to create a mass permanent storage facility for nuclear waste is under ground. Some of the main requirements were that there are no underground water reserves near the site. Water could eventually seep into and erode the containers carrying the toxic waste to unwanted areas. The second was that there could be very little seismic activity. Enough pressure and shaking could break the containers release the waste into the environment. This is where the most infamous Yucca Mountain comes in. It meets all the requirements for becoming the permanent nuclear waste disposal site, yet it is still facing lots of controversy. Despite being placed in the middle of the desert and totally removed from humanity, citizens of Nevada are still fighting the storage facility due to fears of it leaking. Controversy or no, the Yucca Mountain project is projected to be finished in 2010.

2.6.4 Nuclear Policy

If one was to choose which form of energy was by far the most controversial, that title would fall into the hands of nuclear energy. Most average energy consumers don’t understand the nuclear process let alone nuclear waste. More importantly politicians don’t even know how and what risks are associated with radiation. The US has literally been scared away from nuclear energy. Granted, most of the current fear comes from Chernobyl; an event that could never happen today with current plant controls. But once again, people are generally unaware of the constant technological developments that aid the safety of nuclear power plants.

Nuclear power, however, is not the solution to all of the US energy problems. Originally it proclaimed as being an ultra cheap and nearly unlimited source of energy, much like fusion was. Time has told us that not only is Nuclear energy expensive, but also is inefficient, dangerous, and produces toxic waste. The great costs come because of the extreme amount of technology and the care that must be taken when dealing with this substance. The transition from turning what comes from the mine into what goes into the reactor is a huge expense of both time and energy, not to mention the hassle of disposing with the waste. Despite these huge barriers nuclear power still remains to be a competitive industry.

An objective view of the situation would yield a path pertaining not toward the safety or cost of creating nuclear power; but of remaining uranium. As mentioned given current efficiency and levels of uranium the supply will only last about 30 years. Provided we discover some remarkable means of increasing the efficiency of the reaction the US could possible stretch its supply to 100 years. So does the US abandon nuclear power now or later? The solution happens to be along the lines that the government chose. There will be no more money spent on building more nuclear power plants; however, there will be continuing research to increase the efficiency of the process to extend the livelihood of nuclear powers contribution to the US energy grid.

In conclusion the question of waste doesn't seem to be an issue when the source is only going to be around for another few decades. Scientists have found an easy and safe way to dispose of the nuclear waste so why shouldn't the US utilize this source for possible the next 100 years. Not only will keeping nuclear power around longer keep energy prices down, it will also alleviate the yearly energy consumption grown from overwhelming other forms of fuel.

Chapter 3: National Energy Policy

3.1 Introduction

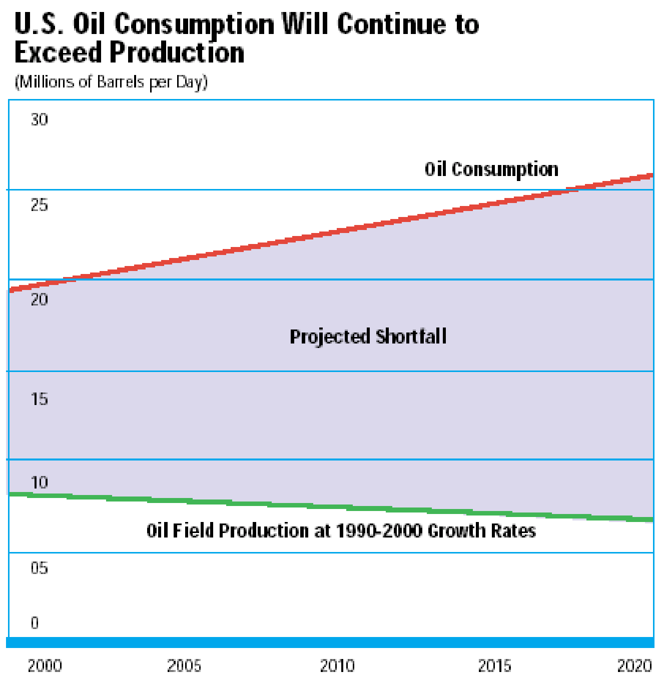
America's energy challenge begins with our expanding economy, growing population, and rising standard of living. Whereas, America needed to meet the principal energy challenges we face: promoting energy conservation, repairing and modernizing our energy infrastructure, and increasing our energy supplies in ways that protect and improve the environment. Meeting each of these challenges is critical to expanding our economy, meeting the needs of a growing population, and raising the American standard of living.

To promote energy conservation, we have already taken action by using energy more wisely. In credit to the new technology, it allows us to go about our lives and work with less cost, less effort, and less burden on the natural environment. The second challenge is to repair and expand our energy infrastructure. Our current, outdated network of electric generators, transmission lines, pipelines, and refineries that convert raw materials into usable fuel has been allowed to deteriorate. However, to match supply and demand will require some 38,000 miles of new gas pipelines, along with 255,000 miles of distribution lines. Similarly, an antiquated and inadequate transmission grid prevents us from routing electricity over long distances and thereby avoiding regional blackouts.

Increasing energy supplies while protecting the environment is the third challenge. Even with successful conservation efforts, America will need more energy. Thus renewable and alternative fuels offer hope for America's energy future.

Estimates indicate that over the next 20 years, U.S. oil consumption will increase by 33%, natural gas over 50%, and demand for electricity will rise by 45%. (As in chart 1 and chart 2). To meet projected demand over the next two decades, America must have in place between 1,300 and 1,900 new electric plants. Much of this new generation will be fueled by natural gas. Nuclear power today accounts for 20 percent of our country's electricity. This power source, which causes no greenhouse gas emissions, can play an expanding part in our energy future. Figures 18-20 provide an adequate division of such electricity distributions generated by fuel sources.

Figure 18: Oil Consumption vs. Oil Production (DOE)

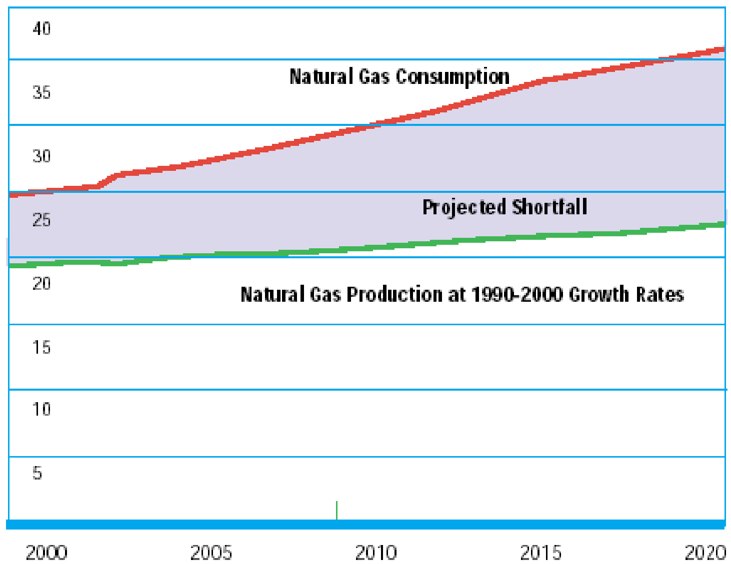


Over the next 20 years, U.S. oil consumption will grow by over 6 million barrels per day. If U.S. oil production follows the same historical pattern of the last 10 years, it will decline by 1.5 million barrels per day. To meet U.S. oil demand, oil and product imports would have to grow by a combined 7.5 million barrels per day. In 2020, U.S. oil production would supply less than 30 percent of U.S. oil needs.

Figure 19: Natural Gas Consumption vs. Production (DOE)

U.S. Natural Gas Consumption Is Outpacing Production

(Trillion Cubic Feet)



Over the next 20 years, U.S. natural gas consumption will grow by over 50 percent. At the same time, U.S. natural gas production will grow by only 14 percent, if it grows at the rate of the last 10 years.

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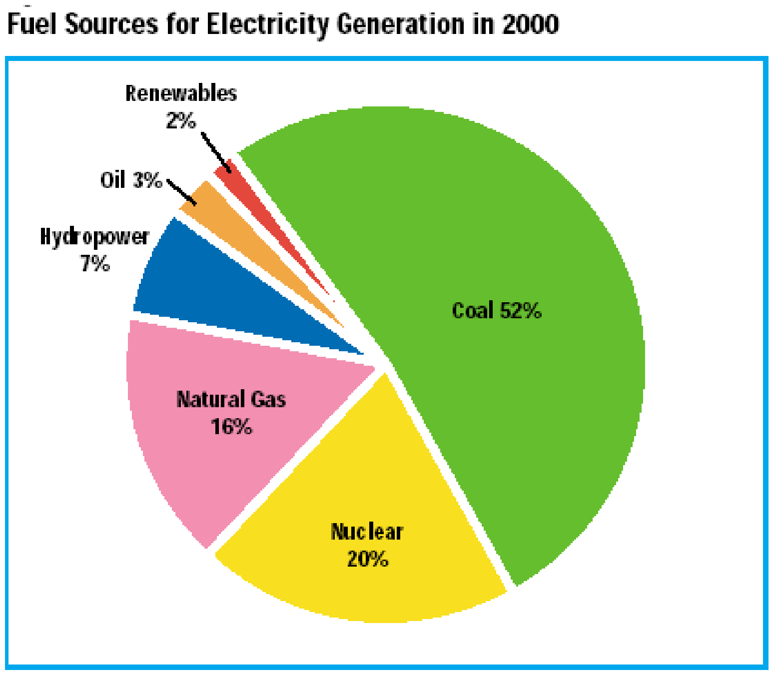
Sources: Sandia National Laboratories and U.S. Department of Energy, Energy Information Administration.

Figure 20: Fuel Sources for Electricity (DOE)



Electricity is a secondary source of energy, generated through the consumption of primary sources. Coal and nuclear energy account for nearly 75 percent of U.S. electricity generation.

3.2 Summary

Figure 20, shown above, was the statistic data from year 2000. However, it is still valid to say that the most abundant domestic fuel source is coal. Given the current consumption rate, America could run on its own coal for another 250 years. In 2000 the US generated over 1 billion tons of coal. While nearly all of the domestically produced coal is consumed by the US itself, 90% of the coal is used to produce local electricity. Since coal is a large domestic power source the prices are projected to keep falling over the next few years. The only problem with coal is its harsh treatment on the environment. The government has remedied that problem with the "Clean Air Act Amendments of 1990" which require generators to reduce harmful emissions.

Nuclear energy, which comes in second after coal, is used only to produce electricity. Unfortunately, the US is not going to rely on fission power in the future. The amount of world wide uranium, potential and existing, represents 60 to 300 TW-years of energy. However, the US has no plans to build more nuclear power plants to try and utilize this energy. Ironically the US nuclear energy output has increased without creating more plants. Standardized plant designs, improved licensing, and effective oversight by the Nuclear Regulatory Committee (NRC), has created a better environment for fission plants to operate. Even though the US has seemed to find an easy way to contain nuclear waste it is still unwilling to utilize the resource fully.

Natural gas is third in line when it comes to US energy production. The US will be banking heavily on natural gas in the next two decades. Current policy expects it to generate 90% of the increase in energy generation between 1990 and 2020. Currently 85% of natural gas energy is produced domestically; the rest is imported from Canada which is well connected to the US through pipelines. The US is depending so heavily on Natural Gas because of its friendliness toward the environment. Natural Gas has lower capital costs, shorter construction lead times, higher efficiencies, and lower emissions than coal. However, since all natural gas is sold in the same region in which it is produced, prices are based on the region rather than the global market. Natural gas prices have been notoriously high in the recent years. This has killed the energy source in the consumer market, but has gotten industry into creating more efficient cost effective methods of production. The challenges facing a plan based off of natural gas will be: the need to fill the gap left by nuclear energy or replacing part of the dependency on coal, and modifying the US gas pipeline network to be able to handle the capacity needed to make natural gas a larger energy source in the US.

Hydropower is next in line producing 7% of the US energy needs in 2000. Needless to say the availability of hydropower depends completely on location. Most all of the potential locations for generation of hydropower have already been used in the US so that there won't be any substantial growth in domestic hydropower energy. Aside from the lack of sites, hydropower's lack of a concrete federal licensing process causes any modification or changes to be extremely cumbersome. The US plans to change the process to ensure that "effective fish and wildlife conditions are adopted." (1-9 National Energy Policy)

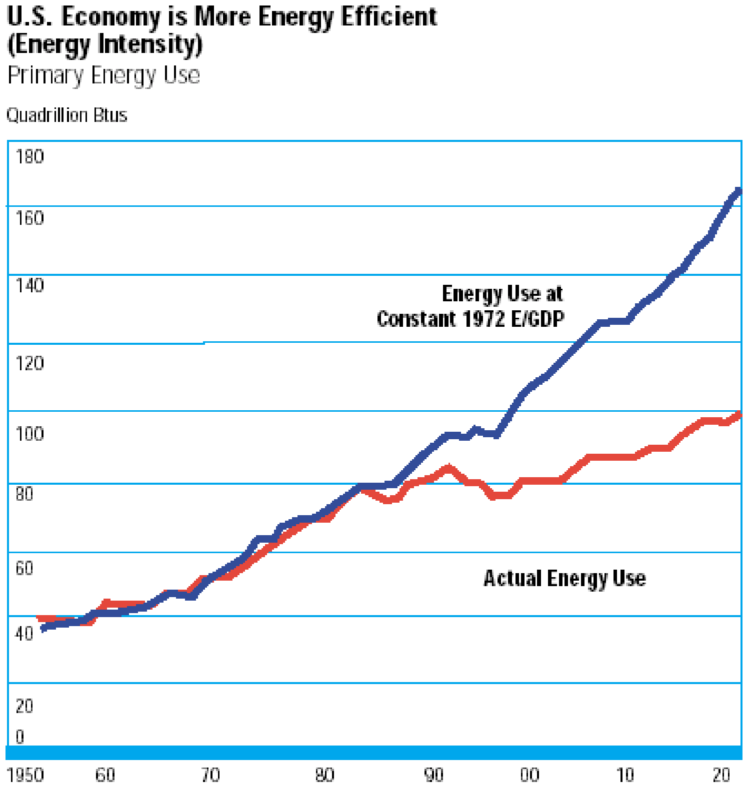
Oil when used for producing electrical energy is expected to decline to only 1% of the total US energy production in the coming years. Oil is really only an important source of energy in Hawaii and Florida. Since the US imports so much oil it is expected that it would want to focus the energy plan on more domestic sources.

Even though current energy policy is based heavily on Bush's environmental creed it has very little to do with renewable energy sources. The main problem is the cost of implementing this modern technology on such a grand scale. Current policy suggests that if current trends progress, 2.8% of the national energy will be produced by renewable sources.

3.3 Modernizing Conservation

It is very clear that America in the year 2001 faced the most serious energy shortage since the oil embargoes of the 1970s. The effects are already being felt nationwide. Many families faced energy bills two to three times higher than they were a year ago. Millions of Americans found themselves dealing with rolling blackouts or brownouts; some employers had to lay off workers or curtail production to absorb the rising cost of energy. Drivers across America have paid higher and higher gasoline prices. The best way of meeting the goal of energy conservation is to increase energy efficiency by applying new technology, raising productivity, reducing waste, and trimming costs. These policies promote hope for improving the quality of the environment. As Figure 21 shows, the increase of energy efficiency resulted in a lower trend of consumption.

Figure 21: Improved Energy Efficiency of the US Economy (DOE)



Improvements in energy efficiency since the 1970s have had a major impact in meeting national energy needs relative to new supply. If the intensity of U.S. energy use had remained constant since 1972, consumption would have been about 70 quadrillion Btus (74 percent) higher in 1999 than it actually was.

The National Energy Policy builds on the nation's successful track record and will promote further improvements in the productive and efficient use of energy. The energy we use passes through a vast nationwide network of generating facilities, transmission lines, pipelines, and refineries that converts raw resources into usable fuel and power. That system is deteriorating, and is now strained to capacity. Nevertheless, America needs more environmentally-sound energy projects to connect supply sources to growing markets and to deliver energy to homes and business. To reach such goal, the National Energy Policy will modernize and expand our energy infrastructure in order to ensure that energy supplies can be safely, reliably, and affordably transported to homes and businesses. The National Energy Policy also claims that to increase and diversify our nation's sources of traditional and alternative fuels in order to furnish families and businesses with reliable and affordable energy, to enhance national security, and to improve the environment. In addition to that, the Policy will build upon our nation's successful track record and will promote further improvements in the productive and efficient use of energy as well as passing a guild to ensure energy security for our nation and its families.

3.4 Social Impact

The current National Energy Policy relies heavily on the growth of natural gas, the consistency of energy produced by coal and the stability of Nuclear energy. The growth of natural gas will increase the supply, bringing prices down for the period of time it takes for demand to increase. Demand will increase with the number of homes and businesses that switch to the less polluting, more efficient, and less costly natural gas utilities. The increase use of natural gas will help lessen the demand for coal making for a lesser increase in pollution over the next 30 years. The increased drilling for natural gas won't have a large effect on the landscape due to the decrease size of drilling diameter and footprints. One factor that may affect citizens is the increase of small residential pipelines that will be installed to new homes. The nuclear energy production will relatively remain constant with slight increase in efficiency. The largest social impact nuclear energy has is the storage of nuclear waste in the yucca mountain that may contaminate ground water in the area. In the sector of renewable energy sources the only societal effect is the amount of money being invested in research, especially in quantum dots. In general this energy policy is building from previous years with adjustments for energy supply to meet expected demand. The social impact will be very little and spread out over time. The cost of energy will increase with inflation and the amount of harmful emission will remain the same.

Chapter 4: Proposed Energy Policy

4.1 Introduction

By now it should be apparent that the United States does need a new energy plan, and that the current energy plan may be too conservative to meet the projected energy demands over the coming decades. Although the national energy policy does have its heart in the right place, it comes off more as a temporary solution instead of along term one.

4.2 Summary

First of all are the major players in the 2003 national energy policy: coal, and natural gas. Although natural gas is a newer technology, which has caused huge price fluctuations from region to region, it has since calmed down and become a reasonable substitute. Notice that it is not a replacement for coal which currently dominates energy production. Natural gas will probably not help less coal to be used; rather it will prevent more coal to be used in the coming decades. Our research has shown that although natural gas is currently the favorite due to its environmentally sound demeanor; new technologies in coal will still allow it to compete with natural gas on the environmental level. Another good point about these choices is that both coal and natural gas are produced locally in the United States or by near by Canada. Increasing the use of any native supply is most always a good thing.

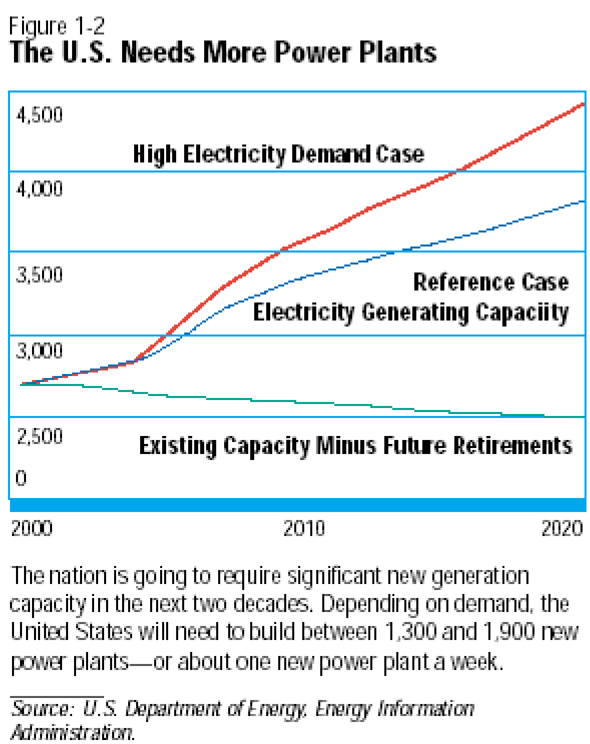
Oil, on the other hand, should be eliminated completely from the US lineup of energy supplies. It seems that the government too has realized this as they have been trying to reduce the use of oil for energy production for the last decade or so. There is no point in using oil for power if the largely bloated transportation industry already causes the US to import billions of barrels of oil a year. Increasing the national deficit more would only cause the currently bad economy to get worse.

Nuclear power is simply put, a tragedy. It is still amazing that the media and small governments managed to stonewall further production of nuclear plants. Nuclear plants now are virtually infallible, and scientists finally found a solution to deal with nuclear waste, yet the government is letting all this research go to waste because of an uninformed media and state government's "not in my back yard" policy. Even though nuclear energy is very inefficient (10%) any hope of raising that percentage to stretch our Uranium supplies to 100 or even 200 years has been lost because of lack a few simple devices. Nuclear power is clearly a great choice for the current century. The only waste it produces can be contained easily in salt mines, unlike coal which is released into the atmosphere. And it is locally produced so unlike oil it will not add to the growing national deficit. Furthermore, the current national energy plan only takes into account current growth based on old consumer trends. However, with Bush's new plan to move some of the transportation energy out of oil and into other sources (e.g. Coal, natural gas, nuclear) through he use of hydrogen cells he will find his current policy severely lacking. There is no way the current energy policy could support both the grid energy and the transportation energy. Nuclear energy is the first choice in order to accommodate that change in this century. In order to pass policy the national government must simply strong arm smaller states and the media with pro nuclear propaganda in order to change how people feel about it. Nuclear energy is a proven technology that is here now and can create instant change.

If there is one thing that can be said for Bush's policy regarding renewable energy, it is poor. Given the fact that wealthy land owners can push around private companies wanting to build wind farms (as is the case in Cape Cod) shows that this country isn't serous about wind energy, let alone any other renewable source. Since the current technology for renewable isn't as earth shattering as most Americans would like, it seems the US has taken a, "let's wait and see", stand point regarding renewable technologies. Both wind and solar seem weak compared to traditional fuel burning plants, none the less they should be given a chance now. Once solar panels approach efficiencies nearing 60-70% efficiency the US must be ready to put them into full scale manufacturing to drive down the initial costs. Private energy supplies will have no choice but to provide renewable energy in order to stay competitive. Even now, with lower than optimal efficiencies, renewable energy sources offer very competitive prices. It is only the private energy producers who lack the will to change.

The most important flaw of the current energy policy is that the usage of every major energy source is larger than the production of each of those sources. The effects of this can be devastating, with the effects ranging from more expensive utility bills for consumers, to a major energy crisis, as was the case in California recently. Any energy policy that we develop will not be feasible unless more power plants are built in this country. When looking at projections of energy use for the next decade or two, the need for more energy production in this country becomes more apparent. If the US begins to ease out of using foreign oil for energy production as they say they will do, this country will need to produce more energy just to reduce the loss that would result. Since the country is reluctant to increase the usage of nuclear energy, the obvious solution is to rely more on domestic fossil fuels for energy production. If this is what happens, there are two major problems with this. The first is the environmental aspect. As we strive to produce energy using "cleaner" methods, an increase in production of coal and natural gas will only harm the environment further. Although natural gas production is relatively clean, other "dirty" methods of energy production, such as coal, will continue to be used in the future. Coal gasification is an up and coming idea that may one day play a major role in energy policy, but as of now it has not been used on a widespread basis. Instead, coal combustion plants produce almost half of this country's energy using a process that emits millions of tons of pollutants into the atmosphere every day. The second problem is the availability of fossil fuels. If we begin depending more and more on fossil fuels, that will only accelerate the time when the supplies will be exhausted. It is not good policy to merely depend on fossil fuels and wait for the answer to our future energy needs to arrive. Figure 22 reinforces this point.

Figure 22: More Power Plants Needed (DOE)



Although there are a number of flaws in the current energy policy, there also have been some good developments. One of these is the steady decrease of pollutants into the air from the production of energy. Reasons for this include the increase of cleaner energy sources, such as nuclear power and renewables, along with federal regulations limiting the emissions of other sources, such as coal plants. In order for there to be enough energy in the coming years, there must be an increase in at least one type of energy production that is not used much currently. There are several different candidates, with the two highest recommendations going to coal gasification and nuclear power. A great deal of money and research has recently gone into coal gasification technology, and that time and money is finally beginning to pay off. Gasification plants are already much cleaner than coal combustion plants, and the efficiency of new plants is beginning to approach that of combustion plants. The DOE predicts that the efficiency of gasification plants will increase dramatically in the next 15 years, to almost 60% efficiency. Also, gasification plants are able to make other products in addition to electricity, such as pure hydrogen that is able to be used to power fuel-cell powered vehicles. Coal gasification is clearly an idea that will become more common in the years to come as an energy source. As for nuclear power, it is not without its drawbacks, such as its hazardous byproducts and the public's fear of nuclear power plants. Considering those drawbacks, nuclear energy can still be an important energy source for the future if it is done right. It is a much cleaner method of producing energy than most current methods of producing energy.

4.3 Social Impact

Our Proposed Energy Policy, relying on the current sources of energy along with wind energy, is more environmentally friendly than the National Energy Policy. With implementing an increase in the use of wind energy, pollution levels will stop increasing making for cleaner air. The price of wind energy, if monitored by the United States Government, could match the price of other types of energy. Wind energy if implemented on the grand scale would allow for the use of natural gas and coal to be used in other sectors, such as the transportation sector. Wind energy doesn't only affect the energy market but also has some physical social impact. This renewable source of energy requires designated land for wind farms that will restrict the growth of communities. Buildings and homes can not be constructed within the farms, but the land could be used for agriculture. The large turbines only require the land that is covered by the base, which is about 14 feet for the foundation. Wind turbines at a distance of 350m produce around 35-45 db of noise that is equivalent to a rural city background noise. The propellers on the turbine are painted with a matted finish to decrease visibility and reflection from the sun. All these social impacts are almost negligible to the impacts of other sources of energy. Our Proposed Energy Policy will also have the same social impact as the National Energy Policy but will increase lifetime of other fuel sources and provide a cleaner energy.

Chapter 5: Conclusions and Perspective

5.1 Future of Power

This paper is designed to give a concise opinion of how currently existing technologies should be used in the future, not to speculate on project efficiencies and production dates. However, a lot of time was taken outlining these future technologies and their possible involvement in the future. It is only fair that this paper presents reasonable conclusions those speculations.

The most important scientific breakthrough could be the production of high efficiency solar cells. High efficiency solar cells would not only allow society to not rely on a particular fuel, but it will also help decentralize power stations. This will help bring the technology to very remote places on the earth. Solar is a much bigger breakthrough than wind because wind farms only work in particular places and must be used in large groups. This is useful for rich communities with the right kind of land, but not that useful for delivering power to everyone. A small scale implementation of high efficiency solar cells should be the scientists aim.

Aside from the renewable sources this project mentioned there are also a wide variety of other sources that scientists conjured up to help solve the energy problem. One such device is an orbital solar power station. This would be a power station outfitted with solar panels that beam collected energy back to earth. Another example would be wave collectors. This would use an array of motion transducers in the break region of a shore to create energy. Finally there is geothermal energy, where scientists try to extract the heat of the core to create surface energy.

The most promising fuel driven technology seems to be the coal gasification process. Once the efficiency of coal gasification challenges the efficiency of combustion there is no reason for the government not to convert all its coal plants. It would be an expensive venture, but there would be a great reduction is pollutants. Other fuel driven ideas may fall short of expectations, much like the nuclear fission plant did. The complexity of fusion may weigh down the efficiency and it will never reach expectations.

Overall these technologies will be able to support the growing energy demands for the next century. The true test of the national energy policy will come when the transportation industry merges with the current plant power production. Now this project has intentionally not mentioned the transportation industry specifically for its controversial nature. However, due to new technologies, such as hydrogen fuel cells (which are basically large batteries), power will be created at the plants then converted into a more mobile form. Within the next century the transportation industry, industrial, and residential electric consumers will all run of the same environmentally sound plant. The true test of the national energy policy will be when it tries to achieve that goal.

5.2 Conclusions

The United States is not in the midst of an energy crisis. The imaginable energy crisis is referring to the depletion of predicted amount of oil. As the oil reserves throughout the world start to diminish the cost for the United States to import this oil will increase. What most American citizens see as the energy crisis is the rising gas price that is already lower than the rest of the world. This rising price in oil only affects 3 % (energy produced from oil) of energy production in the United States.

The largest current crisis is global warming and the amount of harmful emission produced from our current energy sources. The National Energy Policy is supposedly nature friendly but the changes made seem to support capitalism more than the environment. The shift to Natural Gas in the current energy policy reduces the amount of emissions compared to coal but with the increasing annual consumption, the natural gas is only adding to the coal not replacing it. For a cleaner environment the National Energy Policy needs to replace existing harmful energy sources by implementing different cleaner energy sources and more of them. The cleanest forms of energy are the renewable energy sources provided by the sun; hydroelectric, solar, and wind. Since hydroelectric has been applied to ever location available, the growth in this field is minimal. Solar energy doesn't have the technology to be applied to the grand scale but with quantum dots is showing potential in decades to come. The last main type of renewable energy is wind energy. This source of energy is being used in Denmark and is making a significant contribution to their energy supply. A large scale wind farm project is a viable option that could make a large contribution in the United States. The largest drawbacks are the investment needed to construct the many wind farms and the research needed for each designated area. Once completed these wind farms could contribute a reasonable amount of energy and if run by the government this energy could be purchased for a similar price of current energy sources.

The problems discovered in the researching of this topic were the exaggerations used by some sources. We also found the National Energy Policy was hard to change after we were completed with the background information. The United States Government has not overlooked any aspects regarding to the future energy supply but we felt has been distracted by its growing economy. Eventually the natural energy resources stored beneath the earth will diminish and the National Energy Policy will be restricted by supply. When this time comes an experienced view of renewable energy sources will be largely beneficial to the future of the United States. We feel the Government should delay the inevitable and start using the renewable energy sources presented to us today.

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