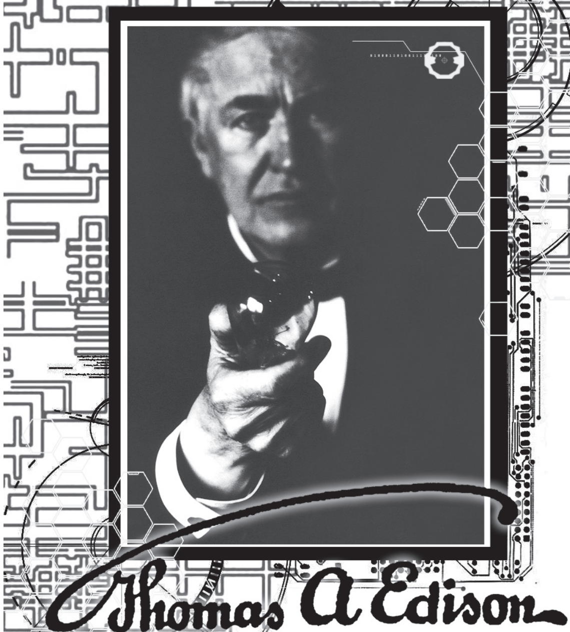

ABOUT ENERGY

AND ITS USE

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CHAIRMAN'S LETTER

Energy is pervasive in our economy and culture, our lifeblood. We are a 24 / 7 nation, Internet powered, and globally competitive. The world energy situation is changing as more large population, developing countries, are coming to the table and competing for the traditional energy resources. This likely will be the key arena of global competition this century.

This short book contains lots of basic and historical information about our energy history and how we arrived at our situation today. We hope you enjoy and benefit from all this data. The booklet is designed for classroom use by teachers as well as individual student and home school learning and experimentation.

If Thomas Edison were alive today, he would be an ardent alternate energy enthusiast, having extolled the virtues of alternate energy back in the early 1910's. He was the world's greatest inventor. His name is synonymous with creativity and innovation. Thomas Edison not only recognized opportunity, he created it. As the man responsible for the invention of the motion picture, recorded sound, power generation and the light bulb, and the creation of the first extensive R&D facility, he has arguably created more value than any other single human in history. It has been said that Edison is responsible for anywhere from 3% to 5% of the world's GNP, over $500 billion for the U.S. alone. Two scientific discoveries in his laboratories later led directly to radio and modern electronics, paving the way for today's telecommunications boom.

So join us in this spirit of Thomas Edison. The experiments have been designed to be easy, economical to perform, and insightful. Have fun and learn!

The Charles Edison Fund ("CEF"), incorporated in 1948 by Charles Edison was, and continues to be, an endowed philanthropic institution dedicated to the support of worthwhile endeavors generally within the areas of medical research, science education and historic preservation. It both operates programs and makes grants to support these endeavors. Since its inception CEF has served as an extension of the benefactions and aspirations of its Founder, a man of discerning foresight, rare achievement and background. The undersigned, as Chairman and President of CEF, committed the funding to create and print this booklet.

The Edison Innovation Foundation (EIF), a sister organization to CEF, is a not-for-profit organization that supports the Edison legacy and encourages students to embrace careers in science and technology.

You can learn more about Thomas Edison and how to support our non-profit efforts through our website at www.charlesedisonfund.org and www.thomasedison.org.

John Keegan
Chairman & President, Charles Edison Fund
Chairman & President, Edison Innovation Foundation

Energy Basics and Background

We all have a visceral feel about human energy, knowing that when we run out of energy we must eat or rest to restore our strength and ability to do work. In fact, one can define energy as the ability to do work; and power as the rate at which we expend energy. The energy we derive from a well-balanced lunch will last all afternoon if we sit and read and do some casual chores around the house (about 200-300 Btu per hour), but if we expend great amounts of energy running, bicycling, and swimming (about 400-600 Btu per hour), then we have a much higher energy use (power) and we may need to refuel our bodies before dinner with a snack or rest.

It is the same with battery powered appliances, like a laptop computer. Fully charged batteries will give us hours of energy with casual use; but use that laptop continuously, and the batteries must be re-charged. So it goes for the family car too. Use the car only for essential trips and the energy in the fuel tank will last for a week or more. Zip around with many trips or at highway speeds and the fuel soon must be replenished.

We live in a world full of energy use and its conversion to many forms. Internal combustion engines convert the chemical energy of the gasoline fuel into mechanical power to turn the car wheels; acoustic energy because we hear the engine running; electrical energy that recharges the battery; and light energy that powers the headlights and accessories. The chemical energy of a battery is used to make electricity to operate a flashlight. The sun's light hitting a photovoltaic panel generates electricity to power home appliances. The mechanical rotation of a wind turbine blade turns a generator and creates electricity to power a local community. The splitting of uranium atoms in a nuclear reactor creates heat to make steam to turn a turbine to generate electricity. At any moment, our world is a symphony of energy conversion processes that satisfy our needs to travel, work, partake in leisure activities, attend school, communicate via our computers…. etc. We very much depend on these energy conversion processes to energize our civilization and operate the vast infrastructures that support it.

The listing which follows is a "laundry list" of the energy resources that we could use to help power our economy. No one single source is the answer, but rather a mix of energy resources working together.

Possible Energy Sources

- Fossil Fuels: Oil, Natural Gas, Coal, Lignite, Oil Shale, Tar Sands, Geopressuized Methane
- Biomass: Wood, Peat, Grasses, Grains, and Agricultural Feedstocks
- Renewables: Hydro, Solar, Wind, Geothermal, Tides, Waves, River Flows, Biomass
- Nuclear: Uranium, Thorium, Plutonium
- Recycled/Waste Streams: Landfill Gas, Refuse Derived Fuels, Sewage Gas, Farm Wastes

For those looking for hydrogen…it is not technically an energy resource. There are no hydrogen mines, nor deposits. It must be made from something else, manufactured, just like electricity.

The Btu, an Old Friend

The basic unit of measure of energy is the Btu….the amount of energy it takes to raise one pound of water 1 degree F. If you want a dramatic reminder or mental picture of what a Btu is, think of an old fashioned blue-tip stick match. When lit, it will generate 1 Btu. As we discussed above, a person at rest will consume 200-300 Btu per hour, or in this case, the energy equivalent of 200-300 matchsticks every hour. If you have a peanut butter and jelly sandwich and a candy bar for lunch, it represents a fuel input of about 2000 Btu. If you run around and play sports after lunch and expend 500 Btu per hour, your lunch will last about 4 hours and you certainly will want to snack to refill your body's fuel tank.

Putting this into perspective further, a gas-fired water heater can consume 30,000-45,000 Btu per hour. A car that gets 30 miles to the gallon, traveling at 60 miles an hour, will consume 2 gallons of gasoline in that hour…… which is 250,000 Btu per hour. Home heating furnaces and boilers can easily consume 80,000 to 215,000 Btu per hour in winter depending upon how big the home is, its temperature inside, and how well it is insulated.
By the way, the average efficiency of a car is about 18-22%. This means only 18-22% of the energy in the gasoline gets converted to useful energy in moving the car and powering its appliances.

Energy sources have very different energy densities, that is, the amount of Btu per volume or pound. The chart below illustrates this.

Fuel	Btu/lb.
Peat	1,750
Wood	6,800
Coal	12,500
Oil (crude)	18,500
Natural Gas	23,500
Nuclear	30,000,000

Man's energy history until now has been a continual march to find and exploit ever denser forms of energy, so smaller volumes would need to be used. The incredibly dramatic energy density of nuclear fuel derives from a switch from chemical energy derived via oxidation, i.e.burning a fuel….to cleaving or fissioning its energy rich atomic structure. When we burn a fuel we play around with its outer electrons. When we cleave a fuel's atomic structure, we separate its tightly bound protons and neutrons and release enormous amounts of tightly bound energy. This makes it possible for nuclear submarines and aircraft carriers to run for several years on an initial load of nuclear fuel, as opposed to millions of gallons of fuel oil that they once needed.

Nuclear fuel also has the potential of manufacturability, that is, humans could make their own fuel from other forms of nuclear materials and substances. Right now, nuclear fuel is used only by the military and electric utilities; but the basic energy form of the universe is nuclear in nature. We just happen to live on a planet that has an oxidizing atmosphere, thus allowing for the active combustion of materials, so we tend primarily to combust plentiful supplies of stored energy in the form of fossil fuels. Such fuels are nothing more than sunshine captured by previously living organic plants, and converted with time and pressure to coal, oil, or natural gas….stored sunshine if I may wax philosophical. Our own sun is a giant nuclear fusion furnace that converts 4 million tons of hydrogen into helium every second. We are a species of life that has adapted to living in the "shine of a giant nuclear furnace" [author's quote].

Food and Energy

Just about every industry requires an energy input of some kind that is ultimately reflected in the price of that product, or the price to ship that product around the country or world….and the food industry is no exception. Food prices always go up when there is an increase in the price of oil. Here is what it takes to grow one pound of food:

- 1/7 pound of fertilizer
- 60 square feet of land
- 800 gallons of water
- gallon of gasoline energy

There is an embedded energy cost to make and ship the fertilizer; and energy costs to pump the water and transport it; and of course the gasoline energy used to harvest it. At harvest…..there will be more energy required to refrigerate and ship it to markets.

Recently, we have talked nationally about making fuel from crops—ethanol and bio-diesel types of fuels. This could be inherently dangerous as it would make our food supply subject to wide price fluctuations as farmers make a choice whether to grow foodstuffs for fuel conversion or straight consumption. At times when traditional fuel prices are high, farmers may choose to grow say corn for conversion to gasoline or diesel. This makes corn crops more scarce, and this drives the prices for that up as well. The trick would be to grow crops that are marginal at best as basic foodstuffs and make fuels from those without harming the price mechanism of the food markets.

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All About Quads

The resources we use to energize our economy have developed over many years. Here is a table of the amount of energy we have used over the years from 1860. The amount of energy a country uses is best measured in a very large unit known as a "quad" of energy or a quadrillion Btu of energy. A quad is 1 followed by 15 zeros, or 1 times ten to the 15th Btu. Look at how the US has grown in its consumption of energy as measured in quads:

Year	quads
2005	100
2000	95
1990	84
1980	76
1970	66
1960	44
1950	33
1940	26
1930	24
1920	21
1910	16
1900	10
1890	8
1880	6
1870	5
1860	3

Two trends are very apparent in these numbers:

- The industrial revolution of the late 1800s ignited a spurt in energy use in the 1900-1940 period; and,
- The post WWII period saw a huge explosion of energy use-culminating in a tripling of energy use between 1950 and 2005.

Most of the 1900-1940 period was characterized by the burning of coal and oil as our major energy resources. This would change radically later. By the way, world energy consumption is about 4 times that of the United States, or 400+ quads, and likely to rapidly increase as population giants China and India industrialize and become world players, competing for energy resources.

The Major Energy Sources or Forms

Today there are five major energy sources or forms we use as shown below:

- Oil
- Natural Gas
- Coal
- Nuclear
- Renewables

The renewables category is further broken down into several additional sub-categories:

- Hydro
- Wood/Biofuels
- Solar/Wind/Geothermal

Let's compare 1950 (33 quads of total energy) and 2005 (100 quads of total energy) to see which of the major energy forms did the biggest job of supplying our energy needs. Again, the numbers are in quads:

Year	**Oil**	**Natural Gas**	**Coal**	**Nuclear**	**Hydro**	(*Renewables*) **Wood/Bio**	**Solar/Wind/Geo**
2005	40	22	23	8	3	3	1
1950	12	6	13	0	2	0	0

During both years, oil, natural gas, and coal did the "heavy lifting". In 1950, 31 quads of the total 33 quads of energy used were supplied by the fossil fuels, or 94% of the energy economy. In 2007, 85 quads of the total 100 quads was fossil fuel, or 85% of the energy economy. The only new energy source of any consequence during this period was nuclear power; and this option was initiated by the electric utilities in 1969 predominantly to stop the burning of high-priced, low sulfur (increasingly subject to supply interruptions), oil from the Middle East; and the pollution from many oil burning plants. Had this not been done our dependence on foreign oil would have made our electricity prices unbearable.

One could argue the utilities deserve a great deal of credit as an industry that got off its oil addiction; but look how long it took to add 8 quads of energy use to the national energy mix! It did not happen overnight. It took decades. Any new energy source we try to add into the energy mix will take years to make a dent. Solar/wind has been pushed hard since the 1980s, along with geothermal ... and now about 25 years later, it is supplying just 1 quad to our national energy economy.

Between 1950 and 2005, coal use just about doubled, largely for electric utility power generation. Oil use tripled and that is because of the explosion of cars and diesel trucks and trains (replacing coal steam units). In fact, right now about 70% of all our oil use is for the transportation sector, and mostly for cars. Natural gas use tripled, becoming popular as a heating fuel for homes, industry, and business. Prior to 1950, many homes and industries were coal powered.

From 1940 through 2005, the use of electricity increased by a factor of 10. More and more of our energy economy became electrically powered. Electricity is an incredibly versatile energy form, which can be manufactured from any of the five major energy sources. Take a look at this table to see how energy use has intensified just in the home during this time period. The data here is from PSE&G Company in New Jersey:

Year	**Energy Consumption (kWh/year)**
1940	755
1950	1307
1960	2489
1970	4995
1980	5549
1990	6035
2000	6650
2005	7050

We consume energy across four sectors of the economy and for 2005, it looked like this, compared to 1950 (in quads):

	2005	**1950**
Residential & Commercial	11	7
Industrial	21	14
Transportation	28	8
Electricity	40	4
Total quads	100	33

All numbers in all the sectors have increased as we would expect from a total energy increase from 33 quads in 1950 to 100 quads in 2005. The really big changes here though occurred in the transportation and electricity sectors, as we have been alluding in previous discussions above…where transportation increased 3.5 times and electricity 10 times.

Electricity Generation

Let us now take a look at how electricity is generated by fuel source. In this table, the values are in percentages of total energy generated in the electric sector. Note how different this breakdown of energy sources is from the general energy picture across all the sectors of the economy as shown above.

All Numbers in % of Total

					(*Renewables)*		
	Oil	**Natural Gas**	**Coal**	**Nuclear**	**Hydro**	**Wood/Bio**	**Solar/Wind/Geo**
2005	3	19	50	19	7	1	1
2000	3	16	52	20	7	1	1
1990	4	13	52	19	10	1	1
1980	11	15	51	11	12	0	0
1970	12	24	47	0	17	0	0
1960	7	21	53	0	19	0	0
1950	11	13	46	0	30	0	0

What we notice over 55 years is:

- Use of oil today has been reduced.
- Coal remains the biggest fuel source for electric generation, about half of all generation.
- Natural gas use has risen
- Nuclear power use has risen dramatically, but has now stagnated.
- Hydro has declined dramatically as available good sites are very limited.
- Minor rise in wood/bio and solar/wind/geo.

Notice how long it took nuclear to become an almost 20% contributor to electric generation…..35 years from the first nuclear plant in 1969. There is a very valuable lesson here about introducing new energy sources into the existing energy mix. It takes time to overcome the existing "inertia" of the system.

The United States has massive coal resources, actually far more energy than the oil exporting companies of the Middle East have in oil. If these coal reserves can be made into a gasified, clean fuel, it would make these huge resources less polluting and incredibly valuable to our economic growth.

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What is Electricity?---- www.42explore.com/electric.htm

WORLD ENERGY USE

As mentioned earlier, the total world energy consumption in quads is about 4 times that of the United States, as indicated in this table:

Year	USA	World	World/USA ratio
2005	100	460	4.6 : 1
2000	95	396	4.2
1990	84	349	4.1
1980	76	287	3.8
1970	66	216	3.3

However, the ratio of world consumption to that of the U.S. is increasing, meaning the rest of the world is ramping up its energy production ... modernizing and industrializing ... especially countries like China, India, and the Southeast Asian rim countries ... where about one-half of the world's population resides. These countries are likely to see the exponential energy growth that America witnessed in resource and electricity demand in the 1950s-2005; but they will do it from a population base much larger than ours, about 10 times as big (3 billion versus 300 million). They probably will grow exponentially for a longer period of time. This likely will put competitive pressures on oil and other fossil fuel reserves worldwide. Examine the next table that shows the breakdown of energy sources for world energy consumption. The demand figures here are once again in quads; and please note that the "other" category in the chart denotes wood/biomass/solar/wind/geothermal renewable resources.

	Oil	Natural Gas	Coal	Nuclear	Hydro	Other	Total quads
2005	158	117	122	27	29	7	460
2000	147	101	90	26	27	5	396
1990	129	83	91	20	22	4	349
1980	128	60	71	8	18	2	287
1970	97	41	63	1	12	2	216

Now for 2005, let's compare the U.S and the world's energy consumption:

	Oil	Natural Gas	Coal	Nuclear	Hydro	Other	Total quads
World	158	117	122	27	29	7	460
USA	40	22	23	8	4	4	100

As plainly seen, the world and the U.S. are both heavily dependent upon fossil fuels. With these figures, it is also possible to make the following observations about the U.S. energy consumption compared to that of the world. The U.S. accounts for (about):

- 25 % of the world's oil consumption
- 20% of the world's natural gas consumption
- 20% of the world's coal consumption
- 33% of its nuclear power consumption
- 14% of hydroelectric usage
- 60% of the alternate energy usage.

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Energy Information Administration----www.eia.doe.gov/

The Tried and True Way

Electricity is a manufactured product. It is made through a series of steps which convert the energy within a fuel form into electrical energy we can use in our homes, and businesses. In a traditional fashion, the making of electricity requires a series of specific steps.

In power plants that use coal, oil, or natural gas, the fuel form is first burned to create a great deal of heat in a large boiler. Through this boiler, water is circulated and turned to steam by the heat. The energetic steam is made under great temperature and pressure and then allowed to expand rapidly against a turbine wheel to create rotational motion of approximately 1800-3600 rpm. This no small amount of energy, as the turbine wheel and its shaft are probably close to 80-100 tons in weight. As this turbine spins, it rotates an electric generator that produces alternating current which we can use in standard electrical outlets. The power generated is stepped-up to high voltages by massive transformers, and then transmitted around the region to local substations where it is stepped-down in voltage and distributed to customers. The voltage is stepped-up after exiting the power plant because it is much more economic to send it long distances at high voltages than at low voltages.

It is much the same in a nuclear power plant, except the boiler of fossil plant operation is replaced with a nuclear reactor. Here in the reactor, the nuclear fuel is arranged in a specific geometry that allows free neutrons to break or cleave uranium atoms, releasing enormous amounts of heat. This heat boils water and the rest of the plant equipment functions quite similar to a fossil plant. After exiting a nuclear plant, the electricity travels over the same electrical system as fossil power plant generated electricity.

Hydroelectric power plants are one of the cleanest forms of electric power generation. There are no boilers, or fuel handling equipment and systems to be concerned with. Water falling from great heights directly turns the generator and electricity is generated. Renewable rain is the fuel source, as well as a suitable site for the dam to be built. Hydroelectric dams are very site specific. Again, the electricity generated can be simply fed into the existing utility grid.

Geothermal power plants are similar to fossil power plants, except no fuel is burned. The steam is already there, or hot water is flashed to steam and a turbine wheel may be turned to spin an electric generator. The electricity generated is then fed into a grid. Like hydroelectric dams, the location and availability of geothermal energy may be quite site specific.

Wood, biomass, and incinerators work very much like a low grade fuel power plant. These fuels are combusted along the same lines as a coal fired boiler and electricity is generated like a traditional fossil fuel boiler.

With the exception of hydroelectric and geothermal power plants, a body of cool water is generally required to take the depleted steam energy that turned the turbine and reduce its temperature down so it can be re-circulated back to the boiler to once again be re-heated. This continuous heating/cooling cycle of the water is closely monitored so maximum efficiency of the power plant may be achieved. Some power plants use air cooling or closed water ponds to reject their waste heat if a nearby river or lake is not available.

Think of the need to cool the power plant using a river as the direct analogy of the radiator in your car to cool the engine. The car radiator rejects its heat to the air rather than water like the power plant. In fact, you can visualize the car engine as a miniature power plant because it does a very similar operation as a fossil power plant. Its main output is rotational motion of the wheels for movement, with electricity generated as a by-product for lighting, battery re-charging, and appliances. In fact, many small municipal and rural utilities or island power plants use large diesel engines to generate electricity. Here the engines are bolted down and turn no wheels at all……just generate electricity by spinning a generator. Like a car, they are air-cooled.

Traditional power plants are typically built in sizes ranging from 300-2000 Megawatt (MW), and may have 1-5 complete generating systems at one site, that is 1-5 boilers, turbines, generators. In hydroelectric stations there may be as many as 20 or more generators housed in one dam. Conventional generating stations can perform this energy output on about several hundred acres of land. (Note: it takes 640 acres of land to make a square mile.)

Coming Changes

It is possible to replace the fuel heat source of a traditional fossil/nuclear/geothermal type power plant and use solar heat instead. Such a plant is called a solar thermal generating station. Sunlight is focused using large heliostats (highly polished mirrors) so that the light from a large circular mirror field is concentrated onto a boiler, so steam can be created to operate a turbine-generator, just like any other traditional electricity making operation. Some of these plants have already been built in the sunny southwestern parts of our country and have operated for 10-20 years. More could be built as their economies become more favorable.

Wind turbines are a lot like a hydroelectric power plant. Wind energy (like the falling water of a dam) spins the machine's blades or propellers, and this turns a generator that makes electricity. It is quite simple and uncomplicated compared to a traditional fossil/nuclear plant, but the energy yield for each turbine is quite small, and the area devoted to installing wind machines can be quite large……tens of square miles for equivalent capacity. Solar thermal stations also require very large land areas for the heliostat fields. Both solar thermal and wind energy systems must be located where the solar and wind resources are ideal. Wind turbines are actually the fastest growing alternate energy power source on the planet.

Direct energy conversion technologies like solar cells, technically referred to as photovoltaic energy conversion—light induced electricity, is one such exciting new alternative. It is simple….. free sunlight in…..clean electricity out, with no noise, pollution, or need to heat-up a nearby river. One could spread out huge arrays of these devices on rooftops, over land areas, on big roof buildings like shopping malls, factories, big-box stores, schools and such, and all this electricity becomes available locally…no need to transmit it long distances. Locally generated to be used locally, photovoltaics holds great promise, with any excess electricity generated sent back into the utility grid for others to use. Large utility size generating stations could also be made in sunny areas, like solar thermal plants, with the energy sent in over high voltage transmission lines….but again, tens of square miles of land would be required for the solar cell arrays. We could see such systems making inroads if the cost of the equipment to be installed is made cheap enough. Already they are being installed on roofs of homes.

Another direct energy conversion technology that holds great promise is fuel cells. Employing a similar chemical conversion process as that of a battery, fuel cells use hydrogen energy and oxygen to create continuous amounts of electricity, with water as their waste product. The space program used fuel cells aboard the space stations and moon capsules. We understand the technology, and their use is a matter of economics at this point. If perfected, we could use them to power our homes, businesses, cars, and a host of other decentralized applications.

These new technologies change the basic landscape of electric power production, offering a chance to move the power plants away from a centralized location on utility company property, and disperse them to local areas where the electricity is used. Often referred to as distributed energy forms, such systems may one day be used by homeowners to produce their own electricity. This could have some interesting national security implications as it becomes harder to injure a country by crippling its central power network.

THE IMPACTS OF ENERGY USE DECISIONS

Certainly, energy use decisions will have impacts across a range of sectors within our society. We shall begin with an examination of the potential impacts to our civilization, and a listing of them. The type of energy system, source or form we want to employ will affect the:

- Environment
- Economy
- Safety
- Financial Community
- Legal Community
- Regulatory Community
- Global Community
- National Security

We can embellish this with an actual example, by assuming a new energy conversion process is now available that somehow uses clean hydrogen fuel (a fuel cell) to make electricity. Here is a pro and con argument of this new energy conversion process, within which we shall see some of the impacts on the sectors above. This by no means an exhaustive review of all the impacts, but serves to place the discussion in perspective. Here we go……

Pros and Cons of Using Fuel Cells

Pros

- This is the cleanest of all fuel uses with no carbon whatsoever to deal with.
- Hydrogen is completely renewable.
- We have used fuel cells before in the space program and understand it.
- Homeowners and businesses will be able to make their own electricity, cleanly on site.
- Fuel cells can be used to power automobiles, getting us off foreign oil for our cars.
- We could sell our technology overseas so they could clean up their fuel use too.
- Hydrogen does not contribute to global warming mechanisms.
- Getting away from overseas oil use will lessen global tensions/reduce terrorism.

Cons

- We have no infrastructure or protocols for storing and distributing hydrogen.
- Local municipal codes might prohibit use/storage of hydrogen on-site.
- Getting the hydrogen from other sources is expensive (electrolysis/ fossil fuel reformation)---there are no hydrogen mines.
- What about the current lifetime limits of fuel cell stacks?
- The catalysts needed to make fuel cells work is expensive and limited.
- What about car accidents involving pressurized hydrogen storage?
- Would hydrogen fuel be taxed like gasoline?

In essence, when doing this kind of an analysis, one quickly comes to the conclusion that all energy sources and forms have pros and cons. Nothing escapes without some drawbacks, trade-offs, or constraints. Suppose we try another one. What are the pros and cons of using wind energy?

Pros and Cons of Using Wind Energy

Pros

- Wind energy is free and totally renewable.
- We are already using it and understand how to make wind turbines work.
- They can be built fast and in modular fashion, giving them great flexibility.
- The technology is being applied worldwide.
- Wind turbines do not contribute to global warming.
- Wind farms can also be used for agricultural applications as well.
- The U.S. is blessed with enormous wind energy in its middle and western states.
- Wind machines can be located in oceanic/near shore areas too.
- Wind energy is the fastest growing alternate energy application on the planet.

Cons

- The wind can be intermittent, with no wind generation.
- Back-up utility generation must be available to pick up slack wind periods.
- Too many wind machines in a utility grid has already caused problems.
- The number of wind turbines in a grid is dependent upon the particulars of that grid—grids are not alike.
- Large clusters of these tall machines are not always pleasing to the eye.
- Bird migratory patterns through a wind farm can be dangerous to the birds.
- Interconnecting many wind turbines and getting the power to a nearby utility grid can be expensive.
- Amount of land area to produce equivalent utility size bulk power is very large.

This is the fundamental bedrock of any discussions about using alternate energy or new energy forms. Clearly there can be many questions and concerns to be addressed, but energy does impact and interact across the different sectors of our society. It pervades everything we do on the planet. It is the lifeblood of our economy.

For those of you teachers or homeschooling parents reading this, these pro and con activities are ideal for debates and discussion, maybe even by teams of students.

ACTIVITIES AND DISCUSSIONS

Identify the energy sources you use in your daily life. What energy sources do you use at home, school, or at leisure?

Identify and discuss some of the great scientists and engineers who made great contributions to how we use energy? Are there great inventors and scientists in your state who are now conducting energy research?

The national laboratories of the U.S. are busy working on a variety of energy research projects. What energy R&D is going on at our national labs, say at Sandia National Laboratories, or the Princeton Plasma Physics Labs?

Which states of our country have vast coal or coal type reserves that can be used or converted to clean fuels?

How do you think the worldwide and pervasive use of computers has and will affect our use of electricity? Will this impact just keep getting bigger or will some activity tend to limit how fast electricity consumption for computers keeps growing?

Does it take more or less energy to send e-mails or information electronically than it does to simply mail the information using traditional post offices? Can you try to calculate the differences if any? What makes the sending of electronic mail so enticing from an energy perspective?

How would the use of battery-powered electric vehicles impact the electric utility companies? What are the pros and cons of this?

The range of most battery equipped cars is about 50-80 miles. How many trips does your family make that fall within this range? Could a battery only car work for your family?

LEARN MORE ABOUT THOMAS EDISON

Here is a fun list of great reads about the famous inventor, spanning the ages from adults to young readers. Many of the earlier published works noted here have been updated and re-printed in paperback form as well. Check with your local bookseller or the Internet for updates, and even more reads about the great man. Better yet, visit the famous West Orange Laboratories in New Jersey and see the world's greatest intact collection of Edison artifacts; and learn how he put them to use creating our modern world. See the website about the West Orange laboratories at the end of this section, and view information for visiting or contacting the site. School and group visits can be accommodated.

Adult Reading

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Some Interesting Websites to Visit

http://www.nps.gov/edis/home.htm (Edison National Historic Site - in West Orange, New Jersey)

http://www.charlesedisonfund.org/ (The Charles Edison Fund)

http://www.thomasedison.org/ (The Edison Innovation Foundation)

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Harry T. Roman is a retired engineer, teacher, and inventor. He holds 10 U.S. Patents and has written and published over 475 papers, articles, and scientific essays, including 17 books. His feature educational articles for teachers and students appear in Highlights for Children, The Technology Teacher, Techdirections, TIES, and Interface. His books have been published by Kelvin Publishing, Hearlihy, Nasco, PublishAmerica, Professional Publications, Inc. and Gifted Education Press. He now serves as an educational consultant to the Edison Innovation Foundation.

ABOUT EIF

The Edison Innovation Foundation (EIF) was founded in 1996 as a non-profit operating foundation to preserve and promote the legacy of Thomas Edison, especially his historic laboratories at West Orange, NJ. The mission of EIF has evolved to include educational outreach programs tailored to inspire teachers, students, women, and minorities to pursue or continue careers in science, engineering, and technology.

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