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CHAPTER 2 - ENERGY USE AND HUMAN WELL-BEING: ENERGY GOALS FOR VERMONT'S FUTURE

I. OUR GLOBAL ENERGY SITUATION

Hundreds of times each day, our well-being depends on energy use. When we take a hot shower, drive to work, turn on a light, drink a cold soda, cook dinner, and countless other activities, we use energy to help meet our needs. Each object we use and see around us also represents an investment of energy. Some objects, such as a car, require a great deal of energy to produce and deliver, while others, such as a container of locally grown, in-season, organic blueberries require much less. Even though energy use continually contributes to our well-being, it often remains invisible. We often don't think about how much energy is embedded in the objects we see and use, or about what it takes to keep our refrigerators, TVs, cars, and computers running every day.

Today, it is crucial for citizens worldwide to start thinking more carefully and more consistently about the ways we acquire and use energy, and the ways that energy contributes to our well-being. Human well-being benefits from energy use, but it also suffers from the consequences of energy use in financial, social, health, and environmental terms. It is important to ask ourselves whether increased energy use always brings about greater human well-being over the long-term. Most countries use much less energy than Americans, but in many cases the health, human capabilities, and basic standard-of-living of people in those countries are not diminished because of it.

Society's failure in the past to focus on issues surrounding energy acquisition and use has left a legacy of burdens for future generations. For example, in order to meet past energy needs, past and current generations released unprecedented quantities of carbon dioxide into the atmosphere, enough to commit the earth to future climate change and unknown warming effects. The environment has already been seriously affected by society's energy use in other ways, including negative consequences from acid rain, smog, oil spills, nuclear waste, strip mines, and traffic congestion; in the future, the natural living systems of the environment will be less and less able to absorb additional negative effects as pollution and other environmental stresses increase and undeveloped land areas decrease. Our past energy use has also greatly reduced the available store of fossil fuels; as fossil fuels become scarcer or more expensive to extract, prices will rise while quality declines. (See Chapter 3 for more on the limits of fossil fuels.) Finally, use of the world's fossil fuel energy resources has contributed to the standard-of-living of humans in some countries much more than to others. Currently, one-half of the world's population does not have electricity in their homes. As population increases and modernization advances in developing countries, the people of those countries will require more and more of the earth's energy resources to fill their most basic needs. If current population and economic development trends continue, global energy use is expected to increase by as much as 50% in only 15 years, compounding all our energy problems (U.S. DOE, *Energy: Our Future is Today*, 1994).

Tragically, the consequences of global warming, depleted fossil fuels, a diminished environment, inequitable energy use, and rising resource demand due to population growth will fall mostly on our children and grandchildren. Even if global population were not rising, our current mode of consumption, with its dependence on fossil fuels, would not be sustainable or environmentally sound over the long-term. In the future, our children and grandchildren will pay the price for our current level of consumption and patterns of energy use.

Our global society is at a critical, transitional time in the history of energy use -- a time which gives us an opportunity to make reasoned and deliberate changes in our approach to energy use. One future trend is clear -- it will inevitably become more difficult to maintain current patterns of energy use. If we don't start gradually changing those energy use patterns now, while we still have choices, we will eventually reach a

time when a radical change is our only option. The danger of failing to start changing now is that new energy systems may evolve too slowly to avoid greater environmental problems and the social and economic upheavals that could accompany those environmental problems (Flavin, 1990, 49). John Holdren, in his essay "Energy Agenda for the 1990s," says:

> We will need transitions in energy-supply systems and patterns of end use *just to maintain current levels of well-being*; without such transitions, cumulative consumption of high-grade resources and the diminished capacity of the environment to absorb energy's impacts will lead to rising total costs *even at constant rates of use*" (Holdren, 1992, 387, emphasis added).

If we begin to change our patterns of energy use now and move toward a more sustainable and environmentally sound future, we give ourselves and future generations a better opportunity for maintaining a reasonable standard-of-living and overall level of well-being.

The energy transition we face is a result of problems and issues that are very different from the problems and issues of the past. Previously, pollution and hazards from energy were localized in small areas; today, these impacts and the problems that accompany them are regional and global in scope. Previously, energy was an issue dominated by decisions and concerns of the Western world; now, the needs and prospects of all regions on earth are linked (Holdren, 1992, 379). Finally, energy problems in the past were caused largely by industry and solved largely by government regulation; today, the actions and values of every individual matter. University of Vermont ecologist Deane Wang argues that today, the cumulative actions of individuals are the largest determining factor in the fate of our global system (Wang, oral presentation, February 1995). Similarly, a study of environmental and human risks to Vermont concludes that "of the risks that originate in Vermont, most are caused not by a few big factories, municipal landfills, or sewage treatment plants, but by the widely dispersed actions of all Vermonters" (Vt. ANR, *Environment 1991*, 1991, 36). It is not just the actions of institutions that are the biggest problem today -- it is also the actions of individual citizens. Now is the time to take a hard look at how we as individuals consume energy and how our actions are affecting the future

II. OUR FUTURE ENERGY PATH: GOALS FOR VERMONT'S ENERGY USE

Compared to other countries, the U.S. has contributed enormously to global energy problems, including fossil fuel depletion, global warming potential, environmental destruction, and inequitable energy use. U.S. energy use per person is 33 times greater than in India, 13 times greater than in China, 2 ½ times greater than in Japan, and 2 times greater than in Sweden. Heavy energy use in the United States has brought us many benefits, and there are also many explanations for our high consumption (e.g., long travel distances, colder climates, higher concentrations of industry, etc.). However, the fact remains that the U.S. and other developed countries have 25% of the global population, but consume 75% of the energy used worldwide. The U.S. has only 5% of the world population, but creates 25% of global carbon dioxide emissions yearly, more than any other nation (U.S. DOE, *Energy: Our Future is Today*, 1994). The U.S. should take the lead in moving toward a sustainable and environmentally sound energy future not only because of the economic and environmental benefits we will enjoy from doing so, but also because we have contributed to many serious global energy problems; because we have great influence over the sources of the impacts; and because we are able to influence change more easily than other countries with lower standards-of-living and fewer resources.

Vermont can play an important role in leading the U.S. toward a sustainable and environmentally sound energy future. Although Vermont is a small state with a small population, and in 1993 used less total energy than any other state, Vermont can and does act as a powerful model for other states. We have been able to manage development, maintain small town centers, and preserve our natural landscape in ways that other states have only hoped to do. Developing more sustainable and environmentally sound energy resources and consumption patterns would continue Vermont's role as a nationwide leader.

To begin to move toward sustainability and environmental soundness, Vermont must form a vision for where we want to be in the future and a plan for getting there. That process began with the production of the 1991 edition of the *Vermont Comprehensive Energy Plan* and continues with this document's focus on energy efficiency and reducing greenhouse gas emissions. Vermont's Legislature has made an important contribution to our statewide energy vision by writing into state law a number of goals that will guide future energy policy (30 V.S.A. §§202, 202a, and others; see Appendix 2). These policy goals direct the state to meet its energy needs in a manner that is: safe, adequate, reliable, secure, sustainable, environmentally sound, efficient, and affordable, while ensuring economic vitality. These goals, in some cases, will conflict with each other. For example, if we harvested wood for energy at a self-replacing rate, but in doing so disrupted a native wildlife species habitat, the result would be sustainable but not environmentally sound. Our challenge is to find solutions that move toward each energy goal without compromising the standards of the other goals.

Why and how are each of these energy goals important for Vermont's energy future? How can conflicts between goals be resolved? How does our energy use affect our well-being? Vermont citizens must ultimately answer these questions. The following discussion that explores each of Vermont's energy goals is a starting point in that dialogue.

A. Safety

Safe energy sources are those which do not harm people or put them in danger. Most energy sources entail some safety risks when they are acquired or used. Vermont's goal is to minimize those safety risks and move toward a safer energy supply.

1. Air Pollution

Some of the biggest safety risks from energy use come from air pollutants. In Vermont, most air pollution emissions come directly or indirectly from energy use. Airborne contaminants such as carbon monoxide, particulate matter, toxic metals and chemicals, and smog precursors such as nitrogen oxides and volatile organic compounds are released when we burn fossil fuels. Vermont's local air emissions mainly come from boilers, small, dispersed sources such as motor vehicles and home heating, and some manufacturing processes. The state's emissions from electric generation plants are from a few local sources, but are mostly from out-of-state plants. Some of these emissions, such as sulfur oxides emissions from coal plants, have significant impacts on the state and are discussed below. (See the Environmental Soundness section later in this chapter.)

Three serious air pollutants in Vermont are ozone, particulate matter, and toxic chemicals. Motor vehicles and related sources account for between 65%-72% of in-state emissions of ozone precursors (Vt. ANR, *Air Pollution from Motor Vehicles in Vt.*; see also Figures 3.III.25 and 3.III.29). Exposure to elevated levels of ozone causes eye and respiratory ailments and aggravates existing respiratory diseases such as asthma. Woodburning accounted for an estimated 75% of combustion particulate matter emissions in Vermont in 1990 (Vt. Agency of Environmental Conservation, *Vt. State Acid Rain*, 1987; and 1990 information in Vt. ANR's Air Quality Division's database for fuel combustion particulate matter emissions).[i] Particulate pollution causes respiratory damage and can limit the activity of people with respiratory diseases. There are many airborne toxic chemicals from energy use which in high enough concentrations can cause cancers or other negative health effects. However, their ambient levels in Vermont are only beginning to be understood. Automotive and auto-related emissions dominate our statewide emissions of certain cancer-causing toxic pollutants like benzene and I-3 butadiene. Although the state has only recently initiated ambient air measurement of these toxic contaminants, the first six months of data suggest that Vermont's annual Hazard Ambient Air Standards for benzene and I-3 butadiene are exceeded by a factor of two in some small towns and a factor of ten in some more densely populated areas. Preliminary data suggests that arsenic coming primarily from vehicle-related uses may also exceed standards (Vt. ANR, *Environment 1995*, 4). (For more information, see the text box on Air Emissions from Energy Use in Chapter 3.)

Indoor air pollution has become another important safety hazard in recent years. Although energy use does not always cause indoor air pollution, making buildings and houses more airtight and energy-efficient demands greater vigilance to control indoor air pollution. (See the Efficiency section below.) One study estimates that more than 200,000 Vermonters are already exposed to a high-risk level of indoor air pollution, making it one of the most critical human environmental risks in Vermont (Vt. ANR, *Environment 1991*, 1991, 9). One of the most serious indoor air pollutants is carbon monoxide, which results from poor combustion and ventilation of heating systems. Carbon monoxide leakages can cause serious illness and death. Indoor air pollution also includes radon, second-hand tobacco smoke, and formaldehyde and other emissions from building materials and home furnishings, and can cause cancer, as well as heart and respiratory conditions. As Vermont pursues its goal of energy efficiency in buildings and homes, we must also take measures that simultaneously reduce indoor air pollution.

2. Extracting and Transporting Energy

Extracting and transporting materials for energy use also pose a range of safety risks. For example, coal miners risk contracting black lung and other respiratory diseases, uranium miners risk lung cancer, especially in poorly ventilated underground mines, and all miners risk accidents. Workers who process wood for energy uses risk accidents involving trees and machinery. Transporting oil and propane in tanker trucks, railcars, or ships can be dangerous if the vehicles are involved in accidents. Natural gas pipelines sometimes breach, which can cause explosions. Electromagnetic fields associated with electrical wiring and transmission may pose a health hazard; scientific evidence is not currently conclusive on this issue.

3. Nuclear Issues

Nuclear energy development and use raise safety concerns from the radioactivity created by nuclear power plant operation. Exposure to high levels of radiation can cause many acute or chronic illnesses.[ii] Radiation exposure from nuclear energy can occur in a number of ways. Workers at certain stages in the nuclear fuel cycle risk radiation exposure. Another potential source of radiation exposure is nuclear accidents. The types of nuclear accidents that have been analyzed have a very low probability of occurrence in U.S.-designed plants when they are maintained and operated properly, but such accidents could have serious or even catastrophic consequences if they were to occur. The U.S. nuclear industry has practiced what is referred to as a defense-in-depth design philosophy which has resulted in a generally clean nuclear safety record. There has not been a documented death or injury as a result of a U.S. commercial nuclear radiation accident.

Another potential source of radiation exposure is from the relatively small amounts of radiation released into the atmosphere during normal operation. There is an open debate on whether these low levels of radiation exposure cause health problems. Studies of populations chronically exposed to low-level radiation, such as those residing in regions of elevated natural background radiation, have not shown consistent or conclusive evidence of an associated increase in the risk of cancer (National Research Council, 1990, 5).

Radioactive waste products could also be a source of radiation exposure. High-level radioactive waste consists of spent nuclear fuel which remains radioactive for thousands of years, and will thus need to be carefully managed for hundreds of generations. Disposal or long-term management of high-level radioactive waste is legally the responsibility of the federal government. However, great uncertainty exists regarding the costs, timing, and safety of the ultimate disposal of high-level radioactive waste. In 1982, the federal government embarked on a policy for high-level waste disposal and began collecting funds from nuclear electricity customers with the expectation that a disposal facility would be available in 1998. Now, however, the projected completion date is 2015. This lack of reasonable progress leaves doubt whether a disposal facility will ever be completed. High-level waste is currently stored in water-filled pools at reactor sites. Without a disposal facility, utilities are requesting and gaining regulatory approval to move high-level waste into dry storage in concrete and metal casks on the reactor sites. As this occurs at more sites, the concern arises that these dry casks may become the final storage/disposal solutions for a long time into the future. This possibility carries the safety and economic uncertainties of waste stored at 74 separate reactor sites across the country long after the generating facilities have been retired.

Nuclear energy also produces low-level radioactive waste in the form of contaminated metals, filters, resins, and other materials used at nuclear plants. Most low-level radioactive waste decays to safe levels within one hundred years. (See the Nuclear Power section in Chapter 3 for details about disposal of Vermont Yankee's low-level radioactive waste.) Nuclear safety issues will continue to confront the state due to the presence of Vermont Yankee Nuclear Plant in Vernon and Vermont's use of nuclear energy from plants in other New England states.

4. Summary

Safety is the most basic element of our well-being. It is the responsibility of those who oversee all activities related to energy production and use, including government, electric utilities, energy extracting and transport companies, and each individual who uses energy.

B. Adequacy

An adequate energy supply is one that meets the energy needs of Vermont's residents and businesses, both now and in the future as our population and economy grow.

The adequacy of our energy supply depends on how much energy we need. Energy, however, is not used or needed for its own sake. Energy use is important because of what it allows Vermonters to do. People do not use electricity, for example, because it is necessary, pleasurable, or meaningful, but because it allows them to do the activities that they consider necessary, pleasurable, or meaningful. An adequate energy supply provides the energy necessary for our well-being.

In order to have an adequate energy supply, we do not necessarily need more energy, even if our population and economy grow. An adequate energy supply provides us with energy that is sufficient to allow us to do the things we want and need to do. More efficient energy use, for example, can allow us to meet our needs with less energy, enabling the freed-up resources to meet other needs. Efficient light bulbs can provide an equivalent quality of light with one-fifth the energy of conventional lighting (Vt. Residential Lighting Programs Group, 1993, 4). Similarly, for every gallon of oil burned in an efficient home hot water heater, roughly two-and-one-half gallons of oil would have to be burned in an oil-fired electric plant to create the electricity to heat the same amount of water in an electric hot water heater (Faesy, 1993, 29, 1994, Appendix C). (See the Efficiency section below.)

The most important aspect of an adequate energy supply is not the total number of kiloWatt-hours or BTUs available. The real issue is what Vermonters can do with that energy. The goal of an adequate energy supply is really the goal of adequate home and business heating, adequate lighting, adequate transportation, and all the other goods and services that energy makes possible.

C. Reliability

Reliable energy means that consumers experience minimal interruptions in energy supply and minimal impairments in quality.

Any time the demand for energy out-paces the available supply, reliability is compromised. This can occur, for example, when the energy supply is interrupted during an electric power outage or a cutoff of foreign oil. It can also occur when storage facilities, transmission capacities, and transportation capacities are not large enough to meet the energy demand. For instance, a shortage of propane during the peak heating season because of limited storage facilities would compromise the reliability of an important fuel source.

Quality is another important consideration in judging the reliability of an energy source. Automobile travel requires not only an uninterrupted supply of gasoline, but also gasoline free from impurities such as water or dirt. Modern electronic equipment and motors are even more sensitive to problems of quality. Brown-outs, fluctuations in voltage, and interference can damage or negatively affect the performance of such equipment.

The more dependent we are on electricity or other forms of energy to provide the things that enhance our well-being, the more important energy reliability becomes. Since the time when most Vermonters had a woodlot and horses to supply their energy needs, we have become more dependent on energy and more dependent on others to supply energy to us. We rely on energy to do more and more tasks today, including raising and lowering garage doors, washing clothes, and writing letters (using either a computer or typewriter instead of a pen); and we rely on businesses and government to ensure that the energy to do these things is available. That is why this plan includes the goal of assisting businesses and government to meet the responsibility of providing reliable energy to Vermont consumers.

D. Security

A secure energy supply is one that will remain safe, adequate, and reliable into the future, continuing to ensure human well-being. A secure energy supply leaves us confident that our energy needs will continue to be met, even though energy needs and availability cannot be predicted precisely.

1. Diverse Energy Supply

One of the best ways to ensure our confidence in a safe, adequate, and reliable energy future is to maintain a diverse energy supply. Over the long term, a diverse supply gives more options and can most easily be adjusted as circumstances change. In addition to maintaining a diverse mix of energy sources, a secure electric energy supply should include diversity in operating characteristics and the length of supply contracts. Cost-effective energy efficiency investments are another important part of a diverse energy mix because they provide security and flexibility by replacing the need to acquire new energy sources. In addition, efficiency improvements lead to less energy demand, and therefore a reduced chance of an energy shortage.

2. Local and Decentralized Energy Supply

In addition, we can increase security by depending more on local, decentralized energy resources. For example, decreasing our country's current reliance on foreign oil would increase our national energy security. The U.S. purchases about 50% of its oil from other nations, many of which are politically unstable. Our oil dependence is projected to increase in the future because U.S. sources of inexpensive oil are declining. In addition to the political problems of foreign oil dependence, our nation sends $51 billion per year out of the country for oil purchases (U.S. DOE, *Energy: Our Future is Today*, 1994). (See Chapter 3 for the global sources of U.S. oil.) This money would enrich our own nation instead of other nations if our energy sources were more local.

In a similar manner, all of the oil used in Vermont and New England is "imported," whether from overseas or from elsewhere in North America and the U.S. Dollars would stay in Vermont and create new jobs here if the state took more advantage of local energy sources and efficiency options. In the long run Vermonters' future will be more secure if our energy supply enhances the statewide economy; we ensure future jobs and economic stimulation. In addition to the economic advantages, a localized energy supply system can provide more flexibility, diversity, local citizen involvement, and security than a highly centralized system. Energy expert Amory Lovins has reinforced this point.

> How secure are you if you rely on electricity or natural gas and if the nation's energy production and distribution system is so centralized that a dozen or so clever saboteurs could paralyze it? How secure are you if your food is not produced locally but instead must go through complex and vulnerable transportation and processing? How secure is your livelihood if you can lose your job on account of a political revolution halfway around the globe? (Quillen, 1986, 50).

The decision to move toward a more local energy supply can also be justified by considering that the full costs of producing, delivering, and using energy usually are not included in the prices we pay. For example, the price of the U.S. military force that protects our oil interests in the Middle East is not included in the price we pay for oil. (Instead, Americans pay for it through taxes.) In addition, the higher health costs for increased pollution due to increased gasoline combustion are not reflected in our gasoline prices. If such external costs were included in the prices of all energy sources, localized sources that initially appear more expensive but that have fewer external costs may actually be cost-competitive. Taking into account the external costs of the energy sources we use will provide a more secure and sustainable energy future. (See text box on The Full Cost of Energy.)

One way to acquire the security benefits from a more decentralized, local energy supply is to move toward a dispersed electricity generation system. (See Chapter 3, Potential Energy Sources and Technologies for the Future section.) In addition, the country and state can begin to move toward reliance on more local energy sources. Vermont already relies more on energy from wood and small in-state hydro power plants (local, renewable energy sources) than many other states.

3. Nuclear Issues

The ability of nuclear power to play a major part in a secure energy future is open to question because of the long-term safety and financial risks involved. It was once hoped that nuclear power could play a major role in meeting the nation's energy needs due to domestic uranium availability and long refueling cycles. However, while 109 commercial nuclear plants currently operate in the U.S. and in 1994 provided 22% of U.S. electricity needs, many have been plagued with financial, engineering, or public acceptance problems.

In addition, as a result of increased competition in the electric industry, a large capital need in the second half of a plant's licensed operation period could result in a decision to retire the plant rather than incur the capital liability. While the operating performance of nuclear plants is improving, a number of these fundamental problems preclude long-term reliance on nuclear energy beyond current nuclear plant licenses. Uncertainties over radioactive waste disposal and increasing costs of maintaining aging equipment, along with inherent safety concerns, have stopped nuclear plant construction and raised concerns about the long-term viability of existing plants after their current licenses expire. No nuclear plant has yet been relicensed to operate beyond its original 40-year license. However, replacing all baseload nuclear production as licenses expire will be a challenge for the electric industry and the regulatory community.

On an international level, the spread of nuclear technology around the world increases national security risks from the possibility of additional countries and terrorist organizations obtaining the means to manufacture nuclear weapons. In addition, nuclear power plants currently store large amounts of radioactive waste, and thus conceivably could be targeted by terrorists. Although U.S. nuclear plants have substantial security measures in place, the large amounts of radioactive material stored and public fears about radioactivity could make nuclear plants attractive targets. While the likelihood of an attack is small, the consequences could be severe.

4. Sustainability

A secure energy supply also needs to move toward sustainability and greater use of renewable energy sources in order to be secure in the future. (See the Sustainability section below.) With fossil fuels becoming more limited in the decades ahead, sustainability ensures that energy options will still be available in the future.

5. Summary

Moving toward diversification, local energy resources, and sustainability, while moving away from oil dependence, will begin to provide more security for Vermonters in the face of an uncertain future. Continued use of nuclear power may also lead us toward problems in meeting our goal of security unless we prepare for a transition toward other sources as nuclear plants are decommissioned.

E. Sustainability

A sustainable energy supply meets today's energy needs without compromising the ability of future generations to meet their needs or shifting the costs of current energy use to future generations. Sustainable energy does not increase options for the present generation by jeopardizing options for or transferring the costs to future generations. Instead, sustainable energy use is economically, environmentally, and socially viable on a long-term basis.

To ensure that resource use is sustainable, it is not sufficient that the rate of discovery of resources is greater than the rate of use of those resources. There are a number of other important factors that determine whether our consumption of resources is sustainable. These factors include how much of a given resource exists, how long it needs to last, how fast it is consumed, whether or not it is renewable, whether other resources could replace it if it's depleted, and whether the consequences of using it affects the sustainability of other resources.

1. Understanding Sustainability

To better understand how these factors affect sustainability, consider a non-energy example: a retirement-aged couple who have saved money for retirement. They can use their retirement money in sustainable or unsustainable ways. If they use it sustainably, they will be able to meet their needs for the rest of their lives. If they use it unsustainably, they are borrowing from their future and will be unable to meet their future needs. They have a number of options.

They can keep their money under their pillow and spend it at a rate that will last the rest of their lives, which is a sustainable use of their resource. Or, they can use the money unsustainably by spending it at a rate that will exhaust the resource quickly. Alternatively, they can invest the money and turn their retirement capital into a renewable resource by earning interest. They can still spend the money unsustainably by depleting it early and spending their final days in poverty. But they can also choose to live on only the interest, or live on both the interest and a portion of the capital, depleting the capital at a rate that should last the rest of their lives. These are both sustainable uses of their resource.

Like this retirement-aged couple, human society can also choose to use resources sustainably or unsustainably. Our use of natural resources or natural capital is analogous to the couple's use of their retirement capital. However unlike the couple, humans cannot name a time beyond which we don't expect to exist. Life on earth is at least 3.4 billion years old, and *Homo sapiens* are at least 50,000 years old (Gould, 1980, 217; Hoffman, 1990, 489). Humans have been around for a very long time and hope to continue to exist for an even longer time. In order to live sustainably, we must act as if humans will exist far into the future, and therefore "draw down" or deplete natural capital at a very slow rate.

2. Non-renewable and Renewable Resources

Using non-renewable resources (such as coal, oil, uranium, aluminum, iron, etc.) is similar to the couple spending money that is kept under their pillow. We have a limited amount of the resource and if we want to consume it sustainably, we must draw it down very slowly or find a way to recycle it so that our use does not limit the ability of future generations to use it. Uranium and fossil fuels represent the most important energy-related non-renewable resources, and as such, they must be depleted very slowly for their use to be sustainable.

Using a renewable resource, on the other hand, is similar to the couple spending their money while it's invested and earning interest. To use renewable resources sustainably, we must live off the "interest" and not the "capital." That means when we use a resource such as wood, we do not draw it down at a rate or in a manner that reduces the environment's ability to provide wood in the future or that is inconsistent with its continued use.

Energy resources are unique because they are "fungible" or interchangeable; that is, renewable and non-renewable resources can both provide similar energy services. For example, automobiles can be built to use gasoline, propane, natural gas, alcohol, or electricity (which, itself, may be generated from renewable or non-renewable fuels). Not all fuel use is equally sustainable, however. Therefore, we need to select those fuels and methods of use that are most sustainable. In the marketplace, there is a tendency, all other things being equal, to choose fuels which have the lowest price, but low prices do not ensure that this use is sustainable or the least expensive when all external costs are included. (See the text box on The Full Cost of Energy.)

3. Energy and Use of Energy

When it comes to determining sustainable energy use, the laws of physics give us more guidance than market prices. Energy and use of energy are governed by physical laws. The most important laws for sustainability are the laws of thermodynamics: energy cannot be created or destroyed, and work cannot be done without decreasing the usable energy of the system. The earth's energy resources combined with these laws determine the earth's energy budget, and from that we can determine the amount of energy that can be used sustainably. There are several sources of energy that the earth stores or receives (including thermal, mechanical, gravitational, chemical, nuclear, and solar radiation), but nuclear energy and the sun's energy play the largest part in our energy use situation.

The sun's energy is ultimately responsible for most of the energy we currently use. Solar energy can be used directly for heating and lighting. It can also be captured indirectly through wind and biomass sources such as wood. Windmills indirectly capture the sun's energy; they harness wind energy due to variations in the temperature and pressure caused by the sun's heating of the earth. Burning biomass sources releases the sun's energy which had been stored as chemical energy in vegetation by the process of photosynthesis. Solar energy can be captured even more indirectly by burning fossil fuels. Under the right conditions and over large amounts of time, decaying vegetation (which originally received its energy from the sun and photosynthesis) can change into fossil fuels such as coal, oil, and natural gas.

We now rely primarily on extracting the energy from these fossil sources, which represent the most indirect forms of solar energy. Fossil fuels are, in some sense, renewable resources (since they are still being created), but they are effectively non-renewable due to the extensive time required to produce them. Given our current consumption of fossil fuels and projected growth rate, estimates of the known and possible supply of these resources vary from about 50 to 100 years or more into the future. (See below for more information about oil. Chapter 3 includes information on future supplies of other fossil fuels.) Within a few generations, we will have consumed most of the fossil fuel capital that is currently economical to recover.

Alternatively, we could more directly consume the incoming solar energy instead of the stored energy in fossil fuels. The most direct way to do this is to utilize the sun's light and heat as they are received. In addition, wind energy can be captured where available, and biomass can be used to the rate of regrowth of those resources. The more indirect the path from solar energy to human use, the more energy is lost. Therefore, one important way to increase the sustainability of our energy use is to seek to use more direct sources of solar energy. The rate of sustainable energy use for more direct sources of solar energy such as wind, photovoltaics, and biomass is much greater than the rate of sustainable energy use for fossil fuels.

However, even if we do not use fossil fuels sustainably and seriously deplete them, new technologies and other resources could conceivably be used to meet future energy needs. In this scenario, fossil fuels may not be needed by future generations, our consumption of fossil fuels may not place further burdens upon them, and therefore we may have no obligation to leave any fossil fuels for them. However, this is a controversial claim based upon a number of uncertain suppositions about the future. It is probably best to err on the side of caution and assume that future generations would suffer from the lack of fossil fuels; if they do not need fossil fuels for energy, there is a good chance they may need them for other uses, such as the manufacture of chemicals and plastics.

4. Biological Consequences of Energy Use

Even if alternative energy resources and technologies were found for the future, our current use of fossil fuels still would not be sustainable because of its impact on biological resources. Biological resources are strongly affected by fossil fuel energy use. For instance, acid rain resulting from electricity generation, and global climate change resulting from fossil fuel use have serious biological consequences. There are many other pollutants from energy use that affect the environment. (See the Environmental Soundness section below.) Important biological resources such as land, water, air, and living organisms provide food, water, oxygen, shelter, and energy for human beings. It is possible to live off the natural increase of those biological resources (the "interest" that resources "earn") without depleting them or the environment's ability to provide them in the future. It is equally possible, however, for our energy acquisition and use to reduce "biological capital," or air, water, rivers, lakes, soil, forests, and species that are healthy and have the ability to regenerate themselves and remain healthy indefinitely. Drawing down our biological capital due to pollution or global warming places serious costs and burdens on future generations.

5. Energy and Biological Impacts: An Example

To ensure that our energy use is sustainable, we must take into account its impacts on both energy resources and biological resources.[iii] For example, consider the energy and biological impacts of just one fossil fuel: oil. The U.S. Geological Survey estimates that the world possessed 2.3 trillion barrels of oil before humans started to use it (called "world ultimate resources"). We have already consumed about 0.7 trillion barrels; estimates of the world's proven reserves of crude oil vary from 0.996 to 1.092 trillion barrels, and there are an estimated 0.6 trillion barrels yet to be discovered or made recoverable by emerging technologies.[iv] At the projected rate of growth in consumption, the proven reserves should last 32 years from 1995; the oil left to be discovered should last a further 11 years. In addition, there are substitutes that can replace oil. There are at least an equivalent of 0.6 trillion barrels of oil in tar sands, which would extend our oil supply for a further 11 years (though financial and environmental costs could be very high for developing these resources). (See Chapter 3, Petroleum Products section, for more information about the above calculations.) Coal could also be substituted for oil for an even greater period of time (Greene, *The Cost of Transportation's Oil Dependence*, 1995, 2).

Given the world's supply of oil, our current rate of use and growth of oil consumption cannot be considered sustainable for time-frames greater than the lifetimes of those alive today. Even if future generations do not need oil or if estimates of oil resources turn out to be exceedingly low, our current use of oil is unsustainable because of its impacts on biological resources. Burning all the world's oil, including tar sands (about 3 trillion barrels), would release 1,427 billion tons of carbon dioxide into the atmosphere, compared to the pre-industrial atmospheric carbon dioxide level of 2,200 billion tons. These emissions, combined with carbon dioxide emissions from other fossil fuels, have significant consequences for earth's climate and living organisms that must adapt to the changing climates. Burning the remaining proven coal reserves, for example, would release an additional 2,500 billion tons of carbon dioxide. In addition, there are other consequences to human and environmental health from burning these amounts of oil and/or coal. (See the Environmental Soundness section below.)

Current oil use is unsustainable because it is not viable on a long-term basis. Its use depletes resources that future generations will most likely need, and the consequences of burning the supplies of fossil fuels will add to levels of carbon dioxide in the atmosphere, forcing future generations to suffer climatic changes because of our energy use. The effect of these changes on the environment will almost certainly reduce the ability of future generations to meet their needs.

Just as oil use has impacts on energy and biological resources, all fossil fuel use has similar impacts. For example, while the supply of coal is much greater than that of oil (world proven reserves of coal should last 96 years from 1995 given the current growth rate in worldwide use), its biological impacts are also much greater. (See Chapter 3, Electricity from Coal section for details on how the coal supply was calculated.) The biological impacts of natural gas use are much lower than both coal and oil.

The failure of markets to include external costs in the prices of energy distorts the choices of policy-makers and consumers. If the full cost of energy use were included in prices, less energy and cleaner energy would be consumed, with less harm to present and future generations and the environment, and more savings in labor, capital investment, and present and future health and environmental costs. Market forces would ensure that cleaner energy sources with less associated costs to society would eventually displace more expensive and dirtier fuels. The advantages of renewable energy sources would become more obvious as these sources became more affordable compared to other sources.

External costs can be "internalized" into the prices of energy in several ways, including through taxes, regulations on emissions or other consequences of energy use, and efficiency standards on appliances, equipment, or buildings. (See Chapter 3 for more on external costs.)

mercury and lead contamination of lakes and fish; and perhaps one of the riskiest and most unknown external costs, the unknown climate change effects from placing carbon dioxide into the atmosphere by burning fossil fuels.

Nuclear energy has its own unique impacts on energy and biological resources. The highly radioactive waste and tailings pose a threat to biological resources and place a burden on future generations for very long time-frames. (See Environmental Soundness, Security, and Safety sections below, and Chapter 3, Nuclear Power.)

From the above analysis, the shortcomings of other criteria for sustainability become apparent. One inadequate criterion of sustainability that has been suggested is that the rate of discovery of a resource be greater than the rate of use. This criterion is inadequate because the current practice of extracting the cheapest resources first places greater financial burdens on future users, who must extract the more expensive oil for their energy needs. Also, as discoveries of the limited resources decline, future generations will have progressively fewer resources to use. And finally, sustainability cannot ignore the biological consequences of fossil fuel use.

6. Conclusion

Certain broad general conclusions about sustainability can be drawn from the above discussion. First, in order to achieve more sustainable energy use, we will need to decrease our dependence on fossil fuels and increase our dependence on renewable resources such as wind, solar, hydro, wood, and others. Renewable resources are not environmentally neutral, but when used sustainably, they do not create impacts on the environment that are inconsistent with continued human use. Second, in order not to pass the burden of our energy use on to future generations, we will need to ensure that energy choices and prices reflect the full cost of energy use. In this way, external costs will not be borne by people who are not yet born. External costs subsidize the unsustainable use of energy. People making energy decisions in the marketplace would use energy less wastefully and in a less costly manner if they paid the full cost of energy use themselves. (See text box on The Full Cost of Energy.)

Third, a sustainable energy supply that relies on renewables and incorporates the full costs of energy acquisition and use will be possible only if energy efficiency is vastly improved. Future energy sources, including renewables, are not likely to be as cheap as oil and other fossil fuels have been. Thus, efficiency is important to keep energy prices affordable. If we improve efficiency, we will not need to sacrifice the benefits of energy use to achieve sustainability. Energy efficiency can be improved by employing more direct uses of solar energy. For example, using passive solar applications for heating and lighting is much more efficient than using the solar energy captured in wood to heat a home or to generate electricity for those purposes. Similarly, burning wood is much more efficient than using the solar energy captured in fossil fuels. Energy efficiency can also be improved by using technologies that increase the efficiency of energy-using devices. (See Chapter 3.)

To make a sustainable energy supply work, we must take a broader, more long-term view than has been taken in the past. Sustainability focuses on the basic needs and well-being of every person in every community far into the future rather than on only some individuals' current choices. For sustainability to be successful, a global, long-term, community-wide ethic and set of values must be developed and followed.

The barriers to moving toward a truly sustainable energy supply and economy are many. Nevertheless, we must begin to move in that direction right away. The pressures of the future and our children’s well-being demand it.

F. Environmental Soundness

An environmentally sound energy supply is one that avoids or minimizes environmental degradation. All forms of energy production and use have some negative effects on the environment. An environmentally sound energy supply is one that minimizes those negative effects through all stages of production and use while remaining consistent with Vermont's other energy goals.

At each stage in the chain from resource identification to final energy use, costs and risks are posed to natural ecosystems and human well-being. These costs and risks are local, regional, and global in character, and can be short-lived or very long-term. They vary substantially between different energy resources and different types of production and use.

Environmental costs and risks associated with energy use can occur at considerable distance from the activities which cause them and may not show up for many years. For example, the acid rain and snow that damages Vermont’s forests and waterways can be traced to coal-fired power stations in Midwestern states. Similarly, the high-level radioactive waste (i.e., spent fuel) generated by nuclear plants will eventually be stored at a remote site and will remain dangerous for tens-of-thousands of years. In the case of emissions of carbon dioxide and other greenhouse gases, there is a serious risk that, as a result of the accumulated effect of human activities worldwide, the planet will warm during the next half-century.

In planning its energy future, Vermont needs to consider regional and global costs and risks to the environment as well as local ones. Ultimately, problems like global warming and acid rain can only be solved through cooperative national and international action, but many of the key adjustments will have to be made at the state and local levels. Because Vermont is affected by out-of-state environmental pollution (for example, acid rain and ozone), we have a strong incentive to lead the way in developing energy policies which properly account for environmental risks.

Currently, individuals who enjoy the benefits derived from energy use often do not bear all the environmental costs associated with that use. These costs are shifted through environmental damage and depletion onto other members of society and future generations. Two strategies can be employed to reduce the environmental costs and risks associated with energy production and use. The first is to reflect the full costs of energy (and not just the costs of production and distribution) in the price of energy. Energy choices would be significantly different if users had to pay directly for the environmental damage their choices cause. (See text box on The Full Cost of Energy Use.) The second strategy is to manage our exposure to environmental risks. This requires identifying risks associated with energy use (as is done briefly in following sections) and seeking to control and manage those risks. Means employed to manage risks include the following: careful planning to reduce risks; extensive preparation for handling accidents or problems if they occur; research to find ways to avoid risks; diversification of energy sources to limit exposure to any one risk; emphasis on conservation and efficiency to reduce risks by minimizing energy use; and strict environmental controls and regulations to limit risks and damage from energy use. If public policy and prices better accounted for the relative environmental costs and risks posed by different sources and technologies, the pattern of energy use would change. This reduction in energy use would contribute significantly to efforts to make Vermont's energy acquisition and use more environmentally sound.

Energy production and use incurs many environmental costs and risks. The categories below represent some of the most important potential environmental problems that Vermont should consider carefully in its energy planning.

1. Global Climate Change

The potential of global climate change continues to be one of the most threatening, long-term, high-risk problems caused by energy use. (See text box on What is Global Climate Change?) Unfortunately, many of the effects of global climate change are still unknown, and are likely to remain unknown until it is too late to mount effective mitigation strategies if they are harmful. Some scientists now believe that environmental change to the global system may not occur gradually, but instead, change may occur with little warning in a more sudden manner.

The U.S. government has set some recent goals to address climate change issues. In 1993, President Clinton issued a *Climate Change Action Plan* and set the goal of reducing greenhouse gas emissions to 1990 levels by the year 2000. Vermont has had similar but stronger goals since 1989. It is imperative that Vermont and the entire U.S. move quickly toward these goals and continue to address these issues.

Producing and using energy accounted for 89% of U.S. greenhouse gas emissions in 1990. On a per capita basis, the average American is responsible for putting nearly six tons of carbon dioxide emissions into the atmosphere annually from normal energy use, the largest amount of any industrial country (Shapiro, 1992, 142-3). The main sources of those greenhouse gas emissions are fossil fuels, which release carbon dioxide and nitrous oxide into the atmosphere. Of the fossil fuels, coal produces more greenhouse gases per unit of energy than oil or gasoline. Natural gas produces less carbon dioxide per unit than either coal or oil. Solar power, wind power, hydro power, nuclear power and, of course, energy conservation do not significantly contribute to global warming.
Fuelwood and other sources of biomass release carbon dioxide into the atmosphere like other fossil fuels, but

these emissions do not come from "fossil carbon." Fossil carbon is the carbon stored in fossil fuels that has been removed from the atmospheric carbon cycle and stored deep within the earth for tens of thousands of years. The carbon dioxide released from biomass sources, by contrast, comes from carbon that is already a part of the atmospheric carbon cycle. Furthermore, if biomass resources are used in a sustainable manner, their emissions of carbon dioxide are less than or equal to the carbon dioxide taken in by new biomass growth, and their use eliminates the fossil carbon emissions from the fossil sources they replace. Therefore, sustainable use of biomass for energy affects the global climate positively, not negatively. Currently, however, wood resources often are not used sustainably, and as a result, deforestation greatly contributes to greenhouse gas emissions on a global scale. The woodlands of the eastern United States are one of only four places in the world where more wood is growing than is being cut; all other forests are being unsustainably consumed faster than they can regenerate (Morgan, 1994, 35).

Roughly 87% of the greenhouse gas emissions associated with energy use and production in Vermont come from the combustion of fossil fuels. Of the carbon dioxide released into the atmosphere, 47% comes from transportation use and another 20% from the residential sector, with the remainder in the utility, commercial, and industrial sectors (Vt. DPS, *Vt. Greenhouse Gas Emissions Estimates*, 1994, 8, 19).

2. Acid Precipitation

A serious environmental risk for Vermont is the threat of damage to the state's lakes, streams, and forests from acid rain and snow. Vermont's precipitation is, on average, always slightly acidic; acid precipitation is a greater problem in Vermont and the Northeast as a region compared to many other parts of the country.

The combustion of fossil fuels produces sulfur oxides and nitrogen oxides emissions. These emissions react with the water molecules in the atmosphere to form sulfuric and nitric acid, which increase the acidity of the rain, snow, fog, and water that is deposited on the New England countryside. The acidity in Vermont's precipitation is composed of about 2/3 sulfuric acid and 1/3 nitric acid. The emissions that cause acid rain, particularly sulfur dioxide and sulfate particles, remain in the atmosphere for up to ten days after they are emitted and can be carried more than 600 miles before they are deposited. Coal power plants in Midwestern states are a major contributor to acid deposition in the Northeastern U.S. and Canada. Other New England sources include motor vehicles and industry. On a national basis, about two-thirds of U.S. sulfur dioxide emissions are from electric utility plants and the rest are from vehicles and industry. These three sources each account for around one-third of nitrogen dioxide emissions.

Acid precipitation can cause the acidification of lakes and streams, which alters natural ecosystems and sometimes causes local extinctions of fish and other aquatic species. Waterways vary in their sensitivity to acidification; some are protected naturally by alkaline soils, while others are not. However, studies indicate that 102 lakes in Vermont are susceptible to acid damage (according to an alkalinity classification), and a further six, all in the southern Green Mountains, are already critically acidified.

The effects of acid rain, snow, and gas on terrestrial ecosystems are less well understood and remain a matter of considerable scientific debate. In parts of northern Europe, acid rain appears to be one of a range of stress factors causing widespread forest decline. In North America there is less evidence of damage, although scientists generally agree that red spruce at higher elevations suffer growth reductions because of acid deposition. At higher elevations in the southern Green Mountains and elsewhere in Vermont, red spruce have been dying at an alarming rate, and acid deposition and other air pollutants appear to be a contributing factor (Vt. ANR, personal communication, 1995).

Except for CFCs, greenhouse gases are naturally occurring and have helped make our planet a warm and habitable environment. However, human-caused activities have substantially increased the levels of greenhouse gases since the Industrial Age. The Intergovernmental Panel on Climate Change (IPCC), a working group of the world's top climate scientists, concluded in a 1995 draft report that the observed increase in global mean temperature of 0.3-0.6 degrees Celsius over the last century is "unlikely to be entirely due to natural causes" and that a "pattern of climatic response to human activities is identifiable in the climatological record" (IPCC, 1995, cited in Brown, *State of the World*, 1996). Other evidence that the global climate system is already changing is mounting. Recent developments and research, such as the breaking off of a large part of the southern polar ice cap, the warming of Siberia, extreme winter weather in northern Europe, the recession of glaciers, rising sea levels (measured by satellite radar), and a measured shift in the timing of seasons all point to the conclusion that changes in the atmospheric chemistry are becoming recognizable (Brown, 1996, 23).

The IPCC projects that the global mean temperature will increase by 0.8-3.5 degrees Celsius by 2100 if current growth trends continue and if no climate change policies are enacted. These increases project changes more rapid than any experienced in the last 10,000 years. Global warming of this magnitude and rate would substantially alter the earth's climate and produce unpredictable effects in local temperature ranges, precipitation patterns, sea level, and the incidence of extreme weather events such as floods,

Acid deposition also accelerates the rate of corrosion of buildings and other human-made structures, and can damage historic and artistic materials. Vermont established a program of monitoring acid precipitation and waterway acidification in 1979, one of the first such monitoring programs in the country. Subsequently the National Acid Precipitation Assessment Program was established and now supports continued research and monitoring in Vermont and other affected states. Controlling acid precipitation is one of the main objectives of the 1990 federal Clean Air Act Amendments. The legislation includes provisions that will reduce levels of sulfur dioxide emissions from 23.21 million tons in 1990 to about 13 million tons, and will reduce electric utility emissions by more than 50%. The Clean Air Act Amendments will also reduce levels of nitrogen oxide emissions from 26.31 million tons in 1990 to about 24 million tons. Because sulfur dioxide emissions are reduced to a greater extent than nitrogen oxide emissions, in the future nitrogen oxide emissions will become increasingly important to address as a contributor to acid rain and ozone pollution. Electric utility plants nationwide account for one-third of nitrogen oxide emissions (Heede, 1995, viii).

Vermonters currently use very little coal in-state (the largest source of sulfur dioxide).[v] In-state emissions of acid rain precursors therefore primarily come from petroleum products used in transportation, the residential sector, and industry. Of the electric energy choices available for the future, only energy conservation and renewable sources such as solar and wind make no contribution to acid deposition. Burning natural gas or biomass does not emit sulfur dioxide in significant amounts, but it does emit nitrogen oxides.

droughts, fires, and heat outbreaks. Climate change could drastically affect agriculture and forestry, coastal communities, water resources, urban infrastructure, recreational options, and many other aspects of life and society. In some parts of the world, including Bangladesh, Egypt, and various Pacific Island nations, most people live and grow food within just a few meters of sea level. Risks from global warming are very high in these regions because of the possibility of melting ice and snow from the polar ice caps, which would raise the level of our oceans. The risk for natural ecosystems is also great, because many species would likely have difficulty adapting to rapid change. Heavy costs would be incurred by future generations to cope with such a quickly changing climate. The IPCC draft report cited above concludes that "projected changes in climate are likely to result in a wide range of human health impacts, most of them adverse, and many of which would reduce life expectancy."

Our understanding of climate systems is not sufficient to provide detailed local predictions of the effects of global warming. However, climate modelers generally agree that in northern locations such as Vermont, significantly warmer winters would be likely (U.S. Congress, OTA, 1991, 51). There is considerable uncertainty about changes in rainfall patterns, but the prospect of reduced water availability must be considered. Other regional resources that are vulnerable to changes in temperature and precipitation include the state's forests, agriculture, wildlife, and recreation opportunities.

There is great danger in waiting for conclusive evidence about the exact timing and effects of global climate change, because greenhouse gases in the atmosphere have very long lifetimes (120 years for carbon dioxide, 132 years for nitrous oxide). The cumulative effects of these gases over time could commit the earth to substantial changes that could take centuries to reverse (U.S. EPA, 1992, ix). Enacting effective greenhouse gas reduction policies immediately is essential to avoid this threat. (For more about global climate change issues, see Chapter 3, Recent Planning Efforts and Legislation, and Appendix 6 - Greenhouse Gas Emissions from Non-Energy Sources.)

3. Air Pollution

Energy use contributes to other atmospheric hazards besides global warming and acid deposition. In Vermont most air pollution emissions result directly or indirectly from energy use. Airborne contaminants such as carbon monoxide, particulate matter, toxic chemicals, and the precursors of low-altitude ozone such as nitrogen oxides and volatile organic compounds are released by burning fossil fuels and wood. Vermont's energy-related emissions of these contaminants are mainly from small dispersed sources such as commercial furnaces and boilers, motor vehicles, and home heating.

On a per-capita basis, Vermont's emissions of the major air pollutants are similar to other states. However, because of their dispersed nature and favorable meteorological conditions, overall levels of locally-generated pollutants are comparatively low. Wind-borne pollutants from high-emitting areas outside Vermont elevate the levels of longer-lived pollutants like ozone and certain toxic chemicals.

Three serious air pollutants in Vermont are ozone, particulate matter, and toxic chemicals. Ozone damages sensitive plant species and is believed to reduce growth and change the structure of the major forest types found in Vermont. Ozone probably contributes to the decline of high elevation spruce-fir forests. Although our ozone levels are lower than in some adjacent areas of the U.S. and Canada, Vermont comes close to exceeding national ambient standards for ozone each summer, and frequently exceeds levels considered unhealthy in other developed countries (Vt. ANR, *Strategic Plan*, 1995, 4). Motor vehicles and other mobile sources account for between 65%-72% of in-state emissions of ozone precursors (Vt. ANR, *Air Pollution from Motor Vehicles in Vt.*; see also Figures 3.III.25 and 3.III.29). Woodburning accounted for roughly 75% of the combustion particulate matter emissions in Vermont in 1990 (Vt. Agency of Environmental Conservation, *Vt. State Acid Rain*, 1987; and 1990 information in Vt. ANR's Air Quality Division's database for fuel combustion.) Woodburning in older wood stoves causes most of the particulate emissions. Nationwide EPA standards now in place for new wood stoves allow only small amounts of particulate emissions. New, efficient woodburning systems such as those used in Vermont schools also have devices to collect particulates.

Particulate matter emissions lead to impaired visibility and negative health effects. There are hundreds of airborne toxic chemicals which in high enough concentrations can threaten animals that eat aquatic organisms and sensitive plants. Important sources of toxins include gasoline and combustion of both fossil fuels and wood. (There are also numerous human health problems resulting from pollutants. See the Safety section above, and the text box on Air Emissions from Energy Use.)

4. Water Resources

The development and use of fossil fuels poses risks to water resources and marine life at various points along the chain from extraction to end use. Some of the more common problems include surface water discharges from mines, leachate contamination of groundwater from coal waste landfills, marine oil spills, increased nitrogen levels from atmospheric deposition, and contamination from acid rain. There is also a growing concern about potential contributions of atmospheric mercury depositions to mercury contamination of Vermont's surface waters and aquatic organisms. A preliminary report by EPA estimates that about 253 tons of mercury are emitted into the air per year in the U.S. from anthropogenic sources. Eighty-five percent of these emissions come from combustion sources, and of the combustion sources, utilities account for 24% (almost all from coal emissions), municipal waste incinerators account for 29%, medical waste incinerators account for 30%, and commercial and industrial boilers account for 14% (U.S. EPA, *Mercury Study Report*, 1995).

Nuclear energy also poses risks such as the release of contaminants from uranium tailings and radioactive emissions from other fuel cycle facilities, as well as, in the long-term, the escape of radionuclides into the groundwater biosphere from radioactive waste disposal. Both nuclear and fossil fuel power stations make thermal discharges from their cooling systems, potentially affecting habitats downstream. Finally, hydroelectric power use significantly alters river and stream ecosystems. See the Natural Ecosystems and Wildlife section below, and the Hydroelectric Power section in Chapter 3.

5. Land Use

Facilities related to energy use and production can degrade land resources through physical disturbance and contamination. In Vermont, land is used for a wide range of energy-related purposes including transmission and distribution lines, substations, gas pipelines, highways and parking lots, fuel storage, and electrical generation.

Different sorts of land impacts are associated with different technologies. Hydroelectric projects can flood extensive tracts of land and modify recreation options. The mining of coal and uranium to fuel power stations damages land through direct disturbance and the generation of large volumes of mine wastes. Wind, solar, and fuel wood energy systems may utilize significant areas of land and, as a result, may have impacts on ecosystem balances which should be minimized.

Land-use development and energy consumption are tightly related. A highly dispersed pattern of land use is wasteful of both land and energy resources. Locating jobs, residences, and other facilities in growth centers which can be served by mass transit and carpools can reduce the consumption of gasoline, the need for additional highways and parking lots, and the need for new infrastructure, including electric transmission lines. Vermont's Comprehensive Planning Law (Act 200) can contribute to better land use and more energy efficient development. (See the Chapter 3 section on Act 200 and state, regional, and municipal planning.)

6. Natural Ecosystems and Wildlife

The use of fossil fuels poses risks to natural ecosystems and wildlife by contributing to acid deposition and global warming. Large-scale tree cropping for fuelwood must be properly managed or it can diminish wildlife populations or cause erosion and stream siltation. Large-scale wind systems also have the potential to adversely affect wildlife and ecosystems. If poorly situated, transmission lines, roads, pipelines and other energy related facilities can damage sensitive ecosystems such as wetlands or uninterrupted forests.

Large- and small-scale hydroelectric schemes significantly alter natural ecosystems and can reduce populations of fish, bird, and other wildlife species. Hydro projects can damage ecosystems by reducing dissolved oxygen, causing erosion, changing water levels, obstructing fish movements, and affecting birds' and mammals' habits. (See Hydroelectric Power in Chapter 3.)

7. Recreation and Scenic Landscapes

Energy use affects both recreation opportunities and Vermont's scenic character. Outdoor recreation opportunities are often influenced by energy production activities that alter land, water, scenic, and wildlife resources. For example, large-scale hydro projects commonly threaten wild rivers and backcountry used for wilderness recreation. Such projects can also reduce populations of migratory species important to hunters and wildlife observers. The non-sustainable use of forests for fuelwood production can diminish their value as a tourist and recreation resource. Finally, air pollution from fossil fuels causes visibility impairment. Emissions from sulfur dioxide and other pollutants reduce visibility in Vermont in the summertime by as much as 66% compared to unpolluted levels (Vt. ANR, 1991, 23). Visibility impairment, as well as acid damage to lakes and forests, affects scenic views and recreation in the mountains.

There are sometimes positive recreation benefits from energy-related facilities. For example, hydro dam releases benefit white-water canoers, and gas pipeline and electric transmission line right-of-ways benefit snow-mobilers.

The state's scenic landscapes can also be affected by energy-related facilities and activities. Vermont's scenic character is defined by traditional townscapes and rural landscapes; many Vermonters are proud of this character and benefit from the tourism it attracts. Energy-related facilities such as transmission lines, smokestacks, pipelines, windmills, and highways can significantly change the aesthetic character of these landscapes. Construction activities associated with energy use can also have a major impact on the aesthetics of neighborhoods for extended periods. While many of these energy facilities and activities are necessary for Vermonters' well-being, we can mitigate negative impacts by using less energy and thus reducing the need for new facilities.

8. Nuclear Issues

Radioactive waste disposal and the possibility of large-scale accidents are serious environmental concerns associated with nuclear power. If not properly managed, nuclear power plants are a potential source of ionizing radiation that can be released to the environment. High doses of ionizing radiation have the potential of damaging cellular material in both human beings and the biotic community.

Spent nuclear fuel must be isolated from the biosphere for many thousands of years. Satisfactory technology has not been demonstrated for this, and indefinite storage poses uncertainties regarding the ability of institutions to safely manage dangerous material for thousands of years. By the year 2000, Vermont Yankee Nuclear Plant will have generated 184 cubic meters (6,499 cubic feet) of spent nuclear fuel. The spent fuel which has been generated so far is being temporarily stored on-site and requires constant monitoring and mechanical water cooling. Congress has repeatedly extended deadlines for the establishment of a high-level waste repository to store commercial spent fuel. Low-level radioactive waste is a less dangerous threat to the environment and humans than high-level waste, but it must be similarly disposed of in a manner which isolates it from humans and the environment for many years.

Radioactive waste disposal (or indefinite storage) has the effect of removing portions of land from use by humankind effectively forever. In addition, radioactive waste disposal poses the threat for hundreds and thousands of years to come that small amounts of long-lived nuclear products will find their way into the biosphere, primarily into groundwater.

The other major concern regarding nuclear power plants is the possibility of accidents that release radiation. Although these risks from an accident are large, the probability in the U.S. is relatively small. U.S. nuclear plants have had engineering breakdowns, emergency shutdowns, latent design flaws, and personnel errors, but no documented fatalities have occurred.

9. Summary

Environmental risks are associated with all energy sources and technologies. Later sections of this plan will discuss measures aimed at ensuring that these risks are better reflected in the energy choices of individuals, businesses, and government. Global warming is a problem that stands out as demanding special attention because of its global nature and potential for changes to ecosystems. Thus, later sections of this plan will focus on solutions Vermont can take to lessen the threats of global warming.

G. Efficiency

Efficient energy production, delivery, and use minimizes waste and therefore requires fewer resources. Energy efficiency does not reduce comfort or convenience, but instead meets the same needs with less energy and environmental damage.

Efficiency measures usually involve technical solutions that improve the working of objects or systems. For example, building a more fuel-efficient car and keeping car tires properly inflated for better gas mileage are two efficiency measures. There are a host of others. Some include: efficient light bulbs, ceiling insulation, insulated water heaters, double-glazed windows that reduce heat loss, and computers and photocopying machines that shut down when not in use. There are also many efficiency measures that power plants can implement.

For instance, cogenerating power systems not only create electricity, but also capture and use waste heat for more electricity or for other purposes. Re-engineering existing power plants can improve their efficiency, reducing the amount of energy wasted in power generation.

Recycling is an energy efficiency measure because it recaptures some of the embedded energy in products. For example, all the energy it takes to create an aluminum can, including mining, transporting, and processing, represents the embedded energy in that can. When we recycle the can, the embedded energy is not buried in the landfill, but instead is reused when the can is made into a new product. Recycling uses energy, but not as much energy as creating products from raw materials. Reusing products is an even better way to recapture embedded energy than recycling because it uses no energy.

Energy efficiency projects and programs can eliminate the need for a new power plant by decreasing demand for energy without decreasing what that energy can do for us. Thus, efficiency measures can be some of the most cost-effective ways to fill our current and growing energy needs. In fact, there is a huge potential still untapped in energy efficiency gains. If that potential were actualized, much of our need for new energy would be eliminated. A study by the Alliance to Save Energy (quoted by the U.S. DOE) estimates that the U.S. could reduce primary energy demand by at least 20% by implementing only those efficiency investment opportunities with a payback of five years or less (U.S. DOE, *Energy: Our Future is Today*, 1994).

Making energy use more efficient is a strategy that benefits everyone. Efficiency measures reduce energy costs, enhance environmental quality, improve security and sustainability, and enhance economic vitality.

H. Affordability

Affordable energy meets consumers' energy needs in an adequate manner at the least total cost to society, giving special consideration to low-income groups. For low-income groups, energy affordability means that individuals' energy needs are met adequately without compromising on other basic needs. Indicators for affordability used in policy assessments in Chapters 4 and 5 include: average income per household after energy costs and average residential energy expenditure as a percent of low income wage.

Affordable energy prices meet needs at the least cost to society, but "affordable" prices are not always synonymous with "cheap" prices. The price of energy is relatively low in the U.S., but there is good reason to believe that this will not always be the case. In many cases, energy remains "cheap" because environmental, social, and other costs are not included in its price. Maintaining such artificially low energy prices is not a sustainable policy in the long run, because it encourages current generations to use more resources than they might use if they were paying the full costs. The consequences of this approach are to leave financial burdens and scarcer energy resources for future generations. Artificially low energy prices therefore do not provide energy at the least total cost to society, when "costs" include environmental and social effects as well as monetary ones, and when the time-frame is long-term. (See text box on The Full Cost of Energy Use, and Current and Future Issues in Energy Use in Chapter 3.)

However, raising the price of energy to account for all costs would negatively affect consumers and businesses, especially those in low-income groups. One solution to this problem is to increase the price of energy to include all costs, and simultaneously invest the funds collected in efficiency so that consumers don't need as much energy. In this way, the unit price of energy would rise, but efficiency measures would help to reduce consumers' total energy bill. (Least-cost planning for utilities seeks to use efficiency measures whenever they are more cost-effective than new energy supplies. See Utility Efficiency Programs in Chapter 3.) Investing in efficiency can be done in many ways. For instance, installing ten energy efficient light bulbs in a typical single-family home can save $41 a year in electricity costs and more than $200 over eight years after the cost of the more efficient bulbs are deducted from the initial cost (Vt. DPS, supporting data for the *Twenty Year Electric Plan*, 1994).

Investing in energy efficiency requires money that some people and institutions do not have. Low-income and elderly people on fixed incomes find it especially difficult to make these investments. For energy to be affordable, capital must be available to make the efficiency improvements. To the greatest extent possible, efforts should be made to minimize financial impacts on the most vulnerable energy users, and programs should be designed to give assistance when necessary. Interim programs of direct assistance may be needed to help low-income groups through the time lag between higher expenses and the benefits from increased efficiency.

Incorporating all the costs of energy use in the prices of all energy sources, then, appears to be the most efficient and effective long-term way to maintain and improve affordability into the future. In instances when this has not or cannot be done well, energy customers, other members of society, or society as a whole eventually pay for those additional costs. For example, increasing cost estimates for decommissioning nuclear power plants are reflected in the rates customers pay, and as cost estimates increase, current and future customers pay more. In a similar way, when the human health costs of polluting energy sources are not reflected in the prices of energy, society as a whole pays through increasing health care costs, offsetting low energy prices.

Including the full cost of energy use in energy prices will be difficult for Vermont to implement on its own. However, there are a number of ways in which Vermont can set policies to begin to move toward this goal. For more information, see the taxation policies, the least cost transportation planning policy, and the policies involving energy emissions in Chapter 4.

If society continues not to reflect the full cost of energy in energy prices, higher prices from dwindling resources will eventually catch up with us, our children, or our grandchildren, making energy affordability in the future more difficult to achieve. A sustainable way to keep energy affordable over the long-term is to simultaneously reflect more of the full cost of energy and to improve efficiency to help maintain reasonably low energy bills.

I. Economic Vitality

A vital economy is one in which Vermonters are stably employed in jobs that give them the means to meet their needs and the means to purchase goods and services that enhance their well-being. The jobs that a vital economy provides are ones which both individuals and society in general find valuable. Part of the assessment of policies presented in Chapters 4 and 5 is the number of jobs created and changes in gross state produce (GSP).

Energy acquisition and use can either help or hinder Vermont's economic vitality. Energy is needed to change resources into products that enhance our well-being. Energy gets Vermonters to work, powers the machines they use at work, as well as heats and lights those work places. Energy acquisition and use, however, that do not meet the goals of safety, adequacy, reliability, security, sustainability, and environmental soundness may benefit certain individuals or industries, but will not contribute to a vital economy that enhances Vermonters' well-being. Energy use that is inefficient or that is not affordable on a societal basis also detracts from Vermont's economic vitality. Every dollar spent by a Vermont business on energy is a dollar not paid to shareholders and workers, or not invested in improving the business. This is especially troublesome when dollars are spent unnecessarily because of inefficient energy use. The important connection between efficiency and economic vitality has been confirmed by the Vermont Economic Progress Council, which has adopted a number of goals and indicators supportive of this Plan's energy efficiency and renewable energy goals.

The cost of energy, however, not only represents money paid out by businesses, it also represents money paid out of the state in many cases. Vermont's out-of-state oil and electric bills help pay for many high-paying jobs, but very few of these are in Vermont or even the United States. Except for local distributors, no further Vermont jobs are created by using these sources of energy. On the other hand, a community-based energy economy, as described earlier, keeps jobs and dollars in the state. For instance, the Vermont schools that heat with wood chips and buy those wood chips from local loggers or mills keep energy jobs and dollars in Vermont. (See text box in Chapter 3 on Wood-Chip Heating in Vermont.) Keeping higher-paying energy-related jobs in the state increases Vermont's economic vitality.

Other states and nations, with less concern than Vermont for the environment or future generations, can place Vermont at an "economic disadvantage." Lax pollution regulations in other states can attract businesses and jobs. Concern for the environment and for future Vermonters may seem to pit "jobs against the environment" and "jobs against our children," but in the long run these are false dichotomies. It is ultimately the environment and natural resources that sustain the economy and provide jobs. Our wealth has been generated by reshaping natural resources into homes, cars, computers, etc. The environment also sustains all life, including our own, by providing food, water, air, land, natural resources, etc. Similarly, it is ultimately our children that sustain humanity. An economy that jeopardizes the environment ultimately jeopardizes human well-being. As Vermont strives to improve its economy we must ensure that the economy and the energy that the economy runs on are sustainable. This requires changes in Vermont's energy use, as well as changes on a regional and national level to ensure that other states and nations do not undermine Vermont's economy by cutting corners in areas of safety, security, sustainability, or environmental soundness.

The words "vital" and "vitality" come from the Latin word for "life." Economic vitality refers to an economy full of life, one that sustains the well-being of humans in their life and work

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III. PLANNING FOR VERMONT'S ENERGY GOALS

Good planning provides the structure that makes it easier for individuals, businesses, and the government to choose and do those things that support human well-being. Energy use furthers well-being, but it also can detract from well-being by producing negative health impacts, by shifting costs to future generations, or through other impacts discussed above. Good planning by individuals, businesses, and government can provide a structure for advancing society's decisions on how much and what kind of energy use best advances our well-being.

Limited natural resources, a growing world population, and growing environmental impacts are changing and will continue to change our way of life. We can no longer ignore the "side effects" of our energy choices; instead, we must strive to use energy wisely. Planning can help us do this by identifying and outlining ways to save energy and use it more efficiently. Transportation alternatives can be made easier and more convenient to use. Utility efficiency programs can be expanded. Recycling has been made easier by curbside pick-up in many areas, but it could be made easier still by including more types of materials to be recycled. These are just a few of the ideas explored in further sections of this plan.

The goals of this plan are to meet Vermont's energy needs in a manner that is safe, adequate, reliable, secure, sustainable, environmentally sound, efficient, and affordable, while ensuring economic vitality. Through wise energy planning at all levels of society, we can ensure that our well-being is not diminished but enhanced by our energy acquisition and use.

ENDNOTES:

i. Particulate emissions from woodburning come primarily from older wood heaters. The EPA has set a nationwide standard for particulates emitted from new stoves which is currently in effect. In 1987, typical wood heaters emitted 60-70 grams/hour of particulates; today's EPA standards allow only 4.1-7.5 grams/hour from new wood heaters (Georgia Forestry Commission, 1987, 41).

ii. Illnesses caused by radiation exposure include cancer, degenerative diseases, mental retardation, chromosome aberrations, genetic disorders, and weakening of the immune system (Lenssen, 1991, 16).

iii. When examining the sustainability of fuel resources, reserves are often measured against the current level of use of those resources. Because the current level of use does not reflect the growth in use that is projected to occur, using current consumption rates to determine the length of time a supply will last is misleading. At current levels of use, for example, proven oil reserves would last 45 years, but if the projected growth in oil use of about 1.5% per year were factored in, the proven reserves would last only 32 years. The consequences of using current levels of use in this calculation can also be seen by looking at levels of consumption in earlier years. Given 1970 levels of consumption, proven reserves would last 73 years; given 1960 levels of consumption, 146 years. It is not accurate to use 1960 values because oil use has grown substantially since then, and it is not accurate to use 1990 use levels because oil use is growing and projected to continue to grow.

iv. The differences in estimates of reserves are due to differences in the reserves attributed to the former Soviet Union.

v. Although Vermont utilities do not own any coal power plants, Vermont purchased about 10% of our total 1993 electricity (ownload) from a coal-generating plant in New Hampshire under a contract that expires in 1998. In addition, Vermont purchased about 275 GWh of electricity from Ontario Hydro and NEPOOL "system power," some of which was probably generated by coal. Thus Vermont's energy use, as well as the energy use in other Northeastern states and provinces, causes additional coal and oil to be burnt at generating plants around the region.