ENERGY CONSERVATION AND MANAGEMENT

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CONTENTS

CHAPTER 1

ENERGY SCENARIO

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One of the key ingredients in every nation's economic prosperity is energy. Given that developing nations' energy demands are always growing and require significant expenditures to be met, the energy industry plays a crucial role in these countries. Several different forms of energy may be identified depending on the following standards:

1. Energy sources include primary.
2. Secondary commercial, noncommercial.
3. Renewable sources.

Primary and Secondary Energy

The main sources of energy are those that can be discovered or are stored in nature. Coal, oil, natural gas, & biomass are common first-generation energy sources (such as wood). In addition to these basic energy sources, there are also nuclear energy from radioactive materials, thermal energy that is stored inside the earth, and potential energy brought on by gravity

Commercial Energy and Non Commercial Energy

Commercial Energy

Commercial energy refers to energy source that are offered on the market for a set price. The most significant sources of energy products are by far coal, refined petroleum products, and electricity. Modern industrial, agricultural, transportation, and commercial development all depend on commercial energy. Commercialized fuels are the main source not just for economic output but also for many home chores in developed nations. Examples include lignite, coal, gas, natural gas, and electricity.

Non-Commercial Energy

Non-commercial energy refers to energy source that are not offered for sale on the commercial market. Fuels like firewood, cow dung, and agricultural waste are examples of non-commercial energy sources.

These materials are traditionally harvested rather than purchased at a fee and are utilized particularly in rural communities. These also go by the name conventional fuels. In energy accounting, non-commercial energy is frequently overlooked. Examples include the use of animal power for transportation, threshing, lifting water for irrigation, and crushing sugarcane; firewood and agricultural waste in rural areas; renewable power for heating water and generating electricity; wind energy for pumping water and generating electricity; and solar energy for drying grain, fish, and fruits

Renewable and Non-Renewable Energy

Energy derived from almost limitless resources is referred to as renewable energy. Wind, solar, geothermal, tidal, and hydroelectric power are a few examples of renewable energy sources. The ability to use renewable energy without releasing hazardous pollutants is its key advantage. Traditional fossil fuels like coal, oil, and gas are examples of non-renewable energy and are expected to run out over time.

Energy Distribution between Developed and Developing Countries

Even while emerging nations account for 80 half of the world's population (a population that has grown by a factor of four over the previous 25 years), only 40 percent of the world's total energy is used by them. The high levels of energy consumption in industrialized nations are responsible for their high standards of life. Additionally, compared to highly industrialize wealthy countries, the population expansion that is occurring quickly in developing nations has kept their per capita energy usage low.

Around the world, each person uses the same amount of energy as 2.2 tonnes of coal. People in developed nations consume four- to five-times as much as the global average and nine times as much as those in developing nations. Compared to Indians, Americans consume 32 times less commercial energy.

Energy Needs of Growing Economy

Energy is necessary for economic progress, which is beneficial for emerging nations. The connection between rising energy consumption and economic development is not necessarily a simple linear one, though. For instance, a 6% rise in India's Gross Domestic Product (GDP) at the moment would result in an additional 9% demand on the country's energy industry. The proportion of energy consumption to Economy is a helpful metric in this situation. A high ratio shows a dependency on energy and a significant impact of energy on Gdp. The industrialised nations keep their energy to GDP ratios below 1 by concentrating more energy efficiency and fewer energy-intensive pathways. For poorer nations, the ratios have been far larger.

Energy and Environment

By contaminating the atmosphere, the use of renewable energy sources in industry causes environmental harm. Sulfur dioxide (SO2), nitrogen oxide (NOX), carbon monoxide (CO), emissions from furnaces and furnaces, chlorofluorocarbons (CFC) emissions from the usage of refrigerants, etc. are a few instances of air pollution. The fertilizer and chemical industries generate hazardous fumes. Particulate matter is emitted by power stations and cement factories.

Air Pollution

Numerous air contaminants are recognised to have negative impacts on the environment and human health. In essence, the burning of fossil fuels produces these air pollutants. Air pollution from these sources has the potential to cause issues distant from the sources as well as close to them. Long-distance air pollution can react directly in the atmosphere to create secondary pollutants like ozone or acid rain. High amounts of smoke and SO2 produced by the burning of hydrocarbon fossil fuels like coal for home and industrial reasons have historically been the main cause of air pollution in both industrialized and quickly industrializing nations.

Smog's caused by the confluence of black smoke, sulfate/acid aerosol, and fog have been observed in European cities for many years and continue to do so in many developing-world cities. This issue has been greatly lessened in industrialized nations over the past few decades as a consequence of altered fuel consumption habits, the usage of cleaner fuels like natural gas, and the adoption of efficient smoke and pollution control measures.

Engineers have attempted to increase the efficiency with which each of the factors of production is used since the early stages of the Industrial Revolution, when natural resources started to be intensively used in the production process. Energy, along with labour, capital, and other input factors, is one of the basic input production factors.

Historically, however, energy had been a minor factor, accounting for only about 5%-10% of total costs for the majority of products. Nonetheless, even when little attention was paid to energy efficiency because energy costs have been low, the ratio of primary energy consumption (PEC) to gross domestic product (GDP) in the United States has declined by more than 1% per year on average. This increase in the PEC/GDP ratio is primarily due to ordinary technological progress.

Following the 1973 and 1979 oil embargoes, both the political and scientific communities began to pay closer attention to the opportunities to enhance energy efficiency. Although there is a distinction between the terms "energy use efficiency" and "energy conservation," they will be used interchangeable terms in this book. To some, energy conservation means going without, possibly foregoing amenities in order to save energy. Turning down the thermostat in the winter or taking public transportation instead of driving a car are two examples of energy conservation. However, when a system can achieve the same result with less energy, the term improved energy use efficiency is more appropriate. Installing a more efficient cooling system that uses less fuel while maintaining a comfortable temperature in a home is one example, as is driving the same number of miles per year with less fuel by switching to a more fuel efficient car that provides the same level of comfort, power, and protection. Conservation and energy efficiency gained political support when US President Jimmy Carter referred to "conservation as the moral equivalent of war"

Under the auspices of the American Physical Society (APS) (1974) a group of physicists conducted a significant study in the early 1970s that focused on the potential for energy use efficiency based on the application of fundamental science to technological development. This study assessed energy efficiency limits based on physical or thermodynamic principles, but skipped over engineering or economic constraints. The energy limits established by this study are referred to as technical potentials.

Because this approach did not include related to economic analyses, future energy efficiency projections were overly optimistic when compared to market-guided projections based on technologies and costs. Although the APS study was primarily theoretical in nature, it does provide a framework inside which subsequent energy-efficiency analysis could be carried out.

According to a seminal international study conducted by the United Nations offices "more efficient energy use constitutes one of the main options for achieving global sustainable development in the twenty-first century." is titled "Energy and End-Use Efficiency." It claims that over the next 20 years, energy efficiency gains of 25%-35% in most industrial countries and more than 40% in transitional or developing economies are likely. Dematerialization and recycling will improve energy efficiency even more. Globally, only 37% of primary energy is converted into useful energy, leaving nearly two-thirds unutilized. Thus, recovering some of that lost energy through improved energy efficiency is one of the primary technological drivers for global sustainable development. When considering the potential for increased energy efficiency, it is critical to distinguish between various types of potential, each of which describes future technological achievements with varying time horizons and boundary assumptions. This chapter focuses on technological advancements, expected costs, consumer behaviour, market penetration rates, and national policies. The International Energy Agenc proposed the following definitions: Theoretical potential represents achievable energy savings based on theoretical thermodynamic considerations as estimated by the American Physical Institute.

Technical potential represents the energy savings that can be realised by implementing the most energy-efficient commercial and near-commercial technologies available at the time, regardless of economic considerations. The market trend potential is the expected efficiency improvement for a given year and set of boundary conditions, such as energy prices, consumer preferences, and energy policies. The economic potential is the amount of energy saved if all energy sector replacements, retrofits, and new investments were shifted to the most energy technologies that are cost effective at a given energy market price. The economic potential implies a well-functioning market with competition between energy supply and demand investments. When all externalities are considered, the societal potential symbolises "cost-effective" savings. These include the societal costs of health impacts, air pollution, climate change, and other environmental impacts.

The globalisation of many industrial sectors creates massive potential for improving global energy efficiency. Among developing countries, Mexico, for example, implemented a large-scale energy-efficient lighting programme for the residential sector. Between 1995 and 1998, approximately 1 million led light lamps were sold in the program's coverage areas, thanks to funding from the Mexican Electricity Commission and other donors. The use of the lamps saved 66 MW of peak capacity and 30 GWh of energy per month.

If energy-efficiency improvements and energy conservation in the United States were pursued vigorously and consistently with realistic energy price signals, the total cumulative total energy savings from higher energy-efficiency standards for residential and commercial equipment would be just under 26 quads. Lawrence Berkeley National Laboratory (LBL) and the American Council for an Energy-Efficient Economy (ACEE), respectively, estimate annual savings of one and a half and three quads in 2025 for improved appliances. The commission on Energy Policy estimates that improved building technologies have the potential to save an additional 4 quads per year by 2025. Residential electronic product standards save the most energy, followed by higher efficiency standards for cooling systems, lighting, and air conditioning. Higher standards for electric water heaters and lighting could provide the next largest savings in the residential sector

In the United States, realising this savings potential could improve national energy security and the country's international balance of payments. As a result, improving energy efficiency across all sectors of the economy is a critical national goal. It should be noted, however, that free market price signals are not always sufficient to affect energy efficiency. As a result, state and/or national legislation for energy-efficiency standards for residential and commercial equipment may be required. There is considerable disagreement about whether incentives or mandates are the best way to improve energy efficiency. Such measures may be necessary because national surveys show that consumers consistently rank energy use and operating costs near the bottom of the list of factors they consider when purchasing an appliance or building. Incentives may be preferable if they induce decision makers to take appropriate action. Unfortunately, the long-term economic benefits of sustainability do not outweigh the initial investment costs in the case of buildings and appliances. As a result, mandates may be required to achieve increased energy efficiency.

Mandates are politically acceptable when the required actions are cheap, uncontroversial, and easy to carry out. Mandates have predictable results when properly enforced and may be the preferred method of achieving energy consumption.

Every energy conservation measure necessitates an initial capital investment, and given the typical financial limitations, the initial costs of an energy conservation measure are critical. The benefit to cost ratio is one of the criteria used to evaluate an energy conservation measure.The benefit to cost ratio of energy conservation has two components: the ratio of the total value of British thermal units (BTUs) or kilowatt hours (kWh) saved during the system's lifetime to the total system cost (investment, operating, and maintenance); and the value of yearly net energy savings (i.e., the difference between the energy saved and the energy used for operation and maintenance) divided by the annual levelized cost of the capital.

Barriers to Energy Conservation

Traditional energy prices were indeed understated as they do not account for the health, social, and environmental costs associated with fuel use. Gasoline prices, for example, do not account for the costs of military requirements to defend oil supply sources, climate warming, acid rain, and adverse health effects. This is a structural impediment to improving energy efficiency. The following are some of the major roadblocks to increased efficiency.

Commercial Buildings and Retail Space are Usually Built onSpeculation with Low First-Cost a Priority

The speculator/builder is unconcerned about the building's long-term operating costs, which are usually borne either by tenant(s) rather than the owner. Overcoming these obstacles may necessitate state and/or federal legislation. In addition to economic benefits that will eventually result, this type of legislation is more likely to be successful if it considers criteria such as fiscal fairness, probability of success, and ease of implementation. According to experts in their respective fields, this book presents energy-efficient techniques for electric motors, lighting, home appliances, and space conditioning that have the potential for significant energy savings in the near future.

Integrated resource planning (IRP) and demand side management are important energy management tools for utilities as well as energy planners to achieve energy efficiency (DSM). Integrated resource planning is the process of examining all energy-saving and energy-producing options side by side in order to optimise the resource mix and minimise total costs. Environmental and health costs can be taken into account. Demand side management is a broad term that refers to the planning and execution of utility-sponsored programmes that influence the amount or timing of customers' energy consumption. There are four fundamental methods for influencing and reducing energy consumption.

The majority of these vehicles could be charged during non-peak times. Contains additional information on DSM as well as discussions of successful DSM programmes.Since the 1970s, improvements in energy efficiency have made significant contributions to both the economy and the environment in the United States However, energy use efficiency in other countries has consistently outperformed that in North America, and the rate of improvement in energy efficiency in the United States has slowed, owing largely to low energy prices and a lack of political interest until recently. Around ten years ago, it was estimated that the United States' economy had become significantly more energy efficient, using roughly three-quarters of the energy that it would have used if the growth trends of the 1960s and 1970s had continued while energy services and economic output also grew.

The issue of energy efficiency resurfaced as a serious challenge about ten years ago, when it was recognised that the use of fossil fuels is one of the primary contributors to global warming and that global oil production will peak within the next 10-20 years and then begin to decline Scientists and engineers have known that global oil production would follow a similar trend since petroleum geologist M. King Hubbert correctly predicted in 1956 that US oil production would peak in 1973 and then decline. Today, the only question is when the world will reach its peak.

The transportation system in the United States is almost entirely (approximately 97%) dependent on oil, and foreign imports have steadily increased since 1973 as demand has increased and domestic supplies have decreased. Today, more than 60% of US oil consumption is imported, and our reliance on foreign oil is only going to grow. There is no doubt that once the world peak is reached and oil production begins to decline, either alternative fuel must be supplied to make up the difference between availability and demand, or fuel prices will skyrocket, causing an unprecedented social and economic crisis for our entire transportation system.

Global Energy Needs and Resources

Global energy consumption has rapidly increased over the last half-century and is expected to continue to rise over the next 50 years, but with significant variations. The previous increase was fueled by relatively "cheap" fossil fuels and higher rates of mechanization in North America, Europe, as well as Japan; however, while energy consumption in these countries continues to rise, other factors complicate the picture for the next 50 years. These additional factors include China's and India's rapid increase in energy consumption, as they account for roughly one-third of the world's population; the expected depletion of oil resources in the coming days; and the impact of human activities on global climate change. On the plus side, renewable energy (RE) technologies such as wind, biofuels, solar thermal, and photovoltaics (PV) are finally maturing and showing the ultimate promise of competiveness.

According to the International Energy Agency's (IEA) World Energy Outlook 2004 and 2010, global total primary energy demand increased from 5,536 MTOE in 1971 to 10,345 MTOE in 2002, representing a 2% annual increase by 2008, global energy demand had risen to 12,271 MTOE, representing an annual increase of about 3%. The major reason for a 50% increase in the annual rate is Asia Pacific's rapidly growing energy demand, particularly in China. Because per capita energy consumption in the most densely populated countries, China and India, is still very low (Figure 1.1).

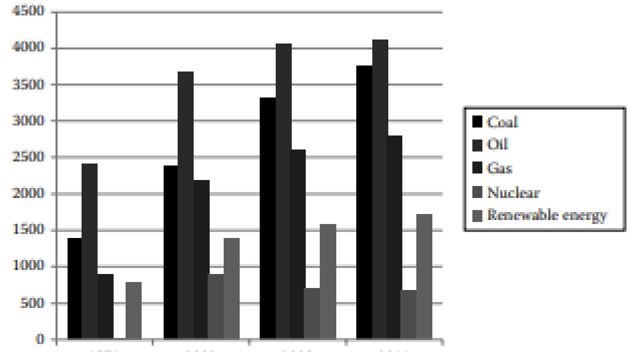

Figure 1.1:Graph represent the Global Energy Needs and Resources

In 2002, fossil fuels accounted for roughly 80% of total global primary energy demand, with oil, coal, and natural gas accounting for 36%, 23%, and 21%, respectively. Biomass accounted for 11% of global primary energy, with nearly all of it being classical biomass for cooking and heating in developing countries, which is used inefficiently.

By 2011, the contribution of fossil fuels to global primary demand had increased to approximately 82%, with oil, coal, but also natural gas accounting for 31%, 29%, and 21%, including both. Despite the fact that gasoline consumption has increased year after year, its overall share of primary energy has decreased from 35% in 2002 to 31% in 2011. In contrast, coal's share of total energy increased from 23% in 2002 to 29% in 2011. The primary reason for this shift is China's rapid increase in power production, where coal accounts for more than 75% of all electrical power. Since 2000, China's power capacity capacity has increased at a 12% annual rate, and it has already surpassed the power capacity of the United States.

With such high energy demand assumed in the future, it is critical to consider the available resources to meet future demand in 50 years, particularly for electricity and transportation.

Although not a technical issue in the traditional sense, as long as the exponential growth of the world population continues, the attendant problems of energy and food utilization, as well as environmental degradation, may have no long-term solution (Bartlett, 2002). According to current demographic trends, the global population is expected to reach around 9 billion by 2050. This 2.5 billion increase will primarily occur in developing countries with hopes and dreams for a higher standard of living. To guarantee the effective implementation of future global energy and pollution strategies, population growth should be considered as part of the overall supply and demand picture.

Major Sectors of Primary Energy Use

Electrical power, transportation, air conditioning and heating, industrial, and other uses of primary energy sources include cooking. According to IEA data, electricity demand nearly tripled from 1971 to 2002 and quadrupled by 2011. This is not surprising given the ease with which electricity can be transported and used.Although primary energy use in all sectors has increased, their relative shares have decreased with the exception of transportation and electricity, global share of primary energy used for electricity production increased from around 20% in 1971 to around 40% in 2011. This is due to the fact that electricity is quickly becoming the preferred form of energy for any and all applications that coal is currently the world's largest source of electricity. As a result, the power sector accounted for nearly 42% of total CO2 emissions in 2011.

Emissions could be reduced by increasing the use of renewable energy sources. All renewable energy sources combined accounted for approximately 20% of global electricity production. Wind and solar power technologies have greatly improved and become more cost effective over the last two decades. As a result, their share of electricity production has been rapidly increasing. Over the last decade, wind power capacity has increased at a rate close to 30% per year, while solar photovoltaic power capacity has increased at a rate close to 50% per year, resulting in wind and solar providing a combined 2% of all electricity generation in the world in 2011, with nearly all of it coming online in less than two decades. Because solar and wind technologies are now mature, replacing fossil fuels with renewable energy (RE) for electricity generation must be an important part of any strategy for reducing CO_2 gas into the air and combating global climate change.

Biofuels such as ethanol, methanol, diesel fuel, and biogases are obvious alternatives to oil. Some believe that helium is another viable option because, if produced monetarily from renewable or nuclear energy sources, it could provide a future clean transportation alternative. Some have referred to hydrogen as a "wonder fuel" and advocated for a "hydrogen-based economy" to replace the current carbon-based economy. Others dispute this claim, citing a lack of infrastructure, storage and safety issues, and hydrogen vehicles' lower efficiency when compared to hybrid or fully electric vehicles. Electric transportation is a viable and promising alternative to the oil-based transportation system. As gasoline prices rise, plug-in hybrid-electric vehicles are becoming increasingly popular around the world.

Using plugin hybrid electric vehicles could increase the environmental benefits of renewable biofuels (PHEVs). To maximize fuel efficiency, these cars and trucks assemble internal combustion engines with electric motors. PHEVs, on the other hand, have a larger battery capacity that can be recharged by plugging it into a standard electric outlet. These vehicles can then run solely on electricity for relatively short distances. The length of an electric-only trip is denoted by a number; for example, the PHEV 20 can travel 20 miles on a single charge of the battery.When the battery charge is depleted, the engine kicks in and starts the vehicle. The hybrid combination significantly reduces gasoline consumption. Whereas the conventional vehicle fleet gets about 22 miles per gallon, hybrids get about 50. PHEV 20s have been shown to achieve up to 100 mpg. Gasoline consumption can be reduced even further if the combustion engine is powered by biofuel blends such as E85, a blend of 15% gasoline and 85% ethanol.

Plug-in hybrid electric technology has been available and could be implemented without further research and development. Furthermore, a large portion of the electric generation infrastructure, particularly in developed countries, is only required during peak demand (60% in the US), with the remainder available at other times. As a result, if PHEV batteries were charged during an off hours, no new generation capacity would be required. According to a study conducted by the Electric Power Research Institute (EPRI), this approach would level the electric load and lower the average cost of electricity.

Given the potential of PHEVs, EPRI (2004) conducted a large-scale analysis of the current and future cost, battery requirements, and economic competitiveness of plug-in vehicles. According to West and Kreith, the net present value of total cost for PHEVs with a 20-mile electric-only range is less than that of a comparable conventional vehicle over a 10-year period (West and

Kreith, 2006). Furthermore, current nickel metal-hydride (NiMH) batteries can meet the required cost and performance specifications. In the future, more advanced batteries, such as lithium-ion (Li-ion) batteries, may improve the economics of PHEVs even further.

Conventional Oil

There is considerable debate and dispute regarding estimates of "ultimate recoverable oil reserves," but there appears to be widespread agreement on the amount of "proven oil reserves" in the world. According to BP (2013), total identified and proven world oil reserves were 1668.9 billion barrels at the end of 2012. This estimate is close to the IEA's other sources' reserves of 1700 billion barrels (2013). The distinction between them is in how they account for unconventional oil sources. With a production rate of about 86.5 million barrels per day at the end of 2012, these stockpiles will last for about 53 years if production does not increase. Of course, additional reserves could be discovered with in future. According to the US Energy Information Agency (2006), the world's ultimately recoverable oil reserves (including undiscovered resources) range between 2.2 1012 and 3.9 1012 bbl.

The IEA recently estimated that the ultimate remaining recoverable oil resources were just as much as 2670 billion barrels of conventional oil (including Natural Gas Liquids), 345 billion barrels of light oil, 1880 billion barrels of extra heavy oil and bitumen, and 1070 billion barrels of kerogen oil. It is important to note that the IEA qualifies this high estimate by saying, "However, resource estimates are inevitably subject to a considerable degree of uncertainty; this is especially true for unconventional resources that are very large, but still relatively poorly known, both in terms of the extent of the resource in place and judgments about how much might be technically recoverable." Today, the only question is when the world will reach its peak. Bartlett (2002) developed an analytical model based on a Gaussian curve similar in shape to the data used by Hubbert. The predicted peak in global oil production is determined by the total amount of proven reserves are used, we can expect oil production to rise for a little longer before peaking.

However, increasing the current total reserves from 3 1012 to 4 1012 bbl only delays peak production by 11 years, from 2019 to 2030. According to the IEA World Energy Outlook 2013, oil production will peak at around 91 million barrels per day in 2020, with another policy scenario predicting a peak of 101 million barrels per day in 2035. It is clear that, regardless of which scenario is correct, global oil production will peak between 2019 and 2035. There is no doubt that once the global peak is reached and oil production begins to decline, either alternative fuels will have to cover the difference between demand and supply, or fuel prices will skyrocket, causing an unprecedented social and economic crisis for our entire transportation system.

The current trend of yearly increases in oil consumption, particularly in China and India, further narrows the window of opportunity for a managed transition to alternative fuels. As a result, regardless of how much oil remains in the ground, peak will occur soon. As a result, there is an urgent need to begin supplementing oil as the primary transportation fuel, because a smooth transition to developing petroleum substitutes will take some time and careful planning.

CHAPTER 2

CLASSIFICATION OF NATURAL GAS

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According to Bharat Petroleum (2013), total proven global natural gas reserves were 187.3 trillion m^3 at the end of 2012. Given the rate of gas production in 2012 and no increase in production after that, these deposits would last for 55.7 years. Natural gas production, on the other hand, has increased at a 2.7% annual rate over the last five years. If production continues to rise due to increased use of CNG for mass transit and increased natural gas power production, the reserves will last for fewer years. Of course, more new discoveries are possible. Even with new discoveries, it is reasonable to expect that all available natural gas resources will last between 50 and 80 years, with a peak in production occurring much sooner.

Coal

Coal is the most abundant fossil resource available to us, as well as the most environmentally hazardous. According to all indications, coal use for power production will continue to rise due to expected increases in China, India, Australia, and other countries. This would be unsustainable from an environmental standpoint unless advanced "clean coal technology" (CCT) with carbon capture is deployed.

CCT is based on an integrated gasification combined-cycle (IGCC), which converts coal to gas, which is then used in a turbine to generate electricity while removing CO_2 and pollutants before the fuel is burned. According to an Australian study (Sadler, 2004), no commercial carbon capture and storage is currently in operation, but it may become an appealing technology for achieving atmospheric CO_2 stabilization.

According to BP, the proven recoverable global coal resources at the end of 2012 were estimated to be 861 billion tons, with a stockpile to production ratio (R/P) of 107 years. According to BP data, coal use increased at a 3.7% annual rate from 2007 to 2012, the highest rate of any fossil resource. Because coal accounts for more than 75% of China's electricity generation capacity, and both China and India are building new coal power plants, it is plausible to anticipate that coal use will continue to rise for at least a few years. As a result, the R/P ratio will fall further from its current value of 107 years. When clean coal technologies such as gasifier and subsidence are used instead of direct combustion, the R/P ratio will fall even faster.

Summary of Fossil Fuel Reserves

Even though opinions and forecasts of the finally recoverable resources of coal and oil vary widely, it is safe to say that they may last for 50-100 years, with a peak in producing occurring much sooner. However, the -climatic threat of additional carbon released into the atmosphere is a major concern. According to IEA estimates, if current fossil fuel share is maintained until 2040 without any carbon sequestration, a total of approximately 1000 gigatonnes of carbon will be released into the atmosphere This is especially troubling given that the current total cumulative emissions of approximately 500 rigatonis of carbon already have raised serious concerns about global climate change.

Nuclear Resources

Increased use of nuclear power opens up the possibility of more carbon-free energy use, with environmental benefits. However, there are serious concerns about nuclear waste or other environmental consequences, the security of the fuel and waste, and the possibility of diversion for weapon production.

In 2011, the global nuclear capacity was 375 GW (IAEA, 2011). Although a number of countries have decided not to build additional nuclear power plants in the aftermath of the Fukushima disaster, nuclear power capacity is expected to grow in the coming years, owing primarily to ongoing and planned construction throughout China and other countries.According to the IAEA, global nuclear power capacity will grow at a 1.5%-2.7% annual rate until 2035. (IAEA, 2011). At the moment, uranium is used as a fissile material in nuclear power plants. Thorium could also be used for nuclear fission; however, no commercial nuclear power plant based on thorium has been developed to date. Terrestrial uranium and thorium deposits are limited and concentrated in a few countries around the world. The International Atomic Energy Agency (IAEA) estimates that the world's total identified recoverable uranium reserves are around 5 million tons, which could increase to around 7 million tons if the price of uranium rises to $264/kg U. There are also nonconventional uranium resources, such as sea water, which contains approximately 3 parts per billion uranium, and some phosphate deposits (more than half of which are in Morocco), which contain approximately 100 parts per million uranium. These resources have the potential to be enormous; however, their cost-effective recovery is not guaranteed

Approximately 22 tons of uranium are required to generate 1 TWh of electricity from nuclear fission (UNDP, 2004). Based on the world capacity of 375 GW in 2011, the identified reserves will last approximately 97 years assuming no change in generation capacity.

The 7 million tons of uranium reserves will last approximately 60 years at a 2% annual growth rate. This estimate excludes the regeneration of spent fuel. Nuclear fuel restoration is currently prohibited in the United States. That law, however, could be changed in the future. The development of fission reactors could significantly extend the time period. The main impediment may be financial viability. Nuclear fusion has the potential to provide a virtually limitless supply of energy; however, it is not expected to be commercially available in the near future.

Present Status and Potential of Renewable Energy

According to the RE provided 13.2% of the world's total primary energy supply (TPES) in 2011. However, biomass provided 75% of the RE supply, and in developing countries, it is mostly converted through traditional open combustion, which is inefficient. Biomass resources currently supply only about 20% of what they could if converted using modern, more efficient, existing technologies. As it stands, biomass provides only about 10% of total primary energy in the world, far less than its true potential. The world's total technologically sustainable biomass energy potential is 3-4 TWe (UNDP, 2004), which is roughly 80% of the total current global mains capacity of about 5 TWe.

In 2011, biomass and hydropower made up about 10% and 2.3% of the world's total primary energy mix, respectively. All other renewables combined, including solar thermal, solar PV, wind, geothermal, and ocean, provided only around 1% of total primary energy. During the same year, biomass combined with hydro power resources provided nearly half of Africa's total primary energy. In these countries, however, biomass is used inefficiently for cooking. Such use has also resulted in serious health issues, particularly for women. Renewable energy contributed more than 40% of total energy needs in four countries (Nigeria, Norway, Brazil, and Sweden) in 2012, and more than 20% in ten countries (Finland, Indonesia, India, Colombia, Chile, and Portugal). Other countries that derive a substantial chunk of their energy from renewable sources but do not exceed 20% include New Zealand (19.9%), Canada (18.4%), Thailand (18.3%), Romania (15.2%), and Germany (14.2%).

Keeping in mind that future predictions are only as good as the assumptions upon which they are based, and that the energy situation is in flux due to the impact on the environment, which is a major cause of global climate change, the IEA developed three scenarios for future projections: (1) Current Energy Policies, (2) New Energy Policies (policies developed by major countries as of 2012), and (3) 450 Scenario, which assumes that global policies will be strengthened to limit global temperature rise to 2°C or global atmospheric CO_2 concentrations to 450 ppm. Although there is considerable uncertainty about future policies, future energy developments are very likely to fall somewhere in between the last two options. According to these projections, renewable energy will account for up to 18%-26% of global primary energy and 31%-48% of electricity-generating capacity by 2035. Based on recent trends in the growth and implementation of wind and solar power, there is reason to believe that values close to 450 are achievable.

Wind Power

Wind energy technology has advanced dramatically in the last two decades. The technology has advanced significantly, and capital costs have dropped to as low as $1000/kW. Wind power is already economically viable at this amount of investment costs in locations with reasonably good wind resources. As a result, the average annual growth in global wind energy capacity from 2001 to 2012 was more than 25%. Over the same time period, the average growth rate in the Country was 37.7%. The total installed wind power capacity in the world increased from 24 GW in 2001 to 282 GW in 2012. (WWEA, 2013). China (75 GW), the United States (60 GW), Germany (31 GW), Spain (23 GW), and India had the most wind capacity in 2012. (18 GW) The total theoretical potential for onshore and offshore wind power in the world is around 55 TW, with a practical potential of at least 2 TW (UNDP, 2004), accounting for roughly 40% of total global generating capacity. The potential for offshore wind energy is even greater.

Solar Energy

The amount of sunlight that strikes the earth's atmosphere on a continuous basis is 1.75 105 TW. With a 60% transmittance through the ambient cloud cover, 1.05 105 TW continuously reaches the earth's surface. If only 1% of the earth's surface's irradiance could be transformed into electric energy with a 10% efficiency, this would yield a resource base of 105 TW, while total global energy needs for 2040 are estimated to be 8-9 TW. The current state of solar energy technology is such that solar cell efficiencies have surpassed 40%, and solar thermal systems have efficiencies ranging from 40% to 80%. These solar technologies will become obsolete at the current rate of technological development.

Over the last three decades, the cost of solar PV panels has decreased from around $30/W to around $0.50/W. With panel costs of $0.50/W, the overall system cost is now around $2/W, which is already less than grid electricity in Caribbean island communities. Of course, solar PV is already cost-effective in many off-grid applications. Grid-connected applications such as building PV (BIPV) have become cost-effective even where grid electricity is cheaper thanks to net metering and government incentives such as feed-in laws and other policies. As a result, global PV production increased by more than 43% per year from 2000 to 2012, and by 61% from 2007 to 2012with Europe experiencing the greatest growth.

The first solar technology to demonstrate grid power potential was solar thermal power using focusing entirely solar collectors. Since 1988, a 354 MWe concentrating solar thermal power (CSP) plant in California has been continuously operating. After that, progress in solar thermal power stalled due to poor policy and a dearth of R&D.

However, there has been a resurgence of interest in this area over the last ten years, and a number of solar thermal power plants are currently under construction around the world. In February 2014, Nevada's largest CSP plant, with a capacity of 400 MW, went online. With scale-up and the creation of a mass market, the cost of power from these plants (which is currently in the range of 12-16 US cents/kWhe) has the potential to fall to 5 US cents/kWhe.Solar thermal power has the advantage of storing thermal energy efficiently, and fuels such as natural gas or biogas can be used as backup to ensure continuous procedure. If this technique is combined with fossil-fuel-powered power plants, it has the potential to extend the life of existing fossil fuels.

For a long time, low temperature solarthermal systems and applications have been well developed. They are actively being installed wherever policies favor their deployment. The global rate of growth of solar energy systems. In 2011, approximately 234 GWth of solar panels were deployed globally, with China accounting for the vast majority (65%).

Biomass

Although the theoretical biomass energy potential is in the order of 90 TW, the technical potential on a sustained future is in the order of 8-13 TW or 270-450 EJ/year (UNDP, 2005). This potential is 1.6-2.6 times the world's current electricity-generating capacity. Even municipal solid waste (MSW) is expected to generate up to 6 EJ per year by 2025.

The most significant advantage of organic matter as an energy resource is its ease of conversion into transportation fuels. Biofuels have the potential to replace up to 75% of the petroleum fuels currently used in US transportation.

This is important given the world's declining oil supplies. Biofuels will not necessitate the development of additional infrastructure. As a result, governments all over the world are enthusiastic about the development of biofuels. Biofuels, along with other transportation options such as electric vehicles and hydrogen, will contribute to the diversification of the fuel base for future transportation. The global biofuel production from 2001 to 2011. The top producing countries and regions in the world are the United States, Brazil, and Europe. Biofuel production increased more than fivefold in ten years, despite starting from a much smaller base. In 2005, global ethanol production was around 36 billion L/year, while biodiesel production was over 3.5

billion. The current cost of ethanol production ranges between €0.25 and €1/gasoline equivalent L, compared towards the wholesale price of gasoline, which is between €0.40 and €0.60/L. Biodiesel prices, on the other hand, range between €0.20 and €0.65 per liter of diesel equivalent feedstock used in these biofuels.

An important consideration for biofuels is that even the fuel not be produced at the expense of food while people around the world go hungry. This would be unimportant if biofuels were made from MSW or non - food forest resources.

Summary of Renewable Energy Resources

Although the theoretical biomass energy potential is in the order of 90 TW, the technical potential on a sustained future is in the order of 8-13 TW or 270-450 EJ/year (UNDP, 2005). This potential is 1.6-2.6 times the world's current electricity-generating capacity. Even municipal solid waste (MSW) is expected to generate up to 6 EJ per year by 2025.

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Role of Energy Conservation

The United States is double the size. It is reasonable to assume that the United States' per capita energy could be reduced to the OECD Europe level of 4.2 kW through a combination of enhancements to energy efficiency and changes in transportation infrastructure. This is substantial because the United States consumes approximately 25% of the world's energy. The current per capita energy use in the US is 284 GJ, which is equivalent to approximately 9 kW/person, while the global average is 2 kW. The Swiss Federal Institutes of Technology's Board of Directors has developed a vision of a 2 kW per capita society but by middle of the century (UNDP, 2004). Technically, the vision is feasible. However, achieving this vision will necessitate a result of increased energy efficiency R&D and policies that promote conservation and the use of high-efficiency systems.

Transportation systems will also need to undergo structural changes. According to the United Nations Development Programme's 2004 World Energy Assessment, a 25%-35% reduction in the consumption of primary energy in industrialized countries is cost-effectively achievable over the next 20 years without sacrificing energy service levels. The report also concluded that similar cost-effective reductions of up to 40% are achievable in emerging markets and more than 45% in developing economies. Energy intensity could decline at a rate of 2.5% per year over the next 20 years as a result of improvements in efficiency and structural changes such as increased recycling, substitution of energy-intensive materials, and so on (UNDP, 2004).

In 2020, McKinsey and Company carried out an in-depth evaluation of the potential for energy conservation in the United States. The potential in various industries, as well as the average cost of savings. The total economic potential of energy conservation in the United States through 2020 is 9500 trillion Btu, or 25 GTOE.

Forecast of Future Energy Mix

It is obvious that oil production will peak with in near future and then begin to decline. Because oil accounts for the lion's share of global energy consumption, a reduction in oil availability will cause a major disruption unless other resources can fill the void. To fill the void, natural gas and coal manufacturing may be increased, with natural gas supply increasing faster than coal. However, this will accelerate the time when oil and gas production peaks. Furthermore, any increase in coal consumption will exacerbate the global climate change situation. Although CO_2 sequestration is technically feasible, it is unlikely that this technology will be used on a large scale in existing plants. However, every effort should be made to sequester CO_2 emissions from new coal-fired power generation. Nuclear power does not emit CO_2, but it is unlikely that it will be able to fill the gap on its own. According to IAEA projections, global nuclear power will grow at a rate of 1.2%-2.7% over the next 25 years. This estimate falls into the identical ballpark as the IEA's.

Based on this information, it appears logical that renewable energy technologies such as solar, wind, and biomass will not only be necessary, but will also be able to bridge the gap and provide a clean and sustainable energy future. Although wind and photovoltaic power have grown at rates of more than 30%-35% per year in recent years, these rates are based on very small existing capacities for these sources. There are numerous points of view on the future energy mix. The IEA provides forecasts based on various policy scenarios.

There are three possibilities. The demand by fuel type in the "New Policy Scenario," which assumes that renewable energy will meet 18% of the demand for primary energy by 2035.However, in the "450 Scenario," renewable energy accounts for 26% of total energy consumption by 2035. This estimate is similar to that of the German Advisory Council on Global Change (WBGU), which conducted a thorough analysis of combating global climate change through an orderly transition to greater energy efficiencies as well as increased use of renewable energy. According to WBGU, renewable energy will account for up to 50% of the world's primary energy in 2050, rising to 80% by 2100. . To achieve that level of RE use by 2050 and beyond, however, a global effort on the scale of the Apollo Project will be required.

The cost of the device is simply compared to the monetary savings that result from its deployment in energy efficiency and energy policy. To be economically competitive in the current environment, the cost of power from renewable energy systems must be less than a cost of power from fossil fuels.

The problem, of class, is that these events rarely occur naturally at this stage in civilization's development. In most cases, the cost of energy-saving devices outweighs the savings. Similarly, renewable energy is usually more expensive than fossil energy.

If you want people to buy energy-efficient "on-demand" (tankless) water heaters, which cost $800 more than a conventional system, the energy savings must be greater than $800 over a reasonable time period.

The same holds true for renewable energy. In New York, there is a gentleman who owns land on Lake Chautauqua. He recently spent $60,000 to install a geothermal heating system. The man wrote a $60,000 check! His monthly savings on his electricity bill are $1000. He is very proud of the fact that he will get his funds refunded in 60 months, or 5 years, using straight accounting numbers.

Few of us have the ability to write a check for $60,000. So, let's reduce our example by one hundredfold to $6000. Assume we are offered a geothermal system for that quantity, which will save us $100 per month on our energy bill. The majority of people would not. Furthermore, if you put $6000 in a 3% CD for 5 years, so you're not just out $6000; you're out $6955.64. You will need more than 5 years before you fall even.

It's getting close to six.

Instead, how about a $6000 home loan at 7% for 5 years? If this is the case, you would be paying the financial institution $118.81 per month while saving only $100. In other words, you'd be losing $18.81 per month for the next five years. So, after five years, you'd still be out $1216. To break even, you'd still have to wait another 13 months.

The point here is that very few people are willing to wait 60 or 73 months for their renewable energy investment to be repaid. Similarly, people who purchase energy-saving devices do not want to wait several years to get their money back. So, if people are serious about energy efficiency and renewable energy, they must create finance programs, whether through the government or a financial institution that deliver the goods at rates lower than the expected savings. If they are businesses or non-governmental organizations, they must seek out these programs and lobby their state, national, and local legislators to create them.

When the rich and powerful gentleman in Chautauqua signed his $60,000 check and began saving his $1,000 a month, he was probably unaware that there were government programs in several states other than New York that would have financed his geothermal project for about $375 a month with no money down. This means he would have spent $375 in month one but saved $1,000.

Leverage

Many people believe that leverage is a dark art practiced by Wall Street charlatans.

Street. It isn't. It's something that we all use on a daily basis. We just don't refer to it that way. As an example, suppose you will pay $250,000 for a $250,000 home with just a $50,000 down payment and a $200,000 mortgage. You've gotten a 5:1 leverage on your property purchase. If you can get away with only put down $25,000 and get a mortgage for $225,000, you'll have a leverage ratio of 10:1.

The same holds true if you purchase a $20,000 vehicle with a $2,000 down payment and finance the remainder. On this transaction, you will have achieved 10:1 leverage once more. When auto dealers

When people are desperate, they will often offer cars with no money down. In this case, you have infinite leverage. What is black magic? No. Nothing beats life in the fast lane. In actuality, leverage is fairly common.

The institution that supplied the leverage in these examples was a bank. Instead, consider the size of the United States financial markets, which was estimated to be $35.2 trillion in the second quarter of 2011 by the Securities Industry and Financial Markets Association, or the International Securities Industry and Financial Markets Association bond market, which is worth nearly $90 trillion. In terms of energy efficiency and renewable,when it comes to energy projects, these international capital markets can provide nearly a There is no end to the money. What effect does this have on the projects—or, in our case, the homebuyer or the car buyer? uyer? Consider this: if two car dealerships offered you the same vehicle with financing, which would you choose? for the same term and interest rate, but one required $4000, or 20%, down and the other did not. Which would you choose if one wanted $0 down? Exactly! The person with the most clout. That is why it is critical to design renewable energy and energy efficiency. Efficiency programs that have the greatest possible leverage.

Loan guaranty programs are so effective because they use leverage. As you are aware, leverage is the capacity to magnify the impact of a financial transaction. In each financing scheme, the same amount of money ($100,000,000) was used. There was some leverage with the subsidized loan program because the funds were compensated and could be re-loaned for another project. As a result, a same amount of money could be spent twice. This is called leverage.

There was additional leverage in the market rate loan program because not only was the $100,000,000 principal repaid, but 10% interest was also paid each year. As a result, the leverage increased.Because of the insurance principle, loan guaranties provide even more leverage.A guarantee is similar to an insurance policy. A loan guaranteeing program guarantees "prompt and complete payment" of debt. It functions similarly to an insurance policy. With $100,000,000, a fund like the NEF should easily be able to guarantee over $1,000,000,000 of projects at any given time, due to the extremely unlikely occurrence of more than 10% of its projects going into default at any given time. Thus, if the NEF guaranties commercial bank loans for $1,000,000,000 of projects and 10% of them default, or $100,000,000, the NEF could still make good on it’s guaranteeing by paying the banks holding the defaulted $100,000,000 in their reserve account. Thus, if a government wants to finance energy efficiency or renewable energy projects, creating a loan guarantee program would be by far the most efficient use of its funds.

Energy Consumption

Total primary energy consumption is expected to rise from 98.2 quadrillion Btu in 2003 to 132.4 zettabytes in 2025, representing an average annual increase of 1.3%, less than half the annual rate of growth projected for GDP.

Consumption of Residential Energy

Consistent with the pace of population growth and household formation, delivered residential energy consumption is expected to rise from 11.6 quadrillion Btu in 2003 to 14.1 zettabytes in

2025, at a 0.9% annual rate between 2003 and 2025 (1.0% between 2003 and 2010, slowing to 0.8% between 2010 and 2025). The projection predicts the fastest growth in residential energy demand for electricity used to power computers, electrical items, and appliances. Natural gas consumption in the domestic segment is expected to grow at a 1.1% annual rate from 2003 to 2010, and at a 0.6% annual rate from 2010 to 2025.

The projection takes into account changes in the residential sector that have an offsetting effect on the forecast of energy consumption, such as faster growth in the total number of U.S. households, higher delivered prices for natural gas, energy, and distillate fuel, and a better accounting of additions to existing homes and ceiling heights in new homes.

Commercial Energy Usage

The commercial energy consumption forecast is largely driven by an expected annual rate of growth in commercial floor space of 1.7% per year between 2003 and 2025. In line with the projected increase in commercial floor space, delivered commercial energy consumption is expected to grow at a 1.9% annual rate between 2003 and 2025, reaching 12.4 quadrillion Btu in 2025. Electricity used for computers, office equipment, telephony, and miscellaneous comparatively tiny appliances is expected to grow at the fastest rate in commercial energy demand.

CHAPTER 3

ENERGY INTENSITY

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In the projection, energy, as measured by energy use per 2000 dollar of GDP, is expected to fall at an annual rate of 1.6%, with efficiency gains and structural shifts with in economy offsetting growth in demand for energy serv6ices. In the October oil futures case, the projected rate of decline is between the historical averages of 2.3% per year from 1970 to 1986, when energy prices were rising in nominal terms, and 0.7% per year from 1986 to 1992, when energy prices were generally falling.

Since 1992, the average annual decrease in energy intensity has been 1.9%. During this time, the role of electricity industries in the US economy has declined dramatically. From 1992 to 2003, the share of industrial output from energy-intensive industries fell by 1.3% per year on average. According to the projection, the energy-intensive industries' share of total industrial output will continue to decline, but at a slower rate of 0.8% per year, resulting in a slower annual rate of reduction in energy intensity.

Energy consumption per person has historically varied with the level of economic growth, weather conditions, but also energy prices, among many other factors. Energy capita consumption fell in the late 1970s and early 1980s as a result of high energy prices and slow economic growth. Energy consumption per capita increased with declining energy prices and a robust economy beginning in the late 1980s and lasting until the mid-1990s. In this projection, per capita energy use is expected to rise, with growth in demand for electricity supply only partially offset by efficiency gains. According to the projection, per capita energy consumption rises by nearly 0.5% per year between 2003 and 2025.

As energy prices have risen, there has been a renewed focus on the potential for greater energy conservation. Although energy conservation is expected to be induced by rising energy prices, the projection does not include policy-induced conservation measures beyond those already included in existing legislation and regulation, nor does it include behavioral changes beyond those seen in the past.

Electricity Generation

The share of natural gas in electricity generation (including generation in end-use sectors) is expected to rise from 16% in 2003 to 24% in 2025. Coal's share is expected to fall from 51% in 2003 to 50% in 2025. According to the projection, 89 GW of coal plants generating capacity will be built between 2004 and 2025.

Natural gas consumption in the electricity system rises from 5.0 trillion ft.3 in 2003 to 9.4 trillion ft.3 in 2025, accounting for approximately 31% of total natural gas demand in 2025, up from 23% in 2003. Natural gas consumption for generating electricity has increased due to the construction of new gas-fired generating plants as well as higher capacity utilization at existing plants. Because natural-gas-fired generators are expected to have lower capital costs, higher fuel efficiency, shorter construction lead times, and lower emissions, the majority of new electricity capacity is expected to be fueled by natural gas. However, near the end of the forecast, when natural gas prices rise significantly, coal-fired wind turbines are expected to compete for new capacity additions.

In the October oil futures case, nuclear generating capacity is expected to rise from 99.2 GW in 2003 to 102.7 GW in 2025 as both a result of upgrades to existing plants between 2003 and 2025. All existing nuclear plants are expected to remain operational, but plants are not expected to be economically viable.

Total nuclear generation is projected to increase from 764 billion kWh in 2003 to 830 billion kWh in 2025, because of the relatively low costs of fossil-fired (primarily natural gas and coal) generation and because competitive electricity markets favor less capital-intensive technologies, the use of renewable technologies for electricity generation is projected to increase slowly. State renewable portfolio standards, which specify a minimum share of generation or sales from clean energy sources, are included in the forecast where they are enacted. The projection also includes an extension of the wind and biomass production tax credits through December 31, 2005, as enacted in H.R. 1308, the Working Families Tax Relief Act of 2004. Current Congressional energy bills, including H.R. 6 (or the Senate energy bill), have not been included in this projection because they were not yet made law at the time this projection was created. Total renewable generation, including heat and power generation, is expected to increase by 1.5% per year from 359 billion kWh in 2003 to 497 billion kWh in 2025.

Natural Gas Supply and Imports

Natural gas supply growth in the United States will be dependent on unconventional domestic production, Canadian imports, natural gas from Alaska, and LNG imports. Domestic natural gas production is expected to rise from 19.1 trillion ft3 in 2003 to 22.2 quadrillion Btu in 2025. Lower-48 onshore output of natural gas is expected to rise from 13.9 trillion ft.3 in 2003 to 15.7 trillion ft.3 in 2012 before declining to 14.7 trillion ft.3 in 2025. Lower-48 offshore production, which was 4.7 trillion feet 3 in 2003, is expected to rise in the near term (to 5.6 trillion feet 3 by 2015) due to the development of several large deepwater fields, including Mad Dog, Entrada, as well as Thunder Horse. Offshore production is expected to fall to 5.3 trillion ft.3 in 2025 after 2015.

Unconventional production is expected to emerge as the primary source of natural gas supply in the United States. Natural gas production from relatively abundant alternative sources (tight sands, shale, and coalbed methane) is expected to grow faster than conventional production due to technological advancements and rising natural gas prices.

Due to an increase in offshore AD gas production, production of associated-dissolved (AD) natural gas from lower-48 crude oil reserves is expected to rise from 2.5 trillion ft.3 in 2003 to 3.2 trillion ft.3 in 2010. Both onshore and offshore AD oil output are expected to decline after 2010, with total lower-48 AD gas production falling to 2.5 trillion ft.3 in 2025.

Decreases in Canadian natural gas imports are expected to be offset by significant increases in LNG imports and the construction of the North Slope Alaska natural gas pipeline. Canadian imports are expected to fall from 3.1 trillion ft.3 in 2003 to about 2.5 trillion ft.3 in 2010, then rise to 3.1 trillion ft.3 in 2016 as a consequence of rising natural gas prices, the introduction of gas from the Mackenzie Delta, and increased production of coalbed methane. Because of reserve depletion and rising domestic demand in Toronto, net US imports of Canadian natural gas are expected to fall to 2.7 trillion ft.3 in 2025. In other words, pipeline imports from Canada fall at the end of the forecast because Canada's gas consumption grows faster than its production. The forecasted Canadian natural gas supply reflects revised Energy Information Administration (EIA) expectations about Canadian natural gas production, particularly coalbed methane and conventional production in Alberta, which is based in part on data and projections from Canada's National Energy Board and other sources.

With the exception of the facility in Everett, Massachusetts, three of the four existing U.S. LNG terminals (Cove Point, Maryland; Elba Island, Georgia; and Lake Charles, Louisiana) are expected to expand by 2007; and additional facilities serving the Gulf, mid-Atlantic, and south Atlantic states, including a new facility in the Bahamas serving Florida via a pipeline, are expected to be built in New England and elsewhere in the lower-48 States. Another facility is planned for Baja California, Mexico, to serve a portion of the San diego market. Total net LNG imports to the US and the Bahamas are expected to rise from 0.4 trillion ft.3 in 2003 to 6.2 trillion ft.3 in 2025.

As a result of favorable investment economics and rising natural gas prices, the North Slope Alaska natural gas pipeline is expected to begin transporting Alaskan fossil fuel to the lower 48 states in 2017. In the October oil futures case, total Alaskan natural gas production is projected to be 32 billion ft.3 in 2025, up from 0.4 trillion ft.3 in 2003.

Major Changes Reflected in the AEO2006 Reference Case

The Annual Energy Outlook (AEO) 2006 is the first edition to include projections through 2030. The AEO2006 reference case projection includes new regulatory changes and laws enacted after the release of AEO2005 but before the completion of AEO2006. Two major regulatory changes that affect air emissions from electricity power plants just weren't represented in the October oil futures case: the ’s Clean Interstate Rule (CAIR), issued on March 10, 2005, and the Clean Air Mercury Rule (CAMR), issued on March 15, 2005. Over the next two decades, the new rules are expected to significantly reduce sulfur dioxide, oxides of nitrogen, and mercury emissions from power plants.

The Energy Policy Act of 2005 (EPACT2005, Public Law 109-58), which became law on August 8, 2005, is also new for AEO2006. The act includes tax breaks and loan guarantees for various types of energy production, such as new nuclear generation (up to 6 GW), integrated gasification combined cycle (IGCC) coal power generation, renewable generation, ethanol use for transportation, and a variety of efficiency programs aimed at reducing energy consumption, primarily in the residential and commercial sectors. The AEO2006 reference case only includes EPACT2005 sections that maintain specific tax credits, incentives, or standards, which account for about 30 of the legislation's roughly 500 sections.

The AEO2006 reference case also has significantly higher world crude oil prices than the October oil futures case. To provide a crude oil price that is more consistent with those reported in the media, the world crude oil price is now expressed in the form of the median price of imported low-sulfur crude oil to US refiners. Import prices for light crude oil are expected to rise from $40.49 per barrel (2004 dollars) in 2004 to $54.08 per barrel in 2025 and $56.97 per barrel in 2030.

The higher prices for imported light, low-sulfur crude oil are the result of significant shifts in expectations for key crude oil market drivers. First, major oil companies do not have access to resources sometimes in key oil-producing countries, and this is not expected to change during the projection period. Second, political insecurity and economic risk limit foreign investment in attractive oil primary sources of income where foreign investment may be welcomed. Third, revenues from national oil companies in key oil-producing countries flow to governments, which are under increasing pressure to fund social, welfare, and physical infrastructure projects to meet the needs of rapidly growing restive populations. In some cases, such demands have led to unilateral changes to agreements, increasing government revenues while increasing investment risks for potential investors. Changes to contracts made unilaterally are likely to reduce the rate of new investments to develop oil reserves. Finally, because global economies have grown robustly over the last 2-3 years despite crude oil prices exceeding $40 per barrel, and petroleum demand has seen only minor changes, there appears to be little incentive for key OPEC suppliers to aggressively ramp up production, significantly lower crude oil prices, and reduce their revenues.

The majority of the trends in the December oil futures case, as well as the reasons for the trends, are similar to the trends in the AEO2006 reference case. As a result, only the most significant differences in trends and their explanations would be highlighted in this section.

None of the projections as well as scenarios in AEO2005 or AEO2006 indicate the onset of "peak oil."Crude oil prices have historically varied significantly with prices in constant 2004 dollars; for example, crude prices exceeded $100 per barrel in the late 1970s and early 1980s. The new high world oil price path in AEO2006 reflects a new money invested and access constrained outlook for crude oil, in which global economies appear to be able to assimilate the new world oil price regime and crude oil exporters are content to reap the revenues.

The challenge for oil-rich producers is to balance the desire to raise prices and revenues with the risk of causing global economic damage by stimulating technological breakthroughs that could undercut their revenues in the long run. Although specific innovations and technological successes cannot be predicted or guaranteed, historical price declines from lofty highs have historically been preceded by innovation and technological and process advances (e.g., horizontal drilling, 3-D and 4-D simulations, breakthroughs in inexpensive computing, and many others). Breakthroughs that allow for relatively inexpensive extraction of oil shale, for example, could be one such future breakthrough for the production of crude oil if prices remain too high; breakthroughs in coal-to-liquids technologies and extraction of ultraheavy crude oils could also be examples. As a result, investors and planners should consider a plausible variety of world oil price scenarios, such as t

The challenge for forecasters and investors is to avoid extrapolating short-term trends into long-term forecasts without supporting analysis that focuses on the industry's changing fundamentals.

Implications of Higher World Oil Prices

Higher global oil prices in the AEO2006 reference case have significant implications for the future evolution of energy markets. The biggest impact is on the outlook for imported fossil fuels. Net petroleum imports are expected to account for a growing proportion of all petroleum demand. Higher world oil prices in the AEO2006 reference case, on the other hand, lead to increased domestic crude oil production and lower demand, reducing the need for petroleum imports to 60% in 2025 and 62% of petroleum demand (in barrels per day) in 2030, up from 58% in 2004.

Higher global oil prices influence fuel selection and vehicle efficiency decisions in the transportation sector. Higher oil prices increase demand for unconventional transportation fuels such as ethanol and biodiesel and, for the first time, stimulate coal-to-liquids (CTL) production. The transition to alternative fluid production is highly dependent on the level of oil prices.

Economic Growth

The federal funds rate, the nominal yield on the 10-year Treasury note, and the AA utility bond rate are all slightly lower than they were in October. In addition, the projected value of industrial shipments has been reduced, in part due to higher projected energy prices in the AEO2006 reference case. Despite higher energy prices in the AEO2006 reference case especially in comparison to the October oil futures case, GDP is projected to grow at an average annual rate of 3.0% from 2004 to 2030 in AEO2006, which is identical to the 3.0% per year growth projected in the October oil futures case from 2004 to 2025.

Energy Costs

The average world crude oil price rises from $40.49 per barrel (2004 dollars) in 2004 to $59.10 per barrel in 2006, then falls to $46.90 per barrel in 2014 as new supplies enter the market, according to the AEO2006 reference case. It then gradually rises to $54.08 per barrel in 2025, average wellhead natural gas prices in the United States are expected to gradually decline from their current level as drilling increases supply and new import sources become viable, falling to $4.46 per thousand ft.3 (2004 dollars) in 2016. After 2016, wellhead prices are expected to gradually rise to more than $5.40 per thousand ft.3 in 2025 and more than $5.90 per thousand ft.3 in 2030. From 2016 to 2025, the projected wellhead natural gas prices in the AEO2006 reference case are consistently higher than the October oil futures case, ranging from 25 to 60 cents per thousand ft.3, owing primarily to higher exploration and development costs.

Average delivered price of electricity are expected to fall from 7.6 cents per kWh (2004 dollars) in 2004 to 7.1 cents per kWh in 2018 as natural gas and, to a lesser extent, coal prices fall. Average real electricity prices are expected to rise after 2018, reaching 7.4 cents per kWh in 2025 and 7.5 cents per kWh in 2030.

Consumption of Energy

Total primary energy consumption is projected to rise from 99.7 quadrillion Btu in 2004 to 127.0 quadrillion Btu in 2025 (an average annual increase of 1.2%), 5.4 quadrillion Btu less than in the October futures case. In the AEO2006, coal, nuclear, and renewable energy consumption are higher in 2025, while oil and natural gas ingestion are lower.

Higher energy prices, particularly for petroleum and natural gas; lower projected growth rates in the manufacturing portion of the industrial sector, which compound word the most energy-intensive industries; highly competitive of hybrids and diesel vehicles in the transportation sector as purchasers focus more on efficiency; and the impact of the recently passed EPACT2005, which reduces encumbrance, total petroleum consumption is projected to rise from 20.8 million barrels per day in 2004 to 26.1 million barrels per day in 2025 in the AEO2006 reference case, 1.2 million barrels per day lower in 2025 than in the October futures case. Petroleum demand growth in the AEO2006 reference case is lower in all sectors, owing largely to the impact of much higher oil prices in AEO2006, with transportation accounting for nearly two-thirds of the decline.

Total natural gas consumption in the AEO2006 reference case is projected to rise from 22.4 tcf in 2004 to 27.0 tcf by 2025, 3.9 tcf less than in the October oil futures case, owing primarily to the impact of higher natural gas prices. Natural gas consumption is expected to fall slightly by 2030, after peaking at 27.0 tcf, as natural gas loses market share to coal to generate electricity in the later years of the projection due to higher natural gas prices.

Total coal consumption in the AEO2006 reference case is projected to rise from 1104 million short tons in 2004 to 1592 million short tons in 2025 84 million short tons greater than the 1508 million tons in the October oil futures case. Coal consumption is expected to grow faster toward the end of the projection, particularly after 2020, as coal overtakes natural gas in power generation due to rising natural gas prices and as coal use for CTL manufacturing expands. In the October oil futures case, coal was not expected to be used for CTL production. Total coal consumption for electricity generation is projected to rise from 1235 million short tons in 2020 to 1502 million short tons by 2030, an average rate of 2.0% per year, in the AEO2006 reference case, while coal consumption for CTL production rises from 62 million short tons in 2020 to 190 million short tons in 2030.

Electricity Generation

The projected average prices of natural gas and coal delivered to electricity generators in 2025 in the AEO2006 reference case are higher than the comparable prices in the October oil futures case. While coal consumption in both projections is similar in 2025, the increase in natural gas prices, combined with slower projected growth in electricity demand and incentives for renewable, nuclear, and advanced coal generation technologies, leads to substantially lower levels of natural gas consumption for electricity generation. As a result, in the AEO2006 reference case, cumulative generation capacity and generation from natural-gas-fired power plants are lower, while capacity additions and generation from coal-fired power plants are similar to the October oil futures case through 2025. In fact, natural gas generation is expected to decline in the later years of the projection as it is displaced by generation from freshcoal mines

The share of natural gas in electricity generation (including generation in end-use sectors) is expected to rise from 18% in 2004 to 22% around 2020 before falling to 17% in 2030. Coal's share is expected to fall from 50% in 2004 to 49% in 2020, then rise to 57% by 2030. According to the AEO2006 reference case, 87 GW of new coal-fired generating capacity is expected to be built between 2004 and 2025. In the AEO2006 reference case, 154 GW of new coal-fired generating capacity is anticipated to be added from 2004 to 2030, including 14 GW at CTL plants.

In the AEO2006 reference case, nuclear generating capacity is projected to increase from 99.6 GWin 2004 to 108.8 GW in 2020 (10% of total generating capacity) and continue to stay at this level through 2030. The 9 GW increase in nuclear capacity among both 2004 and 2030 is made up of 3 GW of uprates of existing plants and 6 GW of new plants stimulated by EPACT2005 provisions. The nuclear plants planned for 2014 and beyond will be the first plants ordered in the United States in more than 30 years. In the AEO2006 reference case, total nuclear generation is projected to increase from 789 billion kWh in 2004 to 871 billion kWh in 2030, but nuclear capacity is projected to account for only about 15% of total generation in 2030.

Higher fossil fuel prices, as well as extended tax credits in the EPACT2005 and state renewable programs, are expected to boost the use of renewable technologies for electricity generation. The projection includes the expected impacts of state renewable purchase standards, which specify a minimum share of era or sales from renewable sources. The AEO2006 reference case also includes the EPACT2005-enacted extension and expansion of the production tax credit for wind and biomass through December 31, 2007. Total renewable generation, including combined heat and power creation, is expected to increase by 1.7% per year in the AEO2006 reference case, from 358 billion kWh in 2004 to 559 billion kWh in 2030.

Energy Intensity

In the AEO2006 reference case, energy intensity, as measured by energy use per 2000 dollar of GDP, is anticipated to decrease at an average annual rate of 1.8% between 2004 and 2030, with efficiency gains and developments in the economy dampening growth in demand for energy offerings. The rate of decline in fuel efficiency is faster than the projected 1.6% annual rate in the October oil futures case between 2004 and 2025, owing to higher energy prices in the AEO2006 reference, which are expected to result in lower levels of energy consumption overall.

Energy Production and Imports
Imports and Production of Energy

Net energy imports on a Btu basis are expected to account for a growing share of total energy demand. Net imports are expected to account for 32% and 33% of total US energy consumption in 2025 and 2030, respectively, up from 29% in 2004, but significantly lower than the partner gets projected in the October oil futures case (36.5%) of AEO2005 for 2025. Higher crude oil and natural gas prices in AEO2006 result in increased domestic energy production and decreased demand, reducing the projected increase in imports.

Net petroleum imports, including both natural gas and refined products, are expected to account for 60% of demand (on a barrel-per-day basis) in 2025 in the AEO2006 reference case, compared to 66% in the October oil futures case, open from 58% in 2004. In the AEO2006 reference case, net petroleum imports account for 60% of demand in 2025 and 62% of demand in 2030.

In the AEO2006 reference case, total domestic natural gas production rises from 18.5 tcf in 2004 to 21.2 tcf in 2025 before falling to 20.8 tcf in 2030. In the AEO2006 reference case, development in LNG imports is projected to meet a large portion of the increased demand for natural gas, but the increase is less than that projected inside the October oil futures case. Higher domestic and imported LNG gas prices, which reduce domestic natural gas demand, moderate the growth of LNG imports in the AEO2006 reference case.

Because of higher petroleum product prices, international oil and gas demand is expected to rise, driving up LNG prices. Higher international LNG prices are expected to reduce demand for LNG in the United States.

Subsidies

When most people think of subsidies, they envision helping the poor pay for things they can't afford. Right? In the game of energy infrastructure, being poor has nothing to do with subsidies...most of the time. Consider Loudoun County, Virginia, which has the nation's highest Median Household Income (MHI). In 2011, their MHI was around $119,000 per year. That was the average. This means that more than half of the households earned more than $119,000. Consider the Loudoun County household with absolute highest income. Would you be surprised to learn that the families receive financial assistance from the Commonwealth of Virginia A wise mentor of mine divides subsidies into two categories? The first type of subsidy is "general, supply-based subsidies." That is what you will find in Loudoun County. The second type of subsidy is "targeted, demand-driven subsidies."

Consider a young family in the west who lives in a double-wide, has a household income of about $22,000 per year, has two young children, one of whom has asthma, and lives in a valley where air quality is classified as nonattainment due to the wood smoke that hangs over their valley like the sword of Damocles. The young couple's home is heated solely by an old wood stove. They have to light it when it gets cold.

When they light it, however, they are slowly killing their asthmatic daughter. There was a $1500 income tax program a few years ago for, among other things, replacing old wood stoves. Our young couple can no longer claim a tax credit. They do not pay any taxes. Their income is insufficient. They are not eligible for the tax credit. On the other hand, wealthy neighbors with weekend cabins on mountain tops can use it. But not for people in desperate need of assistance, such as our young couple. Instead of this wasteful general subsidy, how about a 100% cash rebate (subsidy) for people who: (1) live in nonattainment areas, (2) live below the poverty line, (3) have no other source of home heat, and (4) have a pulmonary ailment. These exceedingly narrow criteria may seem excessive, but this is what we mean by a "targeted, demand-based" subsidy.

Let us now demonstrate how truly wasteful general, supply-based subsidies are by using the most infamous example of all: the tax-exempt municipal bond.The United States Supreme Court ruled in 1895 that Congress lacked the constitutional authority to tax the interest on state or local debt.

This position was made statutory in 1913. The rule of thumb in the municipal bond market is that the best (AAA/Aaa) municipal bonds should have interest rates that are approximately 75% of the US.Treasury bonds with the same name. Assume an interest rate environment in which 20-year treasuries carry an 8% interest rate. Under these conditions, AAA/Aaa tax-exempt municipal bonds should carry a yield of around 6%. Assume that the 8% Treasury was purchased by the richest householder in Loudoun County. We'll refer to her as Ms Loudoun.

She would earn $800 per year in interest if she purchased $10,000 in these bonds. Ms Loudon, who is in the 35% tax bracket, would pay $280 in federal income taxes, resulting in net earnings of $520.Let us instead assume that Ms Loudoun purchased $10,000 in tax-exempt bonds with a 6% interest rate issued by the Commonwealth of Virginia. Ms Loudoun would receive $600 in interest in this latter case. Ms Loudon gets to keep the entire $600 because the interest is tax-free under federal law. She does not pay a single penny of the $600 in taxes. So, if Ms Loudon purchased the 6% tax-exempt bond, she would be $80 better off than if she purchased the 8% Treasury and paid taxes on it.

Overview Impacts of the AEO2006 High-Price Case

Although short-term rain and wind events (e.g., hurricanes) and geopolitical instabilities (e.g., terrorist actions and attempts by some producers to withhold supply) could push crude oil prices well above $100 per barrel in 2004 dollars for months or even years, the author believes that sustained crude oil prices above $75 per barrel for the next 25 years are unlikely for technical reasons. † Nonetheless, such a scenario should be considered for contingency planning purposes. This section assesses the effects of high oil and natural gas prices, as defined by the AEO2006 high-price case, on the transportation and power generation sectors of the United States' energy economy. To provide balance and context, the AEO2006 low-price and reference price cases are also briefly described. The AEO2006 high- and low-price cases reflect lower or higher domestic and international unproven/undiscovered energy resources than the reference case, respectively. Based on the assumptions that unproven/undiscovered global and domestic oil resources are 15% lower than the reference case and that the OPEC cartel adjusts output to maintain higher prices, the high-price path reaches $96 per barrel for foreign low-sulfur light crude oil (FLL) in 2030. In this case, OPEC's share of global oil production is expected to fall to 31% from over 38% in 2005. The low-price case forecasts that crude oil prices (FLL) will fall to around $34 per barrel in constant 2004 dollars because undiscovered oil and natural gas resources are assumed to be 15% greater than in the reference case and OPEC chooses to maintain its 2005 market share of around 38% through 2030. Higher oil prices, all else being equal, will stimulate more exploration and production, particularly in non-OPEC countries, as well as increase crude oil and alternative liquids production from oil sands, coal-to-liquids (CTL), gas-to-liquids (GTL), shale oil, ethanol, and other biofuel liquids. Furthermore, higher prices will help the environment through price-induced conservation (for example, fewer vehicle miles traveled or lower thermostat settings for heat pumps) and increased efficiency uptake (e.g., more efficient cars)

Impacts of High World Oil Prices on Oil Imports

The country's reliance on imported oil is sensitive to global oil prices. Imported oil is projected to increase from 58% of total oil supply in 2004 to 68% in 2030 in the low-price case; in the reference and high-price cases, imported oil shares are 62% and 53%, respectively. Net oil imports are expected to rise from slightly more than 12 million barrels a day in 2004 to more than 17 million barrels per day in 2030 in the reference case. In the low-price scenario, oil imports are expected to exceed 20 million gallons per day in 2030. The high-price scenario is expected to moderate demand, resulting in oil imports remaining close to 2005 levels, around 13 million barrels per day

As in the US, projected oil prices have a direct impact on global oil consumption: higher projected oil prices result in lower projected global oil consumption. In the reference case, global oil consumption is expected to rise from around 82.5 million barrels per day in 2004 to around 118 million barrels per day in 2030, whereas in the low and high-price cases, global oil usage is expected to be 128 and 102 million barrels per day, respectively.

CHAPTER 4

BASICS OF GRANTS

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Grants are essentially subsidies. As a result, they should only be used in exceptional circumstances. And, as previously stated, they should be precisely targeted.

The following are the four legal uses of grants:

1. Paying for unaffordable environmental services for individuals or communities: Remember our young couple with the sick child? They needed a new wood stove to keep their house warm and their baby daughter healthy. What kind of government assistance were they eligible for? They were too poor to take advantage of a tax credit. What did they require? A gift. Either a full grant or something close to it. That is an example of how grants for individuals can be put to good use.

The USDA water and wastewater program is an excellent example of a sound community grant. When the USDA determines that a project will cost a significant portion of MHI and will raise rates higher than in neighboring districts, the USDA will use grant money to reduce the cost of the project to levels that are affordable to the average ratepayer. Grants for specific communities.

2. Inducing people or businesses to make environmental improvements that they are not legally required to make: When the American Reinvestment and Recovery Act (ARRA) was passed in 2009 to help us recover from the subprime mortgage crisis, renewables were just getting started as a big buzzword. ARRA included significant grant funds for those who wanted to reduce their carbon footprint by installing solar panels. Nobody was forced to install any renewable or energy-saving devices. As a result, the taxpayer pays them to do so. That's a good idea.

Another good example is cover crops. A large amount of nitrogen remains in the soil after crops are harvested. With snow and rain on the now-bare soil, much of this nitrogen migrates to the nearest water body, polluting it. After the main crop has been harvested, cover crops are planted. Their sole purpose is to soak up excess nitrogen in the soil, preventing it from polluting streams or ponds. We pay (i.e., give grants to) farmers in the United States who plant cover crops. These grants are funded by "farm bills," which Congress passes in order to maintain its complex scheme of agricultural subsidies. Germany, too, has a cover crop program. It is also an aid program, but in Germany, the grants are funded by a special tax levied each year. The point here is that growing cover crops is beneficial. However, this is entirely voluntary. There is no law requiring farmers to plant cover crops anywhere. As a result, we should use grants to persuade them.

3. Development or commercialization of new environmental technologies. Until recently, installing solar panels was prohibitively expensive. Even with generous government financing programs, the monthly cost of the panels outweighed the electricity savings from the panels. The

United States Department of Energy launched a grant (i.e., a subsidy program) for solar panel manufacturers in order to jump-start the solar industry. China followed suit. However, Chinese subsidies were so large that Chinese manufacturers were able to sell their solar panels at a loss. The Chinese government created subsidies so that their manufacturers could export all over the world, resulting in the creation of thousands of good manufacturing jobs in China. The United States, the European Union, and China are currently engaged in a trade war over this issue. Regardless of the trade issue, using grants to kick-start new, necessary environmental techniques is a great idea.

4. Environmental/Energy Education: Making small grants to community groups is a good way to get them interested in energy efficiency and environmental issues like climate change. This is especially true for poorer groups that are unable to raise funds for projects on their own. The Chesapeake and Atlantic Coastal Bays Trust Fund is a grant fund in Maryland that most residents refer to as the "green fund." This fund is small, but it provides grants to community groups for activities such as streambed restoration and tree planting.

Educating people about the importance of the environment and the steps needed to protect it is unquestionably a worthwhile use of public funds. And, in this case, grant funds are absolutely necessary.

Cost/Benefit Analyses

Cost/benefit analyses are critical for two related reasons. First, to ensure that funds for projects or energy-saving devices are spent wisely, and second, to persuade the public of the very same, so that they will support these programmes.

These analyses can become complicated when it comes to financing water and wastewater facilities. They entail gathering empirical data from the general community, which is difficult to come by in some less-developed countries. However, in terms of energy efficiency and renewable energy, they are quite simple at least in theory.

The benefit of energy-saving devices is the number of kilowatt hours saved.

It is the number of kilowatt hours generated in the case of renewables. For energy efficiency devices, the cost is the price of the device paid over the device's service lifeat the lowest possible rate of interest.

This is simple for devices like light bulbs. You are aware of the four crucial pieces of information required to complete the cost/benefit analysis. How many lumens the bulb will produce.

You are aware of how many watts the bulb consumes per hour. You are aware of the bulb's service life in hours (at least as estimated by the manufacturer). You also know how much the bulb costs. With these four pieces of information, you can perform a cost/benefit analysis on these bulbs, allowing you to compare them to find the best value.

The installed cost of generating one kilowatt hour of electricity is the cost of renewables. This is a little unusual. Most people measure installed power in kilowatts rather than kilowatt hours. However, many renewables, such as wind and solar, do not produce power on a continuous basis. They produce infrequently. Here's a very simpler example that excludes the cost of maintenance, among other things.

Assume two homeowners, one in Buffalo, New York, and the other in Las Vegas, Nevada, each purchase a 4 kW solar array for $5/W installed, or $20,000/W. Assume they each finance the others for a 20-year term at 5% interest for an annual payment of $1605. Las Vegas receives 3825 hours of sunlight per year on average. So our Las Vegas homeowner pays $0.42/kW h.

Buffalo, on the other hand, receives 2207 hours of sunlight per year. As a result, our Buffalo homeowner pays $0.73/kWh.

Impacts of High World Oil Prices on Domestic Unconventional Liquids Supply

High global oil prices encourage the development of unconventional liquids technologies. In the high-price case, gas-to-liquids (GTL) plants are expected to be built on Alaska's North Slope to convert stranded gas into zero-sulfur distillates that will be transported via the Trans-Alaska pipeline to Valdez and shipped to the lower 48 states for use on the west coast. GTL production is expected to be profitable and reach 200,000 barrels per day in 2030 only in the most expensive case because access to cheap Alaskan natural gas supplies is expected to be committed to the Alaska natural gas pipeline, which is expected to be completed by 2015.

For the reference and high-price cases, coal-to-liquids (CTL) plants are expected to be built in the lower 48 states. Full-scale CTL production is expected to begin in 2011 in both the reference and high-price cases, with the reference case reaching just under 800,000 barrels per day in 2030 and the high-price case reaching around 1.7 million barrels per day Significant environmental and water uncertainties may have an impact on the potential expansion of CTL plant investments.

Oil shale syncrude production costs are even unsure than CTL production costs. During a period of low oil prices in the mid-1980s, development of this domestic resource came to a halt. The cost assumptions used to develop the AEO2006 projections are based on an oil shale industry based on underground mining and surface retorting. However, the development of true in situ retorting technology could significantly reduce the cost of producing oil shale syncrude, potentially making it economically viable in the reference case. Oil shale production is not economically viable in the low-price and reference cases of AEO2006, but it is expected to become economically viable in the high-price case around 2020; oil shale production is expected to steadily rise to over 400,000 barrels per day by 2030.

Impacts of High World Oil Prices on Ethanol Production

The Energy Policy Act of 2005 (EPAct 2005) requires that at least 7.5 billion gallons of ethanol be used for gasoline-based transportation by 2012. Following that, consumption must rise proportionally to gasoline consumption. World oil costs are rising enough in all of the AEO2006 price cases to exceed the legal minimums. In 2012, ethanol consumption is expected to be between 9.6 but also 9.9 billion gallons in the three price scenarios, rising to between 11 and 15 billion gallons in 2030.

The highest gasoline prices, as expected, encourage the highest ethanol consumption. The majority of the ethanol is expected to be produced from corn, with only a small amount of cellulosic ethanol (250 million gallons per year) expected to enter the market as a result of EPAct 2005 incentives. Reduced capital costs and breakthroughs in the cost of manufacturing the enzyme required for cellulosic ethanol converting could change the competitive landscape for cellulosic ethanol.

Full Cost Pricing

Now, the remaining ratepayers who can afford to pay the full cost of their service should do so. Nobody wants to pay more. No board member or politician enjoys raising rates. However, interest rates can be gradually increased. (When raising rates over a period of, say, five years, the authorizing resolution should really be passed today for all future increases. This will save the board and/or politicians the agony of having to go back to the people for more money every year.)

Increasing rates, whether to entire pricing or not, will encourage conservation. People will conserve more if interest rates rise. Consider raising our gasoline prices to the $7+ per gallon levels found in Europe. People would almost certainly find ways to drive less. Automobile manufacturers would also improve. The same is true when you raise your power rates. People figure out how to use less.

Finally, higher rates will spur innovation, which will eventually result in lower costs. Consider the installation of a $10 million technology in a system with full-cost valuations, that is, no subsidies. Engineers and scientists will understand that if they can develop a technology that performs the same or better job at a lower cost, they will be able to enter the game without being trumped by some hidden subsidy.

As a result, these main principles should be used to guide the development of any renewable energy or energy efficiency financing programs.

Now that you know how to spend money wisely, please consider a few more principles—these to find the funds that you will spend wisely.

1. Raise funds through a variety of small charges, fees, or taxes rather than a single large one. Many small money sources are more stable than a single large one. A small tax or surcharge applied to vehicle registration based on fuel consumption. A carbon tax is incorporated into electricity bills.

2. Once gathered, place all environmental funds in one basket. Do not splinter or piddle that as well away. Change your behavior while raising funds. Tax the polluters more heavily all whilst rewarding energy efficiency and green practices.

4. Use "dedicated revenue streams" (such as annual taxes or fees) to fund capital expenses rather than operational expenses. Revenue streams derived from charges such as vehicle/fuel ingestion and carbon tax are highly consistent and predictable.

As a result, they are an excellent, high-quality source of repayment for bonds issued to fund energy efficiency and renewable energy projects. They can be used to achieve the highest, AAA, bond ratings, resulting in the lowest possible interest rates, with proper structuring. Furthermore, these reliable revenue streams do not even have to be used to repay bonds in order to achieve AAA ratings! They can simply be pledged to repay! In other words, consider a small business energy efficiency/renewable energy program. Small businesses aren't known for having excellent credit ratings. Furthermore, because many small businesses rent their space, there is no real estate that may serve as collateral. A bond containing an investments of uncollateralized loans to small businesses would receive either no rating or a triple zilch rating in this case. In this case, the bonds could be structured with loan receivables as the primary source of repayment and the revenue stream as a secondary source of repayment, with the revenue stream being called upon only if a small business defaulted on its loan.

5. Make it as easy as possible for yourself. Raising the rates on a general tax, such as the income tax, will elicit howls of protest across the country. It will mobilize armed forces of lobbyists in Washington who will roam the halls of Congress begging and bullying members to vote against it. The same thing will happen at the state level if an income tax increase or a personal property tax increase is proposed. Almost every newspaper in the state will run an editorial opposing it. Lobbyists will also swarm the state legislature. The greater the opposition, the less likely an ecological environment finance program will be implemented.

This chapter is titled "Sound Finance Policies for Energy Efficiency and Renewable Energy." These seven principles should be used not only to design programs that spend money on energy efficiency and renewable energy projects in the most efficient way possible, but also to raise funds for such programs in the most efficient way possible.

High Oil and Gas Prices Increase Coal-Based Generation

As natural gas prices rise, the power generation industry in the United States is expected to rely more on coal-based generation. The electric power sector's consumption of natural gas is the most affected by natural gas prices over time of the four major gas usage sectors (residential, commercial, industrial, and electric power).

The base, intermediate, and reached its peak portions of the electricity load duration curve can be served by gas-fired generation facilities. As gas prices continue to rise, operating costs become a more important consideration in capacity addition and delivery decisions. With higher natural gas prices, an increasing proportion of new electricity generators are expected to be coal-fired facilities, which are placed in the load duration curve ahead of gas-fired facilities, displacing gas-fired generators from operating in the base and later with in intermediate-load portions of the load duration curve, limiting their operation to the peaking portion of the curve.

In the reference case, gas consumption in the electricity sector is expected to rise from 5.3 trillion ft.3 in 2004 to 6.4 trillion ft.3 in 2030. In comparison, the electric power sector is expected to consume 9.9 trillion ft.3 in the low- and high-price scenarios in 2030, respectively.Natural gas prices rise, the construction of steam coal facilities rises, which decreases the amount of gas-fired capacity by 2030 in comparison to the AEO2006 reference case. The reference case increases combined cycle gas-fired facilities from 159 GW in 2004 to 231 GW in 2030. The high-price case projects 191 GW of gas-fired combined cycle capacity in 2030, while the low-price case projects 281 GW of air combined cycle capacity.

In the case of high gas prices, the majority of the reducing in gas-fired electricity generator building works is offset by an increase in coal-fired electricity generation facilities. Coal-fired steam capacity increases from 310 GW in 2004 to 457 GW in 2030 in the reference case. Coal-fired steam capacity is expected to be 380 and 509 GW in the low- and high-price scenarios, respectively.

Economics Methods

As natural gas prices rise, the power generation industry in the United States is expected to rely more on coal-based generation. The electric power sector's consumption of natural gas is the most affected by natural gas prices over time of the four major fuel usage sectors (residential, commercial, industrial, and electric power).

The base, intermediate, and spiking portions of the electricity load duration curve can be served by gas-fired generation facilities. As gas prices continue to rise, operating costs become a more important consideration in capacity addition and dispatch decisions. With higher natural gas prices, an increasing proportion of new electricity generators are expected to be coal-fired facilities, which are placed in the load duration curve ahead of gas-fired facilities, displacing gas-fired generators from operating in the outpost and later in the intermediate-load portions of the load duration curve, limiting their operation to the peaking portion of the curve.

In the reference case, gas consumption in the electricity sector is expected to rise from 5.3 trillion ft.3 in 2004 to 6.4 trillion ft.3 in 2030. In comparison, the electric power sector is expected to consume 9.9 trillion ft.3 in the low- and high-price scenarios in 2030, respectively.

As natural gas prices rise, the construction of steam coal facilities rises, reducing the level of air capacity by 2030 in comparison to the AEO2006 reference case. The reference case increases combined cycle gas-fired facilities from 159 GW in 2004 to 231 GW in 2030. The high-price case projects 191 GW of gas-fired combined cycle capacity in 2030, while the low-price case projects 318 GW of gas-fired combined cycle capacity.

In the case of high gas prices, the majority of the reduction in gas-fired electricity generator construction is offset by an increase in coal-fired electricity generation facilities. Coal-fired steam capacity increases from 310 GW in 2004 to 457 GW in 2030 in the reference case. Coal-fired steam capacity is expected to be 380 and 509 GW in the low- and high-price scenarios, respectively. The emphasis is on microeconomic methods for calculating the cost-effectiveness of individual projects or groups of projects, with explicit consideration for uncertainty.

Making Economically Efficient Choices

Economic-evaluation methods can be used to improve the economic efficiency of energy-related decisions in a variety of ways. There are methods for obtaining the greatest possible savings in energy costs for a given energy budget; methods for achieving a targeted reduction in energy costs for the smallest possible efficiency/renewable energy investment; and methods for determining how much it pays to spend on energy efficiency and renewable energy to lower total lifetime costs, including both investment expenses and energy cost savings.

The first two applications of economic-evaluation methods (obtaining the greatest savings for a fixed budget and obtaining targeted savings for the smallest budget) are more limited than the third, which aims to minimize total costs or optimize NB (net savings) from expenses on energy efficiency and renewable. As an example, a plant owner may set aside a certain amount of money for the purpose of retrofitting the plant for energy efficiency. As an example of the second, state or federal building standards and/or codes may require designers to reduce the design energy loads of new buildings below a certain level. As an example of the third, engineers may be required by their clients to include energy efficiency and renewable energy features in a manufacturing plant that will pay off in terms of lower overall production costs in the long run.

It should be noted that economic efficiency is not always synonymous with engineering thermal efficiency. For example, one furnace may be more "efficient" than another in the engineering sense if it produces more units of heat for a given amount of fuel. However, if the initial cost of the higher-output furnace outweighs the fuel savings, it may not be economically efficient.

Economic efficiency is conceptually illustrated in with an investment in energy efficiency. The level of energy sustainability, Qc, that maximizes NB from energy efficiency, i.e., the most profitable in the long run. It is worth noting that this is the point when the curves are the furthest apart.

The degree of saving energy is raised. The point at which the marginal curves intersect corresponds to the most profitable level of energy conservation indicated. This is the point at which the cost of adding one more unit of conservation is just equal to the corresponding energy savings (i.e., the point at which "marginal costs" and "marginal benefits" are equal). To the left of the intersection, the extra benefits of increasing the level of conservation by that other unit outweigh the extra costs, and it pays to invest more to the right of the intersection point, the costs of increasing the level of conservation outweigh the benefits, and the level of total NB begins to fall. The most economically efficient level of energy preservation, Qc, is one with the lowest total cost curve.

Economic-Evaluation Methods

There are several closely related and widely used methods for assessing economic performance. These are the LCC method, the levelized cost of energy method, the NB (net present worth) method, the benefit-cost (or income) ratio method, the internal rate-of-return method, the overall rate-of-return method, and the payback method. When the important effects could be measured in dollars, all of these methods are used. If unmeasurable effects are critical to the decision, they must be considered as well. However, because these economic methods only include quantified effects in their calculations, unquantified effects must be treated outside of the models.

Life-Cycle Cost Method

The life-cycle costing (LCC) method totals the costs of acquisition, maintenance, repair, replacement, electricity, and any other monetary costs (less any income amounts, such as salvage value) that are affected by the investment decision for each investment alternative. For all amounts, the time value of money must be considered, and the amounts must be considered over the relevant period. All amounts are typically expressed in either present value or annual value dollars. This is covered in more detail under "Discounting" and "Discount Rate." For comparison, the investment alternatives should include at least one "base-case" alternative of not investing in energy efficiency or renewables, as well as at least one case of investing in a precise efficiency or renewable system. Several alternatives can be compared. The preferred investment is the alternative with the smallest LCC that meets the investor's objective and constraints.

where LCCA1 represents the life-cycle cost of alternative Al, IA1 represents the present-value investment costs of alternative A1, EA1 represents the present-value energy costs associated with alternative A1, MA1 represents the present-value nonfuel operating and maintenance cost of A1, RA1 represents the present-value repair and replacement costs of A1, and SA1 represents the current resale (or salvage) value less disposal cost related to alternative A1.

The LCC method is especially useful for decisions based primarily on cost effectiveness, such as whether a specified energy efficiency or renewable energy investment would then lower total cost (e.g., the sum of investment and operating costs). It can be used to compare different system designs or sizes as long as the systems perform the same function. If used correctly, the method can be used to determine the most cost-effective combination of energy efficiency and energy supply investments within a given facility. However, it cannot be used to find the best investment in general because completely different investments do not provide the same service.

Investment

Renewable energy and energy-efficient technologies are typically distinguished by higher upfront costs that result in significantly lower fuel and/or operational cost (although not all technologies fit this description; for example, biomass energy can involve significant ongoing costs for fuel and operations). Many early policy incentives, both federal and state, were aimed at lowering the acquisition cost of these technologies, frequently by applying for tax credits proportional to capital investment costs. In certain cases, such as the early deployment of wind generating technology in California in the 1980s, it was believed that investment incentives provided insufficient incentive for high-quality technology or projects that would continue to operate after the initial incentive was fully realized by the project owner. However, such failures can also be attributed to a lack of technology qualification measures, such as technology criteria or screening. Despite the apparent shortcomings of investment incentives in the early United States wind industry, they are still widely used in federal and state policies for other cleaner energy technologies.

Federal tax breaks proportional to investment in green energy sources aided in the early adoption of these technologies in the 1980s. Originally included in the Energy Tax Act of 1978, the investment tax credit was permanently set at 10% for solar and geothermal facilities by the Energy Policy Act of 1992 (EPACT 92), and is currently 30% for solar facilities through 2016. It directly offsets federal corporate income tax liability in proportion to the initial investment cost of the covered technology. Current federal regulations additionally enable technologies that are eligible for the production tax credit (PTC) (see the following section) to receive a 30% investment tax credit instead. Furthermore, most renewable energy generation technologies qualify for preferential federal tax declining balance allowance schedules.

The Modified Accelerated Cost Recovery Schedule depreciates renewable generation investment costs much faster than other generation technologies, and use a 5-year schedule rather than a 15- or 20-year schedule for combustion turbines or other thermal plants.Some states also offer or have offered tax breaks for investments in renewable energy or energy efficiency. Additional investment tax credits in California during the 1980s, along with other policies such as the Public Utilities Regulatory Policy Act, aided in the state's early adoption of wind and solar thermal generating capacity. Several states currently provide significant investment tax credits for preferred renewable energy technologies such as photovoltaic (PV) systems.

These credits, on the other hand, are not uniformly available, vary significantly between states that do offer them, and may apply to electric generating technologies or facilities that produce renewable fuels such as ethanol. Rebates or exemptions from state-imposed sales taxes on renewable technologies as well as energy-efficient appliances and equipment provide a mechanism for lowering the enduser's initial cost of adopting these technologies. The availability of such programs varies greatly by state, as do sales tax rates and the value and timing of any rebates or exemptions that are offered. Sales tax exemptions may also or instead apply to renewable fuels such as biofuel. In this context, such a program may have more of a production incentive effect than an investment incentive. Certain low-mileage vehicles will be subject to a "gas guzzler" tax, which serves as a disincentive for low-efficiency technology investment.

Production/Utilization

Production-based tax incentives provide a tax credit proportional to the amount of commodity produced or sold in a given year, such as electric generation. Because production-based incentives reward project performance, they should tend to shift project performance risk to the project owner rather than the taxing authority, and they should do so without the need for extensive eligibility conditions or screening of each project or technology.

However, production-based incentives may not be applicable to technologies that do not produce easily marketable (and thus taxable) output, such as most energy-efficiency devices, or where the output is generally consumed on-site (without a fourth transaction), such as on-site PV. In these cases, there may not be a sufficiently auditable record of production, or the establishment of an auditable record (such as internal PV output metering) may add unneeded cost to a project.

The PTC for renewable electricity, established by EPACT 92 and later modified, provides an inflation-adjusted payment of 2.3/kW h in 2013 for third-party electricity sales from the plant during the first ten years of operation. Since its inception, the list of technologies eligible for the tax credit has grown to include wind, various types of biomass resources, geothermal, and landfill gas. Certain technologies, however, do not receive the full credit amount or the same 10-year claim period. Since 1998, the PTC has been widely credited with helping to drive significant growth in wind power in the United States. The credit expired for projects beginning development after December 31, 2013, after being allowed to expire and then extended several times. Several states also provide tax breaks for the production of preferred renewable energy sources.

A $1.00 per gallon tax credit for biodiesel and $0.50 per gallon tax credit for other qualified alternative fuels, including certain biomass-derived fuels, expired at the end of 2013. A number of states also offer tax breaks for ethanol or other renewable fuel production. These credits may be used to reduce income tax liability or, like with the federal credit, to offset motor fuels taxes (in effect, a sales-tax rebate). State programs differ in terms of credit amount as well as restrictions on fuel origin.

Regulator

Regulatory mechanisms generally impose restrictions on market activity. Intended to result in higher adoption of preferred policy technologies or restrictions on Technologies that are contrary to policy. Typically, costs are borne directly by market participantsor by both energy producers and consumers. Although regulatory policy may have an impact this section will look at three major types of regulatory intervention in markets: target-based standards, market facilitation or limitation policies, and technology. Specification standards. Achievement and require regulated industry to achieve the goal. The most significant kinds Renewable electricity targets have been established as part of goal-based standards in US energy policy. The Renewable Fuels Standard (RFS) for transportation fuels, enacted by various states, and the federal government establishes automotive fuel efficiency standards.

Renewable energy targets can be expressed as absolute levels of capacity (or generation) or as a percentage of some future level of total generation (or capacity). Generally these targets, known as renewable portfolio standards (RPS), can be set for a single future year, or on a gradually increasing compliance schedule. Energy from renewable sources Goals found in a few states can resemble RPS programs, but they are generally unenforceable. RPS policies can impose provisions, but they cannot be considered regulatory policy.

Absolute compliance by influenced utilities, or, as is frequently the case, the accumulation of "renewable energy credits" (RECs) that can facilitate either inter-temporal compliance or absolute compliance “banking” (i.e., using RECs earned in 1 year that meet compliance targets in another year) (i.e., using RECs earned in 1 year to meet compliance targets in another year) as well as interutility or interstate credit buying and selling (whereby a utility that over-complies may sell RECs to a utility that cannot meet targets with native resources). The majority of RPS states

Policies restrict the geographic source of compliance to resources within the state. The state's electric power pool(s), or resources that can be "delivered" to the state state or state power pool. The current REC selling price can also be used to calibrate. A fine or alternative compliance payment, usually in the form of a price ceiling the state will provide RECs (even if there is no actual renewable capacity or generation) or otherwise. Actual compliance is waived. Such "safety-valve" prices are typically intended to provide a clear benchmark. The greatest impact on overall electricity prices. Other states might have a "safety valve" in place.

Compliance is explicitly limited based on realized electricity rate impacts, and in some statesCompliance may also be waived or delayed for other legally permissible reasons, such as protecting the financial solvency of affected utilities. Policies differ significantly across states in terms of resource eligibility, "grandfathering" of existing capacity, and mechanisms. To demonstrate preferences among eligible technologies, such as by awarding "bonus" credits or setting different targets for preferred technologies. The federal RFS was established by the Energy Policy Act of 2005 and the Energy Policy Act of 2007.

Act of Independence and Security of 2007. It establishes volume-based ethanol targets. Advanced biofuels, with annual increases through 2022. By this year, the RFS will necessitate billion gallons of renewable fuel will be used. The law requires the use of various fuel types by restricting the use of conventional ethanol (ethanol derived from corn). Compliance and volumetric targets for various advanced biofuels are being established. Advanced biofuels are fuels derived from "cellulosic" feedstocks, such as ethanol and biodiesel. "Drop-in" fuels and other qualifying formulations. Compliance is monitored using the RINs (Renewable Identification Numbers) are assigned to each batch of qualifying fuel. Entering the market. To facilitate compliance, RINs can be banked or tradedin 1975, the federal government set a goal of doubling the fuel efficiency of automobiles. Within ten years, the automobile fleet will be depleted. To achieve this goal, each manufacturer selling cars in the United States had to meet a set schedule for Corporate Average Sales.

Fuel Efficiency (CAFE). The law was updated in 2007, and regulations were issued in 2012. Set a target of more than 40 miles per gallon for passenger cars and light duty trucks by 2021. Gasoline energy equivalent basis, with the potential to exceed 49 miles per gallon by 2025. The current regulation facilitates compliance for any given manufacturer through credit. Provisions for banking and trading. In other words, excess credits earned in a single year may be used to cover a shortfall in the following year, or it may be traded to another manufacturer to help cover their costs. Provisions to encourage the use of electric drive train vehicles may be enacted outside of the CAFÉ program's framework.

CHAPTER 5

MARKET FACILITATION OR RESTRICTION

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Regulatory policy can also be used to help or hinder the market participation of a preferred or unfavorable renewable energy or efficiency technology. Many approaches to facilitation exist, including the target-based and technology-specification approaches. Other types of market facilitation may necessitate nondiscriminatory, if not preferential, market treatment of preferred technologies. Federal or state-level policies may include "feed-in tariff" (FIT) laws, net metering demands, and interconnection standards.

The Public Utilities Regulatory Policy Act (PURPA) of 1978 mandated that electric utilities interconnect (i.e., accept generation feed from) small qualifying amenities that either founder process heat and electricity (combined heat and power or CHP) or use certain renewable resources. Furthermore, PURPA established a price floor for power known as "avoided cost," which was later defined to imply the cost of electricity that the utility would have purchased otherwise. In theory, PURPA established a non-discriminatory framework for the adoption of efficient industrial CHP and decarbonisation, which was established by the federal government but was largely implemented by state regulatory authorities. As federal electricity policy moved toward wholesale power market deregulation, some of the non-discriminatory market features that PURPA specifically applied to renewable and CHP facilities were subsequently applied to the broad class of all power generation technologies.

Many states have adopted retail/distribution-level regulations requiring the acceptance of certain renewable electricity feeds at a set price floor. Such net-metering legislation typically requires load serving utilities to facilitate end-user connection of renewable distributed generation technologies (particularly solar, but also wind and other renewable or non-renewable technologies) on the customer meter side.

When the local resource's instantaneous generation exceeds the utility's instantaneous customer demand, the meter is allowed to "run backward," effectively causing the utility to purchase the excess generation at the prevailing retail rate. Most Americans restrict the size of the distributed resource, sometimes by customer class, and may also restrict the total generation off-set allowed (e.g., the monthly or net annual bill may not be less than zero). Some states have also set caps on the number of customers or assembled, distributed capacity that can participate in net-metering.

Recently, a lot of states, municipalities, and utilities have implemented FITs more akin to those found in Europe. The utility accepts renewable feed, as with net metering, but also offers a premium payment over the consumer's retail value of the generation in the FIT model. In some cases, these FIT programs are set up by a local or state government, but in others, the programs are set up voluntarily by the utility itself, and thus may not be strictly regulatory policy.

Technology Specification Standard

Another common form of regulatory intervention for renewable and energy-efficient technologies is the organization of minimum product specifications, either as consensual targets or as mandatory performance limits. Individual consumers see such standards as an effective way to improve their energy efficiency. Commercial and industrial customers presumably have a strong incentive to improve energy efficiency in their operations in order to maintain or improve profitability. Individuals, while still price sensitive to energy, may be less motivated to seek out products with higher upfront costs in order to achieve lower ongoing electricity costs. Market structures may influence consumer energy efficiency decisions in some cases.The federal Energy Star application provides qualifying products to display the "Energy Star" logo on product advertising and packaging, ranging from computer equipment to household appliances to commercial building equipment.

This acts as a proxy for disclosure in that the consumer is aware that the product is "best-in-class" for energy efficiency (though for products that do not display the logo, the consumer cannot tell if this is due to the product failing to meet the specification or the manufacturer refusing to participate in the program). The federal got also establishes mandatory energy efficiency specifications, such as minimum levels of energy efficiency, for just a wide range of consumer appliances, such as furnaces, air conditioners, light bulbs and fixtures, and kitchen appliances, through the Energy Policy and Conservation Act and its various adjustments. Energy efficiency norms may also be incorporated into building codes at the state and local levels.

Both the federal and state laws on transportation fuel composition provide incentives for renewable fuels, either directly or indirectly. Furthermore, the 1990 Clean Air Act Amendments established a number of fuel specifications, such as oxygenation, that differ by region and/or season. Ethanol has emerged as a preferred oxygenate, particularly in states that offer additional ethanol incentives or have restricted the use of alternatives such as MTBE, but it is also subsidized by the RFS. Sulfur content restrictions in diesel fuels may also encourage the use of "biodiesel" fuels derived from plant oils, if such fuels can be produced economically.

Benefit-to-Cost Ratio or Savings-to-Investment Ratio Method

Benefits are divided by costs or savings are divided by investment in the benefit-to-cost ratio (BCR) method. Benefits are measured in terms of energy cost savings when used to analyze energy efficiency and renewable energy systems. The SIR ratio's numerator is typically calculated as energy savings net of maintenance and repair costs, and the denominator as the sum of investment costs and cost of repairs less salvage value (capital cost items). However, depending on the objective, only the initial investment costs are denominated and the other costs are subtracted in the numerator or only the investor's equity capital is denominated. This method, like the previous three, is based on discounted cash flows.Unlike the previous three methods, which provided a monetary performance measure, this method provides a dimensionless number. The greater the percentage, the more dollars saved per dollar invested.

Internal Rate-of-Return Method

The internal rate-of-return (IRR) method calculates the discount rate at which dollar savings equal dollar costs over the analysis period; that is, the rate at which the net present value (NPV) is zero. One such discount rate represents the rate of return on investment. To determine whether an investment is desirable, it is compared to the investor's minimum acceptable rate of return. The internal rate of return, unlike the previous three techniques, does not require the inclusion of a predetermined discount rate in the calculation; rather, it solves for a discount rate.

The rate of return is typically calculated through a trial and error process in which various compound interest rates are used to discount cash flows until a rate is found for which the net present value of the investment is zero. The strategy is as wants to follow:

(1) Use Equation to calculate NPV, but substitute a trial interest rate for the discount rate, d, in the equation. A positive NPV indicates that the IRR exceeds the trial rate; a negative NPV indicates that the IRR is less than the trial rate.

(2) Using the information, try a different rate.

(3) Determine the rate at which NPV equals zero through a series of iterations.

To facilitate IRR solutions, computer algorithms, graphs, and in simple cases discount-factor tabular approaches are frequently used (Ruegg and Marshall 1990:7172). Because returns are frequently expressed in terms of annual rates of return, expressing economic performance as a rate of return can be advantageous for comparing the returns on a variety of investment opportunities.

The IRR method can be used to accept or reject individual investments or to allocate a budget. The IRR method, like the SIR, must be applied little by little when designing or sizing projects. It is not recommended for choosing between mutually exclusive investments with substantially different lifetimes (for example, a project with a 35% return over 20 years is a much better investment than one with the same 35% return over only two years).

It is a widely used method, but it is frequently misapplied, owing to flaws such as the possibility of: No solution (the sum of all nondiscounted returns during the analysis period is less than the investment costs) various alternative values (some costs occur later than some of the returns.

Overall Rate-of-Return Method

The overall rate-of-return (ORR) method compensates for the IRR's last two shortcomings. The ORR, like the IRR, measures economic performance as an annual rate of return over the analysis period. However, unlike the IRR, the ORR requires a clear reinvestment rate on interim receipts as input and produces a unique solution value.

The explicit reinvestment rate allows net cash flows (excluding investment costs) to be expressed in terms of their own future value at the end of the analysis period. ORRA1:A2 represents the overall rate of return on a given investment alternative A1 relative to a mutually exclusive alternative over a designated study period, Bt represents the benefits from a given alternative relative to a mutually exclusive alternative A2 over time period t, and Ct represents the costs (excluding that part of investment costs on which the return is to be maximized) associated with a given alternative comparable to a mutually exclusive alternative A2 over time t. r is the reinvestment rate, usually set equal to the discount rate, N is the length of a study period, and It represents the investment costs in period t on which the return is to be maximized.The ORR is recommended as a replacement for the IRR because it avoids some of the IRR's limitations and problems. It can be used to determine whether or not to fund a specific project, to design or size projects (if used incrementally), and to make budget-allocation decisions.

Discounted Payback Method

This evaluation method calculates the amount of time that has passed between the time of an upfront outlay and the point in time when accumulated discounted savings or benefits (net of other accumulated discounted costs) are sufficient to offset the upfront outlay, taking into the value of time of money.

If costs and cash reserves are not considered, the technique is referred to as "simple payback.") The shorter the time until the investment pays off, the more desirable an investment for the investor who requires a quick return on investment funds. To determine the shorter payback method (DPB) period, find the smallest value of Y (year of payback) that satisfyes the following equality. Costs of an alternative as especially in comparison with a mutually exclusive alternative, where the upfront cost comprises total investment costs.

When project life is uncertain, DPB is frequently (and properly) used as a supplementary measure. When an investor's time horizon is limited, it is used to identify feasible projects. In the face of uncertainty, it is used as a supplementary measure to indicate how lengthy capital is at risk. It serves as a rough guideline for accept/reject decisions. It's also overused and misunderstood. It is not a reliable guide for selecting the most profitable investment alternative because it indicates the time at which the investment just breaks even, as savings or benefits after the payback time might be significant.

Other Economic-Evaluation Method

Other methods for evaluating the economic growth of energy systems have been proposed, but they are usually hybrids of the ones presented here. One of these is the required revenue method, which computes a measure of the before-tax earnings in present or annual-value dollars required to cover an energy system's after-tax costs Mathematical programming methods, as well as other mathematical and statistical techniques, have been used to determine the optimal size or design of projects.

Risk Assessment

Many of the inputs to the aforementioned evaluation methods will be highly uncertain when it comes time to make an investment decision. An investor should use these methods inside one framework that explicitly accounts for uncertainty as well as risk to make the most informed decision possible.Risk assessment informs decision-makers about the "risk exposure" inherent in a given decision, i.e., the likelihood that the outcome will differ from the "best-guess" estimate. Risk assessment is also concerned with the decision maker's risk attitude, which describes his or her willingness to take a chance on an investment with an uncertain outcome. Risk assessment methods are typically used in conjunction with the earlier-mentioned evaluation methods, rather than as stand-alone evaluation techniques.

Risk assessment techniques range from simple and limited to complex and all-encompassing. Though none of these techniques eliminates the risk of making decisions, when used correctly, they can assist the decision maker in making more intelligent choices in the face of uncertainty.

This chapter provides an overview of the possibility risk assessment techniques listed below: Analysis of expected value Mean-variance and coefficient of variation criterion Risk-adjusted discount rate method

Monte Carlo simulation Decision analysis Real options Certainty equivalent technique Analysis of Sensitivity Other techniques for assessing risks and uncertainty exist (for example, CAP M and break-even analysis), but they are not covered here.

Advantages and Disadvantages of the EV Technique The technique has the advantage of predicting a value that is closer to the actual value than a simple "best-guess" estimate over repeated instances of the same event, supplied that the input probabilities can be estimated with some accuracy.The EV technique has the disadvantage of expressing the outcome as a single-value measure, so there is no explicit measure of risk. Another difference is that the estimated outcome is based on many replications of the event, with the EV effectively being a weighted average of the outcome over many similar events.The EV, on the other hand, is highly probable for a single instance of an event. This is analogous to a single coin toss, with the outcome being either heads or tails, rather than the 68910 weighted average of both.

Expected Value and Risk Attitude

Expected values can help explain risk attitudes. Risk attitude can be defined as a decision maker's preference for taking a chance on an uncertain money payout with a known probability over accepting a certain money amount. Assume a person is given the option of accepting the outcome of a reasonable coin toss in which heads means winning $10,000 and tails means losing $5,000, or accepting a specific cash amount of $2,000. The options can be evaluated and compared using Analysis.

The EV of the coin toss in this case is $2,500, which would be $500 more than the specified monetary amount. Because of the higher EV, the "risk-neutral" decision maker will prefer the coin toss. The decision maker who prefers the $2,000 fixed amount has a "risk-averse" attitude. If the certain sum was increased to $3,000 and the first decision maker still preferred the coin toss, he or she would be demonstrating a "risk-taking" attitude. These tradeoffs can be used to generate a "utility function" that reflects a decision maker's risk tolerance.

A decision maker's risk attitude is typically proportional to the amount at stake. Many people who are risk averse when confronted with the prospect of significant loss get to be risk neutral—or even risk takers—when the potential losses are small. Because decision makers' risk attitudes vary greatly, it is necessary to assess not only risk exposure (i.e., the degree of risk inherent in the decision), but also the decision maker's risk attitude.

Mean-Variance Criterion and Coefficient of Variation

If the mean outcomes and standard deviations (variation from the mean) can be calculated, these techniques can be useful in choosing between risky alternatives. Consider the following scenario: one project has a higher mean NB and a lower standard deviation than the other. This scenario is. In this case, the project with the probability distribution labeled B has stochastic dominant position over the project with the probability distribution labeled A. Project B is preferable to Project A because its output is likely to be higher and there is less risk of loss. But what if project A, the riskier alternative, has a higher mean NB,? In this case, the average criterion (MVC) would yield inconclusive results.

When one project does not have stochastic dominance over the other(s), computing the coefficient of variation (CV) to determine the relative risk of the alternate options is useful. The CV shows which option has the lowest risk per unit of outcomes of the project.

Risk-Adjusted Discount Rate Technique

The risk-adjusted discount rate (RADR) technique incorporates risk into the discount rate. A higher than normal discount rate is used if the benefit stream of a project is riskier than that of the average project in the decision maker's portfolio; a lower than regular discount rate is used if the benefit stream is less risky. If higher-than-average uncertainty is caused by costs, a lower-than-normal discount rate is used, and vice versa. The greater the variation in benefits and costs, the greater the discount rate adjustment.

where RADR denotes the risk-adjusted discounted rate, RFR denotes the risk-free discount rate, which is typically set equal to the treasury bill rate, NRA denotes the "normal" risk adjustment to account for the average level of risk encountered in the decision maker's operations, and XRA denotes the extra risk adjustment to account for risk greater or less than normal risk.

The following is an example of how to use the RADR technique: A business is thinking about investing in a new type of alternative energy system that has a high payoff potential but a high risk on the benefits side.

The projected cost and revenue streams, as well as the discounted present values. The risk-free interest rate is 8% on treasury bills. To account for the average level of risk confronted in its operations, the company employs a standard risk adjustment of 4%. Because the revenues associated with this investment are deemed to be more than twice as risky as the company's average investment, a 6% risk adjustment is applied to the RADR. As a result, the RADR is 18%. The NPV of the investment with this RADR is guesstimated to be a loss of $28 million. Based on the results of this analytical method, the company should decline the project.

The RADR technique has the advantage of accounting for both risk exposure and risk attitude. Furthermore, once a RADR value is established, no additional steps are required to calculate NPV. The disadvantage is that it only provides a rough adjustment. The RADR value is typically an estimate based on categorizing investments and adding a risk premium.

Certainty Equivalent Technique

The certainty equivalent (CE) method adjusts investment cash flows by a factor that converts the measure of economic worth to a "certainty equivalent" amount—the amount that a decision maker will find equally acceptable to a given investment with only an uncertain outcome. The derivation of the risk neutral factor (CEF), which is used to adjust net cash flows for uncertainty, is central to the technique.

Risk exposure can be built into the CEF by establishing risky investment categories for the decision maker's institution and linking the CEF to the CV of the returns—greater variability translates into lower CEF values. The steps are as follows:

1. Divide the organization's project portfolio into risk categories. Low-risk investments: expansion of existing energy systems and equipment replacement; moderate-risk investments: adoption of new, conventional energy systems; and high-risk investments: investment in new alternative energy systems are examples of investment risk categories for a private utility company.
2. Calculate the coefficients of variation for each investment risk category (see the section on the CV technique) (e.g., on the basis of historical risk-return data).

3. Distribute CEFs by year, based on the variance coefficients, with the highest-risk projects receiving the fewest CEFs. Set the CEFs so that a risk-neutral decision maker would be indifferent between receiving the estimated certain amount and the uncertain investment if the objectives are to reflect only risk exposure. Set the CEFs so that the decision maker with his or her own risk attitude is indifferent if the goal is to reflect risk attitude as well as risk exposure.

To use the technique, perform the following steps:

4. Determine the economic performance metric to be used, such as NPV (i.e., NB).
5. Calculate the net cash flows and decide which investment risk category the project falls into.
6. Divide the yearly net cash flow sums by the applicable CEFs.
7. Apply a risk-free discount rate to the adjusted yearly net cash flow amounts (a risk-free discount rate is employed since the risk adjustment is handled by the CEFs).
8. Continue with the rest of the evaluation in the usual manner.

Monte Carlo Simulation

A Monte Carlo simulation involves the generated in response of economic worth from probability functions of input variables. The outcomes are represented by a probability density function and a cumulative distributive function. As a result, clear and specific measures of risk exposure can be calculated using the technique. To calculate economic worth, one of the earlier discussed economic-evaluation methods is used; a computer is used to sample repeatedly—hundreds of occasion's probability distributions and perform the calculations. The following steps can be used to run a Monte Carlo simulation:

1. Transform variable inputs into probability functions. Where input values are interdependent, multiple probability density equations that are linked to one another may be required.
2. Draw a random input value for each input for which there is a probability function; for each input for which there is only a single value, use that value for calculations.
3. Calculate and record the institutional measure of worth using the input values.
4. If the inputs are interdependent in such a way that input X is a function of input Y, draw the value of Y first, then draw at random from the X values that correspond to the value of Y.
5. Repeat the process until you have enough results to create a probability density function and a measure of dispersion.
6. Create the probabilistic density function and cumulative distribution function for the financial measure of worth, and analyze the variability statistically.

The technique's main advantage is that it expresses the results in probabilistic terms, allowing for an explicit assessment of risk exposure.

The fact that it does not explicitly treat risk attitude is a disadvantage; however, by providing a clear measure of hazard, it facilitates the implicit incorporation of risk attitude in the decision. The requirement to express inputs in probabilistic terms, as well as the extensive calculations, are frequently regarded as disadvantages.

Decision Analysis

Decision analysis is a versatile technique that allows for the economic assessment to take into account both risk exposure and risk attitude. It depicts the various options, costs, benefits, and estimate for a given decision.

Although a brief overview cannot capture the richness of this technique, a simple decision tree,, is discussed to provide an idea of how the technique is used. The choice involves whether to lease or build a facility. The decision must be made right away, despite the fact that the data is uncertain.

The decision tree aids in the organization and analysis of the problem. The tree is built from left to right and analyzed from right to left. The tree begins with a box that represents a decision point or node—in this case, whether to lease or create a facility. The two alternative paths are represented by the line segments nerves that branch from the box: the upper path represents the lease decision and the lower path represents the build decision. Each has a costs related with it that is based on the anticipated cost along the path. In this example, the option to build a facility has a minimum expected cost of $6.26 M.

This technique has the advantage of assisting in the understanding of the problem and the comparison of alternative solutions. Another advantage is that it can accommodate risk attitude in addition to treating risk exposure by converting costs and benefits to utility values (not addressed here). One disadvantage is that the technique, as it is commonly used, does not provide a clear and specific measure of the outcome's variability.

Real Options Analysis

Real options analysis (ROA) is a financial options valuation technique4 that is applied to real asset investment decisions. ROA is a decision-analysis method that is used when the decision maker has one or more options for the timing or sequencing of a financing. It explicitly assumes that the investment is partially or totally irreversible, that there is some leeway or flexibility in the timing of the investment, and that future payoffs are uncertain. Real options include the ability to defer, sequence, contract, temporarily shut down, switch uses, abandon, or expand the investment. This is in way of comparison to the NPV method, which implies that the decision is a "now or never" one.

The value of an option-covered investment is said to be equal to the value of the investment using the traditional NPV method (which implicitly assumes no flexibility or option) plus the value of the option.

The analysis begins with the construction of a decision tree that includes the option decision. The risk-adjusted mimicking portfolio (RARP) approach and the risk-neutral probability (RNP) approach are the two basic methods for calculating option value.

The RARP approach discounts expected project cash flows at a risk-adjusted rate, whereas the RNP approach discounts assurance cash flows at a risk-free rate. In other words, the RARP approach accepts the cash flows essentially as-is and adjusts the discount rate per time period to account for the fact that the risk changes as one progresses through the decision tree. The cash flows themselves are essentially risk-adjusted and discounted at a risk-free rate in the RNP approach.

Copeland and Antikarov propose a four-step approach to ROA:

1. Determine a base-case traditional NPV (e.g., without flexibility).
2. Model the ambiguity using (binominal) event trees (still without flexibility; e.g., without options despite the inclusion of uncertainty, the "expected" value of Step 2 should equal the value calculated in Step 1.
3. Create a decision tree with decision nodes for options as well as nondecision and nonoption decisions.
4. Conduct a ROA by pricing the payoffs and working backward in time, node by node, to calculate the ROA value of the investment using the RARP or RNP approaches.

CHAPTER 6

SENSITIVITY ANALYSIS

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Sensitivity analysis is a technique for dealing with uncertainty that does not require probability estimates. It examines the sensitivity of economic strength to parameters associated of key factors that are uncertain. Although sensitivity analysis does not provide a single economic answer, it does demonstrate to decision makers how the economic viability of a renewable energy or efficiency project changes as fuel prices, discount rates, time horizons, and other put change.The sensitivity of a solar energy-heating system's fuel savings to three critical factors: time frames (zero to 25 years), discount rates (D equals 0%, 5%, 10%, and 15%), and energy escalation rates (E equals 0%, 5%, 10%, and 15%). The market price of savings is based on yearly fuel savings valued at $1,000 at the outset.

Other things being equal, the total value of savings grows over time but less so with higher discount rates and more so with higher escalation rates. When going to compare the top line of the graph (DZ0.10, EZ0.15) with the line next to the bottom, the huge impact of fuel price escalation is most visible (DZ0.10, EZ0). Other things being equal, the present value of savings after 25 years is approximately $50,000 with a 15% fuel escalation rate and only roughly $8,000 with no escalation. While the amount of energy saved is constant, the dollar amount varies greatly depending on the escalation rate.

This graphic illustration depicts a situation that is frequently encountered in the economic justification of energy efficiency and renewable energy projects: the majority of the savings in energy costs, and thus the bulk of the benefits, accrue inside the later years of the project and are highly sensitive to the assumed rate of fuel-cost escalation and the discount rate. If the two rates are set to be equal, the straight lines labeled DZ0, EZ0 as well as DZ0.10, EZ0.10 will be offsetting.

Building Blocks of Evaluation

Aside from the formula for basic evaluations and risk assessment techniques, the professional must understand some of the "nuts and bolts" of conducting an economic analysis. He or she must understand how to structure the evaluation process, select a method of evaluation, estimate dollar costs and benefits, perform discounting operations, select an analysis period, select a discount rate, adjust for inflation, take into account taxes and financing, treat residual values, and reflect assumptions and constraints, among many other things. This section contains brief guidelines for these subjects.

Structuring the Evaluation Process and Selecting a Method of Evaluation

Define the problem and the objective as a good foundation for the evaluation process. Determine any limitations to the way to solve and potential alternatives. Consider whether the best solution is obvious or whether economic analysis and risk analysis are required to assist in making the decision. Choose an appropriate evaluation method and risk assessment technique. Compile the required data and decide what assumptions to make. Calculate a measure of economic performance under risk using the appropriate formula(s). Compare alternatives and make a decision while accounting for any unmeasurable effects that are not accounted for in the dollar benefits and costs. Consider the risk attitude of the political appointee, if applicable.

Although the six evaluation methods mentioned earlier are comparable, they are also sufficiently different that they are not always equally appropriate for evaluating all types of energy decisions. The method chosen is more important for some types of decisions than others.classifies various investment types and the best assessment techniques for each. If only one investment is being considered, the "accept-reject" decision can frequently be made using any of several techniques, as long as the appropriate criterion is used.If multiple investment opportunities exist but only one can be pursued (i.e., they are mutually exclusive), any of the processes (except DPB) will usually work if used correctly.

However, because it is less likely to be misapplied, the NPV method is usually recommended for this purpose. The net present value (NPV) of each investment is calculated, and the investment with the highest present value is the most cost-effective. This is true even if the investments require significantly different initial investments, occur at significantly different times, or have significantly different useful lifetimes. Different system sizes (e.g., three different photovoltaic array sizes are being considered for a single roofs), different system configurations (e.g., different turbines are being considered for the same wind farm), and so on are examples of mutually exclusive investments.

If the investments are not mutually exclusive, one must consider whether there is an annual budget limitation that would limit the number of economic investments that could be undertaken. If there is no budget (i.e., no restriction on the available investment funds), there is no comparison to be made, and the investor simply makes an accept-reject decision with each investment individually, as described above.

If funds are not available to complete all of the investments (i.e., a budget exists), the simplest approach is to rank an alternatives, with the best having the highest BCR or return on investment. (The investment with the highest NPV will not necessarily be the one with the highest rank, because present value does not show return per unit investment). Once prioritized, the investments there at top of the priority list are chosen until the budget is depleted.DPB is recommended when a quick turnaround on institutional investors is required. Although the other methods are much more comprehensive and accurate for calculating an investment's lifetime profitability, they do not indicate the time required to recoup the investment funds.

Discounting

Some or all investment costs in fuel efficiency or solar panels are incurred early in the project and are referred to as "first costs." The advantages, on the other side, typically accrue over the project's life cycle in the form of yearly heat stored or produced. To compare benefits and costs that accrue at various times over time, all cash flows must be converted to time equivalents.Discounting is a term used to describe the process of converting cash flows to a time-equivalent basis.

Money's value changes over time for two reasons: For starters, inflation and deflation can affect the purchasing power of dollar. Second, money can be invested over time to generate a return that exceeds inflation. Because of these two factors, a given dollar amount today is worth more than the same dollar amount a year from now. Assume, for example, that a person could earn a max of 10% interest per year risk-free. To be willing to forego having $1 today, he or she would need $1.10 a year from now.

If the person could choose between $1 currently and $1.10 a year from now, the 10% rate of interest would represent that person's time preference for money. The higher the rate of interest needed to obtain future cash flows equal to an awarded value today, the higher the time preference. The optimal rate to use for order to convert present sums to future equivalent sums and future sums to present sums is the rate of interest for which an investor is somewhat adequately compensated for trading money now for money later (i.e., the rate for discounting cash flows for that particular investor). This rate is commonly referred to as the discount rate.

To accurately assess the economic utilization of an energy efficiency or renewable energy investment, the various expenditures and savings that accrue over time must be converted to a lump-sum, time-equivalent value in some base year (usually the present) or to annual values. The remainder of this section shows how to discount different types of cash flows and operating a heat pump versus an alternative heating/cooling system. The LCC calculations for two reference times are shown. The first is the present, and thus it is referred to as a present value. The second is called a yearly basis value because it is based on a yearly time scale. These two frames of reference are the most commonly used in economic investment evaluations. When the evaluation methods are properly developed, the relative ranking of investment priorities will be the same every time.

The following are the suppositions for the heat pump problem, which are provided only for illustration purposes and do not imply actual prices:

1. A residential heat pump (excluding ducting) costs $1,500 to buy and install.
2. The heat pump has a 15-year useful life.
3. The system's annual maintenance costs are fixed at $50 per year for the duration of its useful life.
4. A $400 compressor replacement is required in the eighth year.
5. The annual electricity cost for air - conditioning is $425, as determined at the outset, and has risen at a rate of 7% per year due to rising electricity prices.
6. The discount rate (a nominal rate adjusted for inflation) is 10%.
7. After 15 years, no salvage value is expected.

In the sample problem, the LCCs are calculated only for the heat pump and not for alternative heating/cooling systems. As a result, no attempt is made in this discounting example to compare alternative systems. This would necessitate similar LCC calculations for other types of heating/cooling systems.

The total cost of a heat pump system includes the costs of purchase and installation, maintenance, replacements, and operating electricity. Using the present as the base-time reference point, each of these costs must be converted to the present before being added together. If the purchase and installation costs occur at the starting point (the present), the $1,500 is already in present value terms.

How to convert the remaining cash flows to show values. The first step is to convert the annual maintenance cost stream to present value. According to the cash flow, the maintenance costs are $50 per year, measured in today's money i.e., dollars of the year.

Indirect Policy

Numerous other state and federal policies, while not specifically designed to address development of renewable energy markets, may have a significant or remarkable impact on these markets. Efforts to regulate energy or other markets, maintain government or privately owned lands, and protect the environment are among the most significant in this broad category.

Efforts at the federal level to bring competition in wholesale electricity generation markets, as well as efforts in a number of states to introduce competitive retail electricity supply, have created opportunities for electricity suppliers to sell "green" power typically electricity produced using renewable, low-emission, or high-efficiency technologies.Such programs include competitive supply of clean or renewable power, green power special pricing by regulated utilities, or the sale of the environmental features of renewable power in addition to the sale of electricity. Furthermore, the prototype of competitive wholesale markets for power generation and distribution can have an impact on the competitiveness of some renewable resources, particularly intermittent resources like wind.

Environmental regulation, whether at the federal or state level, for air quality, water quality, treatment and disposal, land use, greenhouse gas emissions, and other pollution levels, can have a significant impact on the cost and value of renewable energy and energy efficiency. The Clean Air Act Amendments of 1990 (CAA) lay the groundwork for cap-and-trade sulfur dioxide regulation, as well as emission limits for other pollutants.

While these programs seldom directly address the use of renewables or efficiency as a pollution avoidance mechanism, their use to reduce overall emissions is not necessarily excluded. Other CAA impacts on energy efficiency and sustainable energy include the previously mentioned reformulated gasoline requirements, which have interacted with state-level groundwater protection efforts to provide (in some states) a preference for ethanol as a preferred fuel additive for CAA compliance. Recently, the EPA has begun to use CAA authority to regulate greenhouse gas emissions, which may have a more pronounced, if still indirect, impact on renewables resources. Some landfill operations have been required to install collection and flaring systems as a result of the Resource Conservation and Recovery Act to prevent the dangerous buildup of methane-rich gas that results from the organic matter that breaks down in landfills. These systems have reduced the cost of deploying small turbines powered by this off-gas significantly.

Land management policy at both federal and state levels can have a significant impact on renewable energy policy, either encouraging or discouraging its development on government-owned land.

At the state level, a number of states have established policies to control greenhouse gas emissions, either alone or in collaboration with other states. For example, AB32 (for Assembly Bill number 32, its ascension number in the legislative session) is a California law that implements a series of regulations to control or limit carbon emissions. ome of these policies, such as a change to the state's RPS or the low carbon fuel standard, specifically answer renewable energy or energy efficiency, whereas others, such as the greenhouse gas emissions cap, may serve to encourage greater use of renewable energy resources and increased energy efficiency. The Regional Greenhouse Gas Initiative is a collaborative agreement among several Northeast states to reduce greenhouse gas emissions that might also incentivize the use of renewable energy resources.

Discount Rate

The discount rate is one of the most significant factors influencing the NB of alternative energy investments. A project that appears profitable at one discount rate is frequently unprofitable at another. For example, a project that generates net savings at a 6% discount rate may generate net losses at a 7% rate.

As the discount rate rises, the present value of just about any future stream of costs or benefits decreases. High discount rates favor projects with immediate payoffs over installations with benefits deferred for a longer period of time.

The discount rate should be considered equivalent to the rate of return available on the next-best opportunity to make money of comparable risk to the project in question, indicating the investor's opportunity cost.

The discount rate can be expressed as a "real rate" that excludes general inflationary pressures or as a "nominal rate" that includes inflation. The former should be applied to cash flows expressed in constant dollars. The latter ought to be utilized to discount current-dollar cash flows.

Successful Promotion of a Sustainable Energy Supply

The transformation of the energy supply system necessitates a number of framework conditions, instruments, and measures capable of dismantling the decades-old structures of the existing energy system's supply and promoting fundamental system changes. A basic commitment of government, presidency, business, and the population is important, if not essential, for such development in a country or an association of countries. In general, a transparent strategy with legally binding development paths is required. The latter must refer to clear and well-calculated indicators with a specific reference to short- and long-term objectives. The growth should be continuously monitored to ensure that the trajectory is followed. The International Energy Agency has proposed broad strategies to promote efficient energy conversion and usein theory, they can also be used to promote renewable energy.

In general, a set of methods addressing specific market segments is required. A strategy focused on a single goal, such as climate protection, will not suffice to achieve the numerous sustainable-development goals. The instruments must be part of reality as needed for long-term energy system transformation and must be coordinated to avoid contradictions. They should encourage the development and application of technology foundations, as well as the market integration of new products and the activation of cost-cutting potential. Along with RE installations, one priority should be the development and use of integrative elements such as power components, load management, and storage facilities to adapt fluctuating wind and solar energy to given load profiles.

Today, this is mostly discussed in the context of power generation, but in order to optimize the energy system as a whole, electricity, heating and cooling, and transportation energy needs must all be considered as a connected system.

Cost-effective efficiency measures should be made mandatory through appropriate legal norms, and longer loan repayment periods should be compensated through appropriate support. To ensure that the expansion of RE utilization does not thwart subsequent efficiency measures in, say, the buildings sector, the evolution of energy supply must be coordinated with the declining energy demand caused by energy efficiency (EE) measures.

Making the energy supply system more sustainable necessitates significant changes. Policymakers, administrations, businesses, and citizens must not only accept but also actively support this transformation. As a result, international organizations and states committed to this task must establish target-group-specific public relations activities in order to communicate the opportunities and challenges it entails. They must also develop new training and continuing education materials to better prepare the people and careers assigned to this task.

Inflation

Inflation is defined as an increase in the general price level. Because future price changes are unpredictable, it is often assumed that prices will rise at the rate of inflation. According to this assumption, it is generally simpler to conduct all economic evaluations in constant dollars and to discount the values using "real" discount rates. Because maintenance costs do not change over time, it is simple to convert the constant dollar annual service costs to a present value by multiplying by a uniform given factor. Some cash flows, however, are more easily expressed in dollar terms, such as equal loan payments and tax depreciation. Using a nominal discount rate, these can be converted to present values.

Analysis Period

The analysis period is the length of time that costs and benefits in an economic evaluation are considered. The analysis period does not have to be the same as the "useful life" or the "economic life," two commonly used investment life concepts. The useful life is the time period during which the investment retains some value; that is, the investment continues to conserve or provide electricity during this time period. Economic life is the time frame in which the money invested in question is the most cost-effective method for satisfying the requirement. Economic life is frequently shorter than useful life. The decision maker's objectives and perspective will influence the choice of an analysis period.

A speculative investor, for example, who intends to develop a project for immediate sale may regard the relevant time horizon as the short period of ownership from property planning and acquisition to the first sale of the project. Although a solar domestic hot water heating system's useful life may be 20 years, a speculative home builder may operate on a two-year time horizon if the property is expected to change hands within that time frame. Only if the speculator expects to profit from the energy savings through with a higher selling price for the building will the higher initial cost of the solar energy investment be likely to be economically viable.

If an analyst is conducting an economic analysis for a specific client, the time horizon for that client should be used as the analysis period. When an analyst conducts an analysis in support of a public investment or a policy decision, the life of the scheme or building is usually the appropriate analysis period.

When comparing multiple investment opportunities, it is best to use the same analysis period for some evaluation methods (such as LCC, IRR, and ORR). Different analysis periods can be used with others, such as NPV and BCR. If the useful life of an investment is less than the analysis period, it may be necessary to consider reinvesting in that option at the end of its useful life. If the useful life of an investment exceeds the analysis period, a salvage value must be estimated.

International Agreements on the Use of Renewable Energy

The debate over global sustainable development has also had an impact on energy organizations. Various global efforts and organizations have been established in this context over the last ten years. They include, but are not limited to, the items briefly described below.

The Sustainable Energy for All initiative was launched by United Nations Secretary-General Ban Ki-moon in 2011. (SE4ALL). It has three goals that must be met by 2030: ensuring universal access to modern energy services, doubling the global rate of improvement in EE, and doubling the share of RE in the world's energy mix. The initiative has created a Global Action Agenda with 11 Action Areas: seven "sectoral" areas (for example, modern cooking appliances and fuels, large-scale renewable power, and buildings and appliances) and four "enabling" areas (energy planning and policies, business design and technology innovation, finance and risk management, capacity building and knowledge sharing). The initiative aims to encourage governments and other actors to take specific actions in these areas. To track progress toward the objectives, appropriate metrics will be developed

The proposal to establish an international organization for renewable energy dates back to the 1981 United Nations Conference on New and Renewable Energy Sources in Nairobi. It took three decades and numerous international efforts before the International Renewable Energy Agency (IRENA) was created on April 4, 2011 in Abu Dhabi, United Arab Emirates. By June 2013, there were 160 registered participants, including 114 countries and the European Union as members, and 45 states as signatories or in the process of joining. IRENA is mandated by its Member States (MS) to serve as a network hub for national, provincial, and global programs and activities, an advisory resource on planning, policy development, and implementation, and an authoritative, unified global voice for RE.

Numerous conferences paved the way for the previously mentioned activities and organizations. The importance of RE was emphasized at the World Summit for Sustainable Development in Johannesburg in 2002, and the establishment of IRENA was mentioned for the first time in the final declaration of the United Nations Renewable Energy Conference in Bonn in 2004.

Following this, a series of International Renewable Energy Conferences (IREC) were held in Beijing, Washington, Delhi, and Abu Dhabi. During Sustainable Energy Week, the 2013 IREC was held in conjunction with the third session of the IRENA Assembly and the Annual World Future Energy Summit

Finally, the Renewable Energy Network (REN21) was formed as a result of the Renewables 2004 Conference. It is a global network that connects actors from gov'ts, international organizations, industry associations, science, and civil society to support knowledge and data exchange as well as global RE activities.

REN21 publishes the Global Status Report, the Global Future Report, and reports on regional activities and RE policies each year, as well as operating several websites. The previously mentioned international activities collaborate and help one another. UN Secretary-General Ban Ki-moon welcomed IRENA as a RE hub within the SE4ALL initiative, and the conferences served to talk and plan global activities, with REN21 actively supporting them. Despite the increasing fervor of this debate, governments must take action to promote RE within their purview.

Renewable Energy Directive

Directive 2009/28/EC on the career advancement of the use of renewable energy sources (RE Directive, RED) is one of the Climate and Energy Package's instruments, and it went into effect in June 2009 It establishes a framework for even further development of RE use in the electricity, heating, and transportation sectors in the EU's Member States, as well as recommendations for designing the environment for RE promotion and expansion. By setting MS-specific targets, the RED distributes the overall EU RE development aim among the MS. Its main contents are as follows: A national action plan and progress reports serve to ensure clear communication between MS, the European Commission, and the European Parliament on progress toward the Directive's goals. By June 31, 2010, the states had submitted their national action plans. They include the energy data structure required to calculate GHG reduction effects (including consumption savings due to energy efficiency) as well as the expected expansion of RE until 2020, with 2-year intermediate values (trajectory). The report also describes the measures and instruments put in place to ensure compliance with the RED. From 2011 to 2019, the MS will produce a progress report every two years, presenting an intervening time assessment of the progress described in the action plan. These reports are evaluated and summarized by the European Commission in a progress report to the European Parliament and Council. The European Commission calls for improvements in MS, such as better framework conditions for RE expansion, in its first progress report, released on March 27, 2013, and finds compliance with the trajectory unsatisfactory in some cases. It has even filed infringement suits against some MS. However, it sees a need for additional action in the own domain.

The fundamental data and methods required to calculate the effects of GHG reduction.

The RED defines mechanisms for the mathematical transfer of used amount of RE joint support schemes, and joint projects for electricity, heating, or cooling cooperation between MS. Projects for electricity production may also be undertaken with non-EU countries. The amounts of energy produced are divided among the countries involved in order to count them toward national targets.

To reduce barriers to RE expansion, the RED addresses in detail the favorable framework conditions for project planning and implementation, grid access and operation, information and training, and recommends appropriate regulatory adjustments.

The system for ensuring the origin of renewable electricity defined by Directive 2001/77/EC has been expanded and may now include heating and cooling. The system ensures that the proportion of renewable energy in electricity, heating, or cooling products can be demonstrated to final customers in a transparent and objective manner.

The RED places a strong emphasis on long-term biofuel supply, addressing the global dimension of relevant markets. Biofuels are only accepted within the scope of the RED, for example, to fulfill RE shares, if their use results in a 35% reduction in GHG emissions compared to the fossil-fuel reference. Savings must be 50% by 2017. This topic is expanded on in the following paragraphs.

The EU-wide target for the share of renewable energy in transport applies equally to all Member States. In addition to biofuels, other RES fuels or electricity may be counted towards such a target. Because highly efficient technologies such as battery systems and new conversion processes (e.g., power to gas) are still not available at affordable prices, this target has put significant pressure on biodiesel production in particular.

The provision and utilization of biomass for energy production typically has negative environmental consequences. In addition to other environmental consequences, intensified land use or the use of previously used land, referred to as land use change (LUC), can increase eutrophication and acidification of soil and water bodies, resulting in higher emissions of highly potent GHG. GHG emissions from fossil-fuelled machinery or artificial fertilizers are almost impossible to avoid. Another relevant issue is competition with food and feed production. The effects of this may be much more pronounced in tropical countries, particularly in poor countries, for example, when food production is displaced to previously virgin rainforest areas (indirect land use change—ILUC). Food production competition can have serious social consequences in these countries, such as rising food prices

These findings cast serious doubt on the long-term viability of biofuels (particularly biodiesel), as well as their positive effects on the environment. Because a widely accepted calculation method does not yet exist, calculated GHG emissions do not yet include the effects of ILUC. As a result, the European Commission presented a contentious initial proposal in the autumn of 2012, based on several expert reports, on how ILUC could be accounted for in disclosures under the RED on the promotion of RES. The proposal's implementation would result in a situation in which a reduction in GHG emissions could no longer be demonstrated for biofuels with a high oil-crop share. This has sparked a heated debate about the contribution of food-crop-based biofuels to the RED's target for RE in the transportation sector by 2020, and a limit to the current level is being considered for this option.

CHAPTER 7

ENERGY AUDITS FOR BUILDINGS

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Energy conservation and energy efficiency are appealing solutions for reducing the operating costs and environmental impact associated with the use of conventional energy resources. Furthermore, energy efficiency can eliminate the need to build power stations that use traditional energy sources at a low cost and with no negative environmental impact. Furthermore, energy efficiency and conservation have the following advantages:

Enhances economic competitiveness. According to the International Energy Agency (IEA), investments in energy conservation outperform investments in energy supply. Reduces air and water pollution and thus improves health conditions by stretching the availability of limited nonrenewable fossil fuels and gaining time for possible development of renewable and reliable sources of energy like solar energy.

There is a vast potential for efficiency all over the world that has only recently begun to be realized in a few countries. All energy end use sectors, including buildings, companies, and transportation, have this potential. One of the major challenges of the new millennium is to increase the efficiency of energy production, distribution, and consumption, which will reduce costs and have a positive impact on the environment. As a result, energy efficiency can benefit economic competitiveness, the environment, and health.

Energy consumption in several industrialized countries has fluctuated in response to significant changes in oil prices, economic growth rates, and environmental concerns, particularly since the early 1970s oil crisis. For example, from 66 quadrillion British thermal units (Btu) in 1970 to 94 quadrillion Btu in 1998, the United States' energy consumption increased (EIA 1998). Energy costs account for approximately 8% of the US economy's gross domestic product (GDP), making it one of the highest among industrialized countries. One of the reasons for high energy prices is that the United States consumes a significant portion of total global energy. As a result, the United States has the highest per capita energy consumption rate in the world, averaging 350 million Btu per year, or the equivalent of 7 gallons of oil per person per day.

The rate of growth in per capita energy consumption and population since 1973. It is worth noting that the per capita energy-use rate has remained nearly constant—with only minor fluctuations—since 1973, despite the fact that the rate of population growth has clearly increased over the years. Higher oil prices in the 1970s (oil embargo in 1973 and Iranian revolution in 1979) forced energy conservation and efficiency improvements. Although the trend toward energy conservation slowed in the 1980s, it continued in the 1990s as a result of the 1992 National Energy Policy Act (EPACT), which promotes more efficient energy use in the United States. The EPACT, in particular, revises building energy efficiency standards, promotes the use of alternative fuels, and reduces this same monopolistic structure of electric and gas utilities.

The distribution of total US energy consumption by major sectors in 1996. As previously stated, buildings and industrial facilities account for 36 and 38% of total energy consumption in the United States, respectively. The transport industry, which consumes the remaining 26% of total US energy consumption, primarily uses fuel products. Buildings and industries, on the other hand, primarily consume electricity and natural gas. Coal is primarily utilized as an energy source for electricity generation due to its low cost.Despite some gains in energy efficiency over the last 25 years, the United States remains the world's most energy-intensive country. If the United States is to maintain its lead in a global and competitive world economy, it must continue to improve its energy efficiency.

Residential and commercial buildings account for a significant portion of total national energy consumption in most countries (nearly 40% in the United States and France). Buildings typically use electricity as well as a primary energy source such as natural gas or fuel oil. Lighting, appliances, and HVAC equipment all use electricity. Summarizes the typical energy density for selected sorts of business and institutional buildings in the United States and France.

The primary source of energy for the US industry is fossil fuels. Electricity accounts for approximately 15% of total industrial energy consumption in the United States. Cogeneration systems are used in some energy-intensive manufacturing facilities to generate electricity from fossil fuels. Due to the vast amounts of energy wasted in industrial processes, there is a significant potential for energy savings in industrial facilities. The United States could save up to 35% of total energy used in the industry by improving housekeeping and recovery some of the waste heat (Ross and Williams 1977.

Despite improvements in energy efficiency since the 1970s, the potential for energy sustainability in both buildings and the industrial sector remains large in the United States and other countries. The sections that follow provide energy management programs that use proven and systematic energy audit procedures that are appropriate for both buildings and industrial facilities. In addition, some tried-and-true and cost-effective energy-efficiency technologies are highlighted.

Energy Audit Procedures

Energy audits are the first step in improving the energy efficiency of commercial and industrial buildings. In general, there are four types of energy audits, which are briefly described below

A walk-through audit typically consists of a brief on-site visit to identify areas where simple and low-cost deeds (typically operating and maintenance measures) can provide immediate energy and/or operating cost savings. A utility products or services includes a thorough examination of metered energy consumption and facility operating costs. Typically, utility data from several years is analyzed to identify patterns of energy consumption, peak demand, weather effects, and the potential for energy savings. A conventional energy audit includes a thorough energy analysis of the facility's energy systems. The standard energy audit includes, in particular, the creation of a baseline for the facility's energy use, the assessment of energy savings, and the cost-effectiveness of appropriately chosen energy conservation measures. A detailed exergy analysis is the most thorough but also time-consuming type of energy audit.

The detailed energy audit, in particular, includes the use of instruments to measure energy-use for the entire building and/or for some energy systems within the building (for example, by end uses such as lighting systems, office equipment, fans, chillers, and so on). Furthermore, for detailed energy audits to evaluate and recommend energy retrofits for the facility, sophisticated computer simulation programs are usually considered.

General Procedure for a Detailed Energy Audit

Energy audits are the first step in improving the energy efficiency of commercial and industrial buildings.A walk-through audit typically consists of a brief on-site visit to identify areas where simple and low-cost deeds (typically operating and maintenance measures) can provide immediate energy and/or operating cost savings. A utility products or services includes a thorough examination of metered energy consumption and facility operating costs. Typically, utility data from several years is analyzed to identify patterns of energy consumption, peak usage, weather effects, and the potential for energy savings. A conventional energy audit includes a thorough energy analysis of the facility's energy systems. The standard energy audit includes, in particular, the creation of a baseline for the facility's energy use, the assessment of energy savings, and the expense of appropriately chosen energy conservation measures. A detailed exergy analysis is the most thorough but also time-consuming type of energy audit.

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Commissioning of Building Energy Systems

It is recommended that a newly constructed building's various systems, including structural elements, building wrapper, electronic wiring, security systems, and HVAC systems, be commissioned prior to final occupancy. The commissioning process verifies and documents the performance of building systems as stipulated by the design intent. During the commissioning process, maintenance and operations personnel are trained to follow procedures that ensure all building systems are fully functional and properly operated and maintained.

Energy Rating of Buildings

The United States Green Building Council recently developed and implemented a new building rating system. The New leader in Energy and Environmental Design (LEED) rating system takes into account the energy and environmental performance of all systems in a building over its life cycle. The LEED rating system is currently used to assess new and existing commercial, institutional, and high-rise residential buildings. The assessment relies on credits earned if the building meets a set of criteria based on existing, proven technology. The total credit earned determines the level of certification for green buildings awarded.

Similar rating systems exist in other countries. In fact, the Building Research Establishment's Environmental Assessment Method was developed and implemented in England as the first national green building rating system (BREEAM). According to the Building Research Establishment, up to 30% of office buildings built in the last seven years have been assessed using the BREEAM rating system. The BREEAM rating system is currently applicable to new and existing office buildings, manufacturing sites, residential homes, and supermarkets.

Building Envelope

The envelope of some buildings has a significant impact on the energy required to condition the facility. The building load coefficient characterizes the energy efficiency of the building (BLC). The BLC can be estimated using either a regression analysis of utility data or a direct calculation based on the thermal resistance of the building-envelope assemblies shows how to estimate the BLC for a given building using utility data.

The following are some widely recommended energy conservation measures for improving the thermal performance of the building envelope:

1. Thermal Insulation is added. This measure can be cost-effective for building surfaces that lack thermal insulation.

2. Window replacement. When windows account for a significant portion of the exposed building surfaces, and used more energy-efficient glass doors (high R-value, limited glazing, air tight, etc.) can help reduce energy consumption while also improving indoor comfort.

3. Reduced air leakage. When the infiltration load is significant, simple and inexpensive weather-stripping methodologies can be used to reduce the leakage area of the building envelope. The infiltration rate in residential buildings can be estimated to use a blower door test setup, which can be used to estimate infiltration or data leakage rates under both pressurization and depressurization conditions.

The envelope energy audit is extremely crucial for residential buildings. Indeed, weather dominates residential building energy consumption because heat gain and/or loss from direct conduction of heat or from air infiltration/exfiltration through wall surfaces account for a significant portion (50%-80%) of total energy consumption. Improvements to the building envelope are frequently not cost-effective for commercial buildings because modifications to the building envelope (replacing windows, adding thermal insulation in walls) are typically quite expensive. However, it is recommended that the packet components be systematically audited not only to determine the possibility of reducing energy consumption but also to ensure the integrity of its overall condition. Thermal bridges, for example, can increase heat transfer and cause moisture condensation. Moisture condensation is frequently more damaging and expensive than an increase in the heat transfer because it can compromise the structural integrity of the building envelope.

Ventilation in Commercial/Institutional Buildings

In both commercial buildings and industrial facilities, the energy required to condition ventilation system can be significant, especially in locations with extreme weather conditions. Whereas ventilation in commercial buildings is used to provide air to occupants, it is used in several industrial applications to control the level of dust, gases, fumes, or vapors. The auditor should guesstimate the current volume of fresh air and compare it to the amount of ventilation air required by the applicable standards and codes. Excessive air ventilation should be minimized if it can result in increased either cooling or heating loads. However, in some climates and at certain times of the year or day, increasing air ventilation can be helpful and may even reduce cooling and heating loads by utilizing air-side economizer cycles. Summarizes some of the minimum external air requirements for various commercial building spaces.

If there is excess ventilation air, the outside air damper setting can be adjusted to provide ventilation that meets the minimum outside requirements further reductions in outdoor air can be obtained by using demand ventilation controls, which supply outside air only when it is required. Monitoring CO_2 concentration levels within spaces is a popular approach for request ventilation. CO_2 is regarded as a good indicator of pollutants produced by occupants and other building materials. The position of the outside air damper is controlled to maintain a CO_2 start within the space. Demand-controlled ventilation based on CO_2 has been implemented in a variety of buildings with intermittent occupancy patterns, including cinemas, theaters, classrooms, meeting space, and retail establishments. However, CO_2 measurements have been used to control ventilation in several office buildings According to field studies, proper implementation of Bio based demand controlled ventilation can result in significant energy savings.

Ventilation of Parking Garages

Parking garages for automobiles can be partially or completely enclosed. Partially open car parks are customarily above-grade structures with open sides that do not require mechanical ventilation. Fully enclosed parking garages, on the other hand, are usually underground and entail ventilators. Indeed, in the absence of ventilation, enclosed parking garages present a number of indoor air quality issues. The most serious issue is the high levels of carbon monoxide (CO) emitted by cars within parking garages. Other issues with enclosed garages include the presence of oil and gasoline fumes, as well as other contaminants like oxides of nitrogen (NOx) and smoke haze from diesel engines.

Two factors are typically considered when determining the appropriate ventilation rate for garages: the number of cars throughout operation and the emission quantities. The number of cars in operation varies depending on the type of facility delivered by the parking garage and can range from 3% (in shopping areas) to 20% (in sports stadiums) (ASHRAE 1999). Carbon monoxide emissions are affected by a variety of factors, including the age of the vehicle, engine power, and level of maintenance. ASHRAE standard 62-1989 specifies a fixed ventilation rate of less than 7.62 L/sm2 (1.5 cfm/ft.2) of gross floor area for enclosed parking facilities (ASHRAE 1989). For garages to 2.5-m ceiling heights, a ventilation flow of approximately 11.25 air changes per hour is required. Some model code authorities, however, specify an air change rate of four to six air changes per hour. Some model code authorities allow ventilation rates to vary and be reduced to save fan energy if CO demand-controlled ventilation is used, which involves continuous monitoring of CO concentrations and interlocking the monitoring system with the mechanical exhaust equipment. The acceptable level of contaminant concentrations varies greatly between codes. It is necessary to reach an agreement on acceptable contaminant levels for enclosed parking garages. Unfortunately, ASHRAE standard 62-1989 does not address the issue of ventilation control in enclosed garages through contaminant monitoring.

As a result, ASHRAE funded research project 945-RP to evaluate current ventilation standards and recommend rates based on current vehicle emissions/usage. Based on this project, a general methodology for determining the requirements for parking garages has been developed also shows the fan energy savings attained by the on-off and VAV systems (in comparison to the CV system's fan energy use). When a demand Catalyst control strategy is used to operate the ventilation system while also maintaining acceptable CO levels within the enclosed parking facility, significant fan energy savings can be obtained. The pattern of car movement within the parking space determines the energy savings. =denotes three types of vehicle movement.

HVAC Systems

HVAC systems can consume up to 40% of the energy used by a typical commercial building. To improve the energy performance of both primary and secondary HVAC systems, a variety of measures can be considered. Some of these initiatives are as follows:

Setting/Restoring Thermostat Temperatures. Heating temperatures should be reduced during unoccupied periods when possible. Similarly, cooling temperature setup can be considered.

Constant-Air-Volume System Retrofit. Variable-air-volume (VAV) systems should be considered for commercial buildings so when existing HVAC systems rely on constant - pressure fans to condition a portion or the entire building. Central heating plant retrofit. By adjusting this same fuel air ratio for proper combustion, a boiler's efficiency can be greatly increased. Furthermore, when replacing old boilers, the installation of new fuel boilers can be economically justified.

Central Cooling Plant Retrofit. There are several chillers available now that are energy-efficient, simple to control and operate, and suitable for retrofits. In general, it is more cost-effective to recommend energy-efficient chillers, such as those that use scroll compressors, to replace existing chillers.

Heat Recovery System Installation. Some HVAC equipment can be used to recover heat. Heat exchangers, for example, can be installed to recover heat from air handler (AHU) exhaust air streams and boiler stacks.

It should be noted that various components of the heating and cooling system interact strongly. When retrofitting a building HVAC system, a whole-system analysis approach should be used. One example of using a whole-system approach to reduce energy use for heating and cooling buildings is optimizing the energy use of a centralized air conditioning plant (which may include chillers, pumps, and cooling towers.

Compressed-Air Systems

Compressed air has become an essential tool in the majority of manufacturing facilities. Its applications range from air-powered hand tools and actuators to advanced air powered robotics.

Unfortunately, massive amounts of air compressor are currently being wasted in a wide range of facilities.Only 20%-25% of the input electrical energy is estimated to be delivered as useful compressed-air power generation. According to reports, leaks account for 10%-50% of waste, while misapplication accounts for 5-40% of compressed air loss (Howe and Scales 1998).

The compressor can be of several types, including centrifugal, reciprocating, or propeller screw with one or more stages. Screw compressors are currently the most commonly used in industrial applications for small and medium-sized Units.Typical pressure, air movement rate, and mechanical power requirements for various compressor types.The following are some energy-saving measures appropriate for compressed-air systems:

Air leaks in distribution lines must be repaired. There are several methods for detecting these leaks, ranging from using water and soap to using sophisticated equipment such as ultrasound leak detectors. Reduced the temperature of the inlet air and/or increased inlet air pressure.

By modifying the processes, compressed-air consumption and air pressure requirements can be reduced. Install heat recovery systems to use compression warmth within the facility for either heating systems or building space heating.

Automatic controls were installed to enhance the process of several compressors by reducing part load operations. Booster compressors are used to provide higher discharge pressures. Booster compressors can be more cost-effective if the highest-pressure air is only a small portion of the total pressurized gas used in the facility. Without booster compressors, the primary cylinder must compress all of the air to the maximum desired pressure.

Energy Management Controls

The automated control of a wide range of energy systems within commercial and industrial buildings is just becoming increasingly popular and cost-effective as the cost of computer technology continues to fall. An energy monitoring and control system (EMCS) can be designed to control and reduce building energy consumption within a facility by closely monitoring and adjusting the energy-use of various equipment's. An EMCS, for example, can monitor and adjust indoor ambient temperatures, set speed of the fan, open and close air handling unit dampers, and control lighting systems automatically.

If an EMCS is already installed in the building, a system tune-up is recommended to ensure that the controls are functioning properly. For example, sensors should be calibrated on a regular basis in accordance with manufacturer specifications. Inadequately calibrated sensors may increase heating and cooling loads and reduce occupant comfort.

Precooling building thermal mass is one example of how the EMCS can be used to reduce operating costs. Building thermal mass precooling can help to reduce building operating costs. When chillers have high loads during periods of high accommodation and high outdoor temperatures, this strategy can have a significant impact (which typically coincide with on-peak periods in rate structures). It is possible to reduce chiller energy use during these difficult periods by reducing on-peak cooling load, thereby lowering energy costs.

The annual energy cost savings affiliated with precooling have been estimated for various time-of-use utility rates using long-term simulation analysis. On-peak to off-peak ratios for energy and requirement charges have been defined for time-of-use rates as follows:

Indoor Water Management

Buildings can save water and energy by using water-saving fixtures instead of standard fixtures for toilets, faucets, showerheads, dishwashers, and clothes washers. Eliminating leaks in pipes and fixtures can also result in cost savings, the average water consumption of traditional and water-efficient fixtures for various end uses. Furthermore, the hot water consumption of the each fixture as a percentage of total water consumption. Toilets, shower rooms, and faucets can save up to 50% of their water use with water-efficient fixtures.

Electrical Energy Management in Buildings

A typical building is built with a forty-year economic life in mind. This implies that its existing building inventory, with all of its good and bad features, is rotated very slowly. Today, we know that designing a high level of energy efficiency into new buildings is cost effective because the savings on operational cost will repay the original investment many times over. Many technological advances have occurred over the last two decades, resulting in dramatic reductions in the amount of energy required to function buildings safely and comfortably. Another advantage of these developments is indeed the reduction in air pollution caused by generating less electricity.

Buildings can be classified in a variety of ways, including use, construction type, size, thermal characteristics, and so on. For the sake of clarity, two categories will be used: residential and nonresidential.Since 1975, there has been a remarkable shift in the residential and commercial sectors. Prior to 1975, the use of natural gas in these sectors increased rapidly, but then flattened out and remained essentially constant. Petroleum consumption has decreased. The most significant change has been the dramatic increase in energy use, which has more than doubled between 1975 and 2004.

This chapter takes the approach of listing two types of specific strategies that are cost-effective methods of conserving electricity. The first category includes metrics that can be implemented at a low capital cost using existing assets that are in essentially untouched condition. The second category includes techniques that necessitate retrofitting, modifying existing equipment, or developing entirely new equipment or processes. In most cases, moderate to significant capital investments are also required.

Residential Electricity Use

Space conditioning is the most important end use of electricity in residential buildings, accounting for roughly one-quarter of total electricity consumption. Electricity is used in space heating and cooling to power fans and compressors, as a direct source of heat (resistance heating), as an indirect source of heat or "cool" (heat pumps), and for controls.

Residential lighting electricity use fell from 10% in the 1980s to 8.8% in 2001, owing to the introduction of more efficient lamps, primarily compact fluorescents, as well as a greater share of electricity being consumed by other end uses. The majority of home lighting is still incandescent, which presents significant opportunities for improved efficiency.

Water heating's share of residences electricity consumption has also decreased over the last decade. It was 9.1% in 2001, down from 10.7percentage points in 1992. Electricity is currently used for this purpose in areas with cheap hydroelectricity or where alternative energy sources are unavailable. Solar water heating is another option that is used sparingly.

Refrigerators are another significant residential energy end use, accounting for 13.7% of residences electricity usage in 2001. For the past 40 years, nearly every home in the United States has had a refrigerator. Refrigerators have thus been fully integrated into the residential market for some time. However, significant changes in energy use occurred during this time period as standards were implemented. For example, the average refrigerator size has more than doubled from less than 10 ft.3 in 1947 to more than 20 ft.3 in recent years. Meanwhile, refrigerator efficiency has increased dramatically.

The average energy usage of a new refrigerator in the early 1960s was around 1000 kWh/year, and they were about 12 ft.3 in size (adjusted volume). Since 2001, new refrigerators have consumed less than 500 kWh per year and have adjusted volumes of approximately 20 ft.3. As a result, modern refrigerators, while 70% larger than those of forty years ago, consume approximately 50% less electricity.

Cooking, clothes washing and drying, and freezers account for another 17.1%, while "other" uses (including home theater systems, personal computers, and miscellaneous items) account for the remaining (25%). Over the last few decades, computers and other consumer electronic devices such as VCRs, DVD players, and digital gaming systems have proliferated in homes. In 1984, only 8% of houses had personal computers (desktop or laptop), whereas in 2001, 51% had desktops and 13% had laptops. Personal computers' energy consumption is increasing. According to the EIA, PC energy consumption increased by 9% between 2001 and 2005, and it is projected to rise by 29% between 2005 and 2010.

Nonresidential Electricity Use

HVAC consumes the most electricity in the commercial sector as a whole. HVAC is the primary electricity end use in most nonresidential buildings that use space conditioning. Of course, there are exceptions—in energy-intensive establishments including such laundries, process energy will be the most important.

In space conditioning, electricity is used to power fans, pumps, chillers, and cooling towers. Electric resistance cooking (for example, in terminal reheat systems) and electric boilers are two other applications.

Except in nonresidential infrastructure with energy-intensive processes, nonresidential lighting is generally second in importance to HVAC in terms of electricity use. Lighting accounts for nearly several of the electricity consumed in a typical office building. Interior lighting in the commercial sector is mostly fluorescent, with a small percentage of metal halide lamps and a small percentage of incandescent lamps.

High-efficiency fluorescent lamps, electronic ballasts, compact fluorescent lamps, and better lighting controls are now standard. In retail, incandescent lamps are still widely used for display lighting, as well as in older buildings or for decorative or esthetic purposes. According to the EIA's Commercial Building Energy Consumption Surveys conducted in 1992 and 1999, the portion of commercial building electricity consumed by lighting fell from 27.7% in 1992 to 23.1% in 1999. Furthermore, according to the EIA's Annual Energy Outlook 2005, the share of commercial construction electricity use for lighting will continue to decline, reaching an estimated 21.4% by 2025.

Water heating is another source of energy consumption in nonresidential buildings, but circulating systems (which include a heater, storage tank, and pump) seem to be more common. There are numerous options for using heat exchange as a source of hot water. During the last decade, the amount of electricity to use for water heating in commercial buildings has remained relatively consistent at a little more than 1%. The EIA, on the other hand, predicts that electricity use for water heating will rise to 2.3% by 2025.

Refrigeration is a significant energy user in supermarkets and other nonresidential facilities. Heat recovery units are now commonplace on commercial refrigeration systems.

Commercial refrigeration electricity use has decreased in recent decades due to efficiency gains, as it has in residential applications. Refrigeration, for example, attributed for 8.6% of commercial electricity use in 1999, down from 10.1% in 1992. According to EIA projections, refrigeration will account for only 3.9% of total energy consumption in 2025.

Since the last edition of this handbook, commercial electricity use by office equipment has increased significantly, rising from 6.7% in 1992 to 17.9% in 1999. The increased use of computers accounts for a large portion of this increase. Specially designed rooms with temperature and humidity control are required for larger computational linguistics used in central data processing systems. As a general rule, the computer's electricity consumption must have at least doubled because cooling is required to remove heat from the equipment, lights, and personnel. With the widespread the use microcomputers, special space conditioning is no longer required. The sheer number of computers, on the other hand, increases the air conditioners load and electrical demand.

In the last decade, these, along with their peripheral equipment such as printers, scanners, and filesystems, have grown rapidly. Other communication systems are being displaced by electronic mail and Internet conferencing. In 1992, 431 out of every 1000 employees in the commercial sector had a computer, compared to 707 out of 1000 employees in 1999. In office buildings, the computer-to-employee ratio is even higher. There were six computers for every 10 employees in 1992, but there were 9.5 laptops for every 10 employees in 1999.

The remainder of the electricity used in nonresidential facilities is for elevators, staircases, and miscellaneous items.

CHAPTER 8

RESIDENTIAL HVAC

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Heat pumps, refrigeration systems, and impedance heaters are the most common types of residential HVAC units that use electricity. Electric furnaces, small radiant heating systems, duct heaters, strip or baseboard heaters, and embedded floor or ceiling heaters are all examples of heaters. Because there are no stack or flue losses and the heater transfers heat directly into in the living space, heating efficiency is typically high.Window air conditioning to central cold room or heat pump systems are examples of cooling systems.In some climates, evaporative coolers are also used. The following are the primary maintenance and operations strategies for existing equipment: system maintenance and cleanup; thermostat calibration and setback; microprocessor controls, time clocks, night cool down; improved controls and operating procedures; heated or cooled volume reduction; and reduction of infiltration and exfiltration losses.

System maintenance is a simple, but often overlooked, energy-saving tool. Heat transfer surfaces that are dirty reduce efficiency. Filters that are clogged reduce pressure drops and pouring power. Dampers that are inoperable or malfunctioning can waste energy while preventing the system from functioning properly. In most residential systems, the bed thermostat regulates heating and cooling. Thermostats should be set to 248C (758F) or higher for cooling and 188C (658F) for heating during the day.The thermostat's calibration should be checked first because the above low-cost devices can be inaccurate by up to G58C. Several manufacturers now offer "smart" thermostats with microprocessor controls that can be programmed to set the temperature back or forward depending on the time of day and weekday. By eliminating the need for manual control, they ensure that the settings are changed, whereas manual thermostat resetting is dependent on occupant diligence. Some utilities have load control programs in place that allow them to communicate with smart thermostats and turn them down (or up) during peak times.

A general rule of thumb is that every 18F of thermostat setting back (heating) or forward (cooling) during an 8-hour period saves 1% in annual heating or cooling electricity prices (the energy savings are generally lower in more severe climates). Simple changes in controls or operational processes can sometimes save energy. Use night air to cool down in the summer. Turn off the refrigeration unit when the outside air temp is cool.

Straight outside air should be circulated. Use the lowest speed that provides satisfactory operation if fan units have more than one speed. Check the system balance and the operation of baffles and vents to ensure that heating and cooling are provided in the required quantities.

Saving energy can be accomplished by reducing its volume of heated or cooled space. This can be achieved by closing louvers, doors, or other suitable means. Heating and cooling an entire residence is usually unnecessary; the spare bedroom is rarely were using, halls can be closed off, and so on.

Air entering or leaving a home is a major source of energy waste. Infiltration refers to unintentional air transfer toward the inside, while exfiltration refers to unintentional air handover toward the outside. However, the term "infiltration" is frequently used to refer to air leakage into and out of a home, and this is the term used in this chapter. Infiltration of cold or hot air will increase heating energy use in a poorly "sealed" residence. A typical home loses 25%-40% of its HVAC energy through infiltration, according to Energy Star.

Infiltration also has an impact on indoor pollutant concentrations and can cause unpleasant drafts. Many cracks and spaces created during building construction, such as those associated with electrical outlets, pipes, ducts, windows, doors, and gaps between ceilings, walls, and floors, can allow air to enter. Wind, natural convection, and other forces cause temperature and pressure differences between the inside and outside of a home, resulting in infiltration. Attic bypasses (paths within walls that connect conditioned spaces with the attic), fireplaces without dampers, leaky ductwork, window and door frames, and holes drilled in framing members for plumbing, electrical, and HVAC equipment are all major sources of air leakage. According to the U.S. DOE's Energy Efficiency and Renewable Energy (EERE) program, the combination of walls, ceilings, and floors is the most significant source of infiltration, accounting for 31% of total infiltration in a typical home. Infiltration is also caused by ducts (15%), chimney (14%), plumbing penetrations (13%), doors (11%), and windows (10%). Fans and vents (4%) and electrical outlets (2%), on the other hand, are of less importance.

House wraps, caulking, foam insulation, tapes, and other seals are used by builders of energy-efficient homes to prevent infiltration. Sealing ducts in the home is also key to preventing heated or cooled air from escaping. Open doors and windows, open fireplace dampers, inadequate weather stripping around doors and windows, and any other openings that can be sealed should all be checked by homeowners.

However, care must be taken to ensure adequate ventilation. The standards differ according to the type of occupancy. According to the American Lung Association's Health House program builder guidelines, "continuous general ventilation is at least 1.0 cfm per 100 sq ft. of floor area plus at least 15 cfm for the first dorm and 7.5 cfm for each additional bedroom" for healthy homes. In addition, the kitchen's intermittent ventilation should be at least 100 cfm. The rates for the bathrooms should be 50 cfm sporadic or 20 cfm continuous. The ventilation rates at the Health House are in accordance with ASHRAE standard 62.2.

The following techniques it'll save energy in retrofit or new design projects:

Site selection and building orientation Design of the building envelope Selection of efficient heaters equipment

The owner/occupant does not always have control over site selection and building orientation. Choose a location that is protected from temperature extremes and wind where possible. Orient the building (in cold climates) with the most southerly exposure to benefit from direct solar heating in the winter. Reduce heat loss on northerly exposed parts of the building by using earth berms. Deciduous trees provide summer shade while allowing solar heating in the winter.

The design of the building envelope can improve absorption of heat and retention in the winter and summer coolness.

The first requirement is that the structure be well-insulated and thermally tight. Synthetic fiber insulation reduces heating and cooling loads by preventing heat transfer through ceilings, walls, floors, and ducts. Because of the larger indoor-to-outdoor temperature differences in winter than in summer, reductions are usually proportionately higher for heating than for cooling. Insulation comes in bat, board, and loose-fill varieties. The best insulation material is chosen based on the climate, building type, and recommended R-value. R-values greater than one indicate better insulating properties.Using higher-than-recommended R-values to improve energy efficiency above and beyond standard building practice is typically cost-effective.

Windows contribute significantly to heat gain and loss. The heat loss through single-pane glazing is approximately 5-7 W/m2 8C. The comparable value for double glazing is 3-4 W/m2 8C, while for triple glazing it is 2-3 W/m2 8C. Window technology is always evolving. To prevent heat gain and/or loss, newer windows frequently have low emissivity (low-E) or spectrally selective coatings. Low-E argon-filled windows have a heat loss rate of about 2 W/m2 8C. They have a higher visible transmittance and a low solar heat gain coefficient, which helps to reduce cooling loads in the summer. Low-E windows can be ordered with an internal plastic film, effectively making them triple glazed. These windows have a heat loss rate of about 1 W/m2 8C.

The best insulation is provided by windows with vinyl, wood, or fiberglass frames, or aluminum frames with a thermal barrier. It is also critical to seal windows to prevent infiltration and to use window coverings to reduce heat loss to the exterior during the evening. By providing daylighting, proper window placement can also save energy.

The heat pump is the most efficient electric heating and cooling system in general. Air-to-air heat pumps are the most common type, available as a single-package unit (similar to a window air conditioner) or as a split system with the air handling equipment inside the building and the compressor and related equipment outside. The efficiency of commercially available equipment varies greatly. Heating performance is measured in BTUs of heat added per Watt-hour of electricity input using a heating seasonal performance factor (HSPF). Typical values for the most efficient heat pumps range from 6.8 to 9.0.

Residential heat pumps, air conditioners, and packaged systems' cooling performance is measured in terms of a seasonal energy efficiency ratio (SEER), which describes the ratio of cooling capacity to electrical power input. Typical values for the most efficient systems range from 10.0 to 14.5. The federal standards for air conditioners, heat pumps, and residential packaged units established in 1992 require a minimum SEER of 10.0 and a minimum HSPF of 6.8. New standards, which go into effect in 2006, require a minimum SEER of 13 and an HSPF of 7.7. Many older units have SEERs of 6-7, which is roughly half of the new minimum requirement. As a result, replacing older equipment can result in significant efficiency gains. When purchasing new equipment, look for models with the highest HSPF and SEER ratings. These units' higher initial cost is almost always justified by operating savings. Furthermore, many utilities provide rebates for installing more energy-efficient units.

Equipment sizing is critical because the most efficient operation occurs at or near full load. Choosing oversized equipment is thus initially more expensive, and it will also result in higher operating costs.Heat pump efficiency decreases as the temperature difference between the heat source and heat sink decreases. Because outside air is usually the source of heat, heat is most difficult to obtain when it is most needed. As a result, heat pumps frequently have electrical backup heaters for extremely cold weather.

Another option is to design the system with a heat source other than outside air. Heated air (such as that which is exhausted from a building), a deep well (which provides water at a constant year-round temperature), the ground, or a solar heat source are all examples. There are numerous solar heating and temperature pump combination options.

Heat Recovery

Straight outside air should be circulated. Use the lowest speed that provides satisfactory operation if fan units have more than one speed. Check the system balance and also the operation of baffles and vents to ensure that both temperature and humidity are provided in the required quantities.

Saving energy can be accomplished by reducing its volume of heated or cooled space. This can be achieved by closing louvers, doors, or other suitable means. Heating and cooling an entire residence is usually unnecessary; the bedroom is rarely were using, halls can be closed off, and so on.Air entering or leaving a home is a major source of energy waste. Infiltration refers to unintentional air transfer toward the inside, while exfiltration refers to unintentional air handover toward the outside. However, the term "infiltration" is frequently used to refer to air leakage into and out of a home, and this is the term used in this chapter. Infiltration of cold or hot air will increase heating energy use in a poorly "sealed" residence.

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Heat pump efficiency decreases as the temperature difference between the heat source and heat sink decreases. Because outside air is usually the source of heat, heat is most difficult to obtain when it is most needed. As a result, heat pumps frequently have electrical backup heaters for extremely cold weather.Another option is to design the system with a heat source other than outside air. Heated air (such as that which is exhausted from a building), a deep well (which provides water at a constant year-round temperature), the ground, or a solar heating element are all examples. There are numerous solar heating and temperature pump combination options.

Thermal Energy Storage

TES systems are used to lower on-peak power requirements caused by heavy cooling loads. TES systems use a variety of storage media, the most common of which are chilled water, ice, as well as eutectic salts.The most space is required for chilled water, which is typically stored in underground tanks. Aboveground, insulated tanks with heat exchanger coils that cause the water to freeze, or one of several types of ice-making machines.In a typical system, a chiller produces ice during off-peak hours (usually at night). Because the chiller can run for a greater duration than during the daily peak, its capacity can be reduced.

When the condensing temperatures are lower at night than during the day, efficiency increases. Chilled water pumps circulate water through the ice storage system and obtain heat during the day. Systems can be designed to meet the total packet or a portion of it, with an auxiliary chiller acting as a backup. This method eliminates peak demand while also reducing energy consumption. It is possible to deliver liquid at a lower temperature than is normally done using ice storage. This allows for smaller chilled water piping and lower pumping power.

A limited air distribution system enables smaller ducts and lower-capacity fans to deliver the same amount of cooling. To ensure comfort conditions in conditioned spaces, the system design must be carefully considered. Customers who install TES systems may be eligible for incentives from federal agencies and electric utilities. The utility incentives could take the form of a fixed rebate per ton of capacity, a fixed rebate per kW of deferred peak demand, or a time-of-use cost structure that favors TES.

Water Heating

The size of a residential water heater typically ranges from 76 L (20 gal) to 303 L. (80 gal). Depending on tank size, electric units typically have one or two immersion heaters, each rated at 2-6 kW. The energy input for water heating is determined by the temperature at which the water is delivered, the temperature of the supply water, and standby losses from the water heater, storage tanks, and piping.

The energy factor refers to the efficiency of water heaters (EF). Water heaters with higher EF values are more efficient. Typical EF values for electric resistance heaters are around 0.8-0.95, 0.5-0.8 for natural gas units, and 0.7-0.85 for oil units, and 1.5-2.0 for heat pump water heaters.

Significant savings can be obtained in single-tank residential systems by: Thermostat temperature roadblock to 608C (1408F) Automated control Supplementary tank insulation Insulation for hot water piping, because electric water heaters do not have flame or stack losses, standby losses through the tank walls and piping are the primary source of heat loss. The temperature difference between the tank and its surroundings determines heat loss. Lowering the temperature to 608 degrees Celsius will result in two savings: (1) less energy required to heat water and (2) less heat lost. Residential hot water uses do not require temperatures above 608°C; for any special use that does, it would be preferable to provide a booster heater to meet this requirement when needed, rather than maintaining 100-200 L of water continuously at this temperature and incurring associated losses.

When the tank is filled with cold water, both heaters activate until the temperature reaches a predetermined level. Following this initial rise, one heating element thermostatically cycles on and off to maintain the temperature, replacing heat lost by conduction and convection during standby operation or heat removed by withdrawing hot water.Experiments show that the heating elements may only be activated 10%-20% of the time, depending on the ambient temperature, hot water demand, water supply temperature, and so on. This time can be greatly reduced by carefully scheduling hot water usage. In one instance, a residential water heater was turned on for one hour in the morning and one hour in the evening. The early afternoon cycle provided enough hot water for laundry, dishes, and other needs. Throughout the day, the water in the tank gradually cooled but remained sufficiently hot for ancillary needs. The nighttime heating cycle provided enough water for cooking, dishwashing, and bathing. Standby losses have been reduced. Electricity consumption was reduced to a fraction of its normal level.

To regulate the water heater, this method necessitates the setup of a time clock and other type of control. To meet special needs, a manual override can indeed be provided. To reduce standby losses, additional tank insulation can indeed be installed at a low cost. The economic benefit is determined by the cost of electricity and the form of insulation used. On older water heaters, however, paybacks of a few months to a year are common. Newer units have improved insulation and lower losses. Heated water piping should also be insulated, especially if the hot water tanks are outside or the piping runs are long. Because copper pipe can provide an efficient heat conduction path, it is especially important to insulate the pipe for the first 3-5 m where it joins the tank.

Because energy input is determined by the water flow rate and the temperature difference between the supply surface temperature and the hot water discharge temperature, lowering either of these two parameters reduces energy consumption. Hot water demand can be reduced by washing clothes in cold water and providing hot water at or near the use temperature, avoiding the need for dilution with cold water. Water should be supplied at the highest temperature possible. Supply piping should be buried, insulated, or otherwise kept above the ambient temperature because reservoirs and subsurface piping systems are generally warmer than that of the air temperature on a winter day in a cold climate.

Solar water heating systems are now available. Simple, low-cost systems can preheat the water, lowering the amount of energy required to make the top temperature. Solar heaters (some with electric backup heaters) are another option, though the initial costs may be prohibitively high depending on the specific installation.

Heat pump boilers can save up to 25%-30% of the energy used by a standard electric water heater. Some utilities have offered thousands of dollars in rebates to encourage customers to configure heat pump water heaters.Tankless water heaters, also known as on-demand or instantaneous water heaters, have been used in Asia, Europe, and South America for decades, but have only recently become common in the United States. There are electric and gas versions available. The flow of water activates the gas-fired or electric heating element, which is the basic operating principle. A microcomputer detects the flow rate and temperature of the water and controls the heat input accordingly. There are two major benefits. First, because the unit only produces hot water when it is needed, standby losses are virtually eliminated.

Second, the units are very small and take up a fraction of the space that tank-type water heaters do. Efficiencies (EF) for gas units range between 0.80-0.82 and 0.95 for powered units. Pilot light losses are eliminated in gas units equipped with only an electric igniter. The larger units perform similarly to tank-type water heaters. The authors' tests in Southern California show that the hot groundwater is adequate for a typical three- or four-bedroom home.Another intriguing technology that is just starting to emerge in both residential applications is the microwave water heater. Microwave water heaters are also tankless systems that create hot water only when it is required, avoiding the energy losses that conventional water heaters incur during hot water storage. These heaters are made up of a stainless steel closed chamber, a silica-based flexible coil, and a magnetron. When a user opens a tap or a heater timing device detects a demand for hot water, water flows into the coil and the magnetron bombards it with microwave energy at a frequency of 2450 MHz. The microwave energy excites the water molecules, causing them to heat up to the desired temperature.

Another technique for preheating or heating water is heat recovery, though opportunities in residences are limited. This is covered in greater depth under commercial heating water. A combined water heater/storage tank, an airflow loop, and a circulating pump are used in apartments and larger buildings. The tank is supplied with cold water, which is thermostatically maintained at a preset temperature, typically 718 degrees Celsius (1608F). The circulating pump keeps water flowing through the circulating loop, ensuring that hot water is always instantly available on demand to any user. This method can also be used in hotels, office buildings, and other public places.

CHAPTER 9

NONRESIDENTIAL SYSTEMS

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Commercial/industrial hot water systems provide numerous opportunities for heat recovery. Heat sources include compressor, chillers, water heaters, refrigeration systems, and water-cooled equipment. In many cases, heat recovery allows for double energy savings. First, recovering heat for hot water or heaters decrease the quantity of direct energy required for heating.The secondary benefit is that less energy is required to dissipate waste heat to a heat sink (typically the atmosphere). This includes the use of energy as well as the energy expended to run cooling towers and heat exchangers.

Solar hot water structures are also becoming more popular. Surprisingly, the requirements for solar hot water systems also allow for heat recovery. After the hot water storage ability and backup heating capability for the solar hot water system have been provided, it is cost effective to connect other sources of excess heat (e.g., water jackets on air compressors.

Lighting

There are seven basic techniques for increasing lighting system efficiency: delamping, relamping, improved controls, and more efficient lamps and devices. Increased use of full sunlight Task-oriented lighting Color changes in the room, lamp maintenance

The first two techniques, and possibly the third, are low-cost and could be classified as operational changes. The last four items are typically retrofit or new designs. A lighting survey is the first step in analyzing lighting electricity use. As a first approximation, an inexpensive handheld light meter can be used; however, a distinction must be made between raw intensities (lux or foot-candles) and illumination quality recorded in this manner.Many factors can influence the "correct" lighting values for a given task, including task complexity, employee age, glare, and so on. Consult a lighting specialist for accurate results, or consult the Illuminating Engineering Society's literature and publications.

The lighting survey identifies areas of the building where lighting may be insufficient or excessive. Overdesign, building changes, change of occupancy, modified layout of equipment or personnel, more efficient lamps, improper use of equipment, dirt buildup, and other factors can all cause deviations from adequate illumination levels.

After identifying areas with potentially excessive lighting levels, the building manager can use one or more of the seven techniques described above. Each of these will be briefly described. The removal of lighting to reduce light to acceptable levels is referred to as delamping. The bulbs in incandescent lamps are removed. Ballasts account for 10%-20% of total energy use in phosphorescent or high intensity discharge lamps and should be disconnected after the lamps are removed. However, delamping frequently alters the lighting distribution as well as the overall level and is thus generally not recommended.

Relamping is the process of replacing existing lamps with lower wattage or more efficient lamps. There are low wattage fluorescence tubes available that use 15%-20% less wattage but produce 10-15% less light. There is a discussion on the idea of using reduced electronic ballasts, as well as more details on efficient lighting technologies, in Energy Efficient Lighting Technologies. In some high-intensity discharge (HID) lamps, a more efficient lamp can indeed be directly substituted (it too will have a lower lumen output). In most cases, however, ballasts must also be replaced.

Improved controls allow lamps to be used just when and where they are required. For example, in some office buildings, all of the lights on a single floor are controlled by a single contactor. These lamps will be turned on at 6:00 a.m. before work begins and will remain on until 10:00 p.m., when maintenance personnel complete their cleanup duties.Installing individual switches for each office or work area, installing timers, occupancy sensors, photocell limits, and/or dimmers, or instructing custodial crews to turn lights on as needed and off when work is completed can reduce energy usage by up to 50%. Building-wide lighting control systems available and are increasingly being implemented, particularly in commercial buildings.

The efficacy (a measure of light production per unit of electricity input) of various lamps varies greatly. Incandescent lamps have the lowest efficacy, typically ranging from 5 to 20 lm/W. Fluorescent lamps should be used instead of incandescent lamps whenever possible. This not only saves energy but also offers significant financial savings because fluorescent lamps last 10-50 times longer. Conventional fluorescent lamps have efficacies in the 30-70 lm/W range, while high-efficiency fluorescent systems currently produce 85-100 lm/W.

Compact fluorescent lights can also be used to replace a variety of incandescent lamps. They are available through wattages ranging from 5-70 W and can replace incandescent lamps while using one-fourth of the energy. In addition to energy investments, they have a rated life of 10,000 hours and thus need not be replaced as frequently as incandescent lamps.

HID lamps, such as metal halide and higher salt lamps, can provide even better improvement. Although they are not generally suitable for residential use (due to their high light output and high capital cost), they are increasingly being used in commercial and industrial buildings due to their high efficiency and long life. It should be noted that HID lamps are not suitable for any application that requires lamp switching, as they still take several minutes to restart after being turned off.

Another way to save lighting energy is to improve ballasts. The transition from T12 (1.5-in. diameter) fluorescent lights with magnetic ballasts to T8 (1-in. diameter) flourescent lights with electronic ballasts is one example of a significant increase in efficacy in the commercial sector. This transformation began in the late 1970s and early 1980s. T8 electronic ballast systems are now the industry standard for both new construction and refurbishments (note that competition from new T5 systems is increasing).Depending on the fixture, the efficacy improvement ranges from 20% to 40% or more. A two-lamp F34T12 fixture (two 1.5-in. diameter, 34-W lamps) with energy-saving magnetic ballast requires 76 W, whereas a two-lamp F32T8 fixture (two 1-in. diameter, 32-W lamps) with electronic ballast requires only 59 W, representing a 22% savings in electricity. The savings are due to the lower lumen output lamps and the significantly more efficient ballast.

In addition to the energy savings from the lighting, there are additional savings from the reduced air conditioning load caused by the ballasts' lower heat output. Another important lamp concept is task lighting. Lighting is provided for work areas in proportion to the requirements of the task in this approach. Lighting is reduced in corridors, storage areas, and other non-work areas. Task lighting can be used instead of the "uniform illumination" method that is sometimes used in office buildings. The rationale for uniform illumination was that the designer could never know the exact layout of desks and machinery ahead of time, so uniform illumination was provided. This also allows for changes to the floor plan. Originally, electricity was inexpensive, and any additional cost was insignificant.

Before the invention of electricity, daylighting was a critical component of building design. Today, daylighting can be used to reduce (if not replace) electric lighting in certain kinds of buildings and operations. Windows, an atrium, skylights, and other techniques are used. There are obvious constraints, such as the need for privacy, 24-hour operation, and building core places with no natural light. The final step is to go over the color schemes and decor of the building and rooms. The use of neutral tones can significantly improve illumination without requiring any changes to existing lamps.An effective lamp proper maintenance can also provide significant benefits. Over the lamp's lifetime, light output gradually decreases. This should be regarded both during the design process and when deciding on lamp replacement. Dirt can significantly reduce lighting; simply cleaning lamps and leading lights more frequently can result in up to 5%-10% more illumination, allowing some lamps to be removed.

Refrigeration

The refrigerator is one of the top six residential electricity users, consuming between 40 and 140 kWh per month depending on the size and age of the model. Refrigerator/freezer design has evolved significantly over the last 50 years, with sizes raising from 5-10 to 20-25 ft.3 today. At the same time, energy input per unit increased until the oil embargo, then after efforts led to a steady decline in energy use per unit from the mid-1970s to today, despite a rise in average refrigerator size. As a result, modern refrigerators use roughly the same amount of energy as refrigerators half their size did forty years earlier.

Refrigerator energy losses are caused by a variety of factors. The most significant losses are caused by heat gains through the facade and door openings. Because the design of a refrigerator influences how much energy it consumes, it should be chosen with care. To maximize efficiency, look for models that are Energy Star certified.Many people who have a serviceable component and do not want to replace it cannot afford to buy a new, more efficient unit. In this case, the power management challenge is to maximize the efficiency of the existing equipment.

Better insulation (although this is not usually a user option for refrigerators) Disconnecting or reducing the operation of automatic defrost and anti-sweat heaters Providing a chilly location for the refrigerator coils (or lowering room temperature); also clean coils frequently Reducing the number of door openings Increasing temperature settings Food cooling before refrigerating

Supermarkets, liquor stores, eateries, hospitals, hotels, schools, and other institutions—roughly one-fifth of all commercial facilities—have commercial refrigeration systems. Walk-in milk and cheese cases, open refrigerated cases, and freezer cases are examples of systems. Lighting, HVAC, and miscellaneous uses account for half of the electricity used in a typical supermarket, while refrigerated display cases, steam turbines, and condenser fans account for the other half. As a result, commercial refrigeration can be a critical component of electric energy efficiency.In some types of units, the compressor and temperature exchange equipment are located outside of the refrigerator compartment. In such systems, a cool location should be chosen rather than placing the compressor near other heat-producing equipment. Many newer commercial refrigerators include heat recovery systems that reuse compressor heat for ventilation and cooling or water heating.

Refrigerators and walk-in freezers lose energy through door openings, whereas refrigerated glass cases have direct heat transfer. These issues can be mitigated by using covers, strip curtains, air curtains, glass doors, or other thermal barriers. In large refrigerators and freezers, the most efficient light sources ought to be employed; every 1 W saved saves 3 W. The elimination of 1 Wof of electricity required to generate light also eliminates an additional 2 W required to extract heat. Other improvements, such as high-efficiency motors, variable-speed drives, more efficient compressors, and continued to improve refrigeration cycles and controls, can help to reduce energy consumption.

Cooking

In 1999, cooking accounted for approximately 7% of household electricity use and approximately 2.1% of commercial electricity use. Consumer attitudes toward cooking have shifted since that edition of this handbook. Consumers are increasingly eating out or purchasing prepared foods rather than cooking at homecompares the number of hot meals cooked at home between 1993 and 2001. According to the data, fewer households roasted one or even more hot meals per day in 2001 than in 1993; additionally, in 2001, more households cooked a few meals or less per week than in 1993.

Convenience is important to the modern family, so consumers are buying more foods which are easier to prepare. As a result, the food processing industry provides a wide range of pre-prepared, ready-to-eat products. Though habits are changing and more cooking is taking place outside the home (in restaurants and food processing facilities), energy conservation remains critical. In general, improvements in cooking energy efficiency can be divided into three categories:

Using more efficient existing appliances using the most efficient existing appliances using more efficient new appliances

The most efficient use of extant appliances can result in significant energy savings. Although geared toward electric ranges and appliances, the observations below also apply to cooking devices that use other types of heat.First, choose the appropriate size necessary equipment. Do not overheat masses or greater surface areas that will wastefully radiate heat. Second, optimize heat transfer by ensuring that pots and pans are thermally coupled to heat sources. On electric ranges, flat-bottomed pans should be used. Third, make sure to cover pans to prevent heat loss and shorten cooking times. Fourth, when using the oven, plan meals so that multiple dishes can be cooked at the same time. Use small appliances (rechargeable fry pans, "slow" cookers, toaster ovens, and so on) whenever they can efficiently replace larger appliances like the oven.

Different appliances behave similarly cooking tasks at varying degrees of efficiency. For example, depending on the method, the electricity used and cooking time required for popular food items can vary by as much as ten to one in terms of energy use and five to one in terms of cooking time. Four baked potatoes, for example, require 2.3 kWh and 60 minutes in an electric range oven (5.2 kW), 0.5 kWh and 75 minutes in a toaster oven (1.0 kW), or 0.3 kWh and 16 minutes in a microwave oven (1.3 kW). When used as intended, small appliances are generally more efficient. Home measurements revealed that a pop-up toaster uses only 0.025 kWh to cook two slices of bread. Unless a significant number of slices of bread (or more 17 in this case) are to be toasted at once, the toaster would be more efficient than the broiler in the electric range oven.

Cooking multiple dishes at once would help you save energy. A ham (2.3 kg), frozen peas (0.23 kg), four yams, and a pineapple upside-down cakewere prepared separately in a toaster oven and an electric range, together in an electric oven, and separately in a microwave oven.

Cooking separately in the toaster oven and range required 5.2 kWh; cooking together in the oven required 2.5 kWh; and cooking in the microwave required 1.2 kWh. When purchasing new appliances, choose the most energy-efficient models available. Heat losses from a traditional oven approach 1 kW, with insulation making up approximately 50% of the total; losses around the oven door edge and through the window come in second. Certain models reduce these losses.

Self-cleaning ovens are typically built with more insulation. Careful design of heating elements can also help with heat transfer. Household electric ranges typically require 3200 W for oven use, 3600 W for broiler use, and 4000 W for self-cleaning.

Because microwave energy is deposited directly in the food, microwave cooking is highly efficient for many types of foods. Because there is no need to heat the food preparation utensil, energy consumption is reduced. Although a microwave oven can effectively prepare many common foods, different methods must be used because some foods are not suitable for microwave cooking. A typical microwave oven uses approximately 1300 W. Convection cookers and induction cook tops are two newer innovations that may help to reduce cooking energy consumption.Commercial cooking operations vary from minor restaurants and cafes that use methods similar to those described above for residences to large institutional kitchens in hotels, hospitals, and food processing plants.

Many of the same methods are used. Microwave cooking is becoming more popular in hotel and restaurant kitchens. Energy can be saved by carefully scheduling equipment use and providing several small units rather than a single large version. Grills, soup kettles, bread warmers, and other restaurant equipment, for example, frequently run continuously. In general, having full capacity during off-peak hours is unnecessary; one small grill could handle mid-morning and mid-afternoon needs, allowing the second and third units to be turned off. The same strategy can be used for coffee warming stations, hot plates, and other similar items.

Heat recovery is an important technique in food processing plants where food is cooked and canned. Normally, heat is ejected from the process via cooling water at some point. This heat can be recovered and used to pre-heat products entering the process, reducing the amount of heating required in the long run.

Clothes Drying

Dryers typically consume about 2.5 kWh per load. To quantify the efficiency of clothes drying, a parameter known as the energy factor, which is a measure of the pounds of apparel dried per kWh of electricity consumed, can be used. 3.01 is the minimum EF for a standard capacity electric dryer. Because new dryers in the United States are not required to exhibit energy consumption information, comparing models is difficult. In fact, most electric drying on the market are built similarly and use the same basic heating technology.

However, the dryer's actual energy consumption varies depending on the type of controls it has and how the operator is using those controls. Models with moisture sensing capabilities can save the most energy savings of up to 15% compared to conventional operation are common. Furthermore, electric clothes dryers work best when fully loaded. Operating at one-third to one-half load saves about 10%-15% on energy.

By reducing the energy required to heat up, placing clothes dryers in heated areas could save 10%-20% of the energy used. Another strategy is to save up loads and do numerous loads in a row so that the dryer does not cool down among both loads.

The heavier the clothes, the more water they can hold. Mechanical water removal (pressing, spinning, and wringing) uses less energy than electric heat. As a result, before putting things in the dryer, make sure the washing machine has completed a full spin cycle (0.1 kWh).

Solar drying has been practiced for millennia and uses very little electricity. It requires a legdrop (rope) and two poles or trees. The main constraint is, of course, bad weather. In the future, new technologies such as microwave or heat exchanger dryers may help to reduce clothes drying energy consumption.

Clothes Washing

The modified energy factor (MEF) may be employed to compare different washer models. It accounts for the energy used by the washing machine, the energy used to heat the water, and the energy used by the dryer to remove any remaining moisture. A clothes washer with a higher MEF value is more efficient.

After January 1, 2004, all new clothes shims manufactured or imported must have a MEF of at least 1.04, and after January 1, 2007, a MEF of at least 1.26. Furthermore, as of January 2004, a clothes dryer must have a minimum MEF of 1.42 in order to qualify as an Energy Rating unit. A typical Energy Star unit consumes approximately 0.7 kWh per load.

Electric clothes washers are intended for loads weighing 3-7 kg. Surprisingly, the majority of the energy used in clothes washing is for hot water; the washer itself requires only a small percentage of the total energy input.

As a result, the use of cold or warm water for washing is the most significant opportunity for energy management in clothes washing. It is not necessary for using hot water in a typical household. After a 208C wash, clothes are just as clean (in terms of bacteria count) as after a 508C wash. If there is a concern about sanitation (for example, a sick person in the house), authorities advise using chlorine bleach. If you need to remove oil or grease stains, use hot water (508C) and detergent to emulsify the oil and fat. A hot rinse serves no purpose. Using full loads can result in additional savings. According to surveys, machines are frequently operated of partial loads, even when a full load of hot water is used.

Computers and Office Equipment

At this point, computers are fairly common in both the residential and commercial sectors. Going to LCD displays instead of CRT displays, as well as enabling the sleep or power saver footwork drills available with the machines, can result in significant energy savings. Making use of laptop computers instead of desktop computers saves money as well.

Commercial buildings contain a wide range of equipment, in addition to computers, depending on their size and function. Due to the wide variety of these items, process equipment within buildings (e.g., clothes washers in laundries, printing presses, refrigerated display cases, etc.) will not be discussed.Major energy-consuming device in commercial buildings, excluding process equipment, generally includes HVAC systems, lighting, and "other" equipment. Because smart energy options for HVAC and lighting have already been discussed, this section will focus on "other" equipment, such as computers, local area networks, and peripherals.

1. Electronic mail, facsimile machines
2. Vending machines and moisture coolers Copiers

Escalators and elevators

The energy management options available with this type of equipment are more limited. One obvious strategy is to ensure that all equipment is turned off when not in use. Another is to size equipment appropriately for the job, avoiding excess capacity, which increases both energy and demand charges.

In general, the most likely opportunity with elevators, escalators, and similar equipment is to turn them off during off hours or other times when they are not in use. Buildings contain a plethora of miscellaneous equipment that contributes only a small percentage of total energy use, is rarely used, and is an unlikely candidate for efficiency improvements.

Heating, Ventilating, and Air Conditioning Control Systems

HVAC system controls serve as a data link between vastly differing energy demands on a building's primary and secondary systems and the (usually) roughly uniform demands for indoor environmental conditions. Without a fully functioning control system, even the most expensive and meticulously designed HVAC system will fail. It simply cannot control the indoor environment to provide comfort. The HVAC designer must create a control system that: Sustains a comfortable building interior environment; Maintains acceptable indoor air quality; Is as simple and inexpensive as possible while meeting HVAC system operation criteria reliably throughout the system's lifetime; and Results in efficient HVAC system operating condition under all conditions. Commissions the structure, equipment, and control systems Documents system operation so that building staff can operate and maintain the HVAC system successfully.

It is a significant challenge for the Hvac designer to design an energy efficient and reliable control system. Inadequate system control design, inadequate commissioning, and insufficient documentation and training for building staff all contribute to HVAC system problems and poor operational control. This chapter covers the fundamentals of HVAC control as well as the operational requirements for successful operation6 Stein and Reynolds (2000), and Tao and Janis (2000) are all recommended readings on the subject (2005).

The HVAC system must be designed correctly and then constructed, calibrated, and commissioned in accordance with the mechanical and electrical system drawings in order to achieve proper control based on the control system design. Primary and secondary systems must be properly sized. Furthermore, air stratification must be avoided, control sensors must be properly provisioned, freeze protection is required in cold climates, and proper care must be given to minimizing energy consumption while maintaining reliable operation and occupant comfort.

The zone temperature (and, to a lesser extent, humidity and/or air quality in some buildings) is the primary and final controlled variable in buildings. As a result, tr will concentrate on temperature control methods. There are numerous other control loops in buildings that support zone temperature control within the primary and secondary HVAC systems, such as boiler and chiller control, pump and fan control, liquid and air flow control, humidifying, and auxiliary system control (for example, thermal energy storage control). This chapter only covers automatic control of these subsystems. An automatic control system is defined by Honeywell (1988) as a system that reacts to a change or imbalance in the variable it handles by adjusting other variables to restore the system towards the desired balance a well-known feedback control problem. Under varying outflow conditions, the water table in the tank must be maintained. As the tank is drained, the float opens a valve that allows water into the tank. This simple system contains all of the components of a control system:

Float sensor; reads the controlled variable, the water level Controller—linkage connecting the float to the valve stem; detects the difference between the full tank level and the operating level and helps determine the required position of the valve stem.Actuator (controlled device) internal nozzle mechanism that controls the flow of the valve (the final control element) in response to a level difference detected by the controller. Water level is a controlled system characteristic that is frequently referred to as the controlled variable.

Because the sensor (float) is personally affected by the action of the controlled device, this system is referred to as a closed loop or feedback system (valve). The sensor operating the controller in an open loop system does not directly sense this same action of the controller or actuator. A method of controlling the valve predicated on an external parameter including such time of the day or, which may have an indirect relationship to water consumption from the tank, is one example.

Feedback control systems use feedback to adjust an output control signal. The feedback generates an error signal, which is then used to drive a control element picts a basic feedback control system. It is possible to use both off-on (two-position) control as well as analog (variable) control. To implement analog control, numerous methodologies have been developed. Control systems of this type include proportional, fractional (PI), proportional-integral-differential (PID), fuzzy logic, neural networks, as well as auto-regressive moving average (ARMA). Most HVAC control applications employ commensurate and PI control systems a steam coil that is used to heat air in a duct. An air temperature sensor, a controller that relates the sensed temperature to the set point, a steam valve controlled by the controller, and the coil itself are all part of the simple control system shown. This example system will be used as a starting point for going over the different control system types.

Pneumatic Systems

Compressed air was used as the signaling transceiver in the first widely used automatic control systems. Air had the advantage of being able to be "metered" via various sensors and powering large actuators. The fact that a normal pneumatic loop's response time could take several minutes was often an advantage as well. Sensors and actuators in pneumatic controls are powered by compressed air (approximately 20 psig in the United States). Although electronic controls are used in most new buildings, pneumatic controls are used in many older buildings. This section will give you an overview of how these devices work.

The majority of pneumatic loop controls are temperature and damper control. epicts a temperature sensing and control signal generation method. A restriction allows main supply wind, supplied by a compressor, to enter a branch line. Depending on the position of the flapper, which is controlled by the temperature sensor bellows, the zone thermostat bleeds out a differential amount of air. The branch line pressure (control pressure) decreases as more air bleeds out. This reduction in total tension to the control element alters the control element's output. This control may function forward or reverse acting. The holes in the restrictions are typically a few thousandths of an inch in diameter and consume very little air. The pressures in the branch lines are typically somewhere around 3 and 13 psig (20–90 kPa). This pressure from a temperature sensor could operate an actuator, such as a control valve for a room heating unit, in simple systems. In this case, the thermostat serves as both the detector and the controller, which is a fairly common configuration.

CHAPTER 10

ENERGY EFFICIENCY

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Energy efficiency and economic use can help to offset the increase in energy prices. It has the potential to reduce energy provision, energy production and conversion installations, and the necessary infrastructure, such as critical infrastructure and storage facilities. Furthermore, energy conservation makes the market more competitive. End-user EE improvement measures concern local energy provision, conversion, and use in those sectors. The numerous and diverse ways in which power losses can occur due to inefficient use necessitate diverse and small-scale measures. The most important are discussed in the following sections.

The goal of Directive 2012/27/EU on fuel efficiency (EE Directive, EED) is to help the Union meet its target of improving EE by 20% by 2020 compared to business as usual. The EED includes a plethora of requirements for MS to increase EE.

Article 7, which requires MS to achieve an annual savings quota of 1.5% by 2020, is a critical component. The renovation of central government-owned public buildings will be accelerated, and energy audits will be performed in all larger enterprises. A flexibility clause allows MS to apply derogations that can be counted toward the Article 7 saving target at a rate of up to 25% (i.e., applying the derogations cannot result in a reduction of more than 25% of the energy savings actually results from the 1.5% target).

The Energy-related Products Directive, also known as Directive 2009/125/EC, establishes a framework for the intangible ecological of energy-related products. It requires all manufacturers who place products on the market in EU Member States to present a conformity declaration indicating that the product's design complies with the provisions of the Edict and the regulations issued under it for homogeneous groups of products. The regulations, for example, limit the power consumption of different subgroups of devices, such as household and office equipment, in stand-by and off-mode. Regulation 1275/2008/EC on electrical office and household equipment alone will save the EU 35 billion kW h per year by 2020. This equates to the elimination of 14 million tons of CO_2 emissions and the construction of nine 800 MW power plants Another regulation, 2013/801/EU, for data network equipment recently went into effect. Televisions, lamps, electric motors, and other organizations are also subject to EE regulations. Due to the legal prohibition on basic incandescent lamps, compact fluorescent lamps, also known as energy saving lamps, are being introduced to the market in a wide range of shapes and sizes.

Under Directive 2010/30/EC many of the appliances discussed previously, as well as dishwashers, washers and dryers, refrigerators, and freezers, are labeled for their annual energy consumption. Initially, beginning in the 1990s, EE was classified into classes A through G for labeling purposes. This system had to be modified in response to the EE improvements brought about by labeling for these product groups. Appliances in classes C to G have largely vanished from the market, and three new classes with one to three plus signs above class A (A+ to A+++) have been added. Between 2005 and 2010, the EE of labeled appliances improved by 7% in the EU (spanning from 0% in the United Kingdom to 18% in Spain). Buildings consume a large portion of total energy consumption. The European Commission estimates a 40% share and addresses existing savings potential in Directive 2010/31/EU on building energy performance The Directive requires EU Member States, among other things, to set minimum performance requirements for new buildings and existing buildings undergoing major renovations in order to achieve cost-effective levels. All new buildings must be nearly zero-energy by the end of 2020. Buyers and tenants must be provided with information about the EE of the constructing; for example, EE parameters must now be indicated throughout housing adverts.

Electronic Control Systems

The majority of HVAC system controllers are electronic in nature. Direct digital control systems (DDCs) made strides in the early 1990s and now account for more than 80% of all controller sales. Low-cost microprocessors now cost less than $0.50 each, making them very cost-effective to use. DDC controls can provide increased functionality as well as lower costs. BACnet has emerged as the standard communication protocol, with most control vendors offering a BACnet protocol version. This section examines the sensors, actuators, and controllers found in modern electrically operated controls for buildings.

Direct digital control (DDC) adds digital features to the previous analog-only electronic system. To control HVAC systems, modern DDC systems use analog sensors (converted to digital signals inside one computer) and digital computer programs. This microprocessor-based system's output can be used to control electronic, electrical, or compressed air actuators, or a combination of these. DDC systems offer stability and adaptability that others do not. For example, it is easier to set control constants accurately in computer software than it is to make adjustments at a control panel with a wrench.

Because the sensor data used for control is very similar to that used in EMSs, DDC systems can operate energy management systems (EMS) and HVAC diagnostic, knowledge-based systems. This capability is not available in pneumatic systems a DDC controller's schematic diagram. The actuators and sensors not shown in this controller-only drawing must be included in the overall control system. Three methods are used to measure temperature in DDC applications:

Resistance temperature detectors (RTDs) Thermocouples Thermistors Each has advantages in specific applications. Thermocouples are made up of two dissimilar metals that are chosen to produce a measurable voltage at the desired temperature. The output voltage is low (in the millivolt range), but it is a well-known function of junction temperature. Except for measuring flame temperature, thermocouples produce voltages that are too low to be useful in most HVAC applications (for example, a type-J thermocouple produces only 5.3 mV at 1008C). RTDs employ small, responsive sensor sections made of metals with well-established and reproducible resistance-temperature characteristics.

Modern electronics measure voltage and current and then use Ohm's law to calculate resistance. The measurement causes energy dissipation in the Variable resistor, which raises the temperature and causes a measurement error. The power dissipated in the RTD can be reduced to reduce Joule self-heating. Raising the resistance of the RTD assists in preventing self-heating, but the most effective method involves pulsing the current and measuring it in milliseconds. Because one measurement per second will typically satisfy even the most stringent HVAC control loop, power dissipation can be decreased by an amount of 100 or more. Modern digital controls are capable of handling the calculations required to implement piecewise linear model and other curve-fitting methods to improve performance.

A is proportional to the nominal resistance at the reference temperature (778F) and is measured in tens of thousands of ohms. The exponential coefficient B (a weak role of temperature) ranges between 5400 and 7200 R. (3000–4000 K). A thermistor's inherent nonlinearity can be reduced by connecting it in parallel with a properly selected fixed resistor. The resulting linear relationship is desirable in terms of control system design. Long-term drift and aging of thermistors can be a problem; the designer and control manufacturer should consult on the most stable thermistor design for HVAC applications. Some manufacturers offer linearized thermistors, which combine positive and negative resistive temperature dependence to produce a more linear response function.

Humidity measurements are required for the control of enthalpy economizers and may also be required for the control of special environments such as clean rooms, hospitals, and computer rooms. The moisture content of air is indicated by relative humidity, dew point, and humidity ratio. The most common sensor type is an electrical, capacitance-based approach based on a polymer with interdigitated electrodes. The polymer material absorbs water and changes its dielectric constant, causing the capacitance of the sensor to change. The sensor's capacitance is part of a resonant circuit, so when the capacitance changes, so does the resonant frequency. If not saturated by excessive exposure to high humidity levels, this frequency can then be correlated to relative humidity and provide reproducible readings Response times in the tens of seconds easily meet the majority of HVAC application requirements. These humidity sensors must be calibrated on a regular basis, usually once a year. If a sensor becomes saturated or develops condensation on its surface, it becomes uncalibrated and displays an offset from its calibration graph. Ionic salts were used on gold grids in older technologies. These expensive sensors frequently failed.

Pressure is measured using electronic devices that rely on a change in resistance or capacitance with applied pressure. Stretching the membrane elongates the resistive element, increasing resistance in the resistance type. This resistor is a component of a Wheatstone bridge; the resulting bridge voltage imbalance is proportional to the applied pressure. The capacitance between a fixed and a thin flexible decreases with pressure in the capacitive-type unit. A local amplifier amplifies the capacitance change and generates an output signal proportional to pressure. Overpressure or the water-hammer effect can cause pressure sensors to burst. Installation must strictly adhere to the manufacturer's specifications.

Flow measurements are required by DDC systems to determine the energy flow for air and water delivery systems. Pitot tubes (or arrays of tubes) and other flow measurement devices can be used in HVAC systems to measure either air or vapor flow. Air flow measurements enable accurate flow control in variable air volume (VAV) systems, building pressurization, and outside air control. Water flow measurements allow for chiller and boiler control as well as monitoring of various water loops in the HVAC system. Some controls only require the presence of flow knowledge. This is met by open-closed sensors, which typically have a paddle which it makes a switch connection in the presence of flow. These switches can also be used to detect "end of range," i.e., whether dampers and other mechanical control elements are fully open or closed.

HVAC systems frequently employ temperature, humidity, and pressure transmitters. They amplify signals generated by the basic devices described in the preceding sentences and generate an electrical signal over a standard range, allowing this aspect of DDC systems to be standardized.

Although the majority of transmitters generate such signals, the values listed above are not universally accepted. The controller's heart is a microprocessor, which can be programmed in either a standard or a system-specific language. The user can program control algorithms (linear or nonlinear), sensor calibrations, output signal shaping, and historical data archiving. Several companies have built controllers on standard computer platforms.

The details of programming HVAC control systems are beyond the scope of this chapter because each manufacturer takes a different approach. However, the essence of any Digital control system is the same. Honeywell (1988) goes into greater detail about DDC systems and programming.

Relays and motor starters—use to power other mechanical or electrical equipment (such as pumps, fans, chillers, and compressors), as well as electrical heating equipment.Transducers, for example, convert an electrical signal to a pneumatic signal (EP transducer) Visual displays are not actuators in the traditional sense, but are used to inform system operators about control and HVAC system function.

Both pressurized and DDC systems have advantages and disadvantages. Cost, hard to find replacements, requiring an air compressor with clean oil-free air, sensor drift, and imprecise control are all growing disadvantages of pneumatic systems. The advantages that have been retained include explosion-proof operation and a fail-soft performance degradation. Because of the ability to integrate the control system into a power turbine management and control system (EMCS), the accuracy of the control, and the ability to diagnose problems remotely, DDC systems have emerged and taken the lead over pneumatic controls for HVAC systems. Both technologies necessitate maintenance and skilled operators.

Basic Control System Design Considerations

The ultimate goal of an HVAC control system is to regulate zone temperature (and, secondarily, air motion and humidity) to ensure maximum occupant comfort and productivity.The HVAC system is assumed to be capable of providing comfort conditions if properly controlled from a controls standpoint. A zone is any area of a building with loads that differ in magnitude and timing from other areas to the point where completely seperate portions of the secondary HVAC system and control system are required to maintain comfort.

After defining the zones, the creator must decide where to place the thermostat (and any other sensors that may be used). Thermostat signals are either sent to a central controller or used locally to regulate the amount and temperature of inculcated air or coil liquid introduced into a zone. The air is either locally conditioned (via a unit ventilator or baseboard heater) or centrally conditioned (via the heating and cooling coils in the central air handler). The thermostat signal controls a flow control actuator in either case. Furthermore, in VAV systems, airflow can be controlled in reaction to zone information. Flow is controlled by valves or dampers, with the exception of motors with variable speeds used in variable air volume air or liquid systems.

Steam and Liquid Flow Control

The flow area determined by the valve stem position, controls the flow through valves. The variable flow resistance provided by valves is determined by their design. The flow characteristic may or may not be positionally linear. The flow characteristics of the three most common valve types are depicted in it should be noted that the plotted characteristics only apply to constant valve pressure drop. The characteristics depicted are idealizations of exact valve characteristics. The curves shown will resemble, but not necessarily correspond, commercially available valves. Volumetric flow, V, and valve stem place, z, are proportional in the linear valve.

In equal percentage valves, the flow increases by same fractional amount with each increment of opening. In other words, is if valve is opened from 20 to 30% of its full travel, the flow will increase by the same percentage as if it were opened from 80 to 90%. The absolute volumetric flow increase in the latter case, however, is much greater than in the former. For a specific application, the type of cylinder (linear or not) must be chosen so that the controlled system is as close to linear as possible. Control valves are frequently used to regulate the thermal performance in coils. The combined characteristic of the actuator, valve, and coil in a linear system should be linear.

Different valves will be required for hot water and steam control, for example.

The part load performance of an air heating hot water coil; at 10% of full flow, the heat rate is 50% of the its peak value. A cross-flow heat exchanger's heat rate increases roughly exponentially with flow rate—a highly nonlinear characteristic. The longer water residence time in a coil at reduced flow, as well as the relatively large temperature difference between the air being heated and the water heating it, cause this heating coil nonlinearity.

If the flow through this heating coil were controlled by an equal percentage valve (positive exponential increase in flow with valve position), the combined valve plus coil defining feature would be roughly linear. , 50% of stem travel equals 10% flow. This near-linear subsystem is much simpler to regulate than the highly nonlinear coil with a linear valve. As a result, the rule is to use equal percentage valves for heating coil control.

Because the transfer of heat by steam condensation is a linear, constant temperature process—the more steam supplied, the greater the heatrate, in exact proportion—linear, two-port valves are to be used for steam flow control to coils. It is important to note that this is a completely different coil flow characteristic than that of hot-water coils.

However, because steam is a compressible fluid, the sonic velocity determines the flow limit for a given valves when the pressure drop across the valve exceeds 60% of the absolute pressure in the steam supply line. As a result, in Equation 6.19, the pressure drop to be used is the littlest of (1) 50% of the absolute stream pressure upstream of the valve or (2) 80% of the difference between the steam supply and return line pressures. In the subsonic flow regime, the 80% rule provides good valve modulation (Honeywell 1988).

Chilled water control valves should also be linear because the performance of chilled water coils (which have a smaller air-water temperature difference than hot water coils) is more similar to that of steam coils than hot water coils, how two- and three-way valves can be used to control flow at part load through the cooling and heating coils. The coil outlet water or air temperature can be used to control the control valve. When used for part load control, two- or three-way valves produce the same local result at the coil. When selecting the valve type, the designer must consider the effects on the secondary system's balance.

In essence, the two-way valve flow control method produces variable flow (tracking variable loads) with continuous coil water temperature change, whereas the three-way valve flow control method produces roughly constant secondary loop flow rate but smaller coil water temperature change (beyond the local coil loop itself). A primary/secondary design with two-way valves is preferred in large systems, unless the primary equipment can handle the range of flow variation that would result without a secondary loop. Because chillers and boilers require that flow remain within a specific range, energy and cost savings from a two-way valve, variable air volume system are difficult to achieve in small systems unless a two-pump, primary/secondary loop approach is used. If this dual-loop approach is not used, the three-way valve method must be used to keep the boiler or chiller flowing.

The designer must also consider the location of a three-way valve at a coil, a mixing, bypass valve used downstream of the coil. If a balancing valve is installed in the bypassline and set to have the same pressure drop as that of the coil, the pressure drop in the local coil loop will be the same for both full and zero coil flow. However, overall flow resistance is lower at the valve's mid-flow position.The three-way valve is also capable of functioning in a diverting mode. The same considerations apply in this arrangement as they do in the previous mixing arrangement.

However, inserting a circulator (small pump), changes the direction of flow in the branch line and requires the use of a mixing valve. Pumped coils are used because they provide better control. The highly nonlinear coil characteristic is reduced with constant coil flow so because residence time of hot water in the coil is constant, regardless of load. This arrangement, however, appears to the external rankine cycle as a two-way valve. As the load is reduced, so does the flow in to local coil loop? As a result, unless the optional bypass is used, the uniform secondary loop flow normally associated with three-way valves is absent.

Heating Control

If the previous system's minimum air setting is high, the amount of outdoor air admitted in cold climates may require preheating. How does a preheating system with face and bypass dampers work?

1. Direct-expansion [DX] cooling coils use a similar arrangement.)
2. The preheat PI controller detects the temperature as it exits the preheat section. It controls the face and bypass dampers to keep the exit air temperature between 45 and 508 degrees Fahrenheit.
3. The water valve at the preheat coil is controlled by the outdoor air sensor and its associated controller. The valve can be a modulating valve (for greater control) or an on-off valve (less costly).
4. The coil freeze protection measures, such as closing dampers and turning off the supply fan, are activated by the low-temperature sensors (LTs).

It should be noted that the preheat coil (as well as all other coils in this section) is wired so that the hot water (or steam) flows in the opposite direction of the airflow.

For a given coil, counter flow offers a more rapid heating rate than parallel flow. Upstream of the control sensors, heated or rather cold bypass air must be mixed.

Using sheet metal air blenders or propeller fans in the ducting can help to reduce stratification. The preheat coil should be installed at the duct's bottom. To avoid condensate buildup and coil freezing at light loads, steam preheat wires must have appropriately sized traps and vacuum breakers.

The face and bypass damper method allows air to be heated to the required system stockpile temperature without putting the heating coil in danger. (If a coil is as large as the duct with no bypass area, it may freeze when the hot water control valve cycles open and closed to maintain discharge temperature.) To keep water velocity above the 3 ft./s required to avoid freezing, the designer should consider pumping the preheat coil. The pump is not required if glycol is used in the system, but heat transfer is reduced.

Heat must be added to the mixed air stream during the winter in heating climates to heat the outside air portion of the mixed air to an acceptable discharge temperature. A common heating subsystem controller used with central air handlers. (If necessary, it is assumed that the mixed air temperature is kept above freezing by the action of the preheat coil.) Because the amount of heat required decreases with increasing outside temperature, the coil discharge temperature in this system is altered for ambient temperature.

Complete Systems

The five preceding example structures are actually control subsystems that must be integrated control system for the primary and secondary systems of the HVAC system. The remainder of this section will provide a brief overview of two complete Heating and cooling control systems that are commonly used in commercial buildings. The first is a constant volume system, and the second is a variable air volume (VAV) system.A single-zone constant volume central air-handling system with supply and return fans, heating coils, and an economizer. The zone thermostat shown will be replaced by a discharge air temperature sensor if the system were to be used for multiple zones. The following is how this constant pressure system works:

1. The control process is triggered when the fan is turned on.
2. The minimum outside air setting is set (usually only once, as described above, during commissioning).
3. The damper controller receives a signal from the OA temperature sensor.
4. The damper controller receives a signal from the RA temperature sensor.
5. Depending on which is cooler, the damper controller adjusts the dampers to use outdoor or return air.
6. The mixed-air low-temperature controller regulates the outside air dampers, preventing excessively cold air from entering the coils. If a preheating system was included, this sensor would be in charge of it.
7. The coil discharge air Compensator is reset by the space temperature sensor. The discharge air control system is in charge of the Heating coil valve.
8. Damper for outdoor air.

Other Systems

In large buildings, fire and smoke supervision are critical for life safety. National codes govern the design of cigarette control systems. The primary goal is to remove smoke from affected areas while keeping adjacent zones pressurized to prevent burn infiltration. Some space conditioning system components (for example, fans) can be used for smoke control, but HVAC systems are not typically designed to be smoke control systems.

The electrical engineer on an engineering team is primarily responsible for electrical systems. HVAC engineers, on the other hand, must ensure that the electrical design tolerates the HVAC control system.HVAC controls activate motors on fans or chiller compressors, pumps, electrical boilers, or other electrical devices, resulting in interfaces between the two.

A ladder diagram is frequently used by the HVAC engineer to convey electrical control logic in addition to electrical specifications. Controlling the supply but also return fans in a central system. The electrical control system, shown at the bottom, is powered by a low voltage (24 or 48 VAC) control transformer. The supply fan is manually started by closing the "start" switch.

This turns on the motor starting pitcher coil labeled 1M, closing the three 1M contacts in the supply fan circuit. After the start button is released, the fourth 1M contact (in parallel with the start switch) keeps the starter closed.

The hand-off auto switch is standard and allows the return fan to be operated both automatically and manually.The fan starts when the switch is moved to the "hand" position. When set to "auto," the fans will only turn on when the adjacent 3M contacts are closed. Either of these behavior stimulates the relay coil 2M, which closes the return fan motor starter's three 2M contacts. When either fan generates actual airflow, a flow switch in the ducting closes, completing the circuit to the pilot lights L. Fuse and overcurrent heaters protect the fan motors. If the motor current draw is too high, the heaters generate enough heat to access the normally closed overheat contacts.

Commissioning and Operation of Control Systems

The significance of making sound choices in HVAC control system design. It is also critical that the controller be properly commissioned and used. Many presumptions about the tower and its use are required during the design process. The designer must be confident that the systems will provide comfort in extreme conditions, and the sequence of design and construction decisions frequently results in systems that are significantly oversized. In general, operation at loads far below design conditions is much less efficient than operation at higher loads. Normal control practice can contribute significantly to this inefficiency.

Due to design flows that are sometimes twice as much as the maximum flow used in the building, it is quite common to see variable volume air handler systems operating as constant volume systems almost all of the time.As a result, it is critical that the control system and also the rest of the HVAC system be commissioned following construction. This procedure is designed to make sure that the control system operates in accordance with the design intent. This is really a bare minimum to ensure that the system works as intended. However, rather than basing these decisions on design assumptions, the control system setup can be modified after construction to meet the loads actually present in the building and to accommodate the way the building is actually used. If the VAV system is set up for more flow than is required, the terminal box minimum flow settings can be reduced below the design value, ensuring that the system operates in VAV mode the majority of the time. A variety of other changes may also be made. Such adjustments, which are commonly made during the Continuous Commissioningw (CCw) version of commissioning, can frequently reduce overall building energy use by 10% or more

(Liu, Claridge, and Turner 2002). When applied to an older building at which control practices have deviated from project plan and undetected component failures have once again eroded system efficiency, energy savings frequently exceed 20%.

CHAPTER 11

CONTROL COMMISSIONING

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The report on a case study whereby the process was implemented to a main Army hospital facility in San Antonio, Texas (2000a, 2000b, 2000c). When the CCw process began, the Brooke Army Medical Center (BAMC) was a relatively new facility. A third-party company operated the facility for the Army, and it has been operated in line with the initial design intent.

BAMC has a total floor area of 1,349,707 ft.2 and is a large, multipurpose medical facility. The complex houses all of the standard inpatient facilities, as well as ambulatory care and research facilities. The complex has a central energy plant with four 1,200 ton water-cooled powered chillers. Water is pumped through the chillers using four primary pumps (75 hp each). Two secondary pumps (200 hp each) with variable frequency drives (VFDs) supply cooled down water from the plant to the building entrance. To supply chilled water to all of the AHUs and small fan coil units, fourteen chilled water risers with 28 pumps totaling 557 hp are used. VFDs are installed on all chilled water riser pumps. This plant has four natural gas-fired steam boilers. Each boiler has a maximum output of 20 MMBtu/h. At 125 psi, steam is supplied to each building where heating liquid was generated (prior to commissioning).

The complex is served by 90 major AHUS with a massive fan power of 2570 hp. On 65 AHUs, VFDs are installed, and the remainder are constant volume systems. The complex has 2,700 terminal boxes, with 27% being dual duct changeable volume (DDVAV) boxes, 71% being dual duct constant volume (DDCV) boxes, and 2% being single duct variable volume (SDVAV) boxes.

A DDC control system manages the Hvac equipment (chillers, boilers, AHUs, pumps, terminal boxes, and room conditions). Individual controller-field panels are used for mechanical rooms' AHUs and water loops. The central computers or even the field panels can change the control program and parameters.

Design Conditions

The EMCS was fully utilizing the design control program. It had the following characteristics:

1. AHUS hot deck reset regulate
2. Some units' cold decks are reset during unoccupied periods.
3. VAV unit static pressure reset among both high and low limits
4. Temperature control of the hot water supply with a reset schedule
5. Control of chilled water pumps via VFD with DP set point value (no reset schedule)

Control and monitoring at the terminal box level

The facility operator was also found to be maintaining the facility in line with the existing design intent. For a large hospital complex, the building is considered fuel efficient.

The commissioning operations were carried out at the terminal box, AHU, loop, and central plant levels. Given the actual function and usage of the areas and rooms, a variety of improved operation measures and energy solutions were implemented in various HVAC systems. Each measure will be briefly discussed, beginning with the plane units.

Optimization of AHU Operation

EMCS trending, combined with site measurements and the use of short-term data loggers, revealed that many supply fans ran at or near full speed the majority of the time. Static pressures were significantly higher than required. Wide temperature swings caused by the AHU shutoff resulted in hot and cold people complaining in some areas. The following potential means of improving the procedure of the two AHUs were identified through field measurements and analysis.

Improve zone air balancing and determine new static pressure set points for VFDs Optimize the cold deck temperature set points with reset schedules Optimize the hot deck temperature reset schedules Improve control of any outside intake air and relief dampers during unoccupied periods to reduce ventilation during these periods To avoid unnecessary preheating, raise the preheat temperature set point. These measures enhanced comfort while lowering heating, cooling, and electricity consumption.

Optimization at the Terminal Box Level

Field measurements revealed that many VAV boxes had higher-than-necessary minimum flow settings, and that some containers were unable to supply adequate hot air due to specific limited regions.In the full heating mode, modern control logic was developed that increased hot air capacity by 30% on average and reduced simultaneous heating and cooling. Minimum flow settings on VAV boxes were decreased to zero during unoccupied periods, and flow settings in constant volume boxes were reduced.

During commissioning, it was discovered that some terminal boxes were unable to provide the required airflow prior to or following the control program adjustment. Specific issues were discovered in approximately 200 boxes, the majority of which had high flow resistance due to screwed down flex ducts.

Water Loop Optimization

There are 14 chilled water risers with 28 pumps that supply chilled water to the entire complex. During the construction phase assessment phase, the following observations were made: All of the riser pumps were equipped with VFDs that were set to run at 70%-100% of full speed. All of the risers' manual balancing valves were only 30%-60% open. The DP sensor for every riser was placed 10-20 feet from the AHU's far-end coil on the top floor. Differential pressure setpoints ranged from 13 to 26 psi for each riser. The return loop lacked a control valve. Although the majority of the cold deck temperatures were holding well, 13 AHUs had cooling coils that were completely open but could not maintain cold deck thermal setpoints.

Traditional manual implementation is successful are ineffective because the risers are equipped with VFDs. By first opening all of the manual balancing valves, all of the risers were rebalanced. The actual pressure requirements for each riser were measured, and it was determined that the DP for each riser could be significantly reduced. Pumping power consumption was reduced by the more than 40%.

Central Plant Measures

During the summer and swing seasons, steam pressure had been reduced from 125 psi to 110 psi, and one boiler operated instead of two. Chilled Water Loop: Prior to commissioning, the plant's blending valve separating the two main loops was completely open. Both the primary and secondary pipes were operational. Although the secondary loop pumps are equipped with VFDs, the manual vents were partially open. Following the commissioning assessment and investigations, the following actions were taken:nClose the blending stations and open the mechanical valves for the secondary loop.Turn off the secondary loop pumps. As a result, the primary loop pumps provide the requisite chilled water flow and pressure to the entrance of the building for the majority of the year, while the secondary pumps are typically turned off. The operator reduces the online cooling numbers based on the load circumstances, and the minimum chilled water flow to the chillers is maintained. Simultaneously, the chiller's efficiency is increased.

Neural Network Introduction

An artificial neural network (ANN) is a massively parallel, dynamic system of interconnected, interconnected parts inspired by aspects of the brain. Because they learn by example instead of by following programmed rules, neural networks are thought to be intuitive. The ability to "learn" is a key feature of neural networks. A neural network is made up of several layers of neurons that are linked together.A connection is a one-of-a-kind information transport link that connects one sending neuron to one receiving neuron.The schematic structure of a portion of a NN. There is no limit to the number of input, output, and "hidden layer" neurons that can be used (only one hidden layer is shown). One of the challenges of this technology is to build a net with enough complexity to learn accurately without imposing an excessive computational time burden.

A neuron is the basic building block of a subnet. Each is given a set of inputs. Each input set element is multiplied by a weight, denoted by the W, and the products are added at the neuron. INPUT is the symbol for the sum of weighted inputs, and it must be determined by calculating for each nerve cell in the network.Where Oi are neuron inputs, i.e., previous layer outputs, Wi are weights, and B is the bias. Following the calculation of INPUT, an activation function, F, is used to modify it, resulting in the neuron's output as described below.

A wide range of methods have been used to train artificial neural networks (McClelland and Rumelhart 1988).One systematic method for training multilayer perceptron neural networks is back-propagation. Small random numbers are used to start the weights of a net. The goal of training the network is to iteratively adjust the weights so that applying a collection of inputs produces the desired set of outputs matching a training data set. Typically, a network is trained using a data set that contains many input-output pairs; this data is referred to as a training set. Back-propagation training necessitates the following steps:

1. From the training set, choose a training pair and apply the input vector to the network input layer.
2. Determine the network's output, OUTi.
3. Determine the ERRORi, network output, and expected value (the target vector from the training pair).
4. Modify the network's weights in order to minimize error.
5. Repeat steps 1–4 for each vector there in training set until the overall error is less than the user-specified, preset training tolerance.

In the JCEM laboratory, where fullscale, repeatable checking of multizone HVAC systems can be done, a proof of concept experiment was conducted in which neural networks (NNs) were used for both local and global control of a commercial building HVAC system. Data collected in the lab was used to train NNs for the two components and the entire system. Any computer vision controller will only be useful if it outperforms a traditional PID controller. Typical PID and NN control results for a heating coil. A PID controller encountered difficulties due to the heating coil's highly nonlinear nature. A PID controller tuned for one level of load is unable to limit acceptably at another, whereas the NN controller is not.

Excellent control is evidenced by the NN controller, with minimal overshoot and rapid response to setpoint changes.Curtiss, Brandemuehl, and Kreider (1993) demonstrated that NNs also provided a method for global control of HVAC systems in a related study. The goal of such controls could be to reduce energy consumption as much as possible while still meeting comfort requirements.

Energy-Efficient Lighting Technologies

Lighting is a critical electrical end use in every industry and building type in the United States (U.S.). In 2003, lighting accounted for roughly one-third of commercial and nearly one-fifth of residential delivered (site) electricity consumption, or roughly one-quarter of all electricity delivered to these two sectors combined The majority of the electricity used for lighting in the United States is consumed by the commercial sector. In 2001, the commercial sector used approximately 51% of total lighting electricity, the residential sector 27%, the industrial sector 14%, and outdoor stationary lighting 8%.

Through the use of more efficient lighting technologies, as well as advanced lighting design standards and control strategies, there is significant potential for saving electricity, decreasing the emission of greenhouse gases associated with electricity production, and lowering consumer energy costs. New, efficient techniques that enter the marketplace later on have the potential to further reduce energy consumption and increase financial savings.

In this chapter, we will look at both traditional and newer, more efficient lighting technologies. Design of energy-efficient lighting systems; Characterizations, applications, and effectiveness of various lighting technologies (including lamps, ballasts, fixtures, and controls); Operation of energy-efficient lighting systems; Current lighting markets and trends; Lighting efficiency standards and incentive programs; and Cost-effectiveness of efficient lighting technologies are all discussed.

Design of Energy-Efficient Lighting Systems

A lighting system is an essential component of the architectural design of a building, interacting with the shape of each room, its fixtures and fittings, and the amount of natural light. Although energy efficiency is an important consideration in lighting system design, creative people must also consider economics, productivity, aesthetics, and consumer preference. It is critical not to sacrifice lighting quality in a new lighting design or energy-efficient retrofit. To improve a building's lighting efficiency, a lighting designer must understand the user's lighting needs and preferences, the most efficient engineering solutions to meet these needs, and how individual lighting components work together as a system.

Attention to task and ambient lighting, effective use of daylighting, effective use of lighting controls, and use of the greatest cost-effective and productive technologies are all components of efficient, high-quality lighting design.

Because people desire less light in nearby areas than they do where they perform visual tasks, lighting an entire space at a level appropriate for visual tasks is usually both unnecessary and inefficient. As a result, lighting designers employ task-ambient lighting design. Ambient lighting in a room should be at least one-third as bright as task lighting for visual comfort and ease of visual shift between task and ambient spaces. A common task-ambient lighting strategy is to design the overall lighting system to provide a suitable ambient level of light and then add task lights (e.g., desk lamps) in work areas.

An important aspect of lighting system design is the effective use of daylighting. After decades of relying on artificial light, many lighting designers are turning back to natural light to illuminate interior spaces. To make good use of natural light, however, more than just adding more windows is required. Light streaming in through windows can cause glare and make other areas appear very dark in comparison; additionally, windows that are too large can allow for excessive heat loss or gain. The challenges of successful daylighting are admitting only the amount of light required, distributing it evenly, and avoiding glare. The overall architectural design of a building can greatly improve the effective use of daylighting. A building design that maximizes surface area, for example, has more sunlight available to it (e.g., a building that is U-shaped or has an interior courtyard). Skylights, wide windowsills, reflector systems, louvers, blinds, and other innovations can also be used to direct natural light further into a structure. Window glazes can be used to reduce heat transmission while allowing visible light to pass through a door or skylight.

The careful selection of price and efficient lighting technologies is essential for efficient lighting design. Lighting control systems are critical components of effective lighting systems. Lighting designers can use lighting controls to minimize lighting when it is not needed to supplement other efficiency improvements. Lighting energy is saved, for example, when occupancy sensors turn off lights now since occupants leave a space as well as daylighting controls dim fluorescent lamps as the amount of natural light in a bed increases. Dimming systems can also be used to keep a consistent light level as a system ages, saving energy when lamps are new. Creative people can install permanent lighting fixtures dedicated to efficient lamps to ensure the sustainability of energy savings. For example, an office retrofit using compact fluorescent lamps (CFLs) instead of screw-in incandescent lamps should use hard-wired CFL fixtures to ensure that the more efficient CFLs are not replaced with incandescent lamps at a later date.

Lighting design that promotes electricity lighting technologies can also have an impact on the design and energy consumption of a building's cooling system. Because efficient lighting systems generate less heat, the capacity of air conditioning systems installed in new buildings with efficient lighting may be reduced. As a result, less money is spent on air conditioners and cooling energy 1.

Properties of Light Sources

There is no direct measure of lamp efficiency because the objective of a lamp is to produce light rather than just radiated power. Instead, a lamp's efficacy is measured, which is the ratio of the amount of light emitted (lumens) to the amount of power (watts) drawn by the lamp. In this chapter, we report system effectiveness, which includes the watts drawn by the lamp and ballast in systems that use a ballast. The lumens per watt unit is used to express efficacy (LPW). The theoretical limit of efficacy is 683 LPW, which would be produced by a perfect light source emitting monochrome radiation at 555 nm.

The laboratory's most efficient white light source produces 275-310 LPW. The most efficient practical light source currently on the market, the T5 fluorescent lightbulb with electronic ballast, produces approximately 100 LPW. Elevated sodium (not a white light source) can generate up to 130 LPW**.**Use, maintenance issues, disposal, environmental consequences (mercury, lead), and electro - magnetic and other emissions (e.g., radio interference, UV light, and noise).nb Most lamps continue to draw the same power consumption but produce fewer lumens over time. The lumen maintenance of a lamp refers to how well the lamp maintains its lumen output and thus efficacy over time. Initial lumens were also measured at the start of a lamp's life, whereas mean lumens are measured after a percentage of the lamp's rated life has passed.

The color temperature and color rendering index of a lamp describe its color properties.

Color temperature, measured in degrees Kelvin (K), is a measure of the color appearance of a lamp's light. Color temperature would be based on the fact that the emitted radioactivity spectrum of a blackbody radiator is solely dependent on temperature. A lamp's color temperature is the temperature at which an optimum blackbody radiator would emit light that is pretty close in color to the lamp's light. Low color temperature lamps (3000 K and below) emit pleasant white light that appears yellowish or reddish in color. The color temperature of incandescent and warm-white cfl is low. Lamps with high color temperatures (3500 K or higher) emit cool white light which it appears bluish. The color temperature of cool-white fluorescent lamps is very high.

A lamp's color rendering index (CRI) is a measurement of how surface colors appear when illuminated by the lamp versus when illuminated by a reference source of the same color temperature. The reference source for color temperatures above 5000 K is a standard daylight condition of the same color; for color temperatures below 5000 K, the reference source is a blackbody radiator. A lamp's CRI measures the difference between the perceived color of items viewed under the lamp and the reference source.

There are 14 different colored test samples, with 8 of them used to calculate the overall CRI index. The CRI is calculated as an average of the results for eight colors observed and is measured on a scale with a maximum value of 100. A CRI of 100 indicates that no difference in perceived color exists for any of the test objects; a lower value indicates that differences exist.

Color rendering indexes of 70 and higher are considered good, while CRI values of 20 and lower are considered poor.

Energy Conservation

China, the world's second largest economy, has maintained an annual growth rate of around 10% for the last 30 years. China's energy sector has made remarkable progress in tandem with the country's rapid economic growth. China is now the world's largest producer and consumer of energy. It has established a comprehensive electricity supply system that includes coal, electricity, petroleum, natural gas, as well as new and renewable energy resources. 1 However, China has paid a high price and faced significant challenges in its transition from a backward developing economy to one of the world's top economies. During the 11th Five Year Plan period (FYP, 2006-2010), China consumed 40% of the world's coal, 50% of the cement, 60% of the iron and steel, and 9% of the world's oil, while producing only 5% of the world's GDP. 2 China's energy consumption per unit of GDP is five times that of the rest of the world. 2 The country's rapid economic development has also had serious consequences for its air, land, and water.

With limited domestic fossil energy resources and significant international emission control pressure, the Chinese government has prioritized resource efficiency and renewable energy. China committed in 2009 to reducing carbon emissions per unit of GDP (carbon intensity) by 40%-45% by 2020, compared to 2005 intensity levels. China announced in 2014 that its carbon emissions would peak in 2030. To achieve these and other related energy efficiency and renewable energy targets, the Chinese government has enacted a variety of laws, rules, and regulations; implemented numerous energy efficiency and renewable energy programs; and restructured its energy-governing agencies to improve their efficiency.

Government agencies but also state-owned enterprises have largely regulated and controlled China's energy sector (SOEs). The National Development and Reform Commission (NDRC) of China is in charge of coordinating energy planning with the wider economic and social development of the country. The National Energy Administration (NEA), established in 2008 and restructured in 2013, reports to the NDRC and is in charge of crafting and carrying out energy growth strategy, planning, and policy proposals, advising on energy system reform, and regulating China's overall energy sector. In particular, renewable energy development in China is primarily the responsibility of the NEA's New Energy and Renewable Energy Department. In addition to the NDRC, the Ministry of Industry and Information Technology (MIIT) is responsible for industry energy efficiency, while the Ministry of Housing and Urban-Rural Development (MOHURD) is responsible for building energy efficiency. In terms of fiscal, tax, and finance incentives; energy-related science and technology; but also technical standards and codes for energy conservation and renewable energy development, all of these government agencies collaborate with each other and other related government agencies such as the Department of Finance (MOF), the Ministry of Science and Technology (MOST), and the Standardization Administration.

Sector-Specific Energy Conservation Policies

Industry

Industry is China's largest energy consumer, accounting for roughly 70% of total national consumption. According to the 12th FYP Plan for Industry Energy Conservation issued by MIIT in 2012, China aims to reduce energy consumption per unit of industrial value-added output by 21% from 2011 to 2015, resulting in 670 million tce of energy conservation. The plan also establishes specific targets for reducing energy consumption in nine energy-intensive sectors (steel, nonferrous metals, petrochemical, chemical, construction material, mechanical, light industry, textile, and electronics) and 20 product types.

The same plan identified key technologies and approaches to improve energy efficiency for each of these 9 sectors and 10 types of prioritized energy efficiency projects, including renewable energy of industrial boilers and burners, engines with internal combustion, generators, waste heat and pressure recovery and utilization, combined heat and power, industrial by-product gas, enterprise energy management and control centers, and telecommunications. MIIT published the National Industry Energy Efficiency Guide (2014) in 2014, providing a comprehensive overview of industry energy efficiency progress since 2000. Readers who are interested can refer to the detailed effort China made in industry energy efficiency over the last decade.

As part of a major initiative to help meet the 670 million tce energy conservation target, the NDRC launched the Top 10,000 Energy-Consuming Enterprises Program, which targets businesses that use mor than 10,000 tce per year. The program, which is a development of the

The Top 1000 Program, which China implemented during the 11th FYP period, aims to save 250 million tce in absolute energy. This represents nearly one-third of the country's total energy savings target for the 12th fiscal year.Building consumes nearly one-third of total primary energy consumption and carbon emissions in China. There are 40 billion m2 of existing buildings in China, but only 1% are energy efficient. Between 2010 and 2020, China would be expected to add 10-15 billion m2 of urban residential space. To improve the energy efficiency of existing and new buildings, the Chinese government has been actively involved in the formulation and implementation of a number of legal and policy instruments.

Three major laws and regulations governing building energy efficiency are the Renewable Energy Law, the Energy Conservation Law, and the Civil Building Energy Efficiency Code. Furthermore, a number of provinces and municipalities have enacted their own general energy efficiency codes and enforced by the government. These laws and regulations, along with the 12th FYP on Building Energy Efficiency issued by MOHURD in May 2012 and the Green Building Work Plan issued by China's State Council General Office in January 2013, form the policy framework for building energy efficiency in China.

According to the 12th FYP on Building Energy Efficiency, China intends to reduce 116 million tce through four prioritized areas: new buildings (45 million), heating supply reform and retrofitting in China's northern areas (27 million tce), government office and public buildings (14 million tce), and renewable energy adoption in buildings (30 million tce).

As early as the 1990s, the Chinese government began to implement a series of policies to promote heat reform as well as retrofitting in existing buildings, particularly in northern areas where most buildings have centralized heating. The goal of the heat reform is to reduce energy consumption by reforming the heating pricing system and establishing a market mechanism to encourage heat suppliers to improve the energy efficiency of their heat supply networks. 8 Given that construction in China's northern regions accounts for more than 40% of total urban building energy consumption in the country, residential retrofitting in northern parts is also important in China's building energy efficiency efforts. China reconfigured 182 million m2 of residential space in northern China between 2006 and 2010. According to the 12th FYP on Building Energy Efficiency, China will complete heat supply measurement and retrofitting of 400 m2 of existing buildings in the northern region by 2015.

Furthermore, the Chinese government is taking the lead in implementing various energy-efficiency polices for government office buildings, big public buildings, and college and university buildings.

This effort is primarily focused on monitoring energy consumption and retrofitting public buildings. China plans to retrofit 120 million m2 of government office buildings as well as public buildings by 2015.

One of the government's priorities in building energy efficiency is the use of renewable energy resources. Major initiatives during the 11th FYP included renewable energy building demo projects and demo cities, as well as renewable energy application in rural buildings. Many supportive policies were introduced and implemented at the provincial and local levels to encourage the use of renewable energy technologies in buildings such as photovoltaic power generation, building integrated photovoltaic (BIPV), solar water heating, and geothermal heat pumps. According to the government's plan, the recently introduced renewable energy buildings will total to by 2015.

Wind Power

China is second only to the United States in terms of wind energy resources. According to the results of the wind energy asset survey and evaluation, China has a land-based and offshore wind power potential of 2380 and 200 GW, respectively, at a height of 50 m.

The total exploitable capacity exceeds that of hydropower. While China was a latecomer to wind power development and deployment in comparison to many Western countries, the country has seen tremendous growth in wind power over the last ten years.

China surpassed the United States as the world leader in installed wind power capacity at the end of 2010, with 16 GW newly added wind capacity and a total of 41.8 GW wind capaci27 According to the Global Wind Energy Council, the United States installed approximately 5 GW of new wind power capacity in 2010, bringing the country's total installed capacity to 40.2 GW.

China also surpassed the United States in total grid-connected wind capacity in 2012, with 50 GW of on-grid wind capacity installed. The cumulative grid-connected installed capacity for wind power reached 100.04 GW by the end of February 2014, making China the first country to surpass the 100GW wind power capacity milestone. With the rapid and continuous expansion of offshore wind installed capacity, China has already established itself as the world's largest wind power market.

China's wind industry has primarily benefited from the favorable market conditions fostered by government policies and regulations. After several years of rapid growth, the wind power industry is transitioning from a frenetic early stage focused on maximum installed capacity to a new development phase focused on quality, safety, reliability, and efficiency. Manufacturing overcapacity, intense market competition, and government policy that delays financing and approval of wind projects have all combined to reduce profit margins for many Chinese wind manufacturers.

The rate of growth in newly installed wind power capacity began to slow in 2011, falling from 18.92 GW in 2010 to 12.96 GW in 2012. The downward trend, however, did not last long. The wind power industry regained momentum in 2013, with 16.08 GW of new wind capacity installed during the year. With 19.81 GW of new wind generation installed in 2014, newly added wind capacity reached an all-time high.

Grid connection is one of the obstacles of China's wind power development. Many local grids are unable to integrate all of the electricity generated by wind power due to limited capacity. Large-scale wind power integration also causes significant issues with power grid dispatch, reactive power regulation, grid safety, and power quality.

Furthermore, because the geographical distribution of wind energy resources does not match the country's power load profile, long-distance electricity transmission is required. However, this is again constrained by power grids' limited transmission capacity.

Every year, a large amount of wind-generated electricity is wasted due to insufficient power grid infrastructure. According to National Energy Administration data, more than 1 trillion and 20 billion kWh of wind-generated electricity were wasted in 2011 and 2012, respectively. The grid connection issue requires not only a technical fix, but also a fundamental change in China's overall power system. After the power generation business was separated from grid companies, which are now only focused on transmission of electricity, grid companies have little incentive to integrate renewables into their grids because doing so will cost them more money due to the additional expenses incurred in grid connection and electricity purchases.

With the implementation of advantageous wind power policies, increased grid transmission capacity, and decreased wind amount, the average rate of abandoned wind power has decreased over the last two years, from 11% in 2013 to 8% in 2014, the lowest level in recent years. However, in the first quarter of 2015, the rate rose to 18.6%. 33 The rate fluctuation indicates that wind power grid integration and absorption have been and will continue to be major challenges for China's wind power development.

CHAPTER 12

INCANDESCENT LAMPS

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In the late 1800s, Thomas Edison in the United States and Joseph Swan in England independently invented the incandescent lamp. When electricity heats the lamp filament towards the point of incandescence, an incandescent lamp produces light. The filament in modern lamps is made of tungsten. Because 90% or more of an incandescent lamp's emissions fall within the infrared (thermal) range of the electromagnetic spectrum rather than the visible range, incandescent lamps are less efficient than other types of lamps.General Service and reflector lamps are the two main types of standard incandescent lamps. The pear-shaped general-service lamps (also known as A-lamps) are the most common household lamps. A reflector lamp has a reflective coating applied to a portion of the bulb; this reflective surface (reflector) is contoured specifically for light distribution control. The reflectors in parabolic aluminized reflector (PAR) lamps are optically contoured. Projector lamps, such as flood or spotlight lights, are commonly used to illuminate outdoor areas or to highlight retail displays and original art inside. They're also frequently used to boost the optical efficiency of ceiling lights (recessed can fixtures). Downlights are used in situations where controlling glare or concealing the light source is critical. Despite being the least efficient lamps on the market today, standard incandescent standard service lamps are used for almost all residential lighting in the United States and are also widely used in the commercial sector. They have high CRI values and a warm color; they are easily dimmable, inexpensive, small and lightweight, and can be used with low-cost fixtures; and, when properly designed, they allow for excellent optical control. Furthermore, incandescent lamps make no annoying noises, provide no electro-magnetic interference, and essentially contain no toxic chemicals. Incandescent lamps are relatively easy to install, maintain, and dispose of.

Tungsten-halogen and tungsten-halogen infrared-reflecting (HIR) lamps are more efficient than incandescent bulbs. Tungsten-halogen lamps, like standard incandescent lamps, produce light when electricity heats the tungsten filament to the point of incandescence. Tungsten evaporating from the filament deposits on the glass envelope of a standard incandescent lamp. Tungsten-halogen lamps, in general, use a quartz envelope rather than a glass envelope, allowing the lamp to operate at much higher temperatures. Tungsten-halogen lamps use a small amount of halogen gas instead of the standard inert gas fill. Because tungsten-halide vapor is not stable at the temperature of the filament, the halogen gas in the lamp reacts with the tungsten that deposits on the quartz envelope to form a volatile tungsten-halide compound; the vapor dissociates and deposits the tungsten back onto the filament. The process is then repeated. This cycle does not necessarily return the tungsten to the same portion of the filament from which it evaporated, but it does significantly reduce net tungsten evaporation and thus extends the life of the filament.

Halogen lamps emit bright white light with color temperatures and CRI values that are comparable to or slightly higher than standard incandescent. Furthermore, they have longer rated lives (2000 hours or more vs. 1000 hours or less), can be much smaller, are slightly more efficient, and have better lumen maintenance than standard incandescent lamps. Halogen general service lamps are available, but they are still uncommon; they have a longer life span and a slightly higher lumen output or lower wattage. Because halogen reflector lamp technology meets the efficacy requirements of the Energy Policy Act of 1992, as discussed in Section 7.6, it has gained market share for reflector lamps. Small reflector lamps powered by low-voltage transformers also use halogen technology. These lamps, also known as dichroic, are used in a variety of applications for accent lighting and sparkle.

The HIR lamp is even more efficient than a standard tungsten-halogen lamp. Because incandescent lamps emit approximately 90% of their energy in the form of heat (infrared radiation), their efficacy can be increased by reflecting the infrared portion of the spectrum back onto the lamp filament. Infrared-reflecting tungsten-halogen lamps have a selective, reflective thin film coating on the halogen-filled capsule or the reflector surface. The coating transmits visible light but reflects much of the infrared radiation back to the filament, allowing it to be heated with less electricity. Reflector lamps are available with HIR technology. HIR lamps have a small market share due to their high cost, despite the fact that they last about 50% longer than regular halogen lamps.

Torchieres, which are floor lamps that reflect light from the ceiling into a room, became popular in the mid-1990s, particularly in the residential sector. The first torchieres used 300 or 500 W halogen lamps, which are gradually being phased out. Their high wattages not only resulted in excessive energy consumption, but the lamp temperature was high enough to pose a serious fire hazard. The high-wattage halogen lamps can reach temperatures of nearly 10008F, which is hot enough to ignite a drape or other combustible material. As a result of the resulting fires, some fire departments and college campuses have prohibited the use of halogen torchieres. In terms of energy, several states have implemented standards that limit the total wattage allowable in the fixture (typically no more than 190 W). Similar national standards went into effect in 2006, as discussed in Section 7.6. Currently, incandescent torchieres dominate the market, typically using 150-W bulbs, but more efficient torchiere lamps equipped with various types of fluorescent lamps are available. A torchiere with a 50-70 W fluorescent lamp costs more than a halogen or incandescent torchiere, but it saves energy over its lifetime.

Fluorescent Lamps

Fluorescent lamps became widely used in the 1950s. An electric discharge excites gaseous mercury atoms within a cathode rays lamp tube in a fluorescent lamp. UV radiation is emitted as the mercury atoms return to their ground state. UV radiation excites this same phosphor coating on the lamp tube, causing it to fluoresce and emit visible light.Early fluorescent tubes, as well as current compact fluorescent lamps and some shorter fluorescent tubes, used "preheat start" with either an automatic or manual having started switch. Then "instant start" lamps were developed, which use a high voltage to strike the lamp's arc. Most fluorescent lamps can be started instantly with electronic ballasts "Rapid start" circuits use low-voltage windings to preheat the electrodes and start the lamps by initiating the arc.

Fluorescent lamps outperform incandescent lamps in terms of efficiency. The efficiency of a fluorescent lamp system is determined by the length and diameter of the light fixture, the type of phosphor used to coat the lamp, the type of ballast used to drive the lamp, the number of lamps per ballast, the temperature of the lamp (which varies depending on the fixture and its environment), and a number of other factors. Fluorescent lighting is used in the majority of commercial applications. Fluorescent lighting is also widely used in industry. In the residential sector, full-size fluorescent lighting is mostly found in kitchens, bathrooms, garages, and workshops.

The most common fluorescent lamps are conical in shape and 4 feet (1.2 meters) long. 8 feet is the next most common length (2.4 m). Fluorescent lamps are also available in lengths of 2, 3, 5, and 6 feet. Four-foot lamps are also available in U-tube shapes that fit into two-foot fixtures. T12 lamp tubes are 1.5 in. (38 mm) in diameter, T8 lamp tubes are 1 in. (26 mm) in diameter, and T5 lamp tubes are 5/8 in. (16 mm) in diameter. (The 12, 8, and 5 refer to the lamp tube's diameter in eighths of an inch.) Other diameters of lamp tubes are also available. Each fluorescent lamp requires a different ballast, depending on its wattage, length, and current (milliamps).

Fluorescent lamps have long life spans and relatively good lumen maintenance. While low-wattage halophosphor (cool and warm white) lamps have CRI values in the 50s and 60s, rare-earth phosphor lamps have CRI values in the 70s and 80s. Fluorescent lamps have rated lifetimes ranging from 12,000 h (8-ft. T12) to 20,000 h (4-ft. T12s and T8s used with rapid start ballasts).

High-performance (third generation) T8 lamps, also known as "super T8s," with rated lives ranging from 24,000 to 30,000 hours and higher CRI values are now available. T5 lamps, which have improved optical control and aesthetics, are frequently used in high ceiling applications and indirect fixtures. T5 lamps are shorter in length than T12 and T8 lamps and require fixtures that are specifically designed for them. The length of a 28 W T5 lamp, for example, is 45.2 in. efficacy by about 9%. T5 lamps use electronic ballasts exclusively. The maximum efficacy of a T5 lamp is slightly higher than that of a T8 lamp, and it is achievable in ambient conditions that are approximately 108 degrees Celsius warmer than those ideal for T8 or T12 lamps. For higher ceiling applications, T8 and T5 high output lamps are also available, but this application must be designed to avoid overheating the ballast. For use in higher ceiling applications, eight-foot lamps have long been available in high-output (HO) and very-high-output (VHO) versions.

Reduced-wattage or "energy saver" lamps, such as the 34-W four-foot lamp, are the most common T12 lamps that meet the current EPAct 1992 lamp standards. In the 1970s, these lamps were widely used to retrofit full-wattage lamps (e.g. 40 W lamps). The reduced wattage lamp is similar to its full-wattage predecessor, except that krypton has been added to the gas fill and a conductive coating has been added to lower the starting voltage. Lumen output is typically reduced proportionally to wattage reduction. Previously popular 40 W halophosphor lamps do not meet the EPAct 1992 lamp standards; however, 40 W lamps with rare-earth phosphors and higher efficacy do meet the standards and have a small market share.

Lighting Efficiency Standards and Incentive Programs, contains more information on the EPAct 1992 fluorescent lamp standards. A lamp's specified or nominal wattage refers to the power draw of the lamp alone. The ballast typically adds 10%-20% to the power draw, lowering system efficiency. Rare-earth phosphor lamps are the most efficient full-size fluorescent lamps available today. Rare-earth phosphor compounds are used to coat the inside of the fluorescent lamp tube in these lamps. Rare earth phosphorlamps are also known as tri-phosphorlamps because they are made from a combination of three rare earth phosphors that produce visible light of the wavelengths to which the human eye's red, green, and blue retinal sensors are most sensitive. These lamps have better color rendition and efficiency.

Rare earth phosphors are almost exclusively used in fluorescent T8 and T5 lamps, as well as those with smaller diameters. 8fluorescent lamp-ballast systems are the most common efficient fluorescent lamp-ballast systems available today. While two T12 34 W halophosphor lamps with an energy saving magnetic ballast have a mean efficacy (in terms of mean lumens) of 54 LPW, two standard 32-W T8 lamps with a standard instant-start ballast have a mean efficacy (in terms of mean lumens) of 75 LPW. Over the last few years, high-performance T8 systems have evolved through a series of incremental improvements in lamp barrier coatings, phosphors, cathodes, and gas fills, as well as ballast circuitry and components.

The technical advancements result in increased initial light output, improved lumen maintenance, longer life, and improved ballast efficiency. The highest mean efficacy of any "white" light source is 90 LPW for high-performance instant start T8 lamp/ballast systems (two-lamp system). The average efficacy of the same T8 lamp system with a programmed start ballast is 82 LPW [2]. Other T8 lamps have higher efficacies than standard T8 systems, such as four-foot T8 lamps in 25, 28, and 30 W versions that use the same electronic ballasts as 32 W T8 lamps, but they have some operating limitations. T8 lamps with higher light output or longer lamp life than standard T8s are also available, but they do not provide the combined benefits of high-performance T8 systems.

The Consortium for Energy Efficiency (CEE), a national non-profit organization, created a specification to define high-performance T8 lamps and ballasts consistently was created for use by utilities and energy-efficiency organizations promoting high-performance commercial lighting systems on a voluntary basis. The CEE website, www.cee1.org, has a list of qualifying products.

Please keep in mind that the specification and qualifying products list are updated and revised on a regular basis. For the most up-to-date information, please visit the CEE website.The installed cost of a high-performance T8 system is currently higher than that of a T12 or standard T8 system; however, that cost differential is narrowing. High-performance systems are the best economic choice for most applications due to their increased efficacy and longer life.

Despite their significantly higher efficiency, fluorescent lamps have several drawbacks when compared to incandescent lamps. Dimming standard and compact fluorescent lamps requires special dimming ballasts, which are more expensive than dimming controls used for incandescent lamps. Standard fluorescent lamps are larger than equivalent-output incandescent lamps and are more difficult to control optically. In addition, fluorescent lamps emit more UV light than incandescent lamps. Because ultraviolet light causes colors to fade and fabrics to age, it must be blocked near sensitive materials such as museum exhibits. Electronic ballasts can interfere with security equipment used in libraries and specialized hospital devices.

Fluorescent lamps contain trace amounts of mercury, a toxic metal, and large users must recycle or dispose of them as hazardous waste. However, mercury is also emitted during the electricity generation process, and the net total mercury emission, including power plant emissions, is lower for fluorescent lamps than for the incandescent lamps they replace.

Lamp manufacturers have begun to produce fluorescent lamps with lower mercury content that meet EPA requirements and allow for the disposal of small quantities of lamps. Regulations differ by state; for more information, Circular-shaped fluorescent lamps in 20-40-W sizes have been available for many years, but their market has been relatively small. A circular lamp is essentially a standard fluorescent lamp tube (as previously described) bent into a circle. Despite having a more compact geometry than a straight tube, circular lamps are still fairly large (16.5–41 cm in diameter). Circular lamps come in a variety of sizes and with magnetic or electronic ballasts.

Fluorescent lamps became popular in the 1950s. An electric discharge in a fluorescent lamp excites gaseous mercury atoms within a phosphor-coated lamp tube. As the mercury atoms return to their ground state, ultraviolet energy is emitted. This UV radiation excites the phosphor coating on the lamp tube, causing it to fluoresce and emit visible light.

Early fluorescent tubes, as well as current compact fluorescent lamps and some shorter fluorescent tubes, use "preheat start" with an automatic or manual having started switch. Then, "instant start" lamps were developed, which use a high voltage to strike its lamp's arc. Most fluorescent lamps can be started instantly using electronic ballasts (see below). Rapid start circuits use low-voltage windings to preheat the electrodes and initiate the arc to start a lamps.

Fluorescent lamps are far more efficient than incandescent lamps. The efficacy of a fluorescent lamp system is determined by the lamp length and diameter, the type of phosphor used to coat the lamp, the type of ballast used to drive the lamp, the number of lamps per ballast, the temperature of the lamp (which varies depending on the fixture and its environment), and a number of other factors. The majority of commercial lighting is fluorescent. Fluorescent lighting is also widely used in the industrial sector. The majority of full-size fluorescent lighting in the residential sector is found in kitchens, bathrooms, garages, and workshops.

Full-Size Fluorescent Lamps

The most common fluorescent lamps were also tubular and 4 feet (1.2 meters) long. The next most prevalent length is 8 feet (2.4 m). Fluorescent lamps are also available in 2-, 3-, 5-, and 6-foot lengths. Four-foot lamps are also available in U-tube shapes that fit into fixtures with two-foot dimensions. T12s are 1.5 in. (38 mm) lamp tubes, T8s are 1 in. (26 mm) tubes, and T5s are 5/8 in. (16 mm) tubes. (The 12, 8, and 5 refer to the number of eights of an inch in the diameter of the lamp tube.) Lamp tubes come in a variety of diameters. Each type of fluorescent lamp requires a different ballast, depending on its wattage, length, and current (milliamps).

Fluorescent lamps have long lives and relatively good lumen maintenance. While low-wattage halophosphor (cool-white and warm-white) lamps have CRI values in the 50s and 60s, rare-earth phosphor lamps have CRI values in the 70s and 80s. Fluorescent lamps have rated lifetimes ranging from 12,000 h (8-ft. T12) to 20,000 h (4-ft. T12s and T8s used with rapid start ballasts). When 4-ft. T8s are used with instant start ballasts and frequently switched on and off, their lifetime is reduced to 15,000 h.

High-performance (third generation) T8 lamps, also known as "super T8s," with rated lives of 24,000-30,000 hours and higher CRI values are now available. T5 lamps with improved optical control and aesthetics are frequently used in high ceiling applications and indirect fixtures. T5 lamps are shorter in length than T12 and T8 lamps and require fixtures designed specifically for their use. The 28 W T5 lamp, for example, is 45.2 in. (1.14 m) long.

T8 lamps can be used with magnetic ballasts, but they are most commonly used with high-frequency electronic ballasts. The use of electronic ballasts increases lamp efficacy by about 9% over the use of magnetic ballasts. T5 lamps are only powered by electronic ballasts. The maximum efficacy of a T5 lamp is marginally higher than that of a T8 lamp, and it is achievable in ambient conditions that are approximately 108 degrees Celsius warmer than those optimal for T8 or T12 lamps. T8 and T5 high output lamps are also available for higher ceiling applications, but this application must be designed to avoid overheating the ballast. Eight-foot lights have long been available in high-output (HO) and very-high-output (VHO) versions for use in higher ceiling applications.

The most common T12 lamps that meet the current EPAct 1992 lamp standards are reduced-wattage or "energy saver" lamps, such as the 34-W four-foot lamp. These lamps became popular in the 1970s for retrofitting full-wattage lamps (e.g. 40 W lamps). The reduced wattage lamp is similar to its full-wattage predecessor, but with krypton added to the gas fill and a conductive coating to reduce starting voltage. The lumen output is generally reduced proportionally to the wattage reduction. Previously common 40 W lamps with halophosphors do not meet the EPAct 1992 lamp standards; however, 40 W lamps with rare-earth phosphors and higher efficacy do meet the standards and have a small market share.

Lighting Efficiency Standards and Incentive Programs, contains more information about the EPAct 1992 fluorescent lamp standards.The specified or nominal wattage of a lamp refers to the power draw of the lamp alone. The ballast typically adds 10%-20% to the power draw, reducing system efficiency.

Rare-earth phosphor lamps are the most efficient full-size fluorescent lamps on the market today. Rare-earth phosphor compounds are used in these lamps to coat the inside of the fluorescent lamp tube. Rare earth phosphorlamps are also known as tri-phosphorlamps because they are made with a combination of three rare earth phosphors that produce visible light of the wavelengths to which the human eye's red, green, and blue retinal sensors are most sensitive. These lamps have improved color rendition as well as efficacy.

Rare earth phosphors are almost entirely used in fluorescent T8 and T5 lamps, as well as those with smaller diameters.T8 lamps with electronic ballasts are the most common efficient fluorescent lamp-ballast systems available today. While two T12 34 W halophosphor lamps with an energy saving magnetic ballast have a mean efficacy (with mean lumens) of 54 LPW, two standard 32-W T8 lamps with a standard instant-start ballast have a mean efficacy (with mean lumens) of 75 LPW. High-performance T8 systems have evolved over the last few years through a series of incremental improvements in lamp barrier coatings, phosphors, cathodes, and gas fills, as well as ballast circuitry and components.

The technical advancements provide higher initial light output, better lumen maintenance, longer life, and improved ballast efficiency. At 90 LPW, high-performance instant start T8 lamp/ballast systems have the highest mean efficacy of any "white" light source (two-lamp system). The same T8 lamp system with a programmed start ballast has a mean efficacy of 82 LPW [2]. Other T8 lamps provide higher efficacies than standard T8 systems, such as four-foot T8 lamps in 25, 28, and 30 W versions that use the same electronic ballasts as 32 W T8 lamps, but these lamps have some operating constraints. T8 lamps with higher light output or longer lamp life than standard T8s are also available, though they do not provide the combined benefits of high-performance T8 systems.

The Consortium for Energy Efficiency (CEE), a national, non-profit organization, created a specification to define high-performance T8 lamps and ballasts consistently. This specification, was created for voluntary use by utilities and energy-efficiency organizations promoting high-performance commercial lighting systems.

Please keep in mind that the specification and list of qualifying products are updated and revised on a regular basis.

Currently, the installed cost of a high-performance T8 system is higher than that of a T12 or standard T8 system; however, that cost differential is narrowing. High-performance systems are the most cost-effective option for most applications due to their increased efficacy and longer life.

Despite their much higher efficiency, fluorescent lamps have several disadvantages when compared to incandescent lamps. Dimming standard and compact fluorescent lamps is possible, but requires special dimming ballasts, which are more expensive than dimming controls used for incandescent lamps. Standard fluorescent lamps are larger than equivalent output incandescent lamps and are more difficult to control optically. Fluorescent lamps also emit more UV light than incandescent lamps. Because ultraviolet light causes colors to fade and fabrics to age, it must be blocked near sensitive materials such as museum displays. Electronic ballasts may interfere with security equipment used in libraries and specialized hospital devices.

Fluorescent lamps contain trace amounts of mercury, a toxic metal, and large users are required to recycle them or dispose of them as hazardous waste. However, mercury is also emitted during the electricity generation process, and the net total mercury emission, including power plant emissions, is actually lower for fluorescent lamps than for the incandescent lamps they replace. Lamp manufacturers have begun to produce fluorescent lamps with lower mercury content that meet US Environmental Protection Agency requirements and allow for the disposal of small quantities of lamps. Regulations vary by state; for more information, visit www.lamprecycle.org or http://www.almr.org/. Circular Fluorescent Lamps— Circular-shaped fluorescent lamps in 20-40-W sizes have been available for many years, but have had a relatively small market. A circular lamp is essentially a standard fluorescent lamp tube (as described previously) bent into a circle. Despite having a more compact geometry than a straight tube, circular lamps are still relatively large. Circular lamps are available in a variety of sizes and with magnetic or electronic ballasts.

Solar Power

China has also surpassed the United States as the world's largest manufacturer of PV products. Six of the top ten solar PV module suppliers in the world are Chinese. Approximately 90% of PV panels manufactured in China were exported to countries with better incentives, such as North America and Europe. There were only a few demonstration solar PV projects in China between 2002 and 2008. 35 This is largely due to the high cost of PV systems and grid connection barriers, which China's wind power industry also faces.

Government subsidy cuts and declining PV demand in European countries have had a significant impact on China's PV manufacturers, who rely heavily on the global market. The imposition of anti-dumping and countervailing duties on Chinese PV products exported to the United States, followed by similar trade investigations launched in the European Union, Canada, and India, added to the pressure on China's PV industry. To compensate for their export losses and absorb manufacturing overcapacity, Chinese PV manufacturers quickly turned to the domestic market, which was largely untapped at the time, and emerging markets, which have seen a surge in renewable energy growth in recent years. Overcapacity has also prompted a new round of mergers and restructuring among PV manufacturers. The Chinese government sees this as an opportunity to upgrade the country's PV industry by eliminating obsolete production capacity. It also announced a number of supportive policies to encourage the growth of the domestic PV market.

According to data from the NPD Solarbuzz quarterly report, demand for PV panels from the Chinese end-market reached 33% of global demand in the fourth quarter of 2012.

With the installation of 12 GW of new PV capacity in 2013, China surpassed Germany, Japan, and the United States as the world's largest solar power market. This represents an increase in generation capacity of 232%. China added 10.6 GW of newly installed PV capacity in 2014, accounting for one-fourth of the world's newly installed capacity that year. China has also made significant progress in the generation of concentrated solar power (CSP) in recent years. The installed capacity for CSP will reach 1 GW and 3 GW by 2015 and 2020, respectively, according to the 12th Five Year Plan for Photovoltaic Power Generation Development. 39 A 50 MW CSP commercial project in Inner Mongolia was launched in 2010 as part of a public tending program.

However, as of this writing, the project has not yet been completed. It wasn't until July 2013 that the first CSP plant in Qinghai province was connected to the power grid and started generating electricity. The plant, which has a 50 MW installed capacity, is expected to generate 112.5 million kWh of electricity, which equates to a reduction of 4,000 tons of standard coal and approximately 103,000 tons of carbon dioxide. CSP plant represents the transition of CSP projects from small-scale technology demonstrations to large-scale commercial projects.

CSP generation has lagged behind many other forms of solar power utilization. This is largely due to the government's lack of clear and robust support for CSP.

To begin with, there is no corrected feed-in tariff (FIT) for CSP generation, and the FIT for a CSP project is determined on an individual basis. The FIT for the 50 MW CSP plant in Qinghai was set at RMB 1.2/kWh in September 2014. Second, the approval process for a CSP project can be very time-consuming and expensive for CSP project investors.

Induction Lamps

An induction lamp is a fluorescent lamp in which the electric discharge is induced by a magnetic field rather than an electric field, and thus has no electrodes.Induction lamps generate light by stimulating the same phosphors found in fluorescent lamps.

The radio frequency (RF) power supply generates an electromagnetic field by sending an electric current to with an induction coil. This field excite the mercury in the gas fill, having caused it to emit UV energy.UV energy strikes and excites the luminescent coating on the inside of the glass bulb, causing light to be produced. Electrodeless lamps have efficiency levels comparable to CFLs or HID lamps with comparable light output.

Rare-earth phosphors are used in electrodeless lamps, giving them color properties similar to higher-end fluorescent lamps. The induction coil limits the life of this system because the lamp lacks electrodes, which usually cause lamp failure. Induction lamps have a lifespan of 100,000 hours. Because of the long life and good color rendition, induction technology is being used in areas where changing the lamp is costly, such as high ceilings in industrial buildings, atria, tunnels, roadway sign lighting, and so on.

Induction lamps are electronics, and like all electronic devices, they can produce electromagnetic interference (EMI) when unwanted electromagnetic signals, which can travel through wiring or radiate through the air, interfere with desired signals from other devices. It is critical to protect personnel and equipment from these emissions by shielding the system. To sell products in any country, manufacturers must follow national EMI regulations.

CHAPTER 13

ENERGY CONSERVATION

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Energy is a vast concept and the essential ingredient for life. Depending on its nature, energy can be divided into a number of categories. Reducing energy usage is accomplished through energy conservation. Energy conservation practices are being taught to society in order to lessen its negative environmental effects. Keep in mind that you are directly defending the environment when you save energy are aware of how valuable energy is. Energy may be changed from one element to another but cannot be generated or destroyed

Law of Conservation of Energy

Energy cannot be generated or destroyed; it can only be changed of one form to another, according to the rule of conservation of energy. An isolated system's total energy is constant throughout time in accordance with the rule of conservation of energy. The law of energy conservation applies to all kinds of energy. During and after the transition, the total amount of energy is constant.

Energy conservation refers to lowering the amount of energy used or produced. This might take the shape of employing energy-efficient gadgets or fewer energy-intensive services. One option to save energy is to not use services or products, but you can also accomplish this by utilising items that are more energy efficient than their normal equivalents. A significant component of sustainability and sustainable growth is energy conservation. Aware of innumerable instances when energy saving has been practiced. These include turning off the lights after leaving a room, disconnecting electronics or other equipment when not in use, and whenever practical, cycling instead of driving.

Energy Conservation Definition

According to the official Collins definition, energy conservation is "the avoidance of the wasteful use of energy, especially to assure its continuous supply." This is significant to remember since the phrase has another definition. "The principle according to which the total power remains unchanged in a system that is subject to external influence" is the definition of energy conservation in physics.The importance of the idea in daily life is demonstrated by the fact that now the wide use definition comes before the explanation of energy efficiency in physics. The definition of energy conservation nowadays focuses mostly on measures to prevent the unnecessary use of energy due to the problems currently linked with energy usage and its related restrictions.

Why is Energy Conservation Important

For several reasons, energy conservation is very essential. It helps you save money on energy expenditures, such as electricity bills or other energy bills, in addition to reducing our dependency on non-renewable energy sources (such fossil fuels). Energy conservation also limits growth if the use of natural resources such as oil or perhaps even lithium has an adverse influence on wilderness regions e can directly lower the quantity of emission of greenhouse gases into the Earth's atmosphere by conserving energy and using it more effectively.

Energy Conservation Matter to Consumers

Consumers care about energy saving because of the financial and environmental advantages it provides. Lower living costs are the effect of energy conservation since it saves money. It helps customers keep more money in their own pockets while simultaneously reducing carbon dioxide emissions and excessive resource consumption.

Reduced need for new electricity plants results in advantages for animals and natural areas from energy saving. Even renewable and carbon-free energy sources can be used to achieve this. For instance, nuclear waste may have catastrophic effects if it leaks into the ecosystem, hydroelectric dams can impair aquatic regions, and wind farms may be harmful to birds. We can achieve widespread energy independence by reducing our reliance on scarce resources; the more gas that is saved, the more electricity independent the whole country can be. By using improved energy management techniques, you may be eligible for tax credits or rebates for conserving energy. Because energy supplies are limited, even minor acts of conserving can have a positive effect

Difference between Energy Efficiency and Energy Conservation

Energy efficiency and conservation have a slight but crucial distinction, despite the fact that we frequently use the terms interchangeably. Utilizing technology that uses less energy to carry out the same targeted purpose or function as these other high-energy utilising equipment is referred to as being energy efficient. Energy conservation, on the other hand, refers to any practise or intentional activity that reduces the consumption of energy.Although these phrases may be connected, the energy industry has significantly different definitions for them. Utilizing demonstrably less energy via changing habits and behaviours is required for energy conservation. Energy-saving technology, on the other hand, uses less energy to accomplish the same or equivalent tasks as a comparable gadget.

All living things, including humans and animals, depend on and/or require energy. The majority of this energy is taken up by plants as part of the process of photosynthesis, which yields our food. For all living things, includes plants and animals, the sun gives energy either directly or indirectly. Read on to learn more about various energy-saving techniques and the necessity of energy conservation. There are many different types of energy, but only electric and thermal energy (fuel) may be stored. If these sources of energy are used excessively, it causes pollution and the destruction of natural resources.

Need of Energy Conservation

Because it lowers the cost of energy usage, energy conservation is essential. For instance, the cost per energy unit decreases when we consume less power when it is not needed. We can lower our power costs by using more energy-efficient equipment and less electricity at home. That is how electricity conservation operates.

Energy conservation aids in lowering the consumption of fossil fuels and other naturally occurring energy sources. For instance, more coal and oil are used in thermal power plants to heat water and produce electricity. By conserving electrical energy, we also conserve the natural resources that are used to produce it. The amount of garbage emitted into the environment is decreased via energy conservation.

Conventional Sources of Energy

Conventional sources of energy, sometimes referred to as non-renewable sources of energy since they are available in a limited amount and have been used by people for a long time, are also known as. These non-renewable energy sources include coal, petroleum, and other decomposing materials that require thousands of years to create. As a result, once they are exhausted, they will never be produced at a rate that can keep up with their rate of use the conventional energy sources may be further divided into the two categories of commercial and non-commercial energy sources.

Commercial Energy Sources

Commercial forms of energy are those whose cost of usage must be covered by the customer. Coal, gasoline, oil, natural gas, or electricity are a few examples.

Coal:

There is no doubt that coal is the most important source of energy. When dead plant material decomposes into peat (an accumulation of partially decomposed organic material or vegetation), which is then transformed into coal by heat and pressure over millions of years, coal is formed. Carbon is the primary component of coal. Other elements including hydrogen, carbon, sulphur, and oxygen are present in varying concentrations.

Natural Gas and Oil

While oil is regarded as liquid gold, natural gas represents one of the most important sources of energy on the planet. When microscopic plants and animals die, they become buried at the ocean's bottom behind many sand and mud layers and mud, where they are subjected to heat and pressure. This is how oil is created. It is extensively utilized in buses, cars, ships, and aero planes. When layers of rotting animal and plant debris are subjected to high pressure and heat for thousands of years under the Earth's surface, natural gas is created. It is utilized for many things, including producing energy, warmth, and food.

Electricity:

A kind of energy known as electricity involves the passage of electrons (electric charge) in a single direction. Nuclear power, renewable energy sources, and dirty energy (coal and petroleum) may all be used to generate electricity (solar, wind, or hydropower). Electricity is a widely available energy source that is frequently employed in both household and business settings. Most electrical equipment, such as refrigerators, air conditioners, TVs, and washing machines, need electricity.

Thermal Power:

At various power plants, thermal electricity is produced using coal and oil. The process of converting fuel into heat produces thermal power. Thermal generators and furnaces that are specifically made are used to generate it. In a thermal power plant, fuels are burned to produce steam and to boil water. The created steam subsequently turns a turbine that is coupled to an electrical generator.

Hydroelectric Power

By building dams across flowing rivers, such as the Bhakra Mangla Project and Damodar Delta Project, hydroelectric power is created or produced. Water in motion produces energy that may be further harnessed and ultimately converted into electricity. When the reservoir is emptied, the water runs via a turbine. The generator generates power while the turbine spins the water.

Nuclear Power

Fuel for nuclear power plants is made up of less affordable than coal uranium and plutonium. Nuclear fission, nuclear fusion, and nuclear breakdown processes produce the largest bulk of the electricity generated by nuclear power.

Non-Conventional Sources of Energy

Non-conventional sources of energy are those that are continually replenished by natural processes, and are also referred to as renewable sources of energy. The pas sources of power are not readily depleted and may be produced continuously for endless usage. Additionally, these energy sources are less expensive and do not harm the environment or the nearby areas. Offshore wind, tidal power, solar energy, geothermal, and biomass energy are a few examples of unconventional sources of energy. They can be created or generated by natural forces at a rate greater or comparable to that of their consumption, which is why they are also known as renewable sources of energy

Non-Commercial Energy Sources

1. Non-commercial energy sources are typically ones that are freely accessible and do not require users to pay a fee for their use. Firewood, straw, dried dung, and other non-commercial energy sources are a few examples.
2. The energy created or generated by sunshine is known as solar energy. The photovoltaic cells is exposed to light based on the type of energy that has to be created or generated. For cooking and water distillation, solar energy is frequently used.
3. Energy created or generated by using the wind's force is known as wind energy. It is extensively used for running water pumps for irrigation. The second-largest generator of wind energy worldwide is India.

Advantages of Non-Conventional Energy over Conventional Energy

1. Nonconventional energy, often known as renewable energy, is a locally accessible source that has a big influence on the local and region economic sectors.
2. Regarding its future and its use in science and other applications, there is also a vast area of research in the non - conventional energy source sectors.

3. Nonconventional energy-based power plants don't have very high fuel costs, making them considerably more accessible to consumers and businesses.
4. In addition to helping to reduce pollution and create a sustainable environment, renewable energy has a low energy density.
5. There is little investment required, and the gestation period is brief.

Indian Energy Scenario

India's energy mix is dominated by coal, which accounts for 55% of all primary energy output. Natural gas's contribution to the generation of primary energy has significantly increased over time, rising from 10% in 1994 to 13% in 1999. Over the same time period, oil's contribution to the production of primary energy fell from 20% to 17%

Energy Supply

Supply of Coal

At least 84,396 million tonnes of proved recoverable reserves of coal were present in India (as of the end of 2003). According to the current Ratio to Production (R/P) ratio, this equates to roughly 8.6% of the world's reserves and could last for 230 years. In comparison, with the present R/P ratio, the worlds confirmed coal reserves are predicted to last just 192 years. a ratio of reserves to production (R/P) The amount of time the surviving reserves would endure if production stayed at its current level may be calculated by dividing the reserves that remain so at end of the calendar year by the output in that year. India ranks fourth in the world for lignite and coal production. Production of coal.

Oil Supply

About 36% of India's entire energy usage is made up of oil. India, one of the top 10 oil-consuming countries in the world today, will soon surpass Korea to become Asia's third-largest oil consumer after China and Japan. Compared to the present peak consumption of over 110 million tonne of crude oil, the country's annual crude oil output peaked at roughly 32 million tonne. According to the current forecast, India's oil consumption would amount to 136 million tonne (MT) by the end of 2007, while domestic production will only account for 34 MT. Assuming a weighted pricing of $50 per person of crude, India will be required to pay an oil bill of around $50 billion. Compared to total exports of $64 billion in 2003–2004.

The vast majority of India's estimated 5.4 billion barrels of oil reserves are found in the Krishna-Godavari, upper Assam, Bombay High, and Bombay. Transport consumes 42% of all petroleum products, followed by home and industrial use at 24% and 24%, respectively. At the end of 2004, India spend more than Rs. 1,10,000 crore on imported oil.

Natural Gas Supply

8.9% of the nation's energy usage is made up of natural gas. Currently, there is a gap between the 67 mcmd of available natural gas and the demand of roughly 96 mcmd. The demand is anticipated to be close to 200 mcmd by 2007. The estimated amount of natural gas reserves is 660 billion cubic metres.

Electrical Energy Supply

As of May 31, 2004, there were 1,12,581 MW of installed electric power producing capacity across all of India's utilities, made up of 28,860 MW of hydropower, 77,931 MW of thermal power, 2,720 MW of nuclear power, and 1,869 MW of wind power (Ministry of Power). In the years 2002–2003, gross energy production totaled 531 million units (kWh).

Nuclear Power Supply

In India, nuclear power produces around 2.4% of the country's electricity. Ten nuclear reactors at five nuclear power plants in India provide energy. The building of further nuclear reactors has also been authorised.

Hydro Power Supply

Only 15% of India's large and practical hydropower potential has been used to generate electricity as of yet. As of the end of May 2004, 25% of the nation's total produced units came from hydropower, a continually declining percentage. At a 60% load factor, the potential is estimated to be 84,000 MW.

Final Energy Consumption

The real energy demand at the user end is the final amount of energy consumed. This is the distinction between primary energy use and the losses incurred during transportation, transmission, and distribution, as well as during refining.

Energy Pricing in India

Energy costs do not accurately represent the full costs to society. Since energy costs are discounted and energy waste is not taken seriously, the fundamental premise behind the efficiency of the market does not hold true in our economy. Similar to many other developing nations, political, social, and economic pressures at the local and federal levels impact pricing policies in India.

This has frequently served as the cornerstone of India's energy sector strategies. The Indian energy industry provides several examples of cross subsidies, such as the subsidisation of diesel, LPG, and kerosene by gasoline, the subsidisation of industrial and commercial power users by petroleum products used for industrial purposes.

Electricity

India has a rather straightforward framework for its electricity rates. According to the tariff structure used by most electricity boards, low-tension (LT) users only pay for the energy they use (kWh), whereas high tension clients are paid based on both demand (kVA) and energy (kWh). The cost per kWh varies greatly between States and within consumer groups within a State. India has changed its tariffs to take into account the supply voltage level and the time of consumption. Some State Energy Boards have additional restitution from customers in addition to the base prices in the form of service charges, electricity duties, and taxes. For an industrial user, for instance, the demand costs might range from Rs. 150 to Rs. 300 per kVA, while the energy charges.

Energy Management

Energy management is the proactive, planned, and systematic coordination of energy production, delivery, and consumption to satisfy demand while taking environmental and financial goals into account. To keep things straightforward, ma describe energy management as an approach that includes maximizing the use of energy to get the greatest results and taking precautions to save it. Planning for the creation of energy and also its storage for later use are also included. Therefore, the ultimate goal of this procedure is to attain total environmental sustainability in addition to financial savings.

To keep things straightforward, we may describe energy management as a method that includes maximising the use of energy to get the greatest results and taking precautions to save it. Planning for the creation of fuel and its storage for later use are also included. Therefore, the ultimate goal of this procedure is to attain total environmental sustainability in addition to financial savings. Accept the fact that, in contrast to popular assumption, the energy management technique relates not just to huge buildings and industrial complexes but also to our tiny living spaces, such as our kitchens or dining rooms. Therefore, you may begin using the method right immediately at home simply turning off the electricity-using gadgets while not in use.

Various aspects of Energy Management

Facility Management

A. Facility management includes energy management.
B. Energy management in corporate settings entails taking measures to lower electrical energy consumption expenses without sacrificing job quality.
C. As we already said, installing energy management systems may help you save up to 29% of your overall energy bills.

Energy Management in Logistics Operations & Transportation

Choosing the best modes of transportation, routes, optimizing loads, employing fuel-efficient vehicles, and choosing clean fuels are all part of energy management in logistics. The usage of roads for transportation accounts for 15% of global CO_2 emissions. Therefore, employing energy management in this situation would not only save shipping costs but also fight climate change and environmental harm.

Energy Management in Manufacturing Industries

The potential for energy improvement in industry is likewise significant. Ensuring optimum energy practises in industries will result in significant cost savings, increased productivity, and a safer workplace. If the following actions are done, industrial plants can save energy.

A. replacing outdated energy-inefficient industrial equipment,
B. planning effectively for production and maintenance tasks,
C. Using novel energy storage techniques, such as electromechanical devices based on lithium,
D. The planning of space.

Utilizing energy-efficient technologies - Using infrared radiation (IR) for cooking or heat treatment is one example of an energy-efficient technology. Up to 78% of the power expenditures at a food processing facility might be saved by IR treatment. Additionally, unlike traditional cooking, which also requires regular oil replacement, it doesn't use any oil. Thus, IR can result in greater cost reductions.

Energy Management in Energy Procurement Process

Energy is procured through the sale and purchase of energy units. A company's energy costs might go up as a result of this bad strategy and transactional choices. In order to reduce energy expenditures, energy management is therefore implied to comprise making proactive and informed purchasing decisions.

The steps involved in Building Energy Management

Mostly concentrate on building power management, which is a subset of facility management and includes the many facets of energy management that we discussed before.

Collection of energy data

The current method of gathering energy data involves measuring and documenting energy use on a regular basis, such as every 15 to 30 minutes. It is feasible to identify patterns of energy waste that would not be attainable without detailed interval energy consumption data. Thus monitor all forms of equipment, including elevators, electricity panels, diesel generators, etc., using our Energy Management System (EMS).

Inspection or Analysis of energy data captured

Don't examine the extensive data you've gathered to estimate the potential for energy savings, it will be of great use. The chances for energy savings that are the simplest and least expensive often call for little to no capital outlay. And here's how to go about it:

Energy Management important

Energy Management saves costs

Up to 29% of a building's total energy consumption expenditures might be saved by utilising an EMS.Second, even a minor action, like swapping out inefficient CFL bulbs with LED lights that use less energy, can lower lighting energy use by more than 50% over time.

Energy Conservation in Thermal Systems

The primary objective of energy management is to manufacture things and deliver services at the lowest possible cost and with the least possible negative impact on the environment. In order to attain and maintain optimal energy purchase and utilisation across the enterprise, energy management has the following goals:

1. To reduce waste and energy expenses without compromising output or quality
2. To reduce environmental impact.

The system or item has a lot of heat energy and is moving swiftly. There is hardly much thermal energy when they move slowly. Heat is the transfer of thermal energy from a system or item that is hotter to one that is colder, or from a high proportion to a lower concentration. The pan was hotter than your palm because it contained more heat energy. Heat was transferred from the pan on your hand when you touched it. Since heat and thermal energy are so closely connected, the term "heat energy" is frequently used to refer to thermal energy.

The excess heat of a body increases with the rate at which its constituent molecules, atoms, or atoms move. The idea of infrared radiation is sometimes confused with that of heat. As a result of temperature differences, heat is viewed in physics as an exchange of electrons from a hotter to a colder body.

The term "heat" refers to thermal energy in motion; it always flows from a material at a higher temperature towards the substance at a temperature lower, temperature is increased of the latter and decreasing that of the former as long as the volume of the bodies stays constant. The study of heat energy and thermodynamics is built on the concept of thermal energy. It is one of the earliest kind of energy that people have ever used. Before the discovery of petroleum and nuclear power, it was already in use.

The most common term used to describe thermal energy is heat. Every material's thermal energy is always governed by the velocity of the atoms and molecules that make up the material. The item is considered to have more kinetic energy if these atoms and molecules are moving more quickly.In essence, heat is energy that is transferring, whereas thermal energy is the intrinsic quality that a thing possesses prior to the transmission of energy as heat.

Thermal Energy Working

The thermal energy in each of the aforementioned cases has been transferred, or transported, from a system or item with high thermal potential to one with low thermal energy. The outcome of thermal energy transfer is that the particles of the receiving item or system start to move more quickly. This energy transfer is seen as a form of work since it causes the particles of an item to move. The transmission of thermal energy can occur in one of three ways. The amount of heat in the water circulates through the pot as we heat water on the stove.

Convection is a sort of transfer that applies here. Conduction is a type of transmission that occurs when we rub our fingers together to warm them. Lastly, when our marshmallow floats over. Similar to this, it is known that an object's temperature rises as its molecules and atoms move more quickly. As a result, thermal energy becomes kinetic energy when there is an increase in motion.

Due to the common confusion between thermal energy and other types of energy as well as terminology like temperatures, many facts are unknown to a large portion of the population. As a result, it is crucial to understand a variety of illustrations and supporting data on thermal energy.

Thermal Energy Storage

A system that enables the transport and storing of heat energy, ice, water, or cold air is known as thermal energy storage. New technologies that support alternative energy sources like solar and hydro have this mechanism built in.

The thermal energy (either chilled or hot water) is generated during off-peak energy requirements or utilization times and collected in a heat storage tank. During peak electrical demand or utilization periods, the thermal energy is withdrawn and delivered to the facility. Diffusers at the top and bottom of the tank allow hot or cold water to enter and depart. The diffusers are meant to eliminate turbulence and enable the stratification of the water in the tank, with cold water at the bottom and hotter water at the top.

The water that contains 25% ethylene glycol is chilled by a chiller at night during off-peak hours. During the circulation of the solution in the heating element within the ice bank, 95% of the water surrounding the exchanger there in ice bank and 95% of the water surrounding the water heater in the tank are frozen. Never leaving the tank, the water surrounding the heat exchanger. In the ice bank tank, counter flow heat exchange tubes create equally sized ice. The water continues to flow freely while ice is being created, protecting the tank from harm. Between six and twelve hours are needed to fully charge the ice bank tank.

Types of Thermal Energy

This sort of thermal energy includes the movement of an object's subatomic particles but not the object's physical structure. It may be displayed by things at all times (solid, liquid, and gas). Each atom or molecule's thermal energy, which is a type of internal energy, increases as a result of the vibratory action of the object's particles and is then shared through contact with nearby atoms and molecules.

CHAPTER 14

BASIC OF CONVECTION

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Convection can happen between two bodies that have come into touch as well as inside a single body. The mobility of fluids is unavoidable if one of the components is a liquid or a gas. Convection is the process by which energy is transferred from a flowing liquid or gas to a solid surface.

Either natural or induced convection occurs with a fluid. The mass per total consumption of a heated liquid or gas often decreases. The hotter, lighter fluid rises whereas the colder, heavier fluid sinks when the liquid or gas seems to be in a gravitational field. Natural convection is the term used to describe motion that results only from temperature differences in fluids when there is a gravitational field.

Radiation

Since the materials transferring heat do not necessarily need to be in touch with one another, this sort of thermal energy differs fundamentally by both conduction and convection. Despite being distanced by a vacuum, thermal energy may still be transferred between two substances using radiation.

Thermal Energy Storage Applications:

The following sectors are possible uses for thermal energy storage.

1. Concentrated solar power facilities, which can deliver movable electricity even at night.
2. To run thermal power plants with more frequent and quick load changes.
3. Ensure the security of the heat supply in combined power and energy plants and spatially separate the electricity and heat production.
4. to salvage and use heat that would otherwise be wasted in process industries

Heat Exchanger

Two fluids with differing temperatures can exchange heat using a heat exchanger. In every substance, heat may be transferred between atoms and molecules. There are several motion states for the atoms at any one time. All matter contains heat, also known as thermal energy, which is created by the movement of atoms and molecules. In order to transfer heat between a number of fluids of different temperatures, like liquids, vapors, or gases, heat exchangers are used. Heat energy is correlated with molecular mobility. But when it comes to heat transfer, it's just a matter of moving heat from a body that is hot to one that is cold.

The heat transfer process could be gas-to-gas, liquid-to-liquid, or water, and it can take place either by direct fluid contact or a solid separator that keeps the fluids from mixing. The many types of heat exchangers may be categorized and classified using additional design criteria, such as fabrication, heat transfer procedures, and flow configurations. There are many different types of successfully engage devices that are created and used in a variety of sectors for both both cooling and heating operations.

Definition of Heat Exchanger

Conduction, diffusion, and radiation are the three recognized methods of heat transmission, and heating systems are devices that transfer heat between two fluids over a separating wall or just by direct mixing. An apparatus that enables the transfer of heat from one medium to another is a heat exchanger. Heat exchangers are utilized in cooling and heating operations. The fluids could be in direct touch or separated by the solid wall to prevent mixing.

Types of Heat Exchangers

Double Tube Heat Exchangers:

A tube within a tube arrangement is used in double tube heat exchangers. Two pipes exist, one of which is constructed within the other. The first fluid moves through the inner pipe, much like in the previous example, while the second fluid circles the first fluid with in outer pipe. It is well known that this kind of heat exchanger is the simplest and least expensive of all. Due to its small size, it fits perfectly in small locations, giving the architecture of the production process more freedom.

Shell and Tube Heat Exchangers

Shell and tube heat exchangers are the most adaptable of all heat exchanger designs. A cylindrical shell encloses a number of tubes in a shell and tube heat exchanger configuration. This type of heat exchanger can withstand a broad variety of temperature and pressures thanks to its popular design. The use of a tube side is an option to need to chill or heat a lot of fluids or gases. Despite being smaller than some of the other varieties, a heat exchanger is nonetheless simple to disassemble, which facilitates cleaning and repairs.

Tube in Tube Heat Exchangers

A tube in tube heat exchanger has two tubes, one for each fluid, just like the other kinds of heat exchangers. The tubes are nonetheless wrapped together to create an outside and interior design. It's possible to use tubes in some rather inventive ways in tube design. The majority of these designs are small but since tubes are coil together. High pressure and temperature are the main uses for tube in heat exchanger. A tube in tube heat transfer process often has a better efficiency since it operates at a higher output.

Plate Heat Exchangers

The plate heat exchanger is the exception to the rule, even though all of the heat exchanger types covered thus far have a similar architecture. Heat is transferred between two fluids using metal plates. The plate is a metallic shell with hollow areas inside each plate that serve as passageways for fluids. A plate heat exchanger offers better rates of heat transfer than any other kind because it has a larger surface area of contact with the fluids. Plate heat exchangers might be more costly, but the added efficiency is a huge benefit. Because of its endurance and cheap repair costs, this sort of heat transfer is best utilized in locations like power plants.

Scraped Surface Heat Exchanger

To provide even heat flow to the product, blades inside of the product channel remove goods from the channel wall. The scraping blades are created from a range of materials to satisfy various processing needs, and they are especially developed for delicate product handling to prevent losing product quality and uniformity. It is possible to place scraped surface exchangers either vertically or horizontally. An electric motor inside rotates a rotor with scraping blades. Rotor movement and product movement through the heat exchanger occur in the same orientation, with product in at the bottom and leaving at the top, to prevent product damage.

Typical applications for scraped surface heat exchangers include:

1. Products that are viscous include infant food, skin creams, shampoos, mayonnaise, hummus, almond butter, muffins, salad dressings, bread dough, and gelatin.
2. Products that are sensitive to heat include cream cheeses, fishmeal, fruit purées, and egg products.
3. Products that crystallise or change phase include extracts of coffee or tea, frostings, sugar concentrates, hydrogenated oils, shortening, creams, gelatine broth, lard, buttercream, and alcohol.
4. Meats, poultry, pet meals, jams & preserve, and rice puddings are examples of particulate items.
5. Caramel, cheese sauces, american cheese, gums, gelatin, mascara, and toothpaste are examples of sticky items.

Cogeneration

Cogeneration is a process that combines the production of heat and electricity, which can save a significant amount of energy. Although cogeneration is frequently connected with the burning of fossil fuels, it may also be accomplished with the help of some renewable power sources and the burning of garbage.

Need for Cogeneration

In India, thermal power plants are a significant source of electricity. Only roughly a third of the main energy supplied into the power plant is really made accessible to the user in the form of electricity, making the traditional method of power generation and distribution to the consumer inefficient. Only 35% of the energy is used efficiently in traditional power plants, while the remaining 65% is wasted. Due to the intrinsic limitations of the various thermodynamic cycles used in power generating, heat is rejected to the adjacent water or air, which is the main cause of loss in the conversion. Additionally, additional losses of between 10 and 15 percent are connected to the distribution and transmission of power through the electrical grid.

Principle of Cogeneration

The sequential production of two separate kinds of useable energy from a single main energy source, often mechanical and thermal energy, is known as cogeneration or Coupled Heat and Power (CHP). A revolving piece of equipment, such as a motor, compressor, pump, or fan, can be driven by mechanical energy to produce electricity. Balance in a typical coal-fired power station, different services. The production of steam, warm air, hot air for dryers, and chilled water for processes cooling can all be done either directly or indirectly using thermal energy.

Cogeneration offers a broad range of techniques for use in several economic activity sectors and, in certain situations.

Technical Options for Cogeneration

Extraction/back pressure power stations, gas turbines with heat recovery boilers (with or without bottoming steam turbines), and reciprocating engine with heat recovery boilers are examples of cogeneration systems that have been widely commercialized.

Steam Turbine Cogeneration systems

The backpressure and extraction types of steam turbines are the two that are most frequently employed. The extraction-back pressure turbine is another kind of the steam turbine peaking cycle cogeneration system that may be used when the end user requires thermal energy at two different temperatures. The full-condensing steam turbines are often installed at locations where process heat is utilized to produce electricity. The ability to use a number of traditional and alternative fuels, including coal, natural gas, fuel oil, and biomass, makes employing steam turbines preferable to using other prime movers.

Gas turbine Cogeneration Systems

The energy needed for the site can be generated entirely or in part by gas turbine cogeneration systems, and the energy that is released at high temperatures in the exhaust stack can be captured for a variety of heating and cooling purposes. Although natural gas is the fuel utilised the most frequently, alternative fuels such light fuel oil or fuel can also be used. Gas turbines typically range in power from a few megawatts (MW) to about 100 MW. Because natural gas is now more widely available, technology is developing quickly, installation prices have dropped significantly, and gas turbine electricity production has perhaps seen the most rapid growth in recent years.

At higher temperatures, more heat may be recovered despite the low efficiency of the heat to electricity conversion. It is possible to have extra natural gas burning if the exhaust temperature is less than what the user requires by adding more fuel to the oxygen-rich exhaust gas to increase the thermal production more effectively. On the other side, if the facility needs additional power, a combined cycle that combines gas turbine with steam turbine cogeneration may be used. A backpressure or evaporation steam turbine uses the steam produced from the gas turbine's exhaust gas to produce additional power. The necessary thermal energy is provided by the steam turbine's exhaust or extracted steam.

Reciprocating Engine Cogeneration Systems

These cogeneration systems, also known as internal combustion (I. C.) engines, offer great power generation efficiency in contrast to other prime movers. Exhaust gas at a high temperature and the engine jacket chilling water system at a low temperature are the two sources of heat for recovery. These systems are more common in smaller energy-consuming facilities, especially those with a greater the need electricity than excess heat and when the quality of warmth required is not high, such as low pressure hot water and steam. This is because thermal efficiency can be quite productive for smaller systems.

Although diesel has traditionally been the most popular fuel, prime movers may also run on heavy fuel petroleum or natural gas. These devices are excellent for sporadic use since they operate less sensitively to variations in ambient temperature than gas turbines. These machines have a modest initial investment, but because of their severe wear and tear, their operation and maintenance expenses are significant.

Classification of Cogeneration Systems

The order of energy usage and the operational methods used are typically used to categorise cogeneration systems. Based on the order of energy usage, a cogeneration systems can be classified as either a topping cycle or a bottoming cycle. In a topping cycle, any fuel provided is first utilized to generate power, after which thermal energy is produced as a byproduct and is used to generate process heat or to meet other thermal requirements. The most extensively utilized and well-liked form of cogeneration is topping cycle cogeneration.

Topping cycle

In a topping cycle, the fuel provided is first utilized to generate power, after which thermal energy is produced as a byproduct and is used to generate process heat or to meet other thermal requirements. The most extensively utilized and well-liked form of cogeneration is topping cycle cogeneration.

Bottoming Cycle

In a bottoming cycle, high temperature thermal energy is produced by the primary fuel, and the heat rejected throughout the process is used to create electricity through a turbine generator and a recovery boiler. Bottoming cycles are appropriate for industrial production operations that need heat at high temperatures in furnace and kilns and reject heat at extremely high temperatures. The cement, steel, ceramic, gas, and petrochemical industries are typical examples of application sectors. Compared to topping cycle plants, bottoming cycle seedlings are far less frequent

Lightning System

A lightning protection system is a non-active way to stop lightning strikes from causing property damage. It functions by offering a channel of least resistance for the electrical charge generated by the clouds to travel to the earth. A correctly constructed lightning protection system is made up of four basic components: copper air terminals, gold cable, copper-clad ground rods, and surge suppressors.

Lighting control systems let you manage and regulate every component of your lighting system's energy output, enhancing performance and cutting down on waste and wasteful energy use. Intelligent building system not only regulates lighting operations but also protects the occupants of the building as well as your assets and property. The effectiveness, productivity, sustainability, and yearly running expenses of your system will all be considerably improved by using lighting conservation approaches in lighting system technology.

Intelligent Lighting System

The infrastructure of commercial building owners has been improved with assistance from Advanced Control Corporation while financial gains have been realised. Our specialists can incorporate a smart building system into your current business processes or design a brand-new one from the ground up. Since every system is connected, your managers may get data that has been saved or is now being processed. You may also incorporate external platforms with your system. Each system in your facility will be completely under the control of authorised staff, who can also monitor and manage it. Additionally, you will develop sophisticated lighting skills using energy-saving methods in smart lighting software that makes use of a wide range of operational tools.

Basic Terms in Lighting System and Features

Lamps

Lamps are pieces of machinery that create light. The following is a basic description of the most popular lamps:

Incandescent lamps:

These light sources use a filament that is burned to incandescence by an electric current running through it. The filament, bulb, fill gas, and cap are the four main components of an incandescent lamp, often known as a GLS (General Lighting Service) light.

Reflector lights:

Reflector lamps are essentially incandescent and come with an internal mirror of exceptional quality that precisely matches the parabolic form of the bulb. Since the reflector is corrosion-resistant, the lamp requires less maintenance and produces a high-quality light.

Gas discharge lamps:

A gas discharge lamp's light is created by the excitement of gas that is either confined in a tubular.

Luminaire

The light output from one or more lamps is distributed, filtered, or transformed by a luminaire. With the exception of the lights themselves, the luminaire contains all the components required for mounting and safeguarding the bulbs. Occasionally, luminaires additionally feature the essential

Circuit auxiliaries and the ways of attaching them to the power source. Reflection, absorption, transmission, and refraction are the four fundamental physical concepts employed in optical lighting.

Illuminance

This is the product of the area of the element and the illuminating flux incident at a point on the surface that contains the point. The illuminance produced on a certain plane is typically used to qualify the illumination level supplied by a lighting installation. This plane, which is sometimes referred to as the working plane, is typically the main plane of the interior duties. An installation's lighting has an impact on both how tasks are completed and how the room appears.

Light distribution

Energy efficiency cannot be attained just by choosing more energy-efficient lighting. The highest level of efficiency is achieved when high effectiveness lamps are used with efficient luminaires.

Energy may be saved by using mirror-optic luminaires with a relatively high ratio and fly light dispersion.

Luminaires with light distribution qualities suitable for the job interior should be used in order to increase efficiency. The luminaires equipped with a lamp should make sure to minimise uncomfortable glare and veiling reflections.

Optimum usage of daylighting

Daylighting can be utilised in conjunction with electric illumination when a building's orientation allows it. This shouldn't cause glare or a serious imbalance in the brightness of the surrounding surroundings. Daylighting will need to be used sparingly in offices and air-conditioned hallways since more solar heat will be dissipating into the space, which will raise the air conditioning demand. It is frequently necessary to develop a switching system to permit the decrease of electric light in the window areas during specific hours

The majority of industries have a lighting burden that ranges from 2 to 10%. The majority of issues with lighting equipment and "gears" are caused by changes in "voltage." Therefore, it is necessary to disconnect the lighting equipment from the power feeders. Better voltage control is provided for the lights as a result. The efficiency of both the lighting system will rise as a result of fewer voltage-related issues.

Refrigeration

The process of chilling a place, thing, or system to keep it at a lower temperature than the surrounding air is known as refrigeration. Refrigeration is seen as an artificial or man-made kind of cooling. Removing energy in the form of heat from a reduced medium and transferring it to a rising medium is referred to as refrigeration. Traditionally, mechanical methods are used to transport energy, however other methods such as heat, magnetism, electricity, lasers, and others may also be used. Cryogenics, air conditioning, domestic refrigerators, and commercial freezers are just a few of the various uses for refrigeration. In addition to using the refrigeration process' heat output, heat pumps may be made to be reversible.

The use of refrigeration has significantly changed industry, way of life, agriculture, and habitation patterns. The ancient Roman Empire is where the concept of food preservation first emerged. Since the turn of the century, mechanical refrigeration has advanced quickly, from ice harvesting to heat train carriages. By enabling settlement in places that weren't on major transportation routes like rivers, ports, or valley pathways, the development of refrigerated rail carriages helped the United States move westward. Infertile regions of the nation that were rich in recently found natural resources were also seeing the growth of settlements.

The two distinct elements connected with temperature are heat and cold. A thermometer is used to determine body temperature. When it's hot outside, we like to wear light-colored cotton clothing. When it's hot outside, we like to wear light-colored cotton clothing. When the temperature is chilly, we like to wear dark-colored polyester clothing. The process of heating involves maintaining body heat. Space is cooled by the process of refrigeration. Removing heat from a tissue and bringing it down to a lower level than it actually is the process of refrigeration. The refrigeration process is carried out in refrigerators.

History of Refrigeration

The Greeks and Romans used this method to use ice brought down from the mountains to cool their meals. The primary motivation for the invention of the refrigeration process is the preservation of food. By preventing the growth of microbes including bacteria, yeast, and mould, refrigeration aids in the destruction of food products. The major purpose of it is to keep food at low temperatures over an extended length of time. Some goods can be kept in storage for weeks, even years. Ice, which is created when water freezes, is a crucial component in many processes. Ice and snow that has been compressed can be kept for months.

Working Principle of Refrigerator

The second rule of thermodynamics governs how refrigerators function. Unwanted heat is transferred from one area to another throughout the refrigeration process. The typical refrigerator that we have within our homes operates on the evaporation principle. In a heat cycle, a refrigerator is a chemical that moves heat from one place to another. A refrigerant passes through the food items in a refrigerator, absorbing heat from them and sending it to an area with a lower temperature.

The Components of Refrigerator

There are four components in the refrigerator system. They are:

1. Evaporator
2. Compressor
3. Condenser
4. Expansion valve

Process

1. The refrigerator's major component, the evaporator, keeps the appliance and its contents cold at all times. High thermal conductivity tubes are a characteristic of the system that aid in collecting heat released by the fan or coil.
2. The low-pressure, low-temperature vapour is compressed by the compressor into a greater, high-pressure vapour. A cylinder is used to compress the refrigerant after it leaves the evaporator in order to make a high-temperature, rising gas.
3. Expansion valve aids in managing the refrigerant flow into the cooling coil or evaporator. Flow control valves are another name for expansion valves. It is a delicate, compact instrument that helps detect changes in the refrigerant's temperature.
4. Condenser: It consists of a group of tubes with rear-facing exterior fins consists of a system of tubes installed at the rear of the refrigerator with exterior fins. This element aids in turning the vapor refrigerant into a liquid.

Working of the Refrigerator

For the refrigeration process, a vapor compression refrigeration cycle is used. In this procedure, copper or steel tubes are used to link the expansion valves, compressor, condenser, and evaporator.

The liquid refrigerant is inserted in evaporator tubes all around the refrigerator; when heat is absorbed, it absorbs the heat and changes to vapor. Through the compressor, the heat transferred from the absorbed condition of vapor to the external world is changed to a liquid. When heat is taken up and transferred from the evaporator to the expansion valve, the process is repeated. This procedure aids in maintaining constant refrigerator cooling.

The evaporator, like the condenser, is called for its primary purpose and is the second heating element in a typical refrigeration circuit. Given that it absorbs heat, like air conditioning does, it functions as the "business end" of a refrigeration cycle.

This occurs when a fan pushes air through the evaporator's fins, chilling the air by absorbing all heat from the area in question into the refrigerant, which exits the evaporation as a low temperature, low pressure liquid.

CHAPTER 15

IMPACT AND ROLE OF ENERGY CONSERVATION IN INDUSTRIES

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Energy conservation is the process of using less energy while maintaining output quality and quantity. It should be accomplished either by efficient energy usage, which results in less energy being used while obtaining the same result, or by reducing the use of energy services.Saving energy increases financial capital, environmental value, personal security, national security, and comfort for all people. Energy conservation may be desired by individuals and groups who purchase energy directly in order to lower energy prices and strengthen the economy. Commercial and industrial users could wish to boost potency to boost profits.

Renewable Energy

Energy derived from almost limitless resources is referred to as renewable energy. Focuses on renewable energy sources including wind, solar, and geothermal energy. Installing solar power plants is one such. Energy (both electrical and thermal), Labor, and Materials are often determined to be the three main operational expenditures in every industry. Energy has the greatest potential for value decrease of the three. To achieve and keep up optimal energy procurement and usage across the organization. Lowering energy costs and waste without sacrificing production or quality in order to lessen environmental effects Both electric and thermal energy are used in industrial equipment such as boilers, compressors, furnaces, and diesel generating units. Refrigeration, pumps, motors, etc.

Motivation to manage energy

The industrial sector is currently under a number of interconnected challenges, which have led to interest in energy management. As follows:

Industrial Competitiveness: decreases in energy use and associated expenses immediately affect operating results. Even though it makes up a minor portion of overall operational costs, energy can be one of the most controllable portions for many companies.

Restructuring of the Energy Supply Sector: There has been a global push to open up the Energy Supply Sector to competition. This covers both electricity and natural gas utilities in North America. As a result, energy customers now have more options than ever before when it comes to choosing energy suppliers and negotiating purchase agreements.

Energy Supply Limitations:

Due to restrictions in the infrastructure supporting the power supply, several industries across South Africa have issues with the quality and dependability of the power supply. More significantly, projections of a substantial supply shortage by 2006 have been made as a result of the economy's continuous expansion and the spread of additional power to more areas and new consumers. The supply constraint can be partially alleviated by conservation initiatives like ESKOM's DSM programme, but it is clearly obvious that far bigger efforts will be needed to lower demands from industrial and business energy users.

Environmental Management:

In several regions of the world, particularly in Europe, the ISO 14001 standard for environmental management is gradually becoming a prerequisite for commerce. Companies in South Africa will need to adhere to this standard in order to maintain their competitiveness as a result of the EU market opening up to South African products. Compliance with this standard, like compliance with the various ISO standards, results in measurable savings, principally because waste—of water, energy, and materials—is reduced. Energy management plays a vital role in ISO14001. It is a crucial part of waste reduction and environmental management methods.

Climate Change:

It is widely accepted that human activity is changing the world's climate, and that one of the primary factors contributing to this change is the release of greenhouse gases (GHG), mostly CO2 into the atmosphere as a result of the burning of fossil fuels. International pressure to curb GHG emissions through lowering energy consumption exists because fossil fuels, whether directly or indirectly, they are significant energy sources for industry. International agreements, which were launched in Rio de Janeiro in 1992 and expanded upon in Kyoto in 1997, serve as the foundation for global action. The Kyoto Protocol became a binding international treaty in February 2005.\

South Africa has some of the highest CO2 emissions per unit of GDP in the world as a result of its strong reliance on coal for both power production and industrial energy. South Africa can profit from the sale of certified carbon reduction (CER) credits even though it is not obligated to satisfy CO2 emission reduction goals during the Kyoto Protocol's initial commitment period. A significant possibility for South African businesses to cut their energy use profitably is the chance to sell certificates from energy efficiency initiatives.

Government Action on Industrial Energy Management

Over 45 to 50 percent of South Africa's total final energy consumption is accounted for by the industrial sector that has relatively high electricity demand. Few energy-intensive sub-sectors, whose energy intensity is often higher than that of first-world nations, dominate this sectoral consumption.

By substituting outdated technology with more recent ones and implementing optimal energy management techniques, it is therefore anticipated that there is room for saving energy in the industry.The draught National Energy Efficiency Strategy, whose final publication was imminent in early 2005, contains provisions for the use of Saving Energy within the industrial sector to determine and implement cost-effective efficiency initiatives within this sector.

Energy management information systems

A performance management system called an energy management system (EMIS) helps people and organizations to plan, make choices, and take effective measures to control energy usage and costs. By transforming energy and utility driving data at local account units into energy performance information, an EMIS makes thermal efficiency visible to all levels of the company.

This is accomplished by comparing performance equations to the organization's energy objectives.

The most consistent strategy to lower operational expenses and increase profits in the unpredictable hydrocarbon market is to save energy. Energy-related initiatives have a reduced risk profile since they depend less on the relative costs of various items. Saving energy will always result in financial savings, both now and in the future. Energy-related initiatives will Systems for Energy Information KBC and Yokogawa By maximizing investment return and steadily reducing operating costs, effective operating practices are utilized throughout the plant life cycle to lower business risks. By lowering emissions and simultaneously enhancing public perception.

Challenges and Opportunities

Despite the fact that most functioning organisations have some components of an energy management system, relatively few have all of the components operating and contributing to optimum energy efficiency and, consequently, profitability.

The ISO50001 criteria for best power management practises must be met in order for a system to be considered best practise. It should also include the technical supplements necessary to guarantee that ISO50001 produces positive outcomes in the hydrocarbon sector. One such approach is KBC's Engaged programme, which has been shown to close gaps by fusing organisational, behavioral, and technological change techniques to find, assess, and implement improvement possibilities.

Any programmer created to offer superior energy performance through an EMS, or Energy Management System, must include all of the instruments, processes, and practices necessary to be a top-performing, sustainable energy provider. The following components must be included in an EMS that follows best practices:

1. The creation of a suitable organizational architecture that is in line with the site's long-term objectives for energy efficiency improvement
2. Best Practices creation and implementation
3. The best technology benchmarking techniques for identifying gaps and presenting a business case
4. a comprehensive set of technologies that uses simulations, utilities system modelling, and pinch technology to find every opportunity to close a gap
5. Optimized RoadMaps for capital expenditure and non-investment operational improvements
6. Enhancing organizational competence and effectiveness to maintain the advantages
7. Modern energy management information systems, such as those that are integrated into daily operations and include:
8. A collection of relevant energy metrics
9. All of this should be preceded by a thorough energy audit that reveals both the organizational and technological gaps and improvements. An efficient Monitoring and Reporting system.

Benefits of an Energy Management Information System (EMIS)

The Energy Management Information System (EMIS), in contrast to the Energy Management System (EMS), is concentrated on the reporting and monitoring of energy measurements. Among the advantages of a metric monitoring system are:

1. Greater attention paid to energy performance across the board, starting with operators and through through process engineers, unit managers, the energy manager, and finally the site leadership team
2. Establishing a system to maintain gains in energy efficiency throughout the whole organisation
3. Benefits being captured right away rather than waited for a monthly or quarterly review, at which point the chance to do so may have have passed.
4. Increasing operational consistency from shifting to shift and fostering a shared knowledge of how and what has to be accomplished.

Metrics Development

Energy measurements are specified at every organisational level according to a hierarchical structure that enables "drilling down" from a related to website level to the process units and then to the item or individual system level. This hierarchy, which may be divided into two categories according to the following two types of metrics:

Key performance indicators (KPI) at the top and middle levels, which can be further classified into:

1. Strategic energy coordinator levels, such as site-specific energy consumption and a site's best technology energy index, enabling management to promote ongoing improvement throughout the whole site.
2. engineering level that are analytical and encourage additional research, such as compressor efficiency and heat exchanger fouling
3. Influencing factors for energy at the operational level (EIV)

Energy metrics into a site energy monitoring system when they have been developed. There are several systems on the market, but the majority of them tend to concentrate on weekly or monthly expense reporting but instead of reporting on real-time data where prompt remedial action may be performed. SUMMIT (Smart Unified Monitoring & Management Information Toolkit), a performance management system that connects top-level strategy to front-line action and vice versa, is the foundation of KBC's best practice energy monitoring and reporting systems.

QUESTIONNAIRE

1. What are energy scenario? State principles of conservation of energy.
2. What are commercial and noncommercial energy?
3. State long term energy scenario for India.
4. States energy utilities in thermal energy.
5. What is energy management?
6. What are cogeneration?
7. What are refrigeration system?
8. What is lightingsystem?
9. What is Energy management information systems?

REFERENCE BOOKS FOR FURTHER READING

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