CHAPTER 5

Changing to Renewable Energy Sources

In a sustainable society, nature is not subject to systematically increasing concentrations of substances extracted from the Earth's crust.

The Natural Step framework's System Condition #11

Introduction: Why switch?

The burning of fossil fuels, such as oil, coal, and natural gas that are extracted from below the earth's surface, is steadily building up carbon dioxide and other greenhouse gases, such as sulfur and nitrogen dioxide, in the atmosphere far beyond their normal levels. The effects of these concentrations, for example, climate change, melting polar ice caps, rising sea levels, are now readily apparent to all those who are willing to see them. Local communities around the world also are experiencing the effects of fossil fuel burning in the form of air pollution, linked to spiraling increases in asthma and breathing disorders. Since September 11, 2001, another effect is now apparent — the link between fossil fuel dependence, the threat of terrorism, and national and community security.

Communities, particularly those in colder climates, have become heavily dependent upon burning fossil fuels for heat and for power. Reducing this dependence requires a combination of steps, including reducing the need for energy in the first place and seeking alternative energy sources that are renewable and, ideally, locally derived.

Communities around the world already are seeking out and using energy sources that are alternatives to fossil fuels. This chapter highlights a few of
the steps taken by Swedish eco-municipalities, large and small, to change from fossil fuels to alternative and local sources of energy, accomplishing significant reduction in fossil fuel dependency. Two strategies used by these exemplar communities are demonstrated here — harnessing the energy of the wind and sun, and using waste as a resource.

In Sweden, municipal governments are responsible for providing power and heat to housing, businesses, and institutions within their jurisdictions. Over one-half of Sweden’s 289 municipalities supply this heat through district heating systems. District heating systems usually deliver heat in the form of steam or hot water that is pumped through a system of underground pipes to homes and commercial buildings. In 1981, over 85 percent of all district heating systems in Sweden used oil or coal as an energy source. By 1993, the proportion of district heating systems using oil had dropped to 23 percent.²

Harnessing the energy of the wind and the sun

FALKENBERG: WIND AND SUN HELP TO HEAT AND POWER A CITY

About Falkenberg
The city of Falkenberg (Fahl’ken-beryh), with a population of 39,000, sits on the scenic and windy coast of Halland County in southwest Sweden. Its twelve miles of seacoast attracts an additional 40,000 seasonal residents and tourists in summer. Its seaport transfers about a million tons of goods per year. Falkenberg features a compact, historic town center, the largest brewery and cheese manufacturer in the country, and a history of freshwater salmon-fishing dating back to the 1600s. The city also is home to a renowned bargain clothes factory outlet that attracts between 15,000 and 20,000 shoppers per year. This outlet and its customer base also generate business for other regional companies.

Falkenberg has been implementing a municipal plan for sustainable development since 1995. To raise community awareness about sustainable development, the city has reached out to schools, daycare centers, and businesses through forums, workshops, seminars, and the media. City officials decreed that all municipal departments should adopt and implement sustainable development goals. The city trained 2,000 staff — 60 percent of all municipal employees — in the Natural Step approach to sustainable development.

Falkenberg city planners use sustainable development objectives as guidelines for city planning. For instance, planning policies discourage location of shopping centers outside urban areas and encourage closer living and working
relationships to reduce driving and support community life. Planners conduct environmental assessments prior to land use decisions. Falkenberg has excelled in protecting soil quality, an area where policies in food production, industrial development, and public health intersect. Falkenberg also uses green purchasing policies, buying municipal supplies, such as paper, cleaning agents, and office equipment, that are made of recycled materials, have low or no toxic chemical content, and which can be recycled in turn.

One Falkenberg goal is to become the cleanest community in the country in terms of its water and air. Toward this end, the city has reduced its fossil fuel use for generating heat and power through two remarkable renewable energy projects — a state-of-the-art windmill farm and a field of solar collectors.

**Falkenberg’s windmill farm**

Falkenberg has developed a windmill farm of ten 660-watt wind turbines that produce a combined 12.5 gigawatt hours of electricity per year, an average power output of 1.43 megawatts (MW). This amount of electricity can completely heat and power 600 homes for a year. In Falkenberg, this represents five percent of all households in the city. The ten wind turbines sit on agricultural land leased from local farmers. In exchange, the farmers receive three percent of the wind electricity value, which comes to about US$2,000 per turbine per year. The city established a non-profit cooperative that now owns the wind farm. City residents and businesses can join the cooperative for about US$500 a year per household, then buy electricity at one-half the going market price. Non-members can still buy wind-generated power but must pay full market price.

The new wind farm allowed the city to reduce by 12.5 gigawatt hours the amount of coal-generated electricity it previously had purchased from Denmark. The total cost of the windmill farm was about US$650,000. The city was
able to procure a government subsidy for 15 percent of this cost. The city’s payback for this investment is just under nine years. The windmill farm is expected to run between 25 to 35 years with good maintenance. About 90 percent of the wind turbine parts can be recycled and reused at the end of their useful life.

Falkenberg’s solar array

In 1989, Falkenberg constructed and put into operation what was at that time the largest array of solar collectors in the world. Covering over an acre of land, the solar array, now the eighth largest in the world, generates 1.8 gigawatt hours of electricity per year. The solar array also heats water that supplies the city’s district heating system. Heat generated by the solar collectors is carried to the central heating plant through a network of pipes, then passes through a heat exchanger to a 290,000-gallon water storage tank. Hot water for the district heating system is then piped from the top of the tank. Wood-fired boilers and a gas-fired back-up system can reheat storage tank water if it is too cool for the district heating system.³

Overall, Falkenberg, whose homes, businesses, and institutions use about 350 gigawatt hours of electricity per year, now generates about 30 percent of this from renewable energy sources.⁴
Villagers realized that if they didn’t decide what their future should be, others would decide it for them. And it might not be good.

KANGOS VILLAGE: “IT DOESN’T HAVE TO BE HIGH-TECH”

About Kangos

Kangos (Kahn’-gos) is a village of 330 inhabitants within the municipality of Pajala (Pah’yah-laah), far in the north of Sweden. Like other rural communities, Kangos had lost many residents to the jobs and more abundant living choices of the country’s urban centers. As its population dwindled, Kangos faced the closing of its school and local post office. Many remaining residents could not find work and means to support their families.

In the late 1990s, Kangos villagers agreed to take part in a project to define a future for their village that people wanted, as opposed to a future forced upon them by trends seemingly beyond their control. The slogan for this initiative was: “Who decides our future?” Villagers realized that if they didn’t decide what their future should be, others would decide it for them. And it might not be good.

The villagers embarked upon a revitalization initiative, deciding that this should occur in an ecologically sound way. This decision and the work that followed it gave birth to between 30 and 40 new eco-enterprises. As one example, the villagers decided to develop a small resort center that could thrive upon the region’s steady stream of fishermen, hunters, and tourists coming in the warmer months to enjoy the region’s bountiful natural resources and beauty. About 60 villagers formed a non-profit organization to develop and eventually manage the center. They bought 56 acres of land for about US$25,000 nine miles north of the village. Using local materials and their own time and labor, Kangos villagers built this center, board by board and building by building. Volunteers contributed countless work hours. County jobs council funding allowed the hiring of three unemployed villagers to work full-time on building construction.

The resort center, completed in 2001, features a large main building for conferences and weddings. A fishing area has been developed at the far end of the property. Four rental cabins for tourists were constructed and brought to the site from a nearby village. These cabins each have two beds, cooking facilities, and a woodstove. A sauna was constructed, of course, next to the river. The main building also houses a “honeymoon suite,” which, according to local lore, is contributing to an increase in school enrollment. The economic future for the center looks promising. In its first two weeks of operations, the center garnered 30 guest-nights.
Choosing Renewable

An ecological goal for the Kangos resort center is for 100 percent self-sufficiency in heat and power. Solar panels are being installed to generate electricity onsite; woodstoves provide heat. And, villagers came up with a down-home solution to heat the swimming pool. The sun heats water for

the pool via rubber hoses installed on the main building’s roof, demonstrating, among other things, that alternative energy solutions are not always costly or high-tech.

For more about the eco-revitalization of Kangos village, see Chapter 9.

Waste as a resource: Biomass

The growth and care of Westernized human society mostly follows a linear pattern that can be called take-make-waste. This means taking resources from the earth, making things out of them, wasting a lot of those resources in the

![Image of Kangos villagers built this eco-resort center as part of their village eco-revitalization.](image1)

![Image of Kangos swimming pool water is heated by the sun while passing through rubber hoses attached to the building's roof, demonstrating that renewable energy solutions don't always have to be high-tech ones.](image2)
process, and then throwing these fabrications “away,” creating further waste.

In nature, recycling is the rule. Each component of a natural cycle becomes the food, or resource, for the next. In a forest ecosystem, plants and berries are the food for some animals and birds. These creatures become the food for other creatures. The droppings and bodies of all these creatures become food for the microbes and nematodes of the earth, whose soil then nourishes the plants, and on it goes. Except for the energy that is lost in any change of state, everything is used.

Eskilstuna, Degerfors, and Övertorneå are just a few of the Swedish eco-municipalities, and others around the world, who are turning waste into a resource. In doing so, they have created a win-win-win strategy: reducing dependence upon fossil fuels, gaining savings in both reduced energy and landfill costs, and contributing to the greater health of the environment and their residents through reduced emissions.

About Eskilstuna

The city of Eskilstuna (Ess'-kils-teu'-nah) is part of the rapidly developing Greater Stockholm region. It is a 60-minute train ride from Stockholm and the Stockholm airport. This metropolis, called the Mälardalen region, has a market area of three million people, with a growing service and commerce sector. Eskilstuna was once an industrialized city with a population of about 130,000. Through loss of factories and jobs, the city’s population dropped to about 90,000. As of 2001 however, due to the changing trends of the larger region, Eskilstuna has grown rapidly. About 20 percent of its population now are refugees who speak several different languages.

HOW THE ESKILSTUNA CHP BIOMASS PLANT WORKS

The plant super-heats water at high pressure, converting it to steam in a boiler heated by wood by-products. Part of the steam runs a turbine and alternator that generate electricity. The remaining steam, together with heat recaptured from waste gases, is condensed back into water and sent into the district heating system, where it is piped to residential homes and businesses. A generator creates high-voltage electricity for transmission, so there is no need for a step-up transformer. This further reduces energy loss. The plant can produce a maximum 39 megawatts of electricity on the coldest winter day. The city’s average daily
Eskilstuna began its sustainable development action program in 1997, coordinating this program with its general (master) plan. For many years, Eskilstuna, which did not have its own electricity-generating facility, purchased power from outside sources. Four years after it began its sustainable development program, Eskilstuna is producing its own power, up to about 25 percent of the city's total requirements.\(^5\)

**Eskilstuna’s CHP biomass plant**

A major boost to Eskilstuna's self-sufficiency in power generation and reduction in fossil fuel dependency was its construction of a state-of-the-art combined heat and power plant (CHP) run entirely on biomass fuel. The biomass fuel consists of by-product cuttings from timber or lumber, sawdust, bark pulp, branches, and chippings from the wood-processing industry.

Eskilstuna's CHP Plant now produces 95 percent of the city's heating in winter, cooling in summer, and 25 percent of the city's electricity requirements. This heat and power plant serves 25,000 multi-family units, 3,000 single-family homes, and all commercial buildings. The plant operates at a high efficiency rate of 90 percent, meaning that 90 percent of the fuel's energy content is used. In contrast, conventional power plants usually burn oil, coal, or natural gas at efficiency rates less than 35 percent.\(^6\)

The CHP Plant is producing about 180 gigawatt hours of electricity and 330 gigawatt hours of thermal energy (heat). Consumer cost for biomass-fueled district heating has remained constant since the switch from fossil requirement for electricity is about 150 megawatts, so the electricity supplied by the plant is about 25 percent of the city's total needs.

Highly efficient flue gas scrubbers reduce sulfur dioxide and nitrogen oxide emissions to very small levels. Energy is extracted from exhaust gases with electrostatic precipitators, then the gases pass through water scrubbers. The plant can produce up to 700 gigawatt hours of power per year with a capacity of 20 megawatts. Heat is pumped to homes and buildings through a 60-mile network of pipes that carry hot water to those buildings, then return that water to the plant for reheating.\(^7\)
fuels. Eskilstuna offers the tenth-lowest price for district heating in the country. Since 1997 when the plant went on-line, the city has reduced its consumption of fossil fuels for heating by 38 percent. The cost for the plant was about US$45 million. The city was able to obtain funding through the national government for 25 percent of the cost.

According to an Eskilstuna official, in 1980, most power plants in Sweden used 80 percent fossil fuels and 20 percent other sources to generate power. Today these ratios are reversed. Of the 150 Swedish municipal district heating systems, 30 percent now use biomass fuel.

About Degerfors

The town of Degerfors (Deh'gehr-fosh) is about a two-hour train trip from Stockholm. Its population of 10,500 inhabit an area of about 40 square miles (about 104 square kilometers). Degerfors is situated in the Bergslagen (Behryhs'-lah-ghen) district, the steel-producing region of Sweden. The literal translation of Bergslagen is “the place where they have broken the mountains to make steel.” Mines, steel works, and iron foundries dot the area. Much like Eskilstuna, Degerfors has lost population, businesses, and jobs over time. Many abandoned buildings and factories line the river running through the town. Younger people left Degerfors for jobs in urbanized areas, leaving the older residents. The burden of paying for municipal services, including eldercare, was falling on fewer and fewer households.

During the 1990s, Degerfors undertook a sustainable development initiative that included economic development, sustainability education, and a green building program. Over 85 percent of the Town’s 1,000 employees took part in sustainability education seminars introducing the Natural Step framework. The town ran similar seminars for its citizens. As of 2001, between 35 and 40 percent of the 10,500 Degerfors population — over 4,000 people — have learned about the Natural Step framework. Degerfors citizen education demonstrates how changing to sustainable practices can provide household economic and social benefits as well as ecological ones. For example, household heating costs can be lowered through converting from fossil fuel to biomass-produced heat. The town is updating its ten-year general (master) plan, using the Natural Step framework as its guiding objectives.

Degerfors converts to biomass

In 1997, Degerfors completed conversion of its fossil-fueled district heating system to one that now uses biomass fuel. One year later, the town’s greenhouse gas emissions had dropped by 30 percent. Heating costs per
household have declined significantly since that conversion, relieving financial burdens borne by hard-pressed Degerfors households.

**Journey to freedom from fossil fuels: The town of Överorneå**

*About Överorneå*

In the early 1980s, Överorneå envisioned a future where the town was 100 percent free of fossil fuel use for energy and power. Like many other Swedish municipalities, Överorneå operates a district heating system that provides heat to 2,500 homes and public buildings including schools and eldercare facilities. The town operates five heating plants, one located in each of its five largest villages. All these burned fossil fuels. The town also runs a public bus system and a fleet of cars, vans, and trucks for its municipal staff. All Town buses and cars ran on petroleum-based fuel. Switching to an alternative to fossil fuels posed an enormous challenge for the municipality.

*Överorneå converts*

One by one, over several years, the town converted the burners in its five heating plants to furnaces that use biomass — wood pellets or wood chips — readily available by-products from nearby forest-based and lumber industries. As of fall 2000, an eldercare center, public health center, and swimming pool in the community were converted to biomass heating. By spring 2001, two schools had been switched over to wood-based fuel, with three more schools and another eldercare facility converted by fall 2001.

By late fall 2001, all municipal buildings, schools, eldercare and daycare facilities, and heat plants in Överorneå had become independent of fossil fuels in their heating and operations. With the conversion of its fleet of buses and staff vehicles to biofuels, such as ethanol, at

![Figure 5.7: This is one of the five village heating plants that the town of Överorneå converted from fossil fuel operation to biomass fuel.](image-url)
the close of 2001, Övertorneå realized its vision, formed over 15 years earlier, of achieving 100 percent freedom from fossil fuels in municipal operations.

This was not only an ecological success story for Övertorneå, but a financial success as well. The town’s oil consumption dropped by 132,000 gallons (about 500,000 liters) per year. Just after all facilities were converted to biofuel use, the price of oil almost doubled to US$89 per barrel. The overall cost of the town’s elimination of fossil fuels as an energy source was about US$375,000. The payback time for this investment was between two and three years.

Waste as a resource: In Umeå, garbage becomes power

About Umeå

Umeå (Euh'-meh-aw) is a city of about 100,000 people in northern Sweden. It is a university community, where a population of 20,000 students has spurred Umeå’s metamorphosis from an old-fashioned town to a major regional educational and cultural center. It is one of the fastest-growing cities in the country, and its average citizen age is 35 years. One-half of Umeå’s population comes from other regions of Sweden, and another ten percent come from other countries. This means, among other things, new ideas are always flowing into the community.

Historically and presently, Umeå is a place where different cultures meet. It is often described as the best city in the country to live and has the highest degree of resident satisfaction. Umeå residents call their community the “capital city of the north.” Umeå combines the advantages of a big city with

HOW A VILLAGE BIOMASS HEAT PLANT WORKS

Wooden pellets for fuel are stored in a silo tower with a feed into the burner system. It takes between 10 to 20 minutes to fill the tower with wooden pellets. Once the silo is filled, it can provide enough energy for the domestic hot water and heating needs of village homes during the three to four summer months. In the winter, a silo full of pellets provides heat.
the atmosphere of a small town. As one Umeå official advises, it is important to preserve this attribute in city planning.

Umeå originally developed as a trade center. Sámi people, known to many Westerners as Laplanders, traveled to this region as they herded their reindeer from winter to summer feeding places. A lively across-the-sea trade developed among the Swedes, Finns, Russians, and the Sámi. When the municipality of Umeå was officially founded in 1622, there were about 200 inhabitants. In the late 1800s, the city became an industrial center, resulting in, among other things, the devastation of its forests. Umeå developed such a bad environmental reputation around the country that a particular term came to describe the city’s poor behavior toward the environment — Baggböleri (Bugg-beu-ler-ee).9 In 1960, the founding of Umeå University, which for years was the only university in northern Sweden, spurred the city’s transition to its present status as a regional cultural and education center. Umeå now offers many festivals and cultural events, such as jazz, chamber music, film, and the only opera north of Stockholm. Baggböleri has been replaced by high environmental awareness among Umeå citizens and throughout their municipal government.

In the early 1990s, Umeå’s municipal government worked to make that environmental awareness official. The city’s governing Executive Council adopted goals for sustainable development and established a coordinating group with representatives from six municipal departments to make those goals a reality. Over the next two years, 50 department supervisors received training about the importance of a healthy environment and sustainable development practices to ensure this. City officials decreed that one working day be set aside to spread this message through all city departments. Included in these environmental training sessions were all employees of Umeå Energi, the city’s municipal energy department that owned and operated the city heating plant.

for the village for about one week. One hundred buckets of pellets, when burned, creates one bucket of ashes. Because the ashes come from 100 percent wood, they can be composted, so there is zero waste. These wooden pellets burn at an 85 percent efficiency rate, compared with a 65 percent efficiency rate for industrial oil, according to the town’s energy coordinator.8

Umeå's Dava plant, which operates at an astonishing 99.5 percent efficiency rate, is fueled entirely by the city's own solid waste.
Umeå's energy crisis
Also in the 1990s, the city of Umeå was growing rapidly and found itself facing an acute power shortage. It became clear that the city's oil-burning power and heat-generating plant, built in the 1960s, was not going to be able to do the job of meeting the increased power demand. Instead of converting or retrofitting the older plant, Umeå officials decided to construct an entirely new facility with greater capacity to both service the increased demand and significantly reduce the city's dependence upon fossil fuel and emission of pollutants. The source of the plant's energy would be the city's own solid waste. Since increasingly strict national regulations were in the works to prohibit dumping of burnable waste and organic waste at landfills, the plant would provide solutions to several problems.

Enter the Đåva power plant
The Đåva power plant, Umeå's win-win solution for its energy crisis, has become known as the world's most energy-efficient and environmentally acceptable waste-burning power plant. Approvals and permits were obtained for Đåva in 1997 to replace the city's oil-burning plant. Construction on Đåva began in February 1998, and the plant went on-line in August 2000. Costing close to US$80 million, the Đåva plant is the single largest environmental project ever undertaken by the city of Umeå. Of its 65 MW of power produced, 55 MW provides district heating for 25,000 homes — 90 percent of all city households. The remaining 10 MW goes toward electricity production. The plant operates at an astonishing 99.5 percent efficiency rate. (As mentioned, a conventional power plant usually operates at between 35 to 45 percent efficiency).

The Đåva plant is fueled entirely by the city's own solid waste. Municipal solid waste is collected, compressed, and stored in wrapped blocks near the plant. Household waste, business and industry waste, building materials, organics, food, plastic, rubber — all are fair game to fuel the plant, with the exception of metal and hazardous substances. Solid waste that cannot be remanufactured into new products has a fuel value that is higher than most biomass fuels, such as wood pellets or wood chips, according to Umeå Energi officials. The energy recovered from these substances is one form of recycling. The solid waste otherwise would be dumped in the city's landfill, creating more environmental degradation, in turn costing the city more to rectify. All solid waste materials are, of course, locally obtained, virtually eliminating the city's cost for importing fuel from afar. Solid waste haulers pay about US$28 per ton to dump at the power plant — far less costly than
dumping at the local landfill. The Dåva plant is also designed to burn biomass — material such as wood chips, pellets, or other wood by-products.

During Dåva’s first year of operation, Umeå’s fossil fuel use for heating dropped by 80 to 95 percent from its previous level. Electricity used as a form of heating energy has disappeared entirely in Umeå. Due to its state-of-the-art power generating and environmental cleaning systems, Dåva receives 3,000 to 4,000 visitors a year from round the world. The European Union, corporations, and international organizations are studying Dåva as a model for how to recapture and use the embodied energy in solid waste that would otherwise be lost.
Umeå's decision to build the Dåva plant was a multi-win solution — always a good sign that an action is aimed in the right direction. That decision drastically reduced fossil fuel use, greenhouse gas emissions, and fuel costs for the city, while meeting the energy needs of its expanding population. The decision dramatically reduced high environmental and financial costs of hauling and dumping the city's trash, and related increasing landfill encroachment.

The Swedish national energy scene: a snapshot

Between 1981 and 1993 in Sweden, oil dropped from 83 percent to 12 percent as a fuel source for district heating. Stemming from a national referendum in the 1980s, Sweden is also gradually phasing out its dependence upon nuclear power to generate energy. The national government's target environmental objectives include clean air, protection of the ozone layer, limited influence upon climate change, and an environment safe from radiation. Changing to locally developed renewable energy sources is seen as a key strategy toward meeting these national objectives.

NORTH AMERICAN EXAMPLES

District heating systems

According to surveys, over 3,000 district heating systems are operating in the United States. Municipalities that are operating district heating systems

HOW THE DÅVA PLANT WORKS

A steam boiler, fired by the burning of solid waste, produces electricity and heat. Two purification systems, one dry, one wet, clean the potential emissions. Combining these systems provides the best of both techniques. The dry purification system is good at collecting particle substances, such as heavy metals, mercury, and carbon dioxides. There is no opportunity for these substances to bypass the system. The wet system involves three scrubbers that wash the outflows with balsam. These scrubbers remove substances, such as hydrochloric acid, and convert sulfur to gypsum — a product that is used to make wallboard. Wastewater is further purified with a double treatment system condenser. Gas is cooled with water, and this water is reused as washwater for the wet scrubbers. Limestone removes 90 percent of acidic substances from the washwater. Ammonia (NH2) is extracted and goes back into the furnace. Heavy metals, such as cadmium, are precipitated through
include Eugene, Oregon; Lansing, Michigan; Fairbanks, Alaska; and Jamestown, New York. Boise, Idaho, and San Bernadino, California, use geothermal heat as a renewable energy source to fuel their district heating systems. In Canada, district heating systems that use biomass as a heat source are operating in Prince Edward Island, Quebec, and in a Cree-owned and operated system in Oujé-Bougoumou.

Renewable energy

Since 1984, the municipally owned electric department of Burlington, Vermont, has provided electricity to city residents and businesses through a generating plant powered by wood chips, bark, and sawdust, eliminating an annual need for 360,000 barrels of fuel oil. The Burlington Electric Department has been working with other city agencies and a nearby university to develop a district heating system using heat generated from this biomass power plant. Since forests cover 75 percent of the state, biomass is a logical source of renewable energy for Vermont. State agencies and organizations are helping to build capacity in Vermont’s regional planning commissions to assist the development of local biomass district energy systems.

The municipal electric department of the Town of Hull, Massachusetts, (pop. 11,000), has generated electricity from wind power since the early 1980s. Recently, the Town replaced its twenty-year-old windmill with a state-of-the-art wind turbine that generates enough electricity for 250

sand filters and combined with sulfur to make a more innocuous substance, such as cadmiu

um sulfide. Excess water not reused is diluted and sent to the Umeå River. Flue gasses are cooled to 600 degrees Celsius. Eight megawatts of power are extracted by compressor heat pumps and reused, saving additional power costs. Before leaving the chimney, the flue gasses are cooled to between 50 to 60 degrees Celsius. Slag, a solid residual product from the waste incineration is quality-assured for use as a road aggregate material, saving the use of natural gravel for this purpose. Natural gravel is another diminishing natural resource in Sweden that has been targeted for conservation. Overall, state-of-the-art cleaning systems have radically reduced greenhouse gas emissions, such as sulfur and nitrogen oxides and carbon dioxide, far below the emissions of the former oil-burning plant, as well as below the standards set by Sweden’s environmental court.
homes. The new turbine, whose installation cost about US$300,000, will save Hull taxpayers about US$50,000 a year, repaying the town's investment in six years.18

Denver, Colorado, and Newton, Massachusetts, are among the municipalities that are promoting the use of solar energy throughout their jurisdictions, with assistance from the U.S. Department of Energy's Million Solar Roofs Program. In Newton, the mayor, board of aldermen, planning department, school system, chamber of commerce, and a citizens environmental organization have joined forces to bring about the installation of 500 solar power systems in public buildings, businesses, and private homes.19

In the United States, one-third of all electricity consumers are now able, if they choose, to purchase renewable energy through green pricing programs offered by utility companies or through independent suppliers.20 As an example, the City of Santa Monica, California, recently signed an agreement with its power supplier that to purchase electricity that is 100 percent generated from renewable energy sources.