Colorado consumers sensibly select clean energy solutions





COLORADO'S Clean Energy CHOICES

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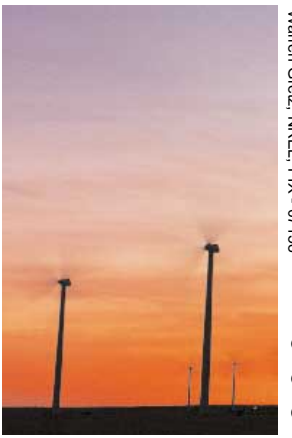
INTRODUCTION

WHAT IS CLEAN ENERGY?

Take a stroll in Boulder, Montrose, Fort Collins, or Limon on a typical day and you'll see and feel two of Colorado's most powerful clean energy resources. The sun shines bright in the sky, and there is likely to be a pleasant 15-mph breeze. It's solar energy and wind energy at your service, part of a broad spectrum of clean energy resources available to us in Colorado.

Today, 98% of Colorado's energy is produced from fossil fuels—coal, oil, and natural gas. They are plentiful and inexpensive today, but their supply is finite and their combustion has environmental consequences. In contrast, clean energy resources are constantly replenished and economically advantageous to the state. Clean energy systems can be classified in two general categories: renewable energy and energy efficiency.



Warren Gretz, NREL, PIX - 07158

Newly arrived at Colorado in 1998, wind energy is now available to the majority of electricity customers in the state.

Renewable energy comes either directly or indirectly from the sun or from tapping the heat in the Earth's core:

- Sunlight, or solar energy, can be used directly for heating, cooling, and lighting homes and other buildings, generating electricity, and heating hot water.
- The sun's heat also causes temperature changes on the Earth's surface and in the air, creating wind energy that can be captured with wind turbines.
- Sunlight causes plants to grow and is the source of all life. The organic matter that comes from plants and from animal wastes is known as biomass. It can be used to produce electricity, transportation fuels, or chemicals for consumer products. The use of biomass for any of these purposes is called bioenergy.
- Rain, created from water evaporating when exposed to sunlight, collected in rivers

and streams, can be turned into electricity called hydropower.

¥Geothermal energy taps the Earth's internal heat, carried by steam or hot water. It can generate electricity or be used directly to heat and cool buildings.

And energy-efficient technologies minimize the energy used to perform work, whether it be running a car or lighting a home.

Why Is Clean Energy Good for Colorado?

Renewable energy and energy efficiency benefits the state in many ways.

Environmental Benefits

Renewable energy technologies are clean sources of energy that have a much lower environmental impact than conventional energy technologies. Energy-efficient technologies minimize conventional energy use and greatly reduce environmental impacts.

Energy for Eternity

Although projections vary widely, no one disputes that we will eventually run out of fossil fuels. Renewable energy will not run out as long as the sun shines on the Earth.

Jobs and the Economy

Most clean energy investments are spent on materials and workmanship to build and maintain renewable energy facilities and energy-efficient equipment, rather than on energy imports. Colorado's clean energy investments can be made within our state. This means energy dollars stay home to create jobs and fuel local economies, rather than going out of the state or overseas.

To put it simply, Coloradans have many clean energy choices that are available today at reasonable cost. Most of us can purchase wind-generated electricity from our electric utilities. All of us can save money by purchasing energy-efficient appliances and using energy wisely at home. Those of us in remote areas can benefit today from solar and wind electricity

Clean energy will help us keep Colorado's environment beautiful for many generations to come.

David Parsons, PIX - 00480

generation. And we can all drive fuel-efficient cars and trucks, or even purchase alternative fuel and hybrid electric vehicles.

This booklet will tell you what your clean energy choices are, where they are being used in Colorado today, and provide you with contacts to help you obtain more detailed information. Since we have the power, let's make it clean power.

For more information:

Clean Energy Basics—National Renewable Energy Laboratory

www.nrel.gov/clean_energy

Provides a definition of the different kinds of renewable energy and how they can be used in the future.

Governor's Office of Energy Management and Conservation (OEMC)

www.state.co.us/oemc

OEMC is the lead agency for energy efficiency issues in the state.

Colorado Energy

www.coloradoenergy.org

Provides information about events, programs, legislation, publications, and other information related to clean energy in Colorado. This Web site is funded by the OEMC.

GREEN POWER IS CLEAN POWER

Today, Colorado consumers can choose two types of renewable energy for their electricity: wind and solar. Other types of renewable energy, such as hydropower and landfill gas (methane), are mature technologies and already form part of the electricity generation system. These types of renewable energy technologies are not marketed separately as clean energy in Colorado as in other states. Other types of renewable energy electricity generation, such as geothermal, mixing biomass with coal (cofiring), and some types of solar technologies (concentrating solar power), do not yet operate commercially in Colorado. Nevertheless they could based on the experience in other states of operating and marketing them to consumers as clean energy.

Wind Power

You have most likely seen Colorado wind power in action on TV newscasts. The Ponnequin Wind Facility, located in northeastern Colorado, provides up to 20 megawatts of power to more than 15,000 customers, including 300-plus commercial customers and four wholesale customers—making it the largest and most successful utility green-pricing program in the country.

Through *Wind*source, Public Service Company of Colorado offers residential and business customers blocks of 100 kilowatt-hours (kWh), with each block priced slightly above existing electric rates. Customers can choose how many blocks of wind energy they would like to purchase up to 100% of their electric load. One block is approximately 15% of an average home's electric usage. The average home in Colorado uses 600 kWh of electricity each month.

Public Service Co.'s *Wind*source is the largest, but not the only, such program, in Colorado. Twenty utilities offer their customers the option to choose wind energy, including Colorado Springs Utilities and Holy Cross Energy, which purchase wind power from Public Service Co.; and the municipal utilities of Fort Collins, Loveland, Longmont, and Estes Park, which purchase

wind power from the Platte River Power Authority. In Aspen and Glenwood Springs, the municipal utilities provide wind power to all customers as part of their regular electric service. In addition, 14 of Tri-State Generation and Transmission Association's 32-member rural electricity cooperatives also offer wind power to their customers.

Today the majority of Colorado electricity consumers have wind power as an option from their electric power companies.

While the use of wind energy is growing rapidly, there is room for much more. Colorado, like all of the states that occupy the Great Plains, has a large wind energy resource. According to the National Renewable Energy Laboratory (NREL) in Golden, our state has enough wind energy to supply 9% of the electricity consumption of the lower 48 states. In this calculation, urban areas, wetlands, parklands, and national forests are excluded from wind power

For more information:

Wind Power: Clean Energy for Colorado

www.cogreenpower.org

Sign up with one of Colorado's power companies offering wind energy under a green-pricing program or find out more about wind energy.

Public Service Company of Colorado

www.ncenergies.com
1.800.824.1688
Sign up for *Wind*source.

Clean Energy Basics—NREL

www.nrel.gov/clean_energy/wind.html

Has a more detailed explanation about how wind energy works with links to resources for homeowners, business owners, and students and teachers.

U.S. Department of Energy's (DOE) Energy Efficiency and Renewable Energy Wind Page

www.eren.doe.gov/RE/wind.html

Provides links to publications, research, industry associations, and information about wind projects around the country. Or call DOE's Energy Efficiency and Renewable Energy Clearinghouse hotline at 1.800.363.3732 for free fact sheets on wind energy.

Public Service Co.'s Ponnequin Wind Facility, located near I-25 and the Wyoming border, is Colorado's first utility-scale wind power plant.

Warren Gretz, NREL, PIX - 07158

development. With a large resource in the state and low costs compared with other sources of renewable energy, wind is poised to make a major contribution to the environment and future economy of the state.

Solar Power

Electricity from the sun is becoming an increasingly viable option for Colorado consumers. Coloradans interested in generating their own electricity using solar-electric photovoltaic (PV) technology have been waiting in line to participate in the Solar Rebate Program. Funded by the Governor's Office of Energy Management and Conservation, the Colorado Solar Energy Industries Association ran the successful program in 1998 and 1999 to give rebates to more than 70 installations on homes. Altogether, more than 100 families applied for rebates.

Joe Burdick, PIX - 07521

The Renewable Energy Trust supported installation of these PV-integrated roofing shingles at the Mount Evans Observatory in 1997. The roof generates about 65% of the electricity needed by the observatory.

PV Goes Mainstream

As of January 2000, more than 100 Coloradans have chosen to generate their own electricity using solar-electric PV technology, while remaining connected to the utility power grid. Thanks to dramatic price drops and growing consumer interest in clean energy options that offer self-sufficiency, PV technology is becoming more popular. The technology is often the cheapest source of power for small and stand-alone applications, but has only recently become affordable to homeowners.

A number of Colorado electric utilities have even begun offering voluntary incentives to their customers who choose solar electricity to meet some or even all of their household electrical needs. Public Service Co., Fort Collins Utilities, Holy Cross Energy, Colorado Springs Utilities and Delta Montrose Electric Association offer retail credit to their customers who feed excess solar electricity back into the utility power lines. Public Service Co. has teamed up with Altair Energy, a Golden-based energy service company, to offer turnkey solar electric services through an unregulated program called *Solar*source[sm].

A Shining Example

In February 1999, the Aspen Community Office for Resource Efficiency, the City of Aspen and Holy Cross Energy launched Sun Power Pioneers, the first solar production incentive program in the country. Participating businesses and homeowners who install a grid-connected photovoltaic (PV) system are paid a solar production incentive of $0.25/kWh. Incentives are capped at $3,000 per system, and the production incentive is good for three years.

The goal of Sun Power Pioneers is to install 30 to 60 kilowatts (kW) of grid-connected PV in the Aspen area.

Solar on Schools

PV systems are going up on schools around the state. The installations are funded by the Governor's Office of Energy Management and Conservation, the Utility PhotoVoltaic Group (UPVG), and Public Service Co.'s Renewable Energy Trust. The Trust is a special tax deductible fund created to develop renewable energy sources for nonprofit, educational use across Colorado. It is managed by the Denver Foundation and supported through contributions by Public Service Co. customers on their monthly utility bills. Today 12,000 Public Service Co. customers contribute a few pennies each month to make the program possible.

Altair Energy, PIX - 09075

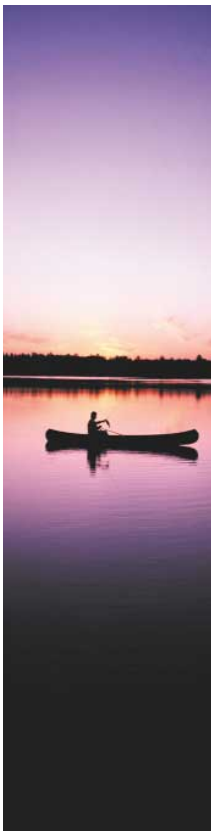
This 2-kW PV system mounted on the roof of the Powell Middle School in Littleton meets some of the electricity needs of the school and provides students opportunities to learn about solar energy.

Because of these contributions, 26 school buildings now boast the latest in PV technology on their rooftops. The systems are typically rated at 2 kW and cost $20,000 to install. The systems reduce the utility bills of the school and support science curriculum for students. Each PV system comes with a computerized display so students can track electricity generation and weather data minute by the minute.

Teachers take advantage of the schools' solar systems to explain the physics of solar energy, the electromagnetic spectrum, how the components of PV systems function, and more. According to Bill Alley, principal of Carbondale Elementary School, "The solar electric system on our school will allow our students to learn firsthand about an important natural resource, the sun."

In addition to schools, the Trust installed 35 renewable energy projects for use by nonprofit agencies and community organizations throughout the state.

Hydroelectric Power



Hydropower is the largest source of renewable energy for both Colorado and the entire country as a whole. About 4% of Colorado's electricity comes from hydroelectric generating stations, mostly from a handful of large dams built by the U.S. Bureau of Reclamation in the 1950s and 1960s.

Theoretically, any flow of water from a higher to lower elevation can be used to generate electricity, including dams and pipelines. Small-hydro projects avoid the environmental problems of habitat destruction and fish mortality normally associated with large dams.

Several cities that obtain their drinking water from mountain sources also generate electricity from small-hydro stations on their municipal water supply systems. Boulder began using hydropower almost 20 years ago, and it has proven to be very popular because it lowers water costs to the city. Including one facility under construction, there are seven generating stations on the Boulder water supply provid-

For more Information:

Public Service Co.

www.ncenergies.com
1.800.824.1688

Provides information about how to make a contribution to the Renewable Energy Trust and how to apply for funding.

Colorado Consumers Guide to Purchasing a Solar Electric System , published by **OEMC** in 1998.

www.state.co.us/oemc/pubs/conguide/index.htm.

For a list of lenders and brokers who will finance a PV system on a home, visit

www.state.co.us/oemc/pubs/pvlenders/index.htm.

The Colorado Solar Energy Industries Association

www.coseia.org
1.800.633.9764

Provides information about solar installations and contractors in the state.

Altair Energy-Solar Schools Program

www.coloradosunshine.com/alliances/school.htm

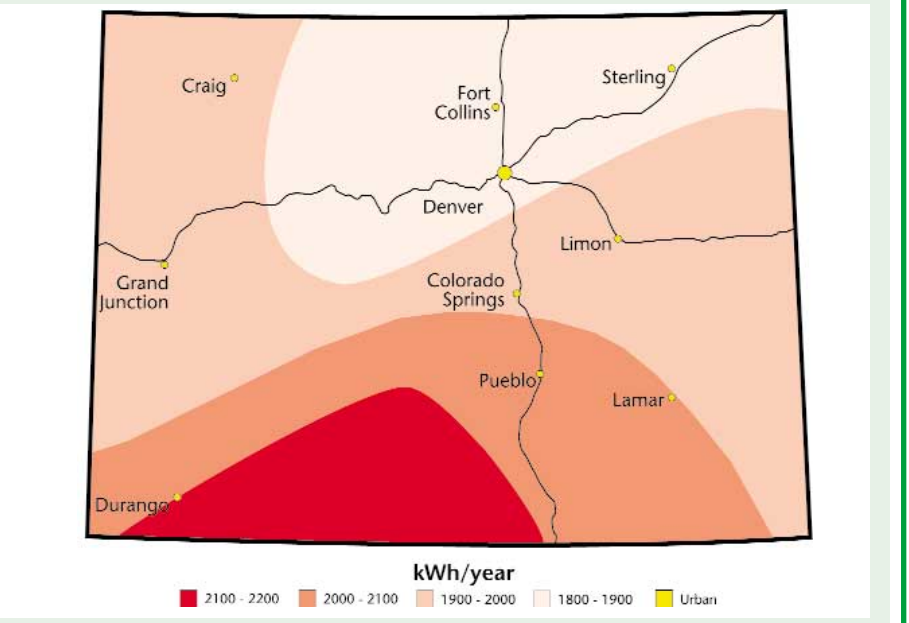
Describes services provided to schools by the Renewable Energy Trust.

Schools Going Solar

www.schoolsgoingsolar.org

Lists suggested classroom activities of other utility-school partnerships across the country.

Electricity Production from a 1-kilowatt Grid-Connected PV System



This mountain home features a 3.6 kilowatt (kW) PV system that meets about 50% of the family's household electric needs and provides back-up power to the family's critical appliances during weather-related utility outages. The family receives credit from Public Service Co. for excess solar electricity they sell back to the utility.

Altair Energy, PIX - 07899

PV systems operate almost anywhere. The system output varies less than 15% from the best solar resource in the state to the worst. Most days in Colorado are sunny, but even on cloudy days PV systems produce about 25% of their output.

This map represents average output for a 1-kW system facing south tilted toward the sky at the angle of the latitude, typical for a rooftop application. To estimate the yearly output for a system of a different size, multiply by the system rating (kW). Take, for example, a 2-kW system located in Durango. Using the average retail price of electricity in the state as $.074 per kWh, you can calculate the number of years to pay for the cost of the system, simple payback, as follows

System Rating	Yearly Output	Yearly Savings	Simple Payback
2 kW	4,200 kWh	$310	20 to 40 years

ing more than 11,000 kW of electric power. Today the city of Boulder generates enough electricity at its small-hydro stations to supply 7% of the city's needs.

Biomass Power

Biomass is the second largest source of renewable energy in the country and makes a small contribution to Colorado's energy mix. Just about anything that is, or once was a living organism can be classified as biomass—forestry residues, grasses, and animal wastes. Biomass has been used to create bioenergy in the form of electricity and liquid fuels. Today there are a three types of biomass facilities operating in the state, including biogas from landfills, wastewater facilities, and animal farms. Potentially trash wood current ly going to landfills could also be used for energy.

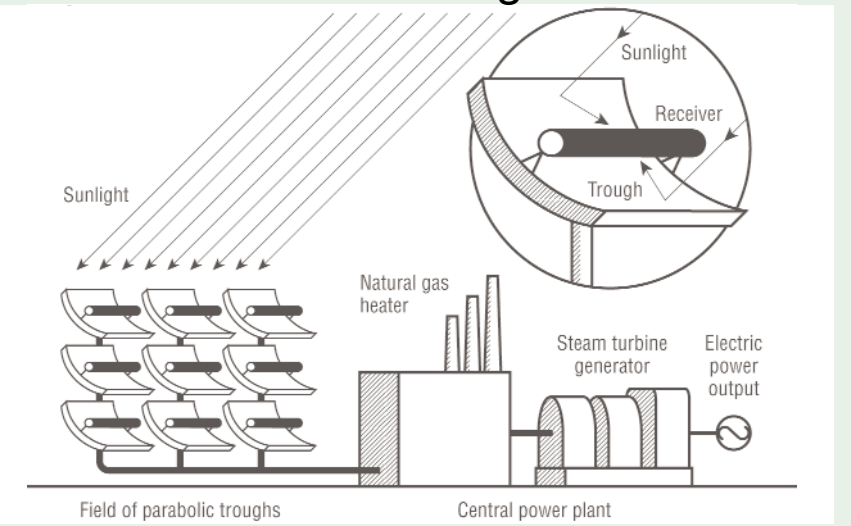
Biogas

Colorado has four biogas facilities that harvest methane produced from the decomposition of biomass in landfills and wastewater treatment facilities. Common bacteria that appear in nature consume the waste and produce methane. Methane is a very powerful greenhouse gas that can be harmful to the environment and health if left to vent to the atmosphere. However, when contained, it is quite suitable for producing heat and electricity, much the same as natural gas. One landfill methane recovery plant is operating in Littleton, and a total of three wastewater recovery plants are operating in Denver and Boulder. They range in size from 200 kW in Boulder to 8,000 kW in Denver.

The city of Boulder obtains the equivalent of 7% of its energy from small hydroelectric facilities, such as this one at the Betasso Water Treatment Facility.

Bill Monk, PIX - 08248

Solar Troughs



Parabolic troughs collect the sun s energy as heat for generating electricity in a conventional steam turbine.

Animal Farms

Animal manure can present an environmental problem when it is concentrated on large-scale animal feedlots. But this animal manure was once plants and grains; thus, it is biomass that can be source of clean energy when converted to a gas in an anaerobic digester and combusted in a turbine generator. The anaerobic digester uses bacteria to break down the manure, producing gas in much the same way as a municipal treatment facility does.

Colorado has one animal feedlot facility near Lamar that operates an anaerobic digester to produce energy from animal waste. In general, such facilities are not as common in North America as they are in other parts of the world. While there are fewer than 100 such facilities operating in the United States, there are more than 600 operating in Europe and as many as a million small-scale facilities in Asia.

Nevertheless, a small number of owners in Colorado are investigating the practicality of turning manure into energy, especially after passage of Amendment 14 in the 1998 election regulating the operation of hog farms. The Governor's Office of Energy Management and Conservation is currently assessing technical, economic, and environmental aspects of biogas-to-energy possibilities at commercial swine production centers in the state.

Used Wood in Urban Areas

A recent study sponsored by DOE suggests that the amount of used wood in urban areas is proportional to the size of the local population. Wood trash comes from industries that use and then dispose of wood products, such as beams and studs used in construction, pallets used in trucking, and even tree trimmings. Most of this used wood winds up in landfills.

This wood going to landfills can potentially be used for electricity production. Several utilities in the East are conducting experiments with mixing used wood in small percentages with coal in their power plants.

Concentrating Solar Power

One type of solar power technology marketed in California has the potential to operate just as well in Colorado. Called concentrating solar power, the technology combines the environmental benefits of solar with the control of natural gas power generation. Such hybrids, combinations of conventional and newly developing solar technologies, are clean energy options to consider for the near future.

Today, concentrating solar panels are used at a small number of locations in Colorado, including the Adams County Detention Center in Aurora and the Jefferson County building in Golden. These —facilities use the concentrating systems to generate hot water for showers, laundry and other needs, but not for electricity.

The principle these systems operate on, however, is similar to those that generate electricity. Sunlight is focused along the (focal) line of series of parabolic mirrors. For electricity generation, more mirror area and higher concentrations of sunlight generate steam instead of hot water. The steam runs through a conventional turbine generator to produce electricity. When it is cloudy, gas-fired backup burners kick in to generate the steam.

The world's only operational concentrating solar power plants are located in the Mojave Desert near Barstow, California. Altogether there are nine such power stations with a combined rated capacity of 350 megawatts that have been operating since the 1980s. They take advantage of the large amount of direct sunlight available in the Mojave Desert.

A similar solar resource exists throughout the southwestern United States, including the San Luis Valley and Four

Corners regions in southern Colorado. In Alamosa, for example, each square meter receives about 2,500 kWh per year of direct sunlight, 90% as much as Barstow.

Although feasible, no plans are currently underway to build a concentrating solar power plant in southern Colorado. The main reason is cost. The average (levelized) cost of electricity from such a plant would be about $0.13 per kWh, substantially more than the average cost from conventional power plants and almost twice the average retail price of electricity in Colorado. The cost of concentrating solar power is not, however, more than some green power programs already operating in Colorado or other states. Whether concentrating solar power can become a viable option for Colorado consumers remains an open question for now.

Geothermal Energy

Geothermal energy, already the third largest source of renewable electricity in the country, is a promising resource in the West. Where available, geothermal energy can provide electricity or inexpensive heating for homes and other buildings.

For more information:

DOE's Denver Regional Office

www.eren.doe.gov/dro
303.275.4826

Provides information about biomass development and demonstration projects supported by the Western Regional Biomass Energy Program.

Governor's Office of Energy Management and Conservation

www.state.co.us/oemc/programs/wetlands.htm

For information on a program for using constructed wetlands to treat wastewater at livestock farms.

Green Power Network

www.eren.doe.gov/greenpower

For information on green electricity markets and utility green pricing programs around the country.

Colorado Renewable Energy Society

www.cres.gen.co.us
303.806.5317

CLEAN ENERGY AT HOME

Colorado's home designers, builders, and homeowners are national leaders when it comes to clean energy systems. The clean energy combination of renewable energy systems, energy-efficient design and energy-efficient appliances (like those with an Energy Star¤ label) can reduce utility bills and help us maintain Colorado's high environmental standard far into the future.

PIX - 07769

This McStain Enterprises home at Lexington Fairway in Lafayette is an energy-efficient, single-family home constructed using Colorado Built Green criteria.

Over the past two years, home builders have constructed more than $1 billion worth of "green homes" in Colorado, far more than any other state in the nation. These homes are part of the Built Green Colorado program, sponsored by the Colorado Home Builders Association and other regional home builders, Public Service Co., E-Star¤ Colorado, and the Governor's Office of Energy Management and Conservation. Built Green Colorado homes must meet strict energy efficiency and water conservation standards.

Each registered home must receive an energy rating of at least four stars (80 points as certified by E-Star¤ Colorado) or be built to national Model Energy Code 1993 standards. The E-Star¤ Colorado program, conducted by the state-supported Energy Rated Homes of Colorado, gives E-Star¤ energy ratings for both new and existing homes. The E-Star¤ energy rating is a score expressed on a scale from 0 to 100 points, and can be thought of as a residential miles-per-gallon sticker. E-Star¤ evaluations have been done on almost 5,000 Colorado homes, both old and new, since 1995.

A Built Green or E-Star¤ compliant home is energy efficient, comfortable, and economical to run. The rating can help home buyers and owners more easily qualify to purchase energy-efficient homes or make energy-efficient improvements in the purchase, home equity, or refinancing process.

Appliances and equipment with the Energy Star¤ label can help you save energy and money in your home or business.

Climate Responsive and Solar Architecture

Colorado homeowners and builders have a wide range of choices when it comes to incorporating clean energy systems into their homes and buildings.

Everything from the materials used to build the exterior envelope to the insulation, roof overhangs, landscaping, siding, heating and cooling systems, lighting, and appliances and equipment that service the building can add to or minimize its overall energy use. Several federal and state programs around Colorado are promoting the concept of the "whole house" strategy, tying all of these components together to create high performance clean energy systems.

In Clear Creek County, Colorado, Otto Van Geet is the proud owner of a high performance home. Built using Van Geet's own architectural design, the home is located at an altitude of 9,200 feet. The passive solar home is constructed with dry-stack concrete blocks. Some of the homes energy-efficient features include:

¥1,200-watt PV system for electricity

For more information:

Energy Star¤ U.S. Environmental Protection Agency, and DOE

www.energystar.gov
888.STAR.YES (782.7937)

For information on energy-efficient appliances and equipment.

American Council for an Energy-Efficient Economy

www.aceee.org

For a list of the most efficient appliances, information on efficiency standards and technologies for buildings, and publications. See, for example, Consumers Guide to Home Energy Savings, 1999, at *aceee.org/consumerguide/index.htm.*

Energy Rated Homes of Colorado

www.e-star.com
1.800.877.8450

Rate your own home or contact a professional to come do it for you.

Dave Parsons, PIX - 08226

Warren Gretz, NREL, PIX - 07921

(Top)

The Van Geet residence in Idaho Springs obtains the majority of its energy needs from the sun.

(Bottom)

This energy-efficient home in Broomfield features low-e windows; radiant floor heating; highly efficient furnace, water heater,and engineered wood wall framing.

- Active solar water-heating for domestic hot water and heating
- Passive solar design for heating
- Energy-efficient lighting using T-8 and compact fluorescent lights.

Because of the home s small cooling requirements, no cooling system is needed. Natural ventilation cools the home in the summer. An active solar water-heating system and wood-burning stove provide heating in the winter.

For more information:

DOE's Solar Buildings Program

www.eren.doe.gov/solar-buildings/sbm.html

For calculating savings from a solar hot water system at your house.

Colorado Solar Energy Industries Association

www.coseia.or
1.800.633.9764

Find a contractor or find out about cost and performance of specific systems.

DOE's Office of Building Technology, State and Community Programs

www.eren.doe.gov/buildings

A great source of information on energy efficiency and low-energy buildings.

Building America: Colorado

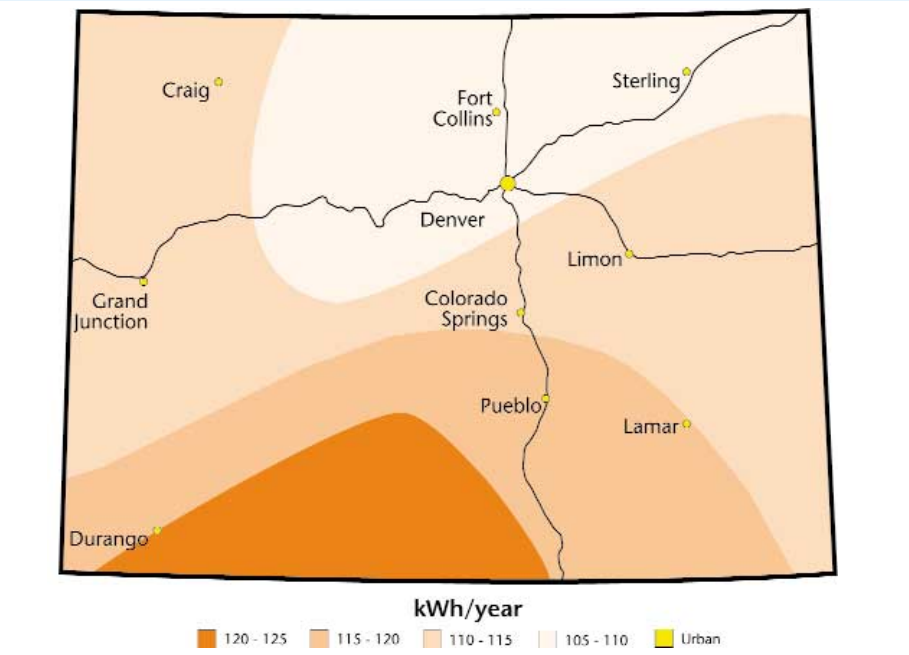
Wonderland Custom Builders is one Colorado home builder moving toward high performance housing. Wonderland participates in DOE's Building America program, which unites members of the building industry in an effort to produce higher quality, more energy-efficient homes. The primary goals of the program are to reduce energy use, construction time, and waste by as much as 50% without increasing costs. In addition to improving the quality and performance of today's homes, research conducted by Building America teams provides valuable information for homes of the future.

Wonderland Custom Builders has completed construction of its 3,500 sq.ft. house at its Broadlands development, which was featured in the 1999 Denver Parade of Homes. This prototype home includes several energy-efficient features: low-e windows; radiant floor heating; highly efficient furnace and water heater; and engineered wood wall framing. The house uses significantly fewer building resources to achieve energy savings of 20% to 50% over similar houses built to meet conventional standards.

This home in Golden has eight solar panels on its south-facing roof that provide heat for an 80-gallon domestic hot water tank and 400 gallons of water for home heating.

Dave Parsons, PIX - 05479

Solar Hot Water System Production Per Unit of Collector Rating



This map shows the thermal output of a solar hot water system in metric units based on a per-unit rating of the capacity of the solar panels (per thousand British thermal units per day [kBtu/d]). You can compare this output with that of a conventional electric water heater.

Solar water-heating systems have solar collectors that face the sun. The systems either heat the water directly or heat a working fluid that, in turn, heats the water. The solar-heated water moves by pumping (active) or by convection (passive) through a system of pipes that supply hot water and heat to a home. In most cases, your solar system will have a conventional gas or electric back-up system.

Using the sun to heat your water saves you money on your monthly utility bill. Because Colorado has a warm, sunny climate, we can tap the power of the sun to meet most of our hot water needs. Once the higher initial costs ($1,500-$3,000) of your solar water-heating system are recovered through lower utility bills, you'll save money for the remainder of the system's lifetime. When cost is included as part of a mortgage on a new home, solar water-heating systems can often increase a homeowner's monthly cash flow from the first day of ownership.

Take, for example, a solar hot water heater consisting of two solar panels with a combined system rating of 30 kBtu/day located in Pueblo.

The panels are mounted on a roof facing south and tilted toward the sky at the angle of the latitude. In Colorado's sunny climate, this would be sufficient to supply about 70% of the hot water needs of a family of four. The savings are:

System Rating	Yearly Output	Annual Savings Simple	Payback
30 kBtu/day	3,600 kWh thermal	$266	6 - 12 years

Geothermal Heat Pumps

Many parts of Colorado often experience seasonal weather extremes, from scorching heat in the summer to sub-zero temperatures in the winter. Yet a few feet below the Earth's surface, the ground remains at a relatively constant temperature. Because of these seasonal temperature extremes, Colorado is an excellent place for use of geothermal or ground-source heat pumps (GHPs).

A GHP system works by moving the heat from the earth (or a groundwater source) into your home in the winter, pulling the heat from the house and discharging it into the ground in the summer. Like a cave, the ground temperature is warmer than the air above it during the winter and cooler than the air in the summer. Heat pumps use underground piping loops, installed vertically or in horizontal trenches 100 to 400 feet below the surface.

While the initial purchase price of a heat pump is often higher than that of a comparable gas-fired furnace and central air-conditioning system, it consumes 25% to 75% less energy.

For more information:

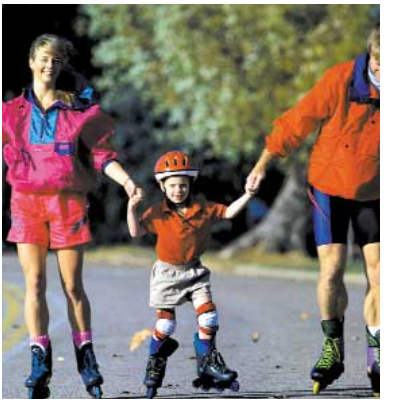
The Geothermal Heat Pump Consortium

www.ghpc.org,
1.800.255.4436

Provids extensive information on heat pumps.

This is because heat pumps deliver three times more energy in the form of heating and cooling to the home as they consume in electricity.

For example, a geothermal heat pump system costs roughly $7,500 for a 3-ton unit, a typical residential size. In comparison, conventional heating and cooling systems with a similar capacity would cost about $4,000 to $5,000. When included in the mortgage, however, the homeowner has a positive cash flow from the beginning because of the monthly savings on energy.



SELF GENERATION FOR RANCHERS AND FARMERS

Small solar and wind electric systems often make sense for Colorado farmers and ranchers. They are often the cheapest and most reliable way to provide water for irrigation and animals, power outbuildings, or secure fences. With the cost of conventional power line installation at as much as $10,000 per mile from a utility, an investment of $200 to $5,000 in a solar or wind power generator makes more sense.

Rick Hinricks, Boulder, Colorado

These ranch hands assembled John Buol s PV-powered water pump in just 20 minutes. When Buol moves his herd to another pasture, he takes his pump with him.

Portable PV Well Pump

Eastern Colorado ranchers, like John Buol, are always looking for better ways to get water to their thirsty livestock herds. When Buol wanted to lease a pasture near the Bonny Reservoir, he talked to a driller about using photovoltaics (PV) to pump water from an old well next to a fallen windmill. The driller, Wayne Parrish, had been working with PV-powered pumping systems for a while. Parrish put together a simple portable system with a 340-watt PV panel and a direct-current motor attached to a pump-jack all mounted on a trailer. The system's total cost was $5,000. According to Buol, "You just pull the trailer up to the well, tie it up to the pump rod, and pump the water.

PV Electric Fences

Don Curry believes electric fences are the best way to keep his cattle where he wants them. They are more efficient, cheaper, and safer than the 5-wire barbed fence commonly used by ranchers. But, they weren't always practical.

For more information:

National Renewable Energy Laboratory

www.nrel.gov/pv
call 303.275.4363.

To obtain a copy of Electricity When and Where You Need It: From the Sun—Photovoltaics for Farms and Ranches , January 1997, NREL/BR-412/21732.

Colorado Solar Energy Industries Association

www.coseia.org
1.800.633.9764

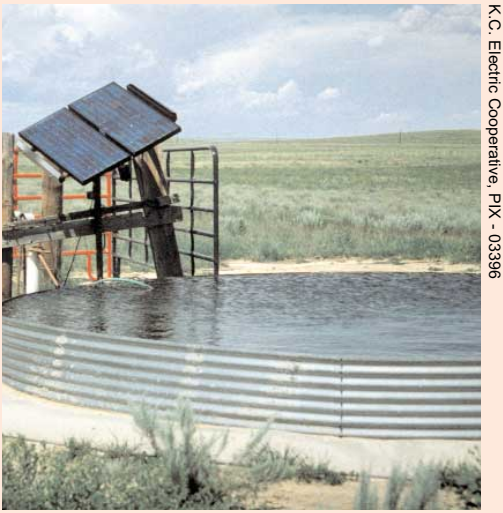
Provides information about equipment suppliers.

Tying the fences into the power grid was cost-prohibitive, and battery-operated fences don't last long enough on a large ranch. PV chargers seemed to be the way to go for Curry. "It just doesn't pay to keep changing batteries up there every other day or so," said Curry. "These solar chargers last all summer and longer. I've had three of them here for three years—same systems, same batteries." The 3-watt PV panels charge the 6-volt rechargeable gel-cell batteries for up to 21 days, and installation of the charger takes about three minutes, according to Curry.

Rural Electric Co-ops Profit from PV

After winter storms broke 645 poles on its electricity lines in 1988, K.C. Electric Cooperative in Hugo was looking for alternatives. K.C.'s 90 miles of lines to stock wells were costing them more in maintenance than they could recover from fees. The co-op decided it was time to consider using PV.

K.C. installed solar-electric systems that operate reliably and pump water for livestock the day after a winter storm or during the hot, calm days of summer. The co-op owns and maintains the systems, and charges customers a flat monthly fee, depending on the size of the system. Ranchers like the PV pumping systems because they can be located where they are needed, no matter how remote. They operate consistently.



K.C. Electric Cooperative, PIX - 03396

This portable PV system pumps 1.75 gallons per minute from a 60-foot well to fill a remote stock tank.

Small Wind Turbines

Colorado settlers in the 19th century used water-pumping windmills to bring water to thirsty farms and ranches. Today, windmills still serve this function. However, due to advances in technology, the wind is now being used to generate electricity as well.

Small wind turbines are relatively simple and hardy pieces of machinery. They consist of a turbine, blades, a tower, wiring, and associated electrical equipment. For remote homes and stand-alone operations, small wind turbines might use a battery for energy storage. Or for grid-tied systems, they will come with an inverter to interconnect with the utility.

Tower height is very important for wind turbines because wind speeds increase with height, and the available wind power increases exponentially with wind speed.

You can estimate what a small wind system will produce at a certain location if you know the average wind speed. A manufacturer will be able to tell you the output to expect from a particular turbine.

For more information:

DOE's Wind Energy Program

www.eren.doe.gov/wind/homeowner.html

Provides information on small wind energy systems for homeowners and ranchers, including sections on economics and wind energy basics.

Call **DOE** s **Energy Efficiency and Renewable Energy Clearinghouse (EREC)** at 1.800.363.3732 for a free short brochure on small wind systems.

American Wind Energy Association (AWEA)

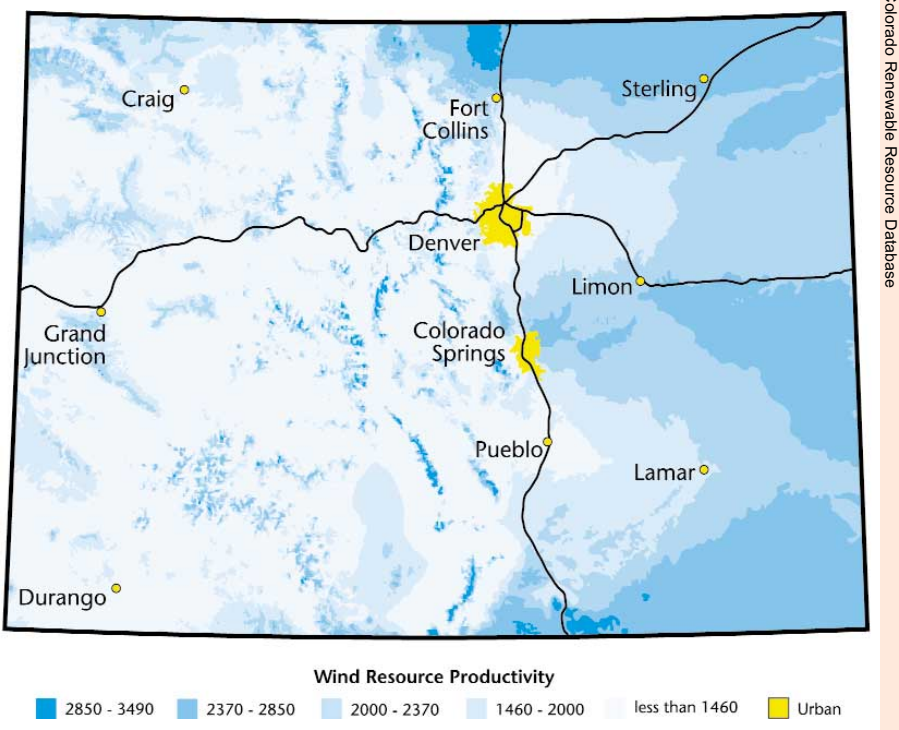
www.awea.org/smallwind.html
202.383.2500

For industry standards on equipment and a list of hardware suppliers. AWEA, also has numerous publications available, such as Wind Power for Home and Business , and an instructive titled, An Introduction to Residential Wind Systems .

Jim Green, NREL, PIX - 09074

This home in Boulder County obtains most of its electricity from a small wind rated at 3-kW and a PV system rated at 8.6 kW. The home has all electric appliances, including a geothermal heat pump for heating and cooling, a range, a washer and dryer, and even an electric car.

Yearly Electricity Production from a 1-kW Wind System in Colorado

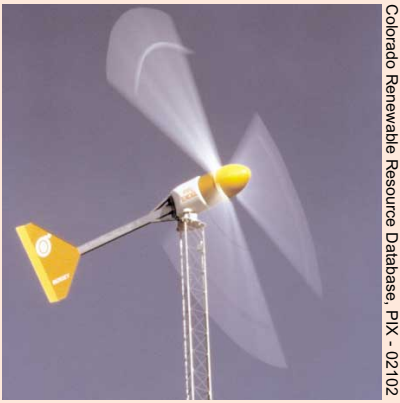


Colorado Renewable Resource Database

The map presents output for a 1-kW system; for systems of different sizes multiply the result by the rated capacity of the turbine. The following assumptions were used to estimate small wind turbine productivity: wind turbine tower height is assumed to be 82 feet (25 m). Wind turbine sites are assumed to be flat with good exposure to prevailing winds

Example

For a 10-kW wind turbine in Sterling, using the average retail cost of electricity in the state for residential customers of $0.074 per kWh:



Colorado Renewable Resource Database, PIX - 02102

This 10-kilowatt wind turbine designed to supply most of the electricity for an average electric home in areas with an average wind speed of 12 mph.

Rating	Expected Yearly Output	Yearly Savings	Typical Payback
10 kW	23,700- 28,500 kWh	$1,754-2,109	18-22 years

NEW

TRANSPORTATION OPTIONS

One of the most important environmental decisions we make as consumers is how we transport ourselves from place to place. Exhaust from cars and trucks on Colorado roadways is one of the leading sources of regional air pollution and the buildup of greenhouse gases in the atmosphere. Vehicle exhaust has grown steadily cleaner over the last 20 years, but the fact is, there are more vehicles on the road, and those vehicles drive more miles than ever before.

As individuals, we can lessen the environmental impact of our transportation choices through two approaches: reducing the miles we travel in our own vehicles, and making the miles we do travel as clean and efficient as possible.

How do we reduce our miles traveled when we need to get to work, run errands, or take our children to school and soccer?

We can take mass transit, walk, bike, carpool, move closer to work, or telecommute. These are familiar alternatives, but they're as important as ever before.

Clean Cities

It takes cooperation among many organizations to help clean up the air. The U.S. Department of Energy s Clean Cities program is bringing broad coalitions of state and local governments, car manufacturers, fuel suppliers, and nonprofit organizations to address the transportation sector s contribution to pollution.

Clean Cities encourages the use of Alternative Fuel Vehicles (AFVs) that run on cleaner fuels. These fuels include natural gas, ethanol, methanol, liquified natural gas, and even electricity.

Clean Cities

In Colorado, Clean Cities has three coalitions working for cleaner air located in:

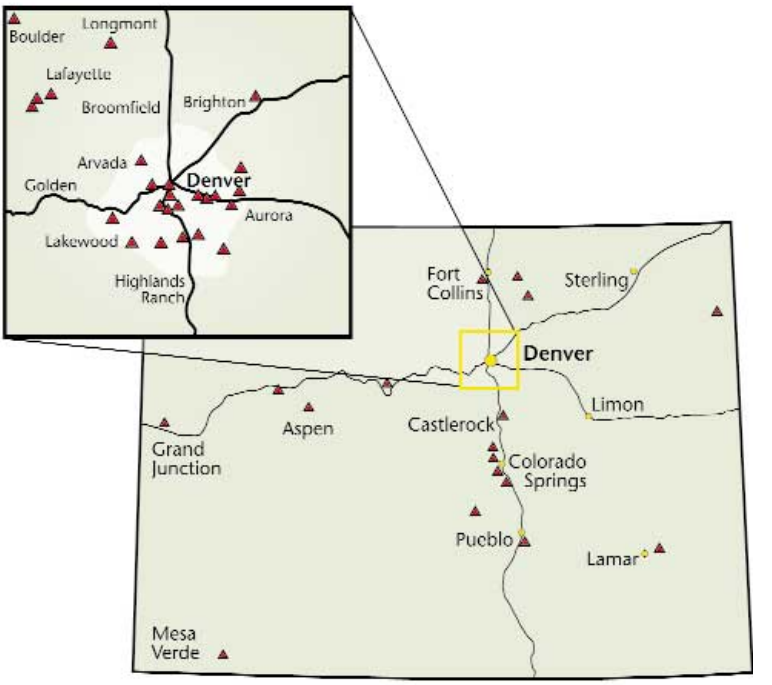
Denver

Colorado Springs

Weld and Larimer Counties and Rocky Mountain National Park

These coalitions are proving that AFVs are not concept cars of the future, they are available today and are being used by thousands of Coloradans.

Compressed Natural Gas Fueling Stations



Colorado s Clean Corridor

The Clean Cities participants in Colorado (Colorado Springs, Denver, Weld and Larimer Counties, and Rocky Mountain National Park) have teamed together to develop a 170-mile Clean Fuels Corridor that ensures ample alternative fuel stations from Colorado Springs to the Wyoming border. The goal is to give AFV drivers plenty of refueling options to make their trips as worry-free as they would be driving a gasoline-powered vehicle. There are 10 other Clean Cities corridors across the country where consumers with AFVs can drive with confidence.

AFVs need special fueling stations, and there are many already in service in Colorado and across the country. In Colorado alone, there are nearly 150 alternative fuel stations. Your local gas station may even sell alternative fuels. Most of the stations in Colorado provide compressed natural gas and propane, but there are a few ethanol and liquid natural gas stations as well. AFVs are the right environmental and economic choice for fleets and general consumers.

Denver's 16th Street Mall

The 16th Street Mall in downtown Denver operates hybrid electric buses to transport business professionals, shoppers, and tourists from one side of the mall to the other. These fuel-efficient buses have been operational since mid-1999 and have proven so effective that another 36 are on order. They are fueled with gasoline,

Warren Gretz, NREL, PIX - 06125

Hybrid electric buses transport hundreds of people each day in Denver's downtown mall. Denver currently operates two hybrid electric busses running on compressed natural gas and has plans to purchase an additional 34 in the future.

but use a battery pack that helps with acceleration.

Rocky Mountain National Park

Poor air quality is not just a city issue. It also affects national parks and other rural areas. Rocky Mountain National Park is dedicated to using AFVs to help reduce air pollution and noise in certain areas. The park, a Clean Cities participant, currently has several compressed natural gas vehicles and electric pick-up trucks in operation. In addition, the park is trying to replace gas guzzling, polluting, and noisy snowmobile engines with those that can run on alternative fuels.

Renewable Fuels

To ensure there is no air in their beer, Coors Brewing Company overfills each can it produces at its facility in Golden. This results in 22 million gallons per year of wasted 7%-alcohol condensate. Coors has joined forces with Merrick & Company and Total Petroleum to recycle the condensate to produce more than 1.5 million gallons of 100% fuel-grade ethanol.

Total Petroleum uses the ethanol as an oxygenate to make cleaner-burning gasoline, which is distributed along Colorado s Front Range. Colorado law requires gasoline stations to sell oxygenated fuel during the winter to combat carbon monoxide pollution. Ethanol oxygenates are the second largest use of renewable energy in the state. Ethanol is a cleaner fuel than gasoline and does not cause problems to car engines.

New Cars

In early 2000, Honda's Insight became the first hybrid electric vehicle (HEV) available in Colorado. Toyota will soon follow suit when it introduces its Prius HEV. An HEV runs on both fuel and electricity. It uses a small internal combustion engine or fuel cell in combination with a small battery pack to assist with acceleration and hill climbing. With this setup, HEVs can achieve 70 to 80 miles per gallon of gasoline.

In the near future, Daimler/Chrysler, Ford, General Motors, and others

will introduce hybrids of their own. These cars are harbingers of a leap in automobile technology on its way that will provide many clean transportation options to Colorado consumers.

Denver officials are following Boulder's example by using electric vehicles for city business. Boulder incorporated electric vehicles (EVs) into its city fleet in 1998. Denver developed the "Take Charge" program in 1999 to include three EV's in its automobile fleet. These small neighborhood EVs look like bubble-shaped golf-carts.

"The city has a commitment to lead by example as it relates to alternative fuels," said Denver Mayor Wellington Webb. "This demonstration project will help us to determine the feasibility of EVs and also educate the public about this exciting technology." The neighborhood EVs carry two people, reach top speeds of 25 miles-per-hour, and are equipped with global positioning systems. They have a 40-mile capacity between charges and will be limited to traveling the streets in downtown Denver.

For more information:

DOE Alternative Fuel Vehicles Buyers Guide

www.fleets.doe.gov

For information on Colorado incentives and laws, select "incentives," then "laws," and then search for "Colorado."

DOE's Alternative Fuels Data Center

www.afdc.doe.gov

Lists the locations of fuel stations on maps with real-time data. You can search for a fuel type based on your zip code, city, or state. You can also zoom-in for more detail and find the address, phone, and other information about the fuel station.

DOE's Clean Cities Program

www.ccities.doe.gov
1.800.C.CITIES (334.8437)

For information on market-based approaches to adopting alternative fuels and vehicles.

Eric Manuel

The owner of this car, and one of the first individuals in Colorado to buy a hybrid-electric vehicle, Kevin Eber, shows off his new Honda Insight to coworkers at the National Renewable Energy Laboratory in Spring 2000.

CHOOSING WISELY

At the beginning of the new millennium, Coloradans have the opportunity to create a place for clean energy in our future. "Colorado has one of the best renewable energy resource bases in the nation," said Kristin Shewfelt of McStain Enterprises, a Boulder-based home builder and partner in DOE's Building America Program. "Our state's leadership in these cutting-edge technologies of the future will help maintain both economic prosperity and environmental quality."

McStain is a member of the newly formed Colorado Coalition for New Energy Technologies, consisting of 15 businesses and non-profit organizations supporting environmentally responsible economic growth through the efficient use of Colorado's abundant and clean sources of energy. Shewfelt applauds the formation in of a nonpartisan Renewable Energy and Energy Efficiency Caucus in the state legislature in March 2000.

As citizens, we can support these businesses and organizations, incorporate clean energy practices and products into our lives, and make clean energy our energy of choice.

For more information:

Energy Efficiency and Renewable Energy Clearinghouse (EREC)

1.800.363.3732
P.O. Box 3048
Merrifield, VA 22116

EREC is the U.S. Department of Energy's (DOE's) source for information and publications on renewable energy and energy efficiency.

Energy Efficiency and Renewable Energy Network (EREN)

www.eren.doe.gov

EREN is the primary Web site of the DOE's Office of Energy Efficiency and Renewable Energy. Through this site you can access the Consumer Energy Information site, *www.eren.doe.gov/consumerinfo/* for how to put renewable energy to work in your daily life.

The Governor's Office of Energy Management and Conservation (OEMC)

www.state.co.us/oemc
1.800.632.6662

OEMC is the lead agency on energy efficiency issues in the state.

Available for a processing fee to U.S. Department of Energy
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DOE Office of Scientific and Technical Information
865.576.8401
e-mail: reports@adonis.osti.gov
www.doe.gov/bridge

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COLORADO'S Clean Energy CHOICES

was printed courtesy of:

PUBLIC SERVICE COMPANY OF COLORADO℠

Public Service Company of Colorado
1225 17th Street
Denver, Colorado 80202
www.ncenergies.com

Clean Cities

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www.ccities.doe.gov

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www.state.co.us/oemc

Produced for the
U.S. Department of Energy (DOE)
by the National Renewable Energy Laboratory,
a DOE national laboratory

NREL/BR-810-27846
April 2000

Printed on paper containing at least 50% waste paper, including 10% postconsumer waste