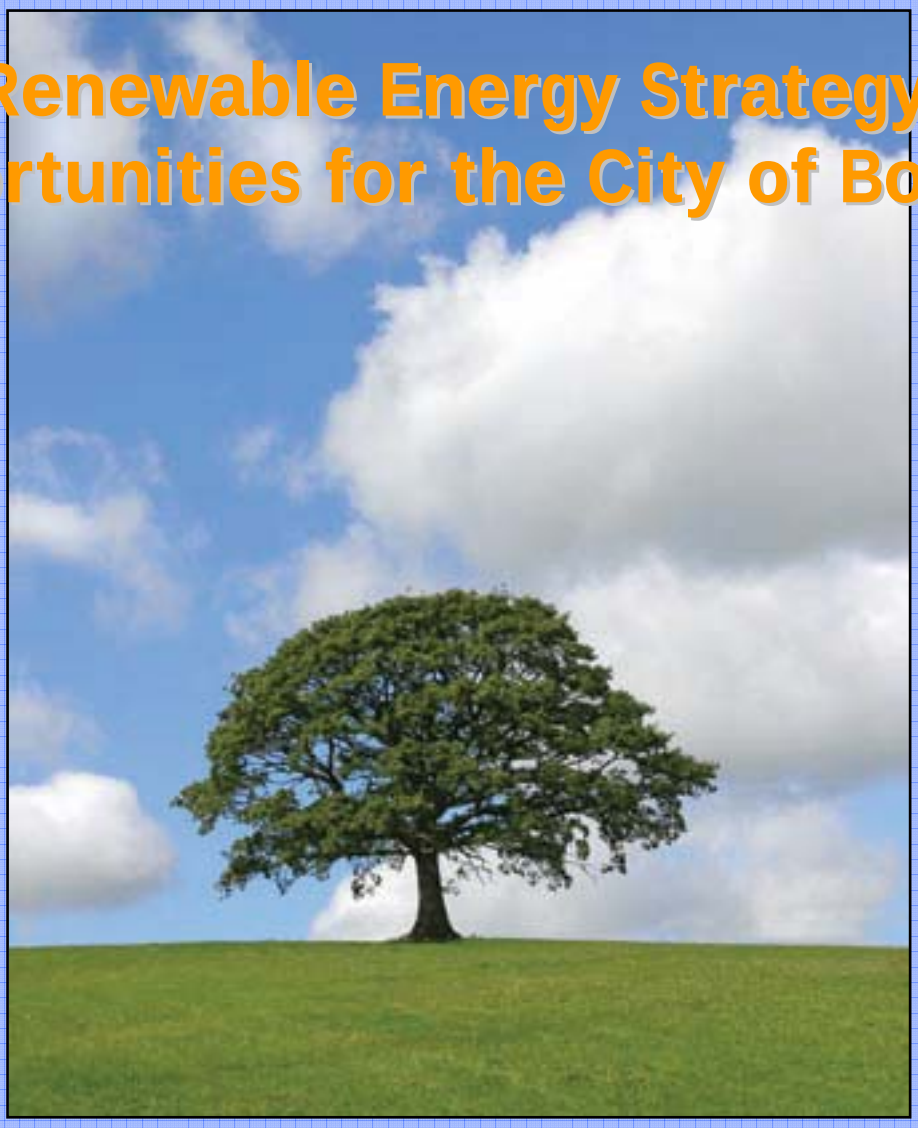
Renewable Energy Strategy: Opportunities for the City of Boulder



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Worldwide electricity consumption is projected to double by the year 2040. This demand represents an unprecedented opportunity for building clean, renewable power generation.

Introduction

Over time, the city of Boulder has continued to explore options to reduce its impact on the local and regional environment, from initiatives that support a strong community, as well as those that enhance environmental, social and economic sustainability. The city is preparing to move aggressively towards a path that supports the development and inclusion of renewable energy sources which produce electricity with no direct global climate-changing greenhouse gas emissions or regional air pollution that comes from burning fossil fuels such as coal and natural gas. Renewable energy technologies also produce regional jobs while limiting the importation of energy from other nations.

Just over 33 percent of greenhouse gases produced in the United States came from electricity production in 2004, making it the leading category of such emissions over other areas such as transportation (27.9 percent), industry (19.6 percent) and agriculture (7 percent). In Boulder, the percentages are even higher, with 51 percent of our local greenhouse gasses coming from electricity consumption.

To this point, the city has not included renewable options at its facilities in a significant way, with only 3% of the city's current energy needs coming from renewable sources (based on 2008 data). The leading cities in renewable energy could have an advantage in any upcoming federal or state regulations aimed at regulating or eliminating greenhouse gas emissions or developing renewable energy standards. If the greenhouse gases that cause climate change get priced, cities with strong renewable energy programs could save a lot of money in the long run and their economies could gain a tax advantage.

As an example, Oakland, California led the nation with 17 percent of its electricity being produced by energy sources such as solar, wind and geothermal energy. Oakland gets some of its wind energy power from one of the largest wind power generating facilities in the nation at nearby Altamont Pass.

San Francisco, Sacramento and San Jose tied for second with 12 percent of their electricity coming from renewable energy sources. California cities rank high in general

because of the state's Renewable Portfolio Standard, which set minimal requirements in 2004 for utility purchases of renewable energy for the state's electric grid. That standard requires a 20 percent renewable energy total for the state's utilities by 2020. Here in Colorado, we also have a 20 percent renewable energy total for the states' utilities by 2020, however, the city of Boulder has a unique opportunity to exceed that requirement.

Some U.S. cities have also set goals for increasing renewable energy ranging from Chicago's 20 percent goal by 2010, to Portland, Oregon's goal of obtaining 100 percent renewable energy by 2010. Here in Boulder, we are fortunate to have access to a variety of renewable resources from solar and wind to hydroelectric capacity. The city manager has made a strong commitment to move the city organization to 100 percent renewable energy by 2018.

The following strategy outlines a conservative path for the city organization to achieve this goal. It is believed that the goal of 100% renewable power could be achieved much more rapidly as new technologies and opportunities arise. The strategy below outlines a pragmatic and conservative approach to meeting the 2018 goal.

The city's interest in pursuing renewable energy opportunities reflects:

1. **A commitment to achieving the goals of reducing Greenhouse Gas emissions,**
2. **A desire to showcase the effective use of renewable energy practices, and**
3. **The efficient use of taxpayer dollars by utilizing rebates and other financial opportunities to help finance renewable energy.**

Climate Change

Fossil fuels emit into the atmosphere large amounts of carbon dioxide and methane — the two major "greenhouse gases." As these gases accumulate, they act as a blanket, keeping heat in our atmosphere and oceans, leading to potentially catastrophic consequences for our planet and everyone living on it. We have already been witnessing the effects of increased greenhouse gases for decades. In the last century, global temperatures have risen an average of about 1.3° F, and twice that in polar zones.

This may not seem like a large increase, but on a global basis, this increase is incredibly fast.

As greenhouse gases continue to accumulate, we may see more "freak" weather conditions here in Boulder, including longer and more severe heat waves, increased disease, stronger storms, megastorms, more frequent and severe floods and

droughts. And the effects don't stop anytime soon. As the Intergovernmental Panel of Climate Change's recent report confirmed, climate effects will continue for centuries even if we all stopped emitting greenhouse gases today. Scientists overwhelmingly agree that we are already witnessing rapid climate change due to human related greenhouse gas emissions. For example, a survey of peer-reviewed articles on climate change found that, of the 928 articles reviewed, 928 agreed with the view that most of the warming we've witnessed in the last 50 years has been caused by human activities.

The end of easily recoverable oil and gas

The phrase *peak oil* refers to the high point of global oil production. Once this point is reached, the oil that remains in the ground becomes more difficult and less cost-effective to extract, hence oil prices climb. According to the Energy Information Administration, conventional oil production peaked in May 2005. We won't know for some time if this is an all-time peak, but the recent rapid decline in production from many large fields -- such as the North Sea region, Kuwait's Burgan oil field and Mexico's Cantarell oil field (25 percent in 2006 alone) -- suggests it may be. The question now is: Can unconventional oil and biofuels come online fast enough to make up for diminishing conventional oil production?

In any case, the debate is no longer about *if* we will hit a global peak for all oil production, but *when.* When we do, we can expect prices to climb well above the high of $100 a barrel, dramatically impacting the city's ability to provide essential municipal services.

Moving away from fossil fuels should be one our region's and our nation's top environmental and economic priority, which has been clearly outlined in the Climate Action Plan (CAP). Simply put, we can no longer afford to rely on fossil fuels — oil, coal, and gas — for most of our energy. The key problems stemming from our reliance on fossil fuels, as discussed in the Preface, are climate change, oil and gas depletion ("peak oil"), national security issues arising from having to import foreign oil, and air pollution.
It is imperative that we quickly progress and actively pursue a renewable energy economy, and use the remaining recoverable fossil fuels to help make that transition. We should focus vigorously on the cost-effective energy efficiency and renewable energy technologies available today, at the same time doing whatever is possible to ensure that other promising renewable energy technologies quickly become more cost-effective.

In Boulder, we have a strong commitment through various strategies such as the CAP, Transportation Master Plan (TMP) and Boulder Valley Comprehensive Plan that work to reduce our dependence on fossil fuels. In the past, we faced a public formerly unaware of the serious problems caused by our dependence on fossil fuels. Now, many people realize that our unsustainable energy use is at the root of many of our most pressing problems. The climate change and national security implications of our energy use, in particular, have been prominent in news reports and commentary both locally and globally. Now that these issues are front and center in the minds of many Boulder residents and Americans, what's next?

This renewable Energy strategy presents a "next step" for the City of Boulder. If these recommendations are implemented, we will be well on our way to doing our part to solve the

many problems stemming from our use of fossil fuels. The good news is that we'll save a lot of money doing it, as described in detail below. The following scenario illustrates a diverse renewable portfolio for the city organization. In order to take advantage of local renewable resources, and to follow the "85/15" strategy for city investment, in which the city will take advantage of 85 percent renewable options that prioritize the "least cost per watt" element, while 15 percent will focus on a public education and include the potential to showcase the city's commitment. In addition to existing incentives, the plan extrapolates each of four types of renewable energy, that when combined, can easily replace the city's current electricity demand.

It is important to note, that the percentages represented below show a "snapshot" of the intended source once the 100% has been achieved. Many of the sources, such as large scale wind and solar systems, will require several years for implementation, as the resources (turbines) do not exist currently, and the implementation will require negotiation with Xcel for the transmission of such power, as well as the approval by the Colorado Public Utilities Commission (PUC).

Fossil fuels have played a pivotal role in the evolution of the City of Boulder– but are also the root cause of many of the most dire problems we face. Not only does the city's current energy use affect the ability to mitigate emissions related to climate change, but the city 's Blue Ribbon Commission on Revenue Stabilization identified facility energy costs as a critical deficiency that adds to a growing gap between revenue and expenditures. While many municipalities are working to address this instability by offsetting utility consumption through renewables, very few have committed to actual investment strategies.

Energy Facts and Figures

- A kilowatt (kW) is a unit of power – or the ability to deliver energy over time. A 3 kW solar photovoltaic installation, for example, will provide much of the power needed for a typical home.
- A kilowatt hour (kWh) is a unit of energy and is enough electricity to run 10 100-watt light bulbs for an hour
- A gigawatt hour (GWh) is one million kilowatt hours
- One kWh is equivalent to 0.03 gallons of automobile gasoline
- Conversely, one gallon of gas is equal to 36.6 kWh

Traditional energy sources, like coal, oil and natural gas currently provide over 95% of the energy the city organization uses. The city of Boulder currently uses 3% renewable energy in its municipal operations. Renewable energy comes from sources that can be replenished in a short period of time like solar, wind, biomass or hydroelectric. There are a number of advantages to using renewable energy sources:

- Energy costs for Boulder's municipal operations have risen in the last 4 years, from $ 1.5 million in FY04 to $2.2 million in FY07; a 19% increase. When taken alone, electricity costs have more than doubled from $703,955 in 2004 to $1.6 million in 2007; a 56% increase. Renewable energy sources like wind and solar offer the

ability to enter into long-term fixed-rate contracts to help stabilize future municipal energy costs.

- Money spent on renewable energy sources often stays in the local economy.
- Renewable energy sources produce less air pollution than fossil fuel based energy and contribute to making our air cleaner and meeting EPA clean air standards.
- Renewable energy sources greatly reduce global warming emissions.
- Increasing reliance on foreign oil threatens our national security and economy.
- Renewable fuels reduce our reliance on imported oil.

Opportunities in reducing our fossil fuel dependence

Staff has been exploring available technologies for energy efficiency and renewable energy use in municipal operations in order to increase the city's use of renewable energy sources. The purpose of this evolution is twofold: to minimize the instability of rising energy costs, and to minimize the city organizations greenhouse gas emissions. At the 2008 City Council retreat, the City Manager declared his intention to move the organization towards future energy independence, and further set a course to have the city organization, equipment and facilities become 100% energy independent over the next ten years. This will also result in a significant increase in the Boulder community's overall renewable portfolio over the next ten years (including negotiating maximum capacity for renewable sources within the Xcel Franchise Agreement; potentially locating a renewable facility within the city).

In order to reach a goal of 100% renewable energy for all municipal operations by 2018 with an associated reduction in community greenhouse gasses, staff has been evaluating options to purchase or produce long-term, fixed-rate "green" electricity from various renewable sources such as facility based, or "on-site" renewables such as solar PV or wind power constructed in Colorado and to provide recommendations on moving forward with green electricity purchase. The purpose of this strategy is to explore the technological options, financing abilities and viability of various renewable energy options.

The Plan in Brief

A dramatic shift away from fossil fuels can only happen if the city actively pursues the following strategies:

Energy efficiency and conservation- The city must aggressively increase our energy efficiency by 30-50 percent in our buildings, which constitutes the majority of our current and projected energy demand.

Energy replacement options- The city will need to produce and purchase large amounts of renewable electricity such as solar and wind in or near our region.

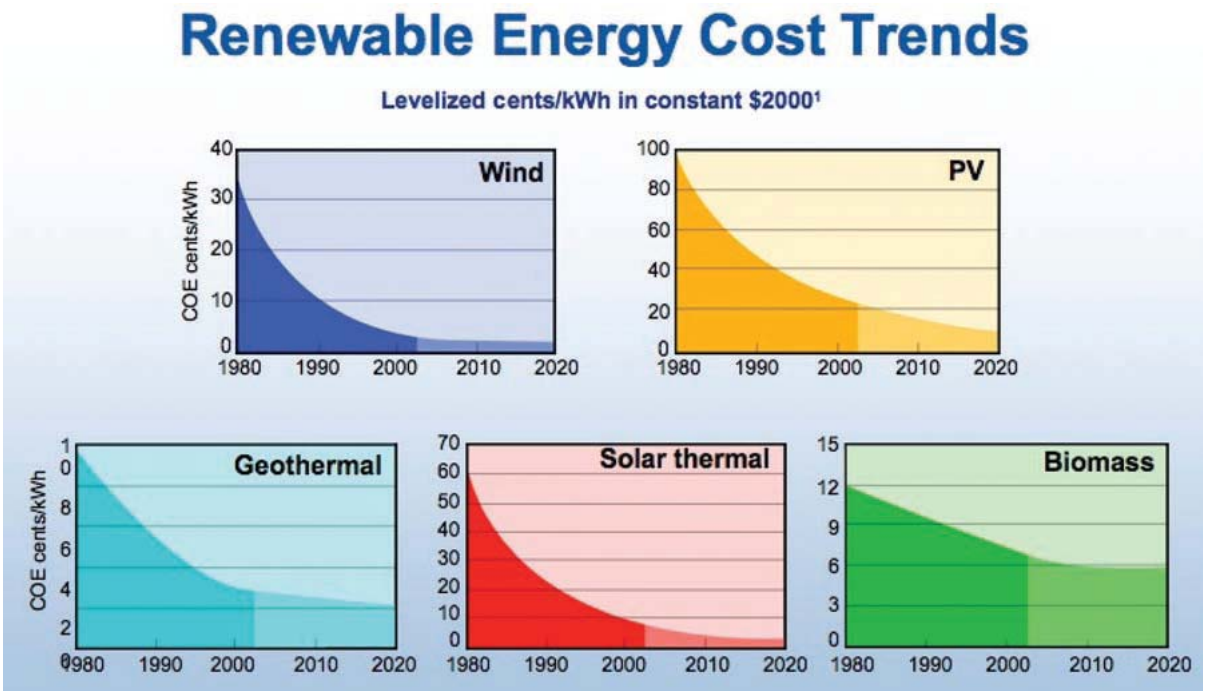
Next generation vehicles- With the implementation of the *Smart Grid* technology, the city can transition to more efficient vehicles and vehicle fuels, such as plug in hybrid vehicles, electric only vehicles and vehicle to grid technology, and potentially hydrogen fuel cell or hydrogen internal combustion engine vehicles, once they are more readily available and affordable in three to five years.

Staff will continue to evaluate and also consider any other technologies and partnerships to help reach established renewable energy goals. The plan is a wide-ranging collaborative, including the collaboration of various entities such as the Governor's Energy Office (GEO), major renewable energy research institutions, Boulder County, CU, and numerous not- for-profit organizations.

Financial Analysis

What will it cost? This is probably the most important question in this strategy. There are, of course, many different ways of measuring cost -- right now we pay for our fossil fuels not just in dollars paid for our utility bills, but in the air we breathe and the water we drink, in our national security and, most importantly, in our ability to sustain ourselves on this planet. The good news is, however, that even when you exclude these other costs and boil it down to strict traditional economics, the city will actually be in much *better* financial shape by adopting renewable technologies than continuing to burn fossil fuels. A renewable strategy for the city is organized to highlight the most cost-effective solutions first, starting with energy efficiency in buildings, then the lowest cost per watt renewable options such as wind power and solar power.

As the demand for fossil fuels from developing nations increases, fossil fuel supplies diminish and the ability to find affordable fossil fuel resources becomes more difficult, costs will continue to rise. It is necessary to reduce our reliance on fossil fuels and begin a transition to renewable energy sources. Fortunately, the cost for renewable energy sources has seen a dramatic decline over recent years.



Staffs analysis found that the City of Boulder will in fact save substantially by switching to renewable energy. Due to projections from Xcel Energy, fossil fuel prices in our region and elsewhere will continue to trend upward at a rate of 4-7% annually. Energy efficiency and renewable energy could potentially save the city $15.4 million by 2020[1]. So the city could make a strong argument to make the renewable switch purely on economic reasons.

By committing to a goal of 30% renewable energy for municipal operations by 2010, the City of Boulder will once again "lead by example" to help the Boulder community begin this necessary transition. By committing to a goal of 100% renewable energy by 2018 for the city organization, City staff can begin to develop the relationships with renewable power providers, and blend the goal into the ongoing Franchise discussions with Xcel. By committing to these renewable energy goals, greenhouse gas emissions should be greatly reduced.

In order to finance future renewable projects, municipalities are faced with unique challenges. Because the city is a tax exempt agency, we are unable to take advantage of tax credits to bring the cost of the project down. These include the Federal Investment Tax credits and accelerated depreciation, both offering substantial incentives for renewable projects. Additionally, high capital expense creates a barrier for self funding. For these reasons, there are several creative options for financing municipal renewable projects:

[1] Savings assumes 7% annual growth on both electricity and natural gas costs. Savings was also determined assuming leveling of costs in 2008 through efficiency and renewable projects resulting in a 0% growth.

Self-Fund Approach- this would require annual budgeting and heavy capital expenses to implement renewable projects. Additionally, the city would assume the liability, replacement cost and maintenance for the life time of the project.

Existing Bonding- The city could choose to issue a municipal bond for large scale renewables, which would require voter approval.

Clean Renewable Energy Bond-The Energy Policy Act of 2005 provides electric cooperatives and municipalities with Clean Renewable Energy Bonds. A "CREB" is a special type of tax credit bond providing municipalities the equivalent of an interest-free loan for financing qualified energy projects. CREBs are largely modeled on the Qualified Zone Academy Bond program that provides tax credit bonds for school renovation and upgrades in certain qualified school districts. They deliver an incentive comparable to the production tax credit that is available to private renewable energy project developers and investor-owned utilities, which the city is unable to take.

Third Party Financing- Third-party financing for renewable power projects can make the high upfront cost of installation, the major obstacle to the city, much more achievable. For the renewable energy market at large, third-party finance directs large amounts of capital into what is currently a relatively fragmented, inefficient marketplace. In the third party scenario, the city partners with an investment/operator through a Power Purchase Agreement (PPA) for the sale and purchase of the generated power. This type of arrangement places much of the risk (capital investment, replacement cost, maintenance, production) on the third party rather than the city. This is the model utilized for the 75th Waste Waster Treatment Facility one megawatt solar PV project, scheduled to begin construction early April, 2008. This model allows the third party investor to take advantage of the tax credits and accelerated depreciation.

In order to most quickly and efficiently achieve energy independence for the city organization, it is staff's recommendation that we consider "financing suites", or efforts to combine several of the above strategies. This diversification has proven most successful for large organizations implementing renewable projects.

While increased energy efficiency and conservation could substantially cut our current demand for energy, they are not by themselves enough to wean us from fossil fuels. To truly address the supply side of the equation, we will need to generate with renewable sources instead of the natural gas and coal that are primarily used to generate Boulder's electricity today.

The steady sunshine and proximity to other attributes that make our region so attractive to live in also make it ripe for energy independence. Renewable energy technologies that harness power from the wind, sun and hydroelectric can contribute to regional electricity supplies, and they won't run out. But while the State is showing leadership in the area of renewable electricity, to truly generate the amount of energy we will need in this region, this effort must come from within our county. In 2006, only about 3 percent of the power from Colorado's electricity grid came from renewable sources: wind and solar, and a small amount

of hydroelectric. This hasn't changed much in 2007, however, Xcel has committed to increasing their renewable portfolio in their 2007 Least Cost Resource Plan.

The renewable component on the Colorado grid is expected to increase substantially in the coming decades, as State law requires that utilities generate 20 percent of their electricity from renewables by 2020. But with electricity comprising roughly 98% percent (excluding vehicle fuel) of the city's overall energy needs, renewable electricity will, in a business-as-usual scenario, constitute only about 5 percent of our total energy needs which would be met with renewable electricity from the utilities. Our current solar projects scheduled for installation in 2008, when added to the city's existing renewables and wind power purchases, will result in a 5.7% overall renewable component by the end of 2008.

In order to continue to move towards energy independence, we need to find other ways to encourage the use and development of renewable electricity above and beyond what state law requires. Wind power offers the most potential today of any renewable energy technology in our region because of its relatively low cost. Other types of renewable electricity — such as the various types of solar power, technologies that convert biomass or waste to energy, and hydroelectric power — are also very promising.

Promoting renewable energy in our region at such a level will require substantial help from local, state, and federal agencies. Fortunately, Smart Grid technology allows for future renewable expansion. For this reason, Xcel will be a key partner for weaning the city off fossil fuels. Further, unlike States that allow "Community Choice" laws, which gives local governments — not the private utilities control over what type of electricity to use, The city's current Xcel Franchise Agreement requires that large scale renewable energy be provided through Xcel. A key strategy of the future Franchise negotiations will be to allow Boulder to have more choice over the type of power we receive.

The following strategy attempts to balance opportunities for future renewable projects with cost implications as well as a public awareness aspect. In other words, the recommended option is based on approximately 85% of the city's future renewable power coming from "least cost per watt" projects, while the remaining 15%, while potentially slightly higher in cost, will take in to account visibility, showcase opportunities and demonstrated commitment by the city.

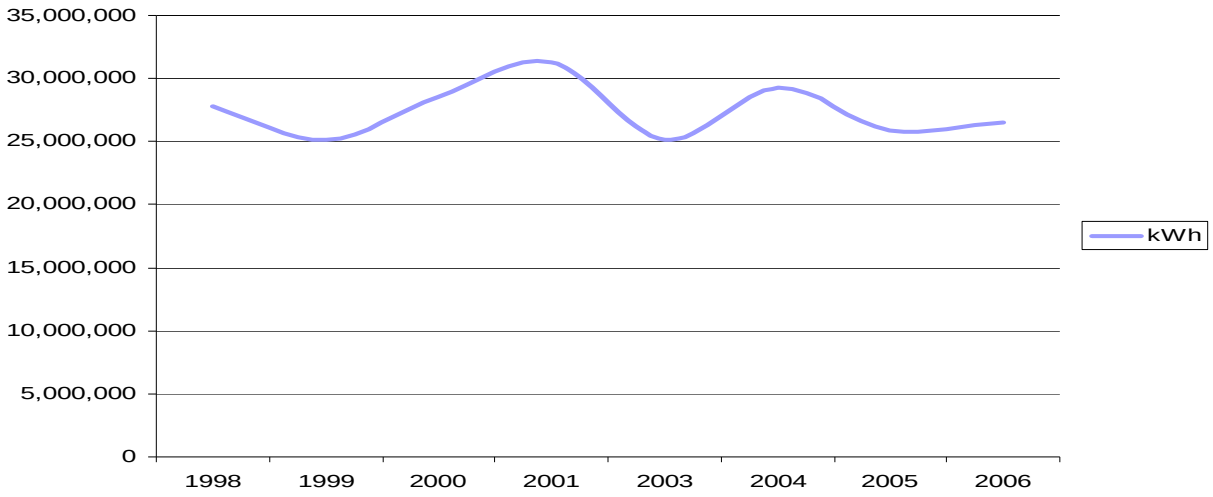
In tackling the ambitious goal of weaning our city from fossil fuels, we first need to recognize the magnitude of the task. In 2006 for example, the city used 26.4 million kWh (or 26,000 MWh) of electricity and 726,679 therms of natural gas of electricity2 (see Fig.1)

Figure 1: City of Boulder Energy Use

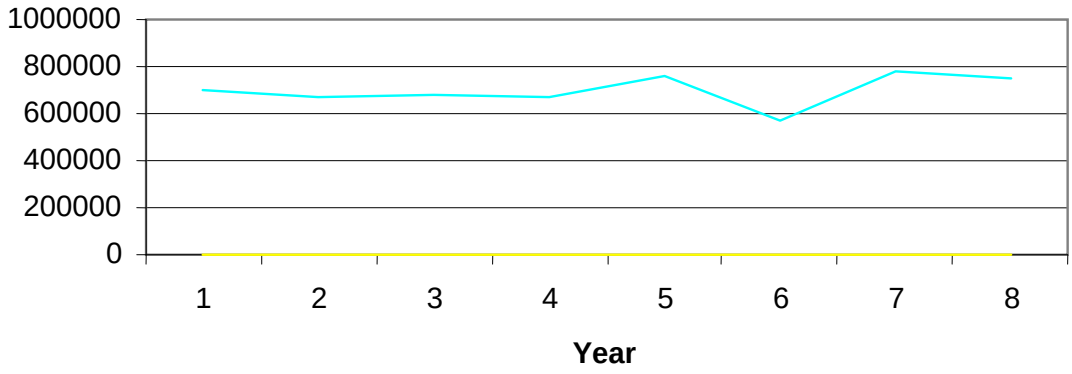
	1998	1999	2000	2001	2003	2004	2005	2006
kWh	27,810,662	25,174,357	28,542,567	31,310,888	25,088,913	29,264,861	25,905,343	26,467,078

Therms	702,634	671,696	684,031	666,857	763,573	567,391	784,809	746,679

Graph 1 (A): City of Boulder energy use (electricity) 1998-2006



Graph 1 (B): City of Boulder energy use (natural gas) 1998-2006



As can be seen by the above graphs, in order to replace 100% of the city's annual consumption, the city will need to install or purchase approximately 18 MW of power.[2] The

[2] The estimate of 18 MW assumes replacement of city electricity consumption, excluding natural gas and vehicle fuel.

following statistics on City energy use suggests a number of measures that, if implemented, could lead to 100% energy replacement or independence, by 2018. In order to make appropriate decisions on a future strategy, the following resource evaluation is presented.

While many utilities offer their customers green energy from one or two sources, the city should strongly implement diversification and the creation of Renewable Portfolio that properly evaluates all reliability, cost, and market issues to ensure an effective implementation. For example, a potential biomass renewable project has the potential to offer a steady supply of renewable energy twenty-four hours a day and during peak conditions. Biomass projects offer greater system reliability benefits than other intermittent renewable resources. However, adequate and reliable fuel supply sources are the single most critical factor in determining the economic viability of a potential biomass project, and associated price risks and may prohibit such projects from being developed. The result may be an overdependence on any one renewable source, contrary to the goal to increase supply diversity. The City should maintain its current flexibility in the purchase and development of its renewable resources. As mentioned earlier, due to the higher cost nature of renewable projects, it is necessary to consider longer-term contracts to finance projects going forward.

Energy costs

Rather than wait until the city is negatively impacted by anticipated rising energy costs, this strategy allows the city to take steps now to manage our energy costs and identify actions that will reduce energy use. Staff undertook a utility bill analysis to determine how the city is spending our energy dollars. Based on the analysis, the city's energy costs have seen a dramatic increase over the past several years.

As mentioned earlier, Staffs analysis found projections from Xcel Energy show fossil fuel prices in our region and elsewhere will continue to trend upward at a rate of 4-7% annually. In 2006, for example, Facilities Maintenance and Xcel recommended a 6% increase for budgeting purposes. If this trajectory continues over time, the city could expect to see a more than doubling of the city's utility costs from $1.8 million in 2007 to $4.3 million in 2020. In this scenario, Energy efficiency and renewable energy could potentially save the city $15.4 million by 2020[3].

However, the utility bill analysis below is more than a 'snapshot' of current and future energy costs. A renewable strategy paired with strong efficiency measures in city facilities is recommended steps we can take to minimize cost increases. The graph below illustrates the unsustainable nature of growing energy costs over the past several years. While electricity costs have continued to grow, as well as the city's total energy costs overall, Natural Gas costs have remained relatively stable, and even saw a slight decrease in recent years. An announcement by Xcel in mid March 2008, however, suggests that this could be changing dramatically.

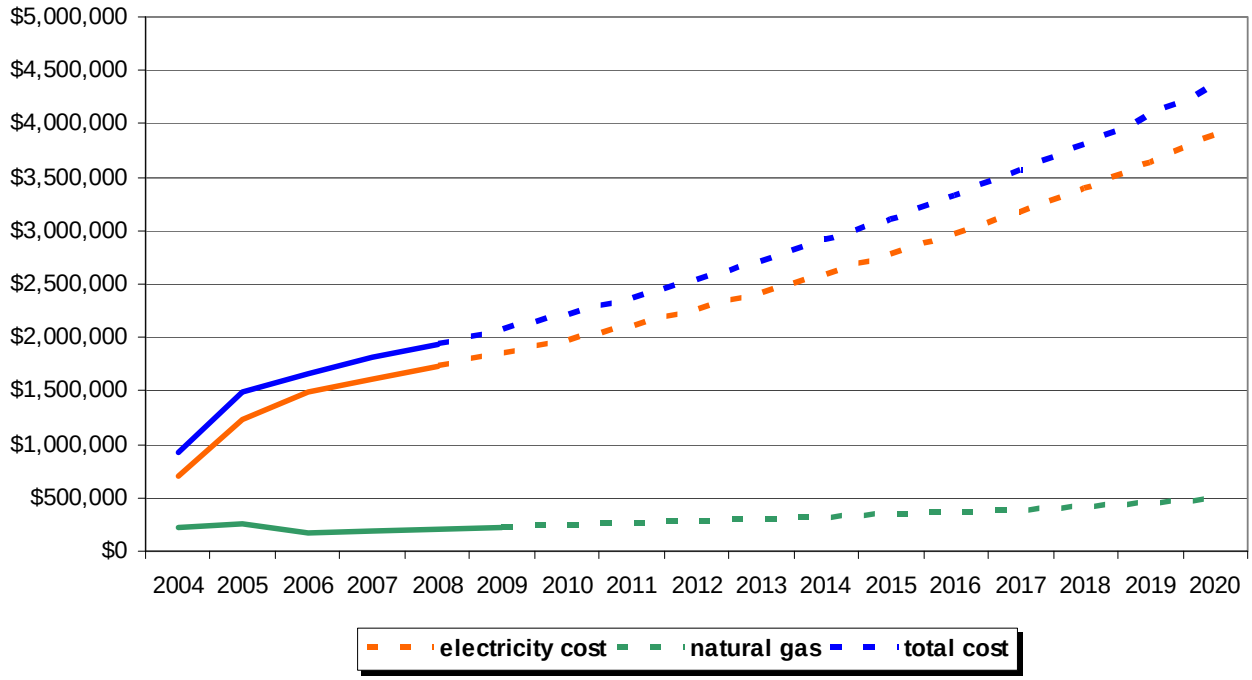
The Rockies Express pipeline opened in January and started carrying natural gas out of the region. Local wholesale natural gas prices will be increasing significantly, according to

[3] Savings assumes 7% annual growth on both electricity and natural gas costs. Savings was also determined assuming leveling of costs in 2008 through efficiency and renewable projects resulting in a 0% growth.

Xcel. Over the last several years we've enjoyed an extended period where local prices were lower than the national average, but the opening of the pipeline has virtually eliminated that advantage. As a result, Colorado is experiencing higher costs for generation fuel and purchased energy, which will translate into a higher Electric Commodity Adjustment (ECA) in 2008, which is a filing by Xcel with the Colorado Public Utilities Commission (CPUC) to recover dollars associated with rising generation fuel and purchased energy costs. Xcel Energy is required by tariff to file adjustments to its ECA whenever its costs are $40 million greater or less than the funds collected under its Electricity Cost Adjustment clause.

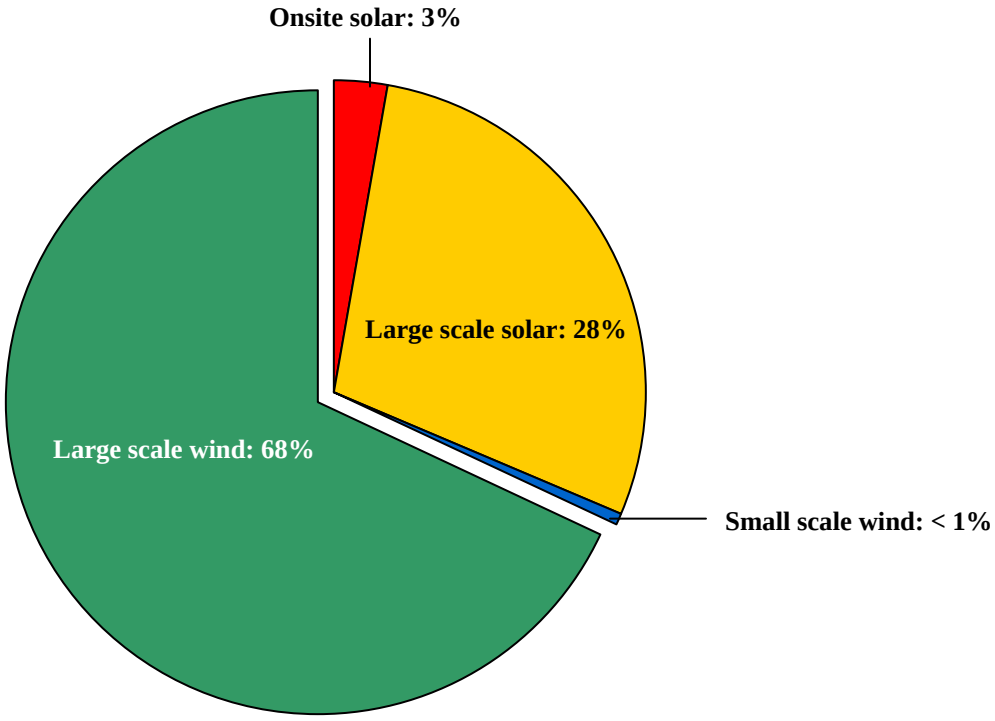
Graph 2: City Utility Costs

2004-2007



The following Renewable Energy composition lays a path for the city to achieve a 30% energy replacement for municipal operations by 2010, a 50% energy replacement by 2013, 75% by 2016 and 100% by 2018.

Large Scale Wind Power: 68%



Pros: Wind power is economical today in Colorado at good sites and is capable of large-scale generation.

Cons: The wind doesn't blow all the time, so it can't be relied on for peak power supplies.

Boulder does not have good wind resources for utility scale wind. As such, turbines would need to be located on Colorado's eastern plains or in Southeast Wyoming. Purchase and transmission of large scale utility power is not currently allowed under Boulders franchise Agreement. Transmission constraints are one of the biggest obstacles for wind power in California. In our region, we have plentiful wind, but it's often far from major transmission lines. The cost of building new transmission lines will probably be the biggest obstacle to new wind farms in our area. However, the cost of transmission is included in the cost of electricity from wind farms, so these costs will necessarily be included in project development considerations. Accordingly, this is an issue that will be handled – from a cost perspective – by developers and is not an issue that policymakers in our county can influence that much.

Wind energy is, however, a major component of our plan for eliminating the use of fossil fuels in Boulder for several reasons. First, it is generally the most economical source of renewable energy, competitive with and sometimes cheaper than electricity from fossil fuels and nuclear power. Good sites can produce wind power at six to eight cents per kilowatt-hour (kWh) – even less when the federal tax credit is factored in. (By comparison, the cost of electricity from a new natural gas plant is eight to nine cents per kWh.) Wind power is expected to become even more cost-effective as the industry develops larger turbines and the price of fossil fuels continues to rise.

Second, we have enormous potential for wind power in this region. Colorado is the 11th windiest state in the nation (see figure___). For example, a small 20 megawatt (MW) wind farm consisting of 8 turbines could theoretically supply more power than the current city's demand for electricity[4]. It is for these reasons – the competitive cost, the strength of the industry, and the regional potential – that wind power is a major component of the city's plan to eliminate the use of fossil fuels in our organization. Staff proposes that the city develop about 10 megawatts of wind power by 2012 from regional sites, enough to meet half of our total current electricity demand. As an alternative, Option B looks at the majority of the city's demand coming from utility scale wind sources, by doubling the amount of energy coming from wind (roughly 20 megawatts total).

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[4] This estimate is based on a 30 percent capacity factor.

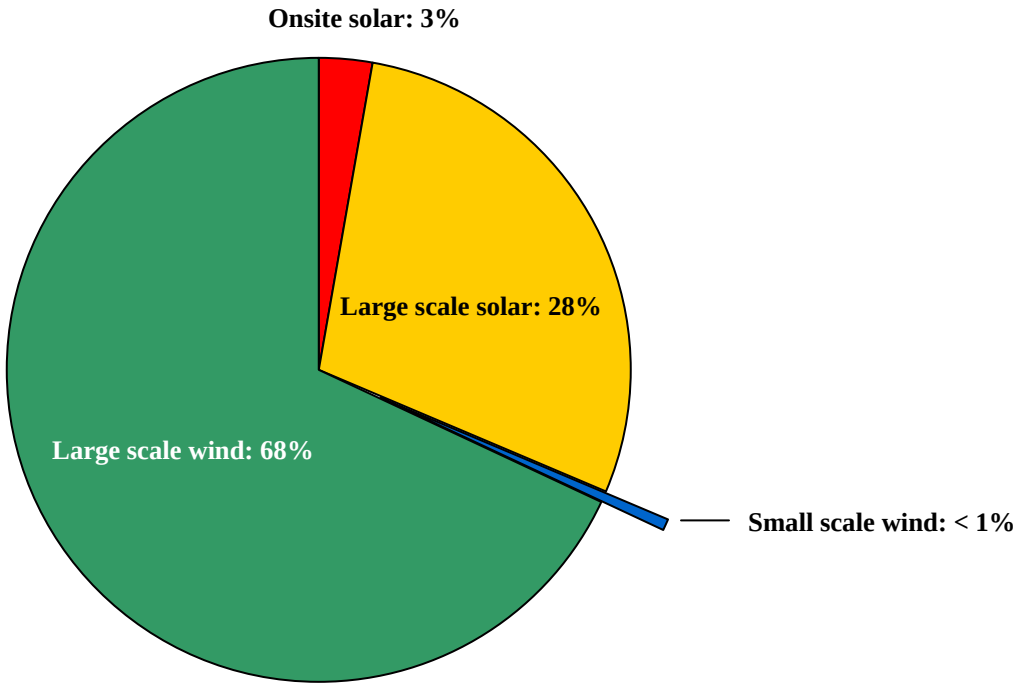
There are challenges with both of these approaches, however. Transmission constraints are one of the biggest obstacles for wind power in Colorado. In our region, we have plentiful wind, but it's often far from major transmission lines. The cost of building new transmission lines will probably be the biggest obstacle to new wind farms in our area. However, the cost of transmission is included in the cost of electricity from wind farms, so these costs will necessarily be included in project development considerations. Accordingly, this is an issue that will be handled – from a cost perspective – by developers and is not an issue that policymakers in our county can influence that much. The city will need to include the option of potential purchase and transmission of renewable energy sources such as wind power, in the ongoing Franchise Agreement negotiations, as the current agreement does not allow this type of scenario.

The city has been approached by several large scale wind developers interested in constructing a new wind farm on the city's behalf. Ongoing discussions with Xcel will Also include the ability to not only transmit and purchase wind power for city needs from these potential sources, but, due to the fact that a large wind project would produce much more than the city organization consumes, we will also discuss the potential to aggregate the power and sell a portion to customers through a PPA or perhaps a city *Windsource* program.

Xcel's announcement of the Smart Grid alters this discussion somewhat, as the availability of the grid to integrate large scale wind power is a positive opportunity for both Xcel and the city. Some states allow their utilities to offer "green pricing" programs, where a customer can choose to receive more renewable energy than normal. For example, Xcel offers a 100 percent wind power product, *Windsource*. Generally, participating in this type of option costs a little more, but in some cases customers have enjoyed a discount over regular customers. For example, Xcel's customers normally pay 15 percent more to receive 100 percent wind power, but when natural gas prices peaked in 2005, they paid 15 percent less than other customers for a short time. As natural gas and other fuel costs continue to spiral upward, such cost discounts will become more common.

Past staff research has shown that for the city to subscribe to 100% wind power, annual costs would be roughly $250,000 on top of our existing utility expense. It is staffs perspective that this should not be included as the primary strategy for the city, rather, any future wind power purchases come from new wind sources, rather than subscribing to the existing *Windsource* program. While extremely beneficial as a consumer resource, it is staff's perspective that the city should use its leverage to support the creation of new wind power sources.

Small Scale Wind Power: <1%



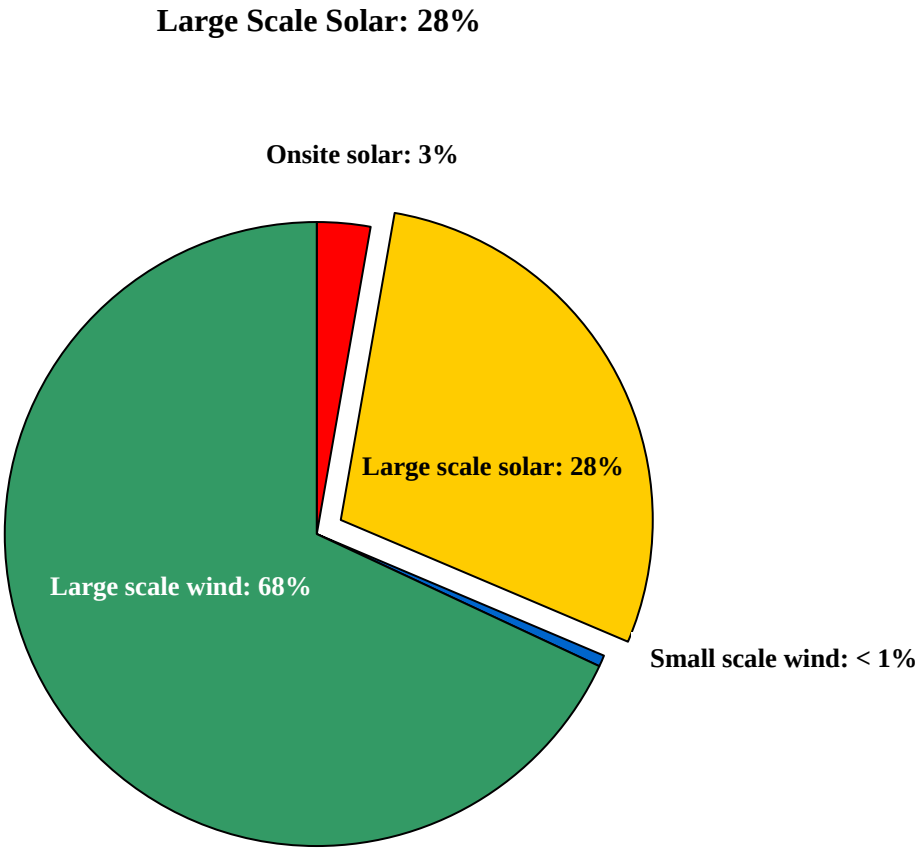
Pros: Wind power is economical at a small scale at particular sites and is an excellent public education opportunity.

Cons: The wind doesn't blow all the time, so it can't be relied on for peak power supplies; small scale wind power is highly variable in urban settings due to erratic wind patterns created by trees and buildings; municipal code complicates installation due to height restrictions; potential visual and audible concerns.

Small wind turbines can be cost-effective at many sites in the city, particularly at facilities on the eastern edge of the city. Where they do not completely pencil out economically, the environmental benefits may be enough of an education opportunity to persuade a business or homeowner to make the investment. In addition, facilities in low-wind areas will be considered for turbines that are designed especially for lower wind speeds. The new small wind turbine costs about $12,000 to purchase and install and can provide enough power for about one third of an average home's

needs. Generally, small wind turbines are mounted on a pole away from buildings. However, some new small wind turbines are designed to be mounted directly on buildings.

Sites being evaluated for small scale wind include: municipal building, Park Central, East Boulder Recreation Center



Pros: Solar photovoltaics, passive solar design, and solar hot water systems are available today as viable options for homes and businesses. Utility-sized “concentrating solar power” can provide large-scale power production at reasonable rates.

Cons: The sun doesn’t always shine, so solar power is not 100 percent reliable as a power source unless the system has a battery or other type of storage. Although the cost of solar power is dropping, some solar technologies can be expensive.

One major advantage for solar power is that many solar techniques and technologies work almost anywhere and can be readily installed on city facilities in our region today. For example, passive solar emphasizes the design and orientation of buildings to take advantage of the sun’s energy for heating, cooling, and natural lighting. Solar hot water is an inexpensive low-tech option that uses the sun’s rays to heat water for building use. This has

been an extremely beneficial strategy for water heating at the North Boulder Recreation Center, for example. And, of course, solar photovoltaic panels (PV) convert sunlight into electricity.

In addition, the city could generate large quantities of solar power through the use of concentrating solar power (CSP). These technologies use mirrors or lenses to focus sunlight on either a central point or a tube filled with oil that turns water into steam, which drives a generator to produce electricity. Of all the solar power options that staff analyzed, CSP is the one that can probably provide us with the most power, reliably, and at the cheapest cost over the long term.

The downside to solar power is that some solar technologies are still expensive compared to fossil fuels and other renewable energy technologies like wind power, hydroelectric power and geothermal power. The upside, however, is that costs of development and financing options are changing quickly, making solar technologies increasingly cost-effective. The economics of each type of solar power technology is discussed in detail below. The various types of solar power could provide 10 MW of energy by 2018. As mentioned previously, because the city is a tax exempt agency, we are not able to take advantage of the tax incentives which bring the total cost of the project down. Third Party financing is the most advantageous financing model for this type of project, such as the 75th Street Wastewater Treatment Plant. Additionally, there is a strong possibility of a joint project between Xcel and the city as part of the renewed Franchise Agreement.

Solar Hot Water

Solar hot water technologies use sunlight to heat water for later use. There are two general types of solar hot water which the city could take advantage of: solar hot water systems for building use, such as the North Boulder Recreation Center and Concentrating Solar (CSP), which has a much bigger impact of overall energy replacement.

Concentrating solar power (CSP) technologies can be a major contributor to the city's future need for new, clean sources of energy, as reliable and affordable supply of electricity. CSP technology is not widespread in Colorado today and there are no installations in our county, but this technology holds great promise for large-scale power production at attractive prices. There is also the potential for smaller residential or business-size applications with some CSP technologies.

Many power plants today use fossil fuels as a heat source to boil water. The steam from the boiling water rotates a large turbine, which activates a generator that produces electricity. However, a new generation of power plants, with concentrating solar power systems, uses the sun as a heat source. In Boulder, there are

two main types of concentrating solar power systems that could be developed: parabolic-trough and dish/engine.

Parabolic-trough systems concentrate the sun's energy through long rectangular, curved (U-shaped) mirrors. The mirrors are tilted toward the sun, focusing sunlight on a pipe that runs down the center of the trough. This heats the oil flowing through the pipe. The hot oil then is used to boil water in a conventional steam generator to produce electricity.

A dish/engine system uses a mirrored dish (similar to a very large satellite dish). The dish-shaped surface collects and concentrates the sun's heat onto a receiver, which absorbs the heat and transfers it to fluid within the engine. The heat causes the fluid to expand against a piston or turbine to produce mechanical power. The mechanical power is then used to run a generator or alternator to produce electricity.

CSP has both advantages and disadvantages compared with other types of renewable systems. Because the lenses must be pointed at the sun, the use of concentrating collectors is limited to the sunniest parts of the country. Tracking of the sun is required to maintain the efficiency. Some concentrating collectors are designed to be mounted on simple tracking devices, but most require sophisticated tracking devices, which limit their use to electric utilities, industries, and large buildings, and require close proximity to the facilities to maintain efficiency. Further, they typically require large parcels of land for construction.

One key competitive advantage of CSP systems, however, is that they closely resemble most of the nation's current power plants in some important ways. For example, much of the equipment now used for conventional, centralized power plants running on fossil fuels such as the Valmont Plant, can also be used for CSP plants. CSP simply substitutes the use of concentrated solar power rather than combustible fossil fuels to produce electricity. This "evolutionary" — in contrast to "revolutionary" or "disruptive" — aspect means CSP can be integrated fairly easily into today's electric utility grid. It also makes CSP technologies the most cost-effective solar option for large-scale electricity generation.

Working in partnership with Xcel, staff has been researching concentrating solar power options at various sites in Boulder, most notably in the vicinity of Valmont Butte due to the proximity to the Valmont Power Plant, site orientation and access to infrastructure needs such as high capacity transmission and water. Staff will continue to work with Xcel and local experts to determine the feasibility of a CSP project in Boulder.

Sites being evaluated for CSP include: Valmont Butte

Solar Photovoltaics (PV)

Solar PV converts sunlight into electricity by exploiting the transfer of electrons stimulated by sunlight in certain materials such as silicon. Historically, the expense of solar PV limited its use to space satellites and other remote off-grid sites, where it would be impossible or prohibitively expensive to connect to transmission lines. However, in the last decade, solar PV has experienced major cost breakthroughs, causing the industry to boom in Colorado and around the world. In our state, the boom has also been aided by significant subsidies; without

these, solar PV would not be growing at its current rate.

Over the last 25 years, solar PV installations have seen steady and, lately, exponential growth in Boulder. If the trend continues, solar PV could contribute a significant share of our energy needs over the next few decades, though it's not at all clear that this trend will continue.

While over the long-term the cost per watt for solar PV has been dropping, in 2003 through 2006 the cost rose substantially due to sharply increased demand and the inability of companies to bring on new supplies fast enough.5 Currently, solar PV modules cost about $5.50 a watt, but over the next decade we may see this reduced to $1 a watt as the industry makes improvements to the technology. At this five-fold reduction in price, solar PV would become cheap enough to be an automatic choice for most consumers as well as for the city through large central station generation.

On-site (small scale) solar PV:

The city can benefit greatly by installing on site solar projects at its facilities throughout the city. This power can be consumed onsite, preventing the energy losses associated with sending an electric current long distance through conventional power lines.

The city's immediate goal is to identify small and mid size facility projects by the end of 2008, and continue with installations utilizing various financing mechanisms each year. In 2008, the city will work to pre-qualify one or more solar teams of developers to provide PV energy to city facilities, by first conducting an engineering study to determine which facilities will provide the optimum opportunity to harness solar power while reaping the benefits of renewable energy rebates. Staff is completing the details for the installation of three 10 kw projects to be installed at the George Reynolds Library, Municipal Building and Park Central.

Large Scale Solar PV:

Large solar projects are generally considered to be those over 100kw. A typical residential installation is usually sized between 2 and 5 kW, which will meet the electrical demand of 50 to 100% of an average home. As a matter of comparison, city staff is concluding contractual agreements on three 10 kw systems to be installed at the Reynolds Library, the Municipal Building and Park Central. On the other end of the spectrum, the 75th Street Waste water Treatment project when completed, will be a 1 megawatt or 1,000.9 kw

system, comprised of close to 7,000 solar panels, covering roughly 7 acres of land.

While capital costs are very high, large scale PV arrays are fairly easy to install and connect. Also, utilities can build PV power plants where they're most needed in the grid, because siting PV arrays is usually much easier than siting a conventional power plant. And, unlike conventional power plants, modular PV plants can be expanded incrementally as demand increases. Finally, PV power plants consume no fuel and produce no air or water pollution while they silently generate electricity. This makes PV power an attractive option for utilities or municipalities that want or need to cut fuel costs.

Unfortunately, using current utility accounting practices, PV-generated electricity still costs more than electricity generated by conventional plants in most places, and regulatory agencies require most utilities to supply the lowest-cost electricity. Furthermore, photovoltaic systems produce power only during daylight hours, and their output thus can vary with the weather. Utility planners must therefore treat a PV power plant differently than they would treat a conventional plant.

For the city, we should be considering the installation of large PV systems at places in utility distribution system service areas where the population is increasing rapidly. In these places, using PV systems could eliminate a utility's need to increase the size of power lines as well as entire servicing areas. Installing PV systems near other utility distribution equipment, such as substations, can also prevent overloading of the equipment in the substation. Further, staff is exploring connecting large PV systems to the utility grid in places where they have a higher value. For example, adding PV generation near the places where the electricity is used prevents the energy losses associated with sending an electric current long distance through conventional power lines. This means the PV system is worth more to the utility when it can be placed near the customer.

Sites being evaluated for large scale solar include: Valmont Butte, 63rd Street Waste Water Treatment Plant, Area 3 Reserve, East Boulder Recreation Center, CU-Boulder South Campus,

Solar Gardens

Staff has been research the feasibility of creating a new market for a hybridized approach to large scale solar PV. In the city of Boulder, there are countless residential and commercial properties that do not have adequate solar access for on site renewables. This could be due in part to site suitability (orientation, shading from vegetation or adjacent structures), legal challenges due to restrictions such as height or neighborhood CCR's, or perhaps due to the fact that occupants of buildings may not have the permission of the building owner.

These challenges will be further exasperated in the future as our local codes such as Green Points continue to aggressively require buildings to perform at levels well above the International Codes such as IECC. As performance requirements are ramped up over time, compliance will necessitate the inclusion of on site renewables. For properties without solar access, a condominiumized "PV-garden" could be the solution.

In this untested model, residents or businesses could invest in solar PV which would be located at central locations around Boulder, similar to community gardens. The large scale of the projects could dramatically impact purchasing power of investors through the creation of a certain size requirement, resulting in a minimum investment before construction takes place. This economy of scale would result in advantageous equipment purchases, as well as avoiding problematic metering issues for customers.

There are several challenges identified with this scenario, none of which are seemingly too difficult to navigate. Metering of the project, financing and site suitability are currently being explored. Staff will continue to research the possibility of such an opportunity, through the creation of a LLC or non-profit to organize and monitor the purchase and installation. Further, staff will continue to work with Xcel to allow for these types of projects.

Hydroelectric Power

Currently, the city of Boulder operates several hydroelectric facilities that generate power, which is sold to Xcel. These hydroelectric systems make use of energy from water that is also used to meet the city's water needs; the energy would be wasted if it was not converted to electricity. Nothing else is consumed or emitted in the process.

Since 1985, the city of Boulder has run a hydroelectric program to turn water power into electricity, generate revenue, and provide sustainable, non-polluting electricity.

Boulder's eight hydroelectric power plants (one purchased and seven constructed over the last 20 years) convert the energy in flowing water into electricity.

The seven constructed power plants were installed on water supply pipelines that were already used to provide water to the city. No new dams or overhead transmission lines - two of the negative impacts often associated with hydroelectric power - were built.

Flowing water spins a turbine, which in turn spins an electrical generator to produce electricity.

The electricity generated by Boulder's hydroelectric facilities is sold to Xcel Energy. Hydroelectric revenues reached $2.1 million for the city in 2006, helping to offset utilities operations and capital costs. These savings are passed onto city water users, who would normally have to pay these costs with higher water bills.

In 2004, the renewable energy program generated just over 41 million kilowatt-hours of electricity. To put this into perspective, an average Boulder County household uses about

7,600 kilowatt-hours of electricity a year. This means that in 2004, enough electricity was produced to meet the annual needs of about 6,800 Boulder County households.

Each kilowatt-hour of electricity generated at a coal-fired plant requires the consumption of about one pound of coal and results in the release of two pounds of carbon dioxide - a greenhouse gas - into the atmosphere. In 2004, Boulder's renewable energy production displaced the need to burn 20,500 tons of coal and eliminated the emission of 41,000 tons of carbon dioxide. The environment impacts associated with mining and transporting over 200 railroad cars of coal were also avoided.

Advantages of Hydroelectricity

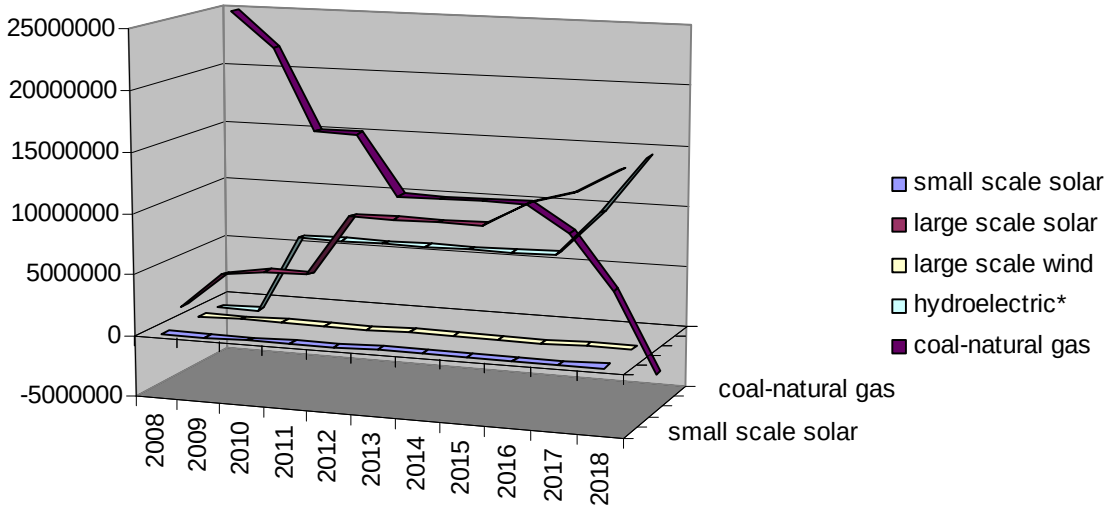
- Hydroelectricity generation is environmentally and economically beneficial to society.
- Hydroelectric power is reliable because it only depends on gravity, water and simple.
- Hydroelectric power production is about twice as efficient as thermal production.

Boulder's eight hydroelectric facilities convert the energy in falling water into over 42.5 million kilowatt-hours of electricity, more than what the city organization consumes. While theoretically, the city could claim that we are already 100% renewably powered, due to the fact that the power is sold to Xcel which in turn, flows onto the grid at large, the generated power was not included in our baseline portfolio. However, because the city negotiated with Xcel to retain ownership of half of the renewable energy credits generated by the hydro facilities, the city's Renewable Energy Credits (Recs) have been included in the Green House Gas inventory.

As part of the Franchise negotiation with Xcel, staff will recommend pursuing the full ownership of Recs from the hydro facilities as the contracts with Xcel at each site expire. As can be seen in the charts below, hydroelectric generation will be included in the portfolio when and if the city acquires full ownership of the Recs.

100% by 2018

The following graph shows a strategy for the city to move to 100% renewable power by 2018. It should be noted that emerging technologies and legislative requirements may change this portfolio. More importantly, is the recognition that the city can feasibly and economically replace its consumption with renewable sources at a relatively quick pace. Staff will continue to evaluate options to grow the city's renewable portfolio and create a clear picture of how projects will be developed each year.



2008 will be a pivotal year for the city's renewable strategy. As city council affirms their desire to wean the city organization from fossil fuels when feasible, staff can begin the strategically implement components of this plan.

Achievements in 2008: It is anticipated that the four solar projects referenced above will be implemented in 2008. Additionally, the city will partner to identify other solar opportunities through a solar RFP, as well as the submission for 2.5 MW of solar at other city sites.