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Dear Reader:

Colorado Governor Bill Ritter issued a Climate Action Plan in 2007. It set a goal of reducing the state's greenhouse gas emissions 20% below their 2005 levels by 2020 and 80% by 2050.

Following is a white paper written by Holy Cross Energy, a cooperative electric utility that serves the resort areas of Vail and Aspen, Colorado. Holy Cross Energy examined how it — and the Colorado electric sector as a whole — could meet those goals.

Climate change is a difficult challenge that will not be easily resolved. Many readers will have strong opinions about how this issue should be addressed. Our purpose in writing this white paper is not to advocate any particular policy. Rather, we hope to elevate the discussion to a new level.

A few caveats are necessary. Our analysis does not calculate the cost of inaction, of the "negative externalities" that could be caused by a warming climate. It also does not attempt to calculate either positive or negative effects on the Colorado economy due to climate action, nor does it try to predict the timing or form of federal climate policy.

We welcome your comments, suggestions, or criticisms on the findings presented here.

Sincerely,

Del Worley
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Reducing Colorado's Electric Sector Greenhouse Gas Emissions

The Difficulty of "Running Down an Up Escalator"

A White Paper

February 2009

This report was researched and written by Holy Cross Energy staff members Del Worley, Chris Hildred, and Diana Golis, with the assistance of independent consultant Randy Udall.

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Reducing Colorado's Electric Sector Greenhouse Gas Emissions
The Difficulty of "Running Down an Up Escalator"

Executive Summary

Colorado Governor Bill Ritter's Climate Action Plan proposes to reduce the state's greenhouse gas emissions 20% by 2020 and 80% by 2050 from their 2005 levels. Holy Cross Energy (HCE), a rural electric utility serving 100,000 people in western Colorado, analyzed how it might meet those goals. HCE also examined what actions would be necessary for the Colorado electric sector as a whole to achieve them. Our key findings follow:

Growth in Electricity Consumption Compounds the Climate Challenge

- Colorado electricity consumption is forecast to grow 40-50% between 2005 and 2020. Reducing emissions in the face of increasing demand is difficult and expensive.

Fuel Switching from Coal to Natural Gas

- In 2005, coal-fired power plants provided 72% of Colorado's electricity; natural gas plants 24%; and hydropower, wind, and solar the rest. To meet the Governor's 2020 goal, coal use would have to fall by nearly half, while natural gas generation would have to nearly double. Carbon-free resources and efficiency savings would need to provide one-third of the state's electricity services by 2020, up from 4% in 2005.
- To meet the 2020 goal, up to 2,700 MW of existing coal generation, out of about 4,900 MW operating today, may need to be retired and replaced with combined-cycle natural gas plants costing at least $2.5 billion.

What Would It Cost to Meet the 2020 Target?

- The statewide price tag for meeting the reduction targets would rise over time as natural gas replaced coal and new lower-emitting plants were built. If electricity consumption grows by 2% annually, then by 2020 Coloradans could be spending $1 billion more each year for power above and beyond normal price escalation.

Could Holy Cross Energy Meet the Governor's Goal?

- Holy Cross Energy developed three scenarios and a base case to model our existing power supply, lower-emitting options, and their costs. We factored in load growth and expected changes in the energy mix of Public Service Company of Colorado (PSCo), our wholesale electricity supplier. To meet the 2020 reduction target, HCE would need to make significant changes in its fuel mix, similar to those required statewide. This would raise wholesale electric rates 19-45% above normal cost escalation, depending on which scenario was implemented.
- Any HCE plan designed to meet the Governor's goal would require the cooperation of Public Service Company of Colorado or other wholesale electric providers.

The Importance of Energy Efficiency

- To be successful, climate policy must be enduring. To be enduring, it must be cost-effective. Some of the cheapest ways of reducing emissions are found in the realm of energy efficiency and conservation. Effective statewide efficiency programs that reduced growth in electricity consumption could save billions in avoided power plant costs.
- Average household electricity use continues to rise. While utilities can provide incentives to conserve, they have little control over how much electricity their customers consume. Policymakers and consumers themselves will be the key to successful conservation and efficiency.

Meeting the 2050 Goal

- The growth dynamic - the difficulty of "running down an up escalator" - also complicates efforts to reach the Governor's 2050 goal. Today, every 1,000 kilowatt-hours sold in Colorado comes bundled with nearly 2,000 pounds of carbon dioxide. A tenfold decrease in that ratio would be needed to achieve 80% reductions by 2050. In that year, almost all of the state's electricity would have to be produced from non-emitting sources.
- Over the coming decades, technological advances in lighting, appliances, motors, solar, wind, geothermal, and carbon-capture may reduce the cost of emission reductions. The wise use of time can also reduce the costs of achieving reductions, making them politically and economically more viable. Faced with a long journey, it's essential to get the pace of investment and power plant replacement right.

Thoughts to Consider

- The Colorado Energy Forum, Rocky Mountain Climate Organization, and Governor's Climate Action Panel have studied various aspects of this challenge, but a politically viable, fiscally responsible and logistically practical blueprint for reducing emissions in Colorado's electric sector has yet to be developed. The topic deserves more careful analysis than it has received since numerous economic, technical, and operational questions need to be answered.
- If Colorado wishes to reduce its carbon footprint, bipartisan political leadership and civic education will be crucial. Citizens must be engaged in the discussion, since effective climate policies can only be crafted with their support and because they will have to pay the costs of climate protection.

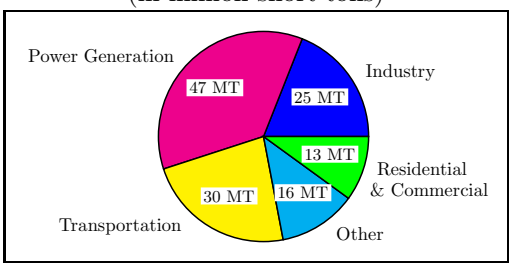
Reducing Colorado's Electric Sector Greenhouse Gas Emissions

The Difficulty of "Running Down an Up Escalator"

Colorado Governor Bill Ritter issued a Climate Action Plan in 2007. It established the ambitious goals of reducing the state's greenhouse gas emissions 20% by 2020 and 80% by 2050 from their 2005 levels. Electric utilities were asked to develop a plan to meet the 2020 goal, and submit it to the Governor's Energy Office by June 1, 2009. In response, Holy Cross Energy (HCE) developed a set of scenarios to explore how it could meet the Governor's goal. HCE also analyzed what the emission reduction targets mean for Colorado electric utilities at large.

Today, every $100 worth of electricity sold in Colorado comes "bundled" with approximately 2,000 pounds of carbon dioxide, the most common greenhouse gas. In developing a plan to reduce emissions, HCE analyzed its current fuel mix and future generation options. This paper explains how HCE could change its generation mix to meet the Governor's plan and what those changes might cost. It also describes some of the contractual constraints and operational barriers that would need to be overcome. Although no two utilities are identical, some of the challenges HCE faces, such as demand growth in the face of climate change, are broadly applicable to other electricity providers. **Our goal in writing this paper is to explore what it would take to achieve Governor Ritter's emission reduction goals, and to share those findings with others who are concerned about this issue.**

2005 Colorado Emissions
(in million short tons)



The Electric Sector's Role in Climate Change

Worldwide, humans now burn about one million tons of oil, coal, and natural gas each hour. As the carbon in those fuels combines with oxygen in the air, carbon dioxide (CO_2) is released. Global emissions of CO_2 now exceed 30 billion tons annually. **In the United States, approximately two-fifths of all CO_2 comes from power plants.** Colorado produced 128 million tons of CO_2 equivalent gases in 2005, of which 47 million tons came from the electric sector. The next largest share came from the transportation sector which produced 31 million tons. In Colorado (as in California, Canada and China), the petroleum-fueled automobile and the coal-fired power plant are at the center of the climate challenge. To first slow and then halt climate change will require dramatic changes in how we produce and use electricity, and equally dramatic changes in how we transport people and move goods. Concern about climate change has come to the forefront in recent years, but discussion of solutions appears piecemeal and abstract. To design a durable, affordable, bipartisan road map for resolving the problem, legislators, policymakers, and citizens need to understand the scale of the challenge. Imagine that you wake up one morning and find yourself running an electric utility in western Colorado.

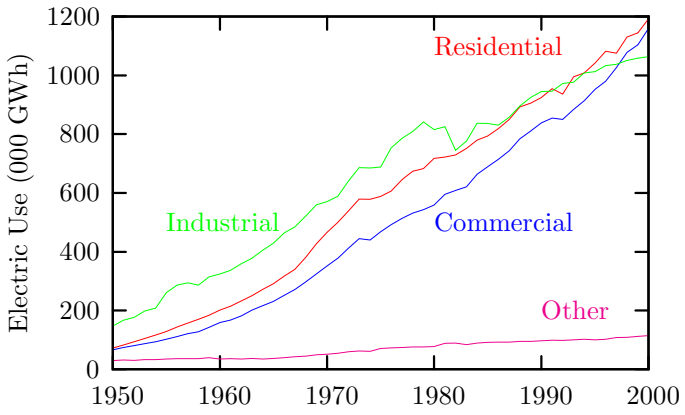
Holy Cross Energy

Holy Cross Energy serves 55,000 meters in Vail, Eagle County, Aspen, the Roaring Fork Valley, and areas west of Glenwood Springs. HCE currently purchases most of its wholesale electricity from Public Service Company of Colorado (PSCo). In 2010 HCE will begin generating about one-third of its electricity from Comanche 3, the new coal plant in Pueblo, Colorado, that is under construction. Like many utilities, HCE is experiencing rapid growth in customer numbers and energy demand. Statewide electricity consumption increased 50% in the last decade. HCE expects its energy sales to increase about 55% between 2005 and 2020, which greatly complicates our efforts to achieve Governor Ritter's emission reduction goals.

The Growth Dilemma

When it comes to emission reductions, growth is often ignored. This is unfortunate, because growth is a big deal. If demand for electricity were not growing, HCE's emissions would be much lower today than they were a decade ago, because of changes in its fuel mix. In the same vein, absent population growth, the United States would be on track to meet the emission targets established by the 1992 Kyoto Treaty. In a talk he has given more than 1,600 times, Dr. Al Bartlett, emeritus professor of physics at the University of Colorado, argues that the "greatest

US Electricity Sales: 1950-2000

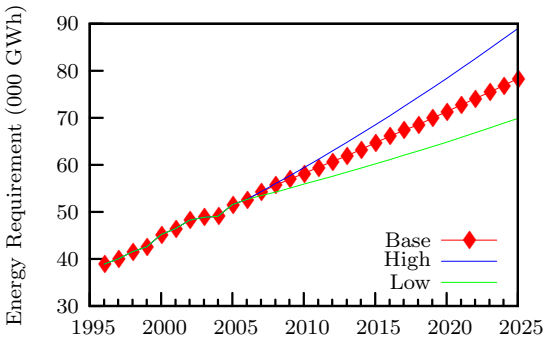


shortcoming of the human race is our inability to understand the implications of exponential growth." Bartlett goes on to explain how seemingly trivial growth rates can have momentous implications. The American electricity industry is a classic example of exponential growth. Between 1949 and 2000, demand for electricity grew by 5% per year. **By 2000, the nation was using 13 times more electricity than it had at the end of World War II.**

Forecast: More Growth

In a recent report the Colorado Energy Forum (CEF) forecast that electricity demand is likely to grow an additional 40% between 2005 and 2020. The implications are sobering. To achieve a 20% reduction in Colorado's electric sector carbon emissions and to simultaneously meet soaring demand, the state's utilities would need to cut their "carbon intensity" - the amount of carbon dioxide produced per unit of electricity - almost in half.

CEF Forecast Energy Requirements



The Flat Screen Effect

Colorado electricity demand is growing for three reasons. The first is population growth. The second is an increase in economic activity. The third is an increase in average house size combined with the flat screen TV phenomenon, the proliferation of air conditioners, microwaves, computers, cell phone chargers, larger televisions, and other electrical appliances. **In 2005, a typical Colorado household used nearly 900 kWh more than it did in 1995.** This sort of growth does not make it impossible to reduce emissions, but it does make it tough sledding.

A key metric in emission scenarios is *carbon intensity*. A typical coal plant produces 2.2 lb CO_2/kWh and a typical combined-cycle natural gas plant emits about 0.8 lb CO_2/kWh. Low- or non-emitting technologies include nuclear, geothermal, solar, wind, biomass, hydro and "carbon capture" plants that sequester their emissions. To achieve the Governor's 2020 goal, electric sector carbon intensity would have to fall by nearly half from 2005 levels. A further 80% reduction would be necessary to achieve the 2050 goal.

A Herculean Task

At the end of the day, reducing electric sector emissions means burning less fuel, burning cleaner fuel or using fuel more efficiently. It is also possible to use flows of water, wind, and sunlight (or nuclear power) to displace electricity now provided by fossil fuel. **If the state's population were not growing, Coloradans could achieve the Governor's goal by burning 20% less oil, natural gas, and coal.** That would be a significant undertaking, since everyone would have to participate, but it's not impossible. In the electric sector, half those fuel savings might be gained through conservation programs and energy efficiency investments. The other half could be obtained through improvements in carbon intensity. For example, utilities could displace some coal-fired electricity with natural gas. (Natural gas has about half coal's carbon content.) Or they could build wind farms, develop hydropower at existing dams, burn beetle-killed trees in biomass plants, install photovoltaic systems and so forth. Alternatively, the Governor's goal could be reached by building a single nuclear power plant or by replacing a couple of small, old coal plants with a large, new coal plant that captures its carbon emissions. But, of course, Colorado's population is growing. Indeed, the State Demography Office expects the state to see one million new residents by 2020.

Now, in order to reduce emissions by 20%, someone needs to convince the newcomers not to use any fuel to heat their homes, run their cars or power their businesses. If, as seems more likely, they insist on burning their share, then improvements in energy efficiency and carbon intensity would have to occur on a Herculean scale.

Colorado is gaining one million new residents every 12 years.

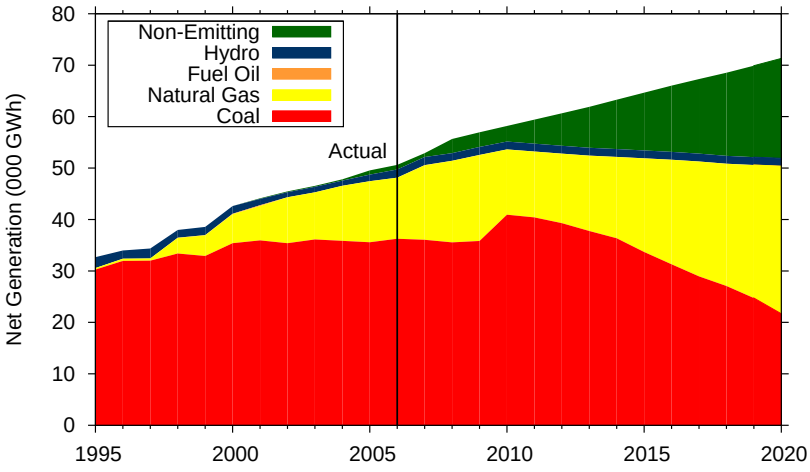
"Running Down an Up Escalator"

In trying simultaneously to meet a 2020 emission reduction goal and serve growing loads, utilities face the challenge of "running down an up escalator." Achieving the goal requires more than conservation or expanding renewable energy generation. These help but for HCE, and for the state as a whole, there's only one way to meet the Governor's target - rapid, dramatic, unprecedented changes in Colorado's fuel mix.

Burn Less Coal?

If electricity consumption continues to grow at the current rate, the only feasible way to reduce Colorado electric sector CO_2 emissions is to burn much less coal and much more natural gas, while simultaneously expanding efforts to promote efficiency and renewable energy. In 2005, coal provided about 72% of Colorado's electricity; gas about 24%; and

hydro, wind, and solar about 4%. To obtain a 20% emissions reduction while meeting load growth, Colorado's fuel mix would have to resemble that shown in the chart at right. Demand expands as forecast by the Colorado Energy Forum, but there is a massive substitution of natural gas, conservation, and renewables for coal. It is difficult to communicate what an enormous transformation this would be. **To sum it up: As electricity production grows by 38% from 2005 levels, coal use falls to only 30% of the power supply, natural gas use nearly doubles to 40% of electric supply, and carbon-free generation and efficiency grow rapidly to provide 30% of electricity services - all in a bit more than a decade. This would be the largest, and perhaps the most costly, change in the history of the Colorado electric industry.**



Colorado's electric sector fuel mix would have to change dramatically to meet the Governor's goal. All growth in demand (shown increasing at about 2% annually) would have to be met with non-emitting generation and a number of existing coal plants would have to be replaced with combined-cycle natural gas units.

Many Critical Questions

Before undertaking such a dramatic course change, many questions must be addressed. Is such a rapid transformation physically possible in the time allotted? Since coal plants provide the state's cheapest power, what would the "dash to gas" cost? (About $500 million per year by 2020 in increased fuel costs alone.) **How many new power plants would need to be built, in what locations, when, and by whom?** (A complete analysis remains to be done, but many new plants would be needed.) Are there operational constraints to bringing on large amounts of new wind? (Yes, some.) Are transmission lines and gas pipelines adequate to the task? (No, upgrades would be needed.) Would contractual obligations inhibit this scenario? (Yes.) Would the economic impacts of this switch affect all utilities equally? (No.) How much higher would bills be at the end of the period? (Significantly. See HCE scenarios.) Would the added costs bring clear benefits? (Possibly, if activities in Colorado were coordinated with those in other states and nations.) What happens after 2020? (Solving the climate problem would require large additional reductions here and globally.) Is there an overlap between actions in the electric sector and reduction opportunities in the transportation sector? (Yes, think plug-in hybrid and all-electric vehicles.) Could conservation reduce the number of new power plants and fuel switching required? (Clearly.) Finally, the most critical question of all: Do electric utility customers, citizens, and voters support making the large investments that would be necessary? (This is not clear.) In a recent poll of HCE consumers, a healthy majority were willing to pay 5-10% more to address climate change, energy security, and sustainability. On the other hand, Amendment 37, which established mandatory renewable energy standards, was narrowly passed by Colorado voters, even though it specifically limited electric bill rate impacts to 1%.

Is There Enough Natural Gas?

Colorado natural gas production has exploded since 1990 and the state now produces about 7% of the nation's supply. Two-thirds of Colorado gas is exported. Making the hypothetical fuel switch shown in the chart above would require a reduction of the state's exports by only 20%, so there is enough natural gas. Estimating what such a fuel switch would cost utilities is more difficult, but the annual price tag could be $500 million or more by 2020 in increased fuel costs. Furthermore, growth of natural gas consumption in the electric sector would likely lead to higher residential and commercial heating bills.

Could Holy Cross Energy Meet the Governor's Goal?

Emissions associated with HCE's 2005 purchases totaled 951,000 tons. The carbon intensity of this electricity was 1.76 lb/kWh at an average wholesale price of 4.8 ¢/kWh.

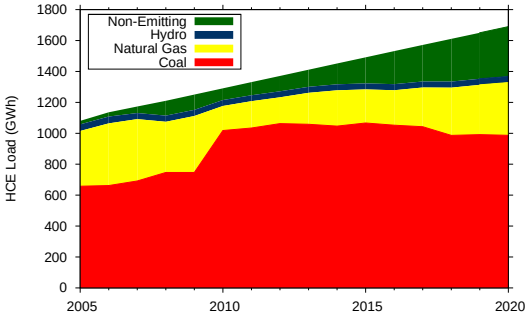
Holy Cross Energy developed a base case and three scenarios to model our existing electricity supply, lower-emitting options, and their costs. We factored in load growth and expected changes in the energy mix of PSCo, our wholesale electricity supplier. In two scenarios HCE meets the Governor's goal, but at substantial cost. Before discussing the modeling results, a few sentences of background are useful. Holy Cross Energy, the state's sixth largest retail utility, provides electricity to roughly 100,000 people. Unlike many of the state's 61 utilities, which are contractually bound to one wholesale provider, HCE has the freedom to purchase power from alternative suppliers. Although the current recession may alter this trend, HCE sales have historically grown more than 3% per year, slightly faster than the state at large. Although Holy Cross Energy has already met Amendment 37's 2020 renewable energy standards, we anticipate our energy sales to be at least 50% higher in 2020 than they were in 2005. This has profound implications for the kind of wholesale electricity we could buy and still meet the emissions goal, as we shall demonstrate.

2020 Emission Scenarios Results for Holy Cross Energy

	Emissions (Tons)	Intensity (lb/kWh)	Meets Goal	Wholesale Electric Rate (¢/kWh)	Wholesale Rate Increase*
Base Case	1,164,000	1.38	No	7.5	-
Scenario 1	1,006,000	1.19	No	8.4	5%
Scenario 2	760,000	0.90	Yes	9.5	19%
Scenario 3	769,000	0.91	Yes	11.5	45%

*Over the 2020 Base Case

The Base Case - Business as Usual

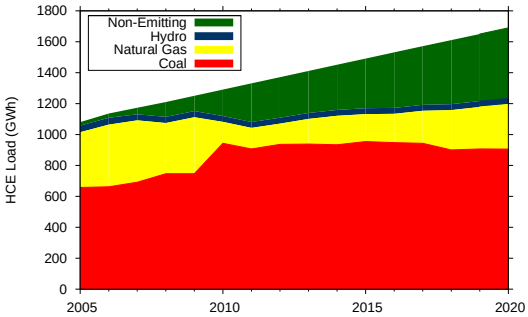


Currently, Holy Cross Energy's carbon intensity mirrors that of PSCo, our largest energy supplier. HCE also purchases small amounts of federal hydro power from the Western Area Power Administration (WAPA). In 2009 our fuel mix will change when Comanche 3, the cleanest and most efficient coal plant in Colorado, is completed. HCE's decision to purchase 60 MW of Comanche's production was driven by a desire to minimize the risks inherent in the 2022 expiration of our wholesale contract with PSCo. In the Base Case our 2020 fuel mix would be 58% coal, 21% natural gas, and 21% renewables. Our carbon intensity would be 1.38 lb/kWh.

In the Base Case, HCE's CO_2 emissions rise by 22%. A 25% decline in carbon intensity is swamped by a 50% increase in demand.

Base Case Results: Because Public Service Company of Colorado has stated that it plans to adopt Governor Ritter's goal, our modeling assumes a significant reduction in PSCo's emissions intensity. Even so, in the Base Case HCE CO_2 emissions rise by 22%. We fail to meet the Governor's goal because a 25% decline in carbon intensity is swamped by a 50% increase in power demand and the addition of Comanche 3.

Scenario 1 - Additional Wind and a Biomass Plant

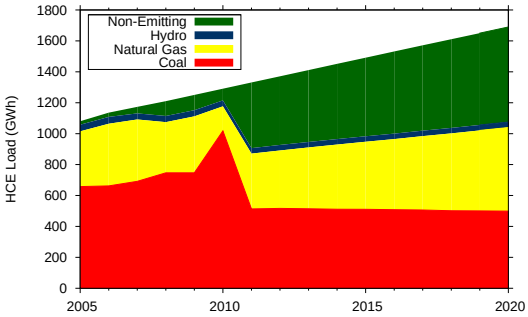


To further reduce its greenhouse gas emissions, in Scenario 1 Holy Cross Energy purchases electricity from a 10 MW biomass plant located near our service territory and a 50 MW wind farm with back up services provided by another utility that operates existing generation. This reduces our purchases from PSCo, but they remain our largest source of power and would have to facilitate our new wind purchases. Additional electricity comes from Comanche 3 and WAPA.

In Scenario 1, our annual CO_2 emissions are about 15% lower than the Base Case, but higher than in 2005.

Scenario 1 Results: Purchasing wind and biomass raises our annual power costs by $7 million. HCE carbon intensity falls to 1.19 lb/kWh, well below the national average. Although energy sales are up 50%, emissions have risen only 5%. That's progress, but further reductions would be needed to meet the Governor's goal.

Scenario 2 - Buy Gas and Wind From PSCo

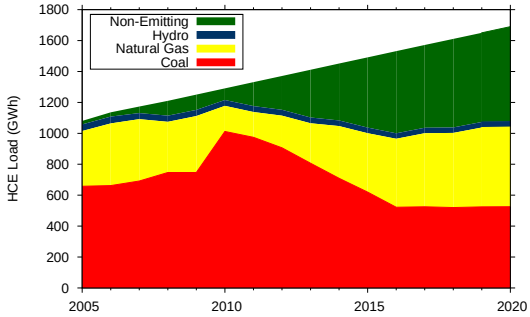


In this scenario, HCE purchases the same share of electricity from Comanche 3, WAPA, and the previously mentioned biomass plant. All other power is supplied by PSCo, but a substitution is required. Instead of buying electricity with PSCo's system average price and carbon intensity, we assume that HCE buys a blend of electricity that excludes coal purchases. This lower-emission blend would be composed primarily of natural gas and wind generation at PSCo's cost of production for these resources.

In Scenario 2, we meet the goal, but the typical family's annual bill has increased by about $200.

Scenario 2 Results: By 2020 our carbon intensity is a stunning 51% below where it was in 2005. We meet the Governor's goal, but our wholesale electric purchase costs are roughly 19% higher than the Base Case and subject to the unpredictable fluctuations of natural gas prices. A typical family's annual bill is about $200 per year higher than in the Base Case.

Scenario 3 - Go It Alone



Colorado utilities face numerous business risks and uncertainties. What will happen to coal and natural gas prices? How long will the recession last? Will the federal government pass climate legislation? For Holy Cross Energy the risk of a lengthy recession or climate legislation is dwarfed by the possibility that our wholesale contract with PSCo will not be renewed in 2022 when it expires. If that were to occur, HCE would need to build its own power plants, venture into the wholesale market to secure electricity, or pursue some combination of the two. In Scenario 3, we investigate a hypothetical future in which the PSCo contract is not renewed. Forced to go it alone, HCE contracts with independent power producers and generation utilities for electricity from natural gas and wind to augment that coming from Comanche 3, the biomass plant, and WAPA.

Emission reductions will not occur in a vacuum; there are other business risks to consider.

Scenario 3 Results: Since HCE's winter loads are twice as large as its summer loads, it is not certain that this scenario could be executed in the real world. If it could be, it would be expensive. Our modeling suggests an annual hike in HCE's energy costs of $60,000,000. Most of this steep increase is not tied to the cost of reducing CO_2 emissions but reflects the cost of purchasing expensive energy from new power plants rather than cheaper power produced by PSCo's existing fleet, for which capital costs have been partially recovered. In Scenario 3, we meet the Governor's goal, but residential rates approach 16.5 ¢/kWh, about twice what they were in 2005. A typical family's annual bill is $400 higher than in the Base Case, and HCE has a significant exposure to natural gas price volatility.

Contractual Constraints

Although the growth and fuel mix dynamics described in the HCE scenarios are broadly applicable to other utilities, there is one critical difference - many Colorado utilities have much less flexibility in their wholesale power contracts. Many municipal or rural electric utilities have a binding, long term "all-requirements" contract with a single wholesale provider. For these munis and cooperatives to meet the Governor's emission reduction goals, their wholesale providers would have to pursue an aggressive reduction in emissions similar to that which PSCo began in the 1990s and early 2000s. That decarbonization began almost accidentally. During an era of very low natural gas prices, independent power producers built combined-cycle and peaking units to power new Front Range subdivisions and air conditioning loads. Fort St. Vrain, a decommissioned nuclear plant, was also repowered with gas. When natural gas prices tripled, it then became economical for PSCo to install $1 billion worth of wind.

A Billion Here, A Billion There

Are HCE consumers willing to pay to meet the Governor's climate goals? This is a question we haven't asked them, but will. There are two primary reasons why carbon reductions have high costs. First, natural gas is typically two to three times more expensive than coal. Second, to put Colorado's emissions on a different trajectory, existing coal plants will need to be replaced with lower-emitting power plants. This is a costly proposition, particularly under a tight deadline. The difference between the depreciated value of existing power plants and the cost of new ones is substantial, even staggering. An automotive analogy may be useful: continuing to drive an old beater is much cheaper than buying a Toyota Prius. Today, PSCo's largely amortized plants are worth about $300/kw of capacity. New plants - of any kind - will cost 3-20 times more, an investment that would need to be recovered through significant increases in electric bills.

It's cheaper to drive an old beater than to purchase a new Prius. PSCo's power plants have an estimated average amortized value of roughly $300/kW of capacity. New plants - of any kind - will cost 3-20 times more.

2020 HCE Electricity Bills

	Residential	Commercial	Wholesale Electricity Cost
Base Case	$1,513	$6,173	$134,394,000
Scenario 1	$1,563	$6,416	$141,355,000
Scenario 2	$1,718	$7,171	$159,644,000
Scenario 3	$1,943	$8,260	$194,111,000

Is Early Retirement Wise?

From an emissions standpoint, Colorado can't afford to operate all its existing coal plants. But from a fiscal standpoint, can it afford not to?

Since new power plants can cost a billion dollars or more, they are not bought on a whim. Once built, they operate for decades. As their capital costs are recovered, well maintained plants become sources of inexpensive power. This explains why many coal plants in Colorado are 30, 40, even 50 years old. They may not be as efficient or clean as new ones, but they are mostly paid for. And so Colorado faces a dilemma: on the one hand, the state cannot meet the Governor's 2020 timetable without retiring approximately 2,700 MW of coal plants (out of about 4,900 MW operating in 2005), some of whose capital costs have not been fully recovered. On the other hand, utilities are reluctant to retire functioning power plants whose replacements cost billions. Is there a way to mitigate this conflict? Yes, by extending the proposed 2020 deadline some years, it is possible to reduce the cost of achieving the 20% emissions reduction target.

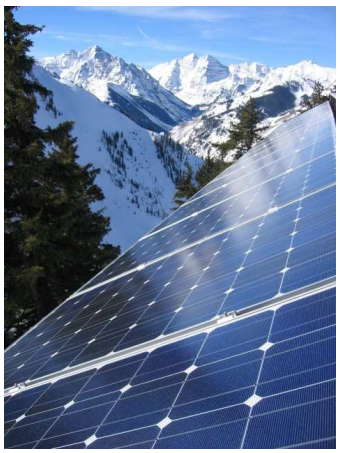
Building New Generation

	Approx. Capital Cost	Build Time	Energy Cost
Conventional Coal	$2,400/kw	4 yrs	6 ¢/kWh*
Combined-Cycle Gas	$1,000/kw	3 yrs	9 ¢/kWh*
Nuclear	$4,300/kw	8-10 yrs	11 ¢/kWh
Wind	$2,500/kw	2 yrs	8 ¢/kWh
Concentrating Solar	$4,000/kw	2 yrs	16 ¢/kWh
Woody Biomass	$3,500/kw	2 yrs	10 ¢/kWh*
Geothermal	$3,600/kw	2 yrs	11 ¢/kWh*
Coal with Sequestration	$6,300/kw	5 yrs	14 ¢/kWh*

*Dependent on fuel costs.

In resolving the climate challenge, time is a critical resource. If the citizens of Colorado want to dramatically reduce emissions by 2050, it's important to get started. But on such a long journey, with so much money at stake, it's equally important to get the pace right too. For Colorado to reduce its 2020 emissions by 20% relative to a 2005 baseline, utilities will need to install many billion dollars of low- and carbon-free power plants. In one possible scenario, where future load growth averages 2%, the electricity now produced by approximately 2,700 MW of coal plants would need to be replaced with generation from five new natural gas plants, which could cost $2.5 billion at a minimum. In addition, the state would need to site, finance, and construct large wind farms, perhaps costing more than $6 billion, and build two of the world's largest concentrating solar plants, at a cost of $4 billion. As an alternative, in lieu of the wind and solar, the state could build two large nuclear stations costing roughly $12 billion. Developing a politically viable, fiscally responsible, and logistically practical strategy for making these large investments is an essential first step, but such discussions have hardly begun.

Carbon-Free Alternatives



The oldest way to produce carbon-free electricity is hydro power, but permitting and construction for new dams is problematic. However, there are hundreds of megawatts of "leftover" hydro sites that could be tapped without building new dams in the Rocky Mountain region. Another commercially proven source of carbon-free electricity is nuclear power, the United States' largest source of non-emitting electricity. However, it has been decades since a new plant was built and costs have grown substantially since the last U.S. installation. A 1,200 MW nuclear plant might cost as much as Denver International Airport to build and take a decade or more to complete. The power from such a plant might cost 11 ¢/kWh and waste disposal could cause additional environmental and legal obstacles. A "carbon-neutral" base load source with a cost in the same range as nuclear power is a biomass plant. Although they emit CO_2, a biomass plant's fuel and emissions are in the natural carbon cycle and permitting is generally much simpler than nuclear. They provide much needed base load capacity for a utility and can provide valuable services to the forestry and waste disposal industries.

Zero-Emission Coal?

Asking Colorado utilities to turn their backs on inexpensive fuel is difficult. Together, Wyoming and Colorado produce half the nation's coal. If coal plants could be developed that captured and stored their emissions in depleted oil reservoirs or saline aquifers, then coal could be used far into the future. The prospects for these zero-emission plants are unclear. A great deal of engineering and legal work remains before "carbon-free coal" is a reality.

Colorado has an excellent wind resource in the Eastern Plains and good solar resources for much of the year throughout the state. Vestas, an internationally recognized manufacturer of wind turbines, has recently built several factories and photovoltaic panel makers are building others in the state. The clean power generated by such technologies is much in demand, as shown by the growth in both small and utility-scale installations all over the world. At the utility scale, PSCo plans to build at least one concentrating solar plant in the San Luis Valley in the next decade, though the expected power cost is about 16 ¢/kWh. Though the cost of solar technologies remains high, it has begun to fall, and electric

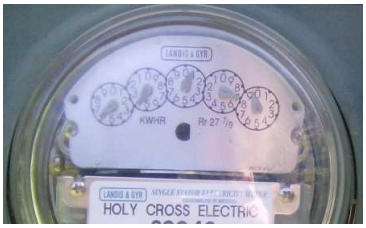
customers are beginning to install solar panels on homes and businesses. HCE has more residential photovoltaic installations than any rural electric utility our size. We hope to have at least one Megawatt of generation installed by 2010, but this will equate to only 0.1% of our energy supplies.

Energy Efficiency - The Fourth Fuel

To be successful, climate policy must be enduring. To be enduring, it must be bipartisan. To be bipartisan, it must be cost-effective. The most cost-effective ways of reducing emissions are found in the realm of energy efficiency and conservation. To resolve the climate challenge, energy efficiency and conservation have to play a leading role. Compact fluorescent lights, Energy Star® appliances, ground-source heat pumps, stronger building codes, mass transit, and smarter land use patterns are essential. If efficiency could reduce demand growth from 2% to 1% per year it would be much easier and cheaper to achieve any emissions goal. In recent years, Colorado has ramped up investments in efficiency, but savings from such measures are difficult to measure.

The cheapest source of new clean power is wind, at 8 ¢/kWh. Lots of electricity can be saved at a lower cost.

The Other Side of the Meter



Although Holy Cross Energy has promoted efficiency for a more than a decade, our ability to control what happens on the customer's side of the meter is limited. We can provide advice, encouragement, free programmable thermostats, and rebates, but if a homeowner wants to add a second refrigerator (1,200 pounds of CO_2 annually), plug in a hot tub (4,000 pounds a year) or purchase a plasma TV, that is their decision. Utilities ultimately have little or no control behind the meter. Despite the price increases of recent years, electricity remains a bargain, which may be why a typical household uses a bit more each year. Can we send a stronger price signal? HCE is considering an inclined block rate that would provide residential customers an incentive to reduce electricity use. Devices that provide real-time information on energy use seem promising and might prompt customers to reduce consumption. Will PSCo's smart grid investments in Boulder lead to significant energy reductions? If so, spending $60 million to install similar technology in our service territory might be a prudent investment. Saving energy saves both money and pollution, but doing it generally requires an up-front investment of capital, intelligence, and labor.

The Energy Landscape of the Future

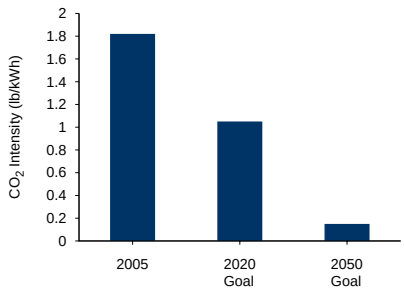
The Last Great Bargain

In 2005, a typical HCE household paid about $1,100 for the nearly 12,000 kWh it used that year. A kilowatt-hour is as much work as the strongest player on the high school football team can do in a day, the same amount of work as is produced in riding a bicycle 100 miles, all for less than a dime. It is one of the world's great bargains.

Since the energy dilemma - in all its dimensions - will not be solved overnight, it helps to take the long view. According to scientists, a 20% reduction in greenhouse gas emissions is not sufficient to resolve the climate challenge. Deeper cuts are needed. Both Colorado Governor Ritter and California Governor Schwarzenegger have proposed 80% reductions by 2050. Meeting that goal would require enormous alterations in the energy landscape. What would a decarbonized world look like, how do we get there, and what role would electricity play in it?

The Electric Power Research Institute (EPRI) has studied these questions and reached some intriguing conclusions. To achieve an 80% reduction in global greenhouse gas emissions, the burning of gasoline, diesel, and natural gas in a billion vehicles and buildings will gradually need to end, because there is no feasible way to capture emissions from so many distributed pollution sources. In the future, a great deal of fossil fuel will still be used - but only at power plants where carbon capture technologies are available. By 2050, electricity's share of primary energy will have soared. Carbon-free electricity would need to be everywhere, much like oxygen. It will be produced by some combination of hydropower, nuclear, solar, wind, tidal, biomass, and geothermal, plus coal and natural gas plants that sequester their emissions.

Electric Sector CO_2 Intensity



If the climate challenge is successfully addressed, by 2050 the electric sector will be thoroughly decarbonized, with a carbon intensity of at most 0.2 lb/kWh - one-tenth that of today's most efficient coal plants, and one-fourth that of today's best natural gas plants. Because they would not have boilers or furnaces, buildings would be super-insulated. Some would harvest electricity with solar cells on their roofs. Heating and air conditioning would come via ground-source heat pumps powered by clean electricity. In the transportation sector, electric vehicles would have replaced those equipped with internal combustion engines. Air travel and long distance road transport would likely use advanced biofuels.

> *Energy will be one of the defining issues of this century.*
> - David O'Reilly, Chevron CEO

Many technological and economic uncertainties exist. Will carbon sequestration prove economical? Will nuclear power enjoy a renaissance? If sequestration and nuclear remain economically uncompetitive, perhaps due to a breakthrough in solar technology, then in 2050 the world might be running primarily on flows of wind, water, and sun rather than fossil fuels. High voltage DC lines might transport solar electricity from the Southwest and wind power from the Great Plains to both coasts.

Reliance on intermittent wind and solar implies expanded electrical storage - in batteries, flywheels, or as hydrogen. Excess power from wind farms might be used to store compressed air in underground caverns for later recovery, a technology being explored in Iowa. In mountainous states, the need to store many days' worth of electricity might require numerous pumped hydro systems. Smart grid technologies, distributed generation, and super-efficient appliances would be widespread. As decarbonization proceeds in China and India, climate change abates.

If this is where we need to go, policies that focus on emission reductions tend to obscure what's needed. If prosperity, national security, and environmental realities prompt us to redesign the energy basis of our economy, electricity will be the primary form of energy consumed by 2050, and even higher electric growth rates can be expected. What would the clean energy transition cost here in Colorado? The question deserves more thorough study. Our calculations suggest that meeting the Governor's 2020 goals might cost a typical HCE household an extra $17 to $36 per month, depending on how it is accomplished. Elsewhere in Colorado, compliance cost would be highest for fast-growing utilities and for wholesale providers who currently rely on coal. Would HCE customers pay this price to keep Colorado a special place? That's a question we intend to ask.

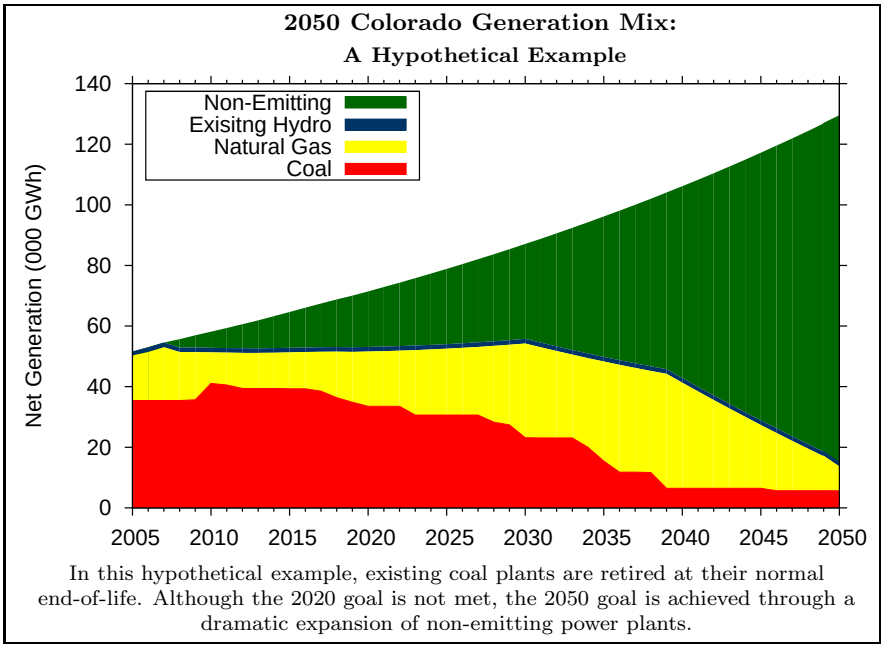
What would the clean energy transition cost? Based on our calculations, it might cost a typical family about $25/month over the Base Case, less than a typical cell phone bill.

A Sensible Colorado Strategy

If Colorado aims to decarbonize its economy over the next four decades, then the state government should develop a comprehensive plan to that end. A detailed blueprint and realistic cost estimates are needed, recognizing that fixed targets and timetables may not be the most cost-effective pathway. Building on work by the Colorado Climate Action Panel, Colorado Energy Forum, and Rocky Mountain Climate Organization, a bipartisan stakeholder's group could identify strategies for overcoming the obvious (and not so obvious) economic and technical challenges.

By 2020, the incremental cost of reducing emissions could be $1 billion or more annually. Bipartisan leadership will be crucial to secure support and citizens must be engaged in the discussion since they will be footing the bill.

One priority is to slow load growth. This would require an aggressive, statewide effort to encourage efficiency and conservation. Utilities can help, but it is policymakers and consumers who ultimately control energy usage. If growth rates can be slowed, then emissions could be reduced through fuel switching and the installation of thousands of Megawatts of new natural gas plants and zero-emitting resources - wind, solar, biomass, geothermal, and perhaps nuclear or coal plants with sequestration. There are no magic wands. The capital investment needed to create a new emissions trajectory is very large and will extend for some decades. This reality must be directly addressed, not ignored. Bipartisan leadership will be crucial to secure civic support and to engage voters in the discussion since they will have to foot the bill.



In this hypothetical example, existing coal plants are retired at their normal end-of-life. Although the 2020 goal is not met, the 2050 goal is achieved through a dramatic expansion of non-emitting power plants.

By 2020 the state might need to spend $1 billion to $1.5 billion each year to reduce its emissions. That estimate, which does not include costs imposed by federal legislation, needs more careful analysis, but it is in the right ballpark.

Simple arithmetic shows that a continued reliance on conventional coal is incompatible with climate protection. However, most of Colorado's existing coal plants will reach retirement age between 2020 and 2040 and will need to be replaced regardless. To avoid stranding valuable assets, the oldest and least efficient plants should be retired first. PSCo's

decision to close its Cameo and Arapahoe plants signal that this process is underway.

By 2050, most of Colorado's electricity will need to come from non-emitting technologies. There are many options, but little certainty about what these replacement resources will cost, where they should be located, who should build them, and when. Operational issues must be addressed. Today's coal plants typically operate 24/7 and will need to be replaced with generation assets that have roughly similar characteristics. Clearly, some new combined-cycle natural gas plants will be necessary. It's likely that another 2,000 MW of wind will need to be installed in eastern Colorado. New transmission lines will be needed to facilitate that, and to tap the solar potential in the San Luis Valley. As time goes on, distributed generation may play a growing role, particularly if there's a breakthrough in photovoltaics.

Our Commitment

The managers of Holy Cross Energy work for our consumers, who are generally supportive of environmental initiatives. Providing reliable electricity is our top priority - but we take the nation's energy challenges very seriously. HCE was a leader in promoting renewable energy and efficiency long before the passage of Amendment 37 and has already met the 2020 renewable energy standards established by the Colorado legislature. The HCE Board has voluntarily set a goal of supplying 20% of energy sales from renewable sources by 2015 and of slowing our growth in carbon emissions to one-half our sales growth rate. We allocate 2% of gross operating revenues to fund these programs.

Our "We Care" program provides free residential energy audits and efficiency grants to commercial customers. Residential consumers are eligible for free electric water heater blankets, compact fluorescent light bulbs, rebates on Energy Star® refrigerators, clothes washers, and programmable thermostats. We subsidize the disposal of old refrigerators and the capture of their greenhouse gases. Approximately 2,900 members participate in our green pricing program, one of the country's most successful. We have net metered renewable systems since 1998, and are one of the few utilities in America that buys electricity from locally-owned, run-of-river hydropower plants at a premium. In our internal operations, we employ sophisticated system design to maximize system efficiency and reliability. We are pleased with what we have accomplished, but recognize that even more remains to be done.

Although it would be difficult to complete the job in a decade, it is possible to make Colorado's energy systems cleaner and more sustainable. Climate change is a particularly taxing challenge that is compounded by the growth dynamic. Resolving it will most likely occur as part of a long-term, bipartisan effort to secure America's energy and economic future. The staff and owner/members of Holy Cross Energy look forward to working with Governor Ritter and the Governor's Energy Office to achieve that end.

Please see the next page for notes on our assumptions and information sources, as well as suggestions for further reading.

Notes, References, and Further Reading

Notes on the Analysis, Plus a Few Caveats

This paper tries to provide an honest appraisal of the actions needed to meet Governor Ritter's 2020 and 2050 goals, however a few disclaimers are required. Our analysis does not calculate the cost of inaction, of the "negative externalities" that could be caused by a warming climate. This paper does not attempt to calculate either positive or negative effects on the Colorado economy due to climate action, nor does it try to predict the timing or form of federal climate policy. Federal policies that impose a carbon price in the $10 to $20 per ton range would increase Colorado electricity prices, but are unlikely to achieve significant reductions in the state's greenhouse gas emissions. On the contrary, the Electric Power Research Institute estimates that a carbon price in the $60 to $80 range would be needed to drive the kind of dramatic transformation described here. We also did not try to model the effects of the current recession on electricity demand, since projected increases in statewide greenhouse gas emissions are primarily driven by population growth. If the state builds a fleet of lower- and non-emitting power plants, electricity prices will rise, which should lead to some increased conservation. We did not model this price elasticity but account for it in some calculations. The cost estimates for new power plants shown on page 6 were derived from utility sources. Federal tax credits could reduce the prices for wind, solar, and biomass plants. Finally, our analysis does not include the effects of future growth in demand due to electric vehicles, which has the potential to increase electric sector emissions significantly, even as they reduce those from the transportation sector.

The Electric Sector's Role In Climate Change

Colorado's 2005 greenhouse gas emissions were calculated by the Governor's Climate Action Panel. Its inventory uses metric tons; in this paper, we converted them to short tons. The report is available at the Governor's Energy Office website: http://www.colorado.gov/energy/in/uploaded_pdf/ColoradoClimateActionPlan_001.pdf.

Coal plants are responsible for 85% of Colorado's electric sector carbon dioxide emissions. A large plant will produce 5 million tons of CO_2 per year, about as much as one million automobiles. It is often said that climate change is a "coal dilemma." This is true, but reducing emissions in the transportation sector poses tremendous challenges as well.

The Growth Dilemma

Absent load growth, Holy Cross Energy's 2008 emissions would be 15% lower than they were a decade earlier, due to changes in PSCo's fuel mix. U.S. per capita emissions are slowly falling. If the nation had not added 50 million people since 1992, the 7% reduction in greenhouse gases proposed in the Kyoto Treaty would be within reach.

Professor Bartlett's lecture is available at www.albartlett.org/presentations/bartlett_presentations.html.

The U.S. Energy Information Administration's overview of U.S. electricity is available at www.eia.doe.gov/emeu/aer/eh/frame.html.

Note: Carbon Intensity

The national average is 1.35 lb/kWh, with large regional variations. Coal-reliant states have intensities of around 2 lb/kWh. The absolute reductions needed to achieve the Governor's 2020 and 2050 goals depend on the growth rate of electricity consumption.

Our calculations for the statewide scenario use the Colorado Energy Forum's base case as a starting point. See "Colorado's Electricity Future" at www.coloradoenergyforum.org/Portals/23/Studies/Colo_Elec_Future_Report.pdf.

A Herculean Task

Colorado's current population is 5 million and it is growing by about 90,000 each year. The State Demographer estimates that 7.3 million people will live here by 2030. Further information is available at: www.dola.state.co.us/dlg/demog/presentations/demographic_fact_sheet.pdf.

"Running Down an Up Escalator"

Logic suggests that to keep electric sector emissions flat, all future growth in demand must be met by non-emitting generation. This axiom is irrefutable, but it takes some effort to grasp the implications.

Burn Less Coal?

The chart is derived from data published by the U.S. Energy Information Administration for years through 2007. For years after 2007, it shows a hypothetical future designed to meet Governor Ritter's 2020 goal. It assumes an average 2% annual growth rate in energy demand.

Many Critical Questions

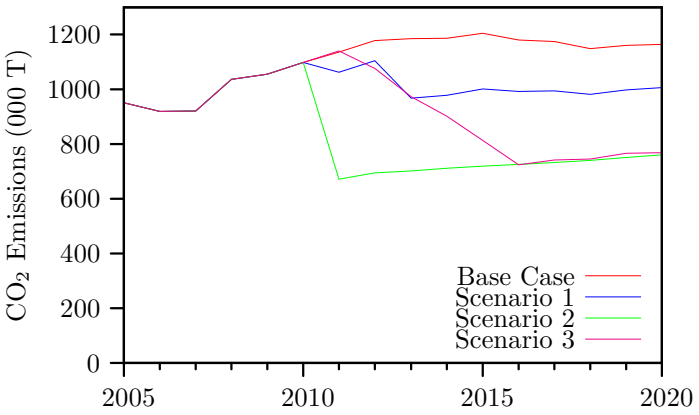
This list of issues that need to be more thoroughly analyzed could be expanded. The annual cost of substituting natural gas for coal could be higher or lower than the $500 million shown here. The future cost of natural gas is a wild card. We use price projections from the U.S. Energy Information Administration.

Note: Is There Enough Natural Gas?

The unlocking of very large shale gas reserves in Texas, Arkansas, New York, and Pennsylvania has led to an unexpected and dramatic increase in U.S. natural gas production. This has caused many experts to alter their view of natural gas fundamentals. For some time to come, Rocky Mountain natural gas prices may be lower, and the pace of drilling slower, than had been anticipated.

Holy Cross Energy Scenarios

HCE Emissions Under Each Scenario



The figures for HCE wholesale power costs and residential bills are in nominal dollars.

Our modeling assumes that PSCo is successful in reducing its greenhouse gas emissions to meet the Governor's 2020 goal.

In the Base Case, electricity rates rise slowly, in real terms, at about 1% per year. The spike in coal purchases in 2009-2010 reflects the beginning of operations at Comanche 3.

CO_2 emissions peak at about 1.2 million tons in 2015 under the Base Case, then remain relatively constant over the forecast period. In Scenario 1, emissions are reduced to approximately 2005 levels after the wind farm and biomass plant are brought online. In Scenarios 2 and 3, HCE's emissions fall to 80% of 2005 levels by 2020. The sudden drop in Scenario 2 reflects a full change in the source of HCE's electricity purchases from PSCo in one year. In Scenario 3, a 5 year period is allowed for transition between PSCo purchases and a cleaner blend from other sources. In both of the scenarios that meet the Governor's 2020 goal, an upward trend in emissions is visible, this is caused by an increase in natural gas usage to meet load growth.

A Billion Here, A Billion There

The average residual value of Public Service Company of Colorado's existing generation assets is derived from documents filed with the Federal Energy Regulatory Commission.

Holy Cross Energy's Share of Comanche 3

HCE exercised a contractual option to purchase a share of PSCo's third coal unit at Comanche Station, near Pueblo, Colorado. Participation in the project provides a hedge against the potential loss of the all-requirements contract with PSCo. Feasibility studies for the project show significant economic advantages for HCE consumers over the long-term, though there are potential negative consequences as well. While Comanche 3 is the cleanest coal plant in Colorado, it would require HCE to reduce the coal portion of its contract to zero in order to meet the Governor's goal and will increase HCE emissions in the short-term.

Is Early Retirement Wise?

Colorado has 14 operational coal plants. The 10 largest plants produce two-thirds of the state's electricity.

Building New Generation

To meet the Governor's 2020 goal, the state must displace coal with natural gas and simultaneously add to its fleet of non-emitting resources. The ballpark cost of building 2,700 MW of combined-cycle gas, 2,500 MW of new wind, 1,000 MW of concentrating solar, plus implementing 600 MW of efficiency savings is in the range of $10 to $12 billion (excluding additional resources to meet reserve requirements). Nuclear or sequestered coal could be substituted for the wind and solar, but probably not by 2020 and probably not at lower cost. The cost of nuclear plants and of coal plants with carbon capture is uncertain, but political opposition to their construction seems likely.

Energy Efficiency - The Fourth Fuel

Between 1985 and 2000, the real cost of electricity fell dramatically. In recent years, it has risen. Nonetheless, consumers' incentive to save a 9¢ kilowatt-hour is relatively weak.

A Sensible Colorado Strategy

The chart shown here is a hypothetical illustration of a future in which Colorado electric sector emissions are 80% below 2005 levels. By 2050 some 90% of estimated Colorado generation would need to come from non-emitting sources (including conservation). By 2035, even natural gas must be phased out in favor of lower-emitting alternatives. Reductions in Colorado's electric sector would need to be matched by reductions in the transportation, agricultural, commercial, and industrial sectors to have lasting climate benefits. And those reductions would have to occur throughout the United States and in the 20 other nations that together produce more than 80% of the world's carbon dioxide.