# POWER TO CHANGE

## HOW ALBERTA CAN GREEN ITS GRID AND EMBRACE CLEAN ENERGY

James Glave and Ben Thibault

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**Clean Energy Canada** (cleanenergycanada.org) is a solutions-focused initiative working to accelerate Canada's transition to an energy-efficient, ecologically responsible, and prosperous low-carbon economy.

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# EXECUTIVE SUMMARY

Within 20 years, Alberta could reduce its heavy reliance on fossil fuel energy and instead supply the province's electricity mostly from clean and renewable energy. In doing so, the province would:

- Cut air and carbon pollution
- Improve air quality, leading to lower public health costs
- Reduce exposure to the economic and security risks that come with relying too heavily on a single fuel source and overly centralized power grid
- Kick-start a new industry

With effective policy, the province could cut the percentage of grid electricity that is supplied from coal energy from over 60 per cent today to less than four per cent by 2033. It can do this without simply throwing the switch over to natural gas, which is where the power sector is now headed. While natural gas burns cleaner than coal, it is also subject to price spikes and long-term price risks that can hurt customers. A large-scale shift to renewable power would reduce the electricity sector's carbon pollution by 69 per cent relative to the wide-scale switch to natural gas power generation expected under business as usual.

Further, Alberta could make this major power shift without creating hiccups on the grid, and without hitting citizens and businesses hard in the pocketbook.

Though Alberta's oilsands sector attracts a great deal of critical attention both at home and abroad, the province's electricity sector generates almost the same quantity of carbon pollution. This is due, in large part, to the province's continued reliance on coal. At present, Alberta burns more coal for electricity than all other provinces combined. On an annual basis, Alberta's coal-fired electricity releases roughly the same quantity of greenhouse gases as half of all the passenger vehicles on the roads in the entire country, in addition to health-damaging sulphur and nitrogen oxides, mercury and particulate matter.

Fortunately, the solution is close at hand.

Alberta enjoys some of Canada's most abundant and reliable renewable energy resources—including 150 gigawatts (GW) of potential wind power, 11 GW of potential hydroelectricity, and 120 GW of potential demonstrated geothermal power (Canadian Wind Energy Association, 2013; Alberta Utilities Commission, 2010; Canadian Geothermal Energy Association, 2013). As for solar photovoltaics, it would be possible to meet Alberta's annual electrical energy needs with solar panels alone; doing so would require 1,746 $km^2$—or 0.26 per cent—of the province's total land area (Kelly, 2014). Myriad opportunities also exist to use electricity much more efficiently.

In a variety of forums and media articles, the Government of Alberta continues to develop an Alternative and Renewable Energy Policy Framework—first suggested by an industry and NGO working group in 2005. In once again committing to the framework in early 2014, the province said the framework would empower consumers to exercise choice within the market-based electricity system.

Meaningful policy is badly needed. It could lower barriers to clean energy development and unlock opportunities to harvest the abundant and largely overlooked renewable resources that shine down, grow from, emerge from, flow over, and blow across the province.

Albertans have the resources, the know-how and the opportunity to become clean energy leaders

# ABOUT THIS REPORT

*Power to Change: How Alberta Can Green its Grid and Embrace Clean Energy* outlines two scenarios under which the province could cut air pollution and greenhouse gases while reducing the energy security and economic risks associated with relying too heavily on a single source of electricity.

This document outlines how quickly—and to what degree—Alberta can reduce its risky reliance on a single source of fuel, be it coal (historically and present day) or, increasingly, natural gas. While this report stops short of prescribing a particular policy, it does identify the main barrier to increased renewable energy adoption in the province and supports policy measures designed to overcome it.

We produced *Power to Change* to inform Albertans that they have the resources, the know-how and the opportunity to become clean energy leaders. We also hope to inspire provincial electricity-policy leadership and set the bar of ambition for what a prospective Alternative and Renewable Energy Policy Framework should look like.

Most of all, the results demonstrate that Alberta can reduce its heavy reliance on fossil fuels for electricity supply, diversifying its grid with a stronger mix of clean renewable sources. A clean electricity transition and transformation is possible, practical, affordable and in the interests of Albertans.

Photos on this page: David Dodge, Pembina Institute

# THE LAY OF THE LAND: HOW ALBERTA SOURCES ITS POWER


David Dodge, Pembina Institute

In early 2009, the Pembina Institute released *Greening the Grid: Powering Alberta's Future with Renewable Energy*. The report outlined how the province could use proven technologies to harvest its abundant solar, wind, hydro, and biomass energy resources. It concluded that the province could transition its grid from one based on coal, to one based on cleaner and more diverse supply, including these renewable resources, within 20 years.

Five years later, Alberta has made some progress in diversifying its electricity system and cutting energy waste.

Since 2009 the province has almost doubled its installed wind power—adding more than 500 MW of capacity to reach 1,120 MW of operating capacity (with another 300 MW to begin operation in 2014), and supplying more than five per cent of the electrons sent over the wires in 2013. While Alberta still has no utility-scale solar generation, more than 700 small-scale systems have been installed under a regulation that allows Albertans to install their own solar systems. While this only accounts for 2–3 MW of supply on a 14,000 MW system, the amount has increased several times over in the past five years.

The Alberta Electric System Operator (AESO) proved an early leader in facilitating grid access for wind. But it has taken more than this to bring turbines to the province. Because of the way that the province's deregulated electricity market is structured, many wind farms would not exist without targeted support, which is no longer available.

For example, in 2011 Calgary-based Greengate Power signed a 20-year purchase agreement that provided a California power utility with renewable energy credits. The agreement helped to finance a 150 MW wind farm in central Alberta and another separate 300 MW project southeast of Calgary.

Ottawa also provided support. Between 2002 and 2012, two federal government programs helped bring most of the province's other wind projects online. Those federal programs have since expired, while California credits are no longer practically available for new projects in Alberta.

Biomass has also played a modest role. Since 2009, Alberta power developers have connected around 72 MW worth of biomass energy onto the grid. Again, those projects benefitted from a provincial production incentive that is no longer available.

Alberta has also made progress on energy efficiency. For example, since 2010 the Climate Change and Emissions

Management Corporation—an arm's-length government organization chartered to reinvest the proceeds of a carbon levy on major industrial polluters—has invested approximately $37 million in support of energy efficiency initiatives in the province.

While these are positive steps, most of Alberta's renewable energy resources lie fallow. The grid remains around 85 per cent fossil fuel powered—and most of that power comes from burning coal.

The numbers are arresting. Alberta's 18 coal power units make the province's electricity the highest polluting in the country—contributing more than half of the total carbon pollution from electricity generation in all of Canada. The plants also release nearly the same volume of greenhouse gases as the province's oilsands sector, as shown in Figure 1.

In 2011, Alberta coal power plants produced 113,000 tonnes per day of greenhouse gas pollution (measured as $CO_2$ equivalent). Each year, that adds up to over 40 megatonnes. That's the same amount produced by roughly half of all cars on the road in Canada today.

Some people in Alberta's government and electricity industry occasionally defend the sector's pollution record by pointing to the United States—where coal remains a leading source of power generation. But the data shows the U.S.'s coal power reliance is falling considerably faster than Alberta's.

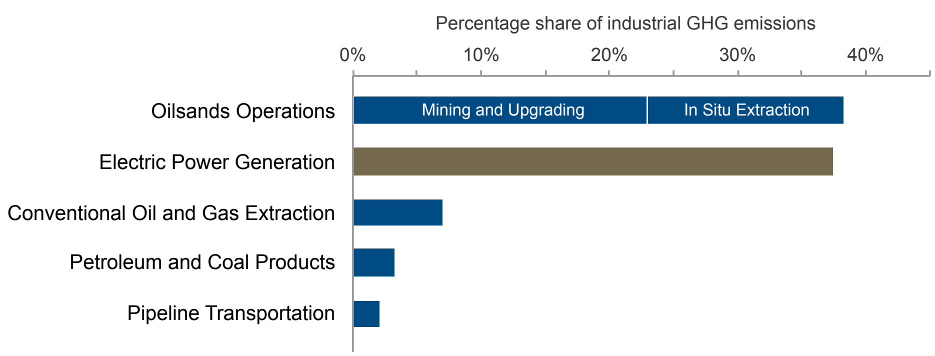
Last year, coal power generation supplied 39.1 per cent of the electricity in the United States, whereas it generated 63.7 per cent of electricity in Alberta's grid. Between 2007 and 2013, total coal power generation in the United States decreased by 21.3 per cent; over the same period, it decreased in Alberta by 13 per cent.

Meanwhile, following a contractual obligation, in late 2013, generation company TransAlta returned a pair of idled coal units to service. As a result, coal power generation actually grew from 2012 to 2013, and could grow further yet, before it shrinks. Our analysis indicates that coal power generation in Alberta could nearly return to peak 2007 levels (with all units fired up) before federal rules kick in that will eventually require the decommissioning of older plants.

What's the result? For a given gigawatt-hour of electricity generated, Alberta's grid emits about 800 tonnes of equivalent greenhouse gases; the United States' national grid emits 500.

In contrast, an Alberta grid powered primarily by renewable energy could diversify the economy, buffer customers from future price shocks, provide rural economic development opportunities, and of course reduce pollution and greenhouse gases.

**Figure 1: Share of industrial GHG emissions by major sector in Alberta**



David Dodge, Pembina Institute

# THE MAIN BARRIER TO RENEWABLE POWER IN ALBERTA

Simply put, it is extremely difficult to finance a wind or solar farm—or, for that matter, a hydroelectricity or geothermal power plant—in Alberta.

Renewable energy is a capital-intensive business. Once a given wind or solar farm is built, the developer can supply electricity at a very low operating cost for the life of the project—but in Alberta the first hurdle is the highest.

The province's deregulated market offers generators both pros and cons. On one hand, a supplier of any kind can directly contract with a customer, and any generator can risk making an investment and sell directly to the market. On the other, the market does not adequately support the benefits of renewable energy; the societal costs of fossil fuel power are inadequately priced with a cap of $15/tonne for carbon and no air quality cap and trade program. Further, there are very few long-term power-purchase contracts available.

So, while renewable energy technologies may be competitive against any other new generation source on an apples-to-apples cost basis—for example, wind energy's levelized cost of electricity is as low as any other energy source—the revenue uncertainty thwarts a developer's ability to attract financing to a project.

This financing barrier remains the most significant barrier to renewable power in Alberta today. As KPMG recently determined, "Providing debt financing to a wind farm … will continue to be challenging unless some market mechanism can be introduced to manage downside risk, or some level of contracting can be arranged" (KPMG, 2014).

Ben Thibault, Pembina Institute

# A POWER SYSTEM PRIMED FOR CHANGE

As any economist will tell you, the price of a given product or service should accurately reflect its true cost and value. In the case of Alberta's electricity market, we know that pollution represents a cost to society—through health impacts and degraded land and water. Although the costs of pollution are challenging to calculate, they are not impossible to quantify.

Just over a year ago, a coalition of public health organizations—the Asthma Society of Canada, Canadian Association of Physicians for the Environment, and The Lung Association of Alberta and NWT—published a study with the Pembina Institute. *A Costly Diagnosis: Subsidizing Coal Power With Albertans' Health* concluded that the price consumers pay for coal power doubles—or even triples—when health and ecological factors are accounted for (Anderson et al., 2013).

*A Costly Diagnosis* found that burning coal in Alberta runs up a tab of roughly $300 million a year in health costs. In the past five years, Alberta's citizens and businesses have spent roughly $1.5 billion on health care costs indirectly related to coal.

Furthermore, Environment Canada's analysis of its own coal regulations found that by limiting coal units to a maximum life of 50 years, more than 590 premature deaths would be avoided in Alberta over the next 20 years—the time horizon of this report (Government of Canada, 2012).

Burning coal in Alberta runs up a tab of roughly $300 million a year in health costs.

A spring 2013 NRG Research Group poll found that more than two-thirds (68 per cent) of Albertans want coal plants phased out or shut down and replaced with natural gas and renewable energy such as wind, solar and hydro (Clean Energy Canada, 2013). A more recent poll found that 80 per cent of Albertans would like their electricity generated from renewable sources such as wind and solar instead of burning black rock. The latter research also found that two-thirds of Albertans are willing to pay higher prices for electricity generated by wind and solar power (Klinkenberg, 2014).

# A GROWING NEED FOR POWER: MIND THE SUPPLY GAP

Alberta's appetite for electricity will grow in lockstep with its oilsands sector. The Alberta Electric System Operator predicts that 6,190 MW of new electricity generation capacity will be needed by 2022, and that 12,965 MW more will needed by 2032 (Alberta Electric System Operator, 2012).

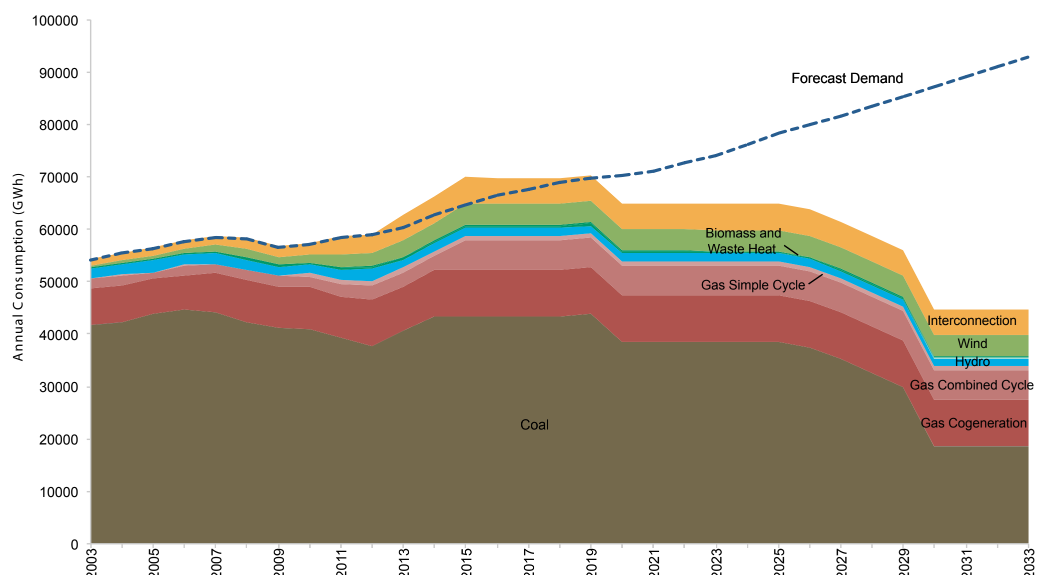
When it comes to significantly reducing greenhouse gas emissions while meeting increasing supply needs, non-emitting renewable electricity is hands-down the most competitive and effective solution. Once a grid is cleaned up, it can enable emissions reductions in other sectors (such as transportation via electric vehicles). Many technologies for carbon sequestration and transformation of waste $CO_2$ into valuable products hinge on low-emitting electricity sources. A cleaner grid enables these technologies and accelerates greenhouse-gas reductions.

To gain a better understanding of how renewables can fill the anticipated demand, we tabulated all the generation capacity currently in place or under construction, and forecasted generation from these sources out to 2033. We then compared this total with the anticipated demand, based on our analysis of data from both the industry and the Alberta Electric System Operator (EDC Associates, 2013, and Alberta Electric System Operator, 2014). The analysis (see Figure 2) shows a "gap" between existing and committed generation and projected demand.

In September 2012, Canada's federal government introduced regulations that limit the operational lives of coal power plants to a maximum of 50 years. The rules will very gradually reduce Alberta's reliance on coal over the next five decades. The last of Alberta's coal-fired power plants could still operate—without any requirement to reduce carbon pollution—through 2061.

Clearly, these existing federal regulations will not spark the province's energy transition and transformation in the near-to-medium term.

**Figure 2: Existing power generation in Alberta and forecast demand**



# THE RISKS OF BUSINESS AS USUAL

Alberta's power industry is of course well aware of the looming demand-supply gap, and has a solution in mind: natural gas. As outlined in Scenario 1 on page 11, the industry expects to ramp up gas generation in the coming years. However, though it may be economic today, gas is far from the panacea that the power industry is holding it up to be.

History shows that natural gas prices are notoriously volatile. The fuel is currently cheap, but with increased demand in the United States and a move to export natural gas through liquefied natural gas terminals, it is very plausible that its price will rise and fall unpredictably.

It's happened before. North American natural gas prices rode a roller coaster between 2001 and 2008 when a lack of spare productive capacity led to tight market conditions (National Energy Board, 2013). More recently, things have settled down—the result of rapidly growing shale and other unconventional gas production. Add in depressed demand in the wake of the 2008 recession, and you end up with the low and relatively stable price that we hear so much about these days.

But as Calgary-based energy economist Peter Tertzakian has noted, potential supply-side constraints could easily kick in—for example, challenges in gaining and retaining social licence for drilling and fracking, and the growing awareness of the impacts of all fossil fuels (Tertzakian, 2014). Similarly, unexpected shifts on the demand side, such as a cold winter followed by a hot summer, could easily drive up consumption. A Citi Group analysis noted that natural gas prices have recently risen, as has price volatility (Citi Research, 2014).

Other industry watchers have expressed concern about production decline rates from shale gas and the impact that liquefied natural gas exports could have on natural gas prices and associated volatility, both of which would be likely to increase (Roche, 2014).

Renewable energy sources present an opportunity to mitigate these price risks by diversifying supply and addressing the supply-demand gap with secure fixed-cost generation.


David Dodge, Pembina Institute

# ONE PROMISING PATH: A RENEWABLE ENERGY POLICY FRAMEWORK

Alberta's generation-demand gap presents the province with an unprecedented opportunity to seriously slash greenhouse gas emissions, lower public healthcare costs, and create new business and investment opportunities.

Around the world, a number of economic, environmental, and security imperatives are accelerating the global adoption of renewable energy. Last year, investors poured $254 billion into solar, wind, and other clean power sources. (Pew/Bloomberg New Energy Finance, 2014). In large part due to massive and ongoing clean energy investments in China, wind and solar—once expensive boutique technologies—are now competitive with fossil fuels in many jurisdictions.

Solar module prices have plunged about 80 per cent since 2008. Total system costs for global best-in-class utility-scale solar installations now run $1.55 per watt, and are expected to continue falling. Meanwhile, global wind turbine prices dipped roughly 35 per cent between 2009 and 2013—a 23 per cent decline in the levelized cost of electricity for wind (Business Council for Sustainable Energy/Bloomberg New Energy Finance, 2014).

Though total worldwide investment in renewable energy declined last year, it continued to grow in Canada—45 per cent, in fact, from 2012, to reach $6.5 billion in 2013. This made Canada the second-fastest growing market for clean energy investment in the G-20 (Pew/Bloomberg New Energy Finance, 2014). Unfortunately, as one of the very few jurisdictions in North America to lack a renewable energy policy, Alberta received very little of this new investment.

This amounts to a tremendous lost opportunity. Alberta's abundant renewable energy resources offer not only a potential multi-billion dollar investment, but also—when combined with energy efficiency measures—some of the most cost-effective pollution reduction opportunities available. With projected growth in carbon pollution from other sectors, the province cannot leave electricity sector greenhouse gas reduction opportunities on the table. As demonstrated by this analysis, transitioning Alberta's electricity supply to clean and renewable sources offers the province substantial and much-needed carbon pollution reductions.

An Alternative and Renewable Energy Policy Framework could set the stage for the clean power transition and transformation.

As noted above, however, Alberta does not yet offer a competitive renewable energy investment climate under the current market design. Wind and solar power developers—including some based in Alberta—pursue more attractive investment opportunities elsewhere, including in other Canadian and U.S. jurisdictions. To grasp this opportunity, the province needs to take concerted action.

An Alternative and Renewable Energy Policy Framework could set the stage for the clean power transition and transformation outlined below. Provincial leaders have been mulling such a framework for many years. We trace its origins to the Clean Air Strategic Alliance's Alternative and Renewable Energy Project Team—a multi-stakeholder group formed in 2002 that included representatives from industry, government, and civil society. As early as 2005, the team recommended that the province develop just such a framework—advice the team reiterated in its 2007 final report (Clean Air Strategic Alliance, 2007).

In the years since, the government committed—and recommitted—to the framework, and did some work on it. But the project largely sat on the back burner until this past December, when the province appointed its first associate minister of electricity and renewable energy—a position since vacated. Several months later, the March 2014 Speech from the Throne reiterated the government's intent to introduce the renewable energy framework.

Though the appetite for leadership on reducing fossil-powered electricity and increasing renewable energy remains uncertain, the opportunity for Alberta to diversify its energy mix and reduce pollution is as clear as ever.

Roberta Franchuk, Pembina Institute

# METHODOLOGY

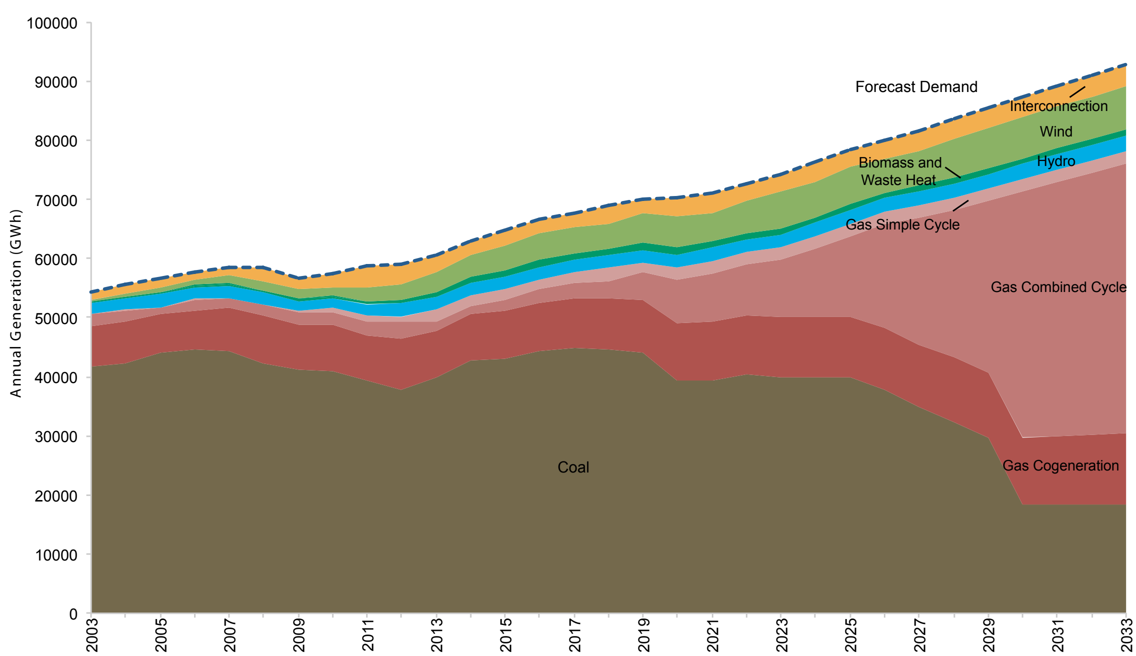
To understand the degree to which provincial policies could reduce coal's share of Alberta's power-generation mix, we modelled three scenarios, which we have called Continued Fossil Reliance, Clean Power Transition, and Clean Power Transformation. We will discuss each of these, along with their results and impacts. For a discussion of our approach to effective capacity, price modelling, and greenhouse gas projection, please refer to the Appendix.

## SCENARIO 1: CONTINUED FOSSIL RELIANCE

Our Continued Fossil Reliance scenario assumes a business-as-usual approach to power demand and production in Alberta. We have based it on two publicly available forecasts of electricity demand and generation supply—those of the Independent Power Producers Society of Alberta (the trade association representing the province's power generators) and the Alberta Electric System Operator (the organization that operates Alberta's electricity grid).

This scenario sees annual electricity demand growing by around 53 per cent by 2033 and sees the province continuing to rely on coal (20 per cent) and natural gas (64 per cent) to supply the majority of its electricity needs. As Figure 3 shows, in this scenario Alberta exchanges its current heavy reliance on coal for natural gas, a more price-volatile fossil fuel.

**Figure 3: Projection of annual generation by fuel source under the Continued Fossil Reliance scenario**



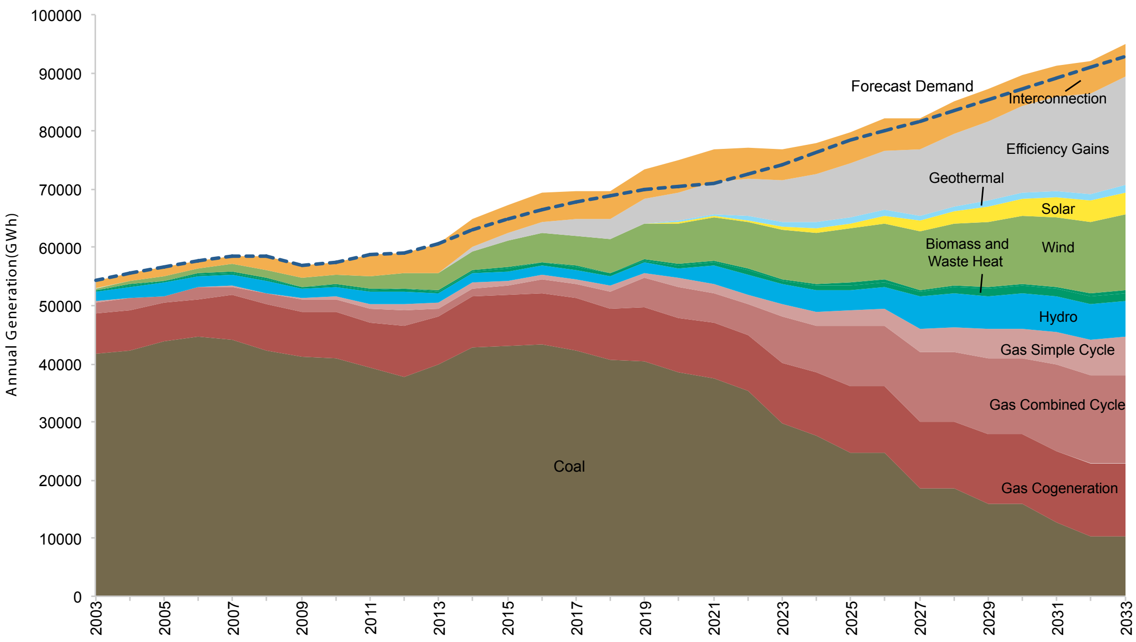
# SCENARIO 2: CLEAN POWER TRANSITION

We rooted this model on the existing and committed generation capacity developed through the gap analysis above, with one notable exception: we specified earlier decommission years for existing coal plants. We chose moderate near-term coal plant shutdown dates, avoiding immediate shutdowns and allowing for more-than-adequate timelines to permit and build replacement generation. This scenario lowers the permissible operating lifespan of coal units, from 47 years for the oldest, to 40 years for those most recently brought onto the grid. This 40-year minimum still allows developers to pay off the capital cost of their assets. In fact, industry proposed this timeframe for provincial and federal regulations of emissions in the past.

We selected energy efficiency targets for this scenario based on a recent Alberta Energy Efficiency Alliance analysis. The Alliance identified economically feasible demand-side energy efficiency upgrades that are currently economic in each of the province's major electricity consumption sectors and estimated the total energy savings, which varied from sector to sector (Row and Mohareb, 2014). We incorporated the electricity-specific energy savings potential into our analysis. We stretched the implementation of these already-economic energy efficiency upgrades across the 20 years of analysis.

For other alternative and renewable generation sources, we chose capacity additions for ambitious but moderate growth, well within the resource potential in Alberta and within the growth rates seen in other jurisdictions that have brought a significant amount of renewable energy onto the grid. We considered population, energy system size, and appropriate siting (for example, rooftops). We balanced the proportions of renewable-energy sources added, factoring in existing capacity, projected growth, expected price impacts, and the need for firm supply.

**Figure 4: Projection of annual generation by fuel source under the Clean Power Transition scenario**



Meanwhile, we allocated moderate growth for geothermal and storage—the latter is a basket of technologies and solutions that balance electricity supply and demand across intervals ranging from milliseconds to hours. Though neither of these currently exists in Alberta, they do in other North American jurisdictions, and it is unrealistic to assume neither will come into commercial feasibility over the next 20 years. Each is increasingly positioned to play a growing role in Alberta's future energy mix.

We then refined installed capacities based on a number of parameters, including the need to meet minimum annual projected generation demand and system requirements for effective capacity, as established by AESO (see Appendix). We modelled a generation mix that included variable-output sources, such as wind power, with rapid-dispatch sources, such as peaking natural gas. We added some combined-cycle natural gas capacity to the gap analysis. We also added more peaking natural gas than under the Continued Fossil Reliance scenario—to complement intermittent renewables.

As Figure 4 shows, a much wider diversity of energy sources meets Alberta's projected demand, reducing reliance on any single fuel source.


Ben Thibault, Pembina Institute


David Dodge, Pembina Institute

# Scenario 3: Clean Power Transformation

As its name suggests, the Clean Power Transformation scenario represents a more ambitious change in Alberta's electricity generation landscape. It relies on a mix of policies and approaches that would all but eliminate coal power generation from the Alberta grid by the year 2033 in favour of cleaner alternatives.

We used the same general methods as in previous scenarios to develop this scenario—including the same level of energy efficiency—but we employed more aggressive targets for alternative and renewable sources.

In this scenario, we assumed government will adopt policies to considerably accelerate clean energy deployment—while still keeping them well within resource potentials—and pro-rated them to match the growth seen or targeted in leading renewable-energy jurisdictions across similar time spans. By adding a larger share of renewable energy to the mix—including firm renewable power such as large hydro, biomass, geothermal, and storage—we reduced the need for both combined cycle and peaking on-demand natural gas plants, relative to the Transition scenario.

Alberta's extensive northern hydroelectricity resource offers the largest known potential for firm energy supply with proven technology and could further displace emitting sources (Government of Alberta, 2013.) However, we moderated this development because of the difficulty of financing the very high capital costs of large hydro in the province.

For this scenario, we simulated a much more aggressive timeline of coal plant shutdowns. We started again with 47-year operating-lifetime limits on the oldest plants to moderate near-term shutdown rates, and reduced this to 37 years for the province's third-newest facility.

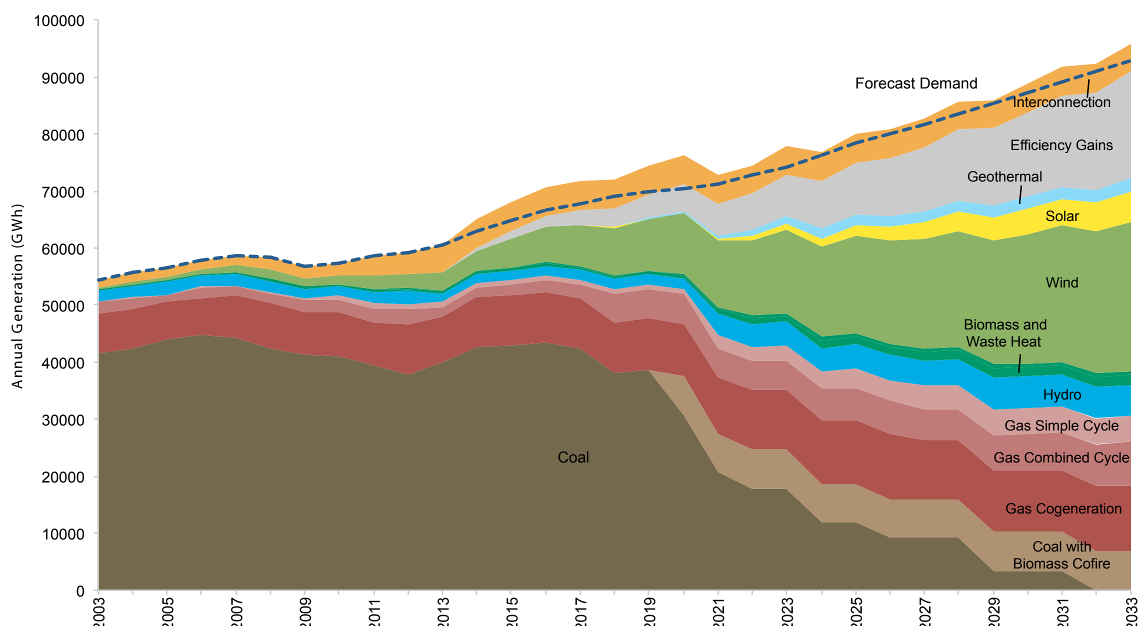
Recognizing that shuttering a plant earlier than anticipated presents an economic burden, we targeted the province's two newest coal units—federal regulations will allow them to operate beyond 2050—for biomass co-firing. Under this scenario, beginning in 2020 the operators of these two plants would gradually begin adding locally available biomass waste, derived from slash from logging operations, to their furnaces to displace coal. Our model adds biomass in 10 per cent increments until it generates half of the plant's total output.

More analysis would prove useful, and we introduced co-firing to this scenario as one possible solution for addressing carbon pollution from the most recent coal unit investments. Still, our initial analysis of Alberta's annual roadside logging slash indicated that meeting half of energy demand from the two coal units was possible from biomass waste generated within 250 km of the units. The phase-in rate allows time to build four to seven facilities that will be needed to collect, process, and distribute the material and accounts for expected efficiency losses in co-firing with these higher proportions.

Government and industry have identified carbon capture and storage (CCS) as a GHG reduction solution. Though a pair of electricity CCS projects received more than $1 billion in Alberta and federal funding commitments in 2008, their developers have since shelved both projects. CCS could also accomplish the greenhouse gas reductions seen with biomass co-firing, should it prove itself as a cost-effective technology.

Under this Clean Power Transformation scenario, "pure" coal plants would not operate beyond 2031, leaving only the two newest plants with 50 per cent biomass co-firing. For comparison, under the Continued Fossil Reliance scenario and existing policy, this would not occur for another three decades.

**Figure 5: Projection of annual generation by fuel source under the Clean Power Transformation scenario**



# RESULTS

Under a Clean Power Transformation scenario, within two decades Alberta could reduce its reliance on coal-fired power for grid electricity from today's 63.8 per cent to a mere 3.6 per cent of energy, without switching to heavy reliance on natural gas. Figure 6 demonstrates the much larger diversity of supply capacity in the two clean power scenarios.

This shift would deliver an impressive 69 per cent reduction in annual carbon pollution from the province's power sector relative to business as usual, as shown in Figure 7. It would also substantially decrease air pollution, improving public health outcomes and lowering healthcare expenditures.

In the Clean Power Transition scenario, the province could reduce its reliance on coal power from 63.8 per cent to 11 per cent. Doing so would cut annual electricity sector greenhouse gas emissions 45 per cent below business as usual by the year 2033.

All of this can be accomplished without significantly increasing costs to the consumer in the near term and actually decreasing costs below the Continued Fossil Reliance scenario in the long run.

We engaged Solas Energy Consulting Inc. to model the consumer price impacts of the different portfolios of generation. The company determined the power price using an average merit order for the years 2023 and 2033 created from actual 2012 merit orders.

**Figure 6: Comparison of supply capacity under different scenarios**

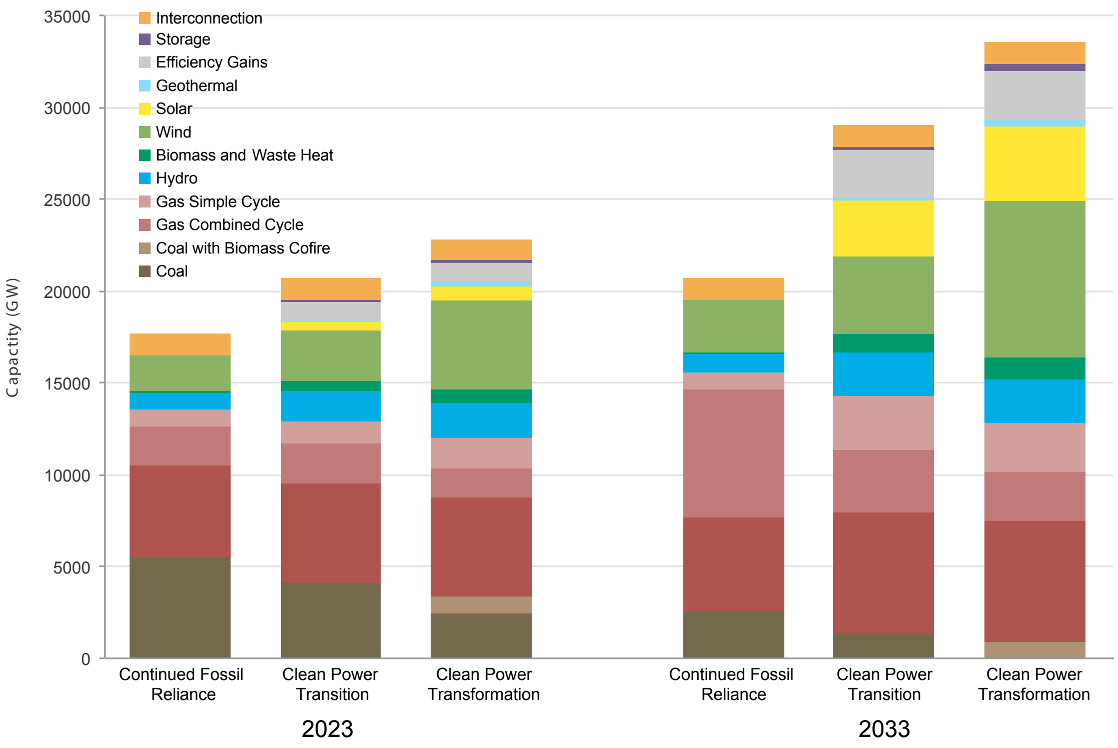
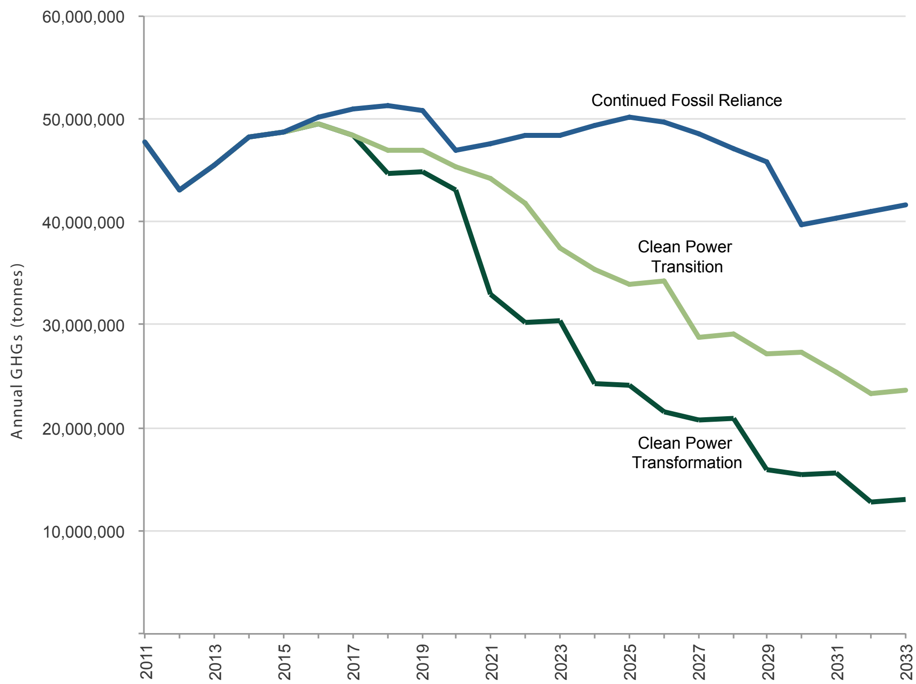


**Figure 7: Annual greenhouse gas emissions under different scenarios**




A summary of the methodology is provided in the Appendix. The assessment yielded wholesale energy prices and per-MWh revenues for various generation technologies.

We worked with Solas to adjust generation mix scenarios. In particular, the modelling relied on an iterative process to ensure a sufficient rate of return to support new builds in gas, hydro and renewable generation. In some scenarios, energy revenue alone was not sufficient to stimulate renewable development, and a policy-based incentive would be required. The cost of the incentive is included in the resulting wholesale cost of power presented in Figure 8.

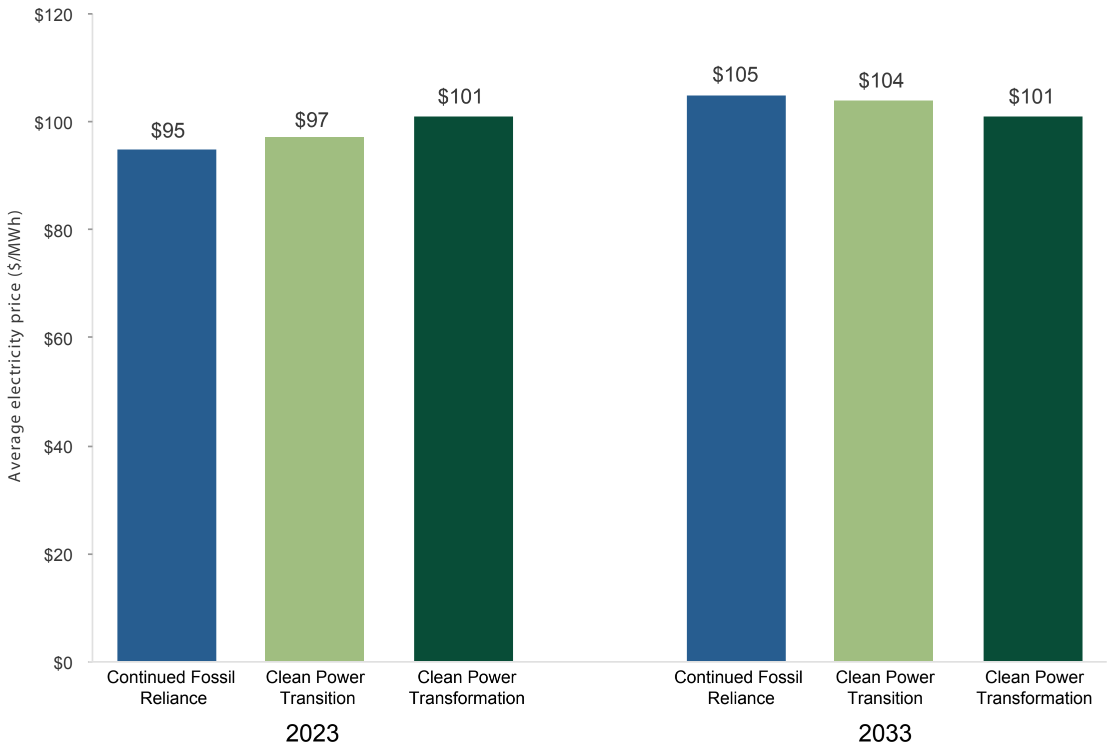
As Figure 8 shows, as we replace existing generation sources with new capital investments, electricity prices will rise under any scenario—i.e., regardless of what new generation sources we choose. With an acceleration of coal unit closures in the Clean Power scenarios, and the upfront costs of new capital investment in a greater diversity of generation sources, there is a small increase in the wholesale energy prices in the medium-term (year 2023). However, in the long-term (year 2033) we see the payoff from investing in renewable energy, which is insulated from fuel cost increases. By the end of our scenario projections, we see clean electricity supply reducing consumer energy costs.

Moreover, both the Clean Power Transition and Clean Power Transformation scenarios significantly diversify the province's energy mix. They avoid the projected continued reliance on fossil fuels that would result under the business-as-usual Continued Fossil Reliance scenario. That scenario projects a simple switch from relying 64 per cent on coal and around 20 per cent on natural gas annually as we do today, to relying 64 per cent on natural gas generation and 20 per cent on coal in 2033.

That business-as-usual projection is rife with risk for Alberta residents, schools, businesses, and industry alike. Natural gas power generation sets the market price more than its proportional contribution to supply—a result of the way in which natural gas power generators bid their energy into the market. As its supply to the generation mix grows, this price-setting dominance will only increase (Beblow, 2013).

When natural gas fuel prices rise, the consumer will bear the brunt of the increases—especially if the province begins to lean heavily on the fuel, as it would in the Continued Fossil Reliance scenario. This can explain why new natural gas generation is currently such an attractive investment—at least, for electricity generation companies. However, this single fuel reliance also presents a major risk to Alberta electricity consumers over the longer term.

**Figure 8: Price of generation under different scenarios**



# RECOMMENDATIONS

This report shows that it is technically feasible for Alberta to eliminate its very heavy coal reliance within 20 years, without simply switching this reliance to another fossil fuel. It acknowledges that natural gas will play an important role in the province's electricity future, but as one of a wide range of sources. As a critical first step, the province must lower the barriers that limit renewable power.

Many would-be renewable energy developers will not overcome the fundamental project-financing barrier identified in this report unless and until policy helps to mitigate the price uncertainty in the province's electricity markets.

This will mean introducing more opportunities for long-term power purchase agreements—legal instruments used in jurisdictions across Canada and around the world to define the terms for the long-term sale of electricity. Policy could help incent long-term agreements with creditworthy electricity users and/or retailers through the private sector. A series of recent reports, by KPMG and others, have identified such agreements as the "missing piece" needed to make renewable power work in Alberta and to begin diversifying the electricity system.

The government could turn to a wide variety of instruments to bring power purchase agreements to fruition. Of these, the Clean Electricity Standard—a more market-oriented variation of the successful renewable portfolio standards in the United States—has attracted considerable attention and support (see sidebar, "The Clean Electricity Standard"). But any number of policy options or take-offs on the above concept could address the existing barriers.

Ultimately, the authors of this report would support any policy options that seek to achieve the following goals for Alberta's electricity system:

- Level the playing field for renewable energy sources by accounting for the presently hidden pollution and greenhouse gas costs of fossil fuel generation
- Address the major hurdle to financing for renewable energy projects by providing some degree of long-term price certainty for the electricity generated
- Prepare the groundwork and dismantle regulatory barriers for the widespread market penetration of new, clean generation technologies—such as distributed generation and storage technologies that integrate renewable energy into the grid
- Allow renewable energy sources—including distributed generation sources—to fully realize the value of the energy they produce

## THE CLEAN ELECTRICITY STANDARD

A variety of policies and regulations could help integrate power purchase agreements into Alberta's electricity market. An Alberta version of the Clean Electricity Standard is one option that has received broad support. Such a policy would direct electricity retailers to obtain their electricity from a mix of lower- or non-emitting sources—without actually specifying what those sources are. In doing so, it would lower the barrier to entry for renewables producers, correct market deficiencies that continue to allow fossil fuels to dominate the wires, and begin in earnest the necessary transition of the electricity system to a modern, low-emissions energy source.

# APPENDIX

## EFFECTIVE CAPACITY

Effective capacity is a measure of a given generator's capacity that the Alberta Electric System Operator can rely upon to be available during the peak load hours, such as early evenings in winter. The operator allocates different effective capacity factors to different generation sources — for example, most firm sources are assigned 100 per cent, while wind is assigned 20 per cent (AESO, 2012).

Using the peak-load projections under our Continued Fossil Reliance scenario, we refined the Clean Power Transition and Clean Power Transformation scenarios until we attained at least a 15 per cent reserve margin in each year. With considerable wind and solar additions—especially in the Clean Energy Transformation scenario—this spurred expectations for a robust energy-storage sector in the province but also sometimes required more quick-ramping capacity in the form of simple cycle natural gas capacity.

## PRICE MODELLING

We engaged Solas Energy Consulting Inc.—a project and business development firm with offices in Calgary and Colorado—to model the impacts of each of our three scenarios on wholesale energy prices. We asked the firm to do so for each of the years 2023 and 2033.

Under the current market design, wind, solar and geothermal power generation do not offer into the merit order. Rather they are included as a negative load and reduce the total demand dispatched through the merit order. The Pembina Institute provided the generation capacities for each technology type.

Wind power generation was forecast by adding capacity to diverse geographic areas based on Solas' experience in the wind industry. A time series of wind power generation was created for each location where wind farms are likely to be located. The individual regional wind power generation time series were then combined to create a total wind generation time series.

Solar power generation for the Clean Power Transition and Clean Power Transformation scenarios was calculated from a time series provided by the NREL solar resource tool and multiplying by installed capacity.

Geothermal power generation capacity was provided by the Pembina Institute and was assumed to operate as baseload at a 70 per cent capacity factor.

We assumed energy efficiency measures would be implemented in proportion to historical demand. That is, efficiency contributions were higher during hours when demand was higher, and the contributions were lower when demand was lower. Improvements in energy efficiency reduced the demand rather than having an effect on the merit order.

Pembina provided the capacity of energy storage for each scenario. Energy storage was implemented in the merit order by inserting bids to purchase energy at low power prices and offers to sell energy at higher prices. Bids and offers for energy storage were structured such that the revenue was sufficient to recover the cost of purchased energy plus efficiency losses. Further, storage bids and offers were structured such that total injections and withdrawals balanced over the course of the year and storage did not affect the total annual energy demand.

A demand time series was then created for 2023 and 2033 by increasing the demand in each hour by the respective demand growth assumption. This was done to maintain correlation between wind generation and demand.

Power prices were determined for each of the six scenarios based on the dispatch and demand for each hour in 2023 and 2033.

## GREENHOUSE GAS ANALYSIS

We modelled the greenhouse gas results of our three scenarios using empirical or widely accepted intensity factors for each fuel source, gathered from federal greenhouse gas emission reporting data and unit-generation data. Because cogeneration produces both steam and electricity from the fuel combustion, it poses a special allocation problem for determining what proportion of the combustion emissions are allocated to electricity generation. The Independent Power Producers Society of Alberta's recent report (EDC Associates, 2013) used a 0.25 t/MWh intensity for cogeneration's electricity emissions. While not endorsing this allocation, we employed the same intensity for consistency in the discussion around different GHG emissions from different scenarios. Moreover, 0.25 t/MWh falls within the range of intensities derived from different allocation methods employed by Doluweera et al. (2011).

Because of the large overall emissions and large variability between units, coal unit intensities were assessed individually—for each unit—using empirical data, accounting for recent or planned incremental capacity increases to existing coal units as efficiency improvements.

We also assigned carbon intensities to the transmission interties connecting Alberta with British Columbia, Saskatchewan and Montana, based on the province- or state-wide carbon intensity of those jurisdictions' respective grids.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