Trends in GHG Emissions in the Alberta Electricity Market

- *Impact of fuel switching to natural gas*

Report prepared for:

Independent Power Producers Society of Alberta

Report prepared by:

EDC Associates Ltd.

May 2, 2013

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Executive Summary

EDC made the following findings:

- Alberta's demand will grow steadily and relatively strongly over the study period, requiring the addition of significant new generation.
- The fleet will double from almost 15,000 MW in 2013 to 30,000 MW in 2050 to cover the growing demand. For the foreseeable future, the Alberta generation will be largely thermal, although wind will continue to grow. As a thermal market, Alberta will emit greenhouse gases to meet its electricity needs.
- The relative capital and fuel costs and different emission intensities of the various types of generation will incent investors to continue to invest most heavily in natural-gas fired generation, especially co-gen and combined-cycle. The coal part of the generation fleet will shrink dramatically after 2019, with another large drop in 2029 as the two federal GHG threshold dates are passed.
- Replacement of coal units by combined cycle and co-gen gas-fired units and some wind, will cut the intensity (t/MWh) of generation emissions in half between today and 2050, and most of that before 2030.
- The doubling in electricity demand will only cause a 7% or 8 MT increase in GHG emissions, even including the emissions from industrial users who produce their own electricity. This is the case even as the fleet is forecast to grow by 100%.
- The reduction in intensity and the nearly flat level of emission over the 33- year period will happen as a result of existing market forces. If policy makers seek to change this evolution, some out-of-market interference would be required, and the forecast outcome could not be guaranteed.

Detailed Findings

Scope of Work

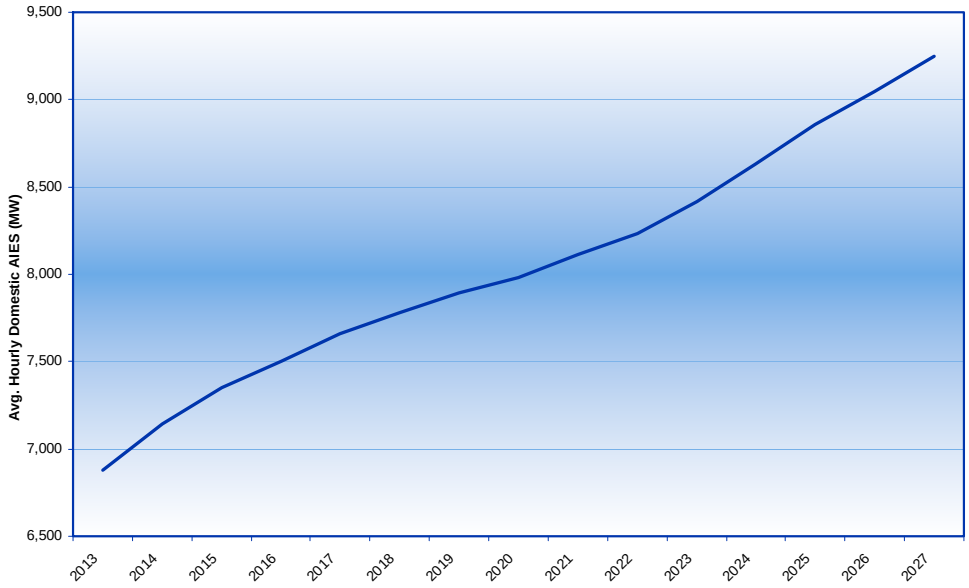
On September 7, 2012, the Independent Power Producers Society of Alberta (IPPSA) retained EDC Associates Ltd. (EDCA) to provide an estimate of the amount of GHG (Mt) that would be emitted by all electricity generation in the province over time. This entailed creating a forecast of Alberta demand for electricity out to 2050 and estimating the likely mix of different technologies. In addition, EDCA calculated metrics on the average intensity (t/MWh) for each of the generation types and for the entire fleet, as its makeup changes over time. The sensitivity of those results was tested for varying penetration of wind units

Detailed Findings

Demand Growth

Using extensive macroeconomic modeling, EDCA expects electricity demand to continue at a healthy 2.02% growth across the study period. The bulk of the growth will come from the industrial sector, especially oil & gas.

Figure 1 - Expected 2.02% Electricity Demand Growth



Generation Fleet Growth and Make-up Over time (2013-2050)

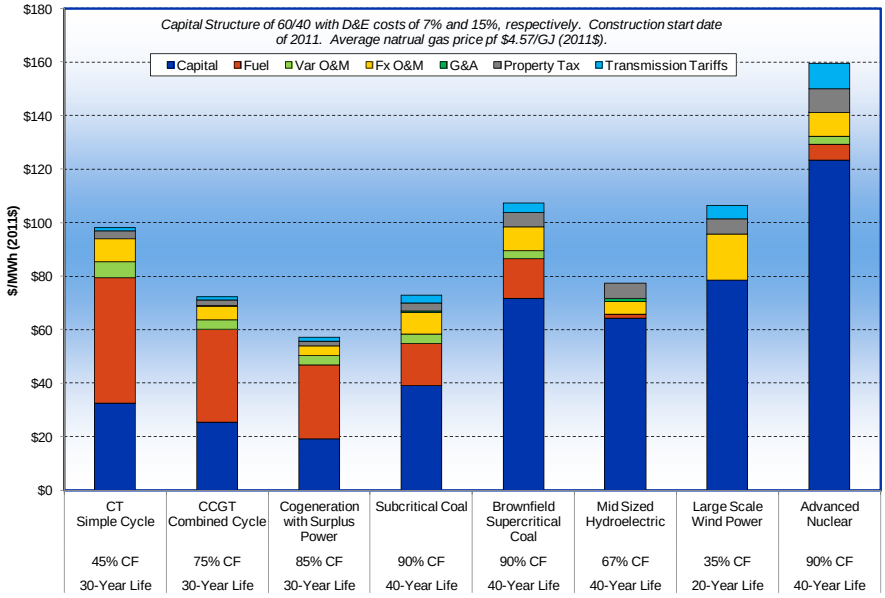
Coal-fired generation will decline dramatically over time. The new federal GHG regulations require coal units, many already very old, to retire after their 50th year of service. The majority of coal plants will be retired before 2029. As they retire and demand relentlessly grows, more supply will be required. Although wind will grow, it will likely never exceed 15% of the total fleet, partly because of the effect of its intermittency on the transmission system, and partly because it typically sees a discount to pool price when it runs. It is still expensive in life-cycle cost terms compared to the much more available and controllable natural gas units. If wind was to receive a substantial increase in GHG credits, it may overcome those cost constraints.

As such, the market is expected to drive investors to build future supply with combined cycle and cogeneration gas-fired plants. Many of the cogens are situated at customer locations and their output will be used “behind-the-fence”. Because Alberta industry uses a large amount of process steam (mostly for oilsands extraction), cogeneration is a natural fit for the province. However, there are not enough large hosts to fully provide the

required provincial electricity demand, so the next best alternative is the combined-cycle gas generation unit. Combined cycle, as the cheapest life-cycle provider of generation, will comprise the lion's share of new generation in Alberta.

Levelized cost is defined as that real price (i.e. before being inflated) which, if collected in every MWh produced over the life of a generator, will just pay all costs, including variable costs and fuel, but also an allocation of the repayment and return on capital costs. The results are very dependent on assumptions used, but offer a useful ranking of the relative price of each type.

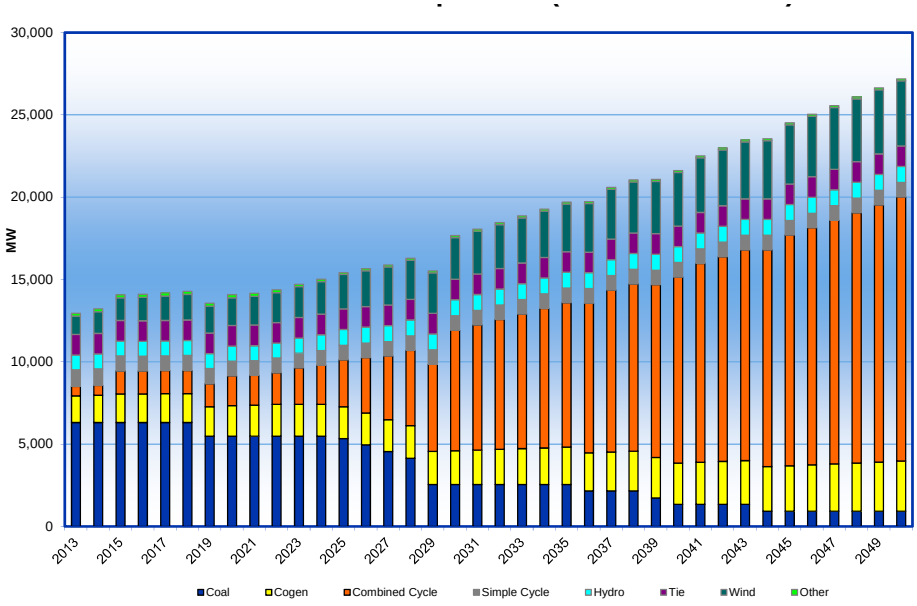
Figure 2 – Comparative Levelized Costs (2013-2027, using EDCA Q1, 2013 Report Assumptions)



Net-to Grid Composition

EDC prepared a forecast of the likely level of each type of generate across time.

Figure 3 - Net-to-Grid Fleet Composition (2013-2050)



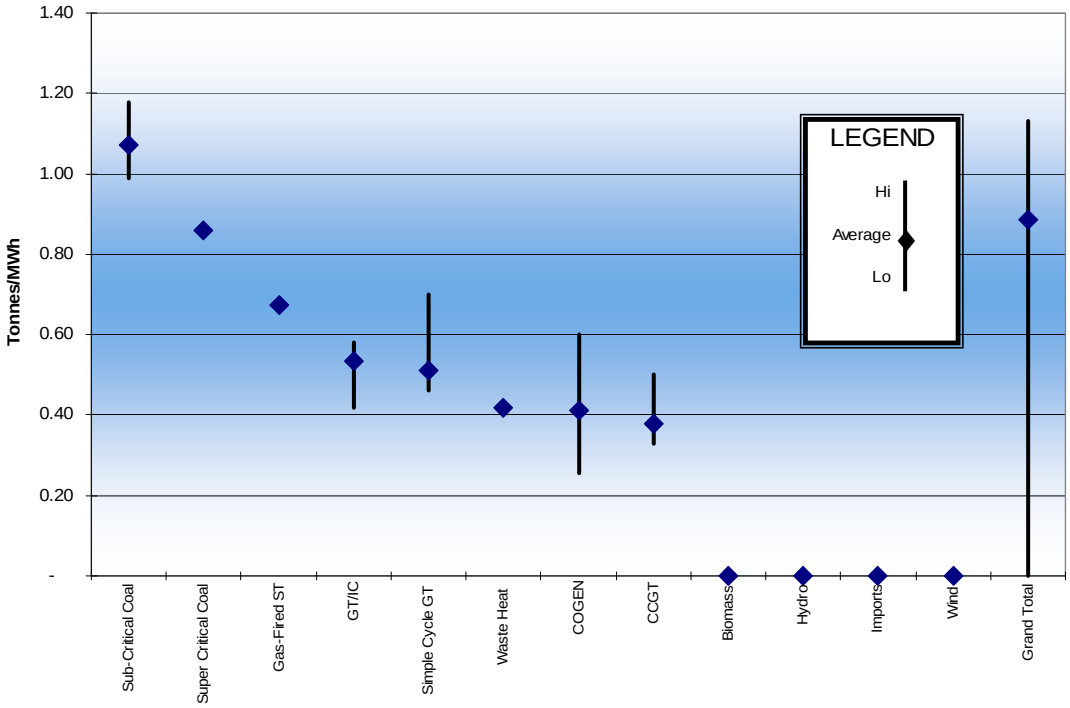
EDCA forecasts the changing composition of the generation fleet over the study period. This chart subtracts any generation that will be serving loads at its own location. Therefore, it is lower than the total generation in Alberta. When calculating GHG emissions, the higher gross generation number is used. However, a fraction of the fuel used, and the corresponding amount of emissions, will ultimately be converted to heat energy, as steam in the cogen host's industrial process. That amount of emission is netted off the costs and emissions purely allocated to generation. A typical cogen would run at about a 0.42 t/MWh emissivity. The EDCA process allocates about 0.17 t/MWh to the steam generation and the remainder, about 0.25 t/MWh to the electricity generated. Other fuel types have different ranges of emissivity, depending on fuel and vintage.

Emissivity

Data on emissions is compiled from several years of Specified Gas Emitters Regulation (SGER) data, both as baseline and as annual achieved amounts. Older coal units usually produce about 1.0-1.2 t/MWh. Newer coal units can achieve a much lower 0.89 t/MWh. Units that have recently been uprated have been assumed to have improved their emissivity by the ratio of their original output to their additional output. For example, if a coal unit adds 20 extra MW to their 200 MW base, it would be assumed that their emissions would fall by 10% from the values measured before the uprate.

Wind, hydro, solar and nuclear have an assumed intensity of 0.0 t/MWh. Combined cycle units would achieve a 0.42 t/MWh emission intensity (40% as emissive as old coal (e.g. Sundance) and about 47% as emissive as new coal (e.g. Genesee 3 or Keephills 3)), while simple cycle units were set at their historical 0.50-0.55 t/MWh.

Figure 4 - Comparison of Range of Emission Intensities by Fuel Type (2010 Data)



So, as the high emission intensity coal is replaced by gas or wind at lower or zero emissions, there is a natural reduction in overall provincial emissions. That decline, which is already down from 2010 levels, continues until most of the coal is gone. Once all the coal is retired and the average intensity falls below the intensity of combined cycle units, adding more cogen, wind or hydro will slightly drop the intensity curve while adding more simple and combined cycle gas units will raise the line. That will only happen if the relative costs structures (capital costs and fuel costs) of different fuel types change enough as to incent different behaviours in generation developers. One such cost parameter is the GHG compliance costs. At lower GHG costs, the cheaper gas units are still more profitable over their lives than non-emitting units. But if emitters' GHG

compliance costs are set high enough or non-emissive generators receive large enough credits, that cost structure eventually will favor the non-emitting technologies. The cost attributed to carbon must be substantial to overcome the inherent cost and operational disadvantages of non-emitting generation.

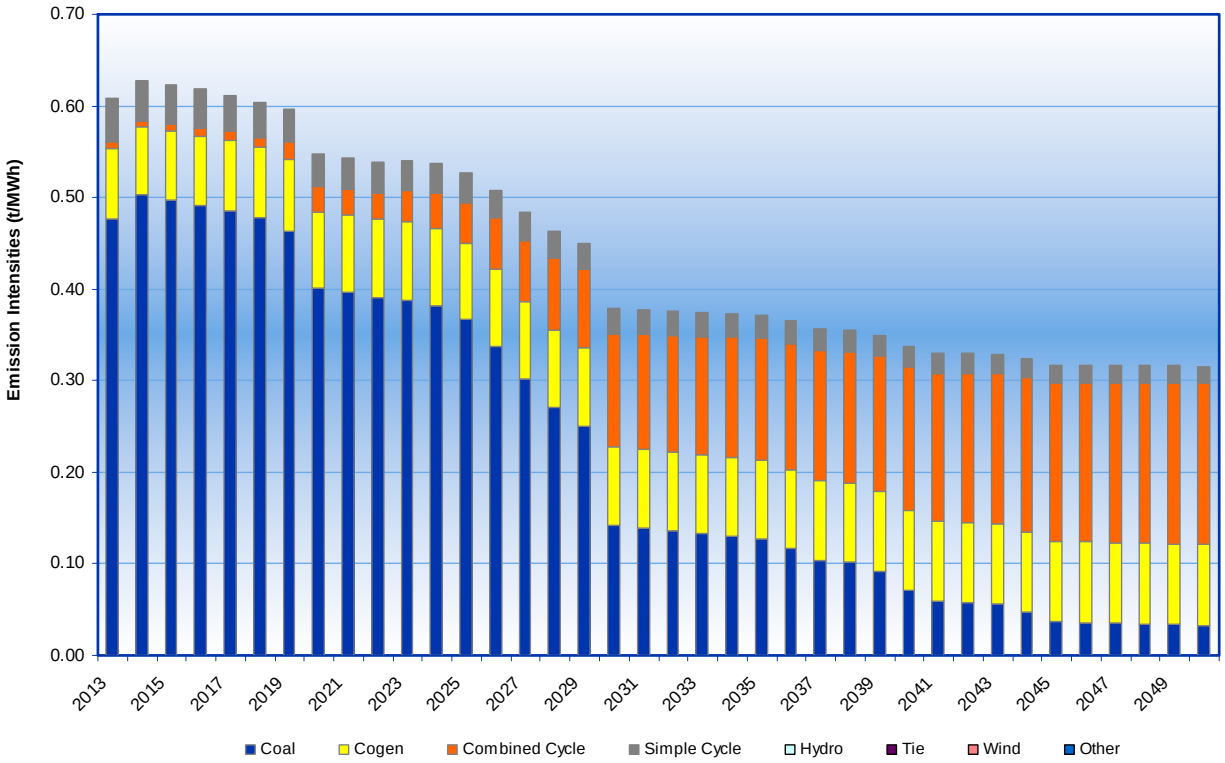
EDCA projected the likely fleet makeup by assuming the amount of new cogen, wind and hydro. The balance of generation needed to meet demand was then filled with combined cycle units. Using EDCA projections of estimated demand and actual offer behaviours (i.e., at what prices each type of unit typically offers its production to the market), the model calculated the production expected from each generation unit in each hour across the 2013-2027 time frame, then projected that to the end of the study (2050). Using historical ranges of intensities for each unit, the overall fleet emissions (t) and fleet intensity (tonnes /MWH) estimate were calculated.

Over time, as the blend begins to favor units with lower emissivity, these units pull the provincial fleet intensity down. The intensity falls over the entire study period to about half of today's levels. The top of the stacked bars shows the expected total average fleet intensity over time, dropping from a high of 0.62 t/MWh in 2015 to a low of 0.32 t/MWh in 2050.

The stacked bars show the contribution of each technology to the total intensity. The values are calculated by multiplying that unit's intensity times its fraction of the total production in that year. So although coal intensity remains roughly the same over time, its fraction of the total fleet falls precipitously, and its contribution to the intensity shrinks accordingly. Conversely, although the intensity of combined cycle units is assumed to be roughly constant over the study period, because it makes up an increasing fraction of the fleet, its contribution to total intensity grows correspondingly.

As zero-emitters, wind and hydro lower the intensity metric, as their fleet percentage rises by adding to the denominator but not the numerator.

Figure 5 –Contribution to Emission Intensity (t/MWh) Across the Study Period (2013-2050)

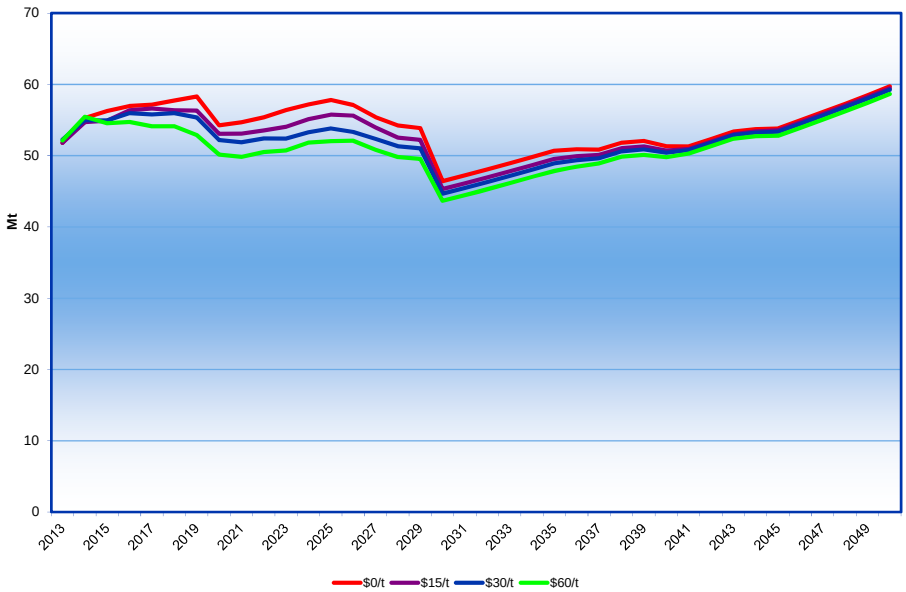


Total Fleet Emission Tonnage

Once most of the coal is gone by 2030 and the intensity curve starts to level off, the persistent economic growth finally causes the total emission tonnage to increase. Different carbon costs ($/t of CO_2) were tested to

determine their effect on total emissions. At high enough values, coal is occasionally dispatched off and displaced by less emissive combine cycle units. This lowers emissions in earlier years but the effect tapers out as coal penetration drops off.

Figure 6 - Total Emissions (t) (2013-2050)



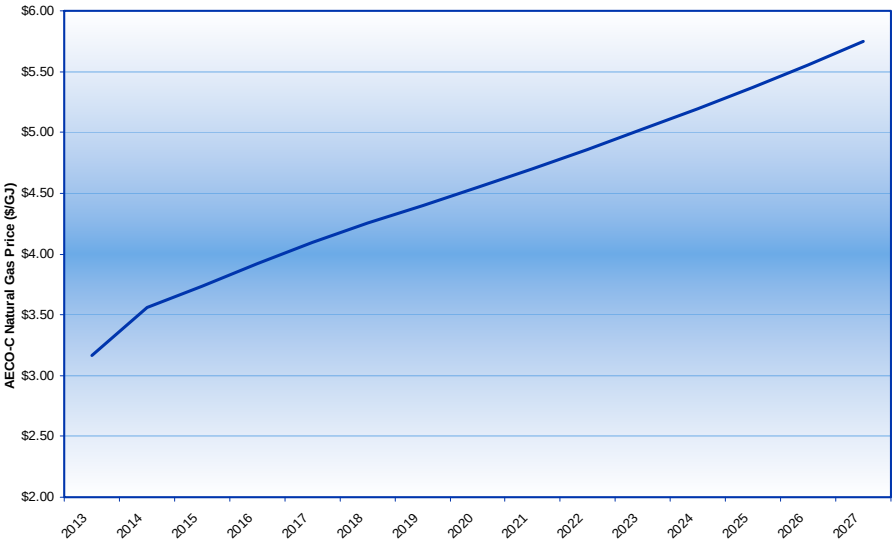
Over the forecast period, total GHG emissions from Alberta's electricity industry are expected to rise by only 8 Mt or 7%. This occurs even though the fleet is expected to grow by 100%.

Emissions intensity is expect to fall by 50% with the market's natural migration to gas fired generation in light of the current and expected price of gas.

Natural Gas Prices

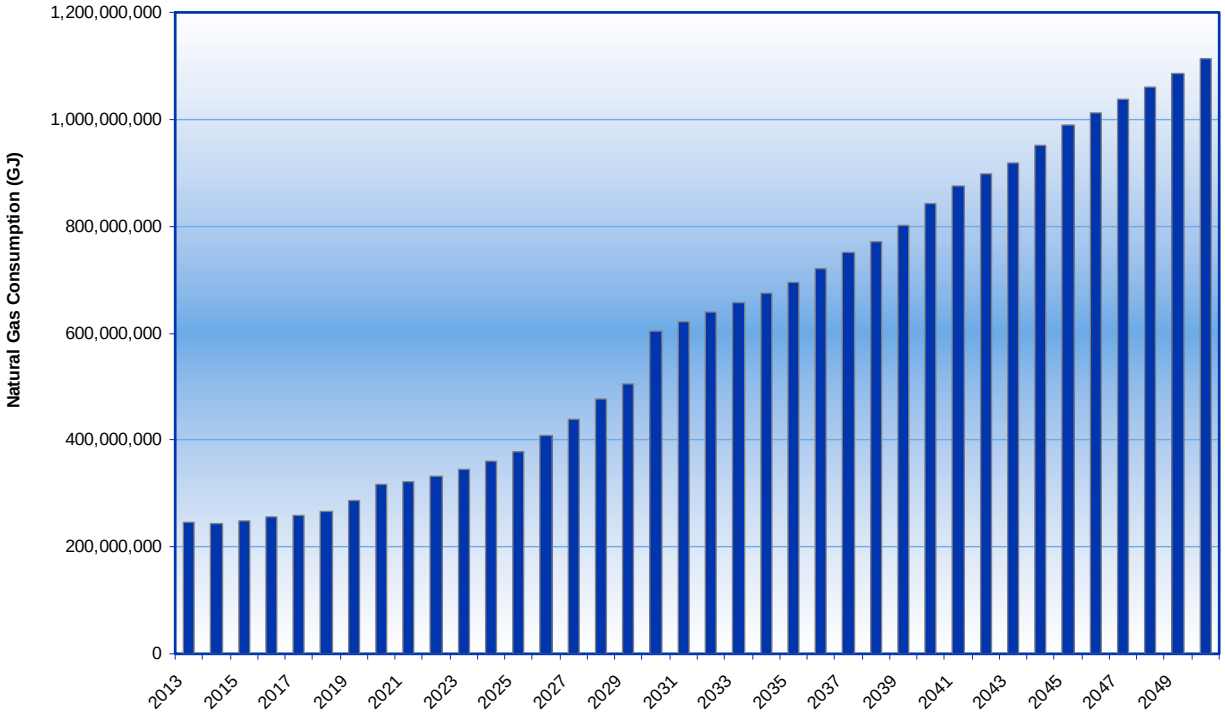
EDC assumed that gas prices would rise in a subdued fashion over the study period, as shale gas continued to provide abundant production in spite of increased usage for electricity generation and transportation.

Figure 7 - Natural Gas Price Estimate (2013-2027, per Q1, 2013)



As the penetration of natural-gas-fired generation rises, so does the amount of natural gas consumed in the province. The sheer volume estimated to be used increase more than 4-fold over the study period. This would create a proportionate increase in gas royalties from the generation of electricity.

Figure 8 - Estimated Natural Gas Usage (2013-2050)



Summary

Because market forces and the new Federal GHG regulation are forcing the retirement of the highest intensity generation, coal-fired generation, the intensity of the fleet will naturally fall to half of its current level over the next 35 years, even without further carbon charges. This will allow total emissions from electricity generation to fall until 2030 and even stay below current levels through to the late 2040s.

Appendix A - Experience, Qualifications and *Curricula Vitae*

Experience and Qualifications

EDC is an independent energy-consulting firm, established in 1992, that provides economic and forecast analytical products and services to the market participants in the electric energy industry. EDC has designed, developed and continually updates and maintains an integrated suite of computer models that are used to provide quantitative analysis.

EDC has been the premier supplier of independent pool price forecasts in Alberta since the start of the electricity industry re-structuring in 1996. EDC has developed and maintains an intricate suite of proprietary forecast models that are based on very detailed and robust market fundamentals and that have been recognized as being leading edge, comprehensive and the "barometer" of electricity pricing used by industry and market participants. These models are used to analyze electric energy market fundamentals with respect to supply, demand and price to produce both short and long-term hourly forecasts, typically from 1 to 25-years.

As part of the Energy Pricing consulting services provided by EDC, the company has been retained to prepare case by case client specific market analysis and forecasts for a wide range of electricity industry participants including marketers, retailers, generation developers, industrial customers, regulators and governmental departments and also publishes several multi-client studies, newsletters and reports on its own volition that are widely circulated to industry clients on a fee for service basis.

This report was prepared independently and objectively under the supervision Duane Reid-Carlson and Allen Crowley and Alex Markowski, whose *curricula vitae* are presented in Appendix A.

Independence and Objective Professionalism

EDC maintains strict neutrality between commodity suppliers, generation developers, marketers and equipment suppliers. EDC owns no generation assets or capacity rights and has no preferred commodity suppliers. This neutrality ensures our actions and advice are always independent and unbiased. No person at EDC or EDC itself has an interest in the companies involved in the above noted arbitration proceeding or the outcome of that proceeding.

Curriculum Vitae
Duane Reid-Carlson, P.Eng.

Duane Reid-Carlson has 21 years experience working in the oil and gas, petrochemical and electric industries. He is currently the President of EDC Associates Ltd – a company that he founded in 1992. Since that time Mr. Reid-Carlson has lead a team of energy economic analysts that have been responsible for providing electric energy supply, demand and price forecast information, energy procurement, risk management, generation development and regulatory analytical services. These services and information is generally used by participants in the electric industry to help support short and long-term energy procurement and investment decisions.

Mr. Reid-Carlson holds a B.Sc. degree in Electrical Engineering from the University of Alberta, Canada.

Following graduation he gained direct oil, gas, pipeline and petrochemical experience working on projects in the Middle East and later in the UK. Working in Alberta, he has lead numerous electric utility planning forecast studies used to assess the need and timing of generation, transmission and distribution facilities. In electricity price forecast matters, he has been instrumental in the development of software used internally, as well as commercially by clients, to assess future marginal and imbedded electricity pricing in Alberta and other jurisdictions in the US.

Mr. Reid-Carlson has authored a series of studies concerning the fundamentals of several electricity jurisdictions, most notably for the Alberta market, that have been utilized by industry, utilities, generation developers and marketers to aid in their energy procurement and capital project decision making processes. He has presented the findings of these studies at many industry conferences and regularly facilitates an introductory course on electric industry operation and restructuring.

Evidence and expert testimony has been given before the AEUB in respect of regulatory proceedings on behalf of the following;

- AltaLink management Ltd., regarding AESO North-South 500 kV Transmission Development Application, December 2004
- Senior Petroleum Producers Association (SPPA), regarding ATCO 2003/04/05 GTA, April 2003
- ESBI Alberta Ltd. (EAL), the applicant, regarding its 1999-2000 GTA, Phase 1 Forecast Panel, September 1999
- Written evidence has been developed and provided in respect of several other applications – some confidential

Evidence has been developed in respect of legal proceedings on behalf of the following;

- Calpine
- TransAlta Wabamum
- Canadian Hydro versus First Canadian Electric Inc.
- Canadian Hydro versus Veco Engineering Et al
- Written evidence has been developed and provided in respect of several other confidential proceedings

Curriculum Vitae
Allen Crowley

Allen Crowley has over 35 years experience in the electricity, telecommunication and water industries. He has held widely varied, senior corporate positions and consulted in electricity, telecommunications, water, sewage and solid waste utilities in the areas of:

- Electricity market design, utility rate making, regulation;
- Retail and wholesale marketing and sales of energy and derivative hedging products;
- Strategic marketing and strategic planning;
- Complex financial modeling and engineering economic studies;
- Process re-engineering, performance measurement and benchmarking;
- Customer service improvement and surveying, Delphi Nominal Group Technique;
- Evaluation of Potential Alberta Direct Load Control (Demand Side Management)

Mr. Crowley holds a BA Economics and Philosophy and an MBA both from the University of Alberta, Canada.

Mr. Crowley has participated in hearings before rate tribunals and consultative sessions in several utilities and jurisdictions (on behalf of Edmonton Telephones, Edmonton Water & Sanitation, West Kootenay Power, Aquila Energy Canada, IPPCAA, Bow City). He has an in-depth knowledge of the proposed FERC SMD NOPR and the Alberta Energy Transmission Policy. He has developed numerous complex financial models including valuation for the sale of a retail electrical distribution company, evaluation and bidding strategy for Alberta PPA's, numerous co-gens and hedging strategies, including weather products, and various rate designs. He prepared several successful comprehensive applications for BC Hydro's "Power for Jobs" and "Real Time Pricing" programs for major mining, chemical and lumber companies. He developed a unique operating lease financing process for Customer-Owned Substations, installing several in BC at a 20% and built the first customer owned substation in Alberta.

Relevant Publications:

"Fill-Adjusted Sinking Fund Depreciation", Engineering Economist, Summer '84

"Real Time Pricing", The Electric Line, 1998

Speaking Engagements:

Numerous guest speaking engagements with Phoenix Gas Seminar, Canadian Institute, Institute of International Research, CERI in BC, Alberta and Ontario

Evidence has been developed in respect of legal proceedings on behalf of the following;

- Calpine Contract Repudiation

Curriculum Vitae
Alex Markowski

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Senior Energy Market Analyst

Alex Markowski holds a B.Sc in statistics (actuarial science minor) from the University of Calgary, and brings over 10 years of quantitative forecasting/data management/modeling experience from a variety of industry settings.

His present role at EDCA focuses on the creation of short and long-term price forecasts for the Alberta power market, in conjunction with generation scenario analysis for a variety of industry clientele.

Further to the above, Mr. Markowski is responsible for the development and implementation of EDCA's data architecture that warehouses, disseminates and analyzes key electricity and natural gas data. He is also responsible for the coding of proprietary in-house models and toolsets in a variety of object-oriented and database-centric programming languages.

Mr. Markowski authors several industry-leading publications, including the Alberta kWh News, the Electricity SMP Predictions (ESP) Forecast Report and the Annual Alberta Electricity Industry Statistics Report. He co-authors the Alberta Electricity Update, the Alberta Quarterly Forecast Update and the Alberta Annual Market Study.

Previous roles have seen him serve as investment counsel for a hedge fund trading closed-end funds and as a consultant within the bio-fuel industry. Mr. Markowski currently sits on the Board of Directors for a local investment management corporation.