ENMAX Energy Micro-Renewable Energy Generation

Final Outcomes Report

December 15, 2016

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ENMAX Energy Micro-Renewable Energy Generation Confidential Final Outcomes Report

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EXECUTIVE SUMMARY

This report is the Final Outcomes Report, a required deliverable for Contribution Agreement G101204, and summarizes the accomplishments of ENMAX Generation Portfolio Inc. (EGPI), a subsidiary of ENMAX Energy Corporation (ENMAX Energy). ENMAX Energy and its subsidiary, EGPI, are referred to individually individually and collectively as 'ENMAX' throughout this report. EGPI is a provider of energy products and services in Alberta's deregulated competitive electricity market, including utility-scale power generation and solar micro-generation systems.

The amended goal of this project was to deploy 9,173 kW of renewable energy generation capacity at residential and commercial sites in Alberta, including homes, businesses, municipal buildings, and institutions. By taking on this project, ENMAX Corporation became the first vertically-integrated electrical utilty and retail organization in Canada to offer solar photo-voltaics (PV) for customers' self-generation behind the meter[1].

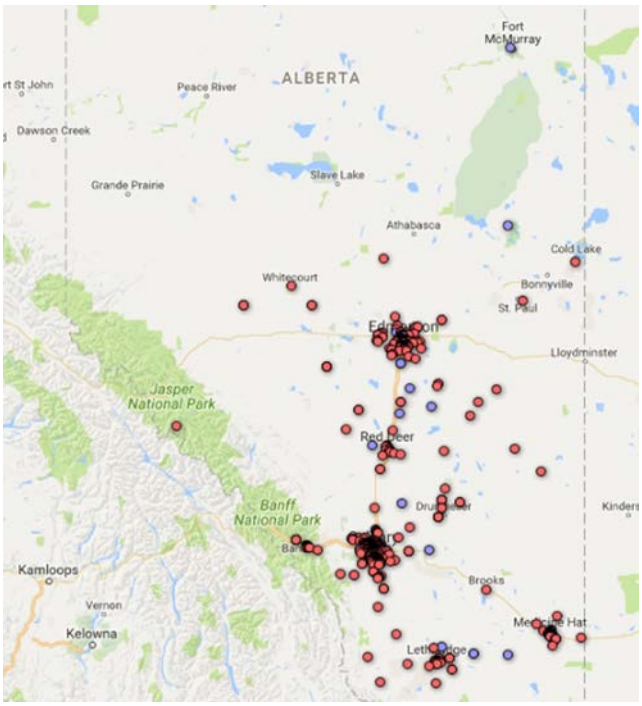
ENMAX's involvement in Alberta's solar industry involved working with all levels of the supply and value chains, including equipment manufacturers, distributors, and a network of local installers across Alberta. From April, 2011 to December, 2016, ENMAX installed 9,146 kW of solar PV and micro-wind generation capacity in alignment with Alberta's Micro-Generation Regulation (MGR), with support from the Climate Change Emissions Management (CCEMC) Corporation, now operating under the trade name Emissions Reductions Alberta (ERA). The lifetime greenhouse gas (GHG) avoidance associated with these systems amounts to over 157,800 tonnes of carbon dioxide equivalent (CO_{2e}). Overall, this project delivered this volume of avoided GHG emissions at a cost of $70.84/tonne to CCEMC.

Initial public uptake of residential solar PV was slow, owing to several factors including the relatively high price of solar and the relative newness of any sort of financing for solar PV. In several communities, the lack of municipal bylaws to enable permitting of solar PV represented a barrier, and ENMAX spent significant time working with large and small municipalities across the province to improve permitting processes, highlighting the best examples that were achieved collectively (e.g. City of Calgary's solar PV permit checklist), and sometimes having to present projects directly to municipal councils for individual project approvals of residential and commercial solar and micro-wind systems.

Over the course of this project, the Contribution Agreement (number G101204) was amended to adjust targets according to achieved market uptake and anticipated market conditions. Following the second amendment, ENMAX began to pursue solar opportunities for several important groups: first nations, small business, agriculture, and municipalities. These customers tend to have large electrical loads and large roof spaces or unused lands for ground-mounted solar. Installing solar PV for these customers helped make solar more visible within local communities, and reflected the leadership aspirations of nearly one hundred of those customers. Nevertheless, the project maintained a strong presence in the residential space, serving some 513 customers, and resulting in a deployed capacity of residential rooftop solar of over 1,948 kW.

[1] Throughout this document, the term 'solar' is used to refer to solar photo-voltaics, as no other forms of solar technologies were offered in this project.

The distribution of solar PV systems across Alberta was broad; over 600 solar PV customers were served from Fort MacMurray in the north to Cardston and Fort Macleod in the south and from Jasper and Banff in the west to Cold Lake and Medicine Hat in the east.



ENMAX attributes this project's success to three main features:

- A long-term, ***reliable solar PV provider***, especially for extended warranty coverage
- Solar PV-specific ***financing*** that works for municipalities, businesses and homeowners
- ***Support from CCEMC***, which improved the economics and the rationale for customers to act

ENMAX continually heard from customers that incentives were not enough to drive adoption because cash was still scarce. Customers large and small required attractive financing; otherwise, solar PV represented a large up front investment akin to purchasing 25 years' worth of electricity up front (a non-starter for many potential customers. Even with financing, several customers, from residential up to municipal and institutional scales, struggled with entering agreements for solar, either because the initial cash investment was large, or the scope and duration of lease agreements were outside of normal procurement practices for energy. The concept of losing the opportunity for support from CCEMC was viewed by customers as a risk, motivating many to proceed with their projects, especially in 2016.

This project will be responsible for approximately a quarter of a billion kWh of solar energy generation over the lifetime of the installed equipment, conservatively reducing GHG emissions by approximately 158,000 tonnes over 25 years (by current offset protocol methodology). As part of the project, ENMAX created a carbon offset protocol that can be used by anyone in Alberta to monetize the avoided GHG emissions under current regulations, and has provided flagship micro-generation systems that rival any in the country. Perhaps most importantly, the entirety of this accomplishment has been made without a single lost-time injury.

ACKNOWLEDGEMENTS

PROJECT DESIGN:

This project was designed with input from C3 (formerly known as Climate Change Central), Alberta's former delivery organization for government and corporate-sponsored energy efficiency programs, and former maintainer of Alberta's carbon offset registry.

For more information about this organization, see https://www.linkedin.com/company/c3-2

STEERING COMMITTEE:

Continued input and guidance was provided via a Steering Committee throughout the term of this project. The Committee was a required advisory mechanism under the Contribution Agreement. It met at least twice per year to discuss project progress and management. Its members provided recommendations regarding proposed changes and updates.

The Steering Committee was made up of representatives from ENMAX, CCEMC (now ERA) and Simon Knight, former Chief Executive Officer of C3.

INTRODUCTION AND CONTEXT

In 2010 ENMAX applied to the first CCEMC call for renewable energy projects, and was chosen as a successful recipient of funding in April of 2011. At this time, governments across the world were looking for greenhouse gas emission (GHG) management strategies, with the Governments of Alberta and Canada having recently passed renewable fuel mandates and were actively weighing the merits of further carbon policy options. In Alberta, the CCEMC had been established as an arm's-length agency to manage GHG abatement and technology innovation programming, funded via one of the compliance mechanisms of the Specified Gas Emitters Regulation (SGER), Canada's first regulated carbon levy.

At the start of this project, the enabling legislation for distributed renewable energy generation, the MGR[2] had been in force for just over two years, with little uptake of distributed renewable energy over that time.

Prior to 2011, global solar PV costs were still relatively high, but decreasing rapidly. By any reasonable measure, distributed solar still came at a premium compared to grid electricity, with no anticipated payback in Alberta based on market conditions, even over 25 or more years. Despite the cost reductions and enabling regulation, solar needed a lift if adoption in Alberta was going to catch up to other jurisdictions.

To help get Alberta's solar industry moving, and to become an active provider of solar PV in this emerging market, ENMAX Corporation and its subsidiaries proposed to become the first vertically integrateded electricity utility and retail organization in Canada to offer solar PV. ENMAX's approach was to catalyze Alberta's solar industry through aggressive pricing and to become a long-term, reliable provider of solar PV with attractive warranty and financing options—the main obstacles to solar PV at the time. The support of Contribution Agreement G101204 helped make that possible.

The original intent of this project was to offer a variety of emerging technologies to customers to help them take control of their own energy generation and use. The recently passed Micro-Generation Regulation provided the enabling mechanism (a streamlined permitting process) to allow grid-connected micro-generation within size limitations and from qualifying generation types[3]. Initially, ENMAX offered both solar PV and micro-wind turbine systems. However, due to maintenance concerns of wind turbines and the relatively poor wind resources available to most landowners in Alberta (especially at just 10 m elevation, and often in urban environments), solar PV became the focus of the project, as this technology provided the best value proposition to customers and the most reliable technology for ENMAX to provide with all necessary permits and long-term warranty (particularly while under lease).

Over the course of this project, the scope was clarified via contract amendments to align with the parameters of the MGR, and to be based on deployed capacity measured in DC kW rather than 'systems' (an arbitrary definition of 6 modules used in 2011), with project targets also expressed in DC capacity. Subsequently, ENMAX implemented marketing changes to clarify that ENMAX'S solar offerings were available to individuals and organizations including businesses, municipalities, and non-profits, in alignment with MGR parameters.

[2] See http://www.qp.alberta.ca/documents/Regs/2008_027.pdf

[3] Key parameters for the current Micro-Generation are: up to 1 MW, and sized to meet up to 100% of the net annual load at any given site; and from sources with emissions of 418 g/kWh or lower from renewable or alternative sources. See http://www.energy.alberta.ca/electricity/microgen.asp

PROJECT VS. PROGRAM

This project was somewhat unique, as ENMAX's proposal was market-based, relying on customers to purchase or otherwise contract with ENMAX to provide distributed micro-generation systems. In this way, the project leveraged investments by both ENMAX and its customers to achieve GHG emission avoidance in Alberta through their investments in distributed solar. For its part, ENMAX provided balance sheet financing to enable long-term leasing of solar PV for qualifying customers in Alberta. This approach acknowledged the need to drive down the cost of renewable energy generation in order to improve public interest, and to bring a large, long-term player into Alberta's solar market to provide long-term warranty support and financing for homes, businesses and institutions to adopt solar PV.

The market-based approach relied on offering as attractive a value proposition as possible to customers ***relative to grid electricity***. Because ENMAX is a price taker in the global PV market, the value proposition of ENMAX's solar offer to customers fluctuated according to the relative prices of solar PV equipment and grid electricity. Over the course of the project, market pricing of solar PV modules improved dramatically, improving the price point of ENMAX's solar offers. However, as was highlighted in regular reporting to CCEMC, the price of grid electricity in Alberta continued to drop over the course of the project. Concurrently, the Canadian Dollar fell relative to the US Dollar and a new federal import duty was implemented on some Chinese-made modules, moderating the otherwise downward cost trajectory for solar PV equipment. The confluence of both pricing pressures resulted in a value proposition for solar PV (in terms of simple payback) in 2016 that is similar to what it had been in 2012.

Another consequence of this market-based approach was that solar generation capacity was built incrementally as each customer chose to acquire solar PV from ENMAX, unlike projects wherein recipients constructed their facilities with CCEMC support and then sought to compete in their respective markets. Owing to its market-based approach, and not unlike some other CCEMC-funded projects that were market-based, the project was often referred to colloquially by some as a 'program'.

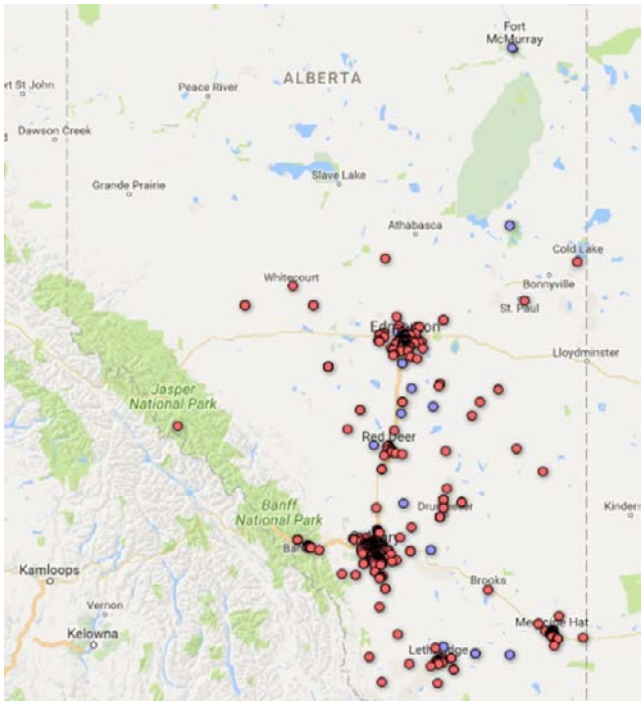
ACHIEVEMENTS

By the end of 2016, ENMAX had installed approximately 9,146 kW of micro-generation across 605 solar PV sites in Alberta representing approximately 9,131 kW, and seven micro-wind generation turbines representing approximately 15 kW. During this period, Alberta experienced a solar market expansion of almost sixteen-fold in five years, and this project resulted in CCEMC's support underlying over 60 per cent of all deployed micro-generation in Alberta as at December 1, 2016. This deployment underscores the success of CCEMC's support for ENMAX in this project and the power of the model it employed, especially during a period of market upheaval, government change, and lingering customer expectations of government incentive programs for solar PV.

This project initially began with ENMAX offering solar PV 'systems' comprised of six modules in order to provide some standardized pricing for marketing purposes. In time, it became evident that customer needs and availability of roof space were more important than consistent 'unit' pricing, and the rated output of modules continued to increase over time (i.e. from 180 Watts per module in 2011 to over 300 Watts on the same footprint in 2016). As of 2013, customers were quoted on the size of system that worked best for their needs, and the project scope was clarified to include all distributed solar PV micro-generation that qualified under the MGR.

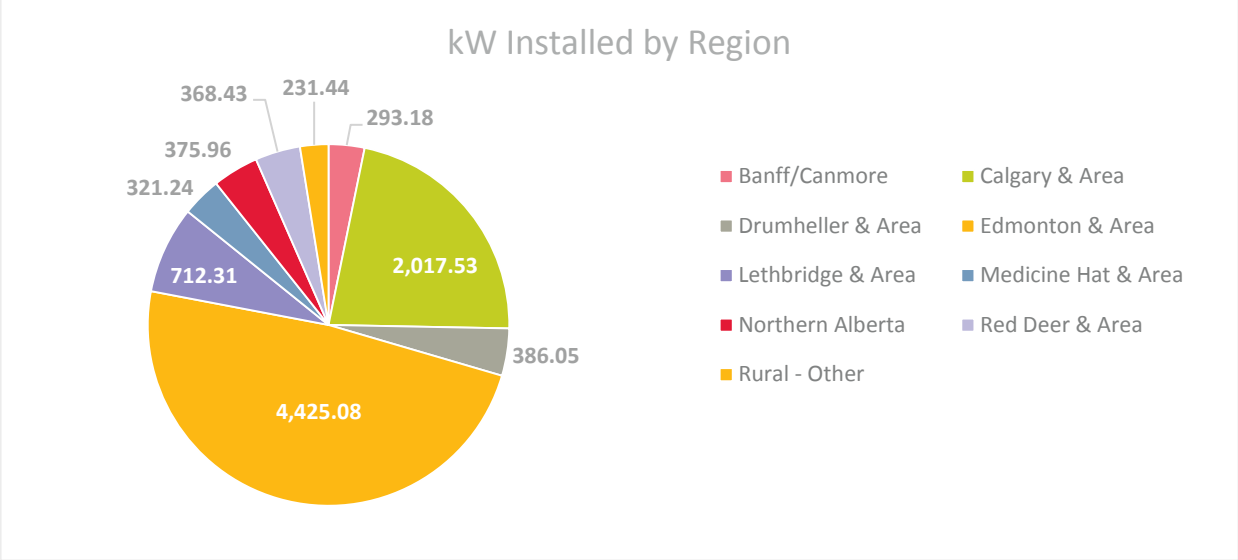
These changes enabled deployment that met customers' needs across the province. The locations of installed micro-generation were relatively evenly dispersed across communities in Alberta, and reflect a mix of residential, small business, farm/agricultural, municipal, and non-profit customers. Figure 1 shows the locations of installed systems. Note that throughout this document, the graphs reflect solar PV but not micro-wind. The red dots represent residential systems, while the blue dots represent systems provided to entities that were not private individuals (e.g. corporations, municipalities, First Nations, schools and commercial farms).

FIGURE 1: LOCATIONS OF ENMAX-INSTALLED SOLAR PV SYSTEMS



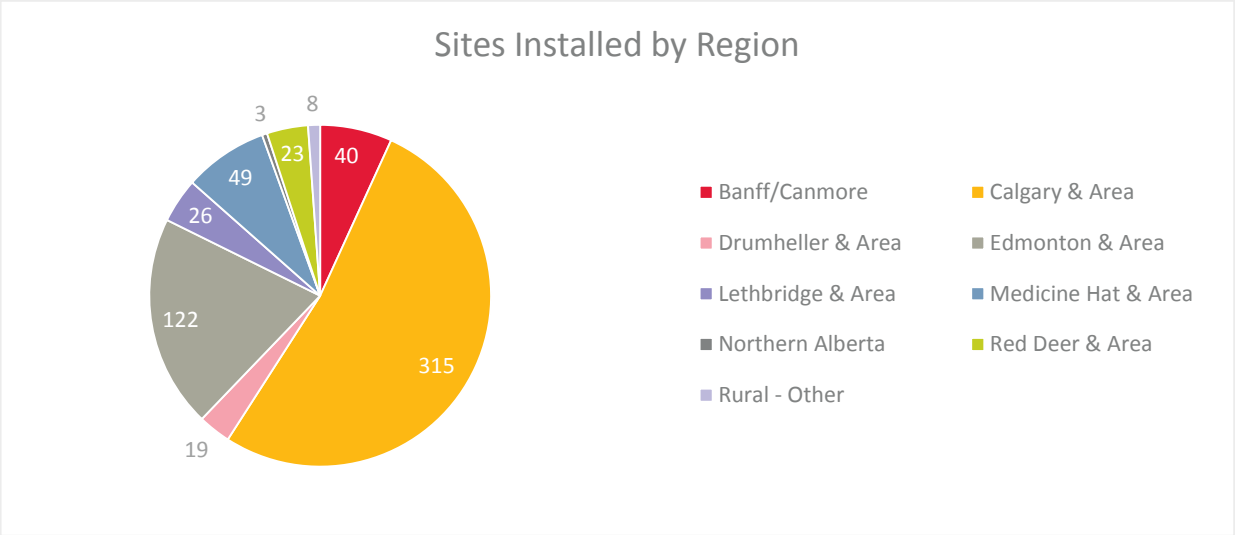
For greater clarity, Figures 2 and 3 provide the regional breakdown of ENMAX-installed solar PV by DC capacity and number of sites, respectively.

FIGURE 2: SOLAR PV CAPACITY INSTALLED BY ENMAX IN ALBERTA 2011-2016



ENMAX's marketing appeared to have more success in the Calgary area by number of sites, but customers in the Edmonton region installed more solar PV capacity than any other region.

FIGURE 3: SOLAR PV SITES INSTALLED BY ENMAX IN ALBERTA 2011-2016



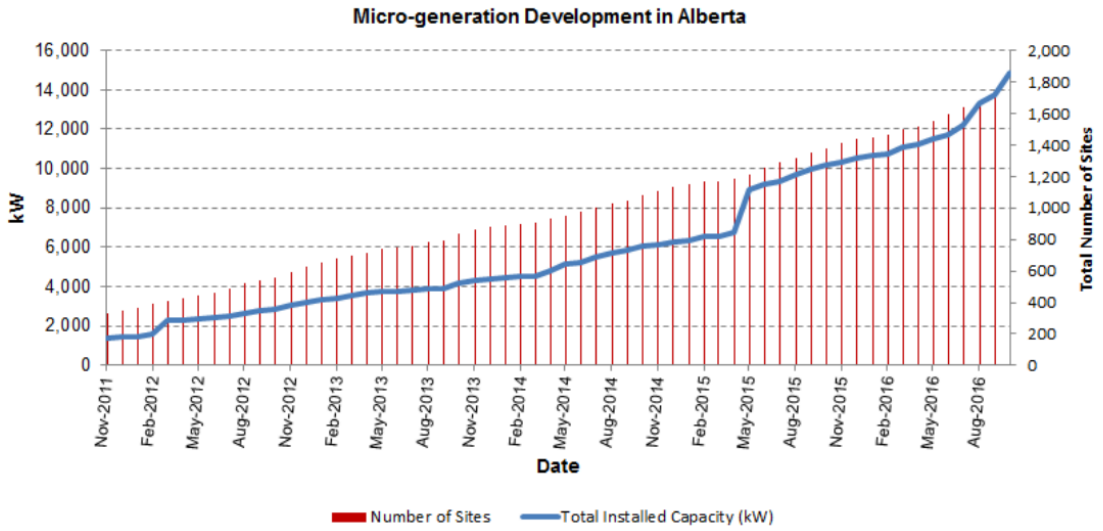
For context, as of the start of this project in 2011, approximately 1 MW of micro-generation had been installed in Alberta since the MGR was passed in 2008 (see the Alberta Electric System Operator's micro-generation tracking in Figure 4 below). This figure includes some early wind turbines installed in association with Alberta's 'wind boom' of the late 1990s and 2000s, and all grid-tied solar PV installed to that date; no large-scale solar arrays of any kind existed in Alberta at that time. Thus, Alberta's solar market was effectively starting from scratch in 2011.

FIGURE 4: MICRO-GENERATION IN ALBERTA AS AT NOVEMBER, 2016

Table 1: Micro-generation by Type

August-2016	Solar	Solar/Wind	Wind	Other	Total
Number of Sites	1,649	29	68	8	1,754
Total Installed Capacity (kW)	13,507	195	912	253	14,866

Figure 1: Micro-generation Development in Alberta



Source: https://www.aeso.ca/market/market-and-system-reporting/micro-generation-reporting/

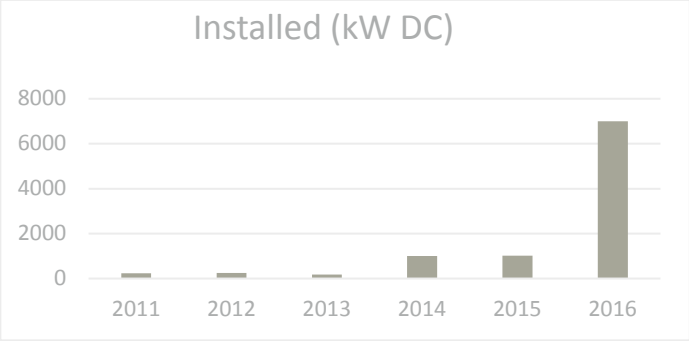
Initial public uptake of residential solar PV was slow, owing to several factors including the relatively high price of solar and the relative newness of any sort of financing for solar PV. In several communities, the lack of municipal bylaws to enable permitting of solar PV represented a barrier, and ENMAX spent significant time working with large and small municipalities across the province to improve permitting processes, highlighting the best examples that were achieved collectively (e.g. City of Calgary's solar PV permit checklist), and sometimes having to present projects directly to municipal councils for individual project approvals of residential and commercial solar and micro-wind systems.

Over the course of this project, the Contribution Agreement (number G101204) was amended to adjust targets according to achieved market uptake and anticipated market conditions. Following the second amendment, ENMAX began to pursue solar opportunities for several important groups: first nations, small business, agriculture, and municipalities. These customers tend to have large electrical loads and large roof spaces or unused lands for ground-mounted solar. Installing solar PV for these customers helped make solar more visible within local communities, and reflected the leadership aspirations of nearly one hundred of those customers. Nevertheless, the project maintained a strong presence in the residential space, serving some 513 customers, and resulting in a deployed capacity of residential rooftop solar of over 1,948 kW.

In addition to the solar PV amounts listed in the following graphs and tables, ENMAX installed approximately 15.1 kW of micro-wind across seven sites in Alberta. These systems were not included in the solar figures, as they were tracked in a separate internal system at ENMAX; the micro-wind product was discontinued in 2013 as it did not perform reliably enough to be offered as a long-term leased product.

The final solar PV deployment figures are provided in Figure 5 below.

FIGURE 5: SOLAR PV INSTALLATION TREND OVER PROJECT TIMEFRAME



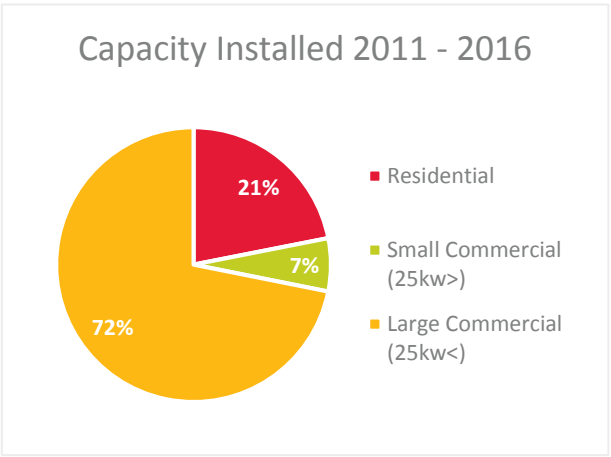
A breakdown of installed capacity by size and number of solar PV sites is provided below.

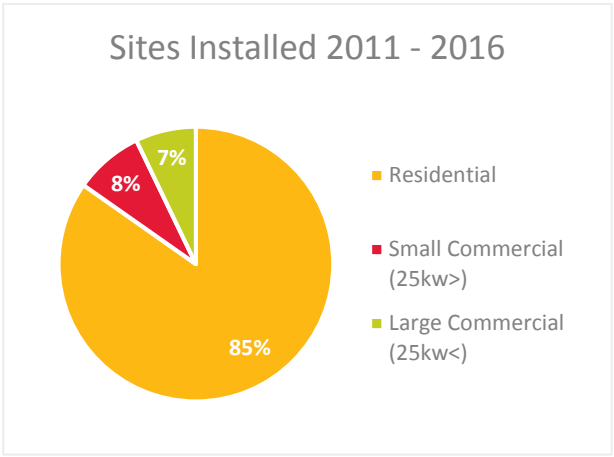
FIGURE 6: TABLE OF RESIDENTIAL VS. COMMERCIAL SOLAR PV CUSTOMERS

Type	kW installed	Sites Installed
Residential	1,948	513
Small Commercial (<25kw)	589	50
Large Commercial (>25kw)	6,593	42

The graphical view of this installed capacity reflects the large proportion of capacity made up by a small number of commercial and municipal solar PV systems, and yet a full 85 per cent of ENMAX's solar customers were residential homeowners.

FIGURE 7: RESIDENTIAL VS. COMMERCIAL SOLAR PV CUSTOMERS





THE ROLE OF FINANCING

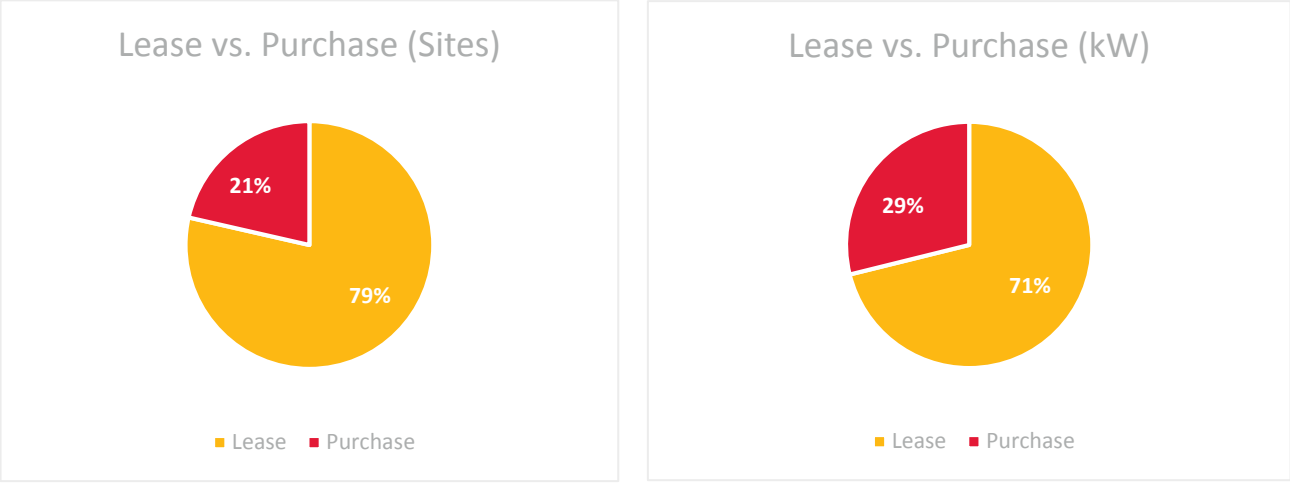
As mentioned above, one of the three most important success factors for this project in ENMAX'S opinion was ENMAX's offer of solar financing for customers, which was chosen by customers representing 71 per cent of this project's installed capacity (in kW), and 79 per cent of the total sites served. Both residential and commercial financing options were made available, offering customers the ability to balance up-front costs with ongoing monthly payments, and to have extended warranty coverage for their leased solar arrays. Both residential and commercial leases were 15 years in duration, with variable initial down payments, and a small residual value (5 per cent). In other words, ENMAX's solar lease spreads the customer's cost over 15 years, even though solar arrays generally last for 25 years or longer. Put another way, the ENMAX solar lease compressed the lifetime cost of leased solar PV into a 15 year lease term, even though the equipment is expected to operate for at least 25 years.

All of ENMAX's solar PV leases were signed on 15 year terms, even though longer terms (e.g. 20 years less a day) were available, reflecting what appeared to be a natural comfort zone for customer financing duration.

FIGURE 8: SOLAR PV LEASES VS PURCHASES BY SITE AND CAPACITY

	Sites		Capacity (kW)	
Lease	478	79%	6,525	71%
Purchase	127	21%	2,606	29%
Total	605	100%	9,131	100%

FIGURE 9: PROPORTION OF LEASED VS. PURCHASED SOLAR PV BY SITE AND CAPACITY



Overall, both residential and commercial customers predominantly chose to lease solar PV (by installed capacity).

This heavy weighting of leased solar capacity underscores the importance of solar financing, and suggests that the ENMAX solar lease offered features that customers felt were valuable. This view is further supported by the success of ENMAX's leased installations during the period where Municipal Climate Change Action Centre (MCCAC) funding was also available (whose eligibility criteria excluded leasing). MCCAC funding effectively competed against this CCEMC-supported project, but the MCCAC structure was based on a simple cash view of eligible costs. As a result, leases were not eligible because a 'paid in full' invoice was not available up front, and title does not transfer to the customer until the customer buys out the lease. Practically speaking, leased solar is as permanent as purchased solar, but comes with long-term warranty and provides the flexibility of lease financing. ENMAX's solar lease allows customers to pay a down-payment, the amount of which is up to the customer (typically within a range of 5-to 50 per cent) to create a lease payment schedule that can work with their cash flow realities. In this way, depending on the down payment, the lease can be used to create monthly payments that may be higher, equivalent to, or lower than the current price of grid electricity—at the customer's choosing (given the system value at the time). However, achieving monthly payments that are similar to the cost of grid electricity has required significant down payments—as high as 25-40% of the system price - depending on the scale of the solar array and market conditions at the time.

Several ENMAX solar customers began their solar projects under the assumption that they would purchase the equipment outright. However, due to budgetary pressures or the desire to deploy larger systems with the same available capital, several customers asked to convert their sale agreements to solar leases, and/or expand their solar systems significantly (sometimes up to ten times the original size).

EXAMPLES OF INSTALLED SYSTEMS

EXAMPLE #1: MONTANA FIRST NATION

One of ENMAX's first large solar installations was done for the Montana First Nation near Ponoka, Alberta. This 100 kW leased system was the outcome of a request for a simple purchase quote for a 10 kW solar array. After exploring the project potential with the client, it was found that a much larger system could be installed using the customer's existing budget as a lease down payment, helping to achieve a lower cost per watt due to economies of scale, and more importantly, a larger solar array whose cost structure fit with the First Nation's cash flow requirements.

FIGURE 10: MONTANA FIRST NATION SOLAR ARRAY

See Solar Energy Society of Alberta's web page for more details.

EXAMPLE #2: MOSAIC CENTRE

The Mosaic Centre is a net zero energy building in Edmonton, whose owner leased over 212 kW of solar PV from ENMAX to offset approximately 100 per cent of the grid electricity consumed by the building on a net annual basis. This achievement is all the more significant because the heating system for this building is a geothermal heat exchange system which runs on electricity. The building incorporates many innovative features including a wall-mounted solar array, and won awards for its integrated design and build process.

FIGURE 11: MOSAIC CENTRE, EDMONTON, ALBERTA

See the Mosaic Centre website for more information.

EXAMPLE #3: LEDUC RECREATION CENTRE

The City of Leduc has leased over 1,600 kW of solar arrays from ENMAX across multiple sites, including Alberta's largest rooftop solar array at the Leduc Recreation Centre, the site of the 2016 Alberta Summer Games. The facility hosts some 3,200 solar modules, and highlights the leadership role of municipalities in adopting solar PV in Alberta.

FIGURE 12: LEDUC RECREATION CENTRE

See CBC News article for more information.

LESSONS LEARNED AND BEST PRACTICES: TECHNOLOGY CHANGES OVER PROJECT TIMEFRAME

During the course of this project, several aspects of the Canadian Electrical Code were updated, which had material impacts on equipment selection and solar PV design. The requirement for arc fault detection was introduced, as was rapid shutoff capability. Code changes and technological evolution (as well as price) have driven equipment selection over time.

In general, solar PV technology has remained fairly constant during the course of this project. From the outset, ENMAX chose micro-inverters as the platform that provided a balance of: ease of installation, monitoring capabilities and safety features. Micro-inverters are small boxes, connected to the back of each module, which convert DC voltage from each module into AC electricity that follows the sine wave of grid electricity. With micro-inverters, no additional space is required in a residential utility room for a string inverter; the AC wiring from the micro-inverters is simply connected directly to a service panel via a breaker, and the array is grounded. The communications capabilities of these micro-inverters occurs via power line carrier (PLC) along the same copper wires that carry electricity, and are received by a small hub/gateway which connects to the internet. Due to pricing advantages and some important new safety features, however, string inverters were used increasingly often over time, especially at larger scales. A range of inverters were used, depending on the scale and application, including Enphase, SMA, Fronius, Solar Edge, and Solectria and Tigo.

FIGURE 13: US INVERTER MARKET TAXONOMY, JUNE 2016

Source: Green Tech Media[4]

Regardless of the inverter, the system output and error tracking of each array installed by ENMAX through this project can be monitored online by both the customer and ENMAX (for maintenance and GHG reporting purposes) as long as the customer provides a working connection to the internet.

In addition to inverter technology, other technologies evolved over the course of this project, notably including racking and solar PV modules. Racking is an integral component for solar arrays, as it anchors solar

[4] See: https://www.greentechmedia.com/articles/read/will-string-inverters-completely-replace-central-inverters-in-the-us-solar

PV modules (panels) to the roof, but its design also determines a number of labour and 'balance of system' (BOS) costs that drive the overall cost of installed solar PV. In particular, installation labour requirements are driven by the simplicity or complexity of attachments, fasteners, and the ability to mount module-level electronics (micro-inverters or optimizers) and to manage wiring efficiently. For ballasted systems, racking design determines the mass of ballast (typically concrete blocks) required to resist wind and keep the solar array safely weighed down on the roof. Racking also serves as part of the grounding means for the entire array, and the interaction of racking parts and equipment that must be bonded to grounding apparatus can drive installation labour requirements. These are also details that can take time to communicate with local electrical inspectors, as there are many types of racking, each with its own proprietary means of complying with electrical code requirements. Over the course of the project, ENMAX noted a general trend for racking that included fewer component pieces, greater flexibility in design and reduced labour requirements for installation.

Solar PV modules have also evolved significantly over the course of this project. Solar PV modules contain the silicon wafers and conductors that convert sunlight to direct current (DC) electricity, which are typically connected together in DC strings when connected to string inverters, or in alternating current (AC) strings when micro-inverters are used to convert each module's energy into AC. Some modules integrate micro-inverters into the module integrally to avoid the need to assemble modules and micro-inverters on-site.

The output of solar PV modules has increased over time, resulting in more Watts of DC generating capacity on the same footprint, or more silicone cells per module on a slightly larger footprint. At the same time, the cost per Watt of solar PV modules has decreased dramatically over the course of this project, from approximately four dollars per Watt in 2011 to less than a dollar per Watt in 2016. As more output is available per module, fewer modules (and thus less racking, wiring and BOS components and less labour) are required for the same output, or more output is possible from the same available roof space. In 2011, 60-cell modules capacity averaged approximately 180 Watts per module; in 2016 leading 60-cell modules are available with outputs in the 310-315 Watt range for less than 25% of the cost (on a dollars per Watt basis) of typical modules in 2011, and high-output 72-cell mono-crystalline modules are available with an output of 345 Watts for less than half the price (on a dollars per Watt basis).

Even the wiring for solar PV modules has changed, with more standardization and safety features incorporated over time, making installation simpler, more reliable and ultimately safer for all involved.

LESSONS LEARNED AND BEST PRACTICES: GREENHOUSE GAS AVOIDANCE

Based on encouraging early estimates, ENMAX explored the potential to aggregate GHG reductions from multiple solar and micro-wind installations. In Alberta's electricity system, microgeneration with solar PV results in avoiding electricity consumption at the customer end of the electricity transmission and distribution system (thus avoiding line losses as well). The similarity of these systems in form and function and the potential for aggregation of GHG avoidance prompted the desire for a recognized, approved method for calculating GHG avoidance and establishing value for this GHG avoidance. To this end, ENMAX embarked on a process to propose, draft, and defend in a public peer review process a new quantification protocol for Alberta's carbon offset system under support of this project. This effort resulted in the ***Quantification Protocol for Distributed Renewable Energy Generation, Version 1.0***, approved by then Alberta Environment and Sustainable Resource Development (AESRD) in March, 2013[5]. This public protocol can be used by any player in Alberta subject to the rules of Alberta's carbon offset system, established under the Specified Gas Emitters Regulation (SGER)[6,7]. This protocol identifies the relevant sources and sinks of atmospheric carbon, and establishes the mechanism by which qualifying renewable energy generation can be eligible for monetization as carbon offsets, including line loss avoidance and using standard inverter-based monitoring.

However, the conservatism and rigour embodied in Alberta's offset system (in terms of contiguous gap-free tracking, 3rd party validation and verification, and the limitation of annual ex-post offset generation audit), and the necessity to transact a sale of offsets to an obligated party under SGER—even internally within ENMAX—resulted in an economic value and risk profile for offsets that was deemed not worthy of pursuing within the scope of this project. Furthermore, the marketing message would have needed to clarify the scope and ownership of environmental attributes such that customers may have become confused or dissuaded from adopting solar PV if they were not going to own rights to these environmental attributes. As a result, the customer-facing contracts that form the basis of this project explicitly recognized the rights to environmental attributes as the property of the customer.

For the purposes of project reporting, ENMAX adopted the methodology of the Quantification Protocol for Distributed Renewable Energy Generation, based on a 25 year project lifespan, in order to align with standardized approaches to lifecycle cost accounting for solar PV as prescribed by the US National Renewable Energy Laboratory (NREL). Because of the linkage to Alberta's carbon offset system and the technical guidance provided as policy memos by the Government of Alberta, the Electricity Grid Displacement Factor (EGDF) for renewable generation was prescribed at 0.59 t/MWh (down from the previous 0.65 t/MWh), but with an additional credit factor for line loss avoidance of 1.083 according to the 2015 Carbon Offset Emission Factors Handbook[8].

To gauge how much energy an ideal solar PV installation may generate in a year, Natural Resources Canada has created a map of Canada's solar potential for PV, normalized to annual generation in kWh per installed kW of solar modules (see Figure 14).

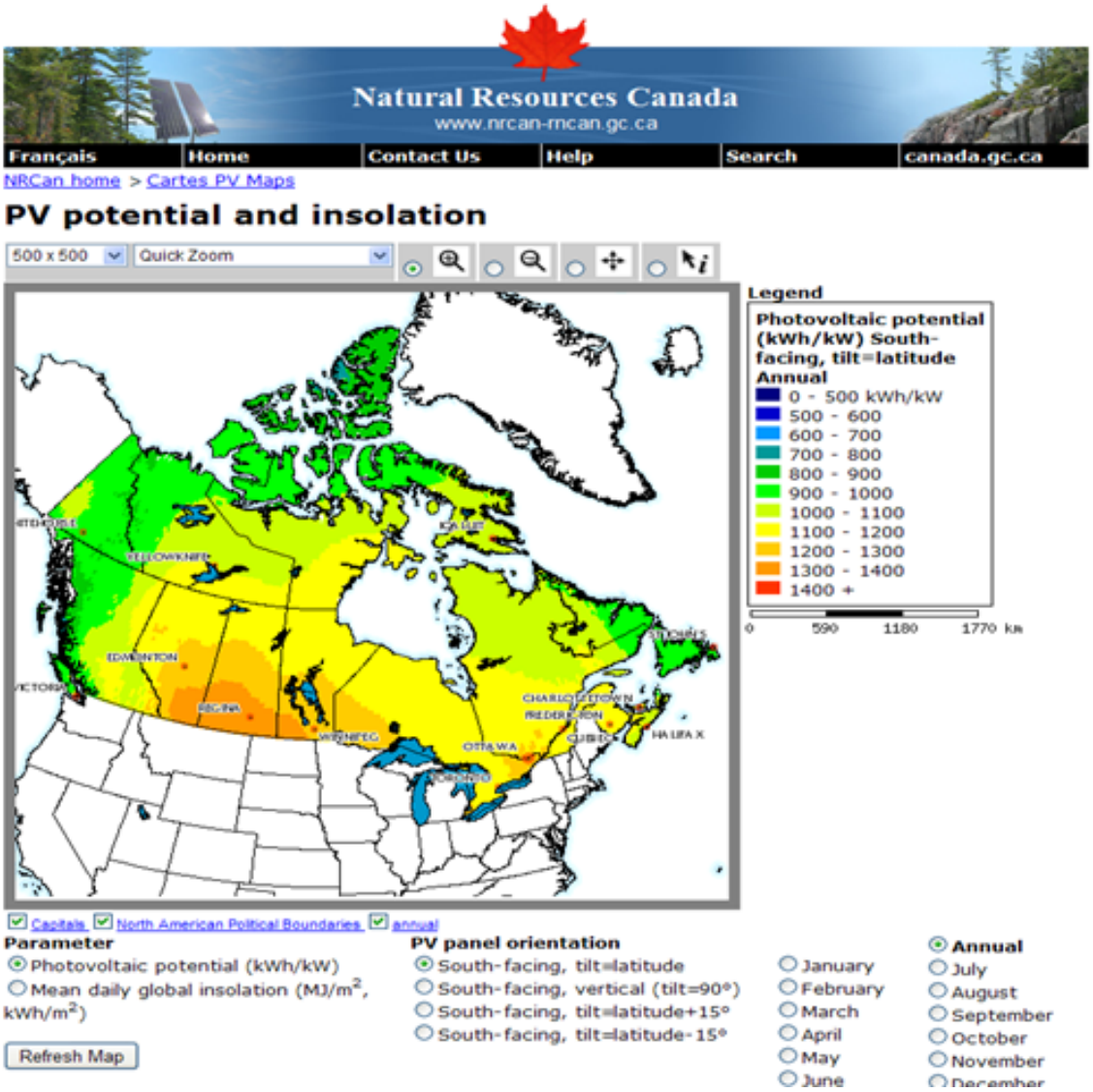
[5] For full text, see: http://esrd.alberta.ca/climate-change/guidelines-legislation/specified-gas-emitters-regulation/documents/ProtocolRenewableEnergy-Mar2013.pdf

[6] See: http://esrd.alberta.ca/climate-change/guidelines-legislation/specified-gas-emitters-regulation/

[7] See also: http://esrd.alberta.ca/climate-change/guidelines-legislation/specified-gas-emitters-regulation/offset-credit-system-protocols.aspx

[8] See http://aep.alberta.ca/climate-change/guidelines-legislation/specified-gas-emitters-regulation/documents/CarbonEmissionHandbook-Mar11-2015.pdf

FIGURE 14: NATURAL RESOURCES CANADA PV POTENTIAL[9]



The figure above illustrates that Alberta, and especially southern Alberta, have high quality solar resource. For the purpose of calculating average annual yield, this report uses 1,200 kWh per installed kW, which is equivalent to conditions in Fort McMurray at ideal slope and azimuth, or conditions in more southerly regions with slightly less optimum conditions (such as may be expected in residential applications).

Given the total deployed capacity of 9,131 kW of solar PV over the course of this project, approximately 247 million kWh are expected to be generated by the installed equipment over their 25-year system lifespans. Figure 15 illustrates the calculation for expected generation of the aggregate installed capacity over the expected system lifetimes. Because the output of solar PV modules degrades slowly over time (approximately 0.5 per cent per year on average, resulting in expected output at year 25 of approximately 80% of the rated output), a lifetime derating factor of 0.9 is used in this calculation. This factor aligns with standard manufacturers' prorated production warranties.

[9] URL: http://pv.nrcan.gc.ca

FIGURE 15: EXPECTED GENERATION OF INSTALLED SOLAR CAPACITY

kW Installed	Avg Prod	Lifetime Derate Factor	Lifespan	Total Gen (kWh)
9131	1200	0.9	25	246,542,940

Applying the approach from the carbon offset protocol noted above, the estimate of lifetime GHG avoidance can be calculated according to Figure 16 below.

FIGURE 16: ESTIMATED GHG AVOIDANCE BY OFFSET METHODOLOGY

Generation (MWh)	x EGDF (t/MWh)	x Line Loss Credit	Avoided tonnes CO2e
246,542,940	0.59	1.083	157,595

Using the values above, this project accomplished real GHG avoidance of approximately 158,000 tonnes.

Given the total contribution by CCEMC to this effort of approximately $11.18 million, the cost per tonne of GHG avoidance is estimated at $71, including the efforts for market development, working with municipalities to establish permitting processes, marketing, and all other eligible project expenses. See Figure 17.

FIGURE 17: ESTIMATED AGGREGATE COST PER TONNE OF GHG AVOIDANCE

Total CCEMC Contribution	Tonnes	Cost per tonne
$11,211,149	157,813	$70.95

ECONOMICS OF SOLAR

The US National Renewable Energy Laboratory (NREL) has monitored solar deployment in various states and found that 10 year simple payback is the point of inflection for market deployment of solar PV[10]. Simple payback is the number of years required to recuperate an up front investment, in non-discounted dollars[11]. Payback calculations factor in the relative pricing of grid electricity and solar PV, but simple payback is a crude measure, and either fluctuates according to market conditions along the life of a project or relies on estimates about relative costs of grid electricity into the future—a notoriously difficult business. ***ENMAX estimates that the inflection point for broad market uptake is when the value proposition of solar PV represents first year savings and sustained savings each year for financed solar with no up-front requirement for customer capital investment, coupled with extended warranty coverage.*** Even with CCEMC support, all scales of ENMAX's solar offerings required up-front customer investment in order to achieve attractive cash flows relative to the low price of electricity in Alberta.

Note: Even with supportive market conditions as described above, only a subset of customers will take up a given technology in a given year, and for that subset, it may take 20 years for all of them to actually take up the technology due to customers' priorities, perceptions of long-term risk, roof condition, and other factors. This adoption curve is referred to as a bass diffusion curve[12], and is an expression of the Technology Acceptance Model[13].

Throughout the project, ENMAX continually adjusted its estimates of the size of the Alberta solar PV market based on electricity and solar PV prices in Alberta at the time, and on best available forecasts for future grid electricity and solar pricing.

To establish the potential market size, ENMAX followed similar methods as those suggested by NREL, namely establishing technical potential (total roof size, with factors for obstructions and south-facing sloped roofs), and the economic potential, which is a measure of the proportion of energy customers who are likely to be interested in this technology at its relative price in any given year. By ENMAX's estimates, Alberta's technical potential for solar PV was well over 1,500 MW of rooftop space for existing commercial and residential buildings. A visual representation of market potential can be made with a modification of Porter's Five Forces[14] (a tool for assessing value proposition), as in Figure 18 below.

[10] See http://www.nrel.gov/docs/fy08osti/42306.pdf

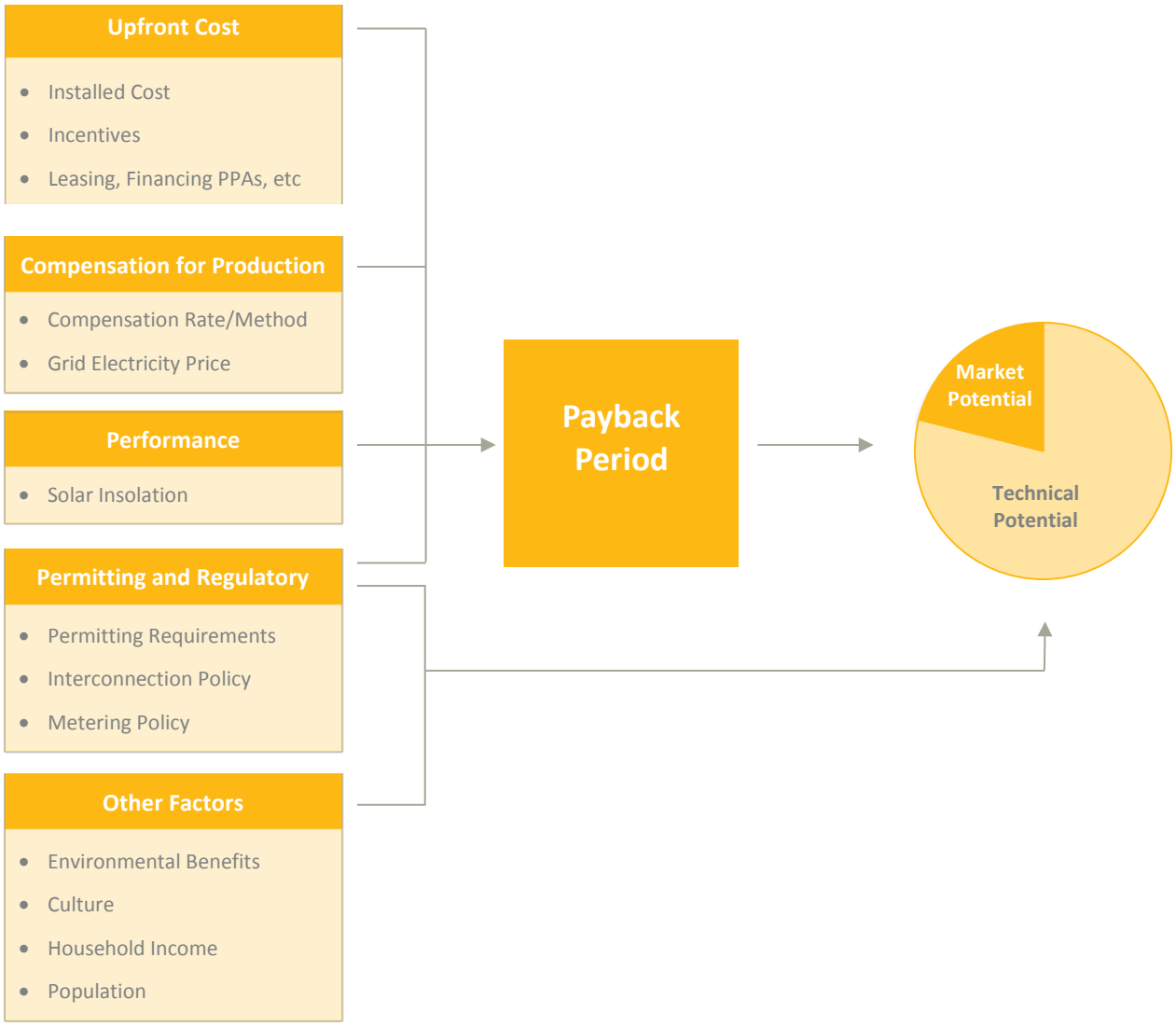
[11] See http://www.investopedia.com/terms/p/paybackperiod.asp

[12] See https://en.wikipedia.org/wiki/Bass_diffusion_model

[13] See https://en.wikipedia.org/wiki/Technology_acceptance_model

[14] See https://en.wikipedia.org/wiki/Porter%27s_five_forces_analysis

FIGURE 18: A FRAMEWORK FOR SOLAR ADOPTION IN LOCALIZED MARKETS



Source: Michael Becker (ENMAX employee) MGST MBA Final Deliverable, 2012

The market potential is a subset of the technical potential, representing the proportion of customers with the confluence of means (property owners with disposable income), and interest (motivation to adopt solar PV for the energy, technology, and environmental attributes and leadership symbolism it embodies).

FIGURE 19: INPUTS TO SOLAR MARKET ASSESSMENT MODEL

FORCAST MODEL OVERVIEW

Inputs:

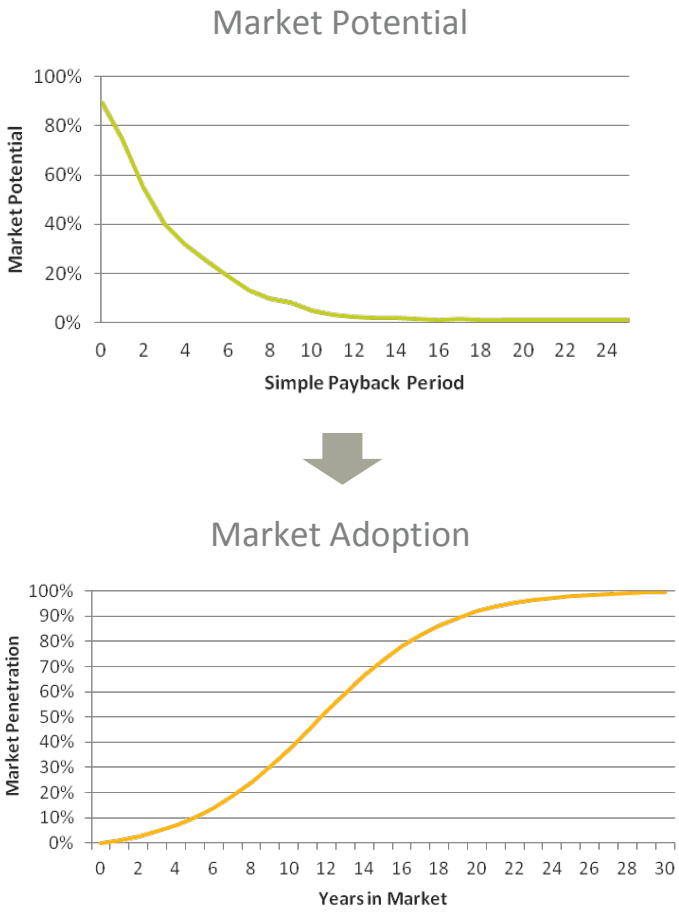
- Wholesale electricity price forecast
- Forecast of customer's variable charges
- Roof space (# of houses, sq.ft. of commercial buildings) and growth rates
- Solar module efficiency forecast
- Solar installed cost forecast
- Forecast ENMAS market share
- CCEMC and other potential incentives

Outputs:

- Wholesale electricity price forcast

Factors for predicating adoption rate of new technologies:

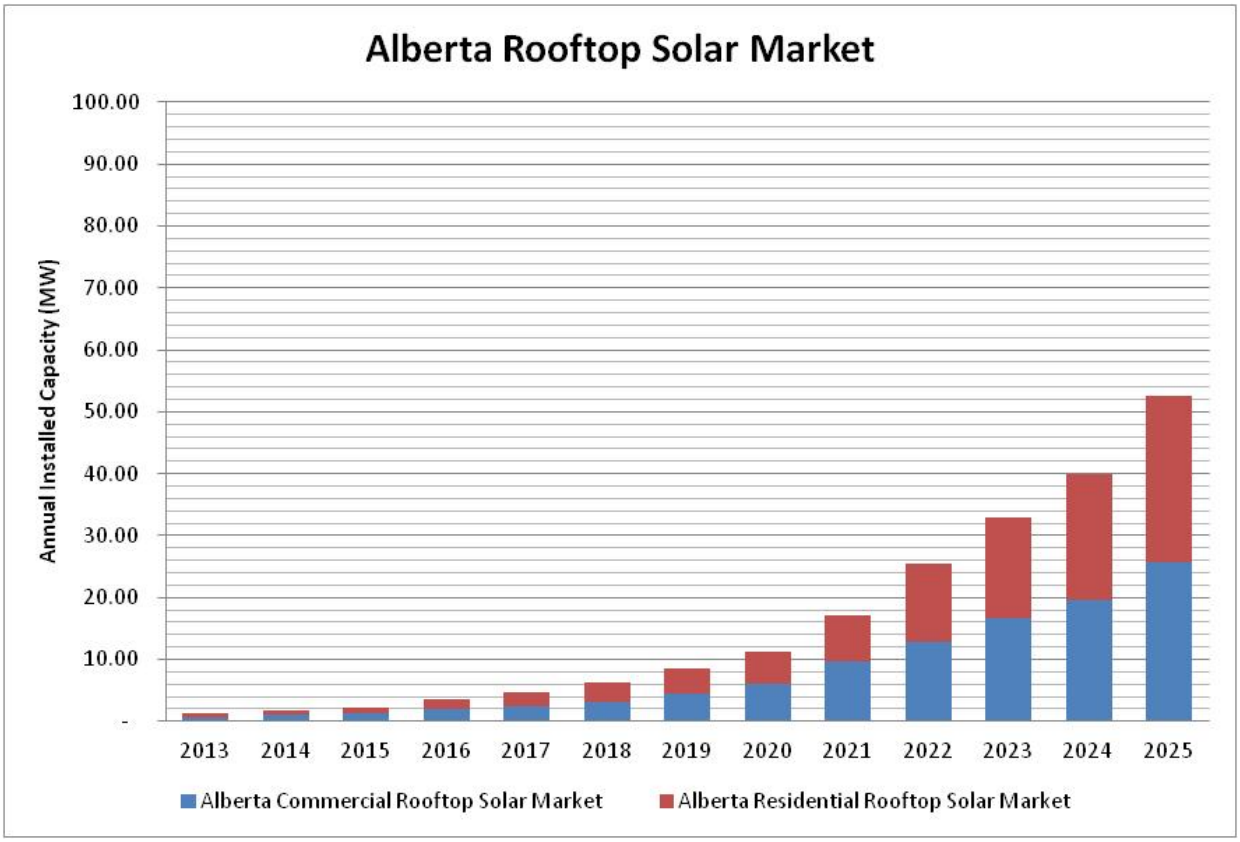
- Equipment Life
- Replacement
- Technology Experience
- Risk
- Regulation



$$\text{Simple Payback} = \frac{\text{Installed Cost} - \text{Incentives}}{\text{Annual Electric Bill Savings}}$$

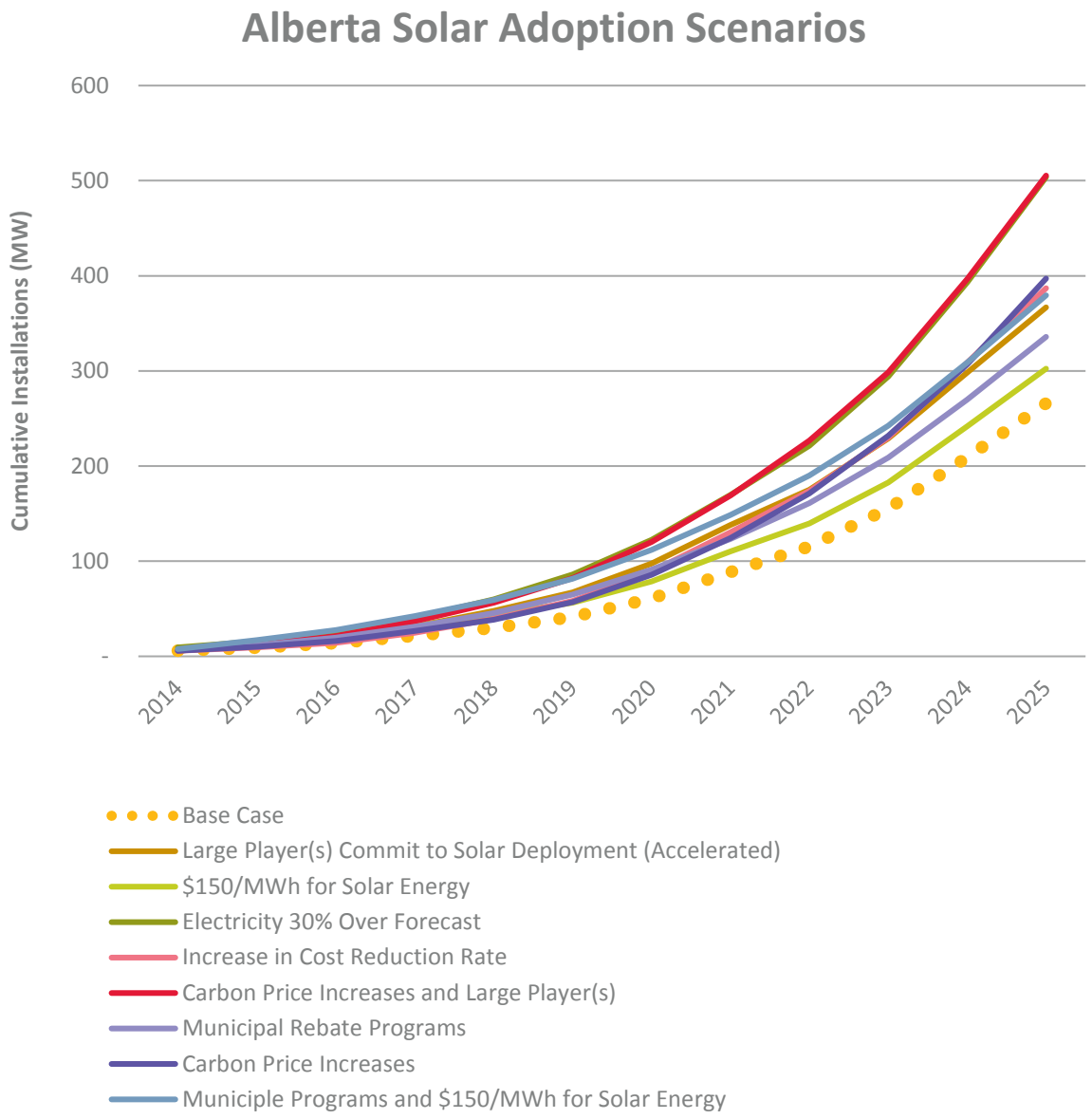
Based on conditions in 2013, an estimate of potential market size at 3 per cent escalation of electricity costs was forecast. At the time, this model could have been called a business as usual scenario (BAU). See Figure 20.

FIGURE 20: ALBERTA SOLAR MARKET FORECAST ASSUMING 3 PER CENT ELECTRICITY PRICE ESCALATION (CIRCA 2013)



To establish the potential of various market and policy changes from business as usual, in 2013 ENMAX modeled a range of circumstances affecting the deployment of solar PV in Alberta. Virtually all of the significant changes that were foreseen at the time were deemed likely to increase the adoption of solar from BAU. The most potent of combination these changes was anticipated to result in installation of up to 120 MW of solar PV in Alberta cumulatively as of 2020. See Figure 21.

FIGURE 21: 2013 SOLAR ADOPTION SCENARIOS (CIRCA 2013; NO LONGER REPRESENTATIVE)

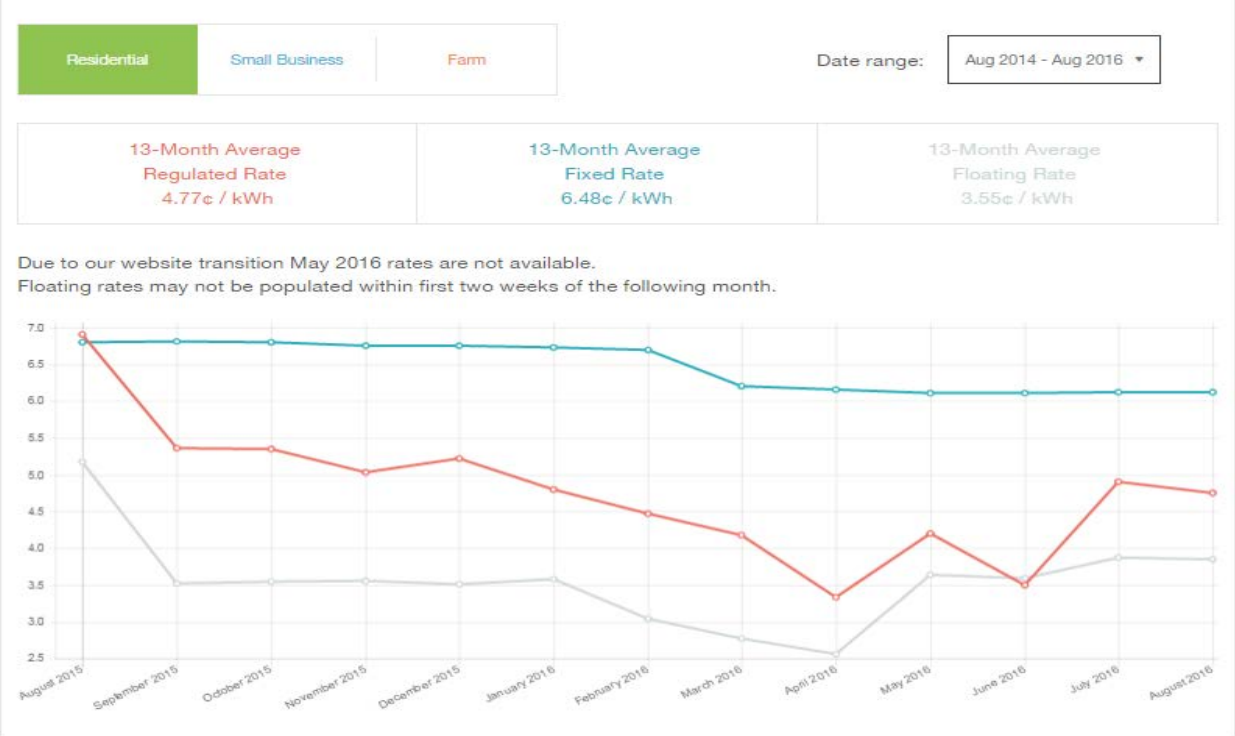


Note that this graph is no longer representative of current solar potential, and due to uncertainty regarding anticipated electricity prices and the market structure itself, such a projection is difficult to make at this time.

A CHANGING MARKET

Alberta's electricity market conditions worsened markedly over the period of 2014-2016, owing to the combination of a recession and low oil prices leading to softening demand for electricity in Alberta and robust supply in the absence of coal retirements, culminating in dramatically lower customer electricity prices compared to market conditions since Alberta's electricity sector deregulation in 2000. This trend had the effect of eroding the relative value proposition for solar PV in Alberta's market conditions.

FIGURE 22: UTILITIES CONSUMER ADVOCATE - RETAIL RATES IN ALBERTA AUG 2014 - AUG 2016



Source: Utilities Consumer Advocate[15]

Within the constraints of the MGR, micro-generation owners may generate their own energy to displace energy that would otherwise be purchased from the grid. When their instantaneous renewable generation is lower than their consumption, the customer is effectively displacing delivered retail electricity. When instantaneous renewable generation is higher than their consumption, the excess energy is exported, and the customer is reimbursed at their retail rate or at the hourly pool price, depending on the size of the customer's micro-generation system and whether they have an interval meter. In both cases, the lower the retail price of electricity the harder it is for solar PV generation to compete.

The impact at the wholesale market (power pool) from 2013 to 2015 was even more pronounced, with average prices falling from over $80/MWh in 2013 to just over $33/MWh in 2015. See Figure 23. In 2016, the year to date average pool price to December 15, 2016 is $18/MWh (i.e. less than two cents per kilowatt hour)[16]. This low rate contributes to low commercial retail energy prices from retailers, posing the same challenge for commercial solar as residential solar (i.e. competing against low retail electricity prices). Further,

[15] See http://ucahelps.alberta.ca/historic-rates.aspx
[16] See http://ets.aeso.ca

because customers with large solar PV systems that have interval meters are reimbursed for exported micro-generation energy at the hourly pool price, there is a market condition-based disincentive to exporting energy from large solar PV micro-generation sites at this time. In this context, a strong incentive for solar is required to get the mainstream market to adopt solar PV at this time.

FIGURE 23: EXCERPT FROM AESO MARKET STATISTICS, 2015

Price of Electricity

Pool Price Fell 33 Per Cent

Pool price averaged $33.34/MWh over 2015—a decrease of 33 per cent from 2014. The AESO separates each day into on-peak and off-peak periods: on-peak periods start at 7 a.m. and end at 11 p.m.; the remaining eight hours in each day make up the off-peak period. In 2015, the average pool price during the on-peak period fell 34 per cent to $40.73/MWh, and the off-peak average pool price fell 27 per cent to $18.55/MWh. Table 1 summarizes historical price statistics over the ten-year period between 2006 and 2015.

TABLE 1: Annual Market Price Statistics

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Average pool price ($/MWh)	80.79	66.95	89.95	47.81	50.88	76.22	64.32	80.19	49.42	33.34
On-peak average price ($/MWh)	101.41	84.37	112.97	58.04	62.99	102.22	84.72	106.13	61.48	40.73
Off-peak average price ($/MWh)	39.54	32.11	43.92	27.36	26.67	24.22	23.51	28.29	25.28	18.55
Average heat rate (GJ/MWh)	13.99	11.45	12.16	13.15	13.63	22.40	28.10	27.49	11.53	13.07

Source: AESO 2015 Market Statistics[17]

This depressed energy price, in combination with a weaker Canadian Dollar and new import duties on some Chinese-made modules, resulted in solar PV deployment roughly on par with ENMAX'S most pessimistic 'Low Scenario' projection, even including a large outlier system was installed outside of this project (i.e. not by ENMAX) for an agricultural client in April, 2014. Refer to Figure 4 on page 8.

In this context, support from CCEMC became very important in reducing customer pricing for solar PV offered by ENMAX, helping customers, especially at larger scales, to see value in solar PV and take the risk of adopting large solar PV systems. Indeed, because no government programs had been formally announced by the spring of 2016, when faced with the potential of losing the opportunity of proceeding with ENMAX with the support of CCEMC, several commercial and municipal, as well as residential customers, chose to proceed with their solar projects. Due in part to the convenience of ENMAX's solar financing, many of these projects were of significant size; the deployment schedule of ENMAX's installed solar capacity on page 9 of this report bears out this trend.

[17] http://www.aeso.ca/downloads/2015_Annual_Market_Stats_WEB.pdf

ALIGNMENT OF SOLAR SUPPORT PROGRAMS

In the first two years of this project (2011-2012), there were no other broadly available support programs relating to solar PV in Alberta. Federal energy efficiency programs were waning (and did not evolve to cover solar PV), and, as a result of high costs at the time, solar PV as a technology did not provide a compelling value proposition to consumers in Alberta. To provide options for overcoming the barrier of up front costs, ENMAX provided a lease option for its solar product, allowing residential, and later, commercial customers, a way to spread the costs of solar generation equipment over time.

Increasingly, customers began to appreciate that unlike bank loans or traditional 3rd party lease financing, ENMAX's solar lease provided extended warranty coverage for contingencies such as module or inverter failure, and damage from hail or lightning—features that provided peace of mind and helped customers focus on their core purpose by removing these risks from their investment during the lease term.

Customer purchasing dynamics from 2013 to 2015 were also challenged by the political signaling of both the opposition and the newly elected provincial government that new support programs may be coming for small-scale solar PV (and other related purposes like energy efficiency). Notwithstanding Alberta's sluggish economy, solar PV equipment costs continued to plummet, but customers may not have been aware because so few sales were proceeding at this time. The market was paralyzed by what solar installers call the 'threat of incentives'.

The dynamic surrounding customers' decision-making for solar PV has been complex, especially in the 2015-2016 timeframe, as governments announced their intentions to offer various support programs that may assist in deploying energy efficiency and solar PV technologies. This public dialogue about possible support programs for solar PV created a dynamic of 'wait and see' mentality among customers, either to understand if future programs would be more attractive than ENMAX offerings, or whether they could be used together to improve the business case of a solar project.

Over time, several small programs were launched and made available in Alberta, including the On-Farm program (a collaboration between Alberta Agriculture and the Government of Canada), Medicine Hat's HAT Smart series of programs (within their city limits), the TAME, TAME+ and AMSP programs offered by the Municipal Climate Change Access Centre (MCCAC), and later, the federal Canada 150 program administered by Western Economic Diversification (known as WED or WD).

Complexity for customers was compounded by the fact that certain programs could be used together (stacked), while others could not, and some programs required cash receipts for simple ownership of solar PV, while a good part of ENMAX's value proposition was made up by the ability to finance solar PV installations via a capital lease, which was not eligible under Canada 150, On-Farm or MCCAC programs.

ENMAX continually heard from customers that incentives were not enough to drive adoption because cash was still scarce. Customers large and small required attractive financing; otherwise, solar PV represented a large up front investment akin to purchasing 25 years' worth of electricity up front (a non-starter for many potential customers. Even with financing, several customers, from residential up to municipal and institutional scales, struggled with entering agreements for solar, either because the initial cash investment was large, or the scope and duration of lease agreements were outside of normal procurement practices for energy.

Nevertheless, the ultimate adoption of over 6.5 MW of solar PV under lease agreements with ENMAX underscores the importance of ENMAX financing in addition to any support programs offered by various levels of government. In fact, alignment of programs with private sector financing mechanisms is likely a key factor

for successful program design in Alberta, allowing the market to leverage both incentives and financial mechanisms for long-term deployment of solar PV.

Experience in Alberta follows what has been witnessed in other jurisdicstions where a large proportion of all distributed solar has been supporting by some type of 3rd party financing in addition to incentive programs[18].

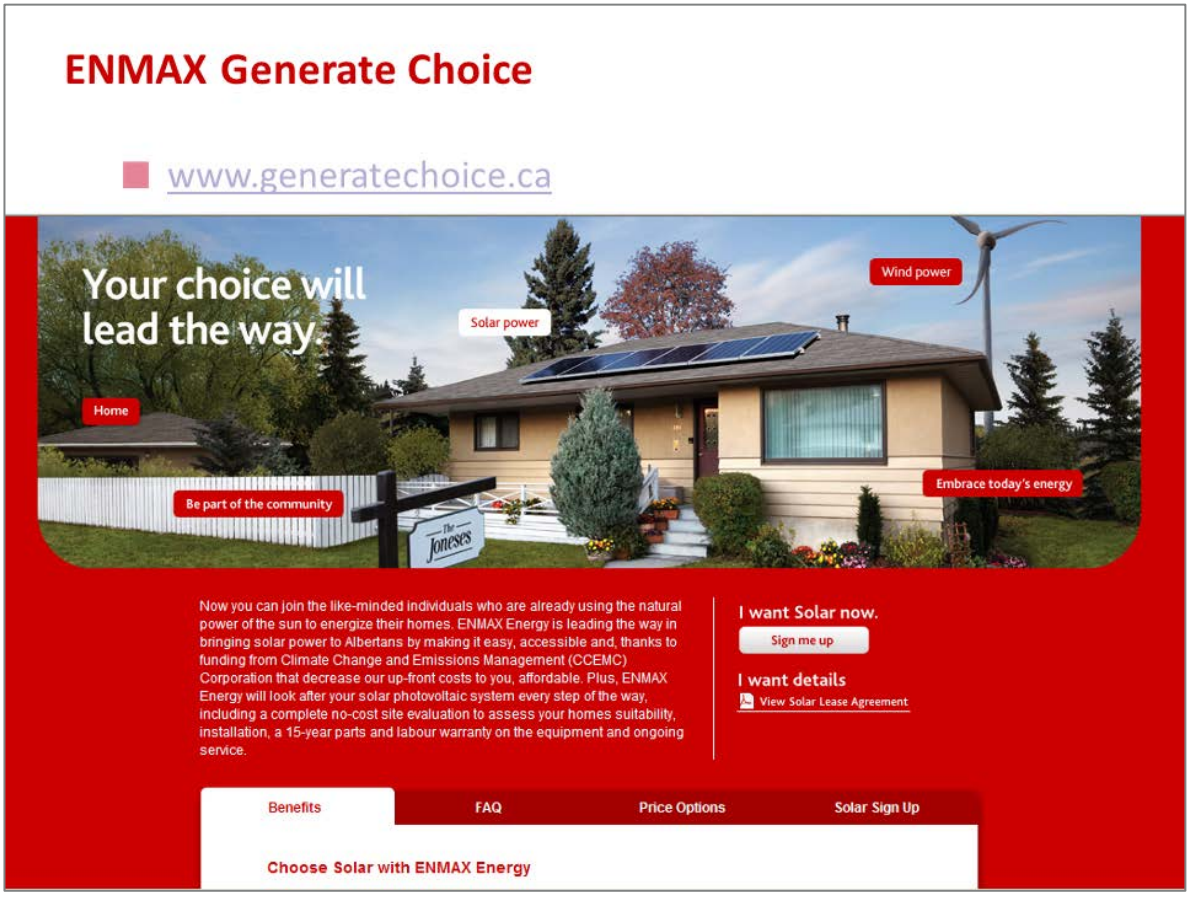
[18] Internal estimates show that over 2/3 of all solar PV installed in Alberta have been supported by some sort of incentive program.

MARKETING FOR MICRO-GENERATION

From the outset of this project, ENMAX believed that the interest in solar would be high among Albertans. What remained untested, however, was the degree of interest within varying product offers (marketing approaches, sale vs lease options, system sizes, and at various costs relative to grid electricity). What became clear was that there is a background level of interest that is always strong for solar PV, but that the rooftop market suffers from conflicting principles of conventional wisdom. On one hand, a general assumption among customers is that solar must make money, or should effectively be free, or provide financial paybacks that are not reasonable to achieve. Conversely, those who have slightly more information about solar in Alberta may have the impression that solar is expensive but getting less so over time, leading to an investor's paradox in which investing tomorrow may be better than today… in perpetuity. Further, the fluctuation of both solar PV pricing and the price of delivered electricity over time made statements about the relative costs of each electricity source difficult.

Early marketing efforts focused on providing solar in simple, understandable increments. This approach was supported by centralized procurement and an assumption of stable pricing.

FIGURE 24: EARLY MARKETING FOR SOLAR (CIRCA 2011) – BRANDED AS "ENMAX GENERATE CHOICE"



ENMAX marketed the Generate Choice messaging through a variety of channels, including TV commercials, a dedicated website, radio and bill inserts. These efforts generated over 7,000 leads for solar and micro-wind in the first year. However, due to the uphill value proposition for solar PV relative to grid electricity, only a small fraction of those people followed through with leasing or purchasing solar or wind generation systems.

The process of offering solar PV became an exercise in educating customers on several aspects of electricity—typically a low-engagement pursuit, but one which took on new currency in the context of self-sufficiency, environmental implications, and personal investment dynamics. It also became clear that while marketing efforts to generate leads could be effective, in the end only a small sub-set of the population will have an appetite for paying any premium for solar electricity, and of that group, a smaller sub-set has the combination of available capital, unobstructed roof space, and amenable timing for making a long-term investment in solar PV.

As of the Third Amending Agreement (i.e. starting in 2013), the structure was changed to offer flexible sizing and just-in-time pricing for systems complying with the Micro-Generation Regulation, versus the earlier standardized system approach, wherein customer prices were calculated based on market costs for equipment and local contractor installation services at the time of each installation. ***This change avoided the potential for inventory purchasing to become out of step with market pricing, and allowed ENMAX to pass on cost reductions for solar PV to customers immediately.***

As the program evolved, marketing became much more targeted to specific interest groups to try to reach interested audiences more quickly and cost effectively. Broad mass marketing was replaced with targeted events, special interest groups and efforts to leverage existing channels where synergies existed (e.g. Green building symposium).

CUSTOMER MOTIVATIONS FOR SOLAR PV

Our solar customers have told ENMAX about various motivations for adopting solar PV. The psychology of solar appears to be rooted in three main themes under the broader banner of leadership:

- self-reliance (often with a focus on early adoption of technology)
- environmental stewardship
- financial performance

These themes are interrelated, and all are rooted in a financial context. For example, even if motivated by environmental stewardship, most solar customers will still need to feel or quantify that they are making a reasonable (defensible) financial investment. Similarly, customers motivated by self-reliance may value control and autonomy over cost, but still need to understand their investment. Early adopters may wish to install solar in more visible (and therefore more expensive) locations, but may wish to justify the efficiency and design of the system, its yield, and its financial performance.

MARKETING OUTREACH

ENMAX sought to connect with customers through a variety of channels, including extensive business-to-business engagement, public advertising, face-to-face marketing at events, sponsorship of events and conferences, and online advertising.

By 2013, ENMAX had undertaken a corporate rebranding, whose look and feel was translated across all products, including solar. New solar flat sheets describing the ENMAX solar offerings were published and circulated, especially in direct business-to-business communications between energy Account Managers and their commercial clients.

FIGURE 25: ENMAX SOLAR PV FLAT SHEET

To reach residential audiences in a face-to-face setting, where both ENMAX and solar contractors could stand side-by-side to answer questions and display real-world examples of solar equipment, ENMAX attended a number of home shows and events across the province. Whether led by ENMAX (as an ENMAX booth) or the solar contractor (with supporting ENMAX materials), ENMAX attended major events in Lethbridge, Medicine Hat, Calgary, Red Deer, Edmonton and Grande Prairie. See Figure 26.

FIGURE 26: ENMAX SOLAR BOOTH AT HOME SHOWS

In addition, ENMAX met with customers face to face at communities all across Alberta, from Lloydminster to Fort McMurray to Banff, Beaumont, Devon, Strathcona County, Lethbridge County, Wheatland County, Cold Lake, Grande Prairie, and to farms, societies, recreation centres, municipal offices, family businesses and First Nations spanning virtually all parts of Alberta (except the far northern reaches).

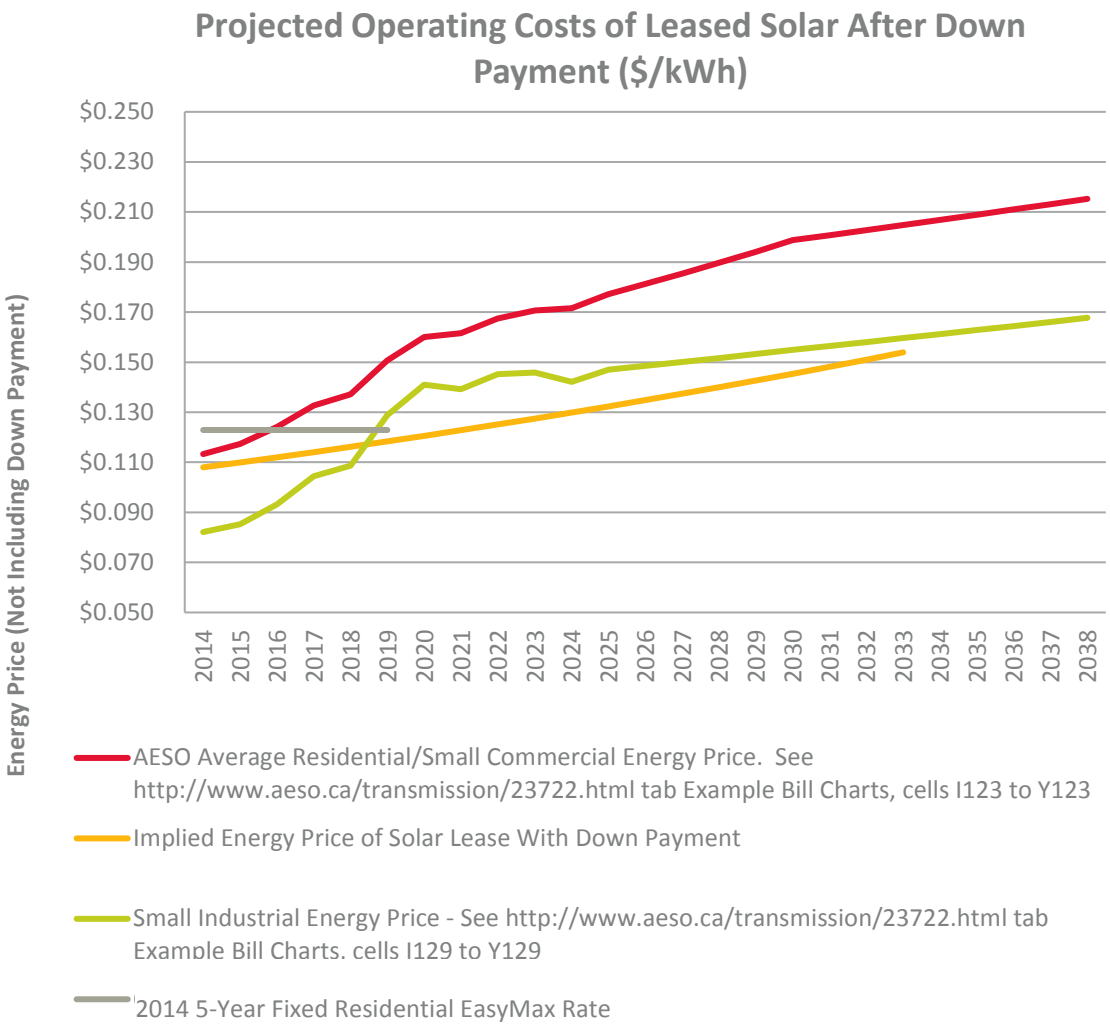
Customers of all kinds have similar questions about solar PV, ranging from the mechanics of how it works, to how reliable it is, to how long it lasts, to how to understand its economics in various applications and contract structures, etc. In our experience, customers generally appreciate the 'feel-good' attributes of solar PV (zero point source emissions etc.), and may ask for these to be clarified, but their most pressing questions relate to how to make solar PVwork for them, in terms of how to pay for solar (and whether solar represents a reasonable investment) and how solar PV helps them control or avoid a proportion of their future energy and utility charges. Customers also need to know that their solar array can integrate safely with their building's structure and electrical systems, and ENMAX provided this information for customers of all sizes, building types, roofing types, and in all relevant wind and snow loading regimes in Alberta.

For larger systems, customers often required detailed feasibility information to present to company boards and municipal or tribal councils. In some cases, ENMAX prepared detailed comparisons of the levelized cost of solar and the cash flow view of leased solar vs expected grid electricity prices.

To help customers understand how future operating costs of leased solar (i.e. after a lease down payment) would compare against expected future electricity prices, ENMAX compared future operating costs in specific modeled solar leases against a forecast published within the AESO long-term transmission forecast (TRIP workbook) as a generalized view of likely future market conditions. See an example in Figure 27.

One important note is that the value of rooftop solar must compare with the *delivered cost of electricity* including the variable costs per kWh of energy purchased from the grid. One important attribute of the ENMAX solar lease is the ability for customers (for example, large organizations or municipalities) to pay a lease down payment from one department, and operating costs (i.e. lease payments) from another. To contextualize the value proposition of solar PV leased in this way, for a brief period in 2014 a comparison could be made between the operating costs of solar PV (i.e ***after a 25-40% down payment***) relative to a forecast of expected prices for delivered electricity contained within AESO's Long Range Transmission Plan Workbook.

FIGURE 27: SOLAR OPERATING COSTS (NOT INCLUDING LEASE DOWN PAYMENT) VS AESO FORECAST FOR SMALL COMMERCIAL GRID ELECTRICITY IN 2014



OPERATIONS AND BUSINESS MODELS

Due to evolving supply, distribution and installation options in Alberta's solar PV industry over the course of this project, ENMAX's supply chain options continued to evolve rapidly over the course of this project. A variety of business model approaches were evident from global and US markets, including various functions from module manufacturing through project development/sales, financing, and post-install monitoring and operations/maintenance support. Over the course of this project, ENMAX reviewed, and ultimately adopted, several different business models for offering solar PV, variously resembling the contrasting models of successful US solar providers like Solar City or Sunrun at different times. See Figure 28.

FIGURE 28: RESIDENTIAL SOLAR PV FINANCE LANDSCAPE MAP

Lead-Gen	Sales	Financing	Installation	Monitoring	Module Supply	Active Markets
SolarCity	SolarCity	SolarCity	SolarCity	SolarCity	Yingli • Kyocera • Trina	
sunrun + Installer Partners	Installer Partners	sunrun	Installer Partners E.g. Verengo • Roof Diagnostics • REC	sunrun	Yingli • Trina • LG • Suntech and Others	
Installer Partners (W/ CPF Tools)	Installer Partners (W/ CPF Tools)	Clean Power Finance For 3rd Parties	Installer Partners E.g. Real Goods • Galkos	Clean Power Finance	Canadian • Sharp • Suntech and Others	
vivint. Often Door-to-Door	vivint.	vivint. + Clean Power Finance	vivint.	vivint.	Canadian • Trina • Yingli	
Constellation. BGE HOME ASTRUMSOLAR	Constellation. BGE HOME ASTRUMSOLAR	Constellation.	ASTRUMSOLAR	ASTRUMSOLAR	Hanwha • SolarWorld • Suntech	
SUNPOWER + Dealers	Dealers	SUNPOWER	Dealer Network E.g. Solar Service Center • Cobalt Power	SUNPOWER	SUNPOWER	
SUNGEVITY	SUNGEVITY	SUNGEVITY	SUNGEVITY Through Subcontractors	SUNGEVITY	Suntech • Motech • Hyundai	

Source: Greentech Media http://www.greentechmedia.com/research/report/u.s.-residential-solar-pv-financing

ENMAX launched its public solar PV offers in 2011 with its own staff, warehousing and distribution in order to have control over procurement, staff training, safety and other essential business functions. The model encompassed import, warehousing/inventory, sales, dispatch, install and financing as in-house capabilities. Over time, this model was shifted to a just-in-time third party ownership model in which most of the engineering, design, install and distribution services were contracted to local trades and service providers, except for project management, larger-scale procurement and ENMAX financing and warranty management. While the initial model created several jobs internal to ENMAX in the form of warehouse staff, dispatchers and installers, marketing and sales staff and supervisors, the latter necessitated a minimum of internal staff (as few as four direct jobs at ENMAX) but facilitated a broader reach for installing solar PV across the province,

and led to greater involvement by local installers, with job creation shifting to private companies rather than internal to ENMAX[19].

Finally, in 2015 and 2016, ENMAX adopted a hybrid model wherein both ENMAX and its contractors pursued solar leads in collaboration, and ENMAX consolidated procurement internally to seek economies of scale and drive down prices as much as possible during this period of low grid electricity prices. This hybrid model allowed ENMAX and our contractors to leverage core strengths and add value to Alberta's solar PV customers.

In its various models, ENMAX worked with over 260 different vendors and service providers during the course of this project, who represented the following functions:

- Local solar installers
- Solar module manufacturers
- Inverter manufacturers
- Racking manufacturers
- Solar equipment distributors
- Electrical equipment distributors
- Electrical engineers
- Structural engineers
- Municipalities
- Insurance companies
- Transport companies
- Brokerage/forwarding companies
- Registries and land titles offices
- Audio-visual equipment rental companies
- Advertising agencies
- Print/copy companies
- Financial auditors
- GHG validator/verifiers
- Hotels and restaurants
- Auditors and legal counsel

The number of direct and indirect jobs created has varied across time and according to business models employed. However, an estimate can be made by comparing workforce requirements for typical solar PV installs against total installed solar PV capacity in this project. Estimates in the table below are based on benchmarking done by The Energy Trust of Oregon for solar PV installs in that state in 2014 and ENMAX's estimates of indirect labour required for equipment distributors, project development and accounts receivable

FIGURE 29: LABOUR ESTIMATES FOR SOLAR PV

Category	Install Labour (per kW)	Soft Cost Labour (per kW)	Indirect (Induced) Labour	Total	kW Installed	Hours
Residential	10.75	8	8	26.75	1948	52,109
Commercial	8.4	5	4	17.5	7183	125,703
Total						177,812

If a typical work year is made up of 2,000 hours, this equates to approximately 89 full time job years supported through this project.

[19] **Note that ENMAX'S competitive entities EGPI and ENMAX Energy are also private sector companies, even if their parent company, ENMAX Corporation, is municipally-owned.**

PROJECT COSTS AND CONTRIBUTIONS

The overall project budget is summarized in the figure below. ENMAX completed this project under budget relative to both the original proposal and the amended forecast in the Fourth Amending Agreement.

FIGURE 30: BUDGET SUMMARY RELATIVE TO FOURTH AMENDING AGREEMENT

Forecast ($ '000)	Actual ($ '000)
34,295	31,891

FIGURE 31: FINANCING SUMMARY (ACTUALS)

Source of Funds	CCEMC ($ '000)	Total ($ '000)
20,710	11,182	31,891

FIGURE 32: WORK PLAN SUMMARY RELATIVE TO FOURTH AMENDING AGREEMENT

Forecast (kW)	Actual (kW)
9173	9146

Overall, this project will result in an expected approximately 158,000 tonnes of GHG avoidance at a cost of approximately $71/tonne over the 25 year lifespans of installed solar PV systems.

This project touched over 260 suppliers and over 600 solar PV customers of all sizes and resulted in installation of small residential to large commercial micro-generation systems. In sum, the project supported over half of Alberta's total installed solar PV to date, and resulted in over 9.15 $MW_{(DC)}$ of new micro-generation capacity installed.

CONCLUSIONS

Overall, this project succeeded in supporting roughly half of the installed capacity of solar PV in Alberta to date, helping the province evolve from a deployed capacity of less than 1 MW in 2011 to an estimated 16 MW, with ENMAX having installed approximately 9.1 MW of that figure. Not only has this success expanded the amount of solar PV in Alberta, it has come in the form of the full range of sizes permitted under Alberta's enabling regulation, and has been adopted by homeowners, small business owners, farms, municipalities, schools and First Nations across Alberta.

ENMAX attributes this project's success to three main features:

- A long-term, reliable solar PV provider, especially for extended warranty coverage
- Solar PV-specific financing that works for municipalities, businesses and homeowners
- Support from CCEMC, which improved the economics and the rationale for customers to act

The concept of losing the opportunity for support from CCEMC was viewed by customers as a risk, motivating many to proceed with their projects, especially in 2016.

This project will be responsible for approximately a quarter of a billion kWh of solar energy generation over the lifetime of the installed equipment, conservatively reducing GHG emissions by approximately 158,000 tonnes over 25 years (by current offset protocol methodology). As part of the project, ENMAX created a carbon offset protocol that can be used by anyone in Alberta to monetize the avoided GHG emissions under current regulations, and has provided flagship micro-generation systems that rival any in the country. Perhaps most importantly, the entirety of this accomplishment has been made without a single lost-time injury.