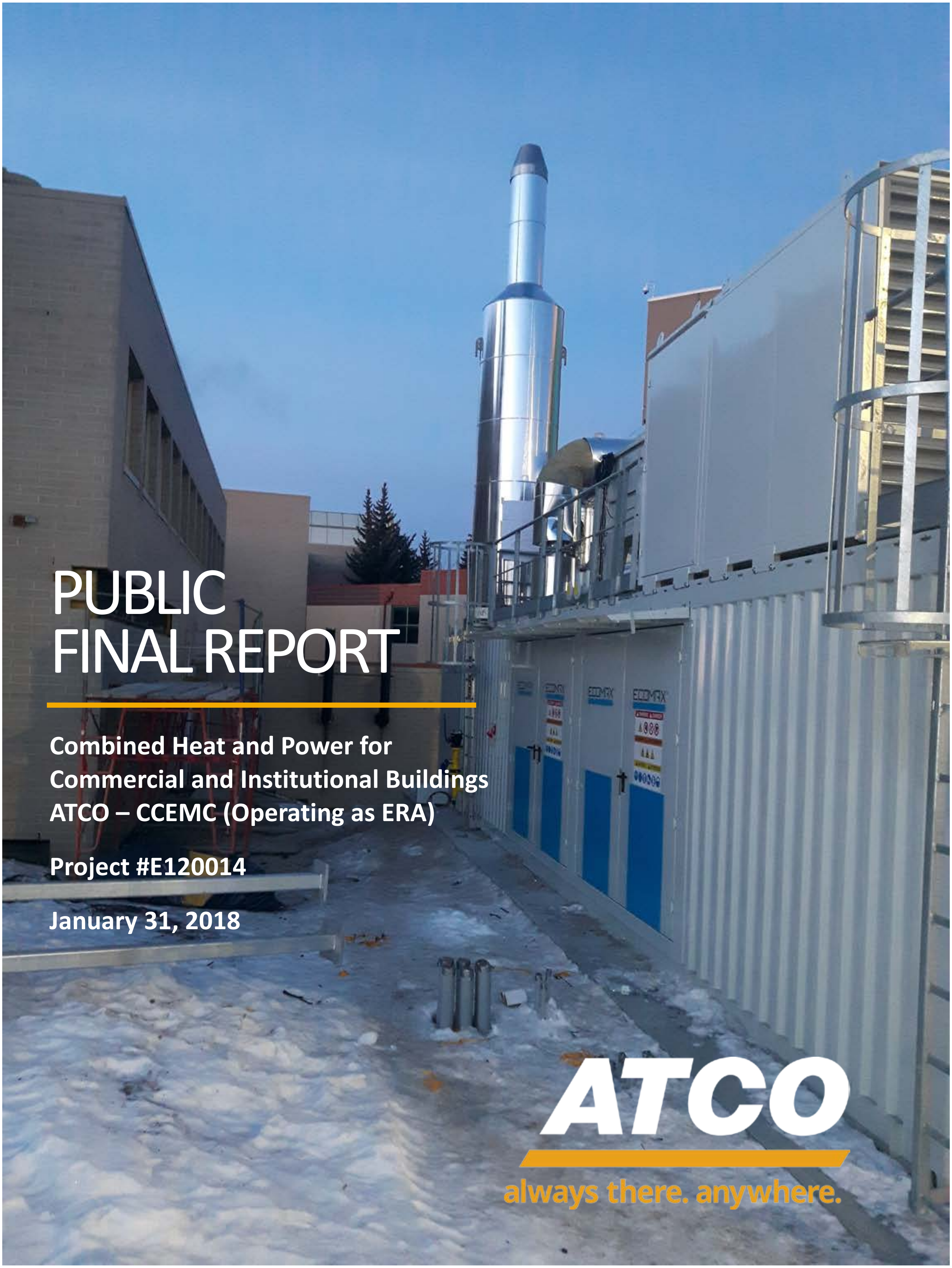

PUBLIC FINAL REPORT

Combined Heat and Power for Commercial and Institutional Buildings
ATCO – CCEMC (Operating as ERA)

Project #E120014

January 31, 2018

ATCO
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FINAL REPORT

PROJECT # E120014

CONFIDENTIALITY STATEMENT & DISCLAIMER

FINAL REPORT

PROJECT # E120014

1.0 EXECUTIVE SUMMARY

ATCO Gas and Pipelines Ltd. ‘s (ATCO’s) successful submission to the Energy Efficiency Call for Proposal by the Climate Change and Emissions Management Corporation (CCEMC) resulted in an executed Contribution Agreement between ATCO and CCEMC on September 5, 2013. This project is committed to the development of Combined Heat and Power (CHP) as an innovative technology deployed to reduce greenhouse gas emissions.

With significant shifts in the economic and regulatory environment since its inception, scope changes throughout the project lifecycle were warranted. The scope evolved from 17 installations of 75 – 100 kW maximum sized CHP units at original execution, to become 1445 kW total installed capacity with a maximum unit size of 850 kW at final amendment. The large upfront capital investment of CHP along with the economic downturn in Alberta, implementation of a Carbon Levy and low electricity prices are challenges to the adoption of this natural gas fired technology. Significant efforts were made by the ATCO CHP project team to overcome these barriers and educate and engage stakeholders on the benefits of CHP. The result is four successful CHP installations varying in size from 168 kW to 785 kW, for a total of 1445 kW total installed capacity and an estimated annual total of 3,600 Tonnes in greenhouse gas reduction.

The evolution of ATCO’s CHP project highlighted numerous opportunities to capture lessons learned and adapt practices to improve future applications of the technology. First and foremost is that CHP is not a universal solution. A robust upfront technical analysis is required to determine viability of the technology for each facility’s unique systems and needs. Secondly, CHP installation projects require intense due diligence. It is imperative to address all potential risks when selecting equipment suppliers, project partners, and executing contractual agreements. Finally, CHP projects take time. Like other construction projects, CHP installation projects are subject to the same environmental factors, which are often out of the control of the project management team. Equipment procurement, permitting and permissions, and integration with existing systems are all key considerations that require significant lead-time, especially in a new market.

Despite the challenges of economics and project management, the overall awareness and interest in the benefits of CHP have improved considerably since the inception of the ATCO CHP project. The Carbon Levy in Alberta has driven increased interest from facility owners looking for a viable solution to reach lower operating cost and make a significant positive impact on the environment. CHP technology can lower GHG emissions using natural gas, an abundant and reliable fuel source for Alberta, to drive energy efficiency. However, continued support through funding is needed for this proven emissions-reducing technology to be feasible for most opportunities.

2.0 ACKNOWLEDGEMENTS

ATCO Gas and Pipelines Ltd. wishes to acknowledge the following partners and participants in the execution and completion of Project #E120014, Combined Heat and Power for Commercial and Institutional Buildings:

Climate Change and Emissions Management Corporation (Operating as Emisssions Reduction Alberta)

Customer Facilities:

Sierras of Tuscany, Calgary, AB – Condominium Corporation No. 0012394

Collicutt Centre, Red Deer, AB – City of Red Deer

JBS Canada Centre (formerly Lakeside Leisure Centre), Brooks, AB – City of Brooks

Mount Royal University, Calgary, AB – The Board of Governors of Mount Royal University

Local CHP Suppliers:

Collicutt Energy, Red Deer, AB (supply of Sierras and Collicutt)

Clark Engineering, Edmonton, AB (supply of Lakeside)

EPS AB Energy Canada Ltd., Okotoks, AB (supply of MRU)

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3.0 INTRODUCTION

On November 21, 2012 ATCO Gas and Pipelines Ltd. (ATCO) submitted Expression of Interest # E120014 to the Climate Change and Emissions Management Corporation (CCEMC), now Emissions Reduction Alberta (ERA), in response to the Energy Efficiency Call for Proposals issued May 1, 2012. ATCO's full project proposal for 'Combined Heat and Power (CHP) for Commercial and Institutional Buildings' was successful and officially executed in a Contribution Agreement between ATCO and CCEMC on September 5th, 2013.

Using funding allocated as part of the Contribution Agreement, ATCO launched a CHP project to provide innovative technology to small commercial, municipal and instuituional buildings throughout Alberta. CHP is an energy efficient technology that uses clean burning natural gas to provide onsite production of both electricity and heat, thus reducing greenhouse gas emissions and overall energy costs for customers. The project also aimed to raise awareness of the benefits of CHP and how it can be best utilized in facilities with consistent high space and/or hot water heating loads, for example; recreation centres, medical centres, food and beverage manufacturing and large residential complexes. Working with various CHP suppliers and contractors, ATCO project managed the installation of four CHP units of varying sizes throughout the province of Alberta.

The scope of the Contribution Agreement was amended several times throughout the more than four years of the CHP project. In response to economic and other environmental conditions of the market, scope changes were required to accommodate larger CHP unit sizes and a smaller total number of units deployed. Upon final amendment the project scope was defined as follows; "ATCO Gas will install, operate and maintain Combined Heat and Power (CHP) units up to 850 kW in size in new or existing commercial, municipal and institutional buildings; for a total installed capacity of 1445 kW. The buildings require an energy profile with a heating load greater than 3100 GJ combined with an electrical load greater than 429,000 kWh. The CHP units will provide electricity to these customers with a significant reduction in greenhouse gas emissions (GHG) compared to the existing electrical grid. In addition, these units will also provide heat energy and reduce the overall cost of energy to these customers."

4.0 ACTIVITIES & ACHIEVEMENTS

Throughout the lifecycle of the CHP project all members of the ATCO project team were involved in a conscious effort to educate and engage stakeholders on the benefits of CHP and energy efficient technology deployment in general. Conferences, speaking engagements, marketing materials, advocacy group participation and documents are some examples of the forums ATCO used to deliver key messaging around the economic and environmental benefits of natural gas fired CHP. The timeline below provides a synopsis of key engagements and accomplishments.

2014

- Alberta Urban Municipalities Association (AUMA) Annual Conference and Trade Show
    - Trade Show booth, CHP brochure and presentation by ATCO senior leadership (Appendix 1)

2015

- Joined as Active Member of the Quality Urban Energy Systems of Tomorrow (QUEST) Alberta CHP Working Group
    - The Alberta CHP Working Group formed in late 2013 and was a result of an initiative by the Canadian Gas Association (CGA) to bring a cross section of industry, government and end-users to increase the profile of the efficient and economical CHP technology. The resulting working group includes utilities, government, and technology suppliers.
- Alberta Association of Municipal Districts and Counties (AAMDC) Conference and Trade Show
    - Trade Show booth, CHP marketing materials
- Alberta Urban Municipalities Association (AUMA) Annual Conference and Trade Show
    - Trade Show booth, CHP marketing materials and presentation by ATCO senior leadership
- CICAN (Colleges and Institutes Canada) Energy Symposium in Medicine Hat
    - Presentation by ATCO CHP project team member (Appendix 2)

2016

- Blue Skies Award co-recipient, Parkland Airshed Management Zone (PAMZ)
    - The Collicutt Centre in partnership with ATCO Gas received the Clean Air Technology Award for installing a Combined Heat and Power system in 2014
- Quality Urban Energy Systems of Tomorrow (QUEST)[1] Annual Conference and Trade Show, Calgary, AB
    - Active QUEST Membership and Co-hostof tour of energy efficient technologies, including CHP, with Brookfield Residential
- Active Membership in Energy Solutions Centre (ESC) CHP Consortium[2]
    - The ESC CHP Consortium was formed with the objective to accelerate the adoption of CHP technologies by all potential customers from a single-family residence through large industrial applications and District systems in North America. Active ESC Membership which includes attendance at quarterly Technology and Market Assessment Forums and semi-annual board meetings, access to the ECS CHP Magazine, etc.
- Alberta Energy Efficiency Alliance (AEEA) Event
    - Presentation by ATCO CHP project team member
- Alberta Association of Recreation Facility Personnel (AARFP) Conference and Trade Show

[1] http://www.questcanada.org/

[2] https://www.energysolutionscenter.org/consortia/distributed_generation_consortium.aspx

- Trade Show booth, CHP marketing materials and presentation by ATCO CHP project team member
- Alberta Association of Municipal Districts and Counties (AAMDC) Conference and Trade Show
    - Trade Show booth, CHP marketing materials
- Alberta Urban Municipalities Association (AUMA) Annual Conference and Trade Show
    - Trade Show booth, CHP marketing materials and presentation by ATCO senior leadership

2017

- Alberta Association of Agricultural Societies (AAAS) Convention
    - Presentation by ATCO Electricity Global Business Unit employee referencing ATCO CHP project
- Alberta Recreation and Parks Association (ARPA) Greener Facilities Conference
    - Presentation by ATCO CHP project team member
- Alberta Association of Municipal Districts and Counties (AAMDC) Conference and Trade Show
    - Trade Show booth, CHP marketing materials
- Alberta Urban Municipalities Association (AUMA) Annual Conference and Trade Show
    - Trade Show booth, CHP marketing materials and presentation by ATCO senior leadership
- Quality Urban Energy Systems of Tomorrow (QUEST) Annual Conference and Trade Show, Ottawa, ON
    - Active QUEST Member and presentations by ATCO senior leadership
- Customer Presentations (Appendix 3)

Testimonials

A key part of the engagement around continued deployment of energy efficient technology is maintaining open and continuous communication with existing customers of the technolgy to understand challenges and benefits from the end user perspective. ATCO project team members maintained ongoing relationships with all key customer contacts and encouraged open feedback. It is inevitable that challenges will arise during a major construction and installation project such as that with CHP. However, ATCO is proud to report continued positive feedback on the capability to address customers' challenges throughout the lifecycle of all four CHP installations. Testimonials from the customers are proof positive of these efforts.

> *"The professionalism of ATCO was paramount and we felt, moving ahead with this project, that it would continue in the same manner. And now with over a year of operation with the CHP unit there has been minimal to almost zero disruption to the operation of our centre."*
>
> *Stan Krawiec*
> *Operations Coordinator*
> *Collicutt Centre, Red Deer, AB*

> *ATCO representatives have been very thorough in managing the project. The communication has been great and they are clearly capable at what they do. We have been well looked after and well informed of the process to this point."*
>
> *Russ Tanner*
> *Recreation and facility Services*
> *Lakeside Leisure Centre, City of Brooks, AB*

In addition to the written testimonials, ATCO worked in partnership with the Collicutt Centre to produce a Combined Heat and Power video that highlights the functionality and benefits of CHP for institutional customers. This video can be viewed at https://youtu.be/CleumES02yg.

5.0 INSTALLED CHP SYSTEMS

In total ATCO has project managed the complete life cycle installation of four CHP units of varied size for customers throughout the province of Alberta. Each installation represented unique opportunities to learn more about the integration of new equipment and technology into existing infrastructure. A brief description of each project is provided below. Note that due to capture/use of waste heat, CHP is considered 75-85% efficient as compared to the baseline case (grid electricity + onsite boilers) which is 45-55% efficient.

Sierras of Tuscany

Project Description:
ATCO installed, and currently owns, operates and maintains a natural gas combined heat and power unit at this residential senior's condominium complex.

Location:	Calgary, Alberta
Date of Installation:	December 2014
Size of CHP Unit:	168 kW
Electrical Efficiency:	31.0%
Thermal Efficiency:	35.0%
Overall Plant Efficiency:	65.0%
Est. Annual GHG Reductions:	400 Tonnes

Project Costs: $493,640 PEC contact versus $760,399.18 total cost (54% increase or $4526/kW total)
Note: In this case increases are due to major deficiencies remaining upon PEC default. In addition, significant costs were incurred due to indoor installation (ie. HVAC mods)
Annual maintenance was originally only $0.021/kWh or $28,742 annually (w/ PEC)
Annual maintenance is now $0.030/kWh or $38,252 annually (on a two year contract w/ Collicutt Energy)

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Collicutt Centre

Project Description:
ATCO installed, and currently owns, operates and maintains a natural gas combined heat and power unit at this recreational multiplex which includes aquatic facilities.

Location: Red Deer, Alberta
Date of Installation: December 2014
Size of CHP Unit: 280 kW
Electrical Efficiency: 31.8%
Thermal Efficiency: 85.0%
Overall Plant Efficiency: 65.0%
Est. Annual GHG Reductions: 760 Tonnes
Project Costs: $720,000 Clark Engineering bid versus $668,940.00 Total (7% decrease) or $2389/kW
Note: In this case back-up power scope was removed from original price.
Annual maintenance has varied from $0.021/kWh or $47,903 annually (w/ PEC)
Annual maintenance is now $0.021/kWh or $44,645 annually (on a two year contract w/ Collicutt Energy)

JBS Canada Centre (formerly Lakeside Leisure Centre)

Project Description:
ATCO installed, and currently owns, operates and maintains a natural gas combined heat and power unit at this recreational multiplex which includes aquatic facilities.

Location: Brooks, Alberta
Date of Installation: April 2016
Size of CHP Unit: 192 kW
Electrical Efficiency: 32.0%
Thermal Efficiency: 45.0%
Overall Plant Efficiency: 65.0%
Est. Annual GHG Reductions: 640 Tonnes
Project Costs: $541,000 Clark Engineering bids versus $610,450.13 Total (13% increase) or $3179/kW
Note: In this case increase are attributable to an approved Change Order for Fortis interconnection. In addition, higher $/kW due to additional project requirements ie. heat metering.
Annual maintenance is $0.024/kWh or $37,540 annually w/ Clark Engineering

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Mount Royal University

Project Description:
ATCO installed and currently operates and maintains a natural gas combined heat and power unit at this main campus building which includes recreation, classroom and food service facilities.

Location:	Calgary, Alberta
Date of Installation:	December 2017
Size of CHP Unit:	785 kW
Est. Electrical Efficiency*:	37.9%
Est. Thermal Efficiency*:	45.0%
Est. Overall Plant Efficiency*:	82.90%
Est. Annual GHG Reductions:	2,000 Tonnes

*As reported by CHP Supplier, EPS AB in a lower heating value of 9.5 kWh/Nm^3

Project Costs: $3.17M or $4038/kW

Annual maintenance ranges from $0.010/kWh to $0.018/kWh

This results in $63,952 to $115,114 annually w/o overhauls (minor overhaul = $162,000)

6.0 LESSONS LEARNED

The evolution of ATCO's CHP project has highlighted numerous opportunities to capture lessons learned and adapt practices to improve future applications of the technology.

Lesson 1: CHP is not a universal solution

As part of the CHP project, ATCO evaluated more than 80 facilities in some capacity to determine their suitability for CHP technology. These facilities met the minimum energy requirements of 3,100 GJ and 429,000 kWh for program eligibility, but upon further investigation were determined not to be viable due to challenging technical or economic viability factors. Facility configuration, operating parameters, and contractual arrangements all impact the viability of a CHP application.

For example, older facilities with vintage boilers often appear to offer a great opportunity for CHP based on its energy consumption profile. However, if the existing heating systems are not driven by a central boiler plant the costs of the retrofit required to integrate the waste heat recovered by the CHP must be factored into economic calculations.

Operating parameters of an existing facility can similarly challenge the viability of a project. An effective CHP integration requires the building heating system to operate within temperature ranges that allow the waste heat from the CHP to be absorbed. For example, when return temperatures on heating loops are too high, there is insufficient opportunity for CHP waste heat to be absorbed in the building and substantial changes to the building heating system, the building automation system, or both could be required.

Another commonly encountered challenge is a potential customer's contractual agreement with their energy retailer. For example, long-term retail energy contracts are often based on specific allocations of electricity and natural gas with penalties incurred for significant deviations. A CHP project is likely to push a customer outside of their allocations as gas consumption increases and electricity consumption decreases.

Lesson 2: CHP projects require intense due diligence

A CHP unit will account for approximately half of the cost of a CHP installation and it is imperative that sufficient diligence is completed before entering into a procurement contract. It is important to select a manufacturer or supplier with a solid track record of meeting stated performance levels. Choosing a partner with factory trained representatives available locally for commissioning, ongoing operations and maintenance also helps mitigate risk, especially throughout the warranty period. Consideration should be given to extended warranty options as well as witnessing a Factory Acceptance Test to further reduce risk.

Partnering with engineering firms who are able to demonstrate expertise in HVAC system retrofits and experience with integrating CHP is crucial for project success. Using a competitive bid process to evaluate partners and confirming the capabilities of any respondents by following up with their references whenever possible, are both worthwhile exercises. In some cases, the "base building" engineers or pre-qualified firms have existing knowledge of customer's facilities that their competitors do not.

Ongoing operations and maintenance costs will represent a significant portion of costs over the course of a CHP unit's life cycle. Ensuring a CHP unit operates within optimal parameters and receives the maintenance required helps to protect the customer's initial investment. Enter into maintenance agreements that include remote monitoring, 24/7 support, and performance guarantees whenever possible and include provisions to have commonly needed parts held in stock locally to prevent extended equipment downtimes.

Lesson 3: CHP deployment requires Performance Specifications

Through engineered Performance Specifications, a CHP deployment can be set up for long-term success (maximum electrical and thermal outputs and overall plant efficiencies). First and foremast, we would recommend sizing CHP units for minimum thermal demand to avoid heat rejection and/or under-utilized CHP units during the summer months which impacts long-term system and economic performance.

The majority of manufacturers state efficiency in lower heating value (LHV) which estimates efficiencies at approximately 10% higher than higher heating value (HHV), which all natural gas is sold or measured in for end users. It should also be noted that there are performance implications of elevation de-rating; again, manufacturers may state electrical or thermal outputs in nominal terms as opposed to de-rating approximately 2.25% per 1,000 ft. To ensure accurate measurement and verification (M&V), there should be use of utility grade electricity and natural gas meters and installation of a thermal monitoring device to obtain accurate plant absorption rates. A robust direct digital interface for proper sequencing with building management system and an on-board data system, accessible through IP addressable user-friendly HTML portal are other ways to obtain accurate data.

Other considerations include sound level, which should be prescribed in advance when dealing with a residential situation (i.e. set minimum requirements for CHP supply, typically 65 dBa at 10m or can be determined via a Noise Impact Assessment). In our experience, an exterior CHP unit deployment is typically preferable to interior due space allowances, structural modifications and other provisions that are required when retrofitting an existing facility.

Lesson 4: There are various ways to delivery CHP

A CHP contract can take a variety of forms and depends on both the Owner and Service Provider's needs. ATCO has deployed two models over the past four years:

- Long term lease with ATCO ownership/maintenance with monthly charges, challenge is that the utility must spend large amount of capital upfront with long-term ROI

- Outright sale of equipment to end user with ATCO providing turn key functional CHP, challenge is that customer must spend capital upfront and may require short-term payback or aggressive ROI that are not achievable at current utility rates/spark spread

As part of our membership in technical organization and our attendance at industry conferences, we've identified the following industry examples of CHP contracts as well:

- Build, own, operate and maintain – option for both Owner or Service Provider
- Lease of equipment – Owner leases from Service Provider, essentially financing equipment (there are likely better rates available from financial institutions)
- Energy performance contracts – Service Provider to provide full operations and maintenance of Owner's equipment meeting contracted performance specifications
- Micro-utility/distributed generation – Service Provider to sell energy back to Owner for contracted $/GJ and $/kWh

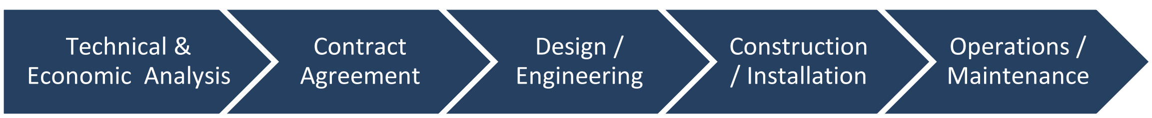
Lesson 5: CHP project execution takes time

In 2013, at the onset of the ATCO CHP project, CHP units less than 1 MW in size were a relatively new technology to the Alberta market, with very limited deployment across the province. Considerable effort was required to educate potential customers on the benefits of the technology before in-depth analysis for viability could even begin. This process was time consuming and required significantly more relative resource allocation than originally anticipated. In addition, feedback from this process led to the re-evaluation of the scope of the ATCO ERA Contribution Agreement to better serve the Alberta market and thus improve potential to meet the ERA mandate of greenhouse gas reductions. Through executed Amendments, the project scope evolved from 17 installations of 75 – 100 kW maximum sized CHP units to become 1445 kW total installed capacity with a maximum unit size of 850 kW.

Redirecting efforts to widen the net of potential target customers also required significant additional time commitment.

The steps for development of a CHP installation project, as shown below, are similar to that of many other construction projects and are therefore subject to the same environmental factors, which are often out of the control of the project management team. Equipment procurement, permitting and permissions, and integration with existing systems are all key considerations that require significant lead-time, especially in a new market. Most CHP suppliers (i.e. AB Energy, TEDOM, ENER-G, etc.) continue to package and ship units out of Europe where CHP deployment is more prevalent. The mature European market allows for mass manufacturing and therefore cost efficiencies. Also, the prime movers (i.e. reciprocating engines) are commonly supplied in Europe (i.e. Jenbacher, Liebherr, MAN, etc.) so there are supply chain efficiencies. The North American market is less mature and therefore local suppliers (i.e. Collicutt Energy, Finning CAT, etc.) have not yet refined their CHP packaging capabilities making their offerings less cost competitive. As such, it is important to set realistic expectations for all stakeholders and remain cognizant of potential for project fatigue.

CHP Project Management Process



Similarly, clear delineation of responsibilities and consistent communication allows focus on core competencies, maximizing the value from each role and lends itself to a more efficient process. To this end, the ATCO project team developed and employed a CHP Project Development Process that identified project stage gates, roles and responsibilities required to deliver a successful CHP installation.

7.0 CHANGES IN TECHNOLOGY

Most technological advancements are driven by consumer necessity or desire. CHP advancements are no different. The specific application of a CHP depends on many factors, including space requirements, facility functionality, thermal needs, emissions goals, fuel availability, interconnections, etc. These factors have motivated manufacturers and engineers to advance CHP technology to become adaptable to a wider range of applications. Micro-CHP, tri-generation, quad-generation and CHP-Solar co-installations are all examples of how CHP has advanced to meet increasing and changes needs of energy consumers.

Tri-Generation refers to electrical generation, thermal heating, and absorption chilling refrigeration. The addition of refrigeration allows for seasonal balancing of efficiency. Rather than wasting the heat in the summer time, the excess thermal energy can be recovered through the refrigeration process. Quad-Generation adds CO2 capture technology for enhanced greenhouse-based plant growth or chemically conversion to commercial by-products. Tri- and Quad-Generation utilize otherwise wasted energy to enable absorption cooling and CO2 recovery which help maintains high levels of operating efficiency. In some instances, grid-export of excess on-site electricity production can be beneficial, depending on spark spread differences between electric and gas prices and compensation mechanisms.

Additionally, CHP provides complimentary energy production to residential renewables enabling 24-hour reliability and backup. Pairing CHP with solar photovoltaic (PV) provides increased reliability during night, overcast, and otherwise non-PV producing times. By utilizing CHP during PV-downtime, customers can reduce their overall GHG emissions more than if they were to backup PV generation with grid-sourced electricity. Pilot projects within ATCO capturing the partnership of PV and CHP have provided opportunities to study demand patterns, control systems, and sequencing parameters. Direct digital controls allow for the optimization of operating efficiency through a site-specific design of electrical or thermal load following. ATCO has additionally demonstrated that these units can be synchronized with the electrical grid or operated in the absence of the grid by combining solar PV and a battery bank. This type of hybrid system has maximized the possible CO2 emission reduction and operating efficiency.

Although not within the scope of the ATCO CHP project, there is also increasing popularity in alternate fuel sources for CHP and numerous types of CHP prime movers, or engines. As the economics for CHP improves so too will the adoption of more varied CHP technologies in increasingly innovative applications.

8.0 MARKET READINESS FOR CHP

Multiple factors continue to affect the commercial readiness of CHP in general and in Alberta specifically. Throughout the lifecycle of the project ATCO has worked to overcome the barriers that have altered the conditions upon which the original contribution agreement was built. The economic and regulatory conditions in the Province of Alberta have changed considerably since the execution of Contribution Agreement with CCEMC (ERA) in September 2013, including but not limited to; an economic downturn resulting from shifts in the oil and gas industry, implementation of Carbon Levy and consistent reduction in electricity pricing thereby increasing competition for natural gas technologies. These condition changes have resulted in a decrease in the number of customer who have the financial capacity to consider the capital investment that a CHP requires, regardless of size and with or without funding.

Government Policies

Both the Canadian and Albertan governments have introduced new policies intended to reduce emissions by applying a price on carbon emissions. Although carbon pricing incentivizes businesses to reduce their carbon footprint, these policies also impact emissions-reducing technologies.

Federal Government:

The Government of Canada has set a greenhouse gas (GHG) target of 523 Mt CO_2 eq. by 2030, a reduction of approximately 30% from the status quo 2030-GHG emission estimate (742 Mt CO_2 eq.)[3]. To facilitate achieving this goal, the federal government also released the Pan-Canadian Approach to Pricing Carbon Pollution[4]. Of particular interest, the Approach requires:

1. Jurisdictions implementing an explicit price-based system: start at a minimum of $10 per tonne in 2018, and rise by $10 per year to $50 per tonne in 2022
2. Jurisdictions with a cap-and-trade system:
    a. Have a 2030 emission reduction target equal to or greater than Canada's 30% reduction target
    b. Have a cap-and-trade system with more stringent emission caps that correspond, at a minimum, to the projected emissions reductions that would have resulted from applying the direct carbon price that year

Provincial Government:

Currently, Alberta's electricity generation is predominantly coal-fired (approximately 41%)[5]. However, changes to public policy are moving energy producers and consumers to significantly reduce fossil fuel as a primary energy source. This has therefore impacted the use of natural gas and, by extension, the adoption of natural gas technologies.

The Government of Alberta has introduced the Climate Leadership Plan (CLP) that aims to tackle GHG reductions[6]. Of particular interest to ATCO, the CLP proposes:

1. Introducing a carbon levy of $20/tonne-$CO_2$ in 2017, increasing to $30/tonne-$CO_2$ in 2018
2. Phasing out coal-generated electricity by 2030
3. Reducing methane emissions by 45% by 2025
4. Supplying 30% of electricity generation from renewable energy sources by 2030

The carbon levy applies to all fuels that produce carbon emissions. As such, natural gas technologies are subject to carbon pricing. Despite having substantial emission reductions potential, CHP technology is economically hindered by

[3] (Government of Canada, 2017)

[4] (Government of Canada, 2017)

[5] (Alberta Energy, 2017)

[6] (Alberta Government, 2017)

carbon policies because of its fuel source. Conversely, electrification is favoured, despite concrete evidence as to the benefit of electrification of thermal loads to reduce carbon emissions.

It is also worth noting that the Alberta Utilities Commission (AUC) has also recognized that microgeneration projects have challenges to uptake and thus responded by altering their regulatory criteria such that any unit under 5 MW now qualifies as microgeneration. The previous regulation incorporated only units under 1 MW. This demonstrates that not only ATCO, but the industry as a whole, now recognizes that these projects require a reduction in barriers, including credit when applicable, to aid in their success.

Public Perception

An anti-fossil fuel mentality is developing that asserts that natural gas (conventionally a fossil fuel) cannot be part of the solution if it is part of the problem. In addition, electrification (i.e. electricity is chosen over other sources of energy) is increasingly popular, partly due to the perception that electricity, especially for vehicles, has low emissions (if supplied by a largerly renewable energy grid). Combined, these perceptions are enabling a potential shift away from natural gas technology use, such as CHP.

Funding

In the context of the current regulatory environment of the Alberta market, funding programs incentivizing CHP development is required to make the technology econimically viable for the end user. Businesses motivated to do their part to reduce emissions, manage energy costs, and increase their resilience to extreme weather events are increasingly looking to CHP as a solution. However, the carbon levy on natural gas as an input fuel increases costs on facilities with CHP, negatively impacting the business case for this capital investment. The carbon levy therefore results in an unintended “policy gap” for CHP, one of several technologies that should be encouraged as part of the Climate Leadership Plan. In the absence of a policy change to overcome this gap, funding programs to alleviate the financial impact to customers is required and currently advocated by ATCO.

Market Segments

Potential CHP adopters include the market segments and specific examples below. Their internal drivers for adoption of energy efficient technology consistently fall within one or more three categories; financial, image, or performance needs. Examples of these needs vary and include needs for reduced operations costs, sustainability marketing or mandates, competitive advantage, business continuity, and life safety considerations. The internal roadblocks or barriers also vary from aggressive private sector financial metrics to lengthy public sector budget/approval processes. Over the past four years, ATCO has explored potential projects in each of these sectors and have had the most success with municipal customers, specifically recreation centres with aquatic facilities and more recent success with institutional customers, likely due to their tolerance for longer-term paybacks on capital projects.

- Commercial – condominiums, hotel, laudromats, malls (with food courts)
- Municipal – recreation centre with aquatic facilities

- Institutional – unversity or college campus, residences and laboratories
- Healthcare – hospitals, nursing homes and long-term care facilities
- Light-Industrial – bottling, breweries, and processing facilities

9.0 GREENHOUSE GAS AVOIDANCE

Operating a CHP plant at point of use to generate primary thermal and electrical energy is proven effective in improving efficiency and reducing the quantity of greenhouse gas (GHG) emissions, in particular carbon dioxide.

With the goal of optimizing the GHG reductions, ATCO has employed intense due diligence to determine when a customer is a good candidate for CHP. We have become known as a trusted advisor in this respect and strive to maximize the benefit for the end user. Proper upfront process in the identification of a viable CHP project is integral to project success, including;

1. Technical Assessment
   - Employ rigorous and detailed technical analysis of existing year-round electrical (15 minute interval) and natural gas (1 hour interval) demand and existing HVAC system configurations to determine the facility's capacity to maximize the use of electrical and thermal output from the CHP unit year-round.
   - Use sensitivity testing to flex parameters and determine optimum CHP unit size.

2. Economic Assessment
   - Test the chosen CHP unit size (to meet GHG/kW reduction targets) to determine if and how the cost/installed kW meets the customer's tolerance levels (versus alternative technologies).
   - Calculate if the customer's current spark spread (difference between electricity and gas rates) can support the CHP business case and provide a suitable return on investment or payback period.

With consistent application of this methodolgy the ATCO CHP project successfully achieved an annual average of more than 3,200 Tonnes in GHG reduction or 2.24 Tonnes/installed kW, as outlined below.

GHG Avoidance: ATCO CHP Project #E120014

Collicutt Centre Performance DATA - 280 kW CHP De-Rated 260 kW - Totals to Date: Dec 2014 to Dec 31, 2017									
Electricity Produced kWh	Electrical Efficiency eEff	Thermal Efficiency Absorption Rated	Facility AFUE Plant Eff	Heat Displaced tEff/AFUE	Gas Consumed GJ	GHG/GJ/Gas Tonnes	GHG/kWh Tonnes	GHG Reduction Tonnes Yr/Avg	GHG Tonnes 20 Year Total*
4,944,748	31.8%	38.0%	65.0%	32,726	55,978	0.0505	0.00064	663	39,808

Sierras of Tuscany Performance DATA - 168 kW CHP De-Rated 155 kW - Totals to Date: Feb 2015 to Dec 31, 2017									
Electricity Produced kWh	Electrical Efficiency kWh/fuel in	Thermal Efficiency Absorption Rated	Facility AFUE Plant Eff	Heat Displaced tEff/AFUE	Gas Consumed GJ	GHG/GJ/Gas Tonnes	GHG/kWh Tonnes	GHG Reduction Tonnes Yr/Avg	GHG Tonnes 20 Year Total*
1,724,718	31.0%	35.0%	65.0%	10,785	20,029	0.0505	0.00064	232	12,740

Lakeside Leisure Centre Performance DATA - 192 kW CHP De-Rated 180 kW - Totals to Date: May 2016 to Dec 31, 2017									
Electricity Produced kWh	Electrical Efficiency kWh/fuel in	Thermal Efficiency Absorption Rated	Facility AFUE Plant Eff	Heat Displaced tEff/AFUE	Gas Consumed GJ	GHG/GJ/Gas Tonnes	GHG/kWh Tonnes	GHG Reduction Tonnes Yr/Avg	GHG Tonnes 20 Year Total*
2,280,989	32.0%	45.0%	65.0%	17,765	25,661	0.0505	0.00064	386	21,222

Mount Royal University Model Results - 848 kW CHP De-Rated 783 kW - Assumptions: April 2018 to Mar 31, 2019									
Electricity Produced kWh	Electrical Efficiency kWh/fuel in	Thermal Efficiency Absorption Rated	Facility AFUE Plant Eff	Heat Displaced tEff/AFUE	Gas Consumed GJ	GHG/GJ/Gas Tonnes	GHG/kWh Tonnes	GHG Reduction Tonnes Yr/Avg	GHG Tonnes 20 Year Total*
5,638,739	31.8%	40.3%	83.0%	30,994	63,835	0.0505	0.00064	1,950	39,007

* 20 Years deemed reasonable lifetime of CHP unit.

Note: Mount Royal Unviersity data set derived from reliminary sizing model, actual data will be available after period of continuous operation.

The following factors and assumptions are considered in the quanitifcation of the GHG emission reductions for both the individual CHP units and the cumulative ATCO CHP project.

- Conversion factors as per protocol outlined in the Carbon Offset Emission Factors Handbook[7]
- Based on the specific CHP, we determine GHG savings based on: electricity displaced (tC02/kWh x kWh) - CHP consumption (tC02/GJ x GJ) - boiler offset (tC02/GJ x GJ)
- When determining value of thermal absorption only absorbed heat is calculated
- Absorbed thermal energy is divided by average plant Annual Fuel Utilization Efficiency (AFUE)

10.0 ECONOMICS OF CHP

The economic viability of CHP projects is determined by two main factors; spark spread and heat absorption. Spark spread is an industry term for the cost difference between purchasing electricity from the grid and producing electricity by burning natural gas. If the cost to purchase grid electricity is equal to the cost to produce power by burning natural gas, then there is no spark spread and no advantage to the customer. When grid electricity is more expensive than natural gas, there is a positive spark spread. With sufficienct spark spread, it becomes more attractive to produce electricty on site using CHP than buying grid electricity.

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

Heat absorption also has a significant impact on CHP economic viability. CHP provides efficiency gains by recovering the waste heat from the electricity production process and making that thermal energy available for use on site. To realize the full efficiency of a CHP unit, customers need a use for the thermal energy recovered. In Alberta, a high proportion of buildings have a space heating requirement throughout the winter but summer thermal loads are limited to domestic hot water systems, which are typically too small to justify a CHP system. Buildings with significant year-round thermal requirements, such as aquatic centres, will have stronger economic viability as more heat will be absorbed into existing heating systems, offsetting boiler use.

Moving forward, electricity rates will continue to challenge CHP economics in Alberta. However, if electricity rates increase as new investment is required to update and expand electrical infrastructure, spark spread will trend in favour of distributed generation sources like CHP. Similarly, finding an effective use for CHP waste heat will continue to be a challenge for CHP in Alberta. Employment of other technologies, such as absorption chilling, can offer opportunities to effectively use CHP waste heat in the summer months without a thermal requirement, a configuration commonly referred to as tri-generation. Applications for tri-generation technology include arenas, grocery stores, office buildings, etc.

11.0 PROJECT COSTS

The following tables show the cost details for all milestones of the CHP project by category as portrayed on the original CCIMS project reporting system used by the CCEMC. A new online reporting system (ERIMS) was implemented prior to Milestone 4 of this project. However, for consistency the CCIMS method was used for all milestones for this demonstration purpose.

	Budget	Actual
Total Project Budget	$ 5,559,520.00	$ 4,979,953.81
CCEMC (ERA) Funding Contribution	$ 1,834,642.00	$ 1,643,383.69
ATCO Contribution	$ 3,724,878.00	$ 3,336,570.12

Detailed Expenditures: Project #E120014

Milestone	Task	Costs		Original Budget	Actual Cost
4	850 kW installed plus expenditures towards meeting final milestone	Labour	$67,798.47	$2,721,840	$2,694,275.64
		Materials	$2,255.31		
		Subs	$1,544,445.51		
		Travel	$833.06		
		Capital	$1,071,404.00		
		Legal (Other)	$7,539.29		
		(Other)	$-		
3	170 kW installed plus expenditures towards meeting next milestone	Labour	$185,243.27	$760,000	$795,701.96
		Materials	$589.20		
		Subs	$583,127.82		
		Travel	$5,936.02		
		Capital	$3,314.70		
		Legal (Other)	$17,023.10		
		Marketing (Other)	$467.85		
2	425 kW installed plus expenditures towards meeting next milestone	Labour	$54,804.97	$1,700,000	$1,291,491.89
		Materials	$N/A		
		Subs	$1,238,235.00		
		Travel	$976.17		
		Other	$ (2,524.25)		
1	Signed Unconditional Contracts for 425 kW installed, Approval, Program Development & Marketing	Labour	$163,155.63	$261,840	$198,481.04
		Materials	$N/A		
		Subs	$2,550		
		Travel	$2,355.11		
		Legal (Other)	$22,540.13		
		Marketing (Other)	$7,880.17		
			Total	**$5,559,521**	**$4,979,953.81**

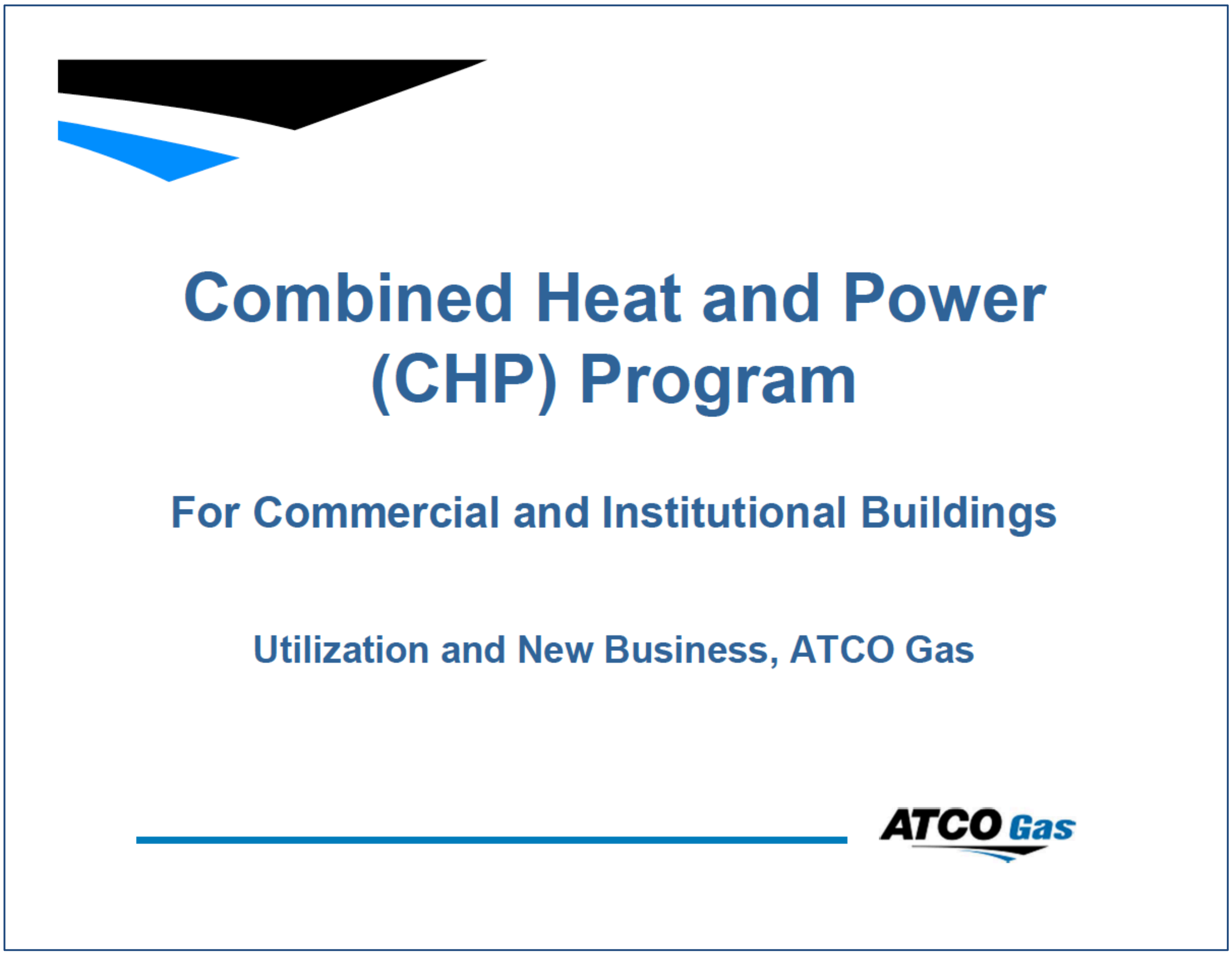
12.0 CONCLUSION

The fulfillment of the obligation to install 1,445 kW total capacity of CHP units highlighted both challenges and opportunities in ATCO's objective to install CHP.[8] A shift in scope throughout the project to focus on deployment of larger sized CHP units was a thoughtful response to address the economic challenges of smaller unit installations. The capital cost per kilowatt decreases on larger CHP units and thereby makes installation more favourable to facilities having slightly larger budgets and access to capital funding, such as in educational institutions. Although the economics continue to be a barrier to adoption, the overall awareness and interest in the benefits of CHP have improved considerably since the inception of the ATCO CHP project. Changes in regulation, specifically the Carbon Levy, have sparked increased interest from facility owners looking for a viable solution to reach lower operating cost and make a significant positive impact on the environment. The technology employed in CHP is sound and with the right market conditions the incidence of deployment would improve considerably. Markets where the spark spread is more favourable, such as Saskatchewan and Ontario, have demonstrated this. In Alberta, support through funding needs to continue for this proven emissions reducing technology to be feasible for most opportunities. ATCO continues to have interest from viable facilities across the province that, if additional funding was available, would become CHP installation projects. CHP is a technology that can lower GHG emissions using natural gas, an abundant and reliable fuel source for Alberta, to drive energy efficiency. Having the ability to use current and upcoming projects as examples will support adoption to more mainstream commercialization of CHP and will become a platform to educate for other technologies, i.e. mCHP, tri-gen, quad-gen, etc.

[8] http://eralberta.ca/about-era/

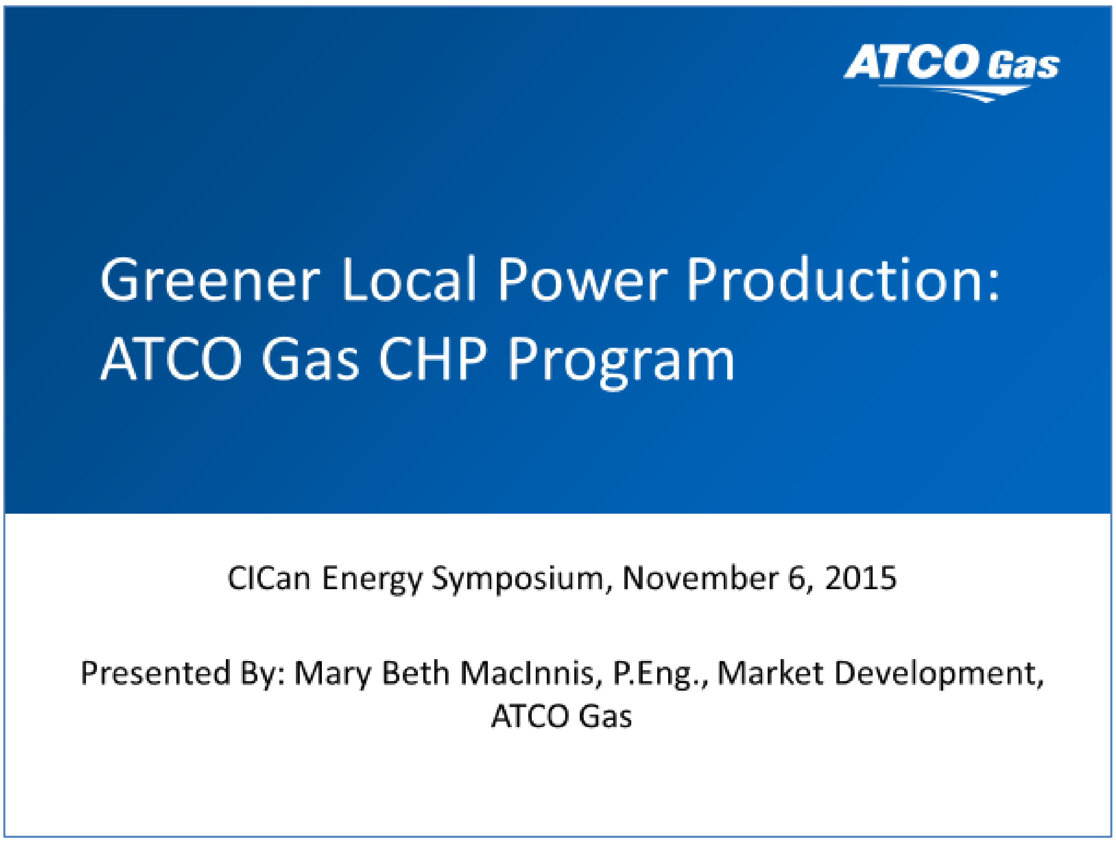
APPENDIX 1: ATCO CHP PRESENTATION

Please see Appendix 1 file attached.



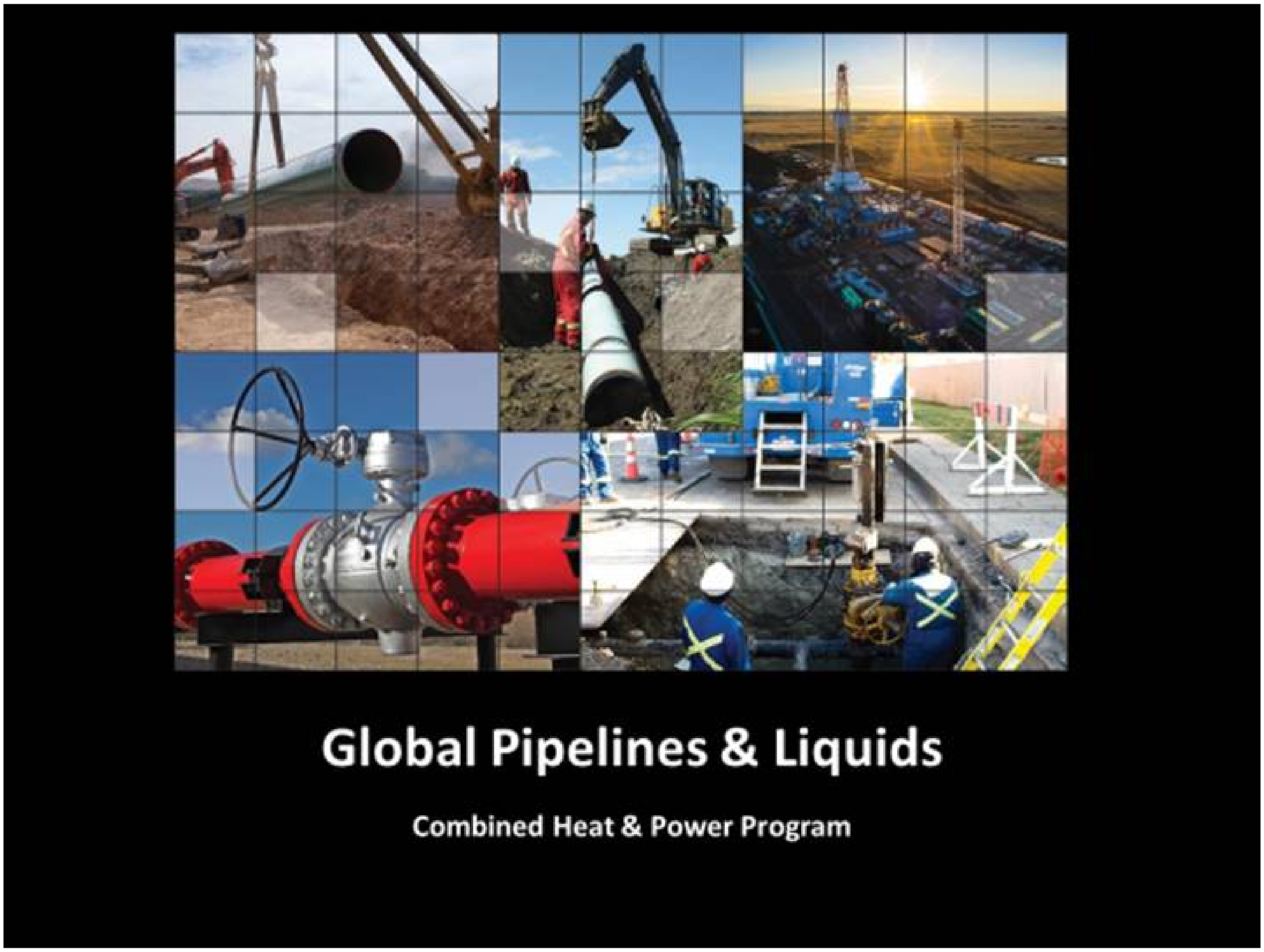
APPENDIX 2: CICAN PRESENTATION

Please see Appendix 2 file attached.



APPENDIX 3: CHP CUSTOMER PRESENTATION

Please see Appendix 3 file attached.



APPENDIX 4: ATCO CHP BROCHURE