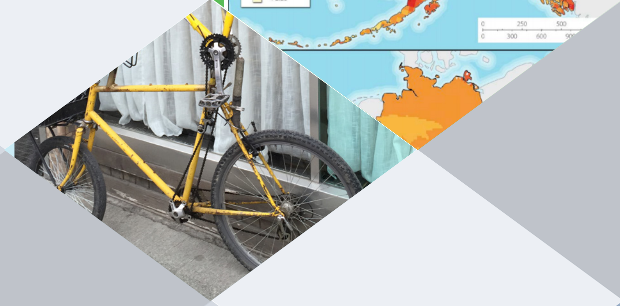

MUNICIPALITY OF ANCHORAGE
MAYOR ETHAN BERKOWITZ

ANCHORAGE ENERGY LANDSCAPE AND OPPORTUNITIES ANALYSIS

MAY 2017

PREPARED BY

Deerstone Consulting

CRIMP ENERGY CONSULTING

ABOUT THIS REPORT

This report combines technical, economic, and institutional perspectives to apply an energy landscape analysis toward assessing the current status, opportunities, and challenges for energy efficiency, renewable energy, and community-based economic development for Anchorage, Alaska. Initiated by the Berkowitz Administration to pro-actively address economic challenges emerging from low oil prices and state fiscal constraints, this initiative aims to facilitate and increase productive economic activity, save residents and businesses money, enhance local resiliency, and mitigate climate change impacts.

ACKNOWLEDGEMENTS AND AUTHORSHIP

The Municipality of Anchorage contracted DeerStone Consulting to conduct this study. DeerStone partnered with Crimp Energy Consulting as subcontractor. Both firms are based in Anchorage and have over 50 years of combined experience in Alaska energy issues, covering rural and urban areas, energy efficiency and renewables, and technical and financial analyses. Analysis North, another Anchorage-based energy consulting firm with a long history in the state, also contributed significant volunteer effort to the report. DDA Alaska contributed to the structure and format of the document and Studio North provided the graphics, including the report cover.

Numerous additional people and organizations provided input to this report. They are listed in Appendix D.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADCM	Anchorage Design Criteria Manual
AEERLP	Alaska Energy Efficiency Revolving Loan Program
AHFC	Alaska Housing Finance Corporation
AIDEA	Alaska Industrial Development and Export Authority
APMP	Anchorage Port Modernization Program
ARL	Anchorage Regional Landfill
ASD	Anchorage School District
ASHP	Air Source Heat Pump
AWWU	Anchorage Water and Wastewater Utility
Bcf	Billion cubic feet (of natural gas)
Btu	British thermal unit
CBEA	Commercial Building Energy Audit
Ccf	100 cubic feet (of natural gas)
CCHRC	Cold Climate Housing Research Center
CEA	Chugach Electric Association
CEM	Certified Energy Manager
Cfm	Cubic Feet per Minute
CHP	Combined Heat and Power
CIRI	Cook Inlet Region, Inc
C-PACE	Commercial Property Assessed Clean Energy
DDC	Digital Data Control
DPT	Department of Public Transportation
DU	Doyon Utilities
EB	Electric Bus
ECI	Energy Cost Intensity
EE	Energy Efficiency
EE&C	Energy Efficiency and Conservation
EEM	Energy efficiency measure
EGS	Eklutna Generation Station
EIA	US Energy Information Administration
ESCO	Energy Services Company
FAST	Fixing America's Surface Transportation
FHWA	Federal Highway Administration
FIWP	Fire Island Wind Project
FTA	Federal Transit Authority
GSHP	Ground Source Heat Pump
GWh	Gigawatt-hour
HEA	Homer Electric Association
IPP	Independent Power Producer
JBER	Joint Base Elmendorf-Richardson
KEA	Kodiak Electric Association
kW	Kilowatt
kWh	Kilowatt-hour
LFG	Landfill Gas
LFGTE	Landfill Gas to Energy
M&O	Maintenance and Operations Department
MASS	Municipality of Anchorage Standards Specifications
Mcf	1,000 cubic feet (of natural gas)
MEA	Matanuska Electric Association
ML&P	Municipal Light and Power
MMBtu	1,000,000 British thermal units
MOA	Municipality of Anchorage
MSW	Municipal Solid Waste
MW	Megawatt
MWh	Megawatt-hour
O&M	Operation and Maintenance
OBF	On-Bill Financing
PACE	Property Assessed Clean Energy
POA	Port of Anchorage
PRV	Pressure Reducing Valve
PV	Photovoltaic
QF	Qualifying Facility
RCA	Regulatory Commission of Alaska
R-PACE	Residential Property Assessed Clean Energy
SCADA	Supervisory Control and Data Acquisition
SPP	Southcentral Power Project
SSO	Sanitary Sewage Overflow
SWS	Solid Waste Services
WTE	Waste to Energy
WWTF	Wastewater Treatment Facility
Wx	Weatherization

EXECUTIVE SUMMARY

This report defines the Anchorage "energy landscape" to identify opportunities and barriers to clean energy development and efficiency improvements. Initiated by the Berkowitz Administration as a pro-active response to economic headwinds driven by low oil prices, declining production and reduced state revenues, this assessment aims to facilitate and increase productive economic activity; save the MOA, residents and businesses energy and money; enhance local resiliency; and mitigate climate change impacts.

As Alaska's largest and most ethnically and economically diverse community, Anchorage possesses a complex and dynamic energy and institutional infrastructure that includes:

+ Numerous utilities with different governance structures and mandates
+ Significant fossil and renewable energy resources
+ Public, private, and military energy consumers and producers
+ "Mission critical" physical infrastructure requiring uninterrupted power
+ Major transportation and cargo hubs serving the entire state and beyond
+ Alaska Native and Tribal entities with unique status and assets
+ Small businesses and sizable branches of national and multi-national firms engaged in energy-related, engineering, and construction services

Energy baseline consumption and production for Anchorage are presented in the tables and figures below. These values are used to calculate energy savings and simple payback economics in relation to proposed projects that are described in detail in the main narrative of this report.

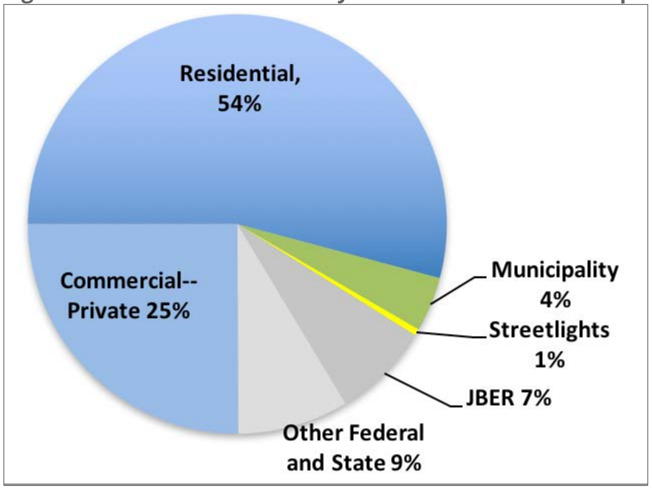
Table 1-ES. Anchorage 2015 End Use Energy Consumption of Major Energy Sources* (Billion Btu)

Sector / Subsector	Electricity	Natural Gas	Highway Motor Fuel	Total
Residential	**2,371**	**14,273**	Not estimated by sector	**16,644**
Commercial				
Municipality of Anchorage				
AWWU	53	106		160
Merrill Field	3	4		7
Port of Anchorage	8	9		17
School District	230	531		761
Solid Waste Services	10	15		26
Municipal Facilities**	125	204		329
Total* **	**430**	**868**		**1,298**
State	Not Estimated			
Federal				
JBER	682	1,612		2,294
Non-Military	Not Estimated			
Streetlights******	156			156
Private	3,648	4,054		7,702
Total Commercial	**5,360**	**8,727**		**14,087**
Transportation	Not Estimated		**34,814**	**34,814**
Total All Sectors	**7,731**	**23,000**	**34,814**	**65,545**

*Does not include wood, propane, distillate fuel oil, kerosene, aviation fuel, or non-utility power. Not all numbers sum precisely because of rounding.
**Total is average of 2009-10. Electricity and natural gas usage prorated using Anchorage-wide commercial proportion.
***Does not include ML&P or Anchorage Community Development Authority parking garage consumption.
****Streetlights include all ownerships (MOA, ML&P, Chugach Electric, MEA, State of Alaska, military).

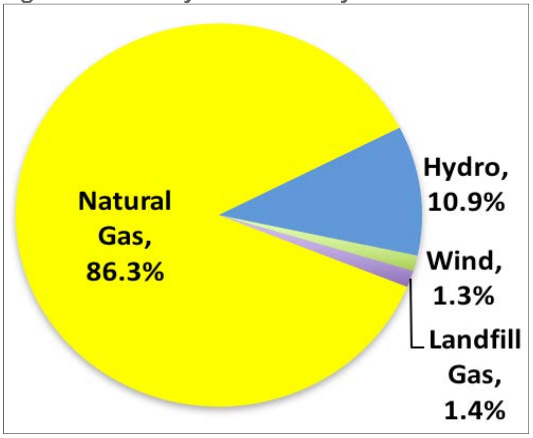
The breakdown of electricity and natural gas consumption by sector and end-user type is illustrated below:

Figure 1-ES. Combined Electricity and Natural Gas Consumption by Sector and End-User Type



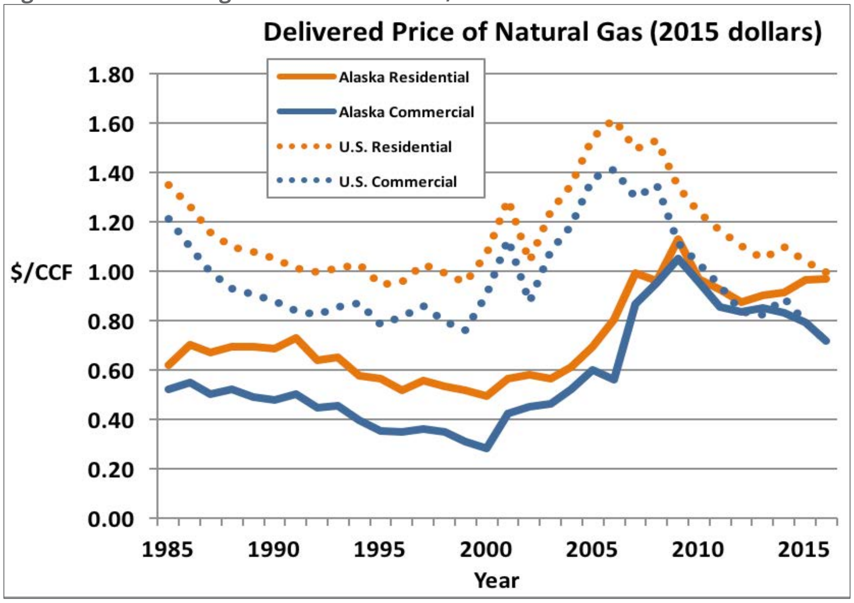
Anchorage is highly dependent on natural gas from Cook Inlet, for generating both heat and electricity. Within the electricity sector, approximately 86% of primary generation was from natural gas in 2013, while hydropower, landfill gas, and wind energy accounted for the remaining 14% (Figure 2-ES. Utility Net Electricity Generation for Anchorage by Fuel Type, 2013).

Figure 2-ES. Utility Net Electricity Generation for Anchorage by Fuel Type, 2013



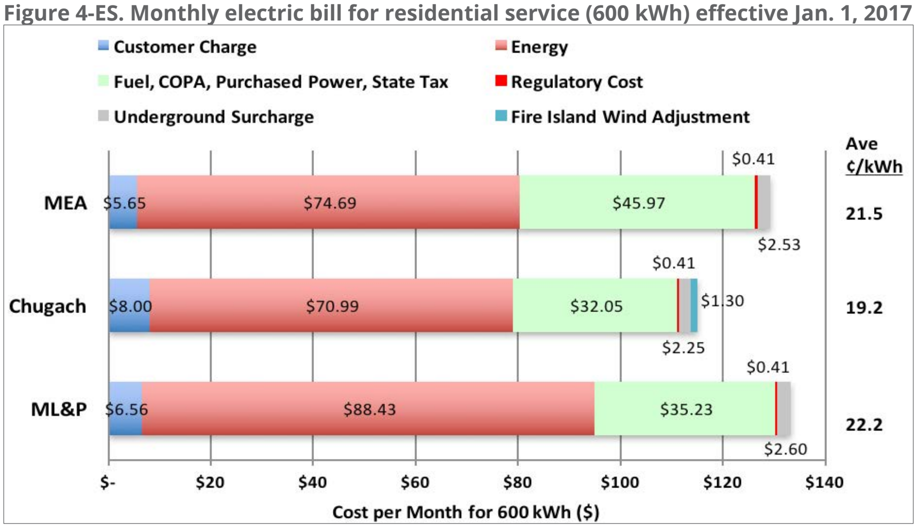
The following graph shows a substantial increase and volatility in residential and commercial natural gas prices in Anchorage during the last fifteen years after many years of relative price stability. The graph also illustrates the recent linking of Cook Inlet natural gas prices with Lower 48 markets.

Figure 3-ES. Anchorage Natural Gas Prices, 1985-2015



Between increasing natural gas costs and recent construction of new generation assets by all three electric utilities servicing Anchorage, electricity prices have also risen in recent years. The table below shows sample residential retail electricity prices for all three electric utilities in the Anchorage area by cost component.

Figure 4-ES. Monthly electric bill for residential service (600 kWh) effective Jan. 1, 2017



The proposed energy efficiency and clean energy production projects identified and evaluated in this report can be grouped into the following categories:

1. Energy efficiency projects within the MOA existing infrastructure
2. Private commercial and residential energy efficiency upgrades
3. Utility power pooling and system operator function to improve power generation efficiencies, economic dispatch, reliability, Independent Power Producer opportunities, and cooperation among the three electric utilities serving Anchorage and the greater Railbelt
4. Renewable energy production from new and existing projects and fuel switching

The following four charts illustrate the energy and cost impacts of deploying the proposed projects that fall into the four categories above.

Figure 5-ES. Electricity and Natural Gas Consumption Before and After EE Measures (Billion Btu/yr)

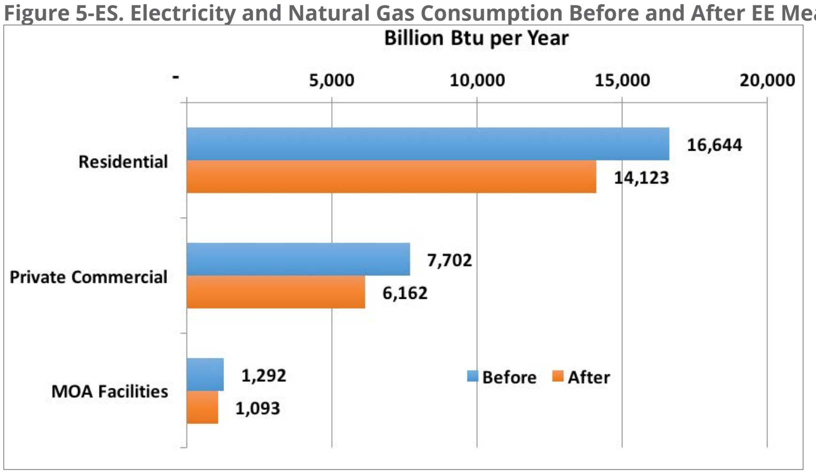


Figure 6-ES. Estimated Annual Savings from MOA EE Projects, Total = $10.4 Million

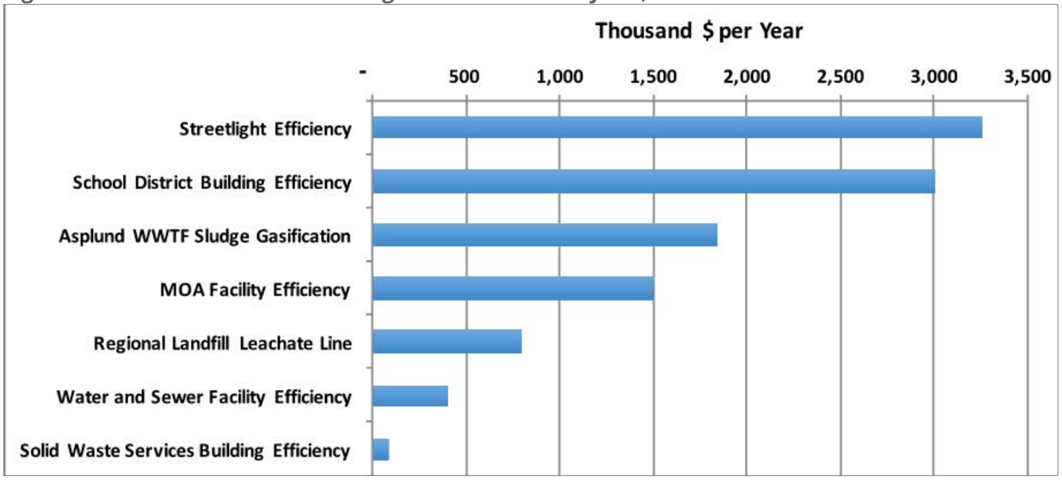


Figure 7-ES. Estimated Annual Savings from Private EE and Utility Power Pooling, Total = $99.8 Million

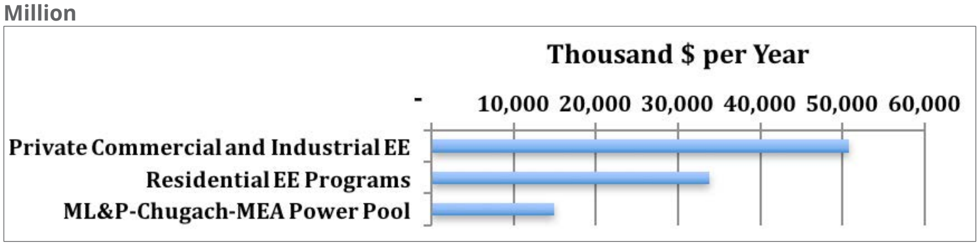
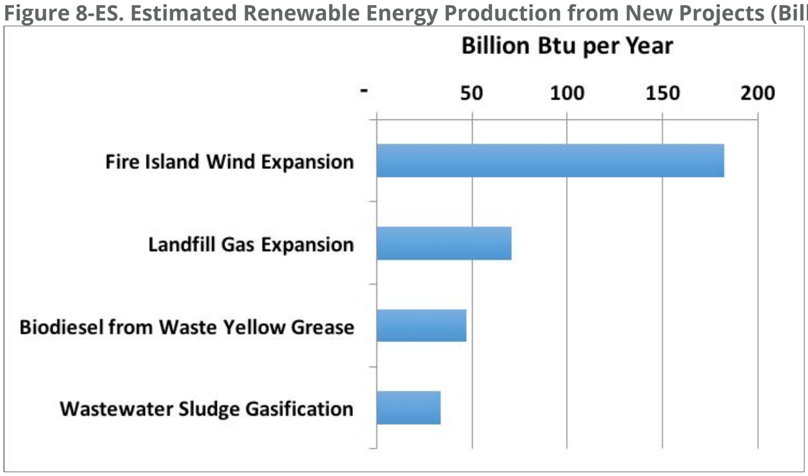


Figure 8-ES. Estimated Renewable Energy Production from New Projects (Billion Btu/yr)



The summary table below identifies all recommended projects and associated economics.

Table 2-ES. Summary Table of Priority Projects

Opportunity	Net Cost (1,000$)	Savings (1,000$/yr)	Simple Payback (yr)	Energy Savings (Billion Btu/yr)	Renewable Energy (Billion Btu/yr)	Note
Energy Manager Position	150	150	1	--	--	One staff position to implement projects described in report; assume revenue neutral annual expenditure
Efficiency #1. Inter-Departmental Cooperation & Aggregate Projects	--	--	--	--	--	Result in labor and cost savings, improved financing terms and streamlined implementation
Efficiency #2. ML&P-Chugach -MEA Power Pool & System Operator	TBD	15,000	0.0	1,000	0.0	Power Pooling estimated at $10-20 Million/1 Bcf gas savings annually plus additional for greater Railbelt; in-process; costs To Be Determined
Efficiency #3. School District Building Efficiency	20,986.1	2,998.0	7.0	121.7	0.0	CHP could add substantial additional savings & generation; microgrid potential
Efficiency #4. MOA Facility Efficiency	10,467.7	1,495.4	7.0	52.6	0.0	Standard EE/Wx, especially LEDs, building controls/ monitoring, condensing boilers
Efficiency #5. Water and Sewer Facility Efficiency	2,806.3	400.9	7.0	20.2	0.0	Standard EE/Wx plus heavy equipment controls, water distribution temperature in-process w ML&P
Efficiency #5a. Asplund WWTF Sludge Gasification	5,000.0	1,834.9	2.7	78.3	33.5	Necessary large capital project, payback on marginal additional cost
Efficiency #6. Solid Waste Services Building & Collection Efficiency	590.9	84.4	7.0	4.0	0.0	LEDs, Wx, system controls, possible rolling stock electrification not calculated
Efficiency #6a. Regional Landfill Leachate Line	3,113.6	795.9	3.9	1.6	0.0	Energy + Health & Safety benefits
Efficiency #7. LED Streetlights and Controls	21,600.0	3,252.2	6.6	74.0	0.0	Across multiple jurisdictions; initiated
Efficiency #8. POA Modernization	--	--	--	--	--	Overall project very large; energy options & impacts need further study; Energy storage & microgrid potential; thermal snow removal potential
Efficiency #9. Private Residential EE Programs	216,652.1	33,827.4	6.4	2,520.7	0.0	Theoretical, based on existing building stock, MOA, AEA, CCHRC & AHFC data
Efficiency #9a. Private Commercial and Industrial EE	355,512.6	50,787.5	7.0	1,540.4	0.0	Theoretical, based on existing building stock, MOA, AEA, CCHRC & AHFC data
Renewable #1. Fire Island Wind Farm Expansion	--	--	--	--	152.4	Tax credit timing constraint; under consideration
Renewable #2. Landfill Gas to Energy Expansion	--	--	--	--	70.6	Currently under evaluation; near future peak fuel production adds urgency
Renewable #3. PV Installations	--	--	--	--	2.9	Primary residential & Commercial benefits could be much higher; estimate is for 1 MW community solar project
Renewable #4. Fats, Oils and Grease Program	--	--	--	--	47.2	Public-Private Partnership likely required
Fuel Switching #1. Large Facility/District CHP	406.0	102.0	4.0	--	--	Highly site specific; estimate here based on vendor-provided results for one project; many projects possible; microgrid potential
Fuel Switching #2. Heat Recovery From Existing Generation	--	--	--	--	--	Project specific opportunities require further evaluation, but may have significant promise for multiple stakeholders, especially EGS and SWS/ JBER/Doyon LFGTE
Fuel Switching #3. Private Electric Vehicles (1,000 vehicles)	11,500.0	1,066.7	10.8	0.0	0.0	Assumes incentive pricing of $0.10/kWh and $3.50/ gallon gasoline; need charging stations
Fuel Switching #3a. People Mover Electric Buses (Fleet of 20)	6,500.0	476.5	8.4	0.0	0.0	Assumes incentive pricing of $0.10/kWh, $3.00/ gallon diesel fuel, and FAST grant; need charging stations
Integrated Lifestyle Opportunities	--	--	--	--	--	Housing, food growing, rentable EVs + walkability, Community Center, job training

Detailed project descriptions, sensitivity analyses where appropriate, and other specifics are included in the main report. Along with basic metrics such as simple payback and energy and cost savings, project implementation priorities and investment decisions should consider fuel diversification, project complexity and deployment timeline, and potential synergies and aggregation to improve economies of scale and community and institutional resiliency.

CHAPTER 1 - INTRODUCTION

ANCHORAGE AT A CROSSROADS

Energy services directly contribute to the unique quality of life in Anchorage and all across Alaska. Primary services include electricity, heat, and transportation, but are also embedded in food production, telecommunications, materials shipping and handling, housing and construction, and other essential economic activities that define our modern lifestyles. It should be no surprise that with extreme climates and low population densities in the state, along with industrial-scale energy and mineral production activities, Alaskans are among the highest per capita consumers of energy in the US, and by extension, the world.

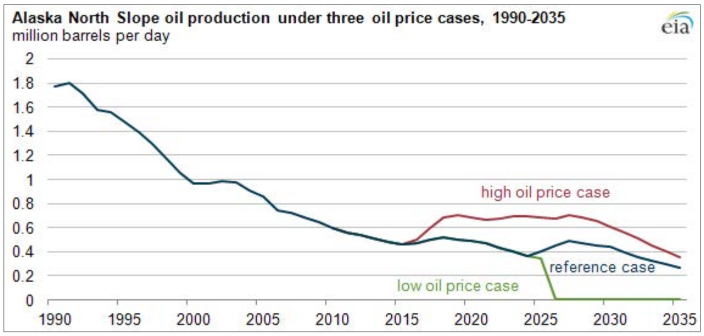
Table 3. Per Capita Energy Consumption by State[1]

Rank	State	Total Energy Consumed per Capita (million Btu)
1	Louisiana	921
2	Wyoming	917
3	North Dakota	865
4	Alaska	818
5	Iowa	496
6	Texas	478
7	South Dakota	459
7	Nebraska	459
9	Indiana	444
10	Oklahoma	433

Since the discovery of oil at Prudhoe Bay in 1968 and eventual construction of the Trans-Alaska Pipeline almost a decade later, Alaska has become an energy dependent export economy with fortunes generally rising and falling in lockstep with the global price of oil. State revenues and resulting economic activity have shrunk as a result of recent low oil prices combined with a long-term trend of declining production in Alaska, although slight recent upticks in production are slowing the overall downward curve. Many observers are comparing this recent situation to the mid-1980s when oil prices were even lower and the Alaska economy contracted substantially and painfully for many, with widespread business bankruptcies, real estate price drops, and loss of population. While there are some similarities between the two historic oil price declines, it has also been noted that, at least for Anchorage, the current economy is more diversified, mature, wealthier, and hopefully wiser with the benefit of hindsight.

1 U.S. Energy Information Administration, State Energy Data System, Table C13, Energy Consumption per Capita by End-Use Sector, 2013. https://www.eia.gov/state/analysis.cfm?sid=AK - 15
and https://www.eia.gov/state/rankings/?sid=AK - /series/12. It should be noted that several of the highest energy consuming states are also top energy producers, and energy production requires a great deal of energy consumption. Within Alaska, for example, energy consumption includes oil production activities on the North Slope and airplane fuel dispensed at Anchorage Ted Stevens International Airport.

Figure 9. Alaska North Slope Oil Production, 3 Price Scenarios, 1990-2035[2]



ANCHORAGE ENERGY LANDSCAPE

By far the largest and most ethnically and economically diverse community in Alaska, Anchorage possesses a unique energy infrastructure and institutional situation that includes:

+ A **municipally owned electric utility (Municipal Light and Power – ML&P)** with a service territory fully within the Municipality of Anchorage (MOA) boundaries that generates revenue and employment for the MOA
+ Two other **ratepayer/member-owned electric utilities (Chugach Electric Association – Chugach, and Matanuska Electric Association – MEA)** that are both cooperatives with distinct service territories partially within, and partially outside the MOA boundaries
+ Substantial **natural gas supplies in western Cook Inlet**—some owned by the MOA, Chugach, and most privately owned— are connected via pipeline to electricity generation and broader distribution infrastructure throughout Anchorage and beyond
+ Significant **hydropower resources** that, to varying degrees based on percentage of ownership and transmission constraints, provide stable, low cost electricity to all three of the electric utilities with service territory within the MOA
+ A **municipally owned water and wastewater utility (Anchorage Water and Wastewater Utility – AWWU)** that generates revenue and employment for the MOA and is also a large energy consumer and essential service provider for the entire municipality
+ The **largest school district in the state (the Anchorage School District – ASD)**, which serves approximately 50,000 students and manages heat and electricity for over 8 million square feet distributed across about 100 buildings and 25 square miles of land
+ A large **military base (Joint Base Elmendorf-Richardson – JBER)**, that meets some of its own electricity needs through landfill-derived methane gas and yet another power provider, Doyon Utilities, but is also inter-connected with ML&P and is a mission-critical load that must be met at all times
+ An **investor-owned natural gas utility (Enstar)** with corporate headquarters in Canada that secures, stores, and distributes gas via underground pipeline for heat and other purposes throughout most of the MOA boundaries and beyond
+ A **municipally owned marine port (Port of Anchorage – POA)** that receives half of all marine cargo shipped into Alaska—including food, liquid fuels, construction materials, and much more to meet consumer, commercial, industrial, and military needs around the state—representing additional mission-critical electric loads with significant near-term capital needs to ensure structural integrity of critical infrastructure, namely pilings and the docks themselves
+ **Alaska Native Tribal entities** with unique governmental status, tribal populations, and ownership of numerous assets within Anchorage
+ **Alaska Native Corporations** with large land holdings and energy resources, including Cook Inlet Region, Inc. (CIRI), which is an independent power producer as a result of its developing the Fire Island Wind Project and selling power to Chugach, and also Eklutna, Inc., which has right of first refusal to monetize valuable engine heat from MEA's new Eklutna Generation Station
+ Branches of major **multi-national oil and gas companies, as well as smaller oil and gas producers**, with significant investment in the Alaska energy economy and substantial presence in the Anchorage area
+ Numerous **small businesses as well as branches of national and multi-national firms** that provide all types of energy-related, engineering, and construction services, from local energy efficiency retrofits and boiler maintenance to sophisticated power electronics controls and microgrid integration and management to meet the unique energy needs of rural Alaska

2 Energy Information Administration http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?f=A&n=PET&s=MCRFPAK2

communities, the Railbelt (extending from Fairbanks to Homer), and the fossil fuel industry

+ Significant **untapped renewable energy resource potential** that could include wind, solar, hydropower, marine/hydrokinetic energy, biomass, and possibly geothermal energy

Figure 10. Anchorage, Alaska Physical Landscape

Photo: Brian Hirsch

With the above physical and institutional infrastructure shaping the Anchorage energy landscape, guideposts that have informed this analysis include the following:

Energy availability – Also viewed as energy security. Along with the mission-critical loads described above, typical winter weather in Anchorage requires secure and readily available heat and electricity for all residents, businesses, multi-modal transportation, and other activities. This is essential, not optional. Anchorage's substantial reliance on Cook Inlet natural gas for heat and electricity through an inter-connected distribution system is a potential vulnerability.

Energy affordability – This relates to access for all income levels and ultimately to economic competitiveness. If energy is expensive, everything from food and housing to new business development is competitively disadvantaged. Alternatively, low cost energy allows some business development activities to occur that would otherwise not happen, such as energy-intensive data centers or value-added food processing, resulting ina a more dynamic and vibrant community and economy.[3]

Energy Economy – This is about viewing energy as an economic development vehicle in and of itself that can generate additional wealth and opportunity, whether it is from job creation emerging from specialized energy start-ups, or providing highly efficient energy services that improve the quality of life and reduce the cost of living in Anchorage such that it draws additional people and investment to our community.

SCOPE OF WORK AND REPORT FORMAT

DeerStone Consulting, as lead contractor to the MOA, and Crimp Energy Consulting as lead subcontractor, drew from their 50-plus years of combined Alaska energy experience to create a broad list of potential projects, policy initiatives, opportunities, challenges, and metrics for comparison. After this preliminary list and metrics were created, several other energy and policy experts, including MOA executive staff, were involved in further refining the framework.

After this preliminary list and metrics were created, several other energy and policy experts, including MOA executive staff, were involved in further refining the framework.

In particular, a meeting on March 2, 2016, hosted by Mayor Berkowitz and attended by several MOA Department Heads and technical staff, provided essential guidance and direction for the subsequent analysis. The potential projects and performance metrics were reviewed and modified at the meeting, and additional people, departments, data, expertise, and other important contributions were identified at that time. This resulted in a detailed table, spreadsheet, and work activities that formed the basis for this report and are discussed further below.

The scope of work consisted of detailed interviews with most MOA Department Heads and key staff to identify and further define the most significant opportunities and challenges, as well as interviews with private sector industry leaders, all of the electric utilities with service territory in Anchorage, representatives from the Alaska

3 It should be noted, however, that economic development is driven by many factors and energy is not necessarily the determining or limiting factor in Anchorage's ongoing economic growth or lack thereof.

Housing Finance Corporation and the Alaska Energy Authority, the Renewable Energy Alaska Project, energy-focused staff at JBER, and others. We also collected specific numeric data on fuel, electricity prices, capital costs of various projects and hardware, existing studies, and other information to ground our quantitative analysis and case studies. Interviewees, data sources, and other references are included as appendices to this report.

Though ambitious, this is far from a comprehensive study. Funding and timing were extremely limited, and the focus here was to identify, prioritize, and help to accelerate the best projects for the MOA, residential energy consumers, and private industry to pursue with preliminary analysis and recommended next steps. It should be noted that not all projects and goals are complementary, but where this occurs, we have tried to delineate the implications and trade-offs. For example, private industry Combined Heat and Power projects that may save an individual business money will also likely result in significant lost revenue by the electric utility depending on regulatory and inter-connection policies. Similarly, substantial adoption of electric vehicles would result in reduced petroleum sales ("Highway Motor Fuel" in the relevant tables in this report) and increased electricity consumption, though a new retail electricity tariff and charging station infrastructure investment may need to be established to make this transition economically viable for most people.

In general, more data was easily available for MOA facilities and operations and hence, our analysis is more accurate and precise when we are focusing on MOA infrastructure and opportunities. We did not initiate new studies or generate new data, but instead relied on existing sources and previous efforts with targeted updates as needed.

Most state and federal facilities were not included in the analysis. This was because relevant data was often difficult to access and/or in various, incompatible formats, and any policy recommendations or initiatives for the MOA would not readily apply to state and federal facilities. For example, Ted Stevens Anchorage International Airport, though a large and distinct consumer of energy, is not included in the energy baseline consumption calculations or energy efficiency opportunities since much of the overall energy use is jet fuel that is essentially not used in Anchorage.

A notable exception is JBER, which is a large federal facility with diverse energy usage, including jet fuel, however, good data was available for JBER and there is a substantial amount of residential and commercial (i.e., non-military) facilities on-base, including banks and grocery stores, for example, that were important to capture in the energy baseline for Anchorage. As discussed further below, JBER has embarked on aggressive energy assessment and efficiency measures and had readily available data to include in this analysis.

Following this introduction, the report first provides energy baseline consumption, costs, and trends for Anchorage, then defines and evaluates energy efficiency (EE) opportunities – residential, public, and commercial – followed by heat and power generation, transportation, and cross-cutting/integrated management opportunities. The report concludes with over-arching and specific findings and recommendations, and appendices that include a list of interviewees, discussion of energy consumption and cost analysis methods, resources for end use efficiency, and data sources and references. Brief case studies that describe particular technologies, business structures, policies, and/or successful projects in other locations are highlighted and distributed throughout the report.

The specific recommendations and projects identified here should be viewed through the lens of "top down" actions that could be directly initiated by the MOA, such as targeted investments or procurements, and "bottom up" policies and incentives designed to affect others' behaviors. The former will likely require additional detailed analysis to more precisely confirm economic benefits while the latter will likely require proper piloting and evaluation to confirm impacts and adjust policies over time.

Throughout this report we use simple payback as the metric for describing economic feasibility. While this is only one approach—and especially for specific large investments, arguably not the most economically meaningful—the analysis here is not designed for precision but rather for initial decision-making to determine if a project is worthy of further pursuit. In general, the publicly available data used here for analysis is not "investment grade," but rather "rough order of magnitude" that can help to better define a project for more detailed assessment and ultimately investment. Project duration, such as the performance life of a combined heat and power microturbine, is also required to determine more detailed economic metrics beyond simple payback, such as net present value.

Many of the energy efficiency assumptions that guide our analysis were based on discussions with EE professionals, such as those at the Alaska Housing Finance Corporation, who have been involved with the Alaska Home Energy Rebate Program and have said that residential EE investments generally have a 6-7 year payback.[4] Similarly, with commercial EE investments, contractors have stated typical investments yield a 7-year payback with 20% savings on electricity and natural gas and an additional 5% savings for operation and maintenance[5] and typical 15 – 20 year lifetimes. We apply these assumptions to the energy consumption and building stock baselines presented in the next chapter.

4 Jimmy Ord, AHFC, 8/16/16, pers. comm.
5 Amber McDonough, Siemens, 4/6/16, pers. comm.

Photo Courtesy Shutterstock

CHAPTER 2 – ENERGY BASELINES

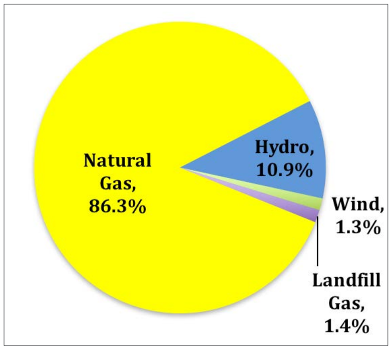
POWER GENERATION

The Anchorage electrical generation landscape has changed drastically in the very recent past. Prior to 2014, Chugach, the largest electric utility in Alaska, generated power for its own service territory as well as most of MEA's and Homer Electric Association's (HEA, based on the Kenai peninsula) customers under long-term wholesale power purchase agreements. HEA's power purchase agreement expired at year-end 2013 and MEA's agreement expired at year-end 2014. Both of these utilities chose to provide for their own members' needs with new and/or expanded generation and did not continue buying power from Chugach when their individual contracts ended.

Meanwhile, both Chugach and ML&P were also constructing new generation as their assets were aging and becoming more costly to operate. Chugach and ML&P joined forces to build the Southcentral Power Project (SPP), a 200 MW natural gas combined cycle facility located at Chugach headquarters to meet parts of both of their loads. This plant was brought on-line in 2013, with ML&P ownership at 30% (about 60 MW) and Chugach ownership at 70% (about 140 MW).[6] Further, ML&P is now in process of completing 120 MW of new combined cycle gas-fired generation known as "Sullivan 2A," which will add to their existing capacity at the Sullivan 2 plant. Sullivan 2A is now scheduled to come on-line in early 2017 at a capital cost of approximately $275 million, and is expected to be one of the most energy efficient natural gas generation units in North America, with heat recovery being used to raise the temperature of the MOA water supply, further reducing energy demand from domestic hot water by end-users and reducing freeze-ups in water main pipes.

Currently, about 86% of Anchorage's electrical generation is fueled by natural gas (Figure 11. Utility Net Electricity Generation for Anchorage by Fuel Type, 2013.). Hydropower from four projects contributes almost 11%, while the Fire Island Wind project and landfill gas each contribute in excess of 1%. Table 4. Installed Capacity, by Unit and Type, for Chugach, ML&P, and MEA shows installed capacity by unit and type of generation asset, along with installation date, for three electric utilities and two independent power producers (IPPs) serving Anchorage.

Figure 11. Utility Net Electricity Generation for Anchorage by Fuel Type, 2013[7,8]



6 Chugach Annual Report, 2015. https://www.chugachelectric.com/system/files/annual_reports/2015_annual_report_final_for_web.pdf

7 AEA and ISER, Alaska Energy Statistics, Table 2.3b updated to 2013 via Alaska Energy Gateway, https://akenergygateway.alaska.edu/.

8 Sonny Turpin, JBER, unpublished data, 7/25/16.

Table 4. Installed Capacity, by Unit and Type, for Chugach, ML&P, and MEA[9]

Utility	Generation Asset Name	Asset Size (MW)	Asset Type/ Fuel	Year Installed	Note
Chugach	Beluga Unit 1	19.6	Natural Gas	1968	
	Beluga Unit 2	19.6	Natural Gas	1968	
	Beluga Unit 3	64.8	Natural Gas	1973	
	Beluga Unit 5	68.7	Natural Gas	1975	
	Beluga Unit 6	79.2	Natural Gas	1976	
	Beluga Unit 7	80.1	Natural Gas	1978	
	Cooper Lake Unit 1	9.6	Hydropower	1960	
	Cooper Lake Unit 2	9.6	Hydropower	1960	
	International Unit 1	14.1	Natural Gas	1964	
	International Unit 2	14.1	Natural Gas	1965	
	Fire Island Wind	17.6	Wind	2012	Purchased power from IPP, Capacity factor ~30%
ML&P	Hank Nikkels Plant 1	88.4 (combined)	Natural Gas	1962, 1964, 1972, 2007	
	Sullivan Plant 2	219.5 (combined)	Natural Gas	1975, 1975, 1979, 1984	
	Sullivan Plant 2A	120 (combined)	Natural Gas	2016	Not yet fully commissioned
MEA	Eklutna Generation Station	171	Natural Gas & Diesel (Dual Fuel Option)	2015	10 units @ 17.1 MW
Chugach & ML&P	Southcentral Power Project	200	Natural Gas	2013	Chugach owns 70%; ML&P owns 30%
Chugach & ML&P & MEA	Bradley Lake Hydro	120	Hydropower	1991	Chugach owns 30.4%; ML&P owns 25.9%; MEA owns 13.8%; Capacity factor ~ 20%
Chugach & ML&P & MEA	Eklutna Hydro Unit 1	20	Hydropower	1955	Chugach owns 30%; ML&P owns 54%; MEA owns 16%; Capacity factor ~26%
Chugach & ML&P & MEA	Eklutna Hydro Unit 2	20	Hydropower	1955	Chugach owns 30%; ML&P owns 54%; MEA owns 16%; Capacity factor ~26%
Southfork Hydro LLC	South Fork Hydro	1.5	Hydropower	2012	

The table below shows peak load in MW and annual electricity sales for 2015 in both MWh and dollars for the three electric utilities serving Anchorage.

Table 5. Peak Load and Annual Electricity Sales for Chugach, ML&P, and MEA, 2015[10]

Utility	Peak Demand (MW)	Annual Sales (MWh)	Annual Revenue (Million)
Chugach	200	1,133,427	$170.1
ML&P	171	1,004,497	$140.7
MEA	148	731,265	$136.0

9 Ownership percentages of shared hydropower projects are approximate; Julie Estey, 8/25/16, pers. comm.; Jeff Warner, ML&P, 12/8/16, pers. comm.; Paul Risse, Chugach, 12/6/16, pers. comm; and http://www.akenergyauthority.org/Content/Programs/AEEE/PDF files/8BProgramFactSheets.pdf; https://www.mlandp.com/redesign/about_mlp.htm; http://www.mea.coop/about-mea/eklutna-generation-station/; http://www.mea.coop/about-mea/eklutna-generation-station/.

10 EIA 2016. Electric power sales, revenue, and energy efficiency Form EIA-861 detailed data files, https://www.eia.gov/electricity/data/eia861/; includes service territory outside of MOA boundaries.

Many observers have noted that while each individual utility's internal rationale may be logical for meeting their own needs, in the big picture, the Railbelt utilities—comprising the interconnected electrical power generation and transmission grid extending from Homer to Fairbanks—are not required to conduct least-cost planning and may have a sub-optimal mix and location of generation and transmission.[11,12] This results in higher overall costs as the new equipment is not used to its fullest capacity but still must be paid off based on a limited amount of kWh sales.

Such a wide range of energy resources, needs, and service providers presents at once tremendous opportunity and daunting complexity. Recent trends both within the Railbelt and nationwide show reduced use of electricity per household, which is compounded in Anchorage as the economy faces systemic challenges and shrinking population growth. Hence, part of the goal of this report is to identify cost effective and environmentally responsible new ways to use the abundance of clean energy that is available in and around Anchorage to better utilize both legacy and newly built, highly efficient generation assets.

ENERGY CONSUMPTION

Although there is a wealth of data that addresses energy production, consumption and cost in the State of Alaska as a whole, there is less published information specific to Anchorage and its various building and transportation sectors. So we have used a number of sources to estimate electrical, natural gas, transportation fuel and other energy consumption by residential, government, and private commercial entities (Table 6. Anchorage 2015 End Use Consumption of Major Energy Sources* (Billion Btu)) Sources include municipal, state and federal agencies, utilities, and other studies. See Appendix B. Methods for Estimating Anchorage Energy Costs and Consumption for detail on the methods used in creating the table.

Care should be exercised in using the energy consumption estimates that are presented in Table 6. Anchorage 2015 End Use Consumption of Major Energy Sources* (Billion Btu). While some estimates are based on well-established and up-to-date databases (e.g., Anchorage School District and other MOA building energy usage, electric power sales to consumers), other estimates may be based on a combination of data sources with differing standards and geographic specificity. For example, private commercial facility energy usage is important to the issues this report addresses, but is not tracked. So we have used MOA property assessment data building area and published regional energy use intensity results to estimate consumption in this sector.

An effort was made to assess state and federal building consumption. However, since neither the federal nor state government have one agency responsible for building energy management, we concluded it was beyond the scope of this study to estimate federal and state facility energy consumption. An exception is that we were able to obtain high quality estimates of electrical and natural gas consumption at JBER.

11 http://www.akenergyauthority.org/Content/Policy/RegionalPlanning/Documents/AlaskaRailbeltREGAStudy-MasterFinalReport091208.pdf

12 A "least cost" or "integrated resource" planning effort is usually required to be performed by utilities in the Lower 48, with regulatory oversight and approval authority by the appropriate public utilities commission. Such a process typically entails both a short- and long-term capital investment plan based on modeling that aims to balance power generation and transmission for the lowest cost, highest reliability delivered power to the end consumer. In Alaska's case, the Regulatory Commission of Alaska (RCA) would be the regulatory body, but such a planning effort is not required and the RCA does not have approval, or siting authority for individual projects, either generation or transmission. http://www.eenews.net/stories/1060021258

Table 6. Anchorage 2015 End Use Consumption of Major Energy Sources* (Billion Btu)

Sector / Subsector	Electricity	Natural Gas	Highway Motor Fuel	Total
Residential	**2,371**	**14,273**	Not estimated by sector	**16,644**
Commercial				
Municipality of Anchorage				
AWWU	53	106		160
Merrill Field	3	4		7
Port of Anchorage	8	9		17
School District	230	531		761
Solid Waste Services	10	15		26
Municipal Facilities**	125	204		329
Total***	**430**	**868**		**1,298**
State	Not Estimated			
Federal				
JBER	682	1,612		2,294
Non-Military	Not Estimated			
Streetlights******	156			156
Private	3,648	4,054		7,702
Total Commercial	**5,360**	**8,727**		**14,087**
Transportation	Not Estimated		**34,814**	**34,814**
Total All Sectors	**7,731**	**23,000**	**34,814**	**65,545**

*Does not include wood, propane, distillate fuel oil, kerosene, aviation fuel, or non-utility power. Not all numbers sum precisely because of rounding.
**Total is average of 2009-10. Electricity and natural gas usage prorated using Anchorage-wide commercial proportion.
***Does not include ML&P or Anchorage Community Development Authority parking garage consumption.
****Streetlights include all ownerships (MOA, ML&P, Chugach Electric, MEA, State of Alaska, military).

Figure 12. Anchorage End Use Energy Consumption by Major Fuel Type, 2015 provides a picture of the major sources of energy that Anchorage residents, businesses and government consume. Gasoline and diesel for cars, trucks, and buses account for approximately half of the energy used in the Municipality. Natural gas for heating accounts for two-thirds of the remaining half. While end user electrical energy consumption is smaller than the other two sources, it should be noted that a substantial amount of natural gas is consumed to generate this power.

Figure 12. Anchorage End Use Energy Consumption by Major Fuel Type, 2015

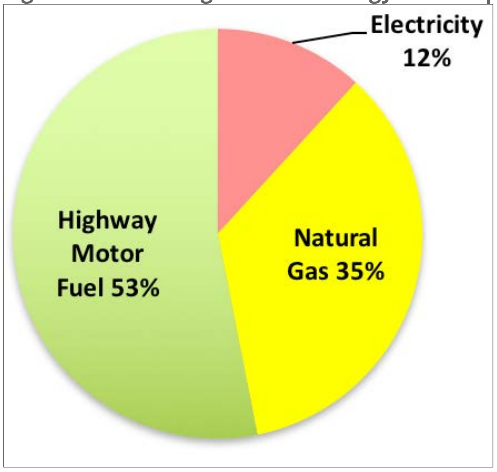
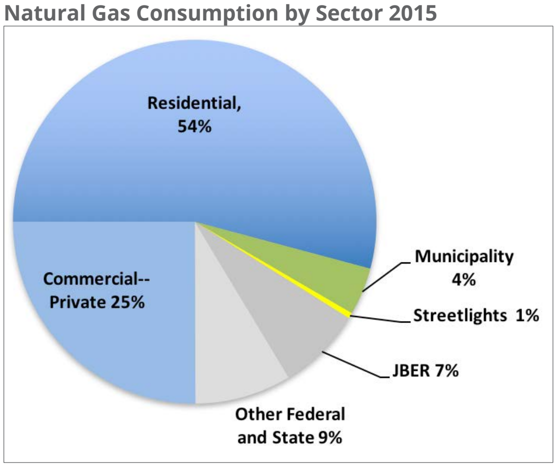


Figure 13. Anchorage End Use Electricity and Natural Gas Consumption by Sector 2015 shows a breakdown of natural gas and electricity consumption among the various sectors. Residents and businesses consume approximately 79% of the energy, while Municipal government uses 4% and streetlights use 1%. State, federal, and military consumption is estimated at 16% of the total.

Figure 13. Anchorage End Use Electricity and Natural Gas Consumption by Sector 2015



ENERGY COSTS

Natural gas and electricity prices for consumers are approved by the Regulatory Commission of Alaska (RCA) through a process that accounts for utilities' costs of doing business. This section describes energy price assumptions used in this report and provides an overview of the concept of avoided cost of electricity.

This report uses average 2015 gas and electricity prices for Anchorage utilities from the Energy Information Administration (EIA) to make estimates of savings from various energy project opportunities. Natural gas prices are expected to trend gradually upward over inflation during the next several decades.[13] However, given this report's limited scope and the relatively short economic paybacks of the projects that it assesses, we do not include forecasts of future energy prices. If natural gas prices in Anchorage do escalate above inflation in the future, our analyses of energy efficiency and renewables projects in this report would be conservative, and actual benefits would be greater.

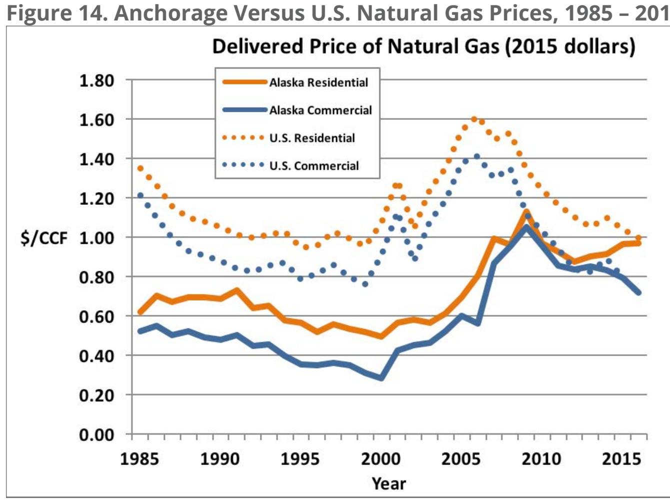
13 EIA 2016. Annual Energy Outlook 2016, table A3. https://www.eia.gov/forecasts/aeo/

NATURAL GAS

For the price of natural gas we assume $0.964 per CCF for residential customers and $0.791 per CCF for commercial customers—the average 2015 price as reported to the EIA.[14] Note that these blended rates include a fixed customer charge.

Figure 14. Anchorage Versus U.S. Natural Gas Prices, 1985 – 2016 shows a substantial increase and volatility in residential and commercial natural gas prices during the last fifteen years, which was preceded by 15 years of relative stability and prices generally lower than the lower 48. This is no longer the case as Cook Inlet natural gas prices now generally track lower 48 price trends and are increasingly connected to global markets. Despite local availability and production, Cook Inlet natural gas prices are no longer typically lower than lower 48 prices and generally follow the same price trajectory.

Figure 14. Anchorage Versus U.S. Natural Gas Prices, 1985 – 2016[15]



ELECTRICITY

Figure 15. Monthly electric bill for residential service (600 kWh) effective Jan. 1, 2017 gives a picture of the components of a residential customer's bill for a typical purchase of 600 kWh from each of the three utilities. The Customer charge is the fixed amount that covers the cost of reading meters, billing and other account costs. The fuel and cost of power adjustment (COPA) charges cover the cost of purchasing natural gas and energy from other utilities (such as hydropower from the Bradley Lake project). Regulatory and undergrounding charges are relatively minor costs that cover the RCA's costs and an MOA-required surcharge for burying power lines. Chugach customers pay a small surcharge to cover the current additional cost of Fire Island Wind energy. The

14 https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SAK_m.htm
15 Ibid

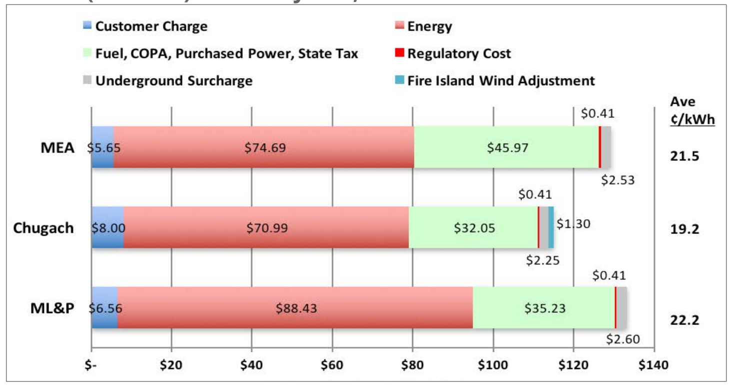
Energy charge covers all remaining costs of providing electricity, including non-fuel operation and maintenance and debt service on transmission, distribution, and generation facilities.

Not listed are prices for Doyon Utility's landfill gas-fueled power sales to JBER.

Many commercial customers pay a demand charge. Demand charges are incurred based on the instantaneous requirement for power, and represent the utilities' need to recover the cost of keeping generation units in operation to satisfy rapid upswings in consumption. For simplicity we do not attempt to model the impact of energy projects on reducing demand charges, though this can be substantial and may be a cost driver influencing decisions on specific projects. Detailed project data and analysis is required for that level of evaluation.

For the purposes of this report, we assume a price of 16.9 cents per kWh for residential customers and 13.6 cents per kWh for commercial customers. These numbers are derived from 2015 data reported by the three utilities to EIA[16] and represent total revenue received by the utilities (including customer, energy, and demand charges) divided by total sales. As utilities have constructed new facilities and price of fuel has increased, the cost of electricity has increased. ML&P rates are to be raised by 25-30% in 2017 to repay debt on the $275 million construction of the George M. Sullivan 2A project[17] that will be replacing several aged units. Thus it is likely that estimates of savings from energy efficiency and other opportunities described in this report are conservative.

Figure 15. Monthly electric bill for residential service (600 kWh) effective Jan. 1, 2017 [18,19,20]



Avoided Cost

Avoided costs are the incremental costs of electric energy and/or capacity above a certain baseline that the utility would incur from self-generating or purchasing from another source in response to increasing demand. At the most basic level, electricity production and delivery costs can be separated into "fixed" and "variable" components. Fixed costs do not change based on how much electricity is generated and cover power lines, poles, some level of staffing, and sunk costs, such as debt on equipment that must be re-paid. Regardless of how much electricity is generated and distributed to customers at any one time, the same poles and wires are being used, and their costs must be recovered. Such fixed costs are spread across all of the electricity that is generated.

Variable costs, alternatively, do change based on how much electricity is generated. Typically the most common (and expensive) variable cost is the actual fuel that is burned in a fossil fuel power plant; if more electricity is demanded, more fuel is burned to meet the demand. As well, some maintenance costs for generation equipment may change based on how much the equipment is used, hence a portion of operation and maintenance (O&M) costs are considered variable costs.

Assigning fixed and variable costs to every kWh of electricity produced is a complicated process that changes based on specific circumstances and portfolio of generation assets, with different utilities approaching it somewhat differently. The Anchorage utilities have a number of power generation units of different sizes, ages, and performance characteristics that result in different fuel efficiencies at different levels of power generation.

16 http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SAK_m.htm
17 https://www.adn.com/alaska-news/anchorage/2016/10/11/city-owned-utility-rates-slated-to-rise-in-anchorage-with-hefty-spike-coming-for-mlp/

18 http://www.mlandp.com/redesign/rates_and_tariff.htm
19 http://www.chugachelectric.com/rate-information
20 http://www.mea.coop/wp-content/uploads/2017/03/Fillable-Quarterly-Rate-Sheet-Q2-2017.pdf

Depending on which generation units are producing power at any one moment in time, and changing demand on the system, it may be necessary to increase or decrease production of a particular unit, or start up additional units, or turn some off.

Estimating avoided cost is based on calculating the variable and fixed costs of generation when additional demand is placed on the existing system. As noted above, these variable costs are mostly fuel but also include some "wear and tear," i.e., variable O&M, on an individual unit and possibly the extra cost associated with needing to start up an additional unit if the existing system cannot meet the additional demand. The "incremental avoided cost" will theoretically change at any moment in time based on which units are currently producing power and how the overall system needs to respond to meet additional demand. The combination of fixed and variable costs, and the impact on avoided cost, is used by utilities to determine the optimal mix of generation units to meet their load demands in the immediate term and investment decisions for new hardware and fuel sources (including renewables) in the long term.

Utilities are required to file their avoided cost projections with the RCA and update them on a regular basis. Avoided cost filings through 2021 for each utility serving Anchorage are presented in the table below.

Table 7. Utility-filed avoided energy costs through 2021 (¢/kWh), effective April 1, 2016[21,22,23,24]

Calendar Year	Anchorage ML&P	Chugach Electric Association	Matanuska Electric Association
2016	3.56	3.8 - 4.4	8.365
2017	3.56	5.1 - 5.9	8.825
2018	3.56	5.0 - 5.7	9.176
2019	3.56	4.9 - 5.7	9.568
2020	3.56	5.0 - 5.8	9.764
2021	3.56	5.1 - 5.9	9.965

Because of the new gas generation that has been installed by several of the Railbelt utilities over the past few years, incremental avoided cost is actually quite stable, since a combination of the highly efficient SPP and about-to-be-commissioned Sullivan 2A plants will be sufficient to meet most demand in Anchorage, and can be topped off with MEA's new Eklutna Generation Station units to meet the highest peaking and variable loads. Avoided cost will be re-visited in Chapter 5 when discussing various potential opportunities including net metering, utility power pooling, combined heat and power, wind and solar power, and possible incentive pricing to encourage particular activities such as electric vehicles.

21 Filings are required by 3 AAC 50.790(e) and are based chiefly on fuel and variable operation and maintenance costs. Chugach range reflects different estimates for various combinations of percentage reduction and summer, winter, and shoulder season peaks and minimums. Estimates do not include integration costs.

22 2016 3 AAC 50.790(e) Biennial Report by Municipality of Anchorage, D/B/A Municipal Light & Power

23 http://www.chugachelectric.com/system/files/regulatory_affairs/ta420-8.pdf

24 http://rca.alaska.gov/RCAWeb/Filings/FilingDetails.aspx?id=4c73ab4d-cabf-462a-8432-c99068942669

CHAPTER 3 - MUNICIPAL FACILITIES AND STREETLIGHTS

OVERVIEW

As the owner-manager of over 10 million square feet of buildings in Anchorage and consumer of approximately 20% of the energy used to heat and power public facilities in Anchorage, the MOA can and is playing a key role in enhancing community energy resiliency and innovation through leading by example.

This chapter addresses energy efficiency and conservation opportunities in facilities owned by the MOA, as well as potential projects associated with MOA facilities that could generate heat, power, and renewable fuels, e.g., landfill gas-to-energy facility expansion, biodiesel production, and power production through sewage sludge combustion.

ANCHORAGE SCHOOL DISTRICT

CURRENT STATUS

With an enrollment of around 50,000 students the ASD ranks within the top 100 U.S. school districts in size. The ASD manages 90 schools and other facilities with a total electrical consumption of 67.5 GWh/yr and natural gas consumption of 5.3 million CCF. Power and gas costs were approximately $15 million in 2015. ASD has direct digital data control (DDC) systems on all of its facilities, which aids centralized energy management and data acquisition along with monitoring energy savings. See Appendix C1. Anchorage School District Facility Energy Consumption 2015 for detail of energy consumption and cost by facility.

The ASD Energy Manager is leading the school district's efforts in planning and implementing energy efficiency upgrades. Last year, following some of the recommendations from energy audits done in 2012, the ASD upgraded 6,000 light fixtures using ASD in-house maintenance personnel to accomplish the work. The ASD's newly refined approach ranks building upgrades by energy cost intensity (ECI) in $/square foot and total volume of savings using a program called School Dude.[25] Current project priorities include a new heating plant at the Student Nutrition Building ($2.5 million), using high efficiency condensing boilers, and upgrading refrigeration, and improvements at other buildings, including the school "bus barn" ($1.6 million).

The ASD is considering using financing from several potential sources including AHFC's Alaska Energy Efficiency Revolving Loan Program (AEERLP), the MUNI Master Lease Program, and private lending institutions. The cost savings generated after these projects are completed are expected to be at least cost neutral, save significant quantities of natural gas and electricity, and will offset the cost of the loan payments.

25 https://www.schooldude.com

OPPORTUNITIES

Substantial opportunity appears to exist for energy and cost savings through an active ASD energy efficiency retrofit program. For the purpose of this report we conservatively estimate that cost-effective retrofits will result in electrical and natural gas savings of 20% and O&M savings of 5% for buildings that have received little to no efficiency upgrades. An example of O&M savings is the decreased need to replace bulbs following upgrades from fluorescent tubes to LEDs. Further assumptions based on discussions with ASD personnel and others are that 1) simple payback for efficiency upgrades is seven years and that 2) 20% of ASD facilities have already received an efficiency upgrade. For the purpose of this simple analysis, costs of financing retrofits are not included.

Based on these assumptions and calculations, the **ASD would save approximately $3.0 million per year in energy and O&M costs through investment of approximately $21 million.**[26] It should be noted that most of the EE upgrades considered here have over a 12 year lifecycle and are expected to yield a positive return on investment. If energy prices continue to escalate, the lifetime savings benefits also increase relative to a business as usual case with no energy efficiency investments.

RECOMMENDED NEXT STEPS

Having established an Energy Manager position in its maintenance and operations department, the ASD is in a good position for continued focus on energy efficiency and facility improvement. ASD has effectively pursued financing and identified priorities, and is now poised to decide among various procurement options. ASD's present course is likely to result in significant costs and energy savings.

Likely options are for the ASD to 1) contract with ESCOs to plan and implement improvements, 2) accomplish upgrades in-house, or 3) use conventional construction procurement delivery methods such as putting projects out to bid or using pre-approved contractors. Smaller scale and/or less complicated improvements are often performed with in-house personnel, while larger, more costly and/or complicated initiatives are often performed by ESCOs who have specific experience and financing capacity or conventional construction delivery methods.

Because of their substantial heating loads, high schools with pools may be attractive sites for applying small-scale combined heat and power technology discussed further in Chapter 5.

ANCHORAGE WATER AND WASTEWATER UTILITY

CURRENT STATUS

Anchorage Water and Wastewater Utility (AWWU) is a public utility and enterprise fund owned by the MOA. Although AWWU shares one workforce it is separated into two economic and regulated utilities—Anchorage Water Utility and Anchorage Wastewater Utility. AWWU provides services in three geographic areas—the Anchorage Bowl, Northern Communities (Eagle River to Eklutna), and Girdwood.

Major facilities include the following:

+ **John M. Asplund Wastewater Treatment Facility** (WWTF) at Pt. Woronzof is the largest AWWU facility. Built in 1972, it provides primary treatment of waste received from the Anchorage Bowl including JBER, as well as sludge from the Eagle River and Girdwood WWTFs. The Asplund WWTF accounts for over 60% of AWWU's natural gas and 50% of its electrical energy consumption and includes a 30-year old system that burns mechanically dewatered sewage sludge. AWWU is reviewing findings of an energy assessment report conducted on behalf of the U.S. Department of Energy by students and faculty of the Idaho Industrial Assessment Center. The report recommends a number of improvements related to incinerator operations.
+ **Eagle River and Girdwood WWTFs** provide secondary treatment with effluent filtration and discharge treated water into Eagle River and Glacier Creek.
+ **Eklutna Water Treatment Facility**, supplied from Eklutna Lake through a 6-mile tunnel, provides approximately 90% of AWWU's water production. AWWU operates a 750 kW turbine generator on the influent raw water line coming from Eklutna Lake. This is used to power the

26 Since the original analysis for this report was conducted, the ASD has updated its energy efficiency programs and has identified additional retrofits that result in an overall larger project that will ultimately save more energy and money but will also have a longer payback period because more expensive measures are included like boiler upgrades. Specifically, the ASD is now considering $35 million in retrofits that will save approximately $3 million/year, for a 12 year payback on items with expected lifecycles generally over 25 years. This proposed larger project is not included in the main analysis of this report. (Tony Friel, ASD, Junuary 18, 2017, pers. comm.)

water plant and returns some energy to MEA.

+ The **Ship Creek Water Treatment Facility** boosts Eklutna water at periods of peak demand and provides a backup source. Additional water is supplied by wells in Girdwood and the Northern Communities.
+ A **maintenance complex** consisting of five buildings on 94th Ave. and a headquarters building in midtown on Arctic Blvd.

In addition, **AWWU's water supply system** includes 835 miles of distribution mains, 20 reservoirs and clear wells, numerous pressure reducing valves (PRVs), 20 booster stations, over 5,900 hydrants, and 45 major valve vaults. The **wastewater collection system** includes 641 miles of gravity sewer line, 14 miles of force main (pipes whose pressure is maintained by pumps), and 27 pump and lift stations.

In 2015 AWWU consumed 15.6 GWh of electricity at a cost of $2.6 million and 1.1 million CCF of natural gas at a cost of $1.0 million. AWWU's major facilities listed above, consumed 7.6 GWh of electricity at a cost of $1.1 million (49% of the total) and 1.0 million CCF of natural gas at a cost $0.9 million (94% of the total). See Appendix C2. AWWU Energy Facility Energy Consumption 2015 for detail of energy consumption and cost by major facility.

OPPORTUNITIES

Facility Efficiency

AWWU management indicates that there is substantial opportunity to maintain and improve efficiency of its facilities. To this end AWWU tracks energy usage and other performance parameters of its ~17,000 pieces of rotating machinery, boilers, and other system components in 150 remote facilities that are tied into the utility's supervisory control and data acquisition (SCADA) system. AWWU uses IBM's Maximo Asset Management software to manage its infrastructure.

For the purpose of this report we estimate potential cost and savings from EE&C activities as follows.

1. We do not attempt to estimate potential efficiency savings for AWWU's substantial water distribution and wastewater collection systems. AWWU has already installed variable frequency drives on all of its pumps, and it is not clear to what extent additional, chiefly electrical measures, would further decrease consumption in the distribution and collection systems.
2. We assume that the bulk of the activities will target the major facilities described above (e.g., LED lighting retrofits, tuning and replacing boilers, and other measures in the three wastewater treatment facilities; two water treatment facilities; and maintenance and headquarter buildings).

We apply the general assumptions for facility efficiency improvement presented in the Scope of Work and Report Format section: 1) 20% energy and cost savings plus an additional savings of 5% from reduced O&M; 2) Simple payback on investment is seven years; and 3) 20% of the opportunity for efficiency upgrades has already been exploited.

Based on these assumptions, we estimate that **AWWU would save approximately $0.4 million per year in major facility energy and O&M costs through investment of approximately $2.8 million.** Note that these estimates include efficiency upgrades at the Asplund wastewater treatment facility, whose incineration system is addressed separately below. Due to the general nature of this report and the presence of a more in-depth assessment under current review, and at the risk of "double-counting", we do not attempt to segregate impacts of energy efficiency impacts to the Asplund facility. As with the ASD analysis above, most EE measures are expected to have at least 15 year lifecycle.

Asplund Wastewater Treatment Facility Sludge Gasification

As noted above, AWWU is considering its options for treating Anchorage sewage sludge at the Asplund WWTF. AWWU contracted with a consultant to prepare an initial assessment of replacing its aging incineration system with a gasification system. GV Jones and Associates' February 22, 2016 study[27] compares technical and economic feasibility of three alternatives: 1) Maintaining and upgrading the existing incineration system, and deploying either 2) an anaerobic digestion, or 3) a thermal gasification system.

The preliminary study concludes that thermal gasification using a fluidized bed reactor could save $1.8 million per year in operation costs for a $51 million gasification system that costs $5 million more than the $46 million base case incinerator upgrade, yielding a simple payback of 2.7 years. Key benefits of gasification appear to be:

27 GV Jones and Associates 2/22/16. Asplund Wastewater Treatment Facility Sewage Sludge Gasification DRAFT Memorandum, Anchorage.

- Sludge volume reduction similar to incineration through a process that is not subject to incineration's air quality rules.
- Reduced expenditures on potable water needed to quench incineration ($1 million/year).
- Potential syngas-fueled power generation that yields an average output of 1.1 MW, satisfies Asplund WWTF's electrical demand, and provides renewable electricity to the grid.
- Reduced expenditures on natural gas.

Based on the GV Jones report, the thermal gasification system is estimated to produce 9.83 GWh of renewable electricity per year. Of this, approximately 55% would be used by the facility, while the remaining 45% (approximately 4.42 GWh per year) would be available to sell to the grid.

A very rough estimate of energy efficiency gains based on the preliminary report is as follows. The report notes that the gasification system would eliminate the current incineration system's consumption of 1,530 CCF of natural gas per day, equating to a savings of approximately 559,000 CCF per year. The incineration system consumes roughly 2.15 Gwh of electricity per year, while the gasification system would provide 4.42 GWh per year to the grid, for a total net savings of 6.57 GWh per year. Total natural gas and electricity savings are therefore estimated at 78.3 billion Btu per year.

Fat, Oils and Grease Management

Like other wastewater utilities across the US and elsewhere, AWWU faces the challenging issue of dealing with cooking fats, oils and greases (FOG) that are dumped into the waste collection system by residential and commercial customers. Congealed FOGs constrict waste flow and can cause backups, blockages, sanitary sewage overflows (SSOs), and operational problems at treatment plants. Based on its 2014 Wastewater Master Plan[28] AWWU management estimates an out-of-pocket expense of approximately $570,000 per year to manage FOG through routine, accelerated and emergency line cleaning; costs and claims associated with SSO incidents; and FOG-related pump station and wastewater treatment plant operation and maintenance. While annual FOG costs are significant, of equal or greater importance is ensuring viability of the Anchorage wastewater system's 301(h) authorization under the Clean Water Act.

28 https://www.awwu.biz/website/media/documents/reports/MasterPlans/MasterPlansFrameWasteWater.htm

Two general types of FOG are differentiated: 1) yellow grease generated by restaurants and other food service establishments usually by frying, and 2) brown (trap) grease which consists of floatable FOGS, settled solids, and wastewater sometimes captured by grease traps and interceptors. Yellow grease is more valuable since it can be more easily converted to a biofuel, livestock feed and other products. Brown grease is more difficult to convert to biodiesel due to higher levels of free fatty acids that inhibit the conversion process. Based on the results of a 1998 national study prepared for National Renewable Energy Laboratory (NREL)[29] Anchorage generates roughly 3,300 tons of FOG per year—40% yellow grease and 60% brown grease—which equates to a ballpark estimate of 370,000 gallons of yellow grease and 530,000 gallons of brown grease per year.

Alaska Waste, the certificated garbage collection utility south of Northern Lights Blvd and Tudor Rd, collects yellow grease from 200-300 customers from the Mat-Su Valley to Girdwood, including fast food restaurants with multiple locations.[30] Currently Alaska Waste either sells the raw, filtered product to Lower 48 firms or processes it into biodiesel in its modern, state-of-the-art plant in midtown Anchorage (Figure 16. Anchorage Waste's Biodiesel Production Plant in Midtown Anchorage). Similar to petroleum, the price of biodiesel has dropped significantly since 2015. While Alaska Waste previously sold biodiesel to two Alaskan fuel distributors for retail sales, current biodiesel production is limited to supplying Alaska Waste's own garbage collection fleet with a 5% biodiesel (B5) blend. Given that current biodiesel production is less than 5% of the plant's 250,000 gallon per year capacity, Alaska Waste is interested in expanding markets.

At Alaska Waste's plant, a batch of 900 gallons of yellow grease, 300 gallons of methanol, and a catalyst yields approximately 1,000 gallons of biodiesel, 300 gallons of glycerin, and a quantity of methanol that can be recovered through distillation. Recovery and processing of all of Anchorage's approximately 370,000 gallons of yellow grease would therefore yield roughly 410,000 gallons of biodiesel. Assuming that biodiesel has about 92% of the energy content of #2 diesel, this equates to approximately 380,000 gallons of diesel fuel. NREL's Handling and Use Guide[31] provides a summary of pros and cons of biodiesel

29 Wiltsee G. 1998. Urban Waste Grease Resource Assessment NREL/SR-570-26141, by Appel Consultants Inc. for National Renewable Energy Laboratory, https://www3.epa.gov/region9/waste/biodiesel/docs/NRELwaste-grease-assessment.pdf.

30 Yellow grease collection and biodiesel production information is based on personal communications with John Fries, Alaska Waste, 10/7/16.

31 NREL 2009. Biodiesel Handling and Use Guide. http://www.nrel.gov/transportation/pdfs/43672.pdf

production and use, e.g., decreased air pollution and greenhouse gas emissions and increased engine lubricity versus poorer low temperature operability and somewhat shorter storage stability.

Figure 16. Anchorage Waste's Biodiesel Production Plant in Midtown Anchorage

Photo: Peter Crimp

Following the analysis of the impacts and costs of FOG in the municipal wastewater system in its master plan, AWWU is actively considering options to incentivize producers to capture and dispose of waste oils and greases properly. One FOG management model option under study is Tempe, Arizona's Grease Cooperative[32], a voluntary partnership between the City of Tempe and restaurant owners. There the City brokers the purchase and maintenance of grease interceptors and traps for food establishments, thus assisting businesses in meeting FOG requirements, maintaining a clean environment, and developing potential renewable fuel supplies while saving money and reducing impact to its wastewater collection system.

RECOMMENDED NEXT STEPS

AWWU is establishing a staff energy-efficiency team to identify and implement improvements. An HVAC technician position was added to the Utility's Operation and Maintenance Division to participate on the team and focus on building energy management. Given the energy intensive nature of the AWWU infrastructure and substantial opportunities for energy and cost savings, this move appears quite appropriate.

Currently AWWU is taking steps to better define costs and energy output of upgrading or replacing its current aging sludge treatment system, including use of a sophisticated sludge gasification system. Their preliminary recommends further evaluation of the business case, air emissions, syngas cleaning, sludge energy content, and potential funding sources. If findings appear promising, further steps would be to evaluate the process by a steam/power engineer, pilot the use of Anchorage sludge in an existing gasifier, and further refine cost estimates and savings. This is a multi-stage and high cost project that will require long-term financing, but replacement of the existing sludge processing system will eventually be necessary and this detailed analysis will be essential for determining the least cost and most efficient option.

As noted above, customers' improper disposal of fats, oils, and greases into the sewer system increases AWWU maintenance costs and risks of sanitary sewer overflows. At the same time, Alaska Waste's modern biodiesel plant is operating at a fraction of its capacity. A public-private partnership between AWWU and Alaska Waste to capture and utilize this waste stream might yield substantial benefits for both parties.

DEPARTMENT OF MAINTENANCE AND OPERATIONS

CURRENT STATUS

Anchorage's Department of Maintenance and Operations (M&O) has broad responsibilities across the MOA infrastructure that includes street maintenance, facility and vehicle fleet maintenance, capital improvement project management and telecommunications. M&O's Facility Management section maintains over 150 office buildings, swimming pools, libraries, and other municipal facilities. This section of the report focuses on the MOA facilities under M&O's management.

In 2009-10, 54 buildings managed by M&O consumed an average of 329 billion Btu per year of electricity and natural gas costing $5.8 million per year. Major energy consumers were the Anchorage Museum, Sullivan Arena, Loussac Library, Transit Maintenance facility, Dempsey Anderson Ice Arena, Performing Arts Center, Egan Center, Anchorage Police Department Headquarters, Ben Boeke Ice Arena, Anchorage Police Department Training Facility, Bartlett High School Pool, Chugiak Senior Center, Animal Control building, and the West High School Pool. See Appendix C3. Maintenance and Operations Facility Energy Consumption and Audit Summary for a breakdown by facility.

32 http://www.tempe.gov/city-hall/public-works/water/pretreatment-pollution-prevention/tempe-grease-cooperative

Supported by AHFC, the Municipality had investment grade energy audits prepared for 19 of its facilities in 2012. Commonly recommended energy efficiency measures (EEMs) were:

+ Room temperature setback thermostats
+ Upgrade to higher efficiency condensing boilers
+ High efficiency motor upgrades
+ Beverage vending machine upgrades
+ Lighting efficiency upgrades
+ Low-flow toilets
+ Modify ventilation system operating schedule using CO2 sensors
+ Utilization of waste heat from refrigeration systems at ice arenas
+ Installing a low-emissivity ceiling curtain at ice areas to minimize refrigeration loads
+ De-stratification fans in high bay areas such as the transit buildings
+ Automatic overhead door closers set on timers
+ Additional insulation

The M&O Director notes that due to aggressive LED lighting retrofits in maintenance shops, fire department facilities and other locations, energy budgets have remained relatively flat despite rising energy prices.[33] He estimates that approximately 90% of MOA buildings warrant LED upgrades, especially offices such as City Hall, the library, and police department facilities. M&O's experience indicates that high efficiency condensing boilers save fuel but are temperamental and require more maintenance. Other promising EEMs include replacement of pneumatic controls with DDCs and, when refurbishing buildings, increasing insulation to R40-R50 and upgrading windows.

OPPORTUNITIES

For the 19 facilities that received audits, the cost of recommended EEMs totaled $4.47 million while yearly savings totaled $1.10 million, yielding a simple payback of 4.1 years. Given that energy costs totaled $3.08 million for these buildings at the time of the audit, savings represented 35% of the annual energy costs.

Similar to other MOA facilities, for the purpose of this report we estimate that cost-effective retrofits will result in electrical and natural gas savings of 20% and O&M savings of 5% for buildings that have received little to no efficiency upgrades. Given the potential 35% energy cost saving estimates in the audits described above, this assumption should be regarded as conservative. As in the ASD analysis, we further assume that: 1) simple payback for efficiency upgrades is seven years, 2) 20% of MOA facilities have already received an efficiency upgrade, and 3) costs of financing retrofits are not included. Since M&O energy consumption data provided did not break out electrical versus natural gas consumption, we derive these estimates from Anchorage-wide commercial consumption figures above (Table 6. Anchorage 2015 End Use Consumption of Major Energy Sources* (Billion Btu)). Based on these assumptions and calculations, the **MOA would save approximately $2.2 million per year in energy and O&M costs through investment of approximately $15.6 million.** Similar to the other MOA EE initiatives discussed above, typical EEM lifecycles are approximately 15 years and yield positive returns on investment.

RECOMMENDED NEXT STEPS

M&O has a large energy-related responsibility for the entire Municipality and already has energy expertise on staff and policies for acquiring LED fixtures and high efficiency condensing boilers for all new construction. Access to capital for investment geared toward facility and equipment upgrades that would save energy and money appear to be the primary challenge. This requires creative financing, similar to other MOA Departments' needs, that could include investment from an ESCO that is paid back over time through energy savings, or some other financing vehicle provided by the MOA.

M&O staff did, however, identify a need for a building controls specialist that would be monitoring all of their systems to ensure maximum savings was achieved. It is not clear if this would merit a full-time position or if the cost savings could justify the position. However, to the degree that M&O's needs are similar to other MOA Departments, a building controls specialist and/or a more broadly focused Energy Program Manager, perhaps situated in the City Manager's office, is a common position in large organizations and would very likely achieve substantial cost savings given current annual energy expenditures of the MOA. Energy benchmarking (see Sidebar) across the MOA's infrastructure could guide where a controls specialist and an Energy Manager would focus his/her attention.

33 Al Czajkowski, M&O, 7/14/16, pers. comm.

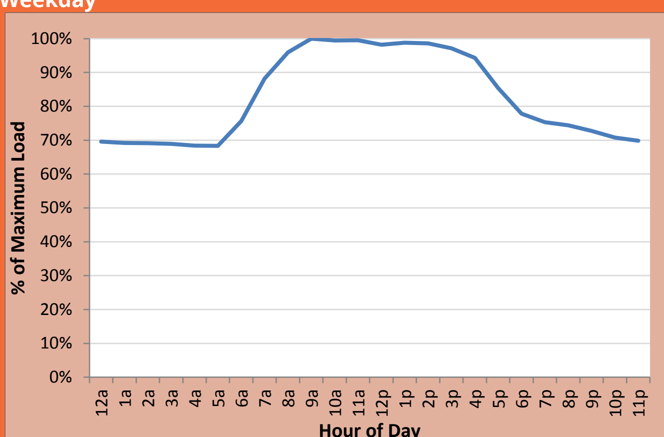
SIDEBAR

BENCHMARKING AND FACILITY ENERGY MONITORING

Looking closely at actual energy use of buildings usually reveals opportunities to save energy. Energy Use Benchmarking is the practice of comparing the energy use of a building to its peers. Such comparisons usually identify some buildings that are using energy substantially in excess of average. Audits and further analysis can then find the cause of the high energy use in these buildings.

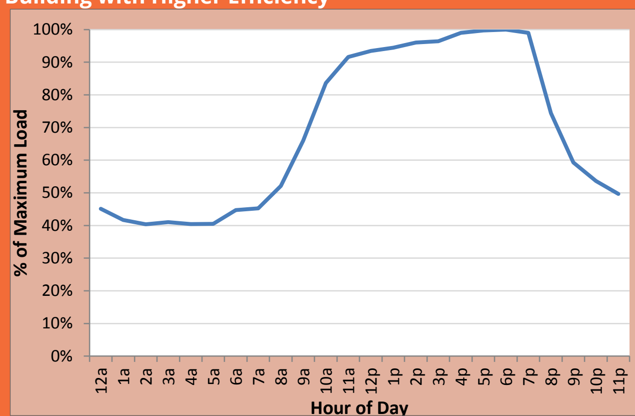
For example, utility bills were collected from about 200 schools in Southcentral Alaska. When the energy use was normalized on a square footage basis, schools ranged from consuming 29% of the average school energy use per square foot to a high of 2.7 times that average. Clearly there are opportunities to be found for saving energy in the high-use school.

Figure 17. Electricity Use for Anchorage Office Building on Typical Weekday



Utility bills provide valuable energy use data, but that data is averaged across an entire month. Much more detailed energy use information can be obtained by installing metering equipment that measures energy use every 15 minutes or even more frequently. Data with higher time resolution can provide more detailed insight into the building's energy use. For example, Figure 17. Electricity Use for Anchorage Office Building on Typical Weekday shows the electricity use of one Anchorage Office Building on a typical weekday. Use is shown as a percentage of the maximum use during the day. For this building, electricity use in the middle of the night drops only to about 70% of the daytime usage, indicating that many loads are operating during unoccupied hours.

Figure 18. Electricity Use for Another Anchorage Office Building with Higher Efficiency



This is a similar graph from a different Anchorage Office Building that does a better job controlling nighttime energy use. Nighttime use falls to 40% of peak daytime usage. With attention and better control systems, nighttime use could be reduced even below this value. Simply addressing high unoccupied energy use can result in annual energy savings of 10-30%.

Watching these patterns of energy use on a day-to-day basis makes it possible to spot anomalous changes. Often these changes point to a perhaps unwanted change in the building control system or failure of some piece of energy-using equipment. $9,000 per year of energy savings was realized when one such change was detected by closely examining high resolution facility monitoring data.

Obtaining this high resolution energy use data is becoming less expensive. Smart electric utility meters have the ability to collect this data as part of their standard feature set. For natural gas meters, pulse-producing attachments are available, or radio receivers can be installed that listen to the automatic meter reading transmissions of the meter and record usage data on intervals of an hour or less. Wireless sensor technology has also improved, making it economical to collect data from energy using systems throughout a building.

- Courtesy Alan Mitchell, Analysis North

MERRILL FIELD AIRPORT

CURRENT STATUS

The Merrill Field municipal airport, an enterprise activity of the MOA, ranks among the nation's busiest small-craft airports. Facilities owned by the airport include the airport manager's building, a maintenance facility, six buildings on Orca St. west of the airport leased for commercial purposes, runway and apron lighting, and a rotating aviation beacon. In 2015 the airport and its leased facilities consumed 909 MWh of electricity at a cost of $141,000 and 36,000 CCF of natural gas at a cost of almost $36,000.

The airport provides long-term leases to numerous other non-MOA-owned facilities including hangars, offices, and the UAA Aviation Technology Center.

In the recent past the HVAC in the airport manager's building has been replaced, the roof in the maintenance facility insulated, and programmable thermostats installed.

OPPORTUNITIES

Starting in 2013 Merrill Field initiated an aggressive LED conversion program. Currently 50-75% of the runway and apron lighting has been replaced with Federal Aviation Administration (FAA)-approved LEDs using FAA grant funding. Management plans to continue these retrofits as funds are available. Airport staff adjust the on/off timers controlling this lighting on a weekly basis. The metal halide aviation beacon cannot be replaced with LED lamps because no FAA-approved LED products are available from vendors.

42% of the airport is underlain by the now-closed Merrill Field landfill. Potential usage of captured methane gas from the landfill is discussed in the Solid Waste Services section, although in this case, the methane gas is now declining as no new solid waste is input to the system and no methane capture and conversion system is economically viable under these circumstances.

PORT OF ANCHORAGE

CURRENT STATUS

The Port of Anchorage (POA) is Alaska's largest inbound cargo terminal by volume and handles about half of all Alaska inbound, marine freight – half of which is delivered outside of Anchorage.[34] About 3.5 million tons of cargo and fuel are shipped through the POA each year. The Port is an intermodal cargo transport hub that connects Alaska's main marine, road, rail, pipeline, and air cargo systems to move goods and fuel that eventually reaches about 85 percent of all Alaska residents and businesses, military bases, and other destinations across the state. The Port is a designated national strategic seaport that is critical to the Department of Defense mission in Alaska. It is critical infrastructure that is vital to timely and successful natural disaster response and recovery plans. It is located adjacent to Alaska population centers, key markets, and hundreds of millions of dollars of freight-related infrastructure. And upper Cook Inlet geography ensures that the POA is virtually tsunami proof.[35] Like many of the other large infrastructure facilities evaluated in this report, the POA is operated as a municipal enterprise under the MOA.

The POA handles some 1,200 inbound and 1,200 outbound containers weekly to ship freight that includes food, consumer goods and other cargo (Alaska imports approximately 95% of its food). The Port also handles bulk commodities including cement and petroleum products for development projects, transportation, heating, power generation and military operations across Alaska.

Figure 19. Aerial View of Port of Anchorage

Photo: Courtesy MOA

The Port of Anchorage opened in 1961 and engineering studies show that its aging wharf piles heave lost as much as three-fours of their original thickness to corrosion and are unlikely to survive another significant earthquake. The Port budgets $3 million annually to install pile jackets that extend the docks' operational capacity, but do little to enhance operational efficiency or earthquake

34 About 90 percent of all Alaska inbound freight is marine cargo, about five percent is air cargo and about five percent is truck cargo (Jim Jager, POA, 2/20/17, pers. comm.).

35 http://www.portofanc.com/wp-content/uploads/Test_Pile_Program_Fact_Sheet.pdf

resilience.[36,37] A multi-year major infrastructure re-development (Anchorage Port Modernization Program or APMP) is underway though some project details and funding sources are still to be determined. While there is a long history with numerous issues and perspectives regarding this critical facility, for the purposes of this report, we will focus on the energy-related challenges and opportunities associated with the new infrastructure that will be developed over the next 2-10 years.

OPPORTUNITIES

Port Modernization Project

Current APMP plans will replace existing docks with new docks that will be constructed farther from shore and in deeper water than the current docks to accommodate deeper-draft ships, reduce the need for dredging, and provide more flexibility at low tide.[38] The current docks are supported by 1,423 hollow-steel piles that were originally 7/16-inch-thick and have an average diameter of 24 inches. Studies show that many of these piles have lost three-quarters of their original thickness to corrosion and that they will have to start closing in about ten years, regardless of any repair efforts or anything else. The new docks are expected to have at least 1,000, one-inch-thick, 48-inch-diameter piles filled with steel-reinforced concrete. They will be driven more than 130 feet into the seafloor and coastal mudflats and will enable facilities to survive extreme seismic events and Cook Inlet's harsh marine environment for at least 75 years.

Figure 20. Installation of Protective Jacket on Corroded POA Piling

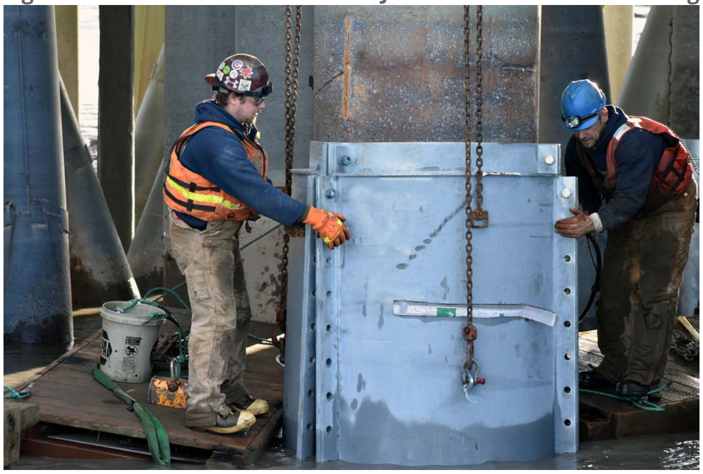


Photo: Courtesy POA

36 http://www.adn.com/opinions/2016/07/30/with-easy-money-gone-and-port-dock-failing-anchorage-will-have-to-pay/ ; http://www.adn.com/anchorage/slideshow/photos-corroded-pilings-port-anchorage/2014/08/18/

37 http://www.ktuu.com/content/news/Crews-race-to-make-repairs--399520291.html

38 Jim Jager and Steve Ribuffo, POA, 4/6/16 and 6/7/16, pers. comm.

The current dock has 3 x 38-gauge gantry cranes (see Figure 23) for container ship loading and unloading. The plans for the new dock call for 4 x 100-gauge cranes, which are much larger and will substantially increase overall electric demand and instantaneous impact on the electric grid when the cranes start and stop. Specifically, these new cranes are rated at 2 MW, which means that each crane can draw up to 2 MW of power at any moment it is in operation, so all four cranes operating at the same time could yield an 8 MW demand on ML&P's portion of the Railbelt grid.

These proposed new cranes are essentially identical to a recently installed crane in the port at Kodiak. The new Kodiak crane required energy "buffering" to soften the instantaneous jolts on their electric grid caused by the rapid starts and stops of the new crane. Kodiak Electric Association (KEA), the local electric utility, along with the crane owner/operator Matson chose to install a flywheel to provide both the energy buffering required and supplement existing energy storage on their electric grid to better accommodate their wind-hydropower-battery-diesel hybrid electric system.[39]

39 Darron Scott, KEA, 9/16/16, pers. comm.

CASE STUDY: KODIAK ELECTRIC ASSOCIATION

Kodiak Electric Association (KEA) is a world leader in renewable energy, meeting essentially all of its annual electric load with a combination of clean hydropower and wind energy. Batteries and an ABB PowerStore Flywheel and Grid Stabilizing technology are also essential components of KEA's energy supply, storage, and delivery system.[40] Prior to the flywheel installation, KEA was unable to fully utilize its wind power, and their batteries were degrading more quickly than expected, because of the extreme fluctuations caused by turbulent winds and the resulting variable power output from the wind turbines. The need for a new electric crane at the Kodiak dock added even more justification for power buffering and battery protection. The Flywheel and Grid Stabilizing technology from ABB enabled full utilization of the wind, provided the necessary battery protection for longer life, and delivered sufficient power buffering to allow the electric crane to operate with little to no impact on the rest of the grid.

PROJECT DETAILS

Electric: 27 MW Peak Load; 99.8% Renewable Energy (Hydro & Wind), provided by KEA

Crane: 2 MW electric; Manufacturer is ZPMC; ABB drives and controls (same as proposed for POA)

Energy Storage: Younicos Batteries - 3 MW/1 MWh; ABB PowerStore Flywheel - 16.5 Megawatt-seconds, 85% round-trip efficiency; ABB PCS 100 Power Converter

Costs: Flywheel Energy Storage System ~$2 Million; Feeder ties, Feeder tap, site preparation ~$1.5 Million

Figure 21. ZPMC 2 MW Electric Crane at Kodiak Port
Photo: Courtesy Darron Scott

Figure 22. Installing ABB Flywheel in Kodiak
Photo: Courtesy Darron Scott

40 https://www.adn.com/energy/article/kodiak-builds-renewably-powered-island-lessons-rural-alaska/2015/09/27/

Along with requiring much more energy to operate when they are lifting loads, the new cranes generate electricity when they are working with gravity and dropping loads similar to a hybrid car during re-generative braking. This electric generation will need to be injected back into the electric grid and/or used on-site.

Figure 23. POA & ML&P Staff in Front of Existing Three Gantry Cranes at POA

Photo: Brian Hirsch

Overall electricity consumption for the POA in 2015 was approximately 2.4 GWh at a cost of $318,024. Natural gas consumption from November 2015 to October 2016 was 87,000 CCF at a cost of $79,800. ML&P is working closely with POA to better understand the potential impacts to the grid and identifying options for use of the power that will be generated by the new cranes and other potential loads. Primary power buffering and storage options include batteries, flywheels, and ultra-capacitors; each of these storage options has different performance characteristics and thus will interact differently with the existing power grid. A scenarios study will need to be undertaken to determine the best combination of performance, costs, technology risk, and services provided to the grid based on these different storage technology options.

The new cranes may also require large electric and control cables embedded in a channel in the new dock if a Panzerbelt system is used instead of an elevated busbar. There is some concern that removing snow in the winter with plows and gravel on the new dock—the current procedure—could damage these channels holding the cables for the new cranes under the Panzerbelt scenario. One possibility that has been discussed is installing an embedded snow melt system in the new dock.[41] This snow melt system would require heat, either generated directly from natural gas or indirectly through electricity, as well as a collection and filtration system to gather and clean contaminants such as oils and hydraulic fluids from the melted snow before it is released back into Cook Inlet. Operationally, an in-ground snow melt system would be preferable to mechanical snow removal, especially on days when active ship loading and unloading occurs, to reduce peripheral activity and multiple large vehicles moving simultaneously on the dock.

Figure 24. A Typical Shipping Container Vessel Departs the POA After Unloading

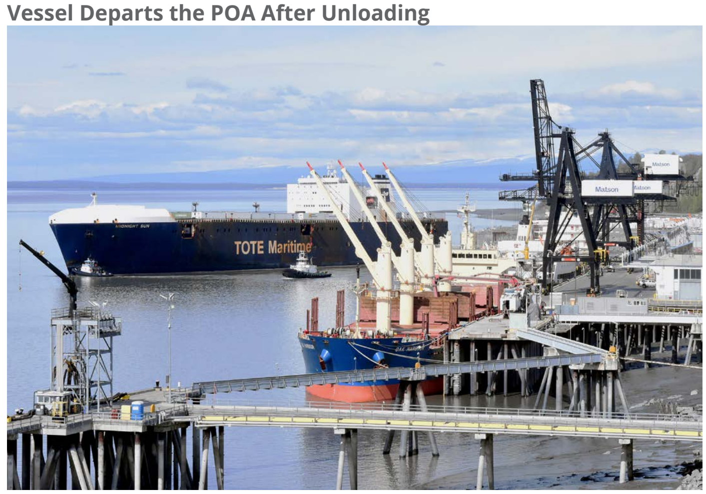


Photo: Courtesy POA

A study will be required to determine the following parameters:

+ How much heat would be required on an annual basis?
+ How would this heat be generated and how much would it cost?
+ How do these costs compare to standard snow plowing and gravel?
+ Can the electricity generated from the new cranes contribute to electric heating or other electric needs at the new facility?

Direct natural gas combustion, electric resistance heaters, and heat pumps are possible technology options for a snow melt system. Relative costs and operational considerations need to be determined to

41 Steve Ribuffo and Jim Jager, POA, 6/17/16, pers. comm.

make an informed choice as to the best technology.[42] POA personnel have expressed particular interest in evaluating the potential for using a heat pump to generate the heat for a snow melt system in the new dock.

Heat pumps are discussed in more detail below, but part of the interest and appeal for using a heat pump is because of the success of the Alaska Sealife Center in Seward, which is using a seawater heat pump and saving over $100,000 annually in energy costs and reducing greenhouse gas emissions.[43] There are numerous differences between the situation in Seward and a possible application at POA—including the price of electricity and availability of natural gas—but from preliminary analysis and discussions it has been determined that seawater in Upper Cook Inlet where the POA is located does not have adequate heat to support a heat pump. Thus, the likely thermal source for a heat pump at POA would be ground water deep below the mudflats where the new piles will be driven to support the new dock.

Average and seasonal temperatures of groundwater below the mudflats that might be used for a POA heat pump are not precisely known at this time, and this is essential information to determine the physical and economic viability of a groundwater source heat pump. Though it would be very costly to drill test wells to determine ground water temperature below the bedrock in this area as a stand-alone project, specialized heavy equipment to drive piles for the new dock is already in-place; this equipment can also be used with marginal additional cost to drill test wells for ground water temperature measurement. This is an unusual well-timed opportunity that could yield valuable temperature data at a fraction of the cost compared to a different time when the specialized equipment was not already mobilized to the site.

If the groundwater temperature and associated calculations showed promise for providing low cost heat to the POA dock, then this heavy drilling equipment could also be used to drill the necessary ground water wells for a complete system. This possible opportunity will likely only last for the duration of the pile driving operation during new Port construction, so needs to be determined within a fairly narrow window of time.

42 Energy analysts with operational experience managing in-ground snow melt systems have noted that energy use and costs can vary widely based on operating practices and sensor controls (Alan Mitchell, Analysis North, 9/26/16, pers. comm.)

43 http://www.alaskasealife.org/news_item/34

Additional activities should include ongoing replacement of outdoor lighting with LEDs as budgets allow, which will contribute to energy and cost savings for both the POA and tenants, while all new construction should be as energy efficient as practicable.[44] Little to no effort or expenditures should be applied to EE improvements on existing infrastructure that will soon be replaced under the APMP.

RECOMMENDED NEXT STEPS

To leverage the possible opportunities presented by the need to modernize the POA, the following activities are recommended:

1. Determine the expected energy demands, production, and power quality impacts of the four new cranes, including energy storage/buffering requirements (KEA and ABB will be good sources of information).
2. Determine the heating needs for a snow melt system at the new dock based on new dock design, square-footage required to be snow-free, and operational best practices, if a Panzerbelt system is selected.
3. Conduct an energy and cost scenarios comparison study of various snow removal options, including:
    a. Mechanical removal (plowing and gravel)
    b. Natural gas generated heat
    c. Groundwater source heat pump, which would ultimately require deep well drilling to monitor groundwater temperatures
    d. Combined Heat and Power
4. Based on results of item 3 above, consider drilling a test well and collecting ground water temperature data while the pile driving equipment is in-place at the POA.
5. Evaluate electric vehicle options for hostlers, forklifts, and other on-site cargo handling equipment based on progress at other commercial ports such as Port of Long Beach/Los Angeles.
6. Conduct a broad system configuration and impact study that includes new cranes, reliable back-up power, and possibly a heating system and electric vehicles, to compare costs and reliability among

44 LED replacements, a recommendation widely distributed throughout this report, could be part of a broader program across the MOA. This is discussed further in the last chapter.

the following:

a. microgrid with energy storage and back-up options, potentially with renewables and/or Combined Heat and Power generation

b. simple emergency stand-by generation with on-site fuel storage

c. Combined Heat and Power sized for optimum economic performance

7. Emphasis on energy efficiency with all new construction as APMP unfolds.

8. Ongoing replacement of outdoor lighting with LEDs and digital system controls, with a focus on how the POA can monetize the cost savings achieved from the energy savings if this is performed for tenants with the POA incurring the upfront costs.

SOLID WASTE SERVICES

CURRENT STATUS

Operated as a municipal enterprise, Anchorage Solid Waste Services (SWS) is funded entirely by user fees. SWS includes two utilities—Refuse Collections and Solid Waste Disposal. Refuse Collections provides residential and commercial garbage collection for an area generally north of Tudor Road east of the Seward Highway and north of Northern Lights Boulevard west of the Seward Highway. Alaska Waste is the certificated collection utility in the remaining areas of Anchorage.

The Solid Waste Disposal utility operates facilities at the Anchorage Regional Landfill (ARL) located in Eagle River, transfer stations in midtown Anchorage and Girdwood, and a small landfill gas flaring station at the old landfill at Merrill Field. Energy opportunities discussed here center on SWS's solid waste disposal operations. SWS staff are actively considering options for reducing energy consumption and operation costs through facility efficiency upgrades, expansion of the landfill gas to energy (LFGTE) project, and development of a leachate pipeline to the AWWU system.

In 2015 SWS facilities consumed 3.1 GWh of electricity and 153,000 CCF of natural gas at a combined cost of approximately $630,000. See Appendix C4. Solid Waste Service Facility Energy Consumption and Cost 2015 for more detail.

OPPORTUNITIES

Facility Efficiency

SWS's office and shop facilities at the ARL and the Central Transfer Station are candidates for energy efficiency improvements. Currently SWS has an engineering firm under contract to assess options at the Central Transfer Station for replacing the aging boiler and snow melting systems. SWS also plans to hire an experienced commercial building energy auditor to assess savings potential at their office and shop facilities.

Assuming that energy efficiency measures will decrease annual O&M costs by 25% (20% decreased energy consumption plus 5% labor and materials) and that the measures are applicable to all of the office and shop facilities, we estimate potential savings of approximately $85,000 per year at a cost of $600,000.

Other industrial facilities, located at the ARL, are assumed to have less potential for energy efficiency. These facilities include landfill gas blowers at the blower/flare building, other landfill gas blowers at the gas processing building, blowers to aerate landfill leachate in one of the two lagoons, and a station for loading leachate into tanker trucks for disposal at AWWU. Potential expansion of the LFGTE plant and development of a leachate pipeline (see below) will drive modifications to these facilities.

Landfill Gas to Energy Plant Expansion

Completed in 2012, the Anchorage LFGTE project is a highly successful partnership between SWS and Doyon Utilities (DU), the electric utility that serves JBER. The project consists of a gas collection and control system, a gas processing system, a one-mile pipeline, and a 7 MW power plant. SWS operates the collection and control system, while DU operates the processing system, pipeline and power plant. SWS is responsible for paying power costs for the gas processing system. Benefits of the system include: 1) substantial revenue to the MOA for sales of landfill gas that would otherwise have to be flared, 2) reliable distributed power that serves over 25% of JBER's load, and 3) renewable attributes that have propelled JBER into the lead green power producer in the U.S. Air Force's Pacific Theatre.

The LFGTE partners are considering expanding the project by 1.4 to 2.8 MW. Currently the landfill is producing 1800 cfm of landfill gas—300-600 cfm more than the 1200-1400 cfm that was originally modeled. Analysis and discussions are underway between SWS, DU, and JBER to resolve issues that impact expansion of the LFGTE project, including:

+ Capacity of the blowers at the processing system building and the pipeline to handle additional gas, and
+ Limited electrical load at Ft. Richardson during the summer and the need to integrate transmission between the Fort and Elmendorf Air Force Base to fully utilize additional energy.

Energy production of the LFGTE project totaled 51,700 MWh between October 2014 and September 2015. Assuming 2.8 MW of additional installed capacity and similar energy production per MW installed, increased energy production is estimated at 20,680 MWh per year. It should be noted that landfill gas fuel production is dependent on solid waste inputs and displays a "bell curve" production profile that is expected to peak in approximately 2045.[45]

Regional Landfill Leachate Disposal

Currently SWS collects water that percolates through the lined ARL, stabilizes it through aeration, pumps the treated leachate into 6000-gallon tank trucks, and transports it via the Glenn Highway approximately 9 miles to an AWWU receiving station at Turpin Street. In 2012, SWS hauled 3,785 loads of leachate to the dump station—an average of over 10 loads per day.

SWS commissioned a study in 2013 to analyze the technical and economic feasibility of constructing a pipeline from the leachate ponds to the AWWU wastewater system.[46] The proposed project would include a pump station at the ARL and a 5-inch pipeline to JBER's system. The pipeline would be routed due south to the Glenn Highway, follow parallel on the Highway's north side, and discharge into a manhole at Ft. Richardson. Leachate would travel 7.3 miles through the JBER sewer into the AWWU system.

The study estimated the installed project cost at $3.11 million, including design, construction management and 20% contingency. Net O&M savings were estimated at over $800,000 per year—chiefly decreased labor and equipment costs for hauling leachate. SWS would accrue other savings through decreased tariff for disposal of the leachate. Currently SWS pays the same relatively high tariff as septage haulers to dump leachate at the Turpin Street facility.

45 Anchorage Landfill Gas to Energy Project, 2013 ("white paper" produced by MOA SWS and Doyon Utilities).

46 ARL Leachate Disposal Pipeline Study, Bristol Engineering Services Corp for MOA Solid Waste Services, 2013.

The project would save approximately 12,300 gallons of diesel motor fuel per year for hauling at the comparatively low energy cost of 40 MWh/year for pumping. Another important benefit is decreased traffic on the Glenn Highway with increased motorist safety.

Issues that will need to be addressed include:

+ Impact of the leachate on the JBER system, including additional flow and possible formation of hydrogen sulfide that could corrode the existing system, and mitigation measures.
+ Right(s)-of-way for the pipeline from Alaska Department of Transportation and Public Facilities and the military.

OTHER POTENTIAL OPPORTUNITIES

Merrill Field Landfill Gas Utilization

In order to control air emissions SWS collects and flares landfill gas at the site of the old Merrill Field Landfill, which closed in 1987. According to SWS, landfill gas production near existing buildings on the northern edge of the old landfill is approximately 180 cfm of gas with energy content of 300 Btu per cubic foot—about 3.2 million Btu per hour.

Feasibility of energy recovery from the Merrill Field Landfill is limited by a number of factors.

SWS notes that by far the biggest and most costly challenge at the Merrill Field Landfill is the actual collection of the landfill gas. Currently, the only wells are located at the north boundary of the landfill to reduce the potential of gas migration to the buildings located there. These wells collect low quality gas since their radius of influence extends into the native soils adjacent to the waste. Higher quality gas is likely available in the middle of the landfill but the geometry of the fill makes that difficult. The maximum depth of waste estimated in 1987 was about 50 feet. That depth has likely decreased 5 to 10 percent due to decomposition and consolidation of the waste. Additionally groundwater depths have risen over the years further limiting the amount of waste available to draw gas from. Finally, the closure plan included a porous cap to allow free venting of the gas. Because the collection features would have to be relatively shallow, either a full to partial seal of the cap or numerous low capacity collection points and associated conveyance piping would be needed.

Economics of a 2010 proposal to the state's renewable energy fund by SWS to heat the Anchorage Fire Training Center on Airport Heights Drive were challenged by the costs of expanding the existing landfill gas collection system; the gas processing, compression, and transmission system; and modifications to the facility heating system. Similarly, feasibility of a smaller project aimed at heating buildings on the northern edge of the airport using existing landfill gas wells is expected to be limited by relatively small heating loads versus the cost of building retrofits, distance from the existing blower/flare station, gas processing cost, and decreased gas availability over time.

Waste-to-Energy

Waste-to-energy (WTE) in its most basic form is an incineration technology in which municipal solid waste (MSW) is burned to make electricity and/or heat. There are numerous versions and nuances of this technology that we will not explore here, but there are over 2,500 WTE incineration plants around the world, mostly in Asia and Europe, with about 100 in North America.[47] WTE is considered a renewable energy resource with greenhouse gas emissions reductions compared to fossil fuel combustion such as natural gas, coal, or diesel fuel. Primary benefits of WTE, depending on the exact conversion technology, are reduction in the solid waste volume, i.e., reduced input to a landfill, and increased potential for recycling, along with the actual energy production.

In Anchorage, as discussed above, most or all of the solid waste stream is currently committed to the ARL and is producing landfill gas that is captured and burned to provide power to JBER. An alternative project has been proposed by Chugach to divert some or all of the waste for combustion in a WTE facility, specifically a 20 MW baseload unit that is estimated to cost $180 million and require five years from siting to permitting to system design and construction.[48] Chugach's location on Electron Drive near the Ted Stevens International Airport, where they have an additional 16 acres of industrial property, could be the disposal point for MSW and reduce much of the hauling from the current transfer station out to the ARL. A waste stream analysis of volume and energy content of Anchorage MSW was conducted to support Chugach's analysis of fuel availability and project sizing, which identified over 400,000 tons of MSW in the Anchorage area available for WTE after diverting construction and demolition wastes.[49]

SWS alternatively estimates that MSW flow to the Anchorage Regional Landfill has been approximately 300,000 tons per year during the last ten years and that combustible organics comprise around 60% of the waste stream.[50] Additional MSW for a WTE facility might be available from the Mat-Su Valley. Assuming 300,000 tons per year of MSW and 500-600 kWh per ton of MSW combusted, an Anchorage WTE plant would yield approximately 165 GWh per year—around 5% of Anchorage's electrical generation—an average output of 19 MW. A WTE plant would also yield substantial amounts of heat.

Despite the LFGTE project's success, the ARL may reach capacity in 35 years.[51] Given limited land suitable for a new or expanded landfill in the Municipality, waste reduction alternatives such as WTE and aggressive recycling may be valuable to extend the life of the existing landfill. WTE project proponents and the MOA should continue to monitor advances in WTE technology and other waste management alternatives. While WTE is a longer-term alternative that should be considered in the context of a solid waste management plan, it may yield substantial energy, economic, and land use benefits and the MOA and other potential stakeholders could collaborate to further define and evaluate any future project. Because this is a longer term opportunity, we do not quantify these benefits in the Priority Table in the Conclusion section in the final chapter of this report.

Wood and Wood Waste

Through a contractor, the MOA operates wood lots in Anchorage, Eagle River, and Girdwood for the public to dispose of brush and woody debris from clearing associated with decreasing risk of wildfire impact on homes. The Anchorage woodlot charges a disposal fee but offers free mulch for pick up. Wood waste is hauled to the ARL for disposal.

SWS estimates that approximately 2,200 tons of wood waste was delivered and ground up into chips at the ARL in 2016.[52] Assuming this wood is partially dry (25%

47 http://www.nrel.gov/docs/fy13osti/52829.pdf
Waste Not, Want Not: Analyzing the Economic and Environmental Viability of Waste-to-Energy (WTE) Technology for Site-Specific Optimization of Renewable Energy Options, Kip Funk National Renewable Energy Laboratory, et al; http://www.renewableenergyworld.com/articles/2014/01/an-independent-engineering-evaluation-of-waste-to-energy-technologies.html
48 Paul Risse, Chugach, 9/14/16, pers. comm.

49 HDR; "Technical Memorandum – Anchorage Area Municipal Solid Waste Summary"; ftp://www.aidea.org/ReFund-7/1081%20Waste%20to%20Energy%20Reconnaissance%20Study/HDR%20Report%20on%20Anchorage%20Area%20MSW%202013.pdf
50 Mark Madden, Solid Waste Services, 12/28/17, pers. comm.
51 WTE Research and Technology Council, http://www.seas.columbia.edu/earth/wtert/faq.html
52 Ibid.

moisture content wet basis) and has an energy content of 8100 Btu per pound, energy content of the landfilled wood was 27 billion Btu—the equivalent of approximately 196,000 gallons of diesel.

Wood-fired heating of homes and commercial buildings is quite common in Alaska, especially in rural areas. Clean-burning, efficient units that are fueled by logs or chips are in operation throughout the state, chiefly in areas where the alternative heating fuel is oil.[53] Given the availability of natural gas in Anchorage, however, less incentive exists for expanded use of woody biomass for heating. Natural gas at the average 2015 residential price of $0.968 per CCF equates to fuel oil at $1.35 per gallon and firewood at $200 per cord. Given the additional costs and effort of wood handling and storage, it is difficult to make an economic case for retrofitting to biomass heating in most of the Municipality. Exceptions may be in more remote areas with limited natural gas availability, plentiful wood, and an incentive to dispose of wood waste.

RECOMMENDED NEXT STEPS

As indicated above, SWS has an active and effective program for pursuing energy and cost savings. They have identified priority projects and have begun taking steps toward implementation. We recommend that SWS move swiftly toward completing energy audits on its office, shop facilities at the ARL, and the Central Transfer Station.

The Central Transfer Station and office complex at East 56th Avenue, as a consumer of over $235,000 per year in natural gas and electricity, would appear to have potential as a candidate for a combined heat and power demonstration project, using a microturbine or other modular generation system. See Combined Heat and Power below for additional information.

The ARL leachate pipeline described above will be a capital-intensive project with significant permitting requirements, but has both an energy/cost savings and safety improvement component that merit full implementation. This project should proceed "full steam ahead."

SWS is flaring 300-600 cfm of landfill gas that exceeds demand of the LFGE project—a waste of a substantial renewable energy resource. The MOA should move forward aggressively with Doyon Utilities and JBER to quickly resolve the issues that are slowing expansion of the LFGE project. If Doyon and JBER are not able to utilize the energy from the excess landfill gas within a reasonable timeframe, the MOA should consider other beneficial uses for the energy resource, such as providing power to the Railbelt grid, supplying the ARL facilities' heat and power, and producing food (a reasonable opportunity given the site's good solar exposure, available space, and heat recovery potential).

53 http://www.akenergyauthority.org/Programs/AEEE/Biomass

STREETLIGHTS

CURRENT STATUS

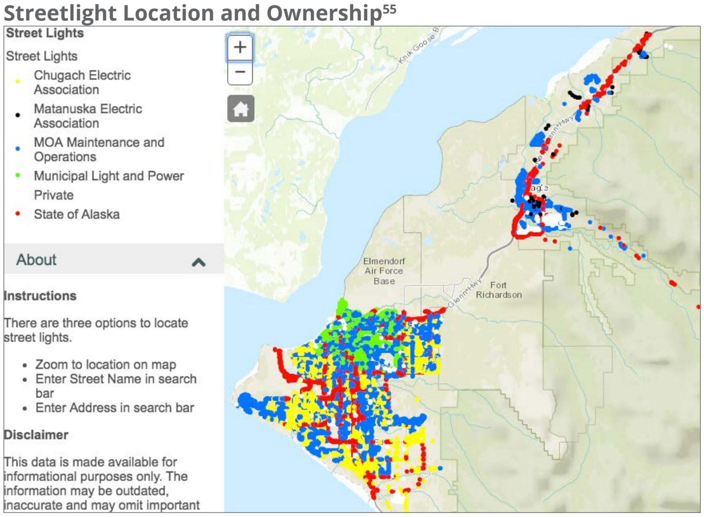
Anchorage has approximately 40,000 streetlights across the Municipality. Ownership and maintenance of these lights is divided among several entities, resulting in numerous challenges and complexities with regard to equipment standardization, monitoring, maintenance, and data collection. The following Table and Figure illustrate these challenges.

Table 8. Institutional Ownership and Maintenance of Selected Street Lights Within Anchorage[54]

Owner	Operation and Maintenance	Number of Lights (approx.)
MOA—Maintenance & Operations	MOA—Street Light Maintenance & Operations	9000
Chugach Electric Association	Chugach Electric Association	4,400
MOA—People Mover	MOA—Transit	300
MOA—Parks & Recreation	MOA—Facilities Maintenance	2300
MOA—ML&P	ML&P	3,300
Alaska DOT	MOA Street Maintenance - TORA	2,100
Alaska DOT	Alaska DOT	2,100
Matanuska Electric Association	Matanuska Electric Association	110
Approximate total		23,610

54 This is only a partial count. Omitted are street lights owned and/or operated by ASD, AWWU, Merrill Field, POA, JBER, and others.

Figure 25. Screen Shot of Interactive Map Showing Anchorage Streetlight Location and Ownership[55]



Recent technology improvements in LED lighting provide significant energy and cost savings, as well as a much longer life cycle, compared to conventional High Pressure Sodium (HPS) lights currently in use. Specifically, LED street lights consume about 50% of the electricity of HPS lights and last about three times longer – up to about 100,000 hours, which translates into about a 15 year lifecycle for economic calculations. Because of the much longer life of LED streetlights and labor costs associated with changing out lights that are no longer operational, overall life cycle cost savings are not fully captured when just calculating the energy savings; in fact, when speaking with MOA staff and others, the labor cost savings may be even higher than the energy cost savings,[56] adding further incentive for retrofitting that is not captured in the savings presented here.

Along with these benefits, a digital wireless control and communication system connected to each individual LED light can provide real-time information on the light's performance and status and allow for dimming or brightening as desired. Further, some cities, such as San Diego, are now leasing "vertical real estate" on light poles to provide wireless communication bandwidth to cell phone providers in downtown San Diego instead of installing separate towers. This is providing significant revenue to the City of San Diego.[57]

Approximately 4,000 streetlights in Anchorage have already been converted from conventional HPS to LED, though this was done several years ago when the technology was not as developed and the energy savings and control technology were less robust. Conventional HPS streetlights range from 150 Watts to 1,000 Watts, though based on preliminary data, it appears most HPS streetlights in Anchorage are between 150 – 400 Watts.

For purposes of this analysis, we will assume that half the HPS streetlights are 150 Watts and half are 400 Watts, and that of the 4,000 LED replacements, half were for 150 Watt HPS and half were for 400 Watt HPS streetlights. We also assume 12 hours of operation daily and electric costs of $0.15/kWh, since some of the lights are owned (and paid for) by the electric utilities themselves, and this is close to the currently published commercial rate.

Based on these assumptions, Table 9. Annual Electricity Consumption Estimate of All Streetlights in Anchorage illustrates the calculation that current energy consumption of streetlights in Anchorage is 45,771,000 MWh annually, costing a total of $6,865,650 each year. In reality, electric rates for streetlights vary and exact consumption is difficult to measure because individual lights are not generally metered.

Table 9. Annual Electricity Consumption Estimate of All Streetlights in Anchorage

Type of Light	Quantity	Hours of Operation Annually	Annual Energy Consumption (kWh)	Annual Energy Cost (@ $0.15/kWh)	Note
150 W HPS	18,000	4,380	11,826,000	$1,773,900	Assume half of 36,000 existing HPS
400 W HPS	18,000	4,380	31,536,000	$4,730,400	Assume half of 36,000 existing HPS
75 W LED	2000	4,380	657,000	$98,550	Assume half of 4,000 existing LED
200 W LED	2000	4,380	1,752,000	$262,800	Assume half of 4,000 existing LED
TOTAL	**40,000**	**4,380**	**45,771,000**	**$6,865,650**	**Total Electricity currently consumed by all streetlights in MOA**

55 http://muniorg.maps.arcgis.com/apps/SimpleViewer/index.html?appid=286aa9d6568f451f8e384d57bdc6f92b
56 Jim Jager, POA & ML&P, 11/10/16, pers. comm., and Al Czajkowski, M&O, 7/14/16, pers. comm.
57 Jim Jager, POA & ML&P, 11/10/16, pers. comm.

OPPORTUNITIES

To its credit, the MOA has embarked on an ambitious LED lighting retrofit program[58] that has begun by cataloging the location, institutional ownership and maintenance of each individual light as illustrated in Figure 25 and Table 8 above. Led by staff at the POA and ML&P, this effort aims to standardize the control system for all future LED replacements to take further advantage of pinpoint dimming and brightening capabilities and more accurate monitoring of energy consumption and performance.

Current estimates for a single LED replacement is $600, consisting of the following:

+ LED fixture: $275 each
+ Control node (one per fixture): $125 each
+ Labor to change out HPS to LED fixture with control node: $200 each

Using the same assumptions as above, Table 10. Annual Energy and Cost Savings of LED Streetlight Replacements below shows annual energy and cost savings estimates that would be realized from replacement of the remaining 36,000 HPS streetlights with LEDs.

Table 10. Annual Energy and Cost Savings of LED Streetlight Replacements

Type of Light	Quantity	Hours of Operation Annually	Annual Energy Consumption (kWh)	Annual Energy Cost (@ $0.15/ kWh)
75 W LED	18,000	4,380	5,913,000	886,950
200 W LED	18,000	4,380	15,768,000	2,365,200
TOTAL	**36,000**	**4,380**	**21,681,000**	**3,252,150**

The annual energy cost in the far right column in Table 8 above is the same number as the cost savings, since the original consumption would simply be cut in half by an LED luminaire that is twice as efficient as an HPS streetlight. In other words, **annual energy savings from retrofitting 36,000 HPS streetlights with LEDs would yield $3,252,150 in cost savings if electricity is priced at $0.15/kWh.**

58 https://www.adn.com/alaska-news/anchorage/2016/12/05/anchorage-slated-to-upgrade-streetlights-to-smart-grid-technology/

The total capital cost of purchasing and installing 36,000 LED lights and control nodes at $600 each is $21,600,000. To calculate a simple payback, this capital cost would be divided by the annual savings, which results in a 6.6 year simple payback. With a 15 year expected lifetime for LEDs, this is a significant benefit. It should be noted that this calculation is highly sensitive to electricity rates and does not include labor and O&M savings associated with a three time longer life of an LED fixture or additional energy savings that may result from programmatic adjustments with new controls such as dimming from 12 midnight to 6 am in the winter months.

RECOMMENDED NEXT STEPS

1. **Identify Financing Options** – A complete conversion to LEDs is estimated to cost $21.6 million. Though the cost savings are considerable and would offer about a six year payback, this will require a financing strategy that could be an ESCO, a financing vehicle coordinated and backed by the MOA, or disparate approaches pursued individually by the various streetlight owners.
2. **Coordinate for economies of scale and increased efficiency** – Additional cost savings can be achieved if the numerous streetlight owners and managers coordinate purchases, labor, and standardize equipment. This could be an obvious role for a MOA Energy Manager.
3. **Modify MASS and ADCM** – The Municipality of Anchorage Standards Specifications (MASS) and the Anchorage Design Criteria Manual (ADCM) currently do not call for LED streetlights as the standard default for new construction. Revising these two documents, along with addressing the issues associated with different lighting intensities (3000°K versus 4000°K) would result in lower lifecycle costs for new installations.

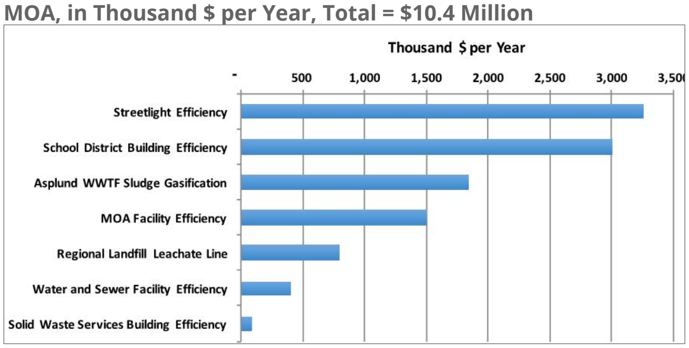
As stated above, the MOA is aggressively pursuing this opportunity and has made important progress. A Request For Proposals has recently been issued to begin establishing a standard control system for all street lights across the MOA, which is an essential first step in managing the entire lighting fleet, ultimately transitioning to all LEDs, and maximizing energy and cost savings while improving safety and quality of life in Anchorage.

CONCLUSIONS

The MOA has several energy savings opportunities identified and to varying degrees, in very early stages of deployment. This chapter catalogued and evaluated these various opportunities across the MOA for both energy and cost savings. **Strategic facility monitoring to establish building energy benchmarking will help to further prioritize the order and scale of upgrading buildings, systems, and controls.**

The chart below displays the results on a single scale to compare energy savings impact in dollars. In total, the projects amount to about $10.4 Million in savings annually.

Figure 26. Energy Savings Impacts Across the MOA, in Thousand $ per Year, Total = $10.4 Million



These projects will require financing and management to ultimately achieve the projected savings. Each individual Department is developing their own approach within the confines of MOA regulations and internal policies. Aggregating projects, especially around financing and technical evaluations, may improve economies of scale and reduce transaction costs.

A common issue that emerged in several interviews and across our research was the procurement challenge, specifically the time and effort required as a result of MOA internal procedures and regulations to purchase goods and services. While everyone was supportive of proper checks and balances to ensure fair and transparent purchasing decisions, it was noted that, for example, contracting services can take up to 18 months and equipment purchases can be overly complicated and constrained by the MASS and ADCM that may not reflect state-of-the-art technology improvements. This is a complicated issue faced by all large organizations with no simple solutions, and this impacts not just procurement for energy goods and services, but it should be noted that long lead times result in missed savings opportunities and additional costs that will make some projects uneconomic. A broad analysis of procurement policies and procedures could facilitate investment, reduce costs, and streamline project deployment and fall squarely within the job duties of an Energy Manager.

Based on the similarity of challenges and needs across numerous Departments within the MOA, **we recommend that the Municipality consider establishing an Energy Manager position, likely housed in the City Manager's Office**, who could address issues ranging from procurement and finance to building controls and energy analysis. This Energy Manager would serve all MOA Departments, with the understanding that some are further along and/or have more in-house capacity than others in achieving their energy goals. This analysis clearly demonstrates that a Muni-wide perspective is essential to coordinate and advance clean energy investment and project implementation. As mentioned above, many large institutions, from governments to corporations, have created similar positions, ranging from Energy Manager to Chief Sustainability Officer.

Job duties would potentially include the following:

1. Monitor energy use and cost in MOA facilities and track performance of efficiency upgrades.
2. Provide input and recommendations for capital improvement projects to reduce energy costs.
3. Manage or assist in managing efficiency upgrade projects for MOA facilities.
4. Serve as the MOA point of contact on Anchorage end use energy issues with state and federal agencies.
5. Organize and participate in an MOA energy committee with representatives from ML&P, ASD, AWWU, M&O, SWS, POA, and other Municipal Departments.
6. Provide regular reports on the effectiveness of the energy management program and prepare an annual report to the Assembly.
7. Lead the development of a commercial energy efficiency program for Anchorage businesses (see Chapter 4).
8. Identify and seek financing opportunities to implement EE&C projects and programs.

Recommended qualifications for the Energy Manager are a bachelor's degree in mechanical or electrical engineering, completion of certified energy manager (CEM) training, and data management and communication skills. The Fairbanks North Star Borough has recently created such a position and it has already begun benefitting the community. Appendix E contains both a job description/position announcement that was used to hire the FNSB Energy Manager and some preliminary analysis that has guided their efforts toward achieving energy savings in their jurisdiction.

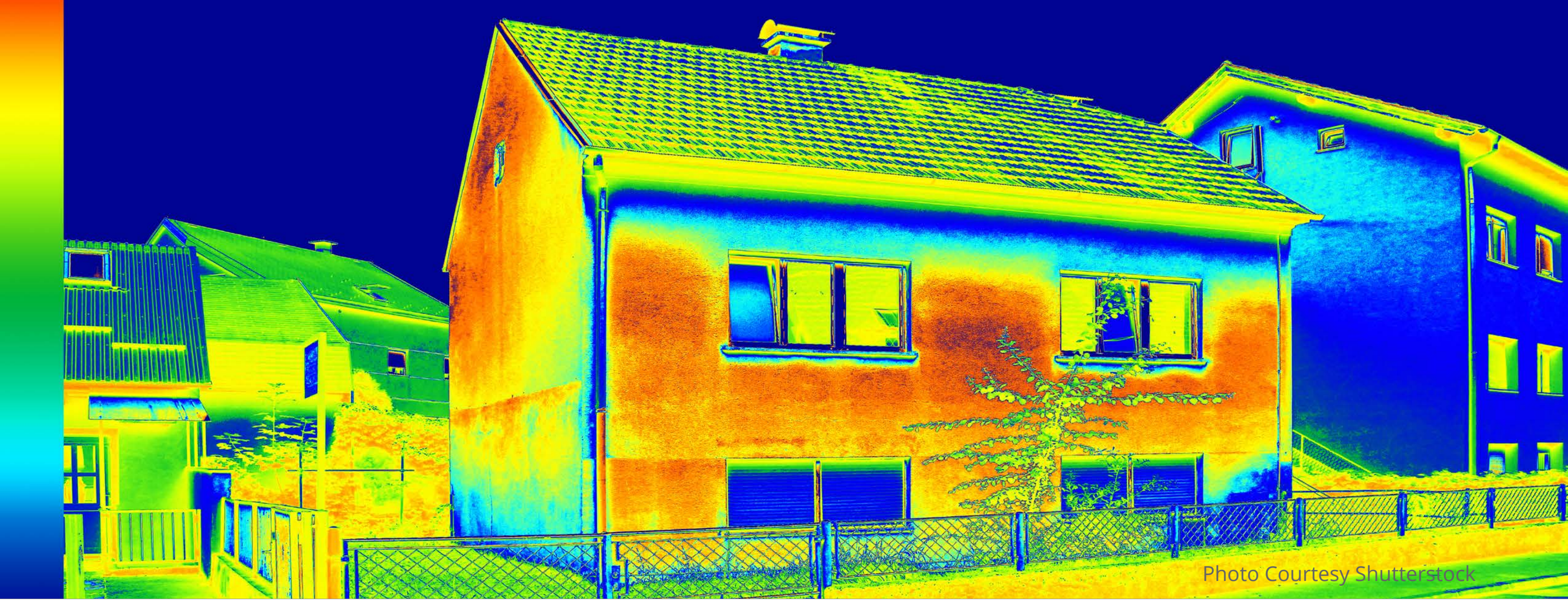


Photo Courtesy Shutterstock

CHAPTER 4 — ENERGY EFFICIENCY IN HOMES AND BUSINESSES

OVERVIEW

Energy efficiency and conservation (EE&C) measures are widely regarded as the easiest and most cost-effective way to reduce energy costs and greenhouse gas emissions. Benefits of energy efficiency and options for statewide EE&C policy are well established.[59] In addition to saving homeowners and businesses money, efficiency measures create jobs, enhance building stock, improve residents' health and comfort, and decrease air emissions from heat and power production. This chapter addresses programs and projects aimed at reducing the amount of energy that Anchorage consumers use to heat and power their homes and businesses.

The Alaska Energy Efficiency Partnership—a forum of over 30 government and private organizations—provides the one-stop website <akenergyefficiency.org> for accessing the substantial base of information, technical assistance, and programs that target EE&C in Alaska.

59 Davies, John and K. Dodge 2012. Energy Efficiency Policy Recommendations for Alaska, Cold Climate Housing Research Center. Prepared for Alaska Energy Authority.

PRIVATE COMMERCIAL FACILITIES

CURRENT STATUS

Private commercial and industrial facilities include offices, restaurants, hospitals, churches, hotels, stores, shopping malls, service stations, car washes, health clubs, banks, non-profit organizations, cinemas, air cargo facilities, hangars, warehouses, manufacturing facilities, and private schools and colleges. For the purposes of this report, efficiency opportunities for multi-family residences, such as multiplexes and apartment buildings, are quantified below under the Residential Energy Efficiency and Conservation section. However, the recommendations provided in the current section are appropriate to larger residential facilities.

Based on property tax appraisal data from the MOA Municipal Property Appraisal Division there were a total of 78.63 million square feet of private commercial and industrial facilities in April, 2016 (see Table 11). In 2015 Anchorage private commercial and industrial customers purchased an estimated 1,069.3 GWh of electricity from Chugach, ML&P, MEA, and Doyon Utilities at a cost of $171.1 million. Private commercial and industrial natural gas customers in 2015 purchased an estimated 4.1 BCF of natural gas at a cost of $32.5 million during the same period. See Appendix B for methods for estimating energy consumption.

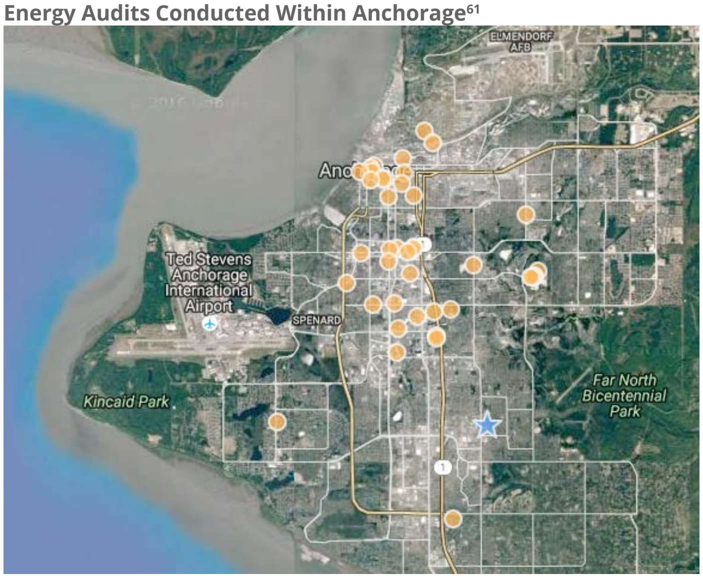
Table 11. Energy Use Intensity and Consumption by Building Type[60]

Building Type	Area (1000 sf)	Energy Use Intensity (kBtu/sf-yr)	Energy Consumption All Sources (Billion Btu/yr)
Food Services	1,291	329.3	425
Healthcare	5,065	145.6	737
Institutional	4,315	100.7	435
Lodging	7,233	113.7	822
Office	13,096	81.9	1,073
Other	3,784	96.7	366
Retail	17,319	102.7	1,779
Service	5,425	106.6	578
Warehouse	21,099	89.7	1,893
Total	**78,627**	**103.1***	**8,108**

*** This total displays *average* kBtu/sf-yr weighted by square footage.**

Alaska Energy Authority (AEA) is the lead state agency for private commercial and industrial EE&C and serves as the federally recognized State Energy Office. AEA's Commercial Building Energy Audit (CBEA) program is designed to reimburse up to the full cost of energy audits for private facilities. To date 42 audits have been performed in private commercial facilities (see Figure 27. Location Figure 27. Location of Commercial Building Energy Audits Conducted Within Anchorage) identifying annual savings of 29.9 billion Btu at $626,000. AEA is not currently accepting applications for the CBEA program.

Figure 27. Location of Commercial Building Energy Audits Conducted Within Anchorage[61]



60 WH Pacific 2012. Alaska End Use Study, fig 45; http://www.akenergyauthority.org/Content/Efficiency/EndUse/Documents/AlaskaEndUseStudy2012.pdf
61 http://www.akenergyefficiencymap.org

OPPORTUNITIES

Statewide, AEA estimates savings from EE&C measures in private commercial facilities of approximately 33% with simple paybacks of a little more than six years.[62] For the purpose of this report, similar to public commercial facilities, we conservatively estimate that cost-effective retrofits will result in electrical and natural gas savings of 20% and O&M savings of 5% for private commercial and industrial facilities. We further assume that all facilities in this sector have potential for such EE&C upgrades and that simple payback on investment is seven years. As an example, the Alaska Literacy Program, a non-profit organization, is upgrading its building envelope and lighting at their Russian Jack facility based on an energy audit supported by AEA's Commercial Building Energy Audit Program (see Figure 28. Alaska Literacy Program Staff and Students at ALP's Russian Jack Facility).

Figure 28. Alaska Literacy Program Staff and Students at ALP's Russian Jack Facility

Photo: Peter Crimp

Scaling up the energy cost savings projected from implementing EE&C measures on the available 42 audits to the full 78.63 million square feet of commercial building space yields an estimate of owners saving approximately 1,540 Billion Btu annually, which is the equivalent of $51 million per year in energy and O&M costs through investment of approximately $356 million—a return on investment of over 14%.

RECOMMENDED NEXT STEPS

The Municipality should place a high priority on policies and programs that help Anchorage businesses improve energy efficiency, save money, and boost competitiveness. Policy and programs should focus on removing barriers to private investment in efficiency measures, including:

+ Unawareness of the low-risk nature and financial benefits of efficiency measures

62 http://www.akenergyauthority.org/Efficiency/CommercialAudit

- + Lack of low cost access to technical resources for identifying and prioritizing beneficial measures
- + Limited time to focus on energy efficiency opportunities
- + Inability of businesses that rent their facilities to take direct steps to improve their energy systems
- + Lack of capital for energy audits and efficiency measures

Commercial Property Assessed Clean Energy (C-PACE) financing holds promise for addressing the need for up-front capital investment for energy improvements in commercial properties for energy efficiency, photovoltaic, and other options that prove feasible. Under a C-PACE program the MOA would offer financing for energy improvements, and property owners would repay the costs as a line item on their property tax bill. Although a property owner would see an increase on their tax bill, they would experience a greater savings on their energy bills. See the text box below for a more detailed explanation. Nationally, C-PACE financing for efficiency and renewables grew five-fold to $338 million between 2013 and 2016.[63] The Alaska Legislature came very close to passing enabling legislation for C-PACE in 2016, and prospects for passage are considered very good for 2017.

An MOA administered C-PACE program could facilitate solar energy adoption in addition to energy efficiency for commercial facilities.

We recommend that the MOA Energy Manager (see above) work with state energy office (AEA) EE&C officials and staff from other municipal departments, including the Mayor's office, to assess options for establishing a commercial energy efficiency program for Anchorage. Elements of the program and related policy should include:

1. **Education and outreach** activities that increase awareness of efficiency opportunities.
2. **Access to auditors**, engineers, construction specialists, and energy service companies with expertise in commercial facility energy retrofits.
3. **Incentives**, such as cost-share, for performing energy audits and preliminary assessment.
4. **Project financing**, e.g. C-PACE, conventional bank financing, and federal tax incentives.
5. **Continuity**—providing a system approach that helps businesses step from initial assessment to final efficiency upgrade as seamlessly as possible.
6. **Program budget**, staffing and sources of funding with an emphasis on eventual self-sufficiency.
7. **Coordination** with the Anchorage Chamber of Commerce, Anchorage Economic Development Council, Green Star, and other organizations with goals that align with cost reduction, business competitiveness, and energy efficiency.

Addressing the above recommendations, the potential barriers and solutions to realizing benefits under this opportunity may be divided between financial issues on one hand—which may be addressed with C-PACE legislation—and behavioral and policy issues on the other—which may be addressed through the Energy Manager and the MOA Assembly. A typical policy approach for governments to encourage private energy efficiency is to provide some sort of tax credit or other financial incentive to cover the initial energy audit of the private facility. In a previous fiscal environment when the State of Alaska had available funds, the State provided funding for such an audit. Under current fiscal conditions, we are not recommending that the state or MOA provide tax credits or other financial incentives to cover audits, but if there were available funds and political support to advance private commercial and residential energy efficiency/weatherization, such an incentive could be valuable and has shown benefit in other locations.

63 http://pacenation.us/pace-market-data/

COMMERCIAL PROPERTY ASSESSED CLEAN ENERGY AS A FINANCING TOOL

PROPERTY ASSESSED CLEAN ENERGY

What is PACE?

Property Assessed Clean Energy (PACE) is a local government mechanism intended to facilitate financing for energy efficiency upgrades and renewable energy projects at commercial properties. It is designed to address the challenges specific to efficiency and renewable projects by offering financing that requires no money down, allows longer loan terms, and fixed low interest rates.

A key differentiator of PACE financing is that the building is the collateral, not a person or particular business operation. A PACE loan assumes a senior obligation on an improved building and is repaid through a voluntary assessment added to the specific property tax bill. As a result, PACE financing does not require a personal guarantee or a high credit rating for the building owner or the business operating at the location. In addition to increased access to financing, this structure has other benefits for the building owner. For example, PACE repayments become an addition to the tax billing of a property allowing the costs of energy efficiency improvements and renewable projects to more easily pass through to the building occupants. This ability addresses a potential misalignment of interests whereby building owners pay for property improvements, but energy savings flow to the tenants in the form of lower monthly energy bills.

How does PACE work?

State legislatures enable local governments to establish PACE programs by ordinance to accomplish a specific goal or objective, such as incentivizing energy efficiency as a means of lowering business energy costs and consumption, promoting job creation and improving air quality. Once a local PACE program is created, the local government may issue revenue bonds, work with local lenders or access other funds to create a financing pool for PACE energy efficiency and renewable energy projects. Funds are then loaned to businesses for the energy efficiency retrofits and renewables projects that an energy audit has shown make economic sense for the specific building.

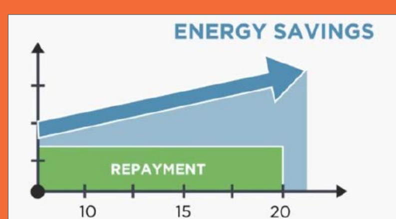
Once a local program is established and funds are available, PACE becomes a voluntary option for commercial property owners to use. An interested building owner must be current on property taxes and if applicable, current on their mortgage payments.

When is PACE a good fit?

PACE is an innovative approach to assist building owners in paying for the often high up-front cost of energy efficiency projects. PACE is available for enactment by local governments in states that have authorized the mechanism. Since PACE repayments attach to the tax bill for a specific commercial property, it will only be available in municipalities that levy a property tax.

PACE was partly conceived as an incentive for building owners who buy and sell commercial buildings frequently to make beneficial energy efficiency and conservation improvements. Since the energy efficiency or conservation improvements and equipment are funded by an assessment on the property itself, the repayment obligation transfers with the building and does not need to be unwound at the time of a property sale.

Many of the buildings that would benefit the most from improvements are owned by individuals that may not have the ability to finance efficiency and conservation projects through traditional methods. As a result, good buildings improve and stressed buildings become less efficient over time. PACE provides an opportunity for building owners with limited access to capital to secure financing they need to reduce the energy consumption and costs of their buildings.



Source: http://www.akleg.gov/basis/get_documents.asp?session=29&docid=52482 , provided by Gene Therriault, Alaska Industrial Development and Export Authority.

RESIDENTIAL ENERGY EFFICIENCY AND CONSERVATION

CURRENT STATUS

According to the latest housing assessment prepared by Cold Climate Housing Research Center for Alaska Housing Finance Corporation (AHFC),[64] there were a total of 112,804 housing units in the Municipality of Anchorage in 2013 with an average size of 1,888 square feet. Of the 105,123 homes that were occupied, 39% are rented while owners reside in the remaining 61%.

In 2015 Anchorage residential customers purchased an estimated 694.9 GWh of electricity from Chugach, ML&P, MEA, and Doyon Utilities at a cost of $117.5 million. Residential natural gas customers in 2015 purchased an estimated 14.3 BCF at a cost of $138.4 million during the same period. See Appendix B for methods and data sources.

AHFC is the lead state agency for residential EE&C in Alaska. Their residential programs include the following:

+ Weatherization Program. Homeowners and renters that meet certain income limits may apply to the weatherization service provider in their area. Service providers in Municipality of Anchorage are RuralCAP and Cook Inlet Housing Authority. Between 2011 and 2015 providers weatherized an average of 627 houses per year.[65,66] Since May 2008, 5,141 units in Anchorage have been weatherized.[67] Measures include caulking and sealing windows and doors, adding insulation to floors and ceilings, and increasing the efficiency of heating systems.
+ Home Energy Rebate (HER) Program. Begun in 2008, this program reimburses costs of an energy audit and up to $10,000 in pre-approved efficiency measures. Homeowners, including single-family houses and condo owners, are eligible. No income limits apply to the HER program. Currently AHFC is not accepting new applications for the HER program since the Alaska Legislature halted additional program funding in fiscal year 2017. Since 2008 the HER program has provided rebates on 14,581 homes in Anchorage averaging $6,960 each.[68]
+ Energy Rebate for New Construction. This program provided rebates of up to $10,000 for new construction that obtained a 5 star plus or 6 star energy rating using AHFC's AKWarm software. Similar to the HER program, legislative funding for the program has been halted and AHFC is not accepting new applications. Since 2008 the program has provided rebates on 600 homes in Anchorage.[69]

OPPORTUNITIES

Residential EE&C has a proven track record for achieving substantial energy and cost savings in Anchorage.

Results of the HER and Weatherization programs in Anchorage to date (Table 12) indicate heating energy reductions of approximately 35% and 20% respectively, and cost savings of 24% and 13%. For the purposes of this report we assume a conservatively low 20% heating energy and cost reduction for residential EE&C measures. Based on results of a 2012 study of HER impacts[70] we further assume a simple 8.5 year payback on heating efficiency upgrades. Given that the HER and Weatherization programs have already covered 19,722 out of the 105,123 homes in Anchorage, we assume there is potential for heating upgrades in 80% of the homes in Anchorage. (Given a level of "self-selection" by individuals whose homes are in greater need of efficiency upgrades, we recognize that this assumption may be overly liberal.)

Since the overwhelming majority of HER and Weatherization measures target heating systems, we address impact and cost of electrical EE&C measures separately. In 2015 Anchorage residential customers purchased approximately 6,878 kWh of electricity per customer. In 2012 the USDOE estimated Alaskan residential lighting electricity consumption at 1,670 kWh per year[71]—24% of Anchorage consumption per year. Compact fluorescent (CFL) bulbs use 75% less electricity than incandescent bulbs, while LEDs use 85% less electricity and last much longer. A 12-pack of 60 W incandescent-equivalent LEDs costs $50 at Costco. Based on relatively inexpensive lighting LED upgrades alone, we assume a conservatively low 10% decrease in electricity

64 Wiltse, N., Madden, D., Valentine, B., Stevens, V. 2014. 2013 Alaska Housing Assessment. Cold Climate Housing Research Center. Prepared for Alaska Housing Finance Corporation.
65 Kent Banks, RurALCAP, 8/26/16, pers. comm.
66 Stuart Brooks, Cook Inlet Housing Authority, 8/16/16, pers. comm.
67 Jimmy Ord, AHFC, 8/16/16, pers. comm.
68 Jimmy Ord, AHFC, 8/16/16, pers. comm.
69 Jimmy Ord, AHFC, 8/16/16, pers. comm.
70 Goldsmith, S., S. Pathan and N. Wiltse 2012. Snapshot: the home energy rebate program, UAA Institute of Social and Economic Research and Cold Climate Housing Research Center.
71 http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf

consumption with a payback on investment of 2.5 years for all Anchorage homes.

Table 12. Scale and Impact of Home Energy Rebate and Weatherization Programs[72]

		Energy per Home (million Btu)			Cost per Home ($)		
Home Energy Rebate Program	**Homes Studied**	**Before Retrofit**	**Savings**	**Percent Savings**	**Before Retrofit**	**Savings**	**Percent Savings**
Single Family and Mobile Homes	8,274	334.1	116.7	35%	$4,283	$1,033	24%
Multi-family Whole Buildings	261	400.9	133.3	33%	$5,459	$1,166	21%
Multi-Family One Unit	1,031	226.4	76.9	34%	$3,114	$690	22%
Average Weighted by # Homes				35%			24%
Weatherization Program	**Homes Studied**	**Before Retrofit**	**Savings**	**Percent Savings**	**Before Retrofit**	**Savings**	**Percent Savings**
Single Family and Mobile Homes	518	246.8	54.2	22%	$3,209	$490	15%
Multi-family Whole Buildings	22	694.7	125.7	18%	$13,579	$1,984	15%
Multi-Family One Unit	344	147.4	25.5	17%	$2,206	$237	11%
Average Weighted by # Homes				20%			13%

Based on potential energy and cost savings impacts of moderate-to-aggressive residential energy efficiency measures as described above, homeowners would save approximately $33.9 million per year in energy costs through investment of approximately $217.4 million.

RECOMMENDED NEXT STEPS

While AHFC's Home Energy Rebate and Weatherization programs have demonstrated substantial success, continued state funding remains in question for the foreseeable future due to low oil prices. Thus an emphasis on removing barriers to private investment appears appropriate.

Unawareness of the attractive benefits versus costs of efficiency measures may remain an important barrier, despite information and outreach programs sponsored by AHFC, AEA, Chugach, MEA, and ML&P. Similar to the commercial sector, other barriers may include lack of access to low cost technical resources, poor alignment of incentives for efficiency between rental owners and tenants, and lack of capital for energy audits and efficiency measures.

Two program alternatives for financing residential energy efficiency improvements are growing in use across the United States—On-Bill Financing (OBF) and Residential PACE (R-PACE). Substantial information is available on OBF and R-PACE and how they are being applied in different locations.[73,74]

OBF. Like C-PACE, OBF piggybacks on a well-established business relationship—in this case the homeowner (or business) and the electric or gas utility. Here the utility or its financial partner pays the upfront costs of the efficiency upgrades, and the customer repays debt through his/her utility bill under terms that are geared to harvesting a net savings in monthly gas, electric or other utility bills. Major benefits of OBF are:

+ The customer begins saving immediately.
+ The utility is protected since it can interrupt service if the customer does not pay.
+ Financing can be associated with the home, so that the homeowner or renter can relocate without paying off the debt. In general, such transferability requires that a special tariff be established that is associated with the electric or gas meter.

Downsides of OBF include increased complexity and administrative requirements for the utility to administer the program. This could be an issue especially in Anchorage, which has three different electrical utilities (although just one gas utility).

72 Wiltse, N. 2016. Unpublished data from AHFC's Home Energy Rebate and Weatherization programs, CCHRC.

73 http://aceee.org/files/pdf/toolkit/OBF_toolkit.pdf

74 http://cesa.org/assets/Uploads/R-PACE-CT-Viability-Assessment.pdf

R-PACE. Similar to C-PACE, the MOA and partners could offer financing for energy improvements, and interested homeowners would repay the costs as a line item on their property tax bill. Also like C-PACE, state legislation would be required to establish the requirements of the program, and the MOA would need to tailor implementation of the program to its specific policy and administrative objectives. Jurisdictions around the country are increasingly looking to this financing mechanism to fund energy efficiency and clean energy production such as solar PV for both commercial and residential buildings.[75]

However, a barrier for implementation of R-PACE in other states has been the requirement of a senior lien position for the R-PACE debt that takes priority over all other debt—a requirement that presents significant concerns to the federal regulator of home mortgage guarantors Fannie Mae and Freddie Mac.

We recommend that the MOA Energy Manager or other staff:

+ Meet regularly with AHFC, AEA, and other partners to assess opportunities for enhancing existing programs geared to residential energy improvements (e.g. weatherization) and increased awareness of low-cost/no-cost residential efficiency measures.
+ In coordination with State partners, work toward achieving a better understanding of the financing and behavioral barriers for residential energy efficiency in Anchorage as a basis for program design.
+ In the longer term, consider options for building a residential efficiency financing program on the foundations of its existing municipal building, streetlight, and (recommended) private commercial energy efficiency programs.

75 http://www.baltimoresun.com/features/green/blog/bs-md-renewable-energy-financing-20161208-story.html


Photo Courtesy MOA

CHAPTER 5 - HEAT AND POWER PRODUCTION

UTILITY POWER POOLING

Many observers have noted that if the Railbelt were in the Lower 48, the customer base and overall size of the system would typically represent a single small rural electric cooperative, whereas in Alaska, the Railbelt is divided among six different utilities, each with a Board of Directors, a General Manager/CEO, and similarly skilled staff.[76,77] One consequence of this situation is loss of opportunity to capture economies of scale and duplication of services, resulting in above average energy costs even with an enviable mix of legacy/low cost hydropower.

Utility "power pooling" is a partial response to this fractured energy landscape and is both a simple concept and a complex undertaking. At the most basic level, the concept is to pool and coordinate different utilities' generation resources to achieve the least-cost power mix to meet all customers' demands. In practice, this requires complicated legal and financial agreements, instantaneous communication, hardware and software controls, ongoing planning across utility service territories, and ultimately regulatory approvals. In essence, the different utilities participating in power pooling, also called "centralized economic dispatch," act almost as a single utility on the generation side, while remaining distinct and separate with regard to power delivery and distribution within their individual service territories.

To ultimately achieve the lowest cost of power delivered to the end user, not only is economic dispatch from the generation side necessary, but coordinated transmission among dispersed generation assets is also required. While this is a broader, Railbelt-wide issue beyond the scope of this report, it touches on energy-related economic opportunities and is directly related to power pooling. These two issues—economic dispatch and creating a transmission-based system operator—are currently in front of the Regulatory Commission of Alaska, with numerous perspectives and diverse interests riding on the outcome. We will not delve into the details here but rather identify the broad contours and potential opportunities ahead.

Currently Chugach, ML&P, and MEA are working on establishing centralized economic dispatch through what they are calling a "tight power pool." Very broadly, this concept is based on all three utilities effectively merging their generation assets to meet their combined demand in the most economically efficient way, not simply meeting their own individual load with their own generation assets first. For example, there may be times when Chugach's load exceeds the capability of their most efficient generators (namely, SPP), and instead of firing up one of their older gas turbines at Beluga, they could purchase power from ML&P's newer and more efficient power

76 http://www.eenews.net/stories/1060021258
77 http://www.akenergyauthority.org/Content/Policy/RegionalPlanning/Documents/AlaskaRailbeltREGAStudy-MasterFinalReport091208.pdf

plant(s) and/or MEA's new units at the EGS. In general, Chugach's and ML&P's new gas turbines are the most efficient but don't follow fluctuating load as well, whereas MEA's new generators are each smaller and not quite as efficient overall but are better for following varying loads.

Figure 29. ML&P Sullivan 2 and 2A Complex

Photo: Courtesy MOA

The three utilities have been working diligently to establish a mutually agreeable framework and are expected to begin actual implementation of power pooling to achieve energy and cost savings in 2017. This is a significant accomplishment that can create further opportunities, for example, by reducing system regulation needs and costs associated with integrating large-scale variable renewable generation sources such as wind and solar energy.

Current projected economic benefits from this tight power pooling arrangement with the three utilities is estimated to save approximately $10-20 million and 1 billion cubic feet of natural gas annually from "economy energy sales" as compared to a base case of no coordinated generation.[78] Though some of this savings is being recognized by existing transactions, tight power pooling is a substantial cost savings and greenhouse gas reduction benefit that should ultimately result in lower retail power prices than without power pooling.

Figure 30. Inside MEA's Eklutna Generation Station

Photo: Courtesy MEA

While the above discussion and analysis is focused on the Anchorage area, this concept could be applied more broadly across the Railbelt to include both Fairbanks and the Kenai Peninsula. Preliminary estimates are that economic dispatch and power pooling would result in Anchorage utilities generating and selling approximately 200,000 MWh annually of economy energy to Golden Valley Electric Association in Fairbanks and less than 7,000 MWh annually of economy energy to Homer Electric on the Kenai Peninsula.[79] The financial and energy savings associated with these sales would be based on the differential efficiencies and costs of the displaced units relative to the more efficient units in Anchorage.

Along with generation of power, the transmission system also impacts the availability and ultimate cost of electricity to the end user. The Railbelt transmission system is currently a mix of ownership and responsibility distributed among the various electric utilities and the state of Alaska represented by the Alaska Energy Authority. Because of this complicated institutional arrangement, moving electrons across the transmission system is not always a straightforward process and can result in both physical constraints and additional administrative costs to power delivery, as well as financial and legal obstacles to incorporate new generation, especially from IPPs.[80]

Current efforts to modify the transmission system include consideration of both institutional arrangements and physical upgrades. This is arguably more of a Railbelt-

78 Jeff Warner, ML&P, 11/8/16, pers. comm., and Julie Estey, MEA, 11/3/16, pers. comm. It should be noted that some economy energy sales do occur presently, but "tight power pooling" would significantly expand this.

79 Jeff Warner, ML&P, 12/8/16, pers. comm.

80 Regulatory Commission of Alaska Order Opening Docket and Requesting Responses on Independent System Operator: http://rca.alaska.gov/RCAWeb/ViewFile.aspx?id=b9823de6-6324-4676-a663-d7b3a65a2f54

wide issue than just focused on Anchorage, and hence, broader than the primary scope of this report. However, Anchorage-based residents, businesses, and economic activity comprise the majority of the Railbelt and much of the costs or benefits from any changes to the Railbelt transmission system will accrue in Anchorage. Thus, we briefly address this issue below.

Though multiple concepts are under consideration for modifying the transmission system, the general commonality among the proposals are that a single entity would be charged with the overall responsibility and management of the physical transmission system and the administrative rules for managing and distributing costs and benefits among the various stakeholders. The composition and governance of this single entity are the details that distinguish the various concepts and specific proposals.[81]

Many electricity markets in the lower 48 are governed by a single system operator that is responsible for making and enforcing transparent rules for power system reliability, interconnection, and dispatch of power onto the transmission system. Such rules aim to provide guidelines and regulatory and financial certainty for both utilities and IPPs, which in turn inform future investment decisions and financial projections, thus encouraging innovation and a robust market. A single entity managing the transmission system could establish a "postage stamp" rate for wheeling power, which could facilitate additional transactions among distribution service territories.

For example, an entity seeking to build a new gas turbine or wind farm or solar PV project, with known and internally controllable construction costs, would determine project financial feasibility in large part on availability and access to the Railbelt market via the power transmission system, which is an external variable. A unitary transmission fee, i.e., a "postage stamp" rate, would provide additional certainty to the total cost of production and delivery. The rules established and enforced by the system operator would provide the basis for determining inter-connection requirements, costs, availability, dispatch, and access to Railbelt customers. Theoretically, this facilitates cost-effective development, since only projects with lower costs than the status quo and access to underserved markets would be built. The Railbelt utilities, with RCA involvement, are currently exploring the potential costs and benefits—with direct financial and broader system reliability implications—of various system operator configurations. Ultimately establishing a system operator, combined with centralized economic dispatch and power pooling, should ideally move the Railbelt utility grid toward lower cost operations, improved short and long term planning, and higher reliability, though a system operator will add some administrative costs to the Railbelt transmission grid.

NON-UTILITY POWER GENERATION AND AVOIDED COST

RCA regulations require that ML&P, Chugach, and MEA purchase power from certain non-utility power generators to encourage energy conservation, renewable energy, and other benefits under terms that serve the general public interest, namely, when such purchases are lower cost compared to utility self-generation.

Two categories of private power generation are differentiated with separate requirements[82]—***net metering*** for facilities with capacity less than 25 kW and ***cogeneration and small power production*** for "qualifying facilities"[83] (QFs) with capacity that is usually greater than 25 kW.

NET METERING

Net metering programs[84] allow utility customers to generate power with renewables (solar, wind, biomass, hydroelectric, geothermal, hydrokinetic, and ocean thermal) to satisfy their own demand and sell excess energy to the utility on a monthly basis. Customers receive a credit on their power bill for the electricity they sell to the utility based on the current "non-firm" power rate (Table 13. Standard net metering and small qualifying facility purchase prices for Anchorage electric utilities) posted quarterly. The non-firm rate represents the value of energy generated by variable, i.e., non-firm sources.

Generators and other equipment must be connected

81 Though many details differentiate the various proposals, the primary institutional arrangements under consideration are a "Unified System Operator" (USO, comprised of a combination of the Railbelt utilities), an "Independent System Operator" (ISO, comprised of a non-profit entity largely independent of the utilities), and a "Transmission Company" (Transco, which would own, develop, and manage transmission assets).

82 See Net Metering 3 AAC 50.900 – 949 and Cogeneration and Small Power Production 3 AAC 50.750 – 820.

83 "Qualifying facility" is a term defined in the Public Utility Regulatory Policies Act (PURPA) 18 C.F.R. 292.101(b)(l), revised April 1, 2015. See https://www.ferc.gov/industries/electric/gen-info/qual-fac/what-is.asp

84 https://www.chugachelectric.com/energy-efficiency/net-metering, http://www.mea.coop/member-services/net-metering/

to the customer's side of the meter and conform to the utility's published interconnection guidelines. The utility is not required to accept a new net metering customer if total capacity of all net metering customers' generation exceeds 1.5% of the electric utility's average retail demand.

Currently, however, net meter customer generation capacity is very low compared to demand. For example, Chugach's latest tariff filing indicates that 1.5% of calendar year 2015's average retail demand is 1,940 kW, while net meter customer capacity was only 121 kW. Still, net metering (mostly photovoltaic) capacity for Chugach customers is increasing rapidly—current capacity has risen to 175 kW.[85]

Table 13. Standard Net Metering and Small Qualifying Facility Purchase Prices for Anchorage Electric Utilities[86]

	Anchorage ML&P	Chugach Electric Association	Matanuska Electric Association
Maximum Facility Capacity (kW)	100	200	100
Purchase Price (¢/kWh)	4.981	3.74 - 4.00*	8.157

*** Varies by voltage delivered.**

COGENERATION AND SMALL POWER PRODUCTION FACILITIES

Qualifying facilities in Anchorage include Fire Island Wind (17.8 MW) and South Fork Hydro (1.5 MW) near Eagle River, and a number of smaller natural gas-fired plants.

RCA rules allow the utility to recover costs of 1) interconnection to the qualifying facility including switching, metering, transmission, and distribution and 2) integration—the need to modify the operation and configuration of the utility's existing system to incorporate the new generation and maintain power quality and other delivery standards. Integration becomes particularly important when the QF is a variable resource, such as wind energy. (See Fire Island Wind Expansion below.)

In addition to interconnection and integration costs, power purchase rates must also be based on the costs of energy and capacity that the utility avoids through connection with the QF, including:

+ Anticipated current and future avoided costs of energy. The utility must estimate these costs on a biennial basis (see Table 13. Standard net metering and small qualifying facility purchase prices for Anchorage electric utilities for current filings).
+ Availability of energy and capacity from the QF during periods of peak demand, including the utility's ability to dispatch the plant, its reliability, and other factors that influence its usefulness to the utility.
+ Potential for the QF to help defer additional utility capacity and reduce fossil fuels.
+ Impacts of the QF on reducing or increasing line loss (the loss of energy in power lines due to electrical resistance).

A utility is not obligated to purchase energy from a QF if the utility could self-generate or purchase energy elsewhere at a lower cost.

Because wind turbines and solar panels for example do not require fuel purchases or combustion, they are essentially all fixed costs and result in a much more predictable cost of generation per kWh over the life of the equipment. However, it is difficult to precisely predict (and impossible to control) when the wind will blow or the sun will shine, so different amounts of kWhs are produced at different times, and more controllable or "dispatchable" generation assets, such as hydropower or gas turbines, are required to make up the difference between total demand and production of wind or solar power at any moment in time. Such dispatchable sources provide "firm" capacity, while variable sources such as wind or solar provide "non-firm" capacity, which are much less valuable to a utility and hence, represent a lower avoided cost.

Further, locations that have different amounts of wind or sun will result in different overall production costs because the installed price (or "capital costs") for any particular system may be the same, but the total amount of energy produced will vary based on overall wind or solar availability at the different locations.

85 Nick Horras, Chugach Electric Association, 11/28/16, pers. comm.

86 Effective 1-Oct-2016 based on avoided costs calculated from the preceding quarter.

COMBINED HEAT AND POWER

CURRENT STATUS

Electricity can be made from several sources, but still the most common method is burning, or combusting, a fuel such as natural gas, coal, diesel fuel, or wood, and ultimately spinning a power generator. This process creates substantial heat that cannot all be used for electricity generation. Depending on the conversion efficiency and specific technology involved, some of this heat is at temperatures that are too low to produce electricity. This heat may be captured and productively used for other purposes such as space or water heating. Often this heat is called "waste" or "rejected" heat.

A system specifically designed to generate both electricity and heat for other purposes is called a combined heat and power (CHP) or cogeneration (cogen) system. Although it varies by the specific application, the overall utilization of energy in a CHP system is generally much more efficient than separate and stand-alone electricity generation and heating systems.[87]

Within Anchorage, because of the existing energy landscape described above, most buildings have two distinct energy bills that are paid to different utilities—one for electricity and one for natural gas (typically for heating, domestic hot water, and possibly cooking and industrial processes). Recent technology advances have created potential opportunities for CHP systems to cost effectively meet most electricity and heating needs from a single device installed on-site for relatively large individual or multiple facilities with resulting fuel consumption and possible cost reductions.

Of course, the economics of any particular project depend on the application, energy usage, proper sizing of the system and institutional policies, among other variables, but generally CHP systems are more cost effective when a facility has a large heating load and the system is sized to meet most or all of that heat demand and very low cost electricity generation is a side benefit. Usually not all the electricity needs are met, so supplemental electricity must still be purchased from the local utility.

87 A CHP device is generally less efficient at making electricity than a dedicated gas turbine generator, for example, but because much of the remaining heat is captured and used, instead of just being rejected out the smoke stack, the overall utilization of a given amount of primary energy is more efficient when the heating element is included.

OPPORTUNITIES

Commercial Facility CHP

Probably the best-known CHP success in Anchorage is H2Oasis Water Park,[88] which claims to have cut its overall energy bill in half by installing a CHP system on-site using natural gas from Enstar to generate electricity and heat its water for the recreational facility, as compared to purchasing electricity from Chugach and natural gas from Enstar for heating. This project was successful in part because of H2Oasis' significant need to continually heat their water.

Around Anchorage, the hospitals, large hotels, industrial facilities, the University of Alaska Anchorage and Alaska Pacific University campuses, and public high schools, especially the ones with swimming pools, also have large heating loads and may be good candidates for CHP systems. As an example, an established business in Anchorage is currently considering opening an industrial warehouse that will have a significant heating load associated with bottling liquids. A CHP equipment vendor claimed preliminary assessments of energy savings realized from the installation of 2 x 65 kW microturbines running all the time (8,760 hours annually) and producing 89,060 kWh/month and meeting the facility's heating needs for eight months per year, displacing electricity at current Anchorage commercial rates, including demand charges, would save this business about $340,000 in energy costs (heat and electricity) over ten years, with a payback of just under four years.[89] These vendor-provided numbers should be viewed cautiously as they are estimates based on numerous assumptions about everything from future energy prices to performance and operating practices of the equipment and end user, but they are instructive and many large industrial customers are installing CHP units around the world to meet varying needs and site-specific applications.

As mentioned above, with a CHP system that is properly sized to meet the heating loads of a given facility, it is likely that such a system will not meet all of the facility's electricity demands at all times, and there will still be a need to remain connected to the electric utility. Electric utilities are then being asked to provide backup power and fill in the electricity gaps—both very valuable and costly services—but are losing substantial kWh sales with little or no compensation.

88 https://www.adn.com/energy/article/using-microturbines-drastically-cut-energy-bill-popular-alaska-waterpark/2013/10/08/
89 Greg Porter, Arctic Energy Alaska, 12/8/16, pers. comm.

In other locations with a different energy landscape, such as California with large investor-owned utilities that provide both electricity and natural gas (such as Pacific Gas and Electric or San Diego Gas and Electric), the fuel and cost savings achieved in a CHP system does not differentially impact the natural gas versus the electric utility because they are the same entity. In Anchorage, however, a large institutional customer installing a CHP system could result in substantial loss to the electric utility and a slight gain for the natural gas utility.

The different electric utilities serving Anchorage have different policies on how they address this issue of individual facilities/customers inter-connecting with the grid when these individual facilities are also generating some of their own power and intermittently relying on the grid. Different policies in different service territories among the Anchorage utilities have resulted in different economics and inconsistencies for individual projects, often making investment difficult. This is an ongoing issue in Anchorage that must take into account the interests of the electric utilities, the natural gas utility, CHP technology providers, and the end-user. The RCA has recently ruled on this issue, which will hopefully provide some resolution and the required certainty for investors and developers.[90]

Use Heat from Existing Power Plants

As mentioned in the above section, fossil fuel combustion such as natural gas creates some high temperature and high quality heat that can be used for electricity production, but it also results in some additional, lower quality heat that is not suitable for electricity production but could be used for other purposes. This excess heat is limited in temperature and distance that it can be transported; typical applications of excess heat are space heating for a nearby building or water heating. Increasingly, people are also looking at piping excess heat into indoor food or other growing operations.

Within Anchorage, for example, taking excess heat from the SPP located at Chugach's headquarters on Electron Drive and piping it about a half mile to "The Dome," the indoor sports and recreational facility on Changepoint Drive, was evaluated but deemed too expensive. However, the new ML&P Sullivan 2A power plant, slated for commissioning by the end of 2016, is designed to use excess heat for water heating and distributing to AWWU's customers. This is expected to save about $1.9 million annually, primarily from reduced domestic water heating needs as incoming potable water will be elevated in temperature, but also from reduced pipe freezing in the AWWU distribution lines.[91] Additional electricity generation efficiencies at Sullivan 2A will be achieved by pre-cooling the air for the gas turbine intakes with available cold water, which, combined with the heat recovery efforts, will result in an overall energy utilization of almost 70%. As a result of these unique circumstances and engineering designs, Sullivan 2A will be one of the most energy efficient plants in the world.[92]

The LFGTE project at the Anchorage Regional Landfill, discussed above, is another potential source of excess heat beyond electricity generation that could be captured and used for other purposes such as on-site greenhouses.

Another large potential source of excess heat associated with electricity generation that has been identified but not yet utilized is the rejected heat from MEA's new Eklutna Generation Station. The 171 MW facility consists of ten 17.1 MW Wartsila engines with no heat recovery currently installed. Eklutna, Inc., the Alaska Native Village Corporation with land holdings in the area, has explored the potential to capture the heat for additional electricity generation and/or other purposes such as food growing. By agreement with MEA, Eklutna, Inc. has the right of first refusal for any project that is proposed with the excess heat.[93]

FIRE ISLAND WIND EXPANSION

CURRENT STATUS

Anchorage is home to the largest IPP wind farm in Alaska, the Fire Island Wind Project (FIWP). Developed by Cook Inlet Region, Inc. (CIRI), an Alaska Native Regional Corporation based in Anchorage, the FIWP is comprised of 11 General Electric XLE 1.62 MW wind turbine generators, installed on Fire Island about three miles off-shore from Anchorage in Cook Inlet. With a nameplate capacity of 17.8 MW, which can power about 7,000 homes, the wind energy output is purchased by Chugach Electric Association, and delivered via underwater cable from Fire Island to a Chugach sub-station on the mainland. Commissioned in 2012, FIWP is a 25 year power purchase agreement at roughly $97/MWH (or 9.7¢/kWh) for the life of the project. Wind generated electricity from the project is estimated to displace about 500 million cubic feet of natural gas consumption and associated greenhouse gas

90 For additional information, see RCA docket number U-15-097

91 This savings is not included in any of our calculations in this report.

92 https://www.mlandp.com/redesign/about_mlp.htm

93 Julie Estey, MEA, 1/20/17, pers. comm.

emissions each year.[94]

Figure 31. Aerial View of Fire Island Wind Farm

Photo: Courtesy CIRI

Because wind is a variable resource that cannot be fully controlled, the rest of the power grid must continually adjust when absorbing and distributing the wind-generated electricity. Broadly, this adjustment process is called "integration" or "regulation" and depending on how much and how quickly the wind output changes relative to the rest of the grid—and what other power generation units are operating and overall demand at any moment in time—there is a variable cost associated with this integration. There are numerous strategies and approaches to optimally perform these integration services, but in general, it is assumed that some combination of a natural gas turbine, a battery/flywheel (soon to be installed by Chugach), and/or quick response hydropower is used to maintain grid stability and adjust as the wind varies. Another approach, though not ideal, is to curtail some amount of the wind output such that it does not vary. Currently, Chugach assigns a cost of 1.1¢/kWh for integration of Fire Island wind power into the grid.

OPPORTUNITIES

CIRI hopes to develop a second phase of Fire Island Wind that would result in about $50 million in construction-related spending over 2017 and contribute another 20.35 MW (11 turbines at 1.85 MW each) of nameplate wind capacity to the Railbelt grid. CIRI is offering another 25 year power purchase agreement at $56/MWH (or 5.6¢/kWh). This lower cost of power in Phase 2 ($56/MWH compared to $97/MWH in Phase 1) is possible because some of the costs related to electrical switchyard, grid interconnection, maintenance building, road, runway and the underwater transmission cable have already been incurred in Phase 1. This reduced power price also reflects a federal tax credit that is available if the Phase 2 project is commissioned by December 31, 2018 and has a material impact on achieving the lower price of power. If the project cannot be brought on-line by the end of 2018 and the tax credit is no longer available, the overall production price increases by about 55% or roughly an additional $30/MWh compared to the currently offered pricing.

Though fluctuating wind energy will cause the rest of the grid to respond to maintain stability, since the wind output is a small percentage of the overall power production, the need (and associated cost) for integration or regulation is also small. As the Anchorage-based utilities move toward power pooling as discussed above, any output from FIWP will be injected into a larger overall power resource pool, which should theoretically lower the cost of integration. Additional wind energy, such as that proposed by FIWP Phase 2, will increase the amount of variable wind that requires integration but the larger power pool should be able to regulate Phase 2 economically.

Figure 32. Fire Island Wind Turbines

Photo: Courtesy CIRI

Another perspective on wind energy is through the lens of avoided cost, as discussed above. Specifically, from an electric utility standpoint, the primary economic value of wind energy results from burning less fuel and avoiding greenhouse gas emissions, which is a variable cost. Fixed costs, such as paying staff or maintaining poles and wires and repaying bonds issued to build power plants, still remain. Thus, a utility's avoided cost from not burning fuel and marginally reduced maintenance, balanced with any other associated variable costs like credits for avoided emissions, must be weighed against the value of wind-generated electricity to determine if the wind power is cost effective.

94 http://fireislandwind.com/

RECOMMENDED NEXT STEPS

The currently offered sale price of 5.6¢/kWh for a 25 year PPA on 20.35 MW of wind for FIWP Phase 2 is dependent on a federal tax credit that requires construction to be complete by the end of 2018, or the credit is reduced. Without the tax credit, the price of power will escalate to approximately 8.5¢ to $9.0¢/kWh. Over the 25 year life of the Phase 2 project, fully capturing the available tax incentives by constructing the project now, will result in savings of about $39.5 million.

Utility power pooling should provide a number of material benefits to the Anchorage-serving utilities, including reductions in the overall cost of integrating variable wind power and better use of Bradley Lake hydropower. However, the full benefits of power pooling and resulting integration costs must be modeled for any utility to make an informed decision about purchasing FIWP Phase 2. This work is ongoing among the three Anchorage utilities. It should be noted as well that non-Anchorage utilities are potentially interested in purchasing FIWP Phase 2, and the proposed power pooling benefits to wind integration costs would still apply. Power Pooling benefits and transmission costs across the Railbelt need to be quickly and clearly determined so IPPs and utilities can make informed decisions about future developments and investments. Fuel diversification and very low technology risk are additional benefits that may not be fully captured in the production price of FIWP.

PHOTOVOLTAIC ENERGY

CURRENT STATUS

Light from the sun can be collected and converted directly into electricity through solar photovoltaic (PV) panels. This is a rapidly growing source of clean and renewable energy globally, and has made some inroads in Alaska. Literally spawned from rocket science and originally very expensive, the technology continues to improve and costs continue to drop.[95] With no moving parts, 25 year warranties on the solar panels, and federal tax credits ranging from 30% to almost 50% of the total installed cost now available for most solar PV systems depending on the circumstances, solar is the fastest growing new energy source in the US and supports over 200,000 jobs—more jobs than coal mining nationally.[96] In 2016, total employment in the solar industry grew another 14% nationally, to almost 240,000 workers.

The primary limitation of solar power, aside from the cost, is that the sun does not always shine and hence PV panels do not always produce electricity. Comparing Phoenix, Arizona, to Anchorage, Alaska, for example, on an annual basis the same solar panel will produce over twice as much electricity in Phoenix than in Anchorage. This comparison is over-simplified and does not reflect the seasonal differences in the two locations or specific opportunities that may be present, but provides broad perspective on the resource. That said, there are substantial and growing solar power development opportunities in Anchorage and across Alaska.

Cook Inlet Housing Authority (CIHA) has had notable success with both solar PV and solar thermal (using the sun to provide heat instead of electricity) along with ground source heat pumps. As a regional non-profit entity providing housing for low and moderate income residents, CIHA has access to federal funding that can be leveraged to lower life cycle energy costs and improve affordability for residents. Their Grass Creek North Complex, for example, in east Anchorage off Muldoon and DeBarr, has both solar PV and solar thermal and is lowering both electricity and natural gas costs for all residents.

Figure 33. CIHA Grass Creek North Housing Complex - Solar PV & Thermal

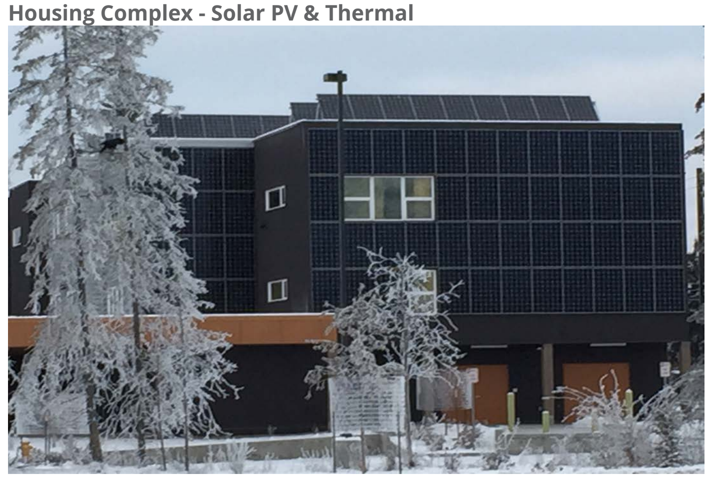


Photo: Brian Hirsch

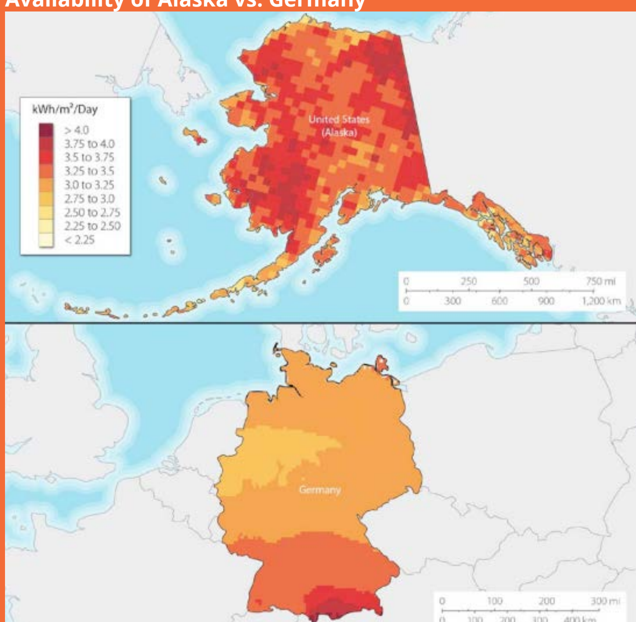
95 Some of the early solar PV panels were used by the National Aeronautic and Space Agency, NASA, to power instruments on satellites in space. https://www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf

96 http://www.thesolarfoundation.org/national/

SIDEBAR

Alaska in general has a similar solar resource to Germany, and Germany is a world leader in solar development and solar energy production. Germany's leadership is clearly not because of the outstanding solar resource in the country, but rather because of a national commitment and policies that have promoted and supported solar power, even at increased costs relative to other options. We are not proposing here that Alaska should adopt policies that support solar power at the expense of lower cost options, but simply that policy matters, and decisions and commitments are sometimes made—even at the national level of a major economy such as Germany—based not just on lowest first cost, but also on other factors that may more fully include a community's values or a broader accounting of costs and benefits. Fuel diversification is another consideration that may not be easily measured but adds value to an overall energy portfolio.

Figure 34. Annual Solar Resource Availability of Alaska vs. Germany[97]



97 http://www.nrel.gov/docs/fy16osti/65834.pdf

OPPORTUNITIES

There are many approaches and business models currently in use to develop and finance new solar projects, often designed in large part to take maximum advantage of the existing federal (and in some other Outside locations, state and local) tax credits. Very broadly, some of the existing approaches that have applicability in Anchorage include:

1. Residential "Rooftop"
2. Commercial "behind the meter"
3. Utility-scale owned and operated
4. Independent Power Producer
5. Community solar

Residential "Rooftop"- In this case, an individual homeowner would have a solar PV system installed on his/her roof. Typically, the system would be sized such that most or all of the power is directly consumed "behind the meter," i.e., there is usually not excess to be sold back to the grid, but under some circumstances, such as the height of summer in Alaska when the sun is producing full power and the homeowner is away on vacation, there may be excess power that is sold back to the utility. A typical residential size system might be 2-5 kW. RCA regulations require the utility to purchase excess power (see Net Metering above). The homeowner is eligible for a 30% federal tax credit against the installation cost of the system if the homeowner purchases the system up-front. Or a solar project developer may purchase and install the system and then the homeowner simply pays a monthly fee, similar to their power bill, over the life of the PV system and avoids the large initial cost. Currently in Anchorage, at least one solar project developer is offering residential consumers a guaranteed price of 9¢/kWh for 30 years for solar power produced on the house's rooftop. On one house in midtown Anchorage that this developer has modeled, for example, a 2.85 kW solar PV system is projected to cover about 81% of the house's annual energy consumption,[98] though of course most of the solar power is produced in the summer and utility grid power is consumed in the winter. For individual homeowners with good solar access who plan on staying in their houses for at least five years, this appears to be an opportunity worthy of further consideration and could be an excellent match with On-Bill Financing discussed above.

Commercial "Behind the Meter" – This is very similar to the above residential rooftop approach but on a larger scale for larger buildings. Because of the larger size system, the dollar-per-watt installed cost is lower, and this same developer is offering a guaranteed price of 5.4¢/kWh for 30 years for solar power produced on a commercial building.[99] Like the residential system, this would be installed behind the utility's meter so the building will first consume what is generated from the solar PV panels, and any excess will be routed through the meter and sold back to the utility under the existing

98 Stephen Trimble, Arctic Solar Ventures, 12/12/16, pers. comm.
99 Stephen Trimble, Arctic Solar Ventures, 12/12/16, pers. comm.

net metering requirements up to 25 kW. C-PACE financing may be a good match for this type of project. Federal tax credits would also apply as above, however, additional credits for accelerated depreciation of the equipment may be available for commercial entities, though these credits require a longer period of time to monetize, not just in the first year of operation. For local businesses with a federal tax appetite, especially those with larger summertime electric demand such as tourist-related businesses, this opportunity also appears worthy of further consideration.

Independent Power Producer – If an independent PV system is greater than 25 kW and wants to connect to the grid, the utility does not have to purchase the power at retail rates, but instead, can negotiate a price based on its avoided cost and the commercial facility would be treated like an Independent Power Producer. Similar to a wind energy system, the larger the PV system is, the more variable the output becomes relative to the overall grid production, and grid integration may become more challenging and costly. Large IPP solar systems feeding the grid in places like Hawaii are now requiring substantial integration measures, though this appears to be a challenge far-off into the future, if ever, for the Alaska Railbelt.

Potential benefits include substantial tax credits (both up-front through the Investment Tax Credit and over the first five to seven years of the project through accelerated depreciation), clean and low cost power (especially for larger systems with lower unit costs), and outside investment that the utility does not have to incur upfront. In some other Outside locations with a better solar resource, IPP-generated solar power is cost-competitive with new utility generation when tax credits are fully leveraged, but within Anchorage and the overall Railbelt, this is a very challenging economic hurdle to overcome without additional incentives or consideration of externalities such as fuel diversification and carbon emissions. One situation in which this may be a viable approach is for solar PV systems installed on MOA-owned parking garages to advance the MOA's clean energy and fuel diversification goals. An IPP would be required to take advantage of the tax credits and pass some of the savings along to the MOA.

Utility-scale owned and operated – Like any other power plant, a utility-scale owned and operated solar PV project would have the advantage of being controlled by the utility so integration costs are minimized and costs and benefits are most equitably distributed across the entire system and range of ratepayers. Within the Anchorage utility context, however, none of the three electric utilities are for-profit tax paying entities, so none of them can directly take advantage of the federal tax credits. A third party developer/investor would be required, which is commonly done in the Lower 48 under various arrangements such as a lease-buyback or ownership flip model designed to share the benefits of the federal tax credits with non-taxpaying entities. Local utilities estimate solar PV costs at about $3.50/Watt installed, which, given Anchorage's solar resource, yields energy costs above current marginal avoided cost. Hence, there is very little interest in pursuing this model without additional incentives or exclusive of other considerations.

Community solar – This is a hybrid approach that may have appeal for both Anchorage electricity consumers and the utilities. The broad concept is that individuals may want to contribute to and purchase power from a solar project, but may not be able to directly install a system on their house for various reasons such as they do not own their home, do not have sufficient capital or credit to make the upfront investment, or perhaps they do own their home but it is shaded and would not produce much power. A community solar project is a vehicle for many people to pool financial resources and build a single, larger project that results in better economics because of proper siting, economies of scale, staffing for maintenance, etc. It could be sponsored and operated by the electric utility to take advantages of the utility-scale approach described above, but it would be paid for and only serve individuals who choose to purchase the designated solar power. This would not negatively affect the utility's bottom line but would require separate accounting to keep track of the costs and power distribution, which the utility would manage. There are also other ownership and non-utility sponsorship models for community solar projects that will not be described here. But in general community solar could be the most energy and cost efficient way to facilitate such large-scale solar development in the near term and leverage the utilities' expertise and other generation assets.[100]

The image below shows results from a hypothetical 1 MW solar PV array installation using the on-line calculator "PV Watts," designed by NREL.[101] Assumptions included:

+ $3.50/Watt installed capital costs
+ Standard PV modules (not thin film or premium)
+ 14% system losses

100 http://www.nrel.gov/docs/fy11osti/49930.pdf ; https://www.greentechmedia.com/articles/read/new-analysis-shows-national-potential-for-solar-power-in-low-income-communi?utm_source=Solar&utm_medium=Newsletter&utm_campaign=GTMSolar

101 http://pvwatts.nrel.gov/pvwatts.php

+ 20 degree tilt
+ 80 degree azimuth
+ Offsetting $0.17/kWh electricity purchased from the utility

Based on the assumptions above and results below, the annual energy production value of $146,811 yields a 23.8 year payback—not an economic investment. However, these results do not include numerous cost-cutting and efficiency improvements that could significantly impact the project economics, including use of the federal Investment Tax Credit, which would result in a 16.7 year payback; significantly improved system performance in early spring due to light reflectance off the snow and cold temperatures (about 15% in March and April); and possible lower installed costs per watt (possibly under $3/watt for larger systems). As electricity prices from natural gas continue to escalate and solar prices continue to drop, the payback will shorten, but currently the economics are marginal for this project.

Figure 35. Screen Capture of NREL's PV Watts Results for 1 MW Solar PV Array in Anchorage

RESULTS

Print Results

863,596 kWh per Year *

System output may range from 809,448 to 893,735kWh per year near this location.
Click HERE for more information.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Energy Value ($)
January	0.52	14,213	2,416
February	1.49	36,705	6,240
March	2.96	79,736	13,555
April	4.10	104,510	17,767
May	5.27	134,706	22,900
June	5.45	130,855	22,245
July	5.09	125,264	21,295
August	3.91	97,139	16,514
September	2.92	71,900	12,223
October	1.44	37,814	6,428
November	0.84	21,699	3,689
December	0.35	9,054	1,539
Annual	2.86	863,595	$ 146,811

RECOMMENDED NEXT STEPS

"Soft costs" for solar PV projects are the non-hardware expenses for a project, such as permitting, inspection, interconnection, and labor. Soft costs typically comprise over 50% of a total PV system[102] and range widely across locations. Nationally there is a major focus on reducing the soft costs, and some localities have been quite successful with targeted reductions through streamlined permitting and utility interconnection procedures, for example. Emulating such practices in Anchorage could reduce the soft costs and hence, total system costs for new PV installations.

HEAT PUMPS

CURRENT STATUS

Based on the same mechanical principles as a household refrigerator, but run in reverse, heat pumps extract and concentrate heat from one location and move it to another. Because heat pumps do not actually generate heat but concentrate and move existing heat, they have the potential to produce more heat per unit of electricity input than if the electricity was used directly to generate heat in a standard resistance heater.

The "Coefficient of Performance" (COP) of a heat pump is the amount of heat output compared with electricity input, and can be much higher than 1. In other words, a COP of 2 means that one Btu of electricity input to a heat pump results in 2 Btus of heat output. Depending on the amount of heat in the source for the heat pump—which can be air, water, or the ground—heat pumps can have a COP of 3 or even higher.

Different types of heat pumps have different characteristics and performance features. For example, an air source heat pump (ASHP) is generally the least costly and easiest to install (about $3,500 for a typical residential application), but its performance is more subject to varying air temperatures because the COP of a heat pump varies based on the source temperature. Hence, an

102 http://www.rmi.org/Knowledge-Center/Library/2013-16_SimpleBoSRpt

In simple terms, ASHPs are most effective in replacing direct combustion of fossil fuels for heat when

- Electricity is clean (ideally hydro), plentiful, and low cost
- Heating fuel is expensive
- There is both a heating and cooling season with relatively mild temperatures

Juneau, Alaska, for example, has abundant and relatively low cost hydropower, no access to natural gas so diesel-based heating fuel is expensive and the primary fuel source available, and relatively mild winter temperatures. Hence, it is no surprise that heat pumps are becoming popular in Juneau and other parts of southeast Alaska with similar dynamics.[104]

As the technology continues to improve and drop in cost, heat pumps are becoming more common, however, the specific energy landscape within Anchorage presents unique challenges to widespread deployment. In particular, because Anchorage has relatively low cost natural gas available for heating residences and businesses, and because electricity is relatively expensive, combined with the (historically) limited need for cooling in the summer, ASHPs are not generally recommended as an economically and environmentally effective option for Anchorage at this time. Further, ASHPs are not well-matched with Anchorage's overall load profile: cold winter temperatures result in peak electric and natural gas demand, and ASHPs lose efficiency as the temperature drops, so more energy would be required, exacerbating the peak demand on the total gas and electric delivery system.

Though the discussion here focuses exclusively on using heat pumps for heating in the winter, as average temperatures increase with climate change, overall winter seasonal efficiencies will improve, while the core technology has also shown efficiency gains, both of which will further reduce costs. As well, as summer temperatures rise in Anchorage, heat pumps could be used for cooling in the summer, which would avoid the cost of purchasing a new air conditioner and improve the overall economics substantially. Finally, it should be noted that we did not consider incentive pricing, such as is discussed for electric vehicles below. Such pricing is more straightforward to implement with electric vehicle charging stations, but would likely be necessary for heat pumps to be cost effective from an end-user perspective.

104 http://www.cchrc.org/sites/default/files/docs/ASHP_final_0.pdf

Photo Courtesy Shutterstock

CHAPTER 6 — TRANSPORTATION AND CROSS-SECTOR OPPORTUNITIES

ELECTRIC VEHICLES

Electric vehicles (EVs) are gaining in popularity across the US and globally. Currently EVs comprise 1.6% of all new light-duty vehicle sales in the US;[105] the US Department of Energy projects up to 6% of all new US auto sales will be plug-in vehicles (including EVs and plug-in hybrids) by 2025.[106] In Europe[107] and parts of Asia where gasoline is significantly more expensive than in the US, EV sales are already much higher, and Bloomberg New Energy Finance projects 35% of all global new car purchases by 2040 will be EVs.[108]

From a technical and economic perspective, the two primary potential advantages of EVs over internal combustion engines are that on a dollar per mile equivalent when comparing gasoline to electricity, it is more efficient and hence less costly to operate a vehicle with electricity and modern Lithium-ion (Li-ion) batteries. As well, electric motors require less maintenance, including no need for periodic oil changes. There are also important downsides to EVs, including limited travel range for batteries, the length of time and limited locations for battery re-charging (compared to the few minutes required to fill a gasoline tank at ever-present gasoline stations), the higher up-front cost of EVs, and reduced travel range in cold weather because of increased demand on the batteries to provide heat.

For this analysis, we evaluated three different scenarios for Anchorage: 1) the economic and grid impact of a 1% adoption rate for light duty, private EVs by 2020; 2) a simple payback analysis for the MOA to purchase and use EVs for a portion of its vehicle fleet; and 3) a simple payback analysis for the MOA to purchase electric buses, starting in 2018, to incorporate into the existing transit fleet.

105 http://www.greentechmedia.com/articles/read/how-to-accelerate-the-electric-vehicle-market?utm_source=Daily&utm_medium=Newsletter&utm_campaign=GTMDaily
106 http://www.eia.gov/todayinenergy/detail.php?id=28192)
107 For example, in mid-September 2016, gasoline sold for $5.70/gallon in Denmark and $6.90/gallon in Norway (http://autotraveler.ru/en/spravka/old/fuel-price-in-europe-09_2-2016.html#.WAPiRLwrly4).
108 https://about.bnef.com/press-releases/electric-vehicles-to-be-35-of-global-new-car-sales-by-2040/

SCENARIO 1:
1% OF PRIVATE LIGHT-DUTY VEHICLES IN ANCHORAGE ARE EVS IN 2020

Table 14. Assumptions for 1% EV Penetration in Anchorage by 2020 below shows the assumptions for this scenario.

Table 14. Assumptions for 1% EV Penetration in Anchorage by 2020

Assumptions	Amount	Units/Notes
Total number of vehicles in Anchorage	100,000	vehicles
1% conversion to EV	1,000	vehicles
Average miles driven per year	10,000	miles/year/vehicle
Base Cost of New Conventional Vehicle	$25,000	per vehicle
Base Cost of New EV	$35,000	per vehicle, no subsidies
Efficiency of Conventional Vehicle	25	mpg
Efficiency of Electric Vehicle	3	Miles per kWh – combination of city & highway driving – Idaho national lab: https://avt.inl.gov/sites/default/files/pdf/fsev/costs.pdf
Gallons consumed per 10,000 miles driven	400	Gallons
kWh consumed per 10,000 miles driven	3,333.3	kWh
Cost of Liquid Fuel	$2.50	per gallon, Oct 2016 approximate price in Anchorage
Maintenance Savings for EVs	0	Highly conservative
Cost of Charging Station	1500	$ per charging station at private residence[109]
Cost of electricity	0.17	$/kWh

Based on the above assumptions, from a private EV owner's perspective, the economic trade-off is $10,000 of additional cost for the purchase of the more-expensive EV plus $1,500 for a charging station,[110] as compared to lower costs for fueling and driving the vehicle over the lifetime of the EV. If either an electric or gasoline vehicle is driven 10,000 miles annually, and electricity is $0.17/kWh and gasoline is $2.50/gallon, the EV results in a "fuel" savings of $433 per year. Dividing the higher up-front costs of an EV by the fuel savings yields a 26.5 year simple payback, which is likely much longer than the life of either vehicle, especially when considering that the EV batteries would require replacement well before the 26.5 year payback cycle. In other words, at current retail fuel and electricity prices in Anchorage, an EV would not be a cost effective purchase.

However, gasoline prices are currently relatively low and may increase over time, and as discussed elsewhere in this report, the electric utilities serving the Anchorage area all have excess capacity with very low marginal avoided cost. In other locations, such as Juneau or California, utilities have created an incentive rate for nighttime EV charging that is above their marginal avoided cost but below retail electric rates, resulting in a price incentive for vehicle owners to purchase EVs and electricity to fuel their cars instead of gasoline and creating additional electricity sales for the utilities that otherwise would not have occurred.

109 A Class I EV charging station—the lowest cost and slowest—was assumed. The premise was based on a use pattern of an individual charging his/her vehicle at home all night such that the EV was fully charged the next morning and did not require another charge until returning home that evening.

110 http://www.greencarreports.com/news/1103133_how-to-buy-an-electric-car-charging-station-buyers-guide-to-evses - This reference covers several EV charging stations, all of which cost less than $1500, but additional labor installation costs are assumed, hence, this is a conservative assumption.

Because the price of gasoline and electricity are such large factors in this payback calculation, we have conducted sensitivity analysis by assuming gasoline may increase in price to $3.00/gallon and $3.50/gallon, and a special incentive rate of $0.10/kWh for nighttime EV charging, which is still above marginal avoided cost and hence the utilities would still be profiting from this sale if it were for kWh's that they otherwise would not have sold.

Table 15. Sensitivity Analysis for EVs, Assuming Different Gasoline and Electricity Prices below shows the results of this sensitivity analysis calculation with all assumptions from the table above still in place except the price of gasoline and electricity.

Table 15. Sensitivity Analysis for EVs, Assuming Different Gasoline and Electricity Prices

Gasoline Price	Electricity Price	Annual Miles Driven	Simple Payback
$2.50/gallon	$0.17/kWh	10,000	26.5 years (base case)
$2.50/gallon	$0.10/kWh	10,000	17.3 years
$3.00/gallon	$0.10/kWh	10,000	13.3 years
$3.50/gallon	$0.10/kWh	10,000	10.8 years

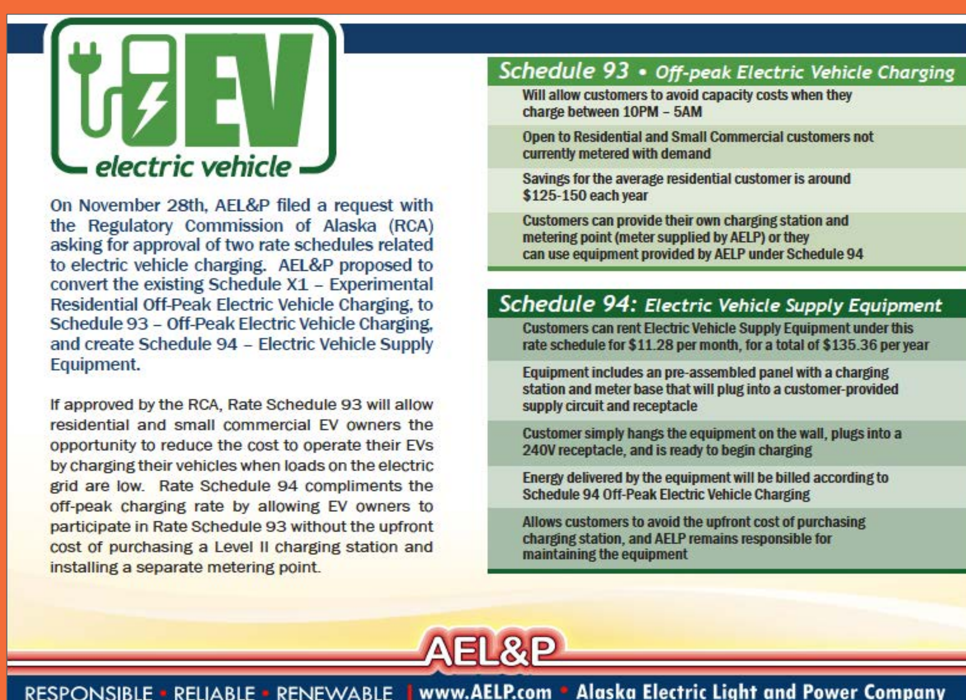
It should be noted that these are just simplified, hypothetical scenarios. More detailed analysis could include several more items such as differential maintenance costs of EV's versus gasoline engines, battery replacement and disposal costs for EVs, existing federal incentives for EV purchases, expected price declines for EVs as they become more popular, and possible additional charging costs if EVs are charged someplace other than one's home. As well, different assumptions could be made with regard to average annual miles driven, miles per gallon efficiency for a conventional vehicle, price differential between the two vehicles, or a more expensive charging station. All of these values would affect the economic payback and each individual likely applies different criteria to deciding on an EV purchase, but this is a preliminary calculation that shows under some conditions an EV may at least be a break-even proposition.

From an Anchorage perspective, if 1,000 EVs were each driven 10,000 miles annually, this would result in a reduction of 400,000 gallons of gasoline consumed and an increase of 3.3 million kWh sold annually. While most of the EV charging could be expected to occur at night in private residences, some charging stations strategically placed around Anchorage could ease range anxiety and facilitate further adoption of EVs.

SIDEBAR

INCENTIVE PRICING FOR EVs IN JUNEAU

Juneau's electric utility, Alaska Electric Light and Power (AELP), has just filed an incentive pricing request with the Regulatory Commission of Alaska to promote electric vehicle adoption among their customers (November 28, 2016 – see below). This proposal would cut the price of electricity in half for homeowners and small business to charge EVs during off-peak hours (10pm – 5 am). AEL&P's generation mix is much different than the Anchorage utilities, but they are all similar in that they currently have significant excess generation capacity at night for which additional demand would enhance, or at least not diminish, generation efficiency because of high fixed costs relative to avoided costs at night during low demand.



From a greenhouse gas perspective, we do not calculate the corresponding amount of natural gas that would be consumed in producing electricity that is displacing gasoline motor fuel because the electricity could be produced in a variety of ways, including hydro and wind power, that alter the amount of natural gas consumed.

SCENARIO 2: PARTIAL MOA VEHICLE FLEET CONVERSION TO EVS

The MOA owns and operates several hundred vehicles to perform various tasks, from police vehicles to plow trucks to basic transportation of employees during the course of the workday. Based on analysis of MOA vehicle fleet data and interviews with MOA personnel[111] it was determined that approximately 5 light-duty ("Class 2b" under 1 ton) vehicles are replaced every year, though these purchases are generally grouped across several years with a single vendor, which results in discounted purchase prices as compared to individual retail prices for a single vehicle. The 2016 data shows that the average light duty vehicle purchased by the MOA costs approximately $19,000, as compared to the $25,000 purchase price of a conventional vehicle assumed in Scenario 1 above. As well, the data shows average annual miles driven of 5,375 for MOA fleet vehicles, which is approximately half of what a private individual drives annually.

Both of these variables—initial purchase price and annual miles driven—work against the basic payback calculation for EVs applied in Scenario 1 above, since there will be a greater initial cost difference and a lower fuel savings as less miles are driven each year. Further, it was assumed that a more expensive, and hence faster, EV charging station would be necessary since each MOA vehicle may need to be charged more quickly if there is not a charging station for each vehicle, and one station may be required to charge multiple vehicles in a single night. Hence, we assume $2,500 for a Class II EV charging station as compared to $1,500 for a Class I EV charging station that individuals would more likely install at their homes. While it could be reasoned that the cost of a more expensive Class II charger should be distributed across the multiple vehicles it would be charging, it should also be noted that the faster charging station may require additional electrical upgrades for drawing more current, and we are not including that cost here. Hence, for simple payback purposes we are assuming a $2,500 charging station cost associated with each vehicle.

Table 16 below illustrates the assumptions and calculation results for MOA fleet replacement of selected light duty vehicles from gasoline to electric.

Table 16. Replacement of Gasoline with Electric Vehicles, Applying MOA Fleet Usage Assumptions

Variable	Gasoline Vehicle	Electric Vehicle	Simple Payback
Purchase Price	$19,000	$35,000	-
Charging Station	-	$2,500	-
Miles Driven Annually	5,375	5,375	-
Efficiency	25 miles/ gallon	3 miles/ kWh	-
Annual "Fuel" Consumption	215 gallons	1,792 kWh	
"Fuel" Price	$2.50/gallon	$0.17/kWh	79.4 years
"Fuel" Price	$2.50/gallon	$0.10/kWh	51.6 years
"Fuel" Price	$3.00/gallon	$0.10/kWh	39.7 years
"Fuel" Price	$3.50/gallon	$0.10/kWh	32.3 years

Considering the above assumptions and resulting simple payback figures in the table, a light duty EV would not make economic sense for the MOA to purchase under any of the fuel pricing assumptions. However, there may be specific vehicles that are used much more than 5,375 miles per year, and/or some special-use gasoline vehicles may have a higher up-front purchase cost that would make the overall payback much better, or perhaps a bulk purchase of EVs by the MOA would result in a lower up-front unit cost per vehicle. As well, it should be noted that if and when a vehicle fleet transition were to occur, the $2,500 charging stations and electrical upgrades would ultimately be in place and that cost would not be incurred with each additional purchase.

Most or all commercially available EVs at this time are using some form of Li-ion batteries that will ultimately need to be removed and receive special handling for disposal. This is currently an additional cost and process that we assume will eventually be factored into commercial and retail purchase programs and hence, we did not assign a value to this in our analysis, though in the short term, this could be an additional cost if the MOA were to purchase EVs and eventually become responsible for proper handling, disposal, and replacement of the batteries.

SCENARIO 3: ELECTRIC BUSES FOR MOA TRANSIT

The Anchorage Metropolitan Area Transportation Solutions (AMATS) is the federally designated Metropolitan Planning Organization for the greater Anchorage area that oversees both short- and long-range transportation

111 Craig Lyon, AMATS, 8/18/16, pers. comm.; Mark Warfield and Al Czajkowski, M&O, 8/24/16, pers. comm.

planning and receives federal funds through the Federal Highway Administration (FHWA) including for public transit/bus service provided by the Anchorage People Mover. The MOA Department of Public Transportation (DPT) operates the People Mover, which also receives funds from the Federal Transit Authority (FTA). The People Mover currently maintains approximately 54 buses and provides 30- to 60-minute frequency service during peak workday periods and 60-minute frequency service on weekends and non-peak weekdays.

Driving an average 130 miles daily, all buses return each night to the "Bus Barn" located on the south side of Tudor and Elmore to be cleaned, re-fueled, inspected, repaired if necessary, and readied for the next day. Detailed data is collected nightly on each bus, including miles driven, fuel efficiency, maintenance needs and costs over time. Currently 17 of the 54 buses have over 300,000 miles on them and average annual miles driven per bus is 37,904.

The DPT has a long-range bus purchase and replacement schedule that is dependent on FTA and some FHWA funds,[112] and currently calls for complete turn-over of the existing fleet in a 6 or 7-year period, starting with orders placed in 2018, and a growth in the fleet to 60 vehicles.[113] Typical lead-time between purchasing a bus and receiving delivery is about 18 months, so a 2018 purchase will not arrive until about 2020.

This analysis considers the economics, grid impacts, and logistical feasibility of transitioning at least some of the DPT People Mover fleet to electric buses (EBs). Similar to light-duty EVs, electric buses are becoming quite popular in cities around the world because of their energy savings and reliability, with ongoing improvements in cost and performance of Li-ion batteries driving the economics.[114]

Because of the need to perform ongoing and on-site maintenance for each bus in the People Mover fleet, any major transition will require not just purchasing a new bus model, but stocking spare parts, training in-house mechanics on the new equipment, changing nightly scheduling to provide ample time for EB charging, upgrading electrical infrastructure for EB charging stations, and making other modifications to the existing system. Hence, the working assumption is that any purchase of new EBs—or even a new model of a conventional diesel bus—would demand a minimum critical mass of multiple new buses to justify training mechanics, stocking spare parts, modifying existing systems, etc.

The DPT is now in the early stages of a study to evaluate the requirements for an EB transition from an internal infrastructure, process, and cost perspective. If a transition to EBs begins, the economics and logistics would favor a substantial and prolonged EB procurement program. However, DPT has legitimate concerns regarding dependence on a single fuel source such as electricity (or diesel, for that matter) for all of their buses, and a concern that the new EB technology has not been road tested sufficiently to justify a wholesale transition, especially in the harsh and remote conditions presented in Alaska.

Similar to the analysis conducted for the MOA light duty vehicle fleet conducted above in Scenario 2, the following analysis uses both current electricity and fuel prices and also considers an incentive electricity rate of $0.10/kWh and a hypothetical increase in liquid fuel prices. In this case, however, the comparison of electricity costs to diesel fuel consumption is somewhat altered because the MOA DPT receives a substantial bulk fuel discount on diesel fuel purchases: current wholesale purchase price is about $1.65/gallon. So diesel fuel escalation comparisons included $2.50/gallon and $3.00/gallon.

In discussions with MOA DPT personnel, it was pointed out that any new EBs would require several charging stations to allow multiple buses to be charged each night, and that significant infrastructure modifications and electrical upgrades would be required at the Bus Barn for expanded electrical service. As well, DC fast chargers would be required at targeted "refueling" stops along certain routes for additional daily charges outside the Bus Barn. A cost for the fastest EB charge station(s), along with additional Class II chargers, and associated infrastructure to meet the DPT's needs was estimated at about $1,500,000 by DPT personnel.[115] Because this is a significant cost and would be spread over several new EBs, this analysis looks at a bulk purchase of twenty EBs over a five-year period.

112 Though some of the FWHA funds that flow through AMATS can be used for bus purchases, none of these funds are allowed to be used for bus O&M.

113 Mark Harlamert, MOA Public Transportation, 9/20/2016, pers. comm.; and Mark Harlamert and Bart Rudolph, MOA Public Transportation, 10/27/16, pers. comm.

114 http://www.idtechex.com/research/reports/lithium-ion-batteries-for-electric-buses-2016-2026-000464.asp and https://www.greentechmedia.com/articles/read/The-Killer-Apps-For-Batteries-Electric-Buses-and-Natural-Gas-Peaker-Plant?utm_source=Daily&utm_medium=Newsletter&utm_campaign=GTMDaily

115 Mark Harlamert and Bart Rudolph, MOA Public Transportation, 10/27/16, pers. comm. And additional calculations by author.

Table 17. Electric Bus Payback Calculation

Variable	Diesel Bus	Electric Bus	Simple Payback	Note
Purchase Price	$500,000	$750,000	-	Cost estimates provided by MOA DPT staff
Charging Stations & Infrastructure	-	$1,500,000	-	One-time charge – includes 2 fast chargers, 5 Class II chargers, building and electrical infrastructure upgrades, installation/labor
Miles Driven Annually	37,904	37,904	-	Per bus
Efficiency	4.17 miles/gallon	1.1 miles/kWh	-	https://www.proterra.com/performance/fuel-economy/
Annual "Fuel" Consumption per vehicle	9,089 gallons	34,458 kWh	-	Miles Driven Annually/Efficiency
Annual "Fuel" Consumption for 20 vehicles	181,794 gallons	689,164 kWh	-	
"Fuel" Price	$1.65/gallon	$0.16/kWh	34.3 years	Combined for 20 vehicles – conventional (diesel) vs. electric
"Fuel" Price	$1.65/gallon	$0.10/kWh	28.1 years	"
"Fuel" Price	$2.50/gallon	$0.10/kWh	16.9 years	"
"Fuel" Price	$3.00/gallon	$0.10/kWh	13.6 years	"

Based on current diesel fuel prices of $1.65/gallon and $0.16/kWh electricity, the analysis results in a 34.3 year simple payback. However, a set of different—but far from unrealistic—assumptions of $3.00/gallon for diesel fuel and $0.10/kWh for incentive-priced electricity yields almost a 14-year payback, which is about the life cycle of most buses in the MOA fleet. Further, for EBs to effectively transition into the MOA DPT fleet, there will also likely need to be additional investment in charging stations in strategic locations around Anchorage,[116] more chargers at the Bus Barn, enhanced safety precautions regarding high voltage electricity and wet floors when the buses arrive in the evenings in winter, and very thoughtful and logistically challenging modifications in the daily maintenance regimen and possibly bus routing. Such changes require substantial support, investment, and training for the MOA staff who will be responsible for implementation.

Based on the assumptions and analysis in Table 20 above, it may be uneconomic—or at least there are no direct cost savings—in converting from a diesel bus to an EB. As well, from a staffing and logistics perspective, a transition to EBs would be a major commitment and challenge for MOA DPT staff and a minimum critical mass of new EBs would be required to justify the additional training and infrastructure enhancements. Alternatively, it is reasonable to assume that as EBs and Li-ion and other batteries continue to become more mainstream, the price differential between EBs and conventional diesel buses will continue to shrink along with DC fast charging stations.[117] As well, if fuel diversity is a goal, as expressed by DPT staff, then distributing the People Mover bus fleet between conventional diesel and electric may be an effective strategy.

It should be noted that the basic economic analysis presented above did not take into account any external incentives, specifically, federal funding potentially available to Anchorage under the "Low or No-Emission Vehicle Program" within the Fixing America's Surface Transportation (FAST) Act for EB and EB infrastructure conversion.[118] The FAST Act provides $55 million in competitive grants nationally each year through federal Fiscal Year 2020, typically in increments of $2-3 million per grantee.[119] These grants are only for EB conversion and would be provided in addition to the annual guaranteed FTA allocation currently received by AMATS. In other words, the MOA potentially has access to federal funds for new EB and charging station purchases that it could not access if only diesel buses were purchased. Cost-sharing requirements—namely, 15% of the total EB, or 10% of the total EB infrastructure (charging station) cost must be provided by the grantee—are similar to the current FTA grant awards.

Assuming a $2.5 million FAST Act grant with all else being equal in the above analysis presented in Table

116 The 6th Avenue and Dimond Boulevard Transit Centers have been considered good candidates.

117 http://www.idtechex.com/research/reports/lithium-ion-batteries-for-electric-buses-2016-2026-000464.asp

118 https://www.transit.dot.gov/funding/grants/low-or-no-emission-vehicle-program-5339c

119 https://www.transit.dot.gov/funding/grants/fiscal-year-2016-low-or-no-emission-low-no-bus-program-projects

20 with diesel fuel at $3.00/gallon and electricity at $0.10/kWh, 20 EBs and associated charging station and infrastructure conversion would have an 8.4 year simple payback.

Other Muni Vehicles

There are other commercial vehicles, such as garbage trucks, hostlers, fork lifts, and fire trucks, that are becoming electrified and used in other locations. At this early stage in their development, it is not recommended that the MOA purchase any of these vehicles to replace existing fleet vehicles, but the technology should be reviewed on a periodic basis and evaluated every few years to measure progress and cost effectiveness. This progress should also be coordinated with fleet updates as new vehicle purchases are scheduled.

If vehicle electrification is to occur within the MOA and more broadly across Anchorage, a focused planning effort around strategic roll-out of charging stations will be important. The MOA can lead this planning effort even if the funding ultimately comes from other sources, which could possibly include a portion of the $8.1 million Volkswagen diesel emissions violations settlement that will be coming to Alaska over the next two or so years.[120]

BICYCLE INFRASTRUCTURE

Anchorage boasts renowned walking, hiking, biking, and ski trails throughout and surrounding the city that meaningfully contribute to the quality of life and vitality of the community. For purposes of this report, we do not provide an estimate of the "energy value" of biking as an alternative to automotive transportation. However, it should be noted that the now popular trend of fat biking was essentially created in Anchorage and continues to support local businesses. As well, the MOA has maintained a commitment to bike commuters through upkeep and lighting of trails and a public education campaign, called "Vision Zero," focused on improving safety of bicycle travel and other modes of transportation throughout the city.[121]

COMMUTER RAIL AND LIGHT RAIL

Commuter and light rail have been an enticing vision for many in Anchorage and in surrounding areas, especially those in the Mat-Su Valley and south Anchorage who commute to work daily during typical rush hour times on the few main road arteries into and out of the central city. For this report, we researched the general viability of such an initiative and found, as expected, that the basic, underlying economics of commuter and light rail require significantly higher population density than is found in Anchorage. In fact, in even the most economically favorable conditions, commuter and light rail require subsidies to function properly. That said, roads and highways also receive large subsidies in the form of federal transportation appropriations. Hence, we have not conducted calculations or assigned any type of energy savings to the development of commuter or light rail for Anchorage, but include the concept here to ensure future consideration if conditions improve.

INTEGRATED HOUSING AND LIFESTYLE FACILITIES

This opportunity—for which we do not quantify the energy savings—is more of an economic development trend that is currently unfolding across lower 48 urban landscapes targeting young, skilled professionals with disposable income and a desire to live their values related to an economically and environmentally sustainable future. In other locations, like San Francisco or Portland or Seattle, the attractions are both the tech sector and the "sharing economy," which includes Uber and ZipCars and dense housing with food and entertainment just a smartphone click or a short walk away.

In Anchorage, perhaps the most compelling analog would be an extremely energy efficient high rise housing development, likely downtown[122] or in the U-Med district, where there are young adults, universities, and the most dynamic sector of the Anchorage economy—health care—all in close proximity to Anchorage's other competitive advantage: mountains and unparalleled outdoor recreational opportunities. The offering would include organic and locally available food in both a restaurant and grocery store in the lobby of the building, a coffee shop, performance space, community garden, and electric cars and bikes for rent, powered in part by renewable energy and a micro-grid with back-up power fully covered by high-speed Wi-Fi. Such an integrated housing project is an example of clean energy development that could leverage additional activity for the Anchorage economy.

120 https://www.adn.com/business-economy/energy/2017/03/29/alaska-seeks-your-ideas-on-spending-8-million-from-volkswagen-settlement/

121 For more information on Vision Zero, see: https://www.muni.org/Departments/OCPD/Planning/AMATS/Documents/Vision_Zero/Vision_Zero_Report_FINAL.pdf

122 Since this section was first written in an early draft of this report, a new housing development in Ship Creek near downtown, called The Rail, was announced with essentially all of these features. See https://www.adn.com/business-economy/2017/01/23/new-development-planned-for-ship-creek-land-owned-by-alaska-railroad/

ALTERNATIVE USE OF EXISTING INFRASTRUCTURE

The following items are brief descriptions of potential clean energy development opportunities and high level concepts. We do not assign a specific energy or dollar value to these potential opportunities, but feel it is appropriate to highlight them as worthy of future research and consideration in the overall energy landscape and Anchorage economy.

DATA CENTERS

The ongoing growth of the global digital economy relies on energy-hungry data centers connected through the internet. Data centers consumed about 70 billion kWh in 2014 in the US, about 2% of the nation's total energy demand, and overall energy consumption continues to grow.[123] Though the primary driver of energy demand in a data center is the computing technology, between 12-50% of energy usage is devoted to cooling.[124] While Anchorage does not have low cost electricity relative to other locations in the US, the cooling need is much lower than other locations, and hence, overall energy demand per unit of data center capacity is less and there may be some opportunity for data center development in Anchorage. Fiber optic connectivity and speed, high reliability of the electric system, and geographic diversity relative to other North American markets and natural disaster resilience are other factors affecting the attractiveness of data center development in Anchorage. Given physical and cyber-security requirements associated with data centers, one targeted approach may be to consider co-location of data centers "within the security fence" of existing power plants, instead of in a remote location that requires additional and costly security. A potential "game changer" could be if Anchorage had high-speed fiber optic connectivity to both the North American mainland and major Asian markets in Japan and China similar to what is now unfolding on the Arctic coast in Alaska.

EGAN CENTER

The Egan Center is an iconic downtown Anchorage landmark that now often sits idle as the new Dena'ina Convention Center bustles with activity that the Egan Center once supported. As an under-utilized asset in the heart of downtown, the Egan Center represents more of a community development than conventional energy opportunity, but it could certainly provide attractive gathering space for community and especially teen alcohol-free events, educational activities, job training, local capacity and skills development, and entrepreneurial space to enhance the Anchorage economy and quality of life for residents and visitors.

123 http://www.datacenterknowledge.com/archives/2016/06/27/heres-how-much-energy-all-us-data-centers-consume/

124 https://www.google.com/about/datacenters/efficiency/internal/

FOOD GROWING

Alaska imports about 95% of its food.[125] The average food item on a grocery store shelf in the lower 48 travels about 1,500 miles before being purchased; in Alaska, this distance is more than doubled.[126] Alaska's climate and soils present particular challenges for large-scale local production, though some are successfully cultivating commercial quantities and high quality food seasonally. Globally, indoor food growing is becoming a popular and cost effective means for enhancing local food security and economic development.[127] Such activity is very energy intensive as all aspects of heat, light, and moisture must be precisely controlled for optimal plant growth, however, new research and development, especially with LED lighting and computerized growth monitoring, are significantly reducing energy demand and increasing diversity of food growing.

Figure 36. Indoor Food Growing in Kotzebue, Alaska[128]

Photo Credit: Inhabitat.com

Two Anchorage-based companies, Alaska Natural Organics and Vertical Harvest Hydroponics, have

125 https://redoubtreporter.wordpress.com/2012/10/24/homegrown-revolution-gardeners-expand-to-tackle-alaskas-food-insecurity/

126 http://www.environmentmagazine.org/Archives/Back Issues/2015/May-June 2015/alaska_full.html

127 http://www.thedailybeast.com/articles/2013/05/07/vertical-indoor-farms-are-growing-in-the-u-s.html
http://www.ecowatch.com/worlds-largest-vegetable-factory-revolutionizes-indoor-farming-1882004257.html
http://blog.aspb.org/2016/08/29/food-for-thought-digital-farming-food-computers-and-openag/

128 http://inhabitat.com/arctic-town-grows-fresh-produce-in-shipping-container-vertical-garden/; Arctic Greens, Vertical Harvest Hydroponics, and Kikiktagruk Inupiat Corporation.

started operations within the past two years. Alaska Natural Organics is growing food indoors at an old dairy warehouse in Anchorage for local consumption, while Vertical Harvest Hydroponics manufactures and ships Arctic-ready, mobile containerized growing systems to remote locations for turnkey indoor food production. These two start-up businesses have seen early success,[129] and ongoing demand for fresh food available all year round, coupled with improved growing technologies and techniques, point to continued expansion of local indoor food production.

We do not estimate the potential energy demand from this industry, but note that high-energy costs will be a potential constraint, and similar to electric vehicles discussed above, an incentive pricing mechanism may be mutually beneficial to both the electric utility providers and local food growers. In other words, electricity priced at $0.17/kWh may not allow for cost-effective indoor food growing, but perhaps an incentive rate of $0.10/kWh would facilitate this industry and still be above marginal avoided cost and thus provide a margin for the electric utilities and create kWh sales that otherwise would not occur.

As noted above in the Landfill Gas to Energy Plant Expansion section, the LFTGE project site at the regional landfill could offer advantages as an indoor food production site with potential excess power, heat, and good solar exposure to reduce the need for artificial lighting.

129 http://www.ecowatch.com/two-indoor-farm-startups-stand-up-to-alaskas-short-growing-season-1882142771.html

CHAPTER 7 – FINDINGS AND RECOMMENDATIONS

CONCLUSIONS

Anchorage is clearly a diverse and dynamic urban center with a complex institutional landscape and a wealth of potential energy savings and development opportunities. The broader context also includes challenging economic headwinds that will likely influence investment decisions.[130]

Most of the individual opportunities discussed in Chapters 3-6 above contain specific next steps and considerations for each initiative identified. This chapter aims to provide broad recommendations and prioritizations among the various opportunities and projects analyzed in the previous chapters. Paralleling the overall structure of this report, the primary focus of this chapter is MOA opportunities and initiatives while also including utility service providers and commercial and residential end-users. In general the opportunities were selected and evaluated by their contributions to the following over-arching goals:

+ Reduce costs for the MOA, residents, and businesses
+ Promote economic development
+ Enhance long-term sustainability and resilience

These goals are related but distinct and at times, conflicting. For example, reducing energy consumption and costs for businesses can free up revenue for additional investments and/or reduce final costs of goods and services, but may result in reduced revenues to local utilities which may result in higher energy prices in the future. Improved energy efficiency may reduce energy costs for residents, which may allow for additional expenditures on goods and services provided by local businesses and promote economic development, but also reduces utility revenues. Widespread EV adoption would increase electric utility sales while likely increasing dependence on natural gas and reduce petroleum consumption. Strategic clean energy investments in local renewables can potentially reduce energy costs for all stakeholders and enhance sustainability and resilience through fuel diversity.

As expected from other energy studies, the analysis here clearly shows the biggest potential impact coming from energy efficiency and conservation measures, followed by renewable energy production. As well, it should be no surprise that combined potential private residential and commercial EE&C measures are much larger than MOA potential simply because private building space and associated energy consumption is so much larger than the MOA's. However, the MOA as a single entity with decision-making authority and visibility of its entire infrastructure has a unique ability to accelerate these projects and have a concentrated impact on both its own operations and the overall municipality.

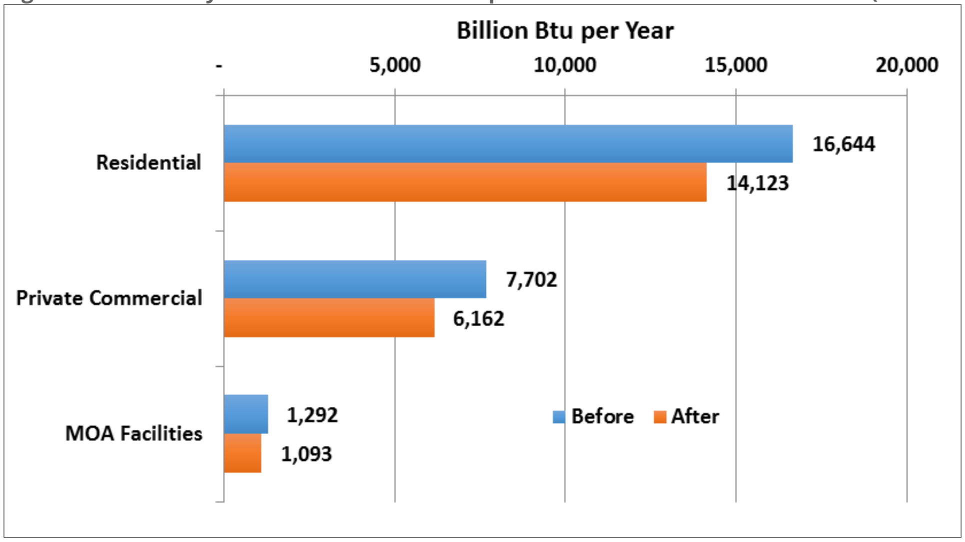
130 https://www.adn.com/business-economy/2016/12/02/recession-grips-state-as-employment-losses-in-alaska-grow-hitting-new-sectors/

The table and figure below illustrate the scale and potential impact of private residential, commercial, and MOA energy efficiency and cost saving measures.

Table 18. Electricity and Natural Gas Consumption Before and After EE Measures (Billion Btu/yr)

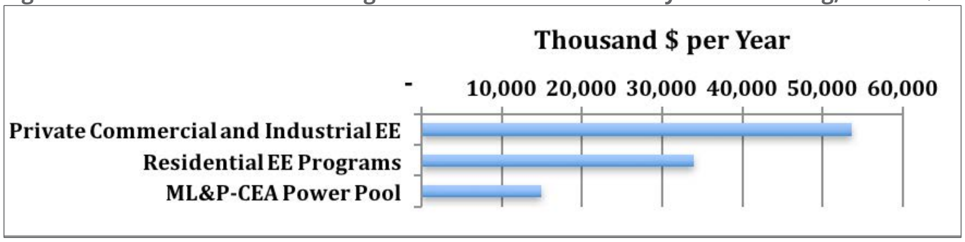
Sector	Before	After	Savings
Residential	16,644	14,123	2,521
Private Commercial	7,702	6,162	1,540
AWWU	160	140	20
Port of Anchorage	17	?	--
School District	761	639	122
Solid Waste Services	26	22	4
Municipal Facilities	329	276	53
Streetlights	156	82	74
Total	1,448	1,159	289

Figure 37. Electricity and Natural Gas Consumption Before and After EE Measures (Billion Btu/yr)



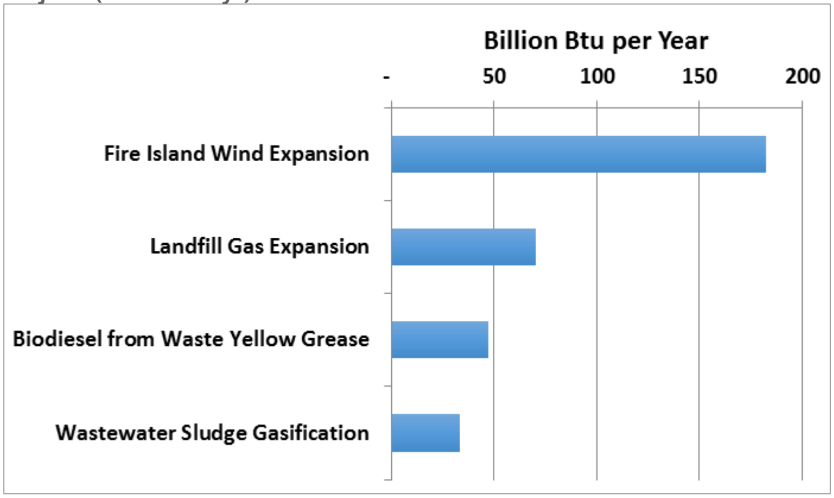
For additional perspective, the following chart illustrates relative energy savings impact from private residential and commercial EE—both of which are future-based and optimistic projections—along-side utility power pooling, which is a project currently being aggressively pursued and should be implemented in 2017.

Figure 38. Estimated Annual Savings From Private EE and Utility Power Pooling, Total = $99.8 Million



On the renewables side, the chart below illustrates the scale of some of the new energy generation opportunities discussed within this report.

Figure 39. Estimated Renewable Energy Production from New Projects (Billion Btu/yr)



RECOMMENDATIONS

Arguably the **single most impactful action the MOA can take in the short term is to hire an energy manager** along the lines of the Fairbanks North Star Borough (FNSB), or even closer to home, similar to what the ASD or JBER has already done for their facilities. If only one position is created and filled, this person ideally needs a skillset that includes technical, project execution, and financial abilities, as well as an administrative and institutional understanding of how to work within the MOA environs. The FNSB Energy Manager position is housed within the Borough's Department of Public Works, Administration Division.[131] A position description for the FNSB Energy Manager position is included in Appendix E to this report.

Within the MOA, we recommend that this position be housed within the City Manager's office so it could more easily address issues beyond the scope of any particular Department. Hiring an Energy Manager to coordinate among individual departments and provide a central focus and expertise on energy for cost savings and productivity enhancement is a common first step for any large organization, whether it is a multi-national corporation or a multi-departmental government. The typical refrain is that "the position pays for itself" through energy savings and generating new revenue opportunities. This report appears to confirm this logic and quantifies the expectation of savings and new prospects.

131 http://www.co.fairbanks.ak.us/pw/Pages/Public-Works-Staff.aspx

Beyond hiring an Energy Manager, the items and recommendations listed below are in rough order of priority based on impact, scale, and feasibility, with short-term opportunities and low/no cost demands on the MOA taking precedence over longer-term prospects with many actors or requirements beyond the MOA's jurisdiction. Along with simple payback and other energy savings and cost metrics evaluated here, other high level concepts that should inform priority-setting and investment decisions are fuel diversification to reduce dependence on natural gas, ease of project implementation (such as with complicated permitting requirements), and lead-time required for deployment. Further, we encourage starting with facility benchmarking and then "deep energy retrofits" when performing EE upgrades so not just the easy and quick payback items like LED lighting are achieved, but also the slower payback but larger savings activities like adding insulation and boiler upgrades are implemented, along with digital controls and communication to enable further savings, performance monitoring, and operational enhancements.

Most if not all of the items catalogued below that feature a lead role for the MOA would fall under the responsibility of the MOA Energy Manager and/or a similar position, such as the existing ASD Energy Manager. Table 19. Priority Table summarizing these opportunities and recommendations is presented below followed by narrative descriptions of each item.

Table 19. Priority Table

Opportunity	Net Cost (1,000$)	Savings (1,000$/yr)	Simple Payback (yr)	Energy Savings (Billion Btu/yr)	Renewable Energy (Billion Btu/yr)	Note
Energy Manager Position	150	150	1	--	--	One staff position to implement projects described in report; assume revenue neutral annual expenditure
Efficiency #1. Inter-Departmental Cooperation & Aggregate Projects	--	--	--	--	--	Result in labor and cost savings, improved financing terms and streamlined implementation
Efficiency #2. ML&P-Chugach -MEA Power Pool & System Operator	TBD	15,000	0.0	1,000	0.0	Power Pooling estimated at $10-20 Million/1 Bcf gas savings annually plus additional for greater Railbelt; in-process; costs To Be Determined
Efficiency #3. School District Building Efficiency	20,986.1	2998.0	7.0	121.7	0.0	CHP could add substantial additional savings & generation; microgrid potential
Efficiency #4. MOA Facility Efficiency	10,467.7	1,495.4	7.0	52.6	0.0	Standard EE/Wx, especially LEDs, building controls/monitoring, condensing boilers
Efficiency #5. Water and Sewer Facility Efficiency	2,806.3	400.9	7.0	20.2	0.0	Standard EE/Wx plus heavy equipment controls, water distribution temperature in-process w ML&P
Efficiency #5a. Asplund WWTF Sludge Gasification	5,000.0	1,834.9	2.7	78.3	33.5	Necessary large capital project, payback on marginal additional cost
Efficiency #6. Solid Waste Services Building & Collection Efficiency	590.9	84.4	7.0	4.0	0.0	LEDs, Wx, system controls, possible rolling stock electrification not calculated
Efficiency #6a. Regional Landfill Leachate Line	3,113.6	795.9	3.9	1.6	0.0	Energy + Health & Safety benefits
Efficiency #7. LED Streetlights and Controls	21,600.0	3,252.2	6.6	74.0	0.0	Across multiple jurisdictions; initiated
Efficiency #8. POA Modernization	--	--	--	--	--	Overall project very large; energy options & impacts need further study; Energy storage & microgrid potential; thermal snow removal potential
Efficiency #9. Private Residential EE Programs	355,512.6	33,827.4	6.4	2,520.7	0.0	Theoretical, based on existing building stock, MOA, AEA, CCHRC & AHFC data
Efficiency #9a. Private Commercial and Industrial EE	374,934.4	50,787.5	7.0	1,540.4	0.0	Theoretical, based on existing building stock, MOA, AEA, CCHRC & AHFC data
Renewable #1. Fire Island Wind Farm Expansion	--	--	--	--	152.4	Tax credit timing constraint; under consideration
Renewable #2. Landfill Gas to Energy Expansion	--	--	--	--	70.6	Currently under evaluation; near future peak fuel production adds urgency
Renewable #3. PV Installations	--	--	--	--	2.9	Primary residential & Commercial benefits could be much higher; estimate is for 1 MW community solar project
Renewable #4. Fats, Oils and Grease Program	--	--	--	--	47.2	Public-Private Partnership likely required
Fuel Switching #1. Large Facility/District CHP	406.0	102.0	4.0	--	--	Highly site specific; estimate here based on vendor-provided results for one project; many projects possible; microgrid potential
Fuel Switching #2. Heat Recovery From Existing Generation	--	--	--	--	--	Project specific opportunities require further evaluation, but may have significant promise for multiple stakeholders, especially EGS and SWS/JBER/Doyon LFGTE
Fuel Switching #3. Private Electric Vehicles (1,000 vehicles)	11,500.0	1,066.7	10.8	0.0	0.0	Assumes incentive pricing of $0.10/kWh and $3.50/gallon gasoline; need charging stations
Fuel Switching #3a. People Mover Electric Buses (Fleet of 20)	6,500.0	476.5	8.4	0.0	0.0	Assumes incentive pricing of $0.10/kWh, $3.00/gallon diesel fuel, and FAST grant; need charging stations
Integrated Lifestyle Opportunities	--	--	--	--	--	Housing, food growing, rentable EVs + walkability, Community Center, job training

ENERGY EFFICIENCY OPPORTUNITIES

1. Facilitate and Enhance Inter-Departmental Cooperation Within MOA Departments and Aggregate Projects Where Possible - This is already happening to some degree, for example, with ML&P and POA on the Port Modernization project and between SWS & AWWU on the leachate pipeline. Standardizing digital control nodes on all streetlights across ownership and entities responsible for O&M, and converting to LEDs is an example of this cooperation that could potentially be advanced via a single financing package and overall coordinated effort to get economies of scale across entities; reduce labor, transaction, and procurement costs; and simplify the technology differences (with multiple kinds of LEDs for example). AWWU, ML&P, SWS, M&O, AMATS, and ASD in particular have expertise to draw from and are doing projects that could perhaps be coordinated with each other through the Energy Manager.

2. Power Pooling and System Operator – Centralized economic dispatch with coordinated power generation among the three electric utilities serving Anchorage and surrounding areas should soon be yielding savings of about 1 bcf of natural gas, representing between $10 - 20 million annually. This is a credit to the participating utilities and the RCA. Additional though limited savings could be achieved with further coordination of power pooling to include the other Railbelt utilities. An effective system operator controlling dispatch for all transmission in the Railbelt could further provide a transparent and stable investment environment for future low cost clean generation and reliability improvements to the power system, though would add administrative costs. Establishing proper governance and institutional composition of a system operator should be a high priority and advanced as soon as possible.

3. ASD Efficiency Upgrades – With an ASD Energy Manager currently in place identifying and evaluating energy efficiency and cost savings opportunities for the school district, this may provide a template for the broader MOA Energy Manager implementation effort. Procurement requirements and other administrative challenges have slowed this effort and limited the impact to date, but committed and talented staff continue to pave the path for institutional energy and cost savings through in-house initiatives, contracted ESCO projects, and creative financing plans. Recent and expected future budget cuts imposed on the ASD make these cost savings opportunities even more important to mitigate direct educational service impacts.

4. MOA Facility Efficiency – M&O staff is already leading LED lighting upgrades, assessing performance of high efficiency condensing boilers, and building weatherization for much of the MOA's existing (non-utility) infrastructure such as office buildings and AMATS facilities, along with vehicle fleet management and digital communications. Investment in Digital Data Controls and an MOA Energy Manager could assist with monitoring building performance and assuring energy savings expectations are being realized.

5 & 5a. AWWU Efficiency Upgrades & Sludge Gasification – AWWU is successfully implementing energy efficiency upgrades to its substantial infrastructure and operations. The Utility's current practice of sewage sludge incineration consumes large quantities of water and natural gas. The Utility is exploring alternatives, including gasification of sewage sludge, for a potential cost-effective and energy-efficient solution for managing biosolids. Additional specific projects and equipment upgrades within AWWU have been identified and evaluated; projects with under three year paybacks could be seeking financing and developing implementation plans, while longer payback projects should be cataloged for an Energy Manager to re-visit.

6 & 6a. SWS Efficiency Upgrades & ALR/SWS Leachate Pipeline – SWS is effectively identifying internal operational efficiency and savings opportunities similar to ASD, M&O, and AWWU. The leachate pipeline project has energy efficiency, cost, and safety benefits along with showcasing inter-departmental cooperation with AWWU, JBER, and other state and federal agencies. Potential corrosion impacts to JBER's system and Rights-of-Way still need to be addressed, but substantial progress has already been made and this appears to be a "no regrets" project for all parties involved.

7. LED Streetlights and Standardized Digital Controls – This is a multi-layered project across multiple jurisdictions that is an excellent candidate for inter-departmental cooperation, joint financing, and technology standardization to optimize energy cost savings, communication and controls, performance, and O&M/labor costs. ML&P and POA have already begun the important process of detailed inventory and standardizing the system controls.

8. POA Modernization – This is likely a $500+ million overall project with statewide implications. Details are discussed above, but the new main dock, cranes, snow removal/winter O&M, other dock construction, integrated multi-modal cargo moving, and other activities are energy and logistics-intensive and merit careful study and planning. The POA staff are skillfully leading this effort with strong ML&P support. Future funding will largely dictate scale, implementation timing, and may limit options that require additional up-front costs but could improve efficiencies over the long-term. These trade-offs should be made clear in economic and energy assessments and feasibility studies to inform large capital investment decisions that will be made over the next few years but have multi-generational impact. It is pre-mature to calculate energy savings; specific project options still need to be defined, evaluated, and compared. Anecdotally, it does not appear that on-shore power for docked cargo vessels is feasible but should be explored in more detail to confirm as this would be a significant revenue stream for ML&P and the POA. To the degree on-shore power would be used more in summer than winter, this is a good match for Anchorage's load profile. Microgrids may be an option to provide additional flexibility, reliability, and growth over time.

9. Residential EE – Through its Energy Manager the MOA should coordinate with State agency partners to understand barriers to and assess opportunities for enhancing existing residential energy programs. In the longer term, the MOA should consider options for building a residential efficiency finance program on the foundations of its existing municipal building, streetlight, and (recommended) C-PACE programs.

9a . Private Commercial & Industrial EE – The MOA should move aggressively toward designing and establishing a C-PACE program after enabling state legislation is passed. The MOA's effort should be coordinated by a designated lead staff person (e.g., the Energy Manager) working with State specialists and informed by implementers with a successful track record, such as the Connecticut Green Bank. On-Bill Financing may be another vehicle to promote EE investments.

RENEWABLES OPPORTUNITIES

1. Fire Island Wind – This project could provide approximately $50 million of construction-related spending in Anchorage on new clean energy infrastructure within the next year during difficult economic times. A federal tax credit, with a looming deadline in 2018, would bring the wholesale cost of power down from about $0.086/kWh to $0.056/kWh, representing a savings of approximately $39.5 million over the 25 year life of the project. Though utility avoided costs are currently lower than this production price, natural gas prices could continue to rise over time, ultimately making this 25-year flat-priced renewable resource a cost-effective investment and diversify Anchorage's fuel mix, decreasing natural gas dependence. "Green Pricing" could also be used to cover any small difference in price between current avoided cost and FIWP Phase 2. Utility power pooling promises to simplify and reduce integration costs over time. The scale, impact, and timing urgency of this project rank it highest on the renewable generation priority list.

2. LFGTE Expansion – This project has a specific window of opportunity for cost optimization because landfill gas production will decline over time and there is effectively no storage capacity for excess gas. The gas collection and electricity production components of the project are well quantified, but other institutional and coordination issues within JBER must still be addressed. As well, use of the additional power may need to be evaluated within the broader Anchorage and Railbelt energy context. Heat recovery may provide further added value to the project.

3. Residential, Commercial, and Community Solar PV – Project developers in Anchorage are offering attractive solar PV packages that leverage federal tax credits, ongoing technology innovations, and existing net metering laws for business and homeowners. From a utility perspective, solar PV production is above avoided cost, but from an end-user perspective, in some cases solar PV appears to be lower cost than retail rates. Community solar may be an effective compromise to allow lower income households to participate as well as to achieve lower production costs through economies of scale and optimized siting, along with reducing integration issues because of utility involvement. Residential and commercial projects can be deployed quickly, while community solar will likely require at least a year.

4. FOG & Bio-diesel – This opportunity represents a true public-private partnership. AWWU has an immediate need to reduce FOG impacts on pipeline infrastructure while there is literally a clean energy resource being dumped down the drain that a local private enterprise, under certain market conditions, could use as feedstock in its currently underutilized biodiesel facility. Potential benefits of recovering yellow grease and converting it into a renewable fuel warrant continued focus on addressing logistical issues.

FUEL SWITCHING OPPORTUNITIES

1. CHP – In specific circumstances, this is already a cost-effective project with relatively mature technology, typically for large commercial facilities, though it could have negative impacts on the incumbent electric utilities. It remains to be seen if the recent RCA effort to address all stakeholders' needs will be successful or if additional policy remedies will be required. The MOA is also interested in CHP projects, for example at high schools with swimming pools, but this raises additional technical, economic, and staffing issues that may delay implementation. SWS in particular has expressed interest in a CHP initiative that could serve as a demonstration/ pilot project to provide lessons learned for other MOA efforts in this arena.

2. Heat Recovery - EGS, ARL, and possibly Sullivan and SPP may have economically valuable quantities of heat to recover from existing power plant emissions. Technical and economic studies with targeted applications are still required to determine viability of each location and proposed project and institutional challenges may exist as multiple parties would likely be involved in any project. Expected time horizons are two years and beyond.

3 & 3a. EVs and EBs – Both private electric vehicles and public electric buses will likely require incentive pricing and charging station infrastructure investment by the electric utilities and possibly MOA for successful deployment. Liquid fuel prices, i.e., gasoline for EVs and diesel for EBs, are also large drivers in the economic analysis, and are currently historically low but volatile and expected to rise in the near term. Arguably, this opportunity transcends strict economics and falls within the broad category of quality of life, but broad adoption of electric vehicles, given Anchorage's abundance of clean energy resources, could result in substantial benefits for the electric utilities, local air quality, and further economic development not presently anticipated. A federal FAST grant is now available to offset EB purchase and charging infrastructure costs that could be pursued by AMATS. MOA fleet vehicle EB purchases do not appear cost-effective considering low annual average miles driven, but targeted high mileage vehicles or shifts in fleet usage and operating practices, along with bulk purchases to reduce up-front costs, could significantly alter the economic analysis. Smart metering may be required to allow for incentive pricing for evening charging and ultimately load control. Electric utility involvement, considering the potential gains in kWh sales and revenues, will likely be a determining factor in establishing EV charging infrastructure and institutional support for adoption of the technology. The MOA and/or individual electric utilities could consider issuing a Statement of Interest to identify potential designers, investors, and developers of EV charging infrastructure and better define the opportunity, which could be substantial in the long-term.

OTHER OPPORTUNITIES AND CONSIDERATIONS

Anchorage "Lifestyle" Opportunities – Though difficult to quantify precisely, lifestyle options that improve quality of life such as new energy efficient housing combined with entertainment, local food production, walkability, and recreation, can attract new investment, skilled labor, and disposable income. Possible new opportunities created by data centers, commercial scale food growing, and light manufacturing facilitated by incentive pricing for energy may leverage additional people, demand, and investments to the region. This broader concept also includes geographic and competitive advantages such as Anchorage's central location between global markets, which results in significant air cargo; Anchorage's central role in statewide commerce, hosting corporate headquarters for many Alaska Native Corporations and support center for rural Alaska; geostrategic investment from the military; Anchorage as a Welcoming and Winter City; and Alaska's role as an important Arctic stakeholder.

Along with the specific projects described and tabulated above, there are other potential opportunities, trends, technology developments, policies, business strategies, and cost drivers that should be periodically monitored to help leverage existing strengths and inform policy makers and potential investors.

From a technology perspective, ongoing improvements and cost reductions may influence future decisions related to:

+ heat pumps from all thermal sources and CO2 as the "working fluid"
+ energy storage including various battery chemistries, capacitors, and flywheels
+ microgrid systems and digital communication
+ smart metering, facility and equipment monitoring and feedback, and load control
+ electrification of cars, trucks, buses, heavy equipment and charging stations
+ renewable generation technologies including

wind, solar, CHP, ocean energy, and geothermal

+ Direct Current (DC) transmission for large-scale, long distance transfer of bulk power
+ Indoor food growing, energy efficient housing, lighting controls and communication

From an economic and business development perspective, Anchorage may prosper from further consideration of:

+ expanded utility cooperation and economy of scale aggregation
+ financing strategies, e.g., public-private partnerships, C-PACE, OBF, R-PACE, others
+ streamlining procurement procedures and timelines within the MOA
+ embracing the “sharing economy” for attracting/ keeping young, skilled residents
+ effective land use planning that facilitates desirable energy-related outcomes, such as more walkable communities and strategic placement of EV charging stations

Though there are certainly challenges ahead, Anchorage has a bright future with highly competent and committed MOA leadership and staff; creative and reliable electric and other utilities providing essential services; and dynamic public, private, and military sectors that are driving innovation and responsible development of regional resources while improving community resilience.

APPENDICES

APPENDIX A. REFERENCES & BIBLIOGRAPHY

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APPENDIX B. METHODS FOR ESTIMATING ANCHORAGE ENERGY COSTS AND CONSUMPTION

This appendix describes the methods that were used to prepare Table 1-ES. Anchorage 2015 End Use Energy Consumption of Major Energy Sources* (Billion Btu)-ES and Table 6. Anchorage 2015 End Use Consumption of Major Energy Sources* (Billion Btu), Anchorage 2015 End Use Consumption of Major Energy Sources 2015. For simplicity we have combined the commercial and industrial sectors and refer to the category as "commercial."

Residential and Commercial Electricity Consumption. We based residential and commercial electrical energy consumption on Energy Information Administration's (EIA's) early release 2015 electricity data from form EIA-861, Electric Power Sales, Revenue, and Energy Efficiency.[132] We included all sales from Anchorage Municipal Light and Power (ML&P) and Chugach Electric Association (Chugach). Although Chugach sales include customers outside of the MOA—Beluga, Cooper Landing, Hope, Moose Pass, Point Possession, Sunrise, Tyonek, and Whittier—their combined population of 1,166 is very small compared to the population of Anchorage, 298,908,[133] and their contribution to power sales was judged insignificant. Since Matanuska Electric Association serves the MOA communities of Birchwood, Chugiak, Eagle River, Eklutna, and Peters Creek (total population 11,640), as well as the Matanuska-Susitna Borough (population 100,178), we prorated MEA power sales by 10.4%.

Joint Base Elmendorf Richardson (JBER) purchases power from Doyon Utilities' landfill gas-to-electric facility and ML&P. Of the expected 2016 electricity sales of 202,736 MWh, JBER's energy staff estimates 25% is non-military.[134] Of the non-military usage, staff estimates 55% is residential (27,876 MWh/yr), while the remaining energy is sold to on-base banks, restaurants, the National Guard and other commercial customers. We added estimated JBER residential sales to the utility residential electricity sales above and subtracted them from utility commercial sales.

Residential and Commercial Natural Gas Consumption. Enstar[135] provided annual residential and commercial natural gas consumption data for the MOA, including JBER, effective 4/30/16.

Similar to the method above for adjusting electricity consumption by use sector, we estimated residential use at JBER based on JBER staff estimates—15% total consumption is non-military and 30% of non-military consumption is residential. The resulting estimate of JBER residential consumption, 72,526 MCF/yr, was used to adjust Enstar's residential and commercial sales statistics.

MOA Commercial Electricity and Natural Gas Consumption. Consumption is based on utility bill summaries furnished by Anchorage School District, Anchorage Water and Wastewater Utility, Port of Anchorage, Merrill Field, and Solid Waste Services.[136, 137, 138, 139, 140, 141] MOA Maintenance and Operations provided 2009 and 2010 energy consumption data for 55 buildings. Electricity and natural gas consumption were not broken out in the energy intensity indices provided for each building, so we prorated electricity and gas consumption using Anchorage-wide figures for commercial facilities.

Streetlights. See the Streetlight section in Chapter 3 for streetlight inventory and approximate electrical consumption.

Private Commercial Electricity and Natural Gas Consumption. We estimated current electrical, natural gas and energy consumption as follows:

+ Using the Municipal Property Appraisal Division's records[142] we separated out privately owned or leased commercial buildings and summed square footage by 92 Building Structure types (i.e. Hotel/Motel High Rise, Bank, etc) that the MOA uses to classify commercial buildings.

132 EIA 2016. Electric power sales, revenue, and energy efficiency Form EIA-861 detailed data files, https://www.eia.gov/electricity/data/eia861/
133 http://live.laborstats.alaska.gov/pop/
134 G. Sonny Turpin, JBER, 8/1/16, pers. comm.
135 John Sims, Enstar, 5/17/16, pers. comm.
136 B. Woods, MOA, 8/15/16, pers. comm.
137 Tony Friel, ASD, 5/11/16, pers. comm.
138 Mark Corsentino, AWWU, 9/30/16, pers. comm.
139 Jim Jager, Port of Anchorage, 5/31/16, pers. comm.
140 Mark Madden, SWS, 4/8/16, pers. comm.
141 Darlene Sivyer and Paul Bowers, Merrill Field, 12/1/16, pers. comm.
142 Public Tape, MOA Property Appraisal Division, 4/27/16.

+ We lumped Building Structure types into the nine non-residential "Building Types" established by the statewide Alaska End Use Study[143], summed square footage by Building Types and multiplied each sum by corresponding average energy use intensity estimates (kBtu/sf-yr) to obtain total energy usage by Building Type.
+ We summed Building Type energy usage to estimate total private non-residential energy usage.
+ Finally, using the End Use Study fuel type assumptions for climate zone 7 (figure 31 on p39) rounded to the nearest 5% (electricity 45%, natural gas 50%, and propane/wood/other 5%), we estimated total energy by fuel type.

Highway Motor Fuel. We estimated Anchorage car and truck fuel usage based on Alaska Department of Revenue reported highway statewide fuel usage in 2015 (374,019,732 gallons)[144] multiplied by an estimate of vehicle miles traveled (VMT) in Anchorage in 2013 (3,471,173),[145] and divided by statewide VMT in 2013 from Federal Highway Statistics (4,848,000).[146] We assumed 130,000 Btu/gallon average diesel and gasoline energy content.

143 WH Pacific 2012. Alaska End Use Study, with Brian Saylor and Assoc, CTG Energetics and Craciun Research Group, for Alaska Energy Authority.
144 http://www.tax.alaska.gov/programs/programs/reports/AnnualData.aspx?60210
145 Solstice Alaska Consulting and Parsons Brinckerhoff 2016. Congestion Management Process Update and Status of the System Report, Anchorage Bowl and Eagle River.
146 http://www.fhwa.dot.gov/policyinformation/statistics/2013/

APPENDIX C.
MUNICIPALITY OF ANCHORAGE FACILITY ENERGY CONSUMPTION 2015

APPENDIX C1. ANCHORAGE SCHOOL DISTRICT FACILITY ENERGY CONSUMPTION 2015

Building Name	Prorated Area	kWh	kWh/Ft²	kWh Cost	kWh Cost/Ft²	NG CCF	CCF/sf	NG Cost	NG Cost/Ft²	Water (1000 gal)	Water gal/sf	Cost	Cost/Ft²	Total Electric and Gas MMBtu	kBtu/sf	Cost	Cost/sf
ABBOTT LOOP	58,341	520,240	8.92	$74,345	$1.27	36,363	0.62	$36,023	$0.62	474	8.1	$5,071	$0.09	5,411	92.8	$110,368	$1.89
AIRPORT HEIGHTS	39,450	412,000	10.44	$60,559	$1.54	27,409	0.69	$27,505	$0.70	490	12.4	$5,588	$0.14	4,147	105.1	$88,063	$2.23
ALPENGLOW	60,219	472,960	7.85	$76,009	$1.26	34,549	0.57	$34,341	$0.57	550	9.1	$6,060	$0.10	5,069	84.2	$110,349	$1.83
AQUARIAN CHARTER K-6	31,327	305,840	9.76	$44,053	$1.41	19,294	0.62	$18,623	$0.59	423	13.5	$4,566	$0.15	2,973	94.9	$62,676	$2.00
AURORA	54,717					29,269	0.53	$39,872	$0.73	-				2,927	53.5	$39,872	$0.73
BARTLETT-HS	360,209	3,724,798	10.34	$499,240	$1.39	295,492	0.82	$259,704	$0.72	2,741	7.6			42,258	117.3	$758,943	$2.11
BAXTER	62,076	416,600	6.71	$65,005	$1.05	48,051	0.77	$46,085	$0.74	526	8.5	$5,898	$0.10	6,227	100.3	$111,090	$1.79
BAYSHORE	58,649	470,640	8.02	$69,899	$1.19	57,676	0.98	$54,317	$0.93	450	7.7	$5,097	$0.09	7,373	125.7	$124,216	$2.12
BEAR VALLEY	50,160	360,640	7.19	$54,509	$1.09	30,561	0.61	$30,960	$0.62	-				4,287	85.5	$85,469	$1.70
BEGICH	174,612	1,446,600	8.28	$211,594	$1.21	146,841	0.84	$132,109	$0.76	875	5.0	$10,622	$0.06	19,620	112.4	$343,704	$1.97
BENSON SECONDARY	27,275	277,280	10.17	$43,433	$1.59	18,656	0.68	$20,657	$0.76	150	5.5	$2,152	$0.08	2,812	103.1	$64,091	$2.35
BIRCHWOOD	48,276	392,160	8.12	$63,578	$1.32	32,202	0.67	$31,821	$0.66	460	9.5	$4,965	$0.10	4,558	94.4	$95,398	$1.98
BOWMAN	66,367	549,600	8.28	$83,093	$1.25	48,754	0.73	$45,982	$0.69	570	8.6	$6,247	$0.09	6,751	101.7	$129,075	$1.94
CAMPBELL	61,438	349,680	5.69	$53,543	$0.87	39,649	0.65	$37,126	$0.60	347	5.7	$4,093	$0.07	5,158	84.0	$90,670	$1.48
CENTRAL	95,837	581,600	6.07	$91,220	$0.95	65,161	0.68	$61,327	$0.64	470	4.9	$5,351	$0.06	8,501	88.7	$152,547	$1.59
CHESTER VALLEY	50,024	248,640	4.97	$38,652	$0.77	24,257	0.48	$25,473	$0.51	210	4.2	$2,936	$0.06	3,274	65.5	$64,124	$1.28
CHINOOK	57,314	541,360	9.45	$80,448	$1.40	42,318	0.74	$40,416	$0.71	500	8.7	$5,587	$0.10	6,079	106.1	$120,863	$2.11
CHUGACH	40,661	268,122	6.59	$43,743	$1.08	22,928	0.56	$24,356	$0.60	250	6.2	$2,992	$0.07	3,208	78.9	$68,100	$1.67
CHUGIAK - ES	61,468	488,400	7.95	$78,215	$1.27	37,734	0.61	$38,435	$0.63	430	7.0	$2,688	$0.04	5,440	88.5	$116,650	$1.90
CHUGIAK - HS	289,309	3,300,162	11.41	$506,212	$1.75	264,680	0.91	$244,025	$0.84	2,911	10.1	$29,587	$0.10	37,728	130.4	$750,238	$2.59
CLARK	180,000	1,298,600	7.21	$200,647	$1.11	103,083	0.57	$93,740	$0.52	860	4.8	$10,040	$0.06	14,739	81.9	$294,386	$1.64
COLLEGE GATE	60,034	342,060	5.70	$57,271	$0.95	29,819	0.50	$30,345	$0.51	470	7.8	$5,355	$0.09	4,149	69.1	$87,616	$1.46
CREEKSIDE PARK	59,825	495,040	8.27	$70,450	$1.18	49,941	0.83	$47,526	$0.79	590	9.9	$6,404	$0.11	6,683	111.7	$117,976	$1.97
DENALI	62,915	453,440	7.21	$77,834	$1.24	41,852	0.67	$40,715	$0.65	420	6.7	$4,661	$0.07	5,732	91.1	$118,549	$1.88
DIMOND-HS	242,440	3,300,520	13.61	$457,650	$1.89	261,545	1.08	$239,208	$0.99	3,162	13.0	$26,522	$0.11	37,416	154.3	$696,858	$2.87
EAGLE RIVER - ES	58,086	368,960	6.35	$58,477	$1.01	37,225	0.64	$36,708	$0.63	290	5.0	$3,533	$0.06	4,981	85.8	$95,185	$1.64
EAGLE RIVER - HS	182,752	1,421,760	7.78	$227,103	$1.24	99,067	0.54	$90,023	$0.49	670	3.7	$8,019	$0.04	14,758	80.8	$317,126	$1.74
EAST HS	342,568	3,025,800	8.83	$465,935	$1.36	275,435	0.80	$245,368	$0.72	2,872	8.4	$31,543	$0.09	37,868	110.5	$711,303	$2.08
FACILITIES/ MAINTENANCE	63,100	966,000	15.31	$124,652	$1.98	22,618	0.36	$24,015	$0.38	875	13.9	$5,075	$0.08	5,558	88.1	$148,668	$2.36
FAIRVIEW	64,312	512,800	7.97	$83,090	$1.29	37,496	0.58	$36,942	$0.57	440	6.8	$4,831	$0.08	5,499	85.5	$120,032	$1.87
FIRE LAKE	50,160	398,704	7.95	$64,659	$1.29	42,341	0.84	$41,081	$0.82	400	8.0	$4,612	$0.09	5,594	111.5	$105,740	$2.11
GIRDWOOD	25,110	244,400	9.73	$35,072	$1.40	15,958	0.64	$15,713	$0.63	160	6.4	$1,963	$0.08	2,430	96.8	$50,785	$2.02
GLADYS WOODS	47,777	414,720	8.68	$63,311	$1.33	22,976	0.48	$25,071	$0.52	280	5.9	$3,456	$0.07	3,713	77.7	$88,382	$1.85
GOLDENVIEW	159,209	1,227,440	7.71	$173,517	$1.09	58,846	0.37	$55,501	$0.35	720	4.5	$7,957	$0.05	10,073	63.3	$229,018	$1.44
GOVERNMENT HILL	58,401	553,760	9.48	$83,387	$1.43	35,636	0.61	$35,438	$0.61	438	7.5	$56,226	$0.96	5,453	93.4	$118,825	$2.03
GRUENING	124,862	1,089,720	8.73	$172,029	$1.38	53,057	0.42	$50,715	$0.41	1,130	9.1	$11,835	$0.09	9,024	72.3	$222,744	$1.78
HANSHEW	150,085	1,392,960	9.28	$199,480	$1.33	83,517	0.56	$77,048	$0.51	751	5.0	$8,053	$0.05	13,105	87.3	$276,528	$1.84
HOMESTEAD	51,965	378,240	7.28	$60,984	$1.17	30,668	0.59	$30,994	$0.60	439	8.5	$5,003	$0.10	4,357	83.9	$91,978	$1.77

HUFFMAN	60,610	406,400	6.71	$62,608	$1.03	33,812	0.56	$33,786	$0.56	-				4,768	78.7	$96,394	$1.59
INLET VIEW	32,470	236,640	7.29	$37,431	$1.15	25,886	0.80	$26,905	$0.83	260	8.0	$3,062	$0.09	3,396	104.6	$64,335	$1.98
IT@WEST	-	81,600	0.00	$12,385	$0.00	3,763	0.00	$4,454	$0.00	324	0.0	$3,625	$0.00	655		$16,839	#DIV/0!
KASUUN	61,599	506,880	8.23	$77,189	$1.25	55,716	0.90	$52,863	$0.86	600	9.7	$6,570	$0.11	7,301	118.5	$130,053	$2.11
KINCAID	61,599	634,480	10.30	$93,551	$1.52	44,927	0.73	$44,765	$0.73	530	8.6	$5,882	$0.10	6,658	108.1	$138,316	$2.25
KING CAREER CENTER	133,669	1,410,240	10.55	$215,769	$1.61	111,966	0.84	$102,854	$0.77	959	7.2	$10,450	$0.08	16,008	119.8	$318,622	$2.38
KLATT	50,160	373,360	7.44	$55,434	$1.11	34,610	0.69	$34,414	$0.69	419	8.4	$4,530	$0.09	4,735	94.4	$89,849	$1.79
LAKE HOOD	61,599	479,520	7.78	$74,978	$1.22	53,282	0.86	$50,665	$0.82	450	7.3	$5,097	$0.08	6,964	113.1	$125,643	$2.04
LAKE OTIS	57,897	442,800	7.65	$64,478	$1.11	31,101	0.54	$31,382	$0.54	660	11.4	$7,213	$0.12	4,621	79.8	$95,860	$1.66
MEARS	150,506	1,109,095	7.37	$162,717	$1.08	79,208	0.53	$72,804	$0.48	649	4.3	$6,776	$0.05	11,705	77.8	$235,522	$1.56
MIRROR LAKE	158,630	1,314,657	8.29	$214,060	$1.35	71,772	0.45	$66,458	$0.42	577	3.6	$3,600	$0.02	11,663	73.5	$280,518	$1.77
MOUNTAIN VIEW	58,158	487,040	8.37	$74,696	$1.28	29,977	0.52	$30,479	$0.52	520	8.9	$5,681	$0.10	4,659	80.1	$105,175	$1.81
MT ILLIAMNA	31,300					27,507	0.88	$28,298	$0.90	-				2,751	87.9	$28,298	$0.90
MT SPURR	42,223					19,699	0.47	$21,552	$0.51	-				1,970	46.7	$21,552	$0.51
MULDOON	61,599	538,560	8.74	$82,226	$1.33	65,457	1.06	$61,052	$0.99	580	9.4	$6,218	$0.10	8,383	136.1	$143,278	$2.33
NORTHERN LIGHTS	61,599	507,600	8.24	$80,576	$1.31	42,979	0.70	$41,621	$0.68	620	10.1	$6,709	$0.11	6,030	97.9	$122,197	$1.98
NORTHSTAR	75,674	390,400	5.16	$62,208	$0.82	52,980	0.70	$50,434	$0.67	590	7.8	$6,476	$0.09	6,630	87.6	$112,642	$1.49
NORTHWOOD	61,115	502,880	8.23	$74,556	$1.22	46,792	0.77	$45,019	$0.74	540	8.8	$5,716	$0.09	6,395	104.6	$119,575	$1.96
NUNAKA VALLEY	44,100	301,600	6.84	$47,966	$1.09	22,988	0.52	$24,363	$0.55	346	7.9	$3,882	$0.09	3,328	75.5	$72,329	$1.64
OCEAN VIEW	59,736	576,320	9.65	$85,299	$1.43	39,034	0.65	$38,106	$0.64	451	7.6	$4,877	$0.08	5,870	98.3	$123,405	$2.07
OMALLEY	50,253	314,560	6.26	$46,268	$0.92	40,215	0.80	$39,384	$0.78	-				5,095	101.4	$85,652	$1.70
OPERATIONS	3,068	134,160	43.73	$17,976	$5.86	2,810	0.92	$2,585	$0.84	-				739	240.8	$20,561	$6.70
ORION	82,488					49,548	0.60	$47,455	$0.58	-				4,955	60.1	$47,455	$0.58
POLARIS ALTERNATIVE	75,264	543,900	7.23	$84,343	$1.12	50,525	0.67	$48,295	$0.64	410	5.5	$4,667	$0.06	6,908	91.8	$132,637	$1.76
PTARMIGAN	59,275	553,920	9.34	$90,363	$1.52	36,155	0.61	$35,782	$0.60	500	8.4	$5,649	$0.10	5,505	92.9	$126,145	$2.13
RABBIT CREEK	53,633	390,000	7.27	$55,819	$1.04	43,494	0.81	$43,516	$0.81	637	11.9	$6,670	$0.12	5,680	105.9	$99,335	$1.85
RAVENWOOD	50,160	322,880	6.44	$51,840	$1.03	36,430	0.73	$36,073	$0.72	-				4,745	94.6	$87,912	$1.75
ROGERS PARK	55,403	543,840	9.82	$83,566	$1.51	32,763	0.59	$33,039	$0.60	960	17.3	$10,100	$0.18	5,132	92.6	$116,605	$2.10
ROMIG	125,614	910,000	7.24	$147,744	$1.18	79,062	0.63	$73,232	$0.58	1,090	8.7	$9,706	$0.08	11,011	87.7	$220,975	$1.76
RUSSIAN JACK	61,599	535,840	8.70	$84,342	$1.37	50,574	0.82	$48,216	$0.78	580	9.4	$6,274	$0.10	6,886	111.8	$132,557	$2.15
SAND LAKE	62,500	435,200	6.96	$66,111	$1.06	21,037	0.34	$22,183	$0.35	500	8.0	$5,588	$0.09	3,589	57.4	$88,294	$1.41
SAVE ALTERNATIVE	18,580	174,640	9.40	$28,604	$1.54	14,539	0.78	$13,526	$0.73	120	6.5	$1,569	$0.08	2,050	110.3	$42,130	$2.27
SCENIC PARK	50,912	476,520	9.36	$71,047	$1.40	33,724	0.66	$33,657	$0.66	375	7.4	$4,354	$0.09	4,998	98.2	$104,704	$2.06
SERVICE-HS	344,360	3,816,243	11.08	$541,465	$1.57	285,651	0.83	$255,221	$0.74	1,185	3.4	$12,338	$0.04	41,586	120.8	$796,686	$2.31
SOUTH-HS	265,000	2,014,200	7.60	$284,499	$1.07	166,315	0.63	$148,719	$0.56	2,035	7.7	$16,417	$0.06	23,504	88.7	$433,218	$1.63
SPRING HILL	50,160	337,920	6.74	$50,654	$1.01	26,880	0.54	$27,806	$0.55	570	11.4	$6,246	$0.12	3,841	76.6	$78,460	$1.56
STELLER ALTERNATIVE	47,765	417,440	8.74	$63,988	$1.34	21,455	0.45	$23,080	$0.48	240	5.0	$3,000	$0.06	3,570	74.7	$87,068	$1.82
STUDENT NUTRITION	48,729	942,400	19.34	$122,951	$2.52	56,054	1.15	$52,869	$1.08	1,240	25.5	$16,178	$0.33	8,821	181.0	$175,820	$3.61
STUDENT TRANSPORTATION	11,574	734,323	63.45	$93,732	$8.10	15,527	1.34	$18,111	$1.56	300	25.9	$4,453	$0.38	4,058	350.6	$111,843	$9.66
SUSITNA	55,023	462,480	8.41	$68,712	$1.25	33,746	0.61	$33,675	$0.61	527	9.6	$5,590	$0.10	4,953	90.0	$102,387	$1.86
TAKU	53,270	459,520	8.63	$69,072	$1.30	28,136	0.53	$28,261	$0.53	530	10.0	$5,883	$0.11	4,382	82.3	$97,333	$1.83
TRAILSIDE	61,599	478,960	7.78	$71,055	$1.15	42,679	0.69	$41,478	$0.67	460	7.5	$5,194	$0.08	5,902	95.8	$112,534	$1.83
TUDOR	56,755	451,520	7.96	$67,202	$1.18	27,132	0.48	$28,009	$0.49	430	7.6	$4,962	$0.09	4,254	74.9	$95,211	$1.68
TURNAGAIN	54,000	418,080	7.74	$65,742	$1.22	33,647	0.62	$33,605	$0.62	506	9.4	$5,384	$0.10	4,791	88.7	$99,348	$1.84
TYSON, WILLIAM	61,599	530,880	8.62	$84,072	$1.36	41,367	0.67	$40,330	$0.65	670	10.9	$7,318	$0.12	5,948	96.6	$124,402	$2.02
WAREHOUSE/ PURCHASING	60,000	434,520	7.24	$62,376	$1.04	18,266	0.30	$20,322	$0.34	80	1.3	$1,173	$0.02	3,309	55.2	$82,698	$1.38
WENDLER	114,461	924,840	8.08	$138,819	$1.21	107,168	0.94	$97,252	$0.85	740	6.5	$7,493	$0.07	13,872	121.2	$236,071	$2.06
WEST-HS	323,311	3,824,700	11.83	$535,251	$1.66	280,627	0.87	$245,865	$0.76	3,923	12.1	$40,117	$0.12	41,113	127.2	$781,116	$2.42
WHALEY ALTERNATIVE	52,188	565,373	10.83	$87,930	$1.68	22,046	0.42	$23,599	$0.45	390	7.5	$4,989	$0.10	4,134	79.2	$111,529	$2.14
WILLAWAW	56,500	474,000	8.39	$74,942	$1.33	26,245	0.46	$27,181	$0.48	610	10.8	$6,491	$0.11	4,242	75.1	$102,123	$1.81
WILLOW CREST	54,304	499,080	9.19	$75,210	$1.38	33,680	0.62	$33,675	$0.62	630	11.6	$6,714	$0.12	5,071	93.4	$108,884	$2.01

WONDER PARK	52,638	423,840	8.05	$66,531	$1.26	31,665	0.60	$31,874	$0.61	527	10.0	$5,590	$0.11	4,613	87.6	$98,405	$1.87
AVAIL SPACE 102	-	15,163	0.00	$2,428	$0.00									52		$2,428	
AVAIL SPACE 104	-	10,453	0.00	$1,731	$0.00									36		$1,731	
RABBIT CREEKSecurity Lighting		53,633		$7,976										183		$7,976	
TUDORSecurity Lighting		56,755		$8,441										194		$8,441	
WILLOW CRESTSecurity Lighting		54,304		$8,076										185		$8,076	
RAVENWOODPole Security Lighting		50,160		$7,460										171		$7,460	
BARTLETT-HSEnergy Cost Adjustment		360,209		$53,571										1,229		$53,571	
TOTAL	**7,627,558**	**67,458,774**	**8.84**	**$10,032,934**	**$1.32**	**5,305,538**	**0.70**	**$5,015,456**	**$0.66**	**57,634**	**0.0**	**$631,058**	**$0.08**	**760,723**	**99.7**	**$15,048,390**	**$1.97**

APPENDIX C2. AWWU ENERGY FACILITY ENERGY CONSUMPTION 2015

All Facilities	Electricity Cost ($)	Electricity (kWh)	Natural Gas Cost ($)	Natural Gas (CCF)	Total Cost ($)	Electricity (MMMBtu)	Gas (MMMBtu)	Total Energy (MMMBtu)
ML&P	553,506	2,928,027			553,506	10.0	-	10.0
Chugach	1,448,535	9,377,713			1,448,535	32.0	-	32.0
MEA	561,444	3,309,393			561,444	11.3	-	11.3
Enstar	-		994,989	1,064,531	994,989	-	106.5	106.5
Total	2,563,485	15,615,133	994,989	1,064,531	3,558,474	53.3	106.5	159.7
Major thermal loads	**Electricity Cost ($)**	**Electricity (kWh)**	**Natural Gas Cost ($)**	**Natural Gas (CCF)**	**Total Cost ($)**	**Electricity (MMMBtu)**	**Gas (MMMBtu)**	**Total Energy (MMMBtu)**
Asplund WWTF	418,015	3,335,520	606,935	672,716	1,024,950	11.4	67.3	78.7
Eklutna WTF			107,490	123,023	107,490	-	12.3	12.3
Eagle River WWTF	271,152	1,658,520	43,733	48,404	314,885	5.7	4.8	10.5
Ship Cr WTF			42,181	44,292	42,181	-	4.4	4.4
AWWU Op and Maint	165,758	658,320	42,011	45,054	207,769	2.2	4.5	6.8
AWWU Op and Maint			32,764	31,840	32,764	-	3.2	3.2
Girdwood WWTF	146,552	1,150,800	19,539	21,228	166,091	3.9	2.1	6.0
Headquarters	104,723	773,520	14,061	14,974	118,784	2.6	1.5	4.1
Total	**1,106,199**	**7,576,680**	**908,715**	**1,001,530**	**2,014,914**	**26**	**100**	**126**
Percent of All Facilities	**43%**	**49%**	**91%**	**94%**	**57%**	**49%**	**94%**	**79%**

APPENDIX C3. MAINTENANCE AND OPERATIONS FACILITY ENERGY CONSUMPTION AND AUDIT SUMMARY

Building Name	Physical Address	Benchmark Area (sf)	Ave. EUI (kBtu/sf)	Ave. ECI ($/sf)	Ave annual cost ($)	E-Factor (EUI x Cost)/100,000	Energy Use (MMMBtu/yr)	EEM Cost from Audit	EEM Savings from Audit	Ave Energy Cost (09-10)	Simple payback (yr)	Energy Cost Reduction
Anchorage Police Dept Headquarters	4501 Elmore Road	73,319	176.6	$4.03	$253,495	448	13	$324,326	$46,667	$253,495		
Anchorage Senior Center	1300 E. 19th Ave.	37,000	164.2	$2.48	$92,535	152	6	$130,520	$28,181	$92,535		
Animal Control	4711 Elmore	21,048	367.9	$4.94	$103,932	382	8					
APD Training Facility	3740 W. Dimond Blvd.	42,574	228.2	$4.03	$194,350	444	10	$147,015	$27,088	$194,350		
Ben Boeke Ice Arena	334 E. 16th Ave.	59,685	171.2	$3.48	$207,537	355	10					
Bering St Heavy Shop	4333 Bering St	27,834	0.0	$0.00	$0	0						
Bering St Light Shop	4337 Bering St	5,000	0.0	$0.00	$0	0						
Bering St. Heavy Shop	4333 Bering St.	27,834	140.5	$2.39	$66,530	93	4					
Bering St. Light Shop	4337 Bering St.	5,000	227.2	$3.65	$18,248	41	1					
Chugiak Senior Center	22424 N. Birchwood Loop Rd.	84,075	106.2	$1.80	$131,471	140	9	$326,475	$46,311	$131,471		
Clitheroe Center/Detox	8000A W. End Road	25,158	139.9	$2.88	$72,466	101	4					
Clitheroe Center/Duplex	8000B W. End Road	3,150	31.9	$1.19	$3,735	1	0					
Dempsey Anderson Ice Arena	1741 W. Northern -lights Blvd.	55,610	333.5	$5.44	$320,750	1,070	19	$345,137	$158,893	$320,750		
Egan Convention Center	555 W. 5th Ave.	98,318	130.6	$2.63	$258,332	337	13					
Emergency Operations Center		12,000	21.5	$0.22	$2,599	1						
Fairview Rec Center (new)	1121 E. 10th Ave.	20,162	195.0	$3.03	$61,069	119	4	$216,598	$33,841	$61,069	includes "old" too	
Fairview Rec Center (old)	1217 E. 10th Ave. (formerly 940 LaTouche St)	4,500	210.8	$3.36	$13,432	28	1					

Fine Arts Museum/ Anchorage Museum at Rasmussan Center	625 C Street	123,000	302.2	$4.98	$612,891	1,852	37					
Fire Station #1 & FS Admin Offices	122 E 4th & 100 E 4th	38,875	225.0	$2.94	$87,925	198	9	$99,143	$26,493	$87,925		
Fire Station #10	14861 Mountain Air Road	6,900	126.9	$2.26	$15,587	20	1					
Fire Station #11	16630 Eagle River Road	9,322	149.5	$3.04	$32,307	48	1	$60,028	$9,150	$32,307		
Fire Station #12 & Dispatch	1301 E 80th & 7920 Homer (Comb)	18,560	167.2	$3.33	$98,805	165	3	$211,277	$31,626	$98,805		
Fire Station #14 (Ref #7)	4501 Campbell Airstrip Road	10,700	125.7	$1.99	$21,265	27	1					
Fire Station #15	11301 Southport Drive	8,500	146.2	$2.32	$19,690	29	1					
Fire Station #41 and Library/ Community Center	186 Egloff Drive	8,064	386.3	$6.27	$50,561	195	3					
Fire Station #7 (Ref #14)	3801. W 88th	10,700	124.1	$1.43	$15,271	19	1					
Fire Station #8	6151 O'Malley Road	6,093	166.4	$2.96	$18,049	30	1					
Fire Training Center	1140 Airport Heights Drive	11,614	108.7	$3.61	$41,876	46	1					
Fire Vehicle Maintenance	1000 Airport Heights Drive	11,520	165.5	$2.86	$32,941	55	2					
Goose Lake Bath House	2811 UAA Drive	4,588	0.0	$0.00	$0	0						
Government Hill Comm Center	432 Harvard Ave.	8,250	91.4	$1.33	$10,948	10	1					
HJ McDonald Memorial Center	13701 Harry McDonald Rd	37,300	111.5	$1.06	$39,379	44						
John Thomas Building	325 E. 3rd Avenue	14,640	135.5	$2.21	$32,293	44	2					
Loussac Library	3600 Denali Street	135,671	151.6	$2.76	$373,697	566	21	$742,550	$119,652	$373,697		
MOA Warehouse #1	3640 E. Tudor Road	10,500	131.7	$2.13	$22,308	29	1					
MOA Warehouse #2	3630 E. Tudor Road	9,000	163.8	$2.97	$26,670	44	1					
Mt. View Rec Center	315 Price Street	27,392	98.8	$1.63	$44,517	44	3	$110,235	$13,246	$44,517		

Muldoon Street Maintenance	109 Muldoon Rd (orig 7909 Boundary)	3,300	129.0	$1.62	$5,344	7	0					
Northwood Storage	5815 Northwood	2,500	0.0	$0.00	$0	0						
Northwood Street Maint. KLOEP	5701 Northwood Drive	23,800	261.2	$3.43	$87,973	230	6	$252,981	$58,052	$87,973		
Northwood Warm Storage	5601 Northwood Drive	60,000	103.3	$0.97	$57,987	60	6					
O'Malley Golf Course	3651 O'Malley Road	8,658	580.1	$10.45	$90,437	525	5					
Old City Hall Bldg	524 W. 4th Ave.	15,700	129.8	$2.07	$32,440	42	2					
Parks & Rec North Maint	2839 Mt. View Dr., Bldg's A & B	6,656	424.2	$5.21	$34,691	147	3					
Parks & Rec South Maint	11440 Lang Street	8,400	166.3	$2.37	$19,930	33	1					
Performing Arts Center	621 W. 6th Ave.	170,000	80.4	$1.55	$263,357	212	14					
Pool / Bartlett HS	25-500 N. Muldoon Rd.	32,704	309.6	$4.84	$194,185	601	10	$291,025	$142,590	$194,185		
Pool / Chugiak HS	16525 S. Birchwood Loop Rd.	18,580	159.9	$2.74	$50,815	81	3					
Pool / Dimond HS	2909 W. 88th Ave.	22,332	163.5	$3.06	$68,220	112	4					
Pool / East HS	4025 E. Northern -lights Blvd.	22,301	285.3	$3.62	$80,763	230	6					
Pool / Service HS	4477 Abbott Road	15,590	347.9	$4.87	$85,024	296	5					
Pool / West HS	1700 Hillcrest Drive	22,480	284.5	$4.42	$99,777	284	6	$220,460	$48,650	$99,777		
Sign & Paint Shop	2839 Mt. View Drive, #A	16,456	161.3	$1.77	$29,050	47	3					
Spenard Rec Center	2020 W. 48th Ave.	32,565	150.2	$2.33	$94,401	142	5	$29,807	$14,986	$94,401		
Sullivan Arena	1600 Gambell Street	146,000	143.4	$2.56	$387,219	555	21	$624,941	$173,451	$387,219		
Transit Admin Bldg	3600 Dr Martin Luther King, A (orig 3650A E Tudor Rd)	17,000	195.0	$3.55	$67,485	132	3	$63,704	$27,333	$67,485		
Transit Maintenance (New) - "Paint Booth"	3701 Dr Martin Luther King, D (orig 3650D E Tudor Rd)	70,000	208.8	$3.00	$322,893	674	15	$179,066	$55,259	$322,893		

Transit Maintenance (Old) - "Radio Shop" and Paratransit Offices	3601 Dr Martin Luther King, C (orig 3650C E Tudor Rd) and 3625A Dr. Martin Luther King	35,825	196.1	$3.33	$136,295	267	7	$98,986	$29,283	$136,295		
Transit Warm Storage	3555 Dr Martin Luther King, B, (orig 3650B E Tudor Rd)	52,110	124.8	$1.77	$92,199	115	7					
Woodland Park School (HLB)	2300 W. 36th Ave.	39,100	108.0	$1.65	$64,314	69	4					
TOTAL		1,955,513			5,762,246		329	$4,474,274	$1,090,752	$3,081,145	4.1	35%

APPENDIX C4. SOLID WASTE SERVICE FACILITY ENERGY CONSUMPTION AND COST 2015

Site	Facility	Square footage	Primary use	Secondary use	Utilities	Enstar Natural Gas (2015) Usage (CCF)	Enstar Natural Gas (2015) Cost	Electricity Total (2015) Usage (kWh)	Electricity Total (2015) Cost	Total MMBtu	kBtu/ sf
Anchorage Regional Landfill	Shop / Admin	22,000	Equipment shop / warm storage	Office/ breakroom space (6700 sf)	Natural gas heat	22,223	23,479	381,200	$62,991	3,523	160
	Hazardous Waste	6,000	Consumer product sorting and packaging (lighting, space heating)		Natural gas heat	21,299	18,646	65,820	$10,991	2,355	392
	Blower / Flare Building	1,600	LFG blowers, space heating		Electric heat			221,560	$36,679	756	472
	Gas Processing Building	1,800	Lfg processing for Power Plant use (blowers, glycol chiller, space heating)		Electric heat			928,640	$150,579	3,169	1,760
	Leachate	1,100	leachate handling (aeration blowers, truck loading pumps, space heating		Electric heat			512,240	$82,959	1,748	1,589
	Recycle Dropoff	N/A	Compactor containers for recycle product		No structure			8,069	$1,694	28	
Central Transfer Station	Transfer Station	30,500	Waste processing (electric cranes, lighting, snow melt system)			51,136	52,069	432,400	$66,870	6,589	216
	Admin / Warm Storage		Vehicle storage and maintenance	Office space		54,655	49,786	431,600	$57,383	6,938	
	AAA Office	4,700	Heated storage			1,535	1,455	34,840	$4,826	272	
	AAA Storage	2x4,400	Heated storage			1,789	1,698	10,040	$1,592	213	
Merrill Field (Power from ML&P)	LFG Blower	760	LFG extraction blowers		unheated shed	5	$1,371	34,737	$5,446	119	157
	Groundwater lift station	N/A	Sewage pumps		underground vaults, no heat					0	
TOTAL		68,460				152,643	$148,505	3,061,146	$482,009	25,709	

	Enstar Natural Gas (2015) Usage (CCF)	Enstar Natural Gas (2015) Cost	Electricity Total (2015) Usage (kWh)	Electricity Total (2015) Cost	Total MMBtu
Office Loads	101,502	95,065	923,500	137,782	13,301
Txfr Station Loads	51,136	52,069	432,400	66,870	6,589
Industrial Loads	5	1,371	1,705,246	277,357	5,819
TOTAL	152,643	148,505	3,061,146	482,009	25,709

APPENDIX D. INTERVIEWS CONDUCTED

Source	Affiliation
Ethan Berkowitz	Municipality of Anchorage
Ona Brause	Deputy Chief of Staff, MOA
Alec Mesdag	Alaska Electric Light & Power
Tony Friel	Anchorage School District
David Germer	JL Properties
Ted Hawley	HDR
Tim Kelly, Mark Madden, Travis Smith, Mark Spafford	Solid Waste Services
Mark Johnston, Jeff Warner, Antony Scott	Municipal Light & Power
Brett Jokela, Mark Spafford	Anchorage Water & Wastewater Utility
Mark Foster	MAFA, Inc.
Sonny Turpin, Allan Lucht	JBER
Amber McDonough	Siemens
Andrew Halcro	Anchorage Community Development Authority
Bart Rudolph, Mark Harlamert	MOA Transit
Hal Hart	MOA City Planner
Greg Porter	Arctic Energy, Inc.
Sisi Cooper	Chugach, Doyon
Paul Risse, Phil Steyer, Arthur Miller, Nick Horras	Chugach Electric Association
Steve Ribuffo	Port of Anchorage
Jim Jager	POA, ML&P
Craig Lyon, Jamie Acton	AMATS
Al Czajkowski	MOA-Maintenance & Operations
Chris Rose	Renewable Energy Alaska Project
Mike Abbott	MOA
Stephen Trimble	Arctic Solar Ventures
Nick Francis	Eklutna, Inc.
Julie Estey	Matanuska Electric Association
Rob Roys	Huntley & Associates
Darron Scott	Kodiak Electric Association
Alan Mitchell	Analysis North
Katie Conway	Alaska Energy Authority
Scott Waterman, Jimmy Ord	Alaska Housing Finance Corporation
John Sims	Enstar
Ben Loeffler	Fairbanks North Star Borough
Suzanne Settle, Ethan Schutt	Cook Inlet Region, Inc.
Stuart Brooks, Shawn Holdridge	Cook Inlet Housing Authority
Kent Banks	RurALCAP
John Fries	Alaska Waste

APPENDIX E. FNSB ENERGY MANAGER JOB DESCRIPTION AND ENERGY ANALYSIS

BASIC FUNCTION:

This position is a joint collaboration between FNSB and the Alaska Center for Energy and Power (ACEP) to provide coordination of programs and projects involving the development, implementation and evaluation of energy efficiency, energy delivery, and alternative and renewable energy systems throughout the Borough. The incumbent will provide analysis of utility billing and consumption, oversight of utility providers and continued development and management of the Borough's energy management program.

TYPICAL DUTIES:

1. Work with Borough stakeholders and ACEP researchers to evaluate emerging and existing energy efficient technologies relevant to the Borough.

2. Performs physical plant engineering duties; evaluates building systems for proper operation and recommends repairs and/or renovations, and changes in operational strategies that are necessary to continue effective operations of Borough facilities in conserving energy.

3. Provides input and recommendations for Capital Improvements Projects to reduce energy costs.

4. Serves as Project Manager for energy conservation projects.

5. Seek funding opportunities and prepare grant proposals for future projects and programs.

6. Develop, maintain and manage a utilities consumption database to monitor and audit utility billings and consumption.

7. Develop long-range plans for implementing energy conservation and recommend sound policies directed towards energy conservation.

8. Evaluate and develop potential projects or activities to lower utility costs to the Fairbanks North Star Borough and conserve energy, taking into consideration payback potential and other benefits.

9. Evaluate, promote and coordinate energy conservation measures with administration, facility managers, staff and the public.

10. Assists in developing and maintaining budget documents for predicting energy usage for future year budget.

11. Compile utility budgets and energy conservation measure cost estimates based upon documented program needs.

12. Provide regular reports as to the overall effectiveness of the energy management program, and provide annual report to the Borough Assembly.

MINIMUM QUALIFICATIONS:

1. A bachelor's degree in mechanical or electrical engineering from an ECPD or ABET accredited college, with an emphasis in building systems management, design and construction and facilities management. Professional registration as an engineer in the State of Alaska is preferred

2. Certified Energy Manager (CEM) is required for this position. If the applicant is not a current CEM, they must be able to complete certification within the probationary period for this position (6 months).

3. Three years of experience in energy management program analysis and development.

4. Three years of experience in building construction / energy management and conservation, and direct digital controls.

5. Demonstrated ability to collect, manage and analyze data.

6. Three years of experience in the design and project management of renewable energy projects.

7. Demonstrated ability to clearly and concisely prepare formal oral and written reports, technical studies and Power Point presentations. Must be capable of performing tasks independently.

8. Must be capable of comprehending facility drawings, specifications, and operation and maintenance manuals.

9. Demonstrated ability to write proposals to external funding agencies.

10. Must be available after hours to occasionally attend meetings and give presentations.

11. Demonstrated familiarity with personal computers and experience with AutoCAD, Microsoft Windows based word processing; spreadsheet and database software is required. (MS Office products)

12. Ability to understand and execute oral and written instructions, possess strong organizational skills and work effectively with co-workers and other job contacts.

13. Ability to develop positive and effective interpersonal relations; and communicate effectively, orally and in writing.

14. Must have and be able to maintain a valid driver's license. Must meet insurance standards and maintain insurability under the Borough's insurance program. If personal automobile is used for Borough business, proof of automobile insurance at statutory limits must be provided. (A CURRENT COPY OF DRIVING RECORD WILL BE REQUIRED AT TIME OF INTERVIEW.)

Figure 40. FNSB Energy Overview, FY 2016 Usage and Cost by Type

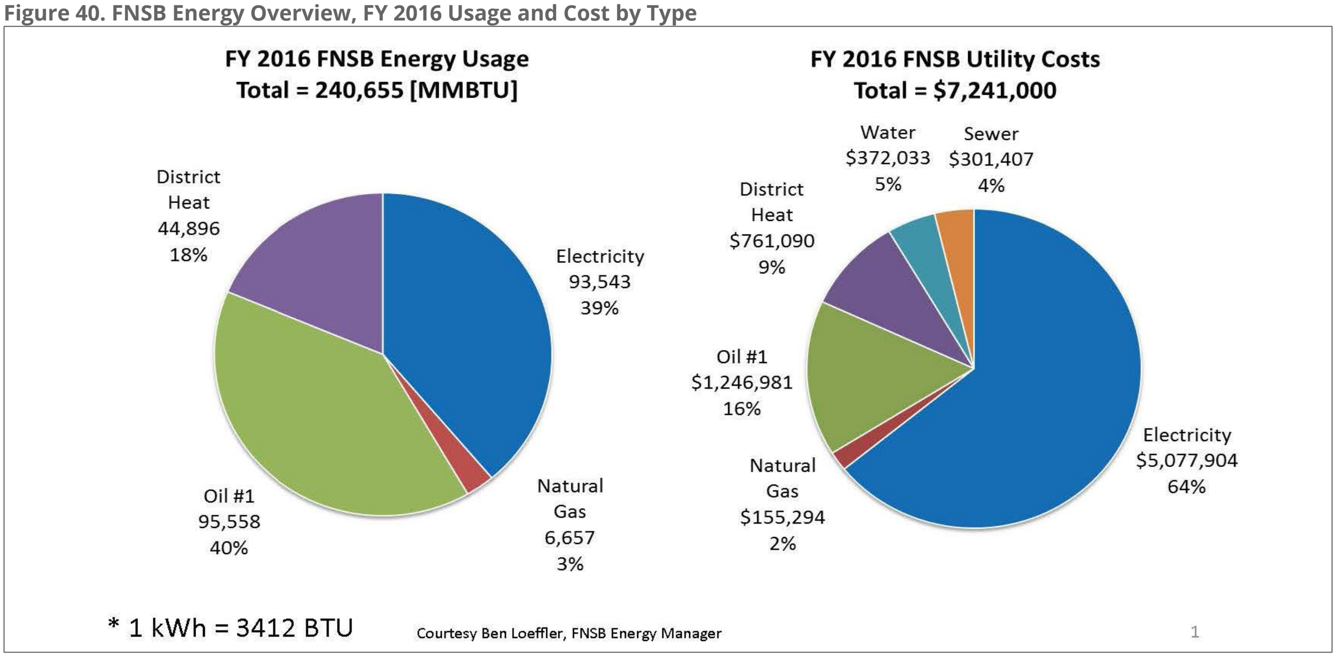

Figure 41. FNSB Energy Overview, Energy Usage Trends