



Alternative Fuels, Public Fleets

Phase I Technical Memo

May 2014



"Keep Alaska Moving through service and infrastructure."

Prepared By:



NORTHERN ECONOMICS INC.

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ABBREVIATIONS

AEL&P	Alaska Electric Light and Power
CAPEX	Capital Expenses
CARTS	Central Area Rural Transit System
CBG	Compressed Bio Gas
CBJ	City and Borough of Juneau
CNG	Compressed Natural Gas
DOT&PF	Alaska Department of Transportation and Public Facilities
EV	Electric Vehicle
FNG	Fairbanks Natural Gas
FNSB	Fairbanks North Star Borough
GGE	Gasoline Gallon Equivalent
JEDC	Juneau Economic Development Council
KPB	Kenai Peninsula Borough
LBG	Liquefied Bio Gas
LNG	Liquefied Natural Gas
MOA	Municipality of Anchorage
MSB	Matanuska-Susitna Borough
NEI	Northern Economics, Inc.
O&M	Operations and Maintenance
OPEX	Operating Expenses
UPS	Unite Parcel Service

EXECUTIVE SUMMARY

In December of 2013, the Alaska Department of Transportation and Public Facilities (DOT&PF) published a request for proposals related to Alternative Fuels for Fleet Use in Alaska. Northern Economics, based in Anchorage, submitted a proposal through DOT&PF's contract administrator, Kittelson & Associates, Inc., and was awarded this project.

This project consisted of two phases. Phase I provides research and interviews, along with an energy supply analysis, that led to a Technical Memo (this document) to be delivered to Kittelson, DOT&PF, and the Advisory Board. Review of this technical memo will direct any Go/No Go decision for Phase II.

Community fleets in the following five Alaska areas constitute the geographical scope of this project:

- Municipality of Anchorage (MOA)
- Matanuska-Susitna Borough (MSB)
- Fairbanks North Star Borough (FNSB)
- City and Borough of Juneau (CBJ)
- Kenai Peninsula Borough (KPB)

The focus of this project is on public fleets within these five boroughs, not on agency fleets (such as federal or state fleets) nor on individuals within the five boroughs, although discussion includes specific examples.

We have presented results in this Executive Summary as a series of questions and answers, focusing on major findings.

Within the five boroughs, who is using (or has used) alternative fuel vehicles?

The Municipality of Anchorage (MOA) owns a handful of compressed natural gas (CNG) cars, several small gas-electric hybrid cars (Toyota Prius) and one CNG-fueled school bus; it also installed a CNG refueling station near its fleet headquarters on Tudor Avenue. Within the other four boroughs, most testing and trial has been conducted by the private sector.

Fairbanks Natural Gas owns and operates a liquefied natural gas (LNG) plant near Point MacKenzie, supplying LNG to the Cook Inlet Region lodge at Talkeetna as well as commercial and residential customers in the Fairbanks North Star Borough (FNSB). Near Fairbanks, the National Park Service has tested propane-fueled vehicles under winter conditions.

The Matanuska-Susitna Borough (MSB) and the Kenai Peninsula Borough (KPB) have reviewed alternative fuel vehicles but have not purchased any yet. One spokesman at Palmer noted that there needs to be a strong economic case before his assembly would move on the issue; he was continuing to monitor the subject.



The City and Borough of Juneau (CBJ) adopted a transit development plan in 2008 that recommended fleet purchases of alternative fuel vehicles and possible consideration of advanced diesel, CNG and hybrid-electric vehicles. Juneau’s hydroelectric power is less expensive than diesel-fuel generation and that, coupled with the relatively shorter road distances in Juneau, suggests electric vehicles may be suitable. Transportation staff noted that private electric vehicles, such as the Chevrolet Volt and Nissan Leaf, are becoming more common in the capital.

What have these boroughs learned?

Specific lessons learned, overall, related to economic and financial considerations. Purchase costs (capital expenses or CAPEX) are overseen by borough staff and borough assemblies; without a clear economic case, it is difficult to advance alternative fuel vehicles. Operational costs (operations and maintenance expenses or OPEX) drive concerns of health and safety issues at maintenance facilities, training costs, and include life cycle cost concerns (do alternative fuel vehicles cost more or less over their entire operating cycle?).

What alternative fuels are there in the five boroughs?

Table ES-1 summarizes results for the five boroughs. Current fuels are summarized at the top half of the table (they do not include less plentiful fuels such as biodiesel, hydrogen, or biogas).

Also, the interest indicated by each of the five boroughs is the team’s interpretation of interviews, research and discussion; the rankings do not express any official borough position. The main context for these interest ratings is economic: with a strong economic case, interest in all five boroughs would likewise be much stronger.

Table ES-1. Five Boroughs, Summary of Alternative Fuel Availability, Concerns

Fuel Availability, Concerns	FNSB	MSB	MOA	KPB	CBJ
Fuels					
Propane	PFS	PFS	PFS	PFS	PFS
CNG	PVS	PVS	PFS	PVS	No Fuel
LNG	No Fac				
Electricity	No Fac	No Fac	No Fac	No Fac	PVS
Concerns					
Costs	Both	CAPEX	CAPEX	CAPEX	CAPEX
Maintenance	OPEX	CAPEX	CAPEX	CAPEX	OPEX
Training	OPEX	OPEX	OPEX	OPEX	OPEX
Interest in Alternative Fuel vehicles	Low	Mod	Mod	Low	High

Notes:

1. PFS refers to public filling station
2. PVS refers to private filling station.
3. No Fac means fuel is available, but no facility exists.
4. No Fuel means there is no fuel (or facility).
5. CAPEX refers to capital expense.
6. OPEX refers to operating (and maintenance) expense.

What concerns do fleet managers within the five boroughs have?

Interviews with public transit staff focused on three areas, noted below and in the bottom half of Table ES-1 (above).

- Costs of purchase and costs of operation are significant and in the current market traditional fueled vehicles are less expensive. One of those interviewed noted testing and trial can add expense that may be eliminated with a critical mass of vehicles, but no borough is yet at this stage.
- Maintenance facilities may require modification for fuels and emissions from CNG or LNG, both of which tend to rise upward instead of settling near the ground.
- Training for mechanics and service personnel is important. The estimated 10 to 15 electric vehicles in Juneau, for example, cannot receive warranty service as there are no trained personnel for either the Volt or Leaf models currently in the area.

Which of the boroughs seems most suitable for further alternative fuels work?

The CBJ presents a strong case for further alternative fuels use, especially as related to light-duty electric vehicles. Relatively lower cost hydroelectric power, including off-peak recharging hours and other load management techniques, are attractive as are the relatively shorter travel distances travels in the Juneau area. However, purchase price premiums for heavy duty vehicles (e.g., buses) are a significant hurdle to adoption.



INTRODUCTION

Alaska’s Community and Public Transportation Advisory Board provides input to the Alaska Department of Transportation and Public Facilities (DOT&PF) as directed under Alaska Statute 44.42.090, specifically “the use of alternative fuels, including compressed natural gas, liquefied natural gas, propane, and biodiesel in community and public transportation vehicle fleets and...recommendations for the use of alternative fuel vehicles where cost effective [emphasis added]” (<http://gov.alaska.gov>, 2014).

This technical memorandum helps the Board meet its directives related to alternative fuels and public fleets and is based on research, interviews, and analysis of public fleets in five Alaska boroughs, Canada and several high-latitude countries in Europe.

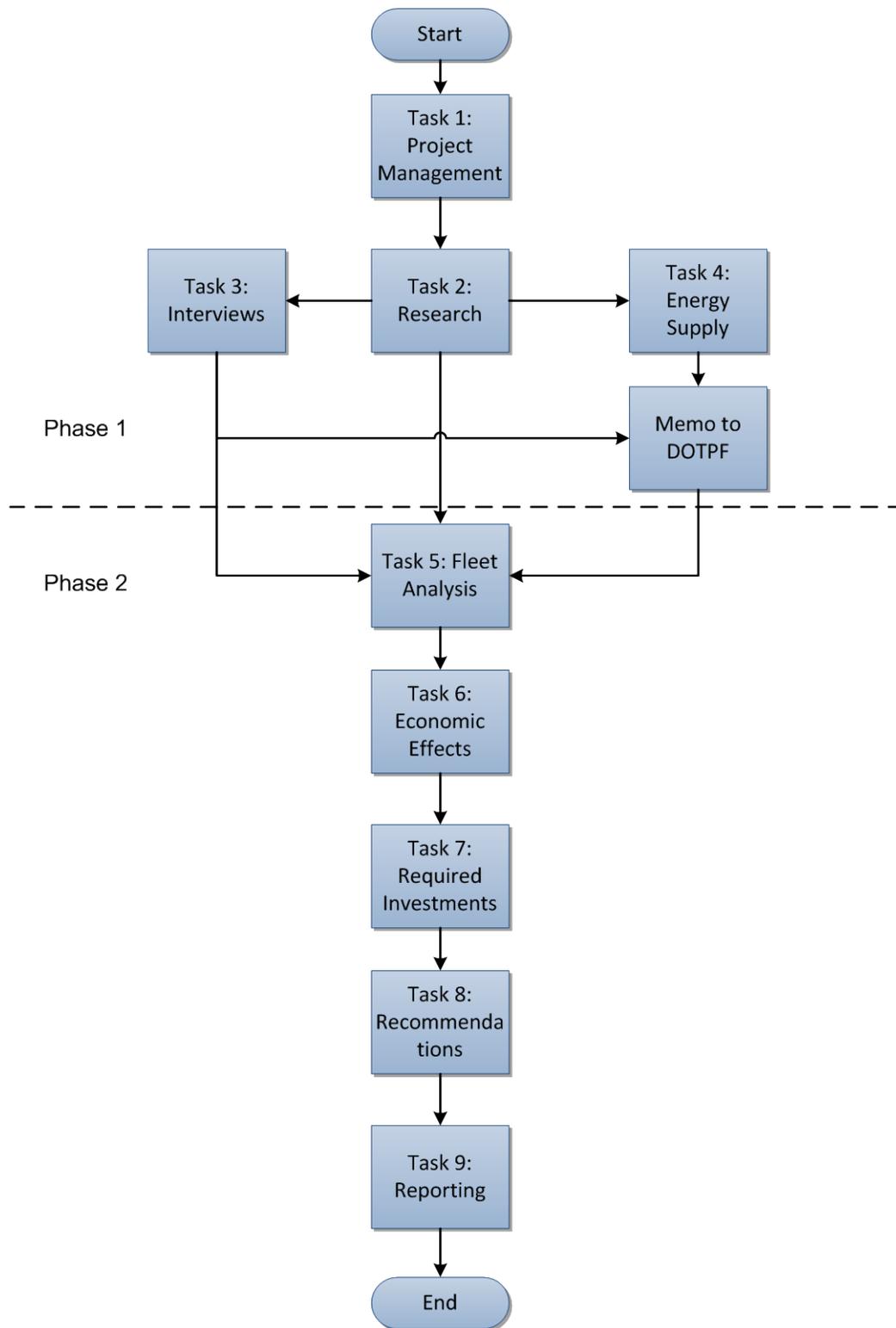
BACKGROUND

In December of 2013, DOT&PF published a request for proposals related to Alternative Fuels for Fleet Use in Alaska. Northern Economics, based in Anchorage, submitted a proposal through DOT&PF’s contract administrator, Kittelson & Associates, Inc., and was awarded this project.

This project consists of two phases. Phase I provides research and interviews, along with an energy supply analysis, that leads to a Technical Memo (this document) delivered to Kittelson, DOT&PF, and the Advisory Board. Review of this technical memo will direct any Go/No Go decision for Phase 2.

Figure 1 provides a graphical illustration of the project phases and tasks.

Figure 1. Project Flowchart, Phase 1 and 2, Alternative Fuels



The second project phase will potentially evaluate fleets in five geographic areas, consider economic effects, and estimate required investments to pinpoint where state investment would make the greatest impact on fleets.

PROJECT SCOPE

Community fleets in the following five Alaska areas constitute the geographical scope of this project:

- Municipality of Anchorage (MOA)
- Matanuska-Susitna Borough (MSB)
- Fairbanks North Star Borough (FNSB)
- City and Borough of Juneau (CBJ)
- Kenai Peninsula Borough (KPB)

The focus of this project is on public fleets within the five boroughs, not on agency fleets (such as federal or state fleets) nor on individuals within the five boroughs, although discussion includes specific examples.

It may be as important to note what was not considered in the project scope. Private companies, such as FedEx and UPS, have extensive experience with alternative fuels, with some reaching as far back as the 1930s. Although they have extensive history, they are not operating under the same constraints as public fleet managers.

Also, there are individuals within Alaska with extensive alternative fuel experience but they, too, operate under different constraints. Federal agencies, such as the National Park Service and the General Accounting Office, offer Alaska's federal agencies options on propane vehicles (Denali National Park) and electric vehicles (EV). Both propane and EVs are considered in testing or early adoption of potential vehicle fuels.

PROJECT TASKS

There are three main tasks for Phase I as shown in Figure 1:

- Conduct research
- Interview borough staff or representatives in the five boroughs
- Evaluate energy supply

Project team members conducted research and used results to develop questions for interviews; many of these sources are identified throughout this technical memo as well as the References section.

BACKGROUND RESEARCH AND INTERVIEWS

This section provides discussion and a summary of research results, along with interviews conducted for the project. There are only a very small number of alternative fuel vehicles within the five boroughs' public fleet, fewer than 20 in a total fleet that exceeds 2,000 vehicles, or approximately 1 percent.

Interviews suggested the five boroughs had varying degrees of interest in alternative fuel vehicles; several cited higher unit costs, coupled with retrofit costs for shop facilities, as well as increased training for mechanics and service personnel.

These increased costs could be difficult for borough officials to support, especially during times of budget constraints and contraction. At least three of the boroughs had reviewed the subject in detail (MOA, MSB, and CBJ) and elected to try small test units (MOA), monitor test results from other sectors (CBJ), or acknowledge the lack of a strong economic case (MSB).

Borough interviews led to three major concerns. First, almost all alternative fuel vehicles are more expensive than conventional units, with EVs cited most often with a price premium of \$8,000 to \$10,000 each. Managers did not have sufficient offsetting operations and maintenance costs to overcome higher capital costs, whether these operation costs were actual or perceived (if the borough did not own any alternative fuel vehicles).

Second, facility costs to meet safety and emission costs for certain alternative fuels (propane, compressed natural gas, liquefied natural gas) were estimated at \$600,000 to \$750,000, mainly for venting lighter-than-air combustible vapors.

Third, training costs for mechanics and support specialists are in the \$10,000 to \$15,000 range per person, depending on the vehicle, amount of training, and required refresher courses. Fuel supply issues were less of a concern for those interviewed.

Discussion in the following sections summarizes research within the five public boroughs.

MUNICIPALITY OF ANCHORAGE

The MOA owns and manages three fleets: a public transportation fleet, public works vehicles, and a utility/enterprise fleet. Vehicles include buses, trucks (heavy and light duty), heavy equipment, tankers, trailers, vans, and cars. The total MOA fleet count is approximately 1,900 vehicles and units of equipment (CH2M Hill, 2012). The MOA also owns hybrid vehicles, such as the Toyota Prius, that are considered alternative fuel vehicles for this memorandum.

The Anchorage School District, like many in the state, contracts student busing (approximately two-thirds of all routes) to firms that provide the service. The District owns one alternative fueled bus, powered by Compressed Natural Gas (CNG).



Public Transportation

MOA Public Transportation, also known as the People Mover, has approximately 53 fixed-route buses with maintenance performed by a staff of 32 workers. These buses are diesel-powered vehicles only. MOA Public Transportation owns approximately 10 vehicles powered by CNG as shown in Figure 2. This vehicle has a range of approximately 150 miles.

Figure 2. Municipality of Anchorage, Alternative Fuel Vehicle, Compressed Natural Gas



Source: Northern Economics

Public Works

Public Works maintains approximately 1,000 pieces of equipment for the Police Department, Parks and Recreation, general government, road maintenance and others within the MOA. Several vehicles are power by CNG on a test basis.

Utility/Enterprise Fleet

Within the MOA, there are three enterprise utilities that conduct business-like operations, supported by fees charged for power (Municipal Light and Power), water and wastewater (Anchorage Water and Wastewater Utility), and solid waste (Solid Waste Services). Each utility has its own facilities and mechanics. None of the vehicles in this fleet are powered by alternative fuels.

MOA staff have tested alternative fuels with a small number of vehicles and have obtained a moderate to low success rate. Refueling is one factor affecting CNG adoption by departments and operators. Figure 2 illustrates the MOA's CNG refueling facility at Tudor Avenue. Gas enters the system at the left, is metered, and is then compressed before reaching hose and nozzle connections at the right. Interviews suggested it could take up to 20 minutes to refuel a vehicle depending on the recovery time from the prior refueling.

Figure 3. Municipality of Anchorage, Compressed Natural Gas Facility



Source: Northern Economics

Another potential fuel use (CH2M, 2012) might be propane for the light duty fleet and Liquefied Natural Gas (LNG) for heavy vehicles. Conversion costs for the vehicles, along with maintenance facility changes to permit a safe working environment for alternative fuel vehicles, were deemed cost prohibitive. Increased costs are a strong disincentive during current budgeting cycles.

MATANUSKA-SUSITNA BOROUGH

The MSB's public works director notes the borough also has three fleets: MSB administrative vehicles (approximately 50 units), private school buses operating under a contract with the borough, and emergency service vehicles including fire, police, and ambulances.



The borough does use propane in certain equipment, such as warehouse forklifts but it has no propane or CNG powered vehicles.

The MSB, like other boroughs, is attempting to “Go Green,” where possible, but budgets tend to drive borough purchases. The price premium of up to \$10,000 per electric vehicle and other alternative fuel vehicles is an impediment. A borough planner noted almost any trip from Palmer requires at least 100 miles of travel, putting current electric vehicles out of contention.

CNG may be a good candidate for consideration though there are no CNG refueling stations in the MSB. LNG is, however, available. Fairbanks Natural Gas (FNG) manufactures LNG just west of Point MacKenzie and dispatches LNG trucks north; the CIRI (Cook Inlet Region Inc.) wilderness lodge at Talkeetna is heated by LNG and is supplied approximately twice each week during the tourist season.

Finally, the director noted a good economic case will sell itself to users as well as assembly members who watch budgets closely.

FAIRBANKS NORTH STAR BOROUGH

The FNSB Director of Transportation noted that the borough has approximately 150 vehicles in its fleet and, while it has looked at alternative-fuel vehicles, it decided against them for several reasons, mostly economic.

The easiest and most convenient alternative fuel for the borough would be CNG; FNG has a refueling site and is testing CNG on at least three company trucks. Though CNG shows promise at Fairbanks, FNG is constrained by its supplies from Cook Inlet gas producers. This could change if current plans to truck LNG south from a North Slope LNG plant are realized.

Fairbanks can experience temperatures colder than -50 degrees F in the winter. Since propane liquefies at approximately -44 degrees F, its use may need to be supplemented with external heating, such as the electric plug-in posts common throughout the FNSB. One propane user noted difficulty with carburetor icing during severe cold.

There are no known electric vehicles or public recharging stations in Fairbanks, though EVs manufactured by both Chevrolet and Nissan could be sold through local dealerships. A basic question is whether electric vehicles could sustain both reasonable driving distances and the ability to keep the vehicle and its passengers warm during the winter.

If a sufficient number of alternative-fuel vehicles were purchased by the FNSB, maintenance facilities would need upgrading and the borough would need to incur additional mechanical and safety training costs for staff. There are currently no maintenance training and support facilities for alternative fuel vehicles in Fairbanks.

The estimated purchase price of a conventionally fueled bus is approximately \$400,000, while the price for a diesel-electric hybrid is approximately \$625,000 or a price premium of \$225,000, based on

experience in Olympia, Washington. The typical life span of a bus in the FNSB is 10 to 12 years, suggesting an additional cost per year of \$17,000 to \$20,000 (rounded) for the diesel hybrid, according to the director.

CITY AND BOROUGH OF JUNEAU

Team members interviewed staff at Public Works, including the Streets and Fleets Superintendent and the Transportation Superintendent. The CBJ owns approximately 300 pieces of equipment, maintained by four full-time mechanics.

The CBJ bus fleet consists of 18, 35-foot buses and 11 para-transit buses or vans. In addition, there are six other vehicles for snow plowing and shuttling drivers. The latter vehicles might be candidates for hybrid gas-electric vehicles with the Ford Escape specifically mentioned.

Electric vehicles may be the most suitable candidate for use in Juneau, given relatively short driving distances on a constrained road system, with relatively low-cost hydroelectric power.

The Juneau Economic Development Council (JEDC) is sponsoring a project to place additional public recharge sites at five locations: Sandy Beach, Eaglecrest Ski Area, Eagle Beach Recreation Area, the University of Alaska Southeast and a downtown parking garage (Juneau Empire, 2014). JEDC will monitor and report on the program, once implemented. A key factor is whether reduced operating expenses (OPEX) can overcome the higher capital expenses (CAPEX).

The local utility, Alaska Electric Power and Light (AEL&P) requested and received permission from the Regulatory Commission of Alaska to operate ten test EVs for a year. A spokesperson for the utility noted that there are approximately 10 to 15 EVs in Juneau consisting of Chevy Volts and Nissan Leafs; AEL&P owns a Volt that is operated by the utility's president. The Volt recharges in approximately 2.5 hours from a half battery charge, using a 3 kW charger. It has a 40-mile range while the Leaf has a longer reach, up to 70 miles in a single charge. The Chevy Volt has approximately a 100 mile gallon of gas equivalent (GGE) rating.

Other potential EVs in Juneau might be tour buses. Alaska Coach Tours owns between 90 and 100 buses that transport cruise ship passengers to tourist sites at Juneau; the estimated purchase price of an all-electric bus for Juneau is approximately \$500,000 with a retrofit of existing buses at \$100,000 to \$200,000 each.

CBJ staff expressed concerns about warranty service; although the local Chevrolet dealer now has trained staff, Nissan lacks trained mechanics to service the EV fleet. If necessary, mechanics may need to be flown into town.

Peak load demand is another concern for the utility. Both EV buses and potential shore-power connections for cruise ships consume large amounts of electricity in relatively short time periods,



creating higher-cost, peak-load charges. Off-peak battery recharging, from an overnight connection for example, would reduce costs and flatten demand.

KENAI PENINSULA BOROUGH

Northern Economics contacted the Executive Director of the Central Area Rural Transit System (CARTS) for discussion of the KPB's fleet and alternative fuels. CARTS notes it serves the cities of Soldotna and Kenai, as well as the communities of Kasilof, Nikiski, and Sterling, and all points in between (<http://ridecartsak.org>, 2014).

The KPB itself has no public transportation fleet and CARTS, which does provide this service, does not have any alternative-fuel vehicles.

CARTS expressed concerns similar to others interviewed, related to fuel availability and qualified mechanical service for maintenance or repair of alternative-fuel vehicles.

INTERVIEW CONCERNS

Interviews with the five boroughs revealed three main concerns, all of which are common to some degree in all five areas. These are cost, maintenance, and training, discussed below.

Cost

Purchase costs are a concern due to limited budgets. That said, public transit vehicles receive federal funding with at least one interviewee suggesting federal funding drove many decisions. For example, public transit officials had to request and then justify purchase of standard fueled vehicles, such as buses, rather than alternative energy units.

Interviewees mentioned the additional cost of electric cars several times. The price premiums most often quoted ranged from \$8,000 to \$10,000 of extra CAPEX for both the Chevrolet Volt (see Figure 4) and approximately the same for the Nissan Leaf. At this point in time, it is uncertain when a 100 mile GGE would overcome the increased CAPEX, though current research at Juneau may provide the answer.

Figure 4. Chevrolet Volt, Electric Powered



Source: Northern Economics.

Operating costs, also known as OPEX, are those costs incurred during vehicle operation. Generally these costs refer to scheduled operations and maintenance with repair costs referring to unscheduled costs of upkeep. Two interviewees noted the almost 100 miles GGE with all-electric vehicles was attractive but even on a total life cycle cost basis, all-electric vehicles were still too expensive. A question is what CAPEX is acceptable with the lower OPEX.

Maintenance

Interviewees also noted current vehicle shops are designed for emissions that are denser than air, dropping to the floor. Natural gas and propane vehicles vent vertically, with fuel and emissions rising in many cases. These vapors could collect on or near ceiling-mounted heating and ventilation equipment, creating a potential explosion hazard. One estimate for an up-fit in the maintenance area is in the neighborhood of \$600,000 to \$750,000.



Warranty work must be done by specialists under terms of most factory warranties. Fleet managers in Juneau noted Chevrolet Volts and Nissan Leafs cannot receive warranty work as there are no trained specialists at local dealerships.

Training

Fleet managers incur training costs for their mechanics and they note their training cost savings with fewer vehicle models. With fewer models, mechanics become very familiar with their fleet vehicles; parts inventories are lower; and repair costs may be lower as vehicle use directs preventative maintenance.

Estimated training costs were in the \$10,000 to \$15,000 range per mechanic, depending on the vehicle and its related courses, number of years of training required, and refresher requirements.

More vehicle types and models could result in higher training costs and more parts inventories, generally considered undesirable in the current budget environment.

Other

Fuel supply was not a high concern. The MOA’s experience with its CNG facility suggests driver behavior might be more of a factor; queue times up to 20 minutes require the most patient of drivers. Anecdotally, the Alaska Railroad reports driver resistance to daily connections for slow-fill CNG refueling, preferring instead to use regular gasoline pumps for filling its three dual-fuel trucks.

Summary of Fuels Availability and Concerns

Table 2. Five Boroughs, Summary of Alternative Fuel Availability, Concerns

Fuel Availability, Concerns	FNSB	MSB	MOA	KPB	CBJ
Fuels					
Propane	PFS	PFS	PFS	PFS	PFS
CNG	PVS	PVS	PFS	PVS	No Fuel
LNG	No Fac				
Electricity	No Fac	No Fac	No Fac	No Fac	PVS
Concerns					
Costs	Both	CAPEX	CAPEX	CAPEX	CAPEX
Maintenance	OPEX	CAPEX	CAPEX	CAPEX	OPEX
Training	OPEX	OPEX	OPEX	OPEX	OPEX
Interest in Alternative Fuel vehicles	Low	Mod	Mod	Low	High

Notes:

1. PFS refers to public filling station
2. PVS refers to private filling station.
3. No Fac means fuel is available, but no facility exists.
4. No Fuel means there is no fuel (or facility).
5. CAPEX refers to capital expense.
6. OPEX refers to operating (and maintenance) expense.

HIGH LATITUDE EXPERIENCE

Team members looked at four high-latitude countries to review their experience with alternative fuel vehicles for possible use in Alaska: Canada, Norway, Finland, and Sweden.

Canada

Canada's greenhouse gas policies encourage the use of alternative fuels, including natural gas, propane, biofuels, and dual-fuel vehicles. The Canadian government states alternative fuels are available at over 6,000 public stations across the country (Natural Resources Canada, 2014), including renewable fuels, propane gas and E-85 (a blend of gasoline and ethanol) bulk fueling stations (federal government only).

Ethanol fuel manufacturing plants are concentrated in the Provinces of Alberta and Saskatchewan, along with facilities extending northeast along the St. Lawrence River. There are fewer biodiesel plants when compared to ethanol production, but they are located in the same two clusters. Feed stocks for both fuels include beets, municipal solid waste, corn, wheat, canola and yellow grease (Canadian Renewable Fuels Association, 2014).

Canada has approximately 80 public CNG refueling stations located in five provinces (Canadian Natural Gas Vehicle Alliance, 2014a). Each dispenses fuel in compressed form at 3,000 pounds per square inch (i.e., fast fill); most are co-located with existing retail gasoline stations. The closest cities to Alaska with natural gas refueling capability are Prince Rupert, Terrace, and Smithers (the latter two are east and inland from Prince Rupert).

Canadian firms appear to be at the forefront of dual or blended fuels technologies for powering medium and heavy-duty trucks (Kenworth and Peterbilt brands) as well as passenger cars and pickups. An estimated 25,000 natural gas engines developed by Cummins Westport are used throughout the world. Initially developed at the University of British Columbia, these engines start with diesel and then burn injected natural gas for a two-phase, high-pressure, direct-injection system (Canadian Natural Gas Vehicle Alliance, 2014b). Similar systems are under review by Caterpillar for its remote site power generation systems.

Norway

The Nissan Leaf topped the list of newly registered vehicles in Norway in October, 2013 (Greenfleet, 2013), leading the Toyota Auris, the Volkswagen Golf, and the Tesla S. Norwegian research suggested alternative-fueled vehicles were fully competitive with conventional gasoline vehicles, with EVs a strong market contender, along with hybrids, as the most preferred technology in certain market segments. Other market segments were reported as indifferent between hybrid and propane technology (Dagsvik, 1996).

In the last 18 years, these projections appear to be generally borne out. Norway's extensive hydroelectric plants suggest electricity is a preferred energy source for many vehicles. In Norway, as



well as other countries, the most plentiful alternative fuel appears to encourage the most appropriate type of alternative fuel vehicle—in this case, EVs.

Finland

Finland's demand for biogas and CNG started to rise in 2004 and effectively doubled in volume by 2009, before flattening. Natural gas as a fuel is available in 15 communities, powering approximately 1,300 units, including trucks (mostly refuse) and urban buses.

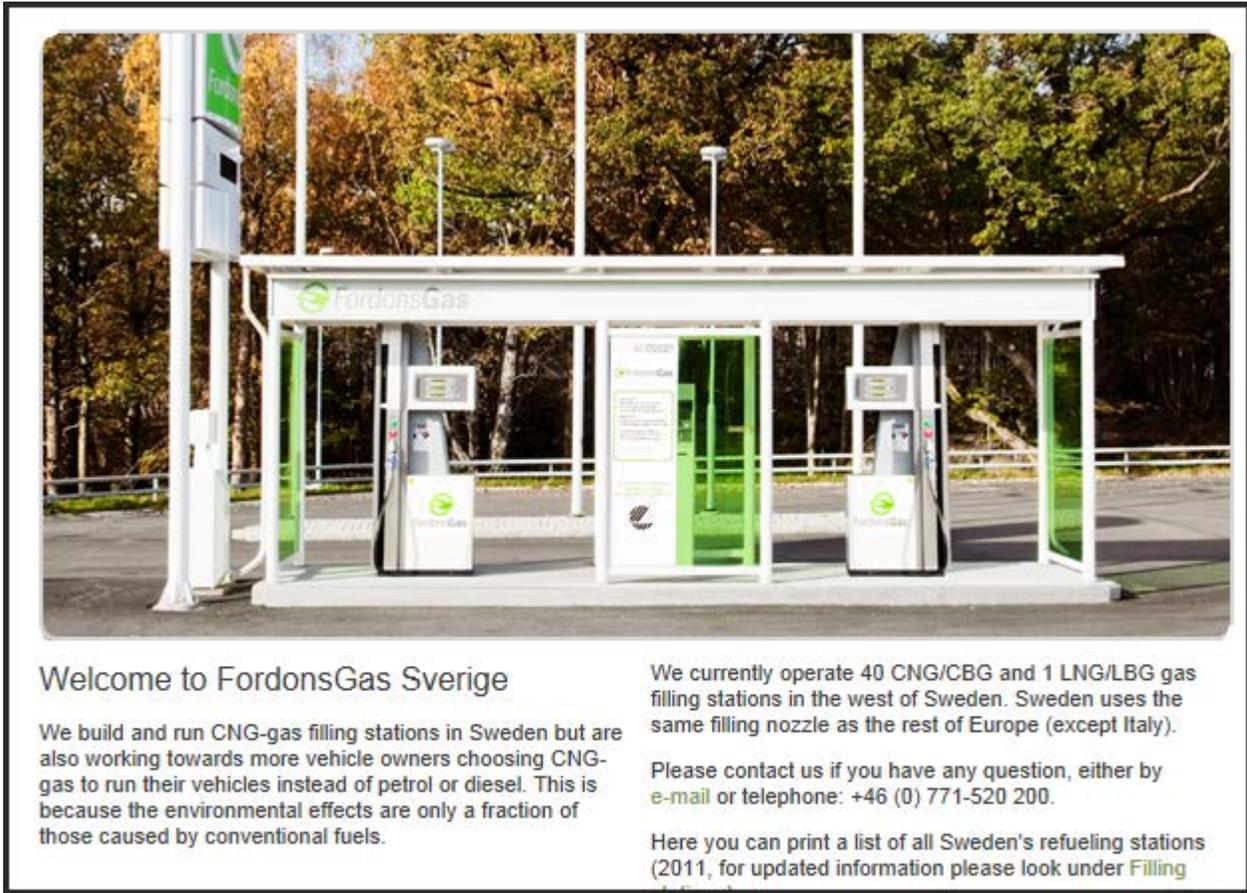
In 2011, the Finnish gas company Gasum started to inject biomethane into a natural gas grid as well as offering it as a transport fuel (NGVA Europe, 2014a). Biomethane, like natural gas, can be compressed and liquefied; the designations are CBG for compressed biogas and LBG for liquefied biogas. Another identified strong (potential) market is LNG/LBG for marine use.

Sweden

Sweden leads the way in biomethane demand, with approximately 37,000 light duty vehicles, 1,500 buses, and 550 heavy duty trucks (NGVA Europe, 2014b). Sweden has focused its efforts on generating local biomethane, especially from forest industry waste. One Swedish innovation is overland transport (truck haul) of LNG/LBG as well as CNG/CBG to supply filling stations. Like the U.S., Swedish CNG vehicle production has seen starts and stops, with Volvo cancelling their CNG model in 2007 but re-offering it via a subcontractor in 2009.

Figure 5 shows a Swedish CNG gas filling station, one of approximately 40 similar stations in the west of Sweden.

Figure 5. Swedish CNG Filing Station (FordonsGas Sverige).



Source: FordonsGas, http://www.fordonsgas.se/English_Home_DXNI-779, accessed March 2014.

ENERGY SUPPLY

Alternative Fuels in the United States

Table 3 illustrates the number of alternative-fuel vehicles by fuel type in two-year increments from 2004 to 2012. The high variability in the number of vehicles reported under the Clean Cities program suggests both real variability and possible reporting issues, though an upward trend is present.



Table 3. Clean Cities Alternative Fuel Vehicles, by Two-year Increments, 2004 to 2012.

Alternative Fuel	2004	2006	2008	2010	2012
E85	47,643	221,834	524,169	403,981	197,187
HEVs	10,674	43,886	101,954	30,613	141,406
Biodiesel*	31,922	91,584	17,222	88,726	103,106
CNG	76,257	57,458	51,121	42,911	59,521
Propane	31,338	25,543	22,260	13,196	16,501
Electric	9,241	9,376	13,761	8,826	17,996
LNG	0	2,271	2,053	3,410	3,411
PHEVs	0	105	374	397	2,459
Hydrogen	23	72	75	62	50
Total	207,098	452,129	732,989	592,122	541,637

Source: US Department of Energy, Alternative Fuels Data Center. Department of Energy, Alternative Fuels Data Center, accessed March 2014

Notes:

1. CNG: Compressed natural gas
2. E85: 85% ethanol
3. HEV: hybrid electric vehicles
4. LNG: Liquefied natural gas
5. PHEV: Plug-in hybrid electric vehicle

Current and Prospective Energy Supply, Alaska

All five boroughs have ready access to conventional fuels, primarily diesel fuel and gasoline. Light duty vehicles are generally gasoline powered while heavy-duty vehicles, such as trucks and buses, burn diesel. The most common alternative fueled vehicles appear to be light-duty, gas-electric hybrids such as those manufactured by Toyota.

The availability of alternative fuels is more dispersed in the five areas. FNG provides CNG to fuel three pick-ups in its truck fleet at Fairbanks but there are no public LNG/CNG fueling stations as yet. Proposed delivery of LNG from the North Slope for residential heating at Fairbanks and North Pole may provide incentives to purchase CNG vehicles. Northern Economics made repeated calls to FNG, trying to get FNG’s opinion on CNG maintenance, but with no success.

Anchorage has access to natural gas, both LNG and CNG, but both public fleet managers and private residents are in an early adoption stage, and have not reached the critical demand levels needed to make CNG/LNG a common alternative fuel. The MSB has a similar situation though it has a LNG manufacturing site near Port MacKenzie. In addition, there is a private LNG refueling site at Big Lake.

The KPB has ready access to both natural gas and LNG from manufacturing facilities at Nikiski, site of the first LNG export operation in the U.S. However, the KPB shares CNG market concerns with Anchorage and the MSB (i.e., economics, fuels, shop retrofits, and training).

Juneau currently has limited access to natural gas, though at least one utility is exploring the potential to deliver natural gas to the area for power production and heating (Juneau Empire 2013).

Alternative Fuel, Infrastructure and Suitability

Refueling stations for alternative fuels are very limited to non-existent within the five boroughs. There is only one public CNG site in Anchorage (Ditch Witch) and one MOA CNG refueling site, near Tudor road. The LNG refueling site at Big Lake is also private. Figure 6 is a picture of the public CNG refilling station in Anchorage; the small metal box at the left is for card readers and compressor starting; the white cylinders contain CNG; and the hose at the far right is the dispensing hose for automobiles.

Figure 6. Public CNG Service Station, Anchorage



Source: Northern Economics

One MSB resident, an engineer, built a slow-fill CNG facility at his home in Palmer; the same individual has helped guide the Alaska Railroad toward dual fuel (CNG and gasoline) use in three of its trucks at Ship Creek. Discussion indicated driver behavior tended toward gasoline refueling on an as-needed basis rather than daily (overnight) connections and disconnections with a slow-fill CNG unit.

The current estimated capital cost for a fast-fill CNG station that could service a fleet consuming approximately 9,000 gallons of diesel per month is \$1.0 to \$1.5 million (NREL 2010). The 9,000 gallons is based on FNSB's fleet of 14 buses, with ten on routes each day. At 35,000 miles per year and diesel consumption of 3.3 miles per gallon, the estimate monthly fuel consumption is 9,000 gallons.



A LNG station, with an estimated 15,000 gallons of storage capacity, was estimated in the \$1.7 million to \$2.0 million capital cost range, with the latter cost including a CNG fueling point (USDOE 2010). Small CNG units, suitable for home use, cost approximately \$10,000 per month. A former MAPCO employee noted that firm installed a public CNG fueling point at \$250,000, in Anchorage, but removed it due to low use. Estimated capital costs for fast-fill stations are shown in Table 4 (USDOE 2010).

Table 4. Estimated Capital Costs, Fast-fill Refueling Station Size and Maximum Capacity.

Refueling Station Type	Maximum Capacity	Estimated Cost
CNG, Small	<500 scfm	\$400,000
CNG, Medium	500-2000 scfm	\$600,000
CNG, Large	>2000 scfm	\$1,700,000
LNG, Large	15,000 gal storage	\$1,700,000
CNG/LNG, Large	>2000 scfm	\$2,000,000

Source: USDOE, 2010

Note: scfm refers to standard cubic feet per minute.

In Juneau, the JEDC is managing a project to site EV recharging stations within the borough, to offer private (and public) operators a more convenient way of recharging EV batteries. Lower cost hydroelectric power provides an opportunity for more EV adoption, especially if off-peak power trials are successful and lower OPEX can compensate for higher CAPEX on a life-cycle basis.

Hybrid vehicles may be the most economical alternative fuel vehicles for all five boroughs, though they are light-duty almost exclusively. Compared to other alternative fuels, hybrids are a transition-type vehicle with lower capital costs than EVs and generally have operating characteristics like current passenger cars and light-duty trucks. Figure 7 illustrates a hybrid electric (and biodiesel) bus operating in Olympia, Washington on two alternative fuels at one time.

Figure 7. Hybrid Electric and Biodiesel Bus, Olympia, Washington.



Source: Northern Economics

CNG and LNG seem most suitable for the three current boroughs with access to natural gas: the MSB, MOA, and KPB. Market resistance appears tied to purchase cost premiums, along with very limited refueling sites for private operators. Public fleet managers point to much heftier costs for vehicle repair shops and the needed training for mechanics. Table 5 summarizes results.

Table 5. Vehicle by Type, with Estimated Capital Cost and Premium over Base Cost.

Vehicle	Type	Capital Cost	Premium over Base
Bus	Diesel	\$400,000	Bus Base Cost
Bus	Diesel-electric	\$600,000	\$200,000
Bus	Biofuel-electric, (1)	\$650,000	\$250,000
Bus	Biofuel-electric, (2)	\$723,000	\$323,000
Step Van	Gas, diesel	\$64,000	Van Base Cost
Step Van	CNG	\$72,000	\$8,000
Small vehicle	Gasoline	\$35,000	Small Vehicle Base
Small vehicle	Electric	\$45,000	\$10,000

Sources: Fairbanks, Olympia (WA), Anchorage.

- Note
- 1: Standard batteries only, no interior camera system
 - 2: Gel batteries, full video system



Propane may be a suitable alternative fuel in areas without natural gas, but propane-powered vehicles in public fleets have the same high costs of adoption as CNG and LNG. Interviews and research suggest these issues are solvable with increased funding and budget support from borough assembly members.

Electricity as an alternative fuel appears most suited for the CBJ. Limited road lengths, hydroelectric power, and a relatively mild climate during most of the year suggest EVs will see continued use in Juneau.

Other alternative fuels (biodiesel, E85 gasoline, hydrogen) seem less likely to fuel vehicles within public fleets of the five boroughs over the next several years.

CONCLUSIONS AND RECOMMENDATIONS

Currently, both public fleet managers and private vehicle owner/operators question the economic viability of most alternative powered vehicles with the notable exception of gasoline-electric hybrids.

Public fleet managers point to warehouse retrofits, mechanic training, and larger parts inventories as part of their reluctance while private vehicle operators appear to focus on convenience of refueling sites, along with perceived slow refueling speeds.

Team members note the U.S. has not signed any treaties on greenhouse gases, a fact that drives much of the Canadian and European push to alternative fuels. If the U.S. adopts a policy close to the Canadian stance, regulatory impacts could be expected in the form of mandates or perhaps increased fuel taxes, to encourage alternative fuel adoption.

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