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1 New Efficient Diesel Generator Systems

1.1 Introduction

1.1.1 Review of Screening Study

The preliminary screening analysis identified microprocessor-based engine controls and switchgear improvements as alternatives that have potential economic benefits compared to existing diesel systems due to diesel fuel cost savings.[1]

1.1.1.1 Engine Controls

The screening study identified *microprocessor-based engine controls* as a promising diesel technology for rural Alaska.[2] Microprocessor-based engine controls are one of many technologies that are being used by diesel engine manufacturers in order to improve combustion efficiency and reduce emissions. Rather than focus on any specific upstream technologies for diesel engine manufacturers, this study is focused on commercially available diesel engine generator sets that can be purchased for deployment in rural Alaska. Since retrofits of microprocessor controls on existing diesel generator sets do not appear to be commercially viable, the scope of this study has been revised to examine the installation of new diesel generating units that provide improved fuel economy relative to existing diesel generator units.[3]

1.1.1.2 Switchgear Improvements

The screening study identified *switchgear improvements* as a promising diesel technology for rural Alaska. The screening study divided switchgear improvements into three subcategories of improvements: 1) switchgear automation upgrades; 2) real-time economic dispatch (RTED); and 3) microprocessor-based protective relays.[4]

Switchgear automation upgrades were described as enabling the control system to automatically *match diesel-generator units to the load requirements*. Real-time economic dispatch systems were described as an enhancement to automated control systems whereby the control system selects *which unit* will carry *the next increment of kW*.[5]

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[1] Including the potential to avoid costs associated with new or expanded local diesel fuel tank farms.

[2] Precision Power estimated that micro-processor based engine controls might provide *up to 10% more horsepower for a limited period*.

[3] This study also has the benefit of some hindsight – a number of responses to a request for proposal for efficiency improvements from the AEA/AIDEA were framed as replacement of an existing diesel-generating unit with a new more efficient generating unit.

[4] While microprocessor-based protective relays were found to improve reliability and provide net economic benefits on the order of $50,000 for a "typical village," they were dropped from further consideration due to the use of an *average* rate screening criteria of 1 cent per kWh.

[5] The actual difference between these two options depends upon the capability of the control system, the knowledge of the diesel generating unit performance curves, the load profile, and the imagination and creativity of the programmer. In the end, the differences between the options (automated controls vs. automated controls + real time economic dispatch) may or may not be significant depending upon specific field conditions and potential control regimes.

Screening study estimates for the potential fuel savings associated with the installation of automated switchgear ranged from 4 to 20 percent. See Table 1-1 below.

Table 1-1. Automated Switchgear Fuel Savings Potential Screening Study Estimates for Potential Fuel Savings Associated with Automated Switchgear

Source	Fuel Savings	Notes
Alaska Village Electric Cooperative	Occasional improvements; Range up to 10%[6]	AVEC: Our experience is that the cost of installing automated switchgear upgrades is significantly higher than the installed cost figures cited in the screening report. Although efficiency improvements have, *on occasion*, resulted from the completion of switchgear automation upgrades, the costs of the upgrade have greatly overridden any resulting savings associated with efficiency improvements.
Alaska Power and Telephone	May be closer to 4%	APT: Proper sizing strategies will significantly reduce the fuel savings associated with the 20% fuel savings figure reported [in the screening study].
EPS	5-10%	[Screening Study, p. 2-9, footnote 7]
Tanana Power Company, Inc.	13%	TPC: While the use of automated control has tremendous benefits, without the local understanding of how to operate and maintain it, *automation could actually make the system less reliable*.[7] Before trying to implement any automated control system, *the use of recorders to obtain accurate information about the community's electrical usage is a fundamental place to start.* These devices are relatively inexpensive. Making sure that the recorder is working and that the information was sent in on a regular basis could be the start of an accountability program. Along with fuel usage, this information would tell AIDEA much of the information with regard to the utility. The information gained would help size generators for a community, which would lead to better efficiency, as well as allow AIDEA to discern which communities would benefit the most from an automated control system. [*emphasis added*]
Precision Power	20%	

Source: Screening Study and Screening Study Review Comments

[6] AVEC e-mail, January 2004

[7] Control systems which are set once by an outside expert and left to automatically adjust to a wide variety of potential field conditions still tend to fail more often than the typically available manual labor resulting in an evaporation of efficiency gains promised by automated controls. While the controls may be more "efficient" when they are working, the amount of time they are actually performing up to specification remains variable enough to warrant caution.

The Screening Study suggested the "industry standard expectation for fuel savings from real-time economic dispatch is generally 5 percent."[8] AVEC comments on real time economic dispatch indicate:

> *Real time economic dispatch systems tend to increase the load factor on the gen set, resulting in increased generating efficiency. However, the time to overhaul is substantially reduced as load factors are increased. Without clearly knowing the life cycle cost of overhauling diesel engines, it is difficult to determine whether the fuel savings associated with real time economic dispatch offsets the reduced time to overhaul and the commensurate cost of completing overhauls and other associated maintenance.*

Since real-time economic dispatch does not appear available without the installation of automated control systems as a prerequisite, the screening study recommended an analysis of real-time economic dispatch capabilities in combination with automated switchgear upgrades.

1.1.2 This Study

1.1.2.1 Scope

This study examines specific diesel generator related efficiency improvements including:

- ❑ New efficient diesel generator units with higher efficiency over a wider range of load conditions (stand-alone option)
- ❑ New automated control systems designed to dispatch the most efficient diesel generating unit to match load conditions (stand-alone or bundled with real-time economic dispatch capability)

In addition, this study recommends additional metering and supervisory control and data acquisition (SCADA) systems as an integral baseline requirement to enable management (and public funding agencies) to better assess which operational and capital improvements make sense in light of operations, diesel-generating units' performance, and system load profiles and variability.[9]

1.1.2.2 Objective

The objective of this study is to refine the evaluation of the costs and benefits of new efficient diesel systems that are suitable for rural Alaska and determine the extent to which these systems could potentially reduce the cost or improve the reliability of electricity for rural communities.

In addition, this study reviews program implementation alternatives with the goal of maximizing program effectiveness.

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[8] An analysis of the claims of vendors and providers of automated switchgear and real-time economic dispatch systems by MAFA has been unable to determine if and whether the fuel savings benefits for these improvements have been appropriately attributed to each separate option. Based on system modeling and discussions with field personnel, MAFA believes that some of the higher fuel savings figures that have been attributed to automated switchgear may be combining the effects of automated switchgear, improved economic dispatch and the installation of new generator sets.

[9] See also comments of Tanana Power Company, ARECA, and AVEC's experience with improving its system efficiency over the years. The old adage "you can't manage what you don' t measure" is well worth consideration in this context.

1.1.2.3 Key Economic Evaluation Parameters

The key parameters driving the economic assessment of new efficient diesel systems include:

- Relative performance of new diesel generating unit vs. existing diesel generating unit over the range of local load conditions
- Relative performance of automated controls vs. manual operations at matching diesel units to loads
- Price of avoided diesel fuel
- Difference between the capital and overhaul costs of new efficient diesel generators compared to existing diesel generators
- Installed capital cost of new automated control systems
- Economic value of potentially delayed or avoided costs associated with reducing diesel fuel storage needs

1.1.2.4 Economic Evaluation Criteria

Criteria:	Economic Evaluation Net Present Value is positive Benefit / Cost Ratio > 1.0
Assumptions:	5 percent Real Discount Rate (sensitivity analysis 3 to 15 percent) 15-year time horizon Individual assumptions and associated cash flows are median values. Sensitivity analysis of the assumptions allows one to assess which parameters are driving the economic valuation—providing the largest change in the results for an incremental change in the input. As a result of the use of median values for initial assumption sets, ad-hoc adjustments to the discount rate or benefit/cost ratio to incorporate risk may double count the downside uncertainty of a particular alternative and ignore the upside uncertainty.

1.2 Attractive Opportunities

1.2.1 Replace Existing Diesel Gen sets with New High Efficiency Diesel Gen sets

1.2.1.1 Economic Analysis

Based on an economic analysis of currently available information on individual PCE eligible communities, it would appear as if *almost all* rural Alaska communities present **attractive** opportunities for replacing old diesel gen sets with new high efficiency gen sets.

These communities represent, in aggregate, a total present value benefit of $496 million and a total present value cost of $470 million, for a net present value of $26 million (discount rate of 5 percent and a 15 year life). The benefit cost ratio for individual communities in the "new more efficient diesel gen set" scenario ranges from 1.02 to 1.15, with an aggregate weighted average of 1.06.[10]

Due to the significant potential for fuel savings relative to the modest incremental capital and overhaul costs, the replacement of existing diesel gen sets with new high efficiency diesel gen sets continues to be attractive for *almost all* rural Alaska communities even when analyzed using a *real discount rate of 10 percent over 15 years*.

The exceptions to this general statement include prime movers that have been replaced within the last five years with a prime mover that is optimized for the current load profile.

On its face, there appear to be few economic cost reasons *not* to be replacing *prime mover* diesel gen sets on a regular basis (every 5 to 10 years depending upon hours, operating configuration, etc.) to take advantage of ongoing improvements in diesel gen set efficiency and to optimize the sizing of the prime mover to the load profile.[11]

In light of fuel efficiency considerations, all villages that are receiving new sewer and water projects should be reviewed for the potential installation of a new diesel gen set optimized for the new loads.

1.2.1.2 Market Analysis

A recent study of efficiency improvements across communities from the early 1990s to the late 1990s suggest that fuel efficiency improvements are occurring across a wide spectrum of communities from small to large, and from "stand-alone" to regional utilities.[12]

While fuel efficiency is generally higher in larger communities compared to smaller communities and in smaller communities where regional utilities operate compared to smaller communities that operate without regional utility support, the **change in efficiency** over the past five years within each of the market segments does not appear to point to any specific potential cause of flat efficiency.

It does appear from anecdotal evidence that a variety of causes may be limiting potential diesel efficiencies both within individual communities, within individual utilities across multiple communities, and across multiple utilities and multiple communities.

Thus, this report recommends a variety of policy measures that address a number of the potential causes behind the general stall in diesel efficiency improvements. It is hoped that the combination of revised incentive structures; reduced regulatory barriers to mergers, acquisitions and regional management and operations; and improvements in the availability of capital will drive some additional efficiency improvements by enabling more replacement of older diesel gen sets with newer more efficient prime movers.

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[10] See Excel Spreadsheet Model, DieselBC, Tab "Summary." Also note that actual local field conditions may vary from the reconnaissance model estimates. Thus, the benefit/cost ratios for individual communities could range from under 1.0 (new, more efficient unit installed that does not integrate into existing operating regime or match up to load well) to over 1.6 (new, more efficient unit integrates well and replaces a fairly inefficient unit and inefficient operating regime).

[11] Charlie Walls, former general manager of AVEC, indicated to the OMM Study Group that in many cases AVEC replaced existing diesels prior to the end of their operational lives, because new units were more fuel efficient. Efficiency improvements over the past decades have made it economic to replace existing units with new more efficient units rather than overhaul the diesel units in an effort to obtain three overhaul cycles and reach run times of 80,000 hours or more on a unit.

[12] See Appendix A: Rural Alaska Utilities Standards—Review of the Power Cost Equalization Efficiency and Staffing Standards.

Given the favorable underlying economics of new high efficiency diesel gen sets, it may be prudent **to target** government funded capital investments in this area to those utilities and communities who meet minimal standards for management information (adequate metering and monitoring) and do not appear to have ready access to capital in order to avoid:

- Undue dependency upon free or cheap capital from the government[13]
- Restraining development of private capital markets (banks, equipment leasing)
- Reducing equipment vendor profit margins because of reduced leasing opportunities, potentially resulting in higher prices than otherwise[14]
- Reducing the attractiveness of the Alaska diesel gen set and support equipment markets to small or new entrants, resulting in reduced competition

The combination of the Alaska Energy Authority RPSU and Efficiency Improvement RFP process may be providing some modest programmatic incentive to avoid displacing private capital by requiring some level of matching funds. It may be prudent to review the results of the matching fund formula with the Department of Agriculture Rural Utility Service, private banks and equipment vendors to ascertain the nature and extent of potential displacement of other sources of capital and adjust the formula if appropriate.

1.2.2 New Diesel Control Systems

Based on an economic analysis of currently available information on individual PCE eligible communities, it would appear as if *very few* rural Alaska communities present **attractive** opportunities for upgrading existing control systems with new automated control systems, with or without real time economic dispatch capabilities.[15]

It is possible that automated controls*, by themselves*, can achieve incremental fuel savings on the order of 4 to 5 percent compared to consistent reliable manual operations (ramp up before 8 am, ramp down after 8 pm to10 pm weekdays). See Excel Spreadsheet Model **DieselDispatch788**, for comparisons between manual operations and automated controls. The Excel spreadsheet model is available on-line at: http://www.aidea.org/RuralEnergyPlan.htm.

The actual costs for a completed automated control system installation (including the time spent to dial-in or calibrate the system) appear to be beyond the small incremental benefit for most village settings.[16]

Sensitivity analysis suggests that there *may be* some exceptions to the general characterization that automated controls are not likely to be economic. For example:

- Complete installed costs of systems are considerably less (50 percent) than field experience of utilities with good cost accounting (AVEC)

[13] This prospect was highlighted in many comments received from utility managers in response to the screening report indicating the importance of improving utility management through reducing subsidies.

[14] See GE Capital for an example of equipment leasing effects on profit margins. See also CAT, Cummins, Detroit Diesel annual reports which indicate that financing remains a relatively profitable line of business.

[15] See Excel Spreadsheet Model DieselBC, Tab “NACNPV”“ for economic analysis of automated controls.

[16] See also AVEC Comments on Screening Report.

- o Existing manual operations are not reliable and automated controls may be more reliable (after taking into account the additional incremental costs to dial-in and maintain the control systems with outside labor)
- o Price of fuel is high
- o The automated controls systems are part of a wind-diesel hybrid or hydroelectric-diesel hybrid system and the combined effects of the controls and the new technology achieve net economic benefits

1.2.3 New Supervisory Control and Data Acquisition (SCADA) Systems

Based on an economic analysis of currently available information on individual PCE eligible communities, it would appear as if *many* rural Alaska communities, present **attractive** opportunities for installing or upgrading supervisory control and data acquisition systems (SCADA) and automated meter reading (AMR) systems.

Absent better data on existing system loads (including schools, sewer and water utilities), individual diesel gen sets and system performance, and distribution and billing system performance, the **uncertainty** associated with planning, installing, operating, and managing new infrastructure **remains quite high** outside of a few larger "regional utilities."

As noted by Tanana Power Company in reply comments to the Screening Study,

> *Before trying to implement any automated control system, the use of recorders to obtain accurate information about the community's electrical usage is a fundamental place to start. These devices are relatively inexpensive. Making sure that the recorder is working and that the information was sent in on a regular basis could be the start of an accountability program. Along with fuel usage this information would tell AIDEA much of the information with regard to the utility.* ***The information gained would help size generators for a community, which would lead to better efficiency, as well as allow AIDEA to discern which communities would benefit the most from an automated control system.***

Indeed, the AVEC experience in achieving efficiency improvements described in their comments on the Screening Study is due in part to metering and measurement of system performance.

The installation of SCADA systems and AMR systems are management tools that enable the identification of what is efficient and what is not. These investments enable management to direct capital to where it is more likely to provide net positive benefits.

If one assumes that SCADA systems can lead to a 2 percent increase in fuel efficiency and that in combination with AMR the systems can reduce distribution "losses" by 2 percent in aggregate, a management information system program on the order of $36 million over roughly five years appears economic.[17]

[17] Assume 180 communities X $200,000 average per community = $36 million. An aggregate 4% system efficiency improvement is a break-even on average with a $200,000 investment over 15 years at 5% discount rate.

1.3 Recommendations—Summary

Based on the initial market reconnaissance study, MAFA recommends diesel efficiency development program on the order of **$36 million** over roughly five years

The program includes site-specific reconnaissance, preliminary design, and final feasibility, and, contingent upon final feasibility determinations, is expected to improve the long run efficiency of capital deployed for electric utilities throughout rural Alaska.

In order to maximize the economic value of new efficient diesel systems, the recommended program focuses on systematically reducing the uncertainty associated with diesel system performance parameters—including load profiles, operations, "unaccounted for" distribution losses, and existing gen set performance.

This is accomplished through the widespread deployment of improved SCADA and AMR systems throughout rural Alaska.

After a*t least* two years of detailed local data within each community (for those communities without detailed information), projects can be identified which are likely to provide economic benefits for those communities that cannot otherwise be funded from existing capital markets.

1.4 Analysis

1.4.1 Organization of Analysis Section

- General Market Considerations
  - New Diesel Generators
  - New Automated Control Systems
  - New SCADA Systems
- Specific Market Triggers
- Market Intervention Program Design Considerations
  - Program Goals
  - Trends absent Government Intervention
  - Program Alternatives
  - Recommendations
  - Market Reconnaissance
  - Introduction
  - Analysis of Results

1.5 General Market Considerations

Factors favoring new efficient diesel systems as an attractive cost effective alternative to existing diesel systems include:

- *Fuel Consumption Represents 85 to 88 percent of the incremental life cycle costs of diesel-fired electrical generation in many rural Alaska communities*. See Excel Spreadsheet Model **DieselBC**, Tab "UnitSubNPVModel." The Excel spreadsheet model is available on-line at: http://www.aidea.org/RuralEnergyPlan.htm. Relatively modest improvements in fuel efficiency (4 percent) are sufficient to justify purchase of new diesel gen set, especially if the existing diesel gen set is due for an overhaul. The incremental capital and overhaul costs over a 15 year life are on the order of 15 percent of the cost of fuel.
- *New Efficient Diesel Performance vs. Existing Diesel Performance.*
  - Small-scale diesels in the 1920s were capable of achieving peak fuel consumption efficiencies of 0.4 lb per brake horsepower per hour, or roughly equivalent to 12.5 kWh per gallon of diesel fuel.[18] The most efficient small-scale units available today are capable of achieving peak efficiencies in the 15.8 kWh per gallon of diesel fuel range – a 25 to 30 percent improvement in peak performance over 80 years.
  - Diesel technology improvements in the past twenty years, especially those associated with electronic fuel injection, have reduced air pollution and noise and have continued to extend the fuel efficiency over an increasingly wide range of load conditions due to more efficient combustion processes.[19] Diesel generating units currently available in the Alaska market today have a wide range of performance characteristics that enable managers to match units to their particular operational needs and load profile (which may now be changing with the addition of new sewer and water projects).
    - Some units offer excellent fuel economy over a quarter of their load range. Others have good fuel economy over a third or more of their load range. Some operators find that units that are somewhat oversized relative to current load requirements appear to have more reliable ramp up performance as the school and other facilities come on line during weekday mornings.
    - Thus, in addition to fuel economy considerations, operators and managers may be evaluating trade-offs between fuel economy, load profile over the day and evening, manual dispatch of units, ability of diesel generating units and control systems (manual or automated) to reliably chase rapidly changing loads.

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[18] See The Modern Diesel: Development and Design, Edited by Williams, Revised by Willams, Keig, Dickson, Simpson, (Butterworth Group, 1972), p. 15, citing a direct injection four-cylinder, 1050 rpm engine from M.A.N. that appeared at the Berlin Diesel Engine Show in December 1924.

[19] Please note there are reports in the industry (Diesel & Gas Turbine Worldwide Monthly Magazine) indicating that diesel fuel economy has improved on the order of 25% in the last twenty years. This author has found these figures difficult to verify -- they appear to be based on an average calculation over some, usually unspecified, range of engine load. These figures appear to pick up those portions of the performance curve under the peak that have improved the most while leaving off the portion of the performance that have not experienced as great an improvement. The left off portion of the curve appears to be where the engine is loaded at less than 50% of its rated capacity, presumably because most units are not run for a large number of hours at these low levels.

See below for an example of two relatively fuel efficient diesel gen sets. While the Detroit Diesel may have superior fuel economy, it may not be as well suited to some variations in load conditions as the CAT. Thus, a manager may prudently opt for one or the other depending upon reliability considerations, load characteristics, and local operational capability.

Figure 1-1. Fuel Economy vs. Load – CAT & Detroit Diesel Comparison

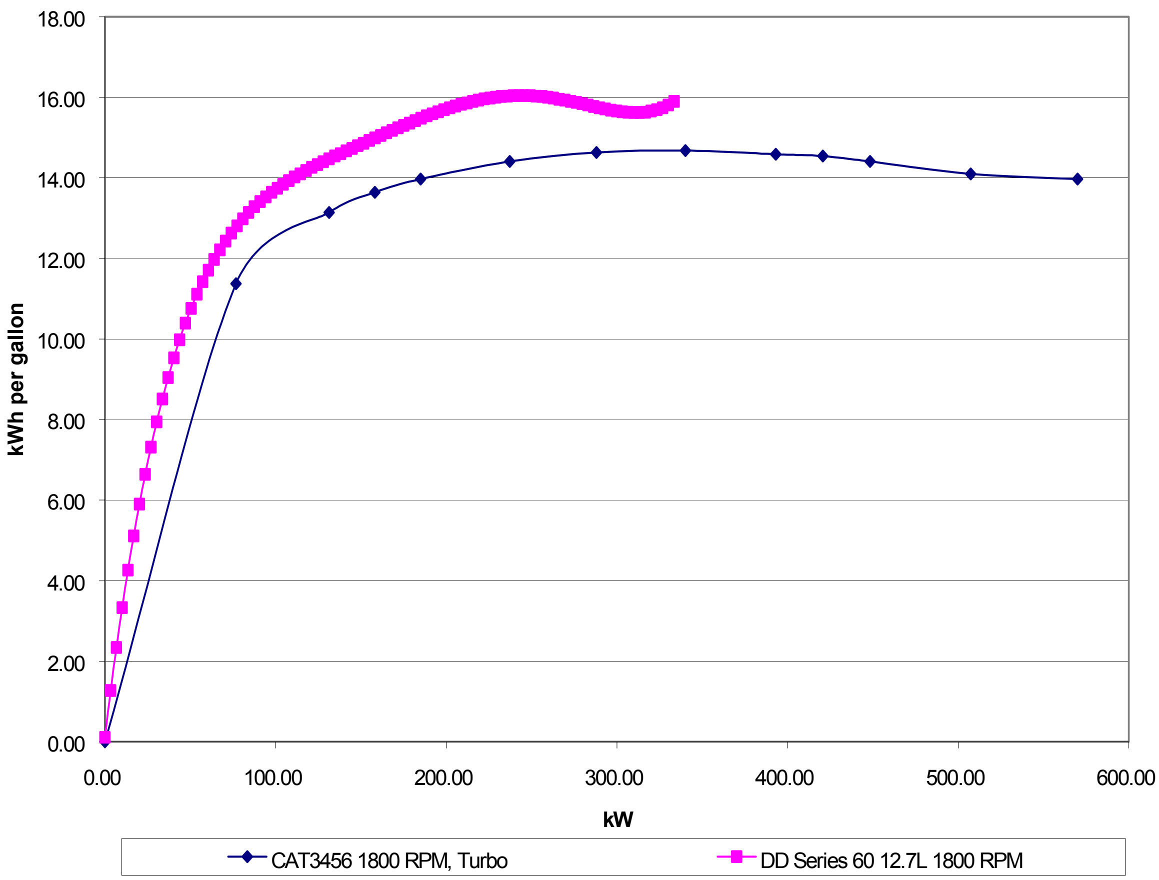
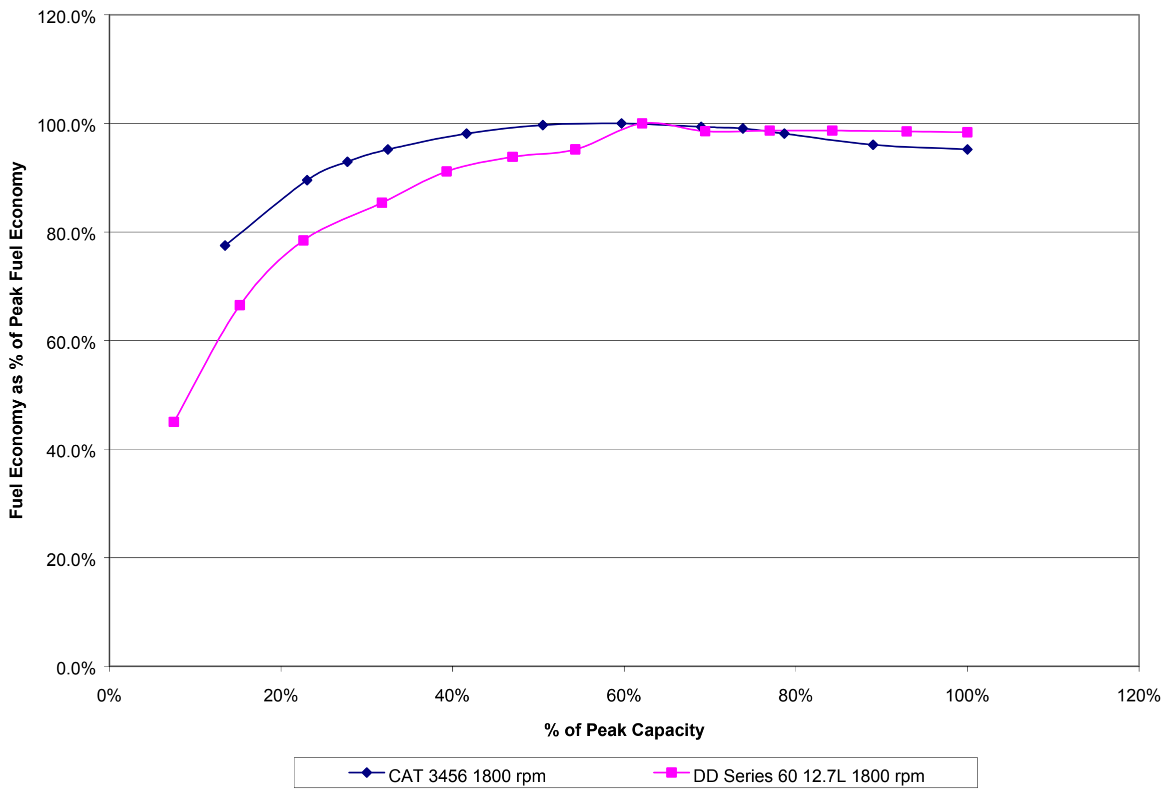


Figure 1-2. Figure 3: Percentage of Peak Fuel Economy vs. Percentage of Peak Capacity



In summary, the potential benefits of newer, typically more fuel-efficient diesel systems include:

- Reduction in the fuel required to generate a kWh of electricity at top performance
- Reduction in the fuel required to generate a kWh of electricity over a wide range of load conditions
- Potential improvement in the ability of the unit and its control system (manual, mechanical or digital) to reliably chase load variations

However, potential limitations on the attractiveness of newer, typically more fuel efficient diesel systems include:

- The time and expertise to dial-in a new unit and associated controls to provide reliable and efficient service may not be available, leaving a promising system performing under specifications.
- High performance systems may require more time and expertise than is reasonable to expect in rural Alaska in order to achieve their high performance specifications.
- Some new fuel efficient units and controls systems may simply not reliably follow loads compared to other systems.

1.6 Specific Market Triggers

In addition to the general economic conditions that favor new efficient diesel systems, the following market conditions may trigger economic opportunities for the installation of new efficient systems:

- Existing diesel(s) are at or near time for overhaul or replacement.
- A significant new demand for electricity, associated with new or upgraded sewer/water facilities; new housing project; or new or upgraded school would otherwise drive demand for expanded diesel facilities and new diesel fuel storage capacity.

Thus, the best opportunities to create economic value with new efficient diesel systems are likely to be found at the confluence of:

- Moderate to high cost of diesel fuel (Price of fuel plus potential cost of storage and handling requirements)
- Moderate to high operations, maintenance, and management sophistication (including reliable information on system operations and performance typically available from SCADA systems)
- Existing diesel(s) are due for an overhaul or replacement
- A significant new demand for electricity is imminent in the community

1.7 Market Intervention Program Design Considerations

1.7.1 Program Goals

The primary goal of this report is to develop *cost effective* initiatives that reduce unit costs and improve reliability of energy services for rural Alaska residents, businesses, non-profits and government agencies.

In addition, the initiatives are to be examined for how they distribute the benefits to as many communities and as many rural households as possible.

Additional considerations include the extent to which the initiatives can be designed to use private sector contracts to accomplish the specific program purpose.

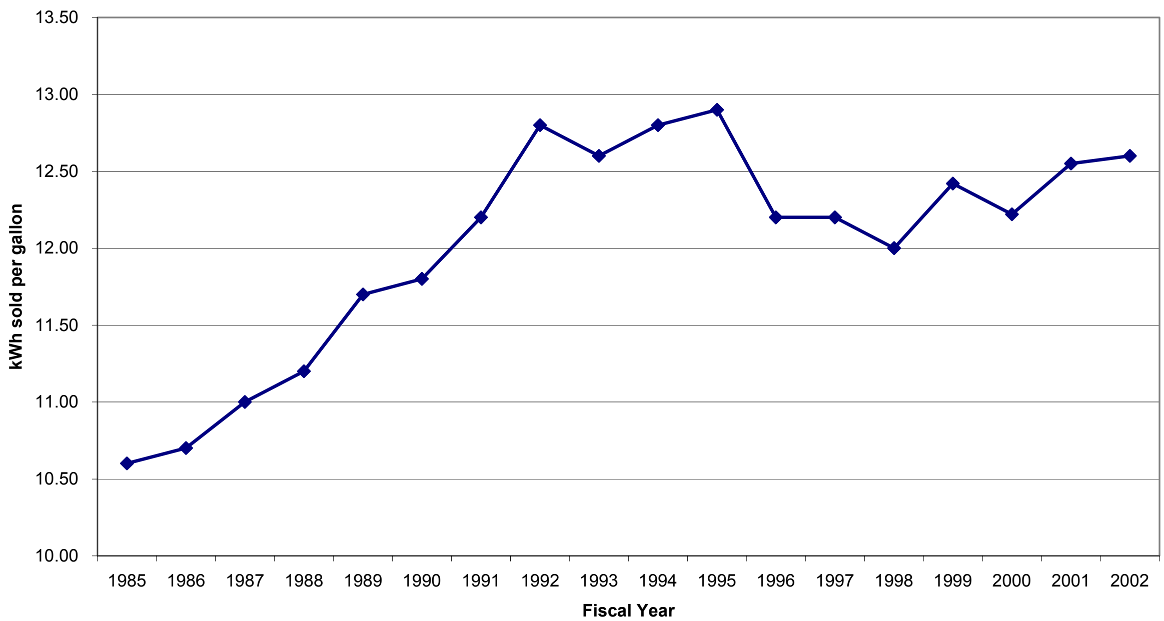
In the search for effective programs to implement energy infrastructure improvements in rural Alaska, the following questions may be helpful to frame the discussion:

- What happens without government assistance?
- What cost effective infrastructure should be developed to provide value to Alaskans?
- What are the barriers to cost effective infrastructure?
- What are some alternative measures to reducing barriers to cost effective infrastructure development?
- What are the benefits, costs and risks of those measures?

1.7.2 Market Trends Absent New Intervention

Based on a review of the utility-reported PCE data, it appears that in aggregate the fuel efficiency of rural Alaska PCE participant diesel systems had increased from roughly 10.5 kWh per gallon of fuel in the 1980s to roughly 13.0 kWh per gallon in 1995. The aggregate fuel efficiency of PCE participants has subsequently bounced around the 12.0 to 13.0 kWh per gallon range from FY95 through FY02;higher efficiencies in the period are generally associated with higher fuel prices.

Figure 1-3. Aggregate Fuel Efficiency of PCE Program Participants (FY85-FY02)



Why has aggregate fuel efficiency flattened in the 1995-2002 period?

Potential explanations for the flattening of the aggregate fuel efficiency include:

- The "easy" fuel efficiency improvements (a.k.a. "low hanging fruit") have been made; smaller and more difficult incremental improvements remain.
- Given variations in loads and operational considerations involving fuel efficiency, staffing, remote monitoring, maintenance, and system reliability, the theoretically remaining fuel efficiency gains may require detailed case-by-case analysis as opposed to simple programmatic prescriptions and as a result, fuel efficiency improvements have become more difficult to obtain.
- New water and sewer projects, new housing, and new school facilities on the upside and the loss of income associated with fishing on the downside have caused increased volatility in loads, leading to lower overall fuel economy.
- Access to capital has slowed, and diesel gen sets that might have otherwise been replaced leading to fuel efficiency improvements have remained in place for longer, reducing the rate of improvement.

- o Access to operating expertise has reached an equilibrium and new opportunities to improve fuel efficiency are not being identified and implemented.
- o Access to management expertise has reached an equilibrium and new opportunities to improve fuel efficiency are not being pursued, identified and implemented.
- o Management *incentives* to improve efficiency beyond the "low hanging fruit" have reached an equilibrium and further improvements may require a re-alignment of incentives.
- o Fuel costs have diminished to roughly 30 percent of total costs and management attention has shifted toward achieving efficiencies in non-fuel costs (admin, customer service, operations and maintenance) which represent 70 percent of total costs.

Quick Review of Market Segments:

In the large community category (>10,000,000 kWhs per year in sales in community), the aggregate average fuel efficiency reported in FY96 through FY02 appeared to be on the order of 13.3 kWh per gallon.

It appears that Bethel, Kotzebue, and Tok have all reported relatively flat fuel efficiency over the FY96 throughFY02 period averaging around 13 kWh per gallon.

Nome has reported relatively flat fuel efficiency over the FY96 through FY02 period averaging around 14.5 kWh per gallon, ranging from a low of 13.4 to a high of 15.3 over the seven-year period.

Year to year variations in fuel efficiency on the order of 10 percent are common.

Additional case studies may be appropriate to ascertain why Nome has been able to report an efficiency of 14.5 kWh per gallon while other large utilities are reporting efficiencies ranging from roughly 12.7 kWh per gallon up to 13.7 kWh per gallon.

In the medium community category (less than 10,000,000 kWhs per year in sales and greater than 1,000,000 kWhs per year), the aggregate average fuel efficiency reported in FY96 through FY02 appeared to be on the order of 11.8 kWh per gallon.

Point Hope reported an average fuel efficiency of 14.2 kWh per gallon, while Kotlik reported an average fuel efficiency of 9.3 kWh per gallon. Year-to-year variations in fuel efficiency on the order of 15 percent are common. Some utilities, notably AVEC and APC, appear to have smaller annual variations, typically less than 7.5 percent.

In the small community category (less than 1,000,000 kWhs per year in sales), the aggregate average fuel efficiency reported in FY96 through FY02 appeared to be on the order of 10.2 kWh per gallon.

Year-to-year variations in fuel efficiency on the order of 25 percent are common.

A recent study of efficiency improvements across communities from the early 1990s to the late 1990s suggest that fuel efficiency improvements are occurring across a wide spectrum of communities from small to large and from "stand-alone" to regional utilities.[20]

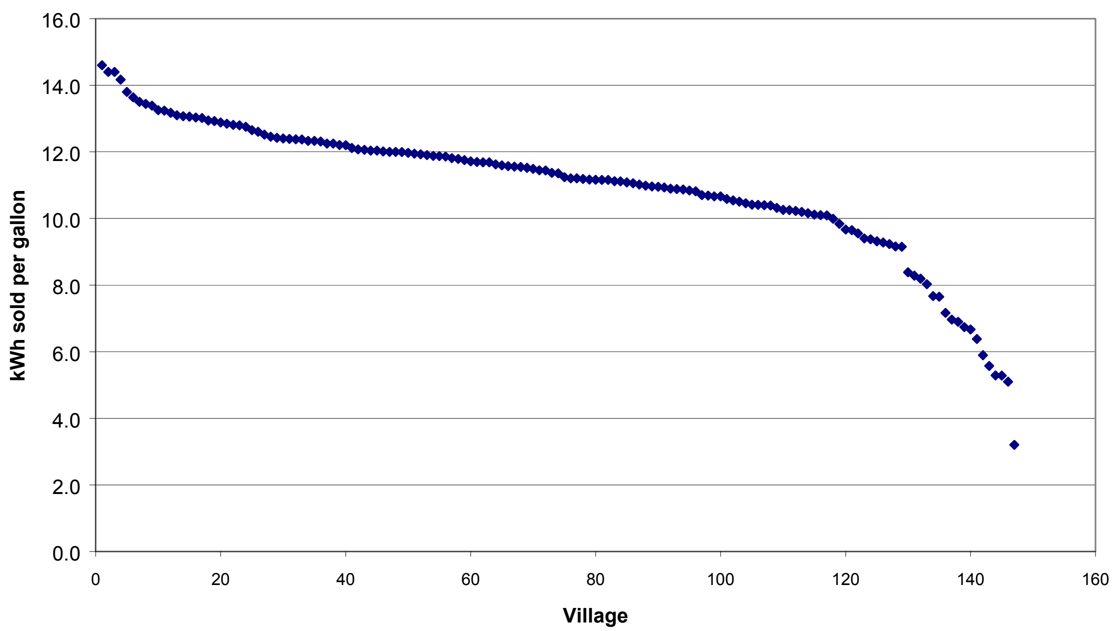
While fuel efficiency is generally higher in larger communities compared to smaller communities and in smaller communities where regional utilities operate compared to smaller communities that operate without regional utility support, the **change in efficiency** over the past five years within each of the market segments does not appear to point to any specific potential cause of flat efficiency.

[20] See Appendix A.

It does appear from anecdotal evidence that a variety of causes may be limiting potential diesel efficiencies within individual communities, within individual utilities across multiple communities, and across multiple utilities and multiple communities.

In addition, diesel fuel efficiency continues to span a wide range depending upon the community. Note that the tail end of the distribution—communities below rank order 120 and an efficiency below 10 kWh sold per gallon—falls off rapidly. The systems at the tail end of the distribution tend to represent vary small systems that generally report low kWh sales to kWh generated ratios (sometimes referred to loosely as "line loss") which may be a result of electrical usage that is not adequately metered or consistently reported.

Figure 1-4. kWh sold per gallon, PCE Annual Statistical Report (FY00)



Diesel fuel efficiency appears to be improving in small and large communities alike at least over the past decade. (See Appendix A.)

During the course of this report, the survey data on the condition of Rural Power Systems in Alaska were reviewed (2001 Revised Data).

The statistical analysis of the data on the age and condition of existing diesel generating units do not indicate any significant correlations with **fuel efficiency**.

It did appear from the data that for-profit utilities tended to have higher grades for "plant condition" than other types of utilities (municipalities, coops).

See also the supporting chapters of the report entitled Sustainable Utilities in Rural Alaska Effective Management, Maintenance and Operation of Electric, Water, Sewer, Bulk Fuel, Solid Waste Final Report by Steve Colt, Scott Goldsmith, Amy Wiita July 15, 2003, available at: http://www.iser.uaa.alaska.edu/Home/ResearchAreas/RuralUtilities.htm.

What are the barriers to cost effective efficiency improvements?

Key barriers to consider include:

- Limited local labor market (operations, maintenance and management)
- Political economy of local operations
    - Local labor vs. outside labor: Local labor may be less efficient, effective and reliable compared to outside labor that is flown in depending upon the capacity of the local labor pool or the adjacent community labor pool. However, the local labor may be less expensive on a per hour basis, and may be more generally available during some winter months when flight schedules are interrupted due to weather.
    - Local maintenance vs. outside maintenance (see local vs. outside labor)
    - Replacement of manual operations using local labor with "automated" equipment
- Limited Management Information; high transaction costs to get better information
- Scale Economies
- Uncertainty about benefits of efficiency improvements
- High Cost of Capital
- Artificial Market Structure Impediments (existing regulatory and subsidy systems)

Limited Local Labor Market (Operations, Maintenance, and Management)

The *supply* of trained operations, maintenance and management personnel may be limited, especially in smaller, more remote communities. To the extent that people in the local markets receive training and develop skills, many migrate to larger regional hubs or suburban/urban communities.

Within the local community, the problem is exacerbated by *differentials in compensation* between the local utility operations and the local school. In addition to often higher wage rates, the operations and maintenance personnel working at the local school tend to receive a retirement package that is more reflective of urban labor markets. As a result, the career ladder in a small or medium size village for skilled personnel may start with on-the-job training at the local utility where pay and benefits are modest, followed by improved pay and benefits at the local school, followed by migration to regional hubs or suburban/urban markets.

Some local managers adjust to this by attempting to develop informal mentor programs where experienced personnel provide guidance to less experienced personnel.

Additional support for mentorship arrangements (with minimal administrative overhead) may be one way to improve the local labor pool.

This support may take the form of increasing the PCE endowment with an encouragement toward, but not a requirement for "retirement benefits."

Political Economy of Local Operations

Local managers may not be pre-disposed to invest in "efficiency" improvements in general due to the perception that efficiency improvements may lead to reductions in local labor. This perception may extend across a variety of considerations including:

- Local labor vs. outside labor on new capital projects
- Local maintenance vs. outside maintenance on overhauls

- Perceived replacement of local labor with potentially more reliable automated equipment

Depending upon the particular community, the perception may reflect reality.

For example, using local, potentially less-efficient labor may generate more economic activity and benefits for the local community (assuming the locals spend or distribute benefits locally) than flying in outside help whose wages may get spent outside the local community.

In addition, the increased cost for flying in outside help plus the higher cost of wage and benefits may in fact be less efficient than using potentially less-efficient, lower-wage, local personnel. The local operators may be able to solve problems on their own or with a little help on the phone or via e-mail with photos and low bandwidth video technologies.

High Transaction Costs (Management Information)

Some of the "best practices" lessons learned from the rural Alaska electric utilities include:

- Know your load.
- Know your existing diesel gen sets.
- Know how your people operate the system.

Individual utility managers (who may be covering electrical, sewer, water and refuse utilities) in remote rural communities may not have the time and resources necessary to develop the detailed knowledge of their loads and system performance parameters.

It may be more effective (in terms of cost and quality) for a larger regional or statewide organization to contract with knowledgeable personnel in the procurement and use of SCADA systems. This may enable an experienced team to carefully manage the tradeoffs between capital costs, reliable components, easy to use (troubleshoot) system design, reliability-inherent systems installation, and what management information is helpful to identify and implement efficiency improvements.

Scale Economies: "The High Cost of "Small Scale" and "One-At-A-Time" Projects in Rural Alaska"

The manager of a small rural utility may not find it cost-effective from an individual community perspective to mobilize installation equipment and crews unless other communities in the region are also going to require similar mobilizations in order to share common costs.

With respect to operations and maintenance costs, a similar scale effect appears.

For example, while an individual utility may not be able to afford to hire a full time SCADA technician and operational data analyst for their operations, they may be able to obtain adequate operations and maintenance support from a contract with experienced SCADA system technical and operational analyst personnel from another utility or from the AEA.

Diesel Efficiency Measurement Uncertainty

What can be done to reduce the uncertainty in the estimate of the value of new efficient diesel generators or new control systems?

Development of cost-effective efficiency improvements depends upon a clear, detailed understanding of the local operating conditions.

SCADA systems and AMR systems can be viewed baseline infrastructure to provide management with information about their system which can reduce the uncertainty about existing unit and system performance.

The funding for SCADA systems and AMR systems may be made available to local communities.[21] The local community may contract the design/installation activities to a utility or energy services company.

Based on current rural Alaska market reconnaissance, this may amount to a statewide SCADA and AMR design/installation effort on the order of $36 million over a five-year period. Consolidated procurement with SCADA system vendors, communications systems vendors, and construction contractors and equipment should significantly drive down installation costs.

Thus, while an individual utility manager may not find a significant incentive to invest in SCADA and AMR systems, the collective potential value of reliable SCADA and AMR systems throughout the State to direct resources toward capital and operating improvements is sufficient to justify an investment on the order of $200,000 per community.

New Diesel System Cost Uncertainty

In additional to the uncertainty associated with the efficiency of new diesel units, there remains uncertainty over the capital and operating costs and the reliability of diesel units.

The costs to consider include:

- o Reliability of system (time that the generators are available to produce electricity)
- o Potential fuel economy improvements vs. load matching of unit to a stable or changing local load profile
- o Potential fuel economy improvements vs. load following capability of new unit and associated controls
- o Major overhauls cost and frequency (on the order of magnitude of 75 percent of the price of a new diesel gen set). Frequency of overhaul may increase significantly due to higher load on individual diesel gen sets.

In short, the costs for a new diesel gen set and control system in rural Alaska may vary over a wide range due to potential variance across many factors—especially reliability of the new system and its ability to follow the load profile.

High Cost of Capital

Cost of capital is the expected rate of return that the market requires in order to attract funds to a particular investment. Please see the Wind Power Chapter for a detailed discussion of cost of capital.

1.7.3 Market Intervention Program Alternatives

The basic market intervention alternatives available to the state/federal government policy makers include:

- ❖ Investment Incentives
  - o Accelerated Depreciation

    Typically, a business is allowed to depreciate the value of its assets such as equipment and other capital. This depreciation can then be deducted from the business' yearly income taxes paid to the government. Usually, this reduction is based on the acquisition value of the equipment and can only be depreciated at a certain, defined amount. However, allowing

[21] See U.S. Senate Bill 517, SA 2996.

accelerated depreciation of new diesel units (for example, allowing 100 percent depreciation of a new diesel unit in the first year of operation or over the first few years) will significantly lower the amount of income taxes paid during the initial stage of the project. This helps alleviate the extra burden wind developers experience relative to other technologies due to the higher initial capital costs of a wind plant.

Again, since most rural Alaska communities are served by non-profits, the potential tax benefits of this approach are limited.

However, for regulated utilities (both for-profit and non-profit), this has some attraction given historic Alaskan successes. In the 1980s, the APUC/RCA granted accelerated depreciation to enable rural telephone companies (for-profit and non-profit) to install digital switching. As a result, Alaska was the first state in the U.S. to achieve 100 percent digital switching in its local telephone networks.

RCA could grant accelerated depreciation for new cost effective “energy efficiency” initiatives. To the extent that the RCA allows the capital investment in PCE rate determinations, a portion of the allowable deprecation expense could be paid for by the PCE program. The attractiveness of this solution may be limited since depreciation on capital that may be funded by grants has not allowed in PCE rate determinations by the RCA.

In contrast, the Denali Commission, ANTHC, RUBA, and others involved in bringing new sewer and water infrastructure to rural Alaska have started to include at least a portion of the depreciation expense from these grant funded projects in their rate development process. This appears to be part of an effort to migrate utilities from a dependency upon grant funded capital toward a more sustainable funding model where an increasing portion of capital is funded by the local community.

Finally, even if the new efficient diesel units are funded by loans or private capital, the RCA may be reluctant to provide accelerated depreciation in light of the relatively high potential for free riders – these investments in infrastructure appear likely to have been made whether or not an accelerated depreciation allowance program is offered.

- Grants

  Direct cash payments might be a very efficient way to promote cost effective diesel efficiency investments. Many times, a direct cash payment for the installation of new infrastructure is more beneficial to a potential developer who has a limited revenue base. This type of incentive also helps both taxable and non-taxable entities (such as a municipal or state-owned utility). In addition, grants add an extra benefit to a private investor by reducing the tax burden since the granted portion of the power plant usually is not taxed. On the other hand, the RCA typically treats grants as “contributed capital” to the utility and does not allow depreciation or a return on these investments (see also accelerated depreciation discussion above) in rate making.

  In the 107th Congress, S. 517 contains provisions to provide $100 million per year for FY2003-FY2009 for housing, energy, water, wastewater, bulk fuel, telecommunications and utility services. The Department of Energy is designated to distribute to communities with populations less than 10,000 and electricity prices in excess of 150 percent of the national average.[22]

[22] SA 2996, Subtitle A: Rural and Remote Community Development Block Grants

In addition, there are provisions for $20 million per year for FY2003-FY2009 for increasing energy efficiency, lowering or stabilizing electric rates to end users, or providing or modernizing electric facilities in rural and remote communities.[23]

Finally, there are provisions for $100 million per year for FY2003-FY2009 for comprehensive rural development planning, affordable housing, and wastewater, water, telecommunications and other infrastructure needs determined to be critical to the further development or improvement of a designated industrial park.[24] This money is to be distributed to rural recovery areas where population out migration is 1 percent or more over the previous 5 years, per capita income is less than that of the national nonmetropolitan average, and the area does not include a city with a population of more than 15,000.

The administration of grant programs could be efficiency delegated to the Denali Commission given the grant administration infrastructure in place.

The key to cost effective use of grant funds is to identify market opportunities where grant funds can be used to develop cost-effective efficiency alternatives that would not otherwise be accomplished with existing capital markets.

SCADA and AMR system improvements, which may not receive adequate attention and funding priority from remote rural managers, may be a cost-effective way to initiate energy efficiency improvements in many rural Alaska communities.

- Customer Focused Programs
  - Community Meetings

Some jurisdictions have encouraged utilities and energy service companies to conduct rural community meetings to more directly assess the needs of local customers. This is essentially the process that is currently being used by ANTHC to assess rural community water and sewer needs. An energy component could be added to the ongoing water and sewer deliberations to help share costs where possible. In addition, the collaboration between water and sewer and energy could help the coordination between the utilities -- water and sewer typically being the largest or second largest customer of electricity in many communities. In addition, information about the implications of new sewer and water systems on local energy bills could be valuable for customers.

Cost Elements

- Facilitator
- Electric Utility Representative
- Water/Sewer Utility Representative
- Alternative Energy/Energy Service Co. Representative
- Round Trip Travel from Anchorage
- Lodging & Meal Allowance
- Incentive for Meeting Attendance (Free Heating Oil)

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[23] SA 2996, Subtitle B: Rural and Remote Community Electrification Grants

[24] SA 2996, Subtitle C: Rural Recovery Community Development Block Grants. The phrase “designated industrial park” is not defined in SA 2996.

Approximate cost per community may be on the order of $5,000. Amortized as a start-up cost over 60 months, this amounts to roughly $1,000 a year, or about 1/10 of 1 cent per kWh for a community with 1,000,000 kWh per year.

The benefits include a relatively direct expression of informed community interest and the potential to build community support for the energy alternative selected.

1.7.4 Recommendations

In order to improve the efficiency of diesel-fired electrical systems in rural Alaska and in turn reduce the unit cost of service and improve system reliability, it is useful to segment the market by size, cost of service and reliability.

In the small village market segment, reliability tends to be medium to poor with a significant variance in the cost (and underlying efficiency) of service from medium to high.

In the medium village market segment, reliability ranges from good to poor with significant variance in the cost of service from medium to high.

In the large village market segment, reliability ranges from very good to medium with moderate variance in the cost of service.

In the small and medium market segment, the focus is on providing basic management information systems to enable better assessments of operations, enabling better analysis and identification of improvements that are likely to provide a reduction in unit costs and improve reliability.

In the medium to large market segment, the focus is on providing **matching** funding to utilities with basic management information systems in place to enable them to identify improvements that are likely to provide a reduction in unit costs and improve reliability.

Small & Medium Market Segment

The basic outline of the **Plan** would contain the following elements:

- **Basic Management Information**
- Phase I Reconnaissance:
  - Develop list of communities where new and upgraded SCADA and Automated Meter Reading Systems have the potential to provide basic management information that enables diesel system efficiency improvements. Targets of opportunity—communities with relatively low fuel efficiency, high fuel costs, below average condition, thin local labor market, school reports mediocre reliability, etc.
  - Estimated cost = $50,000
- Phase II Preliminary Design/Installation Specification ($100,000)
  - Develop preliminary design and associated installation specification based on target market identified in reconnaissance phase.
- Phase III Grant Application Technical Assistance & Consolidated Procurement ($100,000)
  - The SCADA/AMR Recon/Design/Installation Specification Contractor would be required to work with local communities to provide technical assistance to put together grant applications to the funding agency.

- o The SCADA/AMR Design Contractor would be required to provide local communities and their utilities with an option for a consolidated procurement for the acquisition, installation, testing and turn over of SCADA/AMR systems
- o As a condition of receiving funding for SCADA/AMR projects, communities/utilities agree to make their information available to government granting agencies in electronic form.
- o Part of project should help pay for equipment to enable periodic polling of local data.
- o The SCADA/AMR Contractor would be required to post all information developed as part of their contract on the web.
- o Individual communities and their utilities have an incentive to participate in a consolidated procurement in light of the following statutory language contained in the energy bill:
  - *In allocating funds under this section, the Secretary shall give special consideration to those rural and remote communities that increase economies of scale through consolidation of services, affiliation and regionalization of eligible activities under this title.*[25]

- o **Provide Basic Infrastructure to Enable Basic Level of Reliable Service**
  - o Rural Power System Upgrades. Where existing systems are distressed and capital markets do not appear to be readily accessible, provide funding for new projects where there is local support, reasonable prospect for basic operations and maintenance of the systems including management information systems that will enable remote monitoring of plant.

Medium & Large Market Segment:

Where utilities have in place basic metering and monitoring functions which enable active management of the utility, provide matching funds for efficiency & reliability improvements where benefits exceed costs. A general solicitation for projects that are designed to improve efficiency and reliability and reduce overall unit costs provides an effective means to have utilities and energy service providers submit proposals for review and funding.

[25] See S. 517, **SA 2996,** Title IX—Rural And Remote Community Development Block Grants, Sec. 906. Allocation And Distribution Of Funds.

1.8 Recommendations – Portfolio of Policy Options

The following policy options merit consideration in the New Efficient Diesel Development Program (

Table 1-2. Policy Options for Rural Energy Plan – Economic Measurement Considerations

Reduce Cost of Capital **Provide government funding of diesel efficiency improvements where positive economic benefits are likely**				
	Alternatives	**Benefits**	**Costs**	**Risks**
	What measure(s) to use:			
A.	B/C > 1.0; Net Present Value Analysis, real discount rate = 5%; time horizon = 15 years	Focus on opportunities that are likely to deliver benefits sooner	Requires cash flow estimates	Risk of under-investing relative to longer time horizon
B.	B/C > 1.0; Net Present Value Analysis, real discount rate = 5%; time horizon = 30 years	Focus on opportunities that may deliver benefits over the long term	Requires cash flow estimates	Risk of over-investing relative to shorter time horizon
C.	Incorporate qualitative risks explicitly where those risks are not delineated in the assumption sensitivity analysis	Allows explicit risk trade-offs	Requires relative risk assessment metrics	Qualitative relative risk assessment may be biased. Double counting of uncertainty impounded in median assumptions may occur.

Table 1-3. Policy Options for Rural Energy Plan – Implementation Considerations

Reduce Cost of Capital **Provide government funding of Management Information Systems development where positive economic benefits are likely**				
	Alternatives	**Benefits**	**Costs**	**Risks**
	Detailed Reconnaissance Phase:			
A.	Contract for SCADA/AMR Reconnaissance	Consolidated procurement can reduce program overhead and reduce transactions costs for individual communities	Should have a simple independent "audit" function to verify recon results	Contractor has an incentive to sell to as many communities as possible; may oversell potential
B.	Provide grants to individual project submissions from rural communities	Directly responsive to the initiative of individual communities	Grant administration tends to involve more assistance to local communities and higher fixed costs (Gov't grant admin tends to be a portion of a position vs. Contract grant admin = hours)	Transaction costs for individual communities can be high; many attractive opportunities may go unexplored
C.	Provide grants to individual project submissions from utilities or energy service companies	Funding is provided directly to energy service provider – also likely to be the developer	Should have a simple independent "audit" function to verify recon results	Local community involvement and responsiveness to market may be diminished due to utility incentive structure
	Design/Build Phase:			
A.	Provide for consolidated procurement of SCADA/AMR Installation for communities who wish to participate	Consolidated procurement for $2 million of capital investment can drive risk sharing to contractors resulting in lower unit costs for buyer		Large consolidated procurement may preclude some small in-state firms from bidding as prime contractor
B.	Provide grants to individual project submissions from rural communities	Directly responsive to the initiative of individual communities	Grant administration tends to involve more assistance to local communities and higher fixed costs (Gov't grant admin tends to be a portion of a position vs. Contract grant admin = hours)	Transaction costs for individual communities can be high; many attractive opportunities may not be developed
C.	Provide grants to individual project submissions from rural utilities or energy service companies	Funding is provided directly to energy service provider		Local community involvement and responsiveness to market may be diminished due to utility incentive structure