1.9 Market Reconnaissance

1.9.1 Introduction

The basic economic analysis compares the following alternatives:

A: New Diesel Gen Sets

- Installing a new efficient diesel gen set

  to

- An existing diesel gen set

B: Automated Control Systems (with and without Economic Dispatch)

- Compare new automated control systems (electronic)

  to

- Existing manual Operations
- Existing mechanical control systems

C: SCADA

- Compare new or upgraded SCADA system

  to

- Break-Even efficiency improvements required to justify the system

D: AMR

- Compare new or upgraded AMR system

  to

- Break-even efficiency improvements required to justify system

A time horizon of 15 years is used to reflect the expected economic life of the system capital assets.

A real discount rate of 5 percent is used to reflect the time value of government investment based on the forward looking expected rate of return from the Alaska Permanent Fund.[26] An additional sensitivity analysis is conducted to reflect a potential range of the real discount rate for government funded projects from 3 to 7 percent.[27] Finally, a sensitivity analysis is conducted at a real discount rate of 15 percent to identify the potential for "free riders" to the program.

The key parameters driving the differences between the new diesel system efficiencies and the existing diesel system include:

- Ability of new system (gen sets, controls, operating regime, collections) to improve system efficiency compared to potential reliability degradation
- Price and cost of fuel

The analysis is based on:

- Interviews with utility personnel

[26] See Alaska Permanent Fund Second Quarter, 2002 report, dated December 31, 2001. The forward looking real rate of return is estimated at 4.95%.

[27] See Sections "High Cost of Capital" and "Government Funded Discount Rates"

- Feasibility studies of numerous diesel gen sets and automated control systems submitted to AEA in response to request for "efficiency" proposals
- Development and application of an economic model comparing new diesel gen sets to existing diesel gen sets
- Application of economic model to reconnaissance level community specific data to identify magnitude of diesel efficiency economic opportunities
- Sensitivity analysis of economic model
- Identification of key market failures which prevent or impede diesel efficiency development relative to socially optimal economic investment, defined here as B/C>1.0, 15 years, 5 percent real discount rate.

Use of Additional Screening Criteria:

Rate Criteria: 1 cent per kWh

If applied to a "typical utility" case as was done in the Screening Report, a "1 cent per kWh" screening criteria may significantly preclude consideration of many economic opportunities that would otherwise pass the criteria if it were applied on an individual utility basis.

In short, scale economies favor large regional communities (Bethel, et al with rates of roughly 20 cents per kWh) over smaller communities (Tuntutuliak, Napaskiak, et al. with rates of roughly 45 to 50 cents per kWh).

If applied on an individual community basis, the 1-cent per kWh screen provides little incremental benefit relative to a net present value analysis for smaller communities.

For larger communities, many of whom have already achieved efficiencies in part due to scale, the 1-cent per kWh screen may preclude consideration of efficiency projects that may be cost-effective and relatively easy to implement.

1.9.2 Analysis of Market Reconnaissance Study Results

1.9.2.1 Results

Table 1-4. Market Recon Summary of Results

	Key Valuation Drivers	Comments
Efficient Diesel Gen sets	Fuel efficiency compared to existing gen set Reliability compared to existing gen set Values of 4% fuel efficiency compared to an existing gen set are often sufficient to justify investment	Economic modeling of potential fuel efficiency gains supports replacement rather than overhaul of gen sets in many cases Existing PCE subsidy system may reduce fuel efficiency improvement incentives compared to alternative subsidy systems
Automated Controls	Fuel efficiency compared to existing system Reliability compared to existing system Values of 4-5% fuel efficiency compared to an existing control regime are **not** usually sufficient to justify investment	High cost of installation relative to fuel efficiency gains limits economic attractiveness Potential decrease in reliability compared to manual or mechanical control systems may eat up any potential efficiency gains
SCADA Systems	Potential to identify operating efficiencies Potential to identify high value capital investments to improve fuel efficiency Values of 2% increase in system efficiencies may be enough to justify investment	TPC, AVEC, AP&T have found that accurate and timely management information about operations and gen set performance is an important prerequisite to being able to identify and analyze efficiency initiatives that are likely to provide positive economic benefits
AMR Systems	Potential to identify “unaccounted for” losses in distribution system and reduce them Potential to provide insight into load characteristics; used in conjunction with SCADA information should help managers with efficiency, sizing, and reliability considerations Values of 2% increase in system distribution efficiencies (including collections) in combination with load profile insights to help optimize system may be enough to justify investment	The “unaccounted for” losses between kWhs generated and kWhs sold remain high in many systems compared to what has been achieved by AVEC. Efforts to enable managers (existing and future) to more accurately assess system usage (billed and otherwise) should help reduce uncertainty about efficiency measures involving analysis of distribution system and loads. Many AMR projects are justified on basis of labor savings. While it is possible to achieve labor savings with AMR investments, these savings are not explicitly considered here due to the relatively high potential for those labor savings to get absorbed into other activities

1.9.2.2 Sensitivity & Break-Even Analysis:

Table 1-5. Sensitivity & Break-Even Analysis

	Break-Even	Sensitivity
Efficient Diesel Gen sets	*Fuel efficiency increases on the order of 4%* are typically sufficient to justify installation of new more efficient diesel prime mover gen sets	Capital and overhaul cost of new gen sets is relatively minor portion (15%) of life cycle cost. As a result, real discount rates ranging as high as 15% do not appear to limit the attractiveness of new more efficient prime movers. However, this suggests that *new* programs directed at providing capital for new prime movers may simply displace funding that would have occurred otherwise in many cases.
Automated Controls	*Capital costs need to fall by more than 50%* in order reach break-even range Efficiency improvements over existing systems need to reach around 15% in order to reach break-even range Fuel costs need to reach $2.85 a gallon in order to reach break-even range	Due to high up front capital costs, results remain sensitive to discount rate. Even so, a zero discount rate is not sufficient to reach break-even.
SCADA Systems	Values of 2% increase in system efficiencies may be enough to justify investment	Concerns with capital cost overruns and collection of system information that is not used may be mitigated by consolidating procurement and requiring information access as condition of funding of future efficiency projects may mitigate concerns System design and implementation that requires frequent maintenance may erode benefits.
AMR Systems	Values of 2% increase in system distribution efficiencies (including collections) in combination with load profile insights to help optimize system may be enough to justify investment	Concerns with capital cost overruns and collection of system information that is not used may be mitigated by consolidating procurement and requiring information access as condition of funding future efficiency projects may mitigate concerns System design and implementation that requires frequent maintenance may erode benefits.

1.9.2.3 Market Level Sensitivity Analysis

Table 1-6. Market Sensitivity

	Medium to Large Communities 2,000,000 kWh/year +	Small Communities <1,000,000 kWh/year
Efficient Diesel Gen sets	Medium to large communities tend to be operating at higher efficiencies than smaller communities Nonetheless, relatively modest fuel efficiency gains (4% range) are often sufficient to justify replacement of a prime mover	Smaller communities exhibit a wide range of fuel efficiencies *independent of diesel gen set age (newer gen sets assumed to be more efficient than older gen sets)*. While some smaller communities may benefit from new efficient prime movers, many smaller communities may not due to operational considerations (including efficiency related to what is running when and reliability of new unit over wide range of operating conditions). May be prudent to invest in management information prior to investment in new gen sets and new control systems
Automated Controls	Medium to large communities tend to be operating at higher efficiencies than smaller communities In short, the "theoretical upside" in efficiency from an automated system is likely to be lower in a larger system resulting in a narrower window of economic opportunity (fewer combinations of circumstances where automated controls might be economic)	Given the larger "theoretical upside" in potential efficiency that may be obtainable with automated controls in a small community, there may be some circumstances where controls might be economic. These circumstances require a reliable control system. While an automated control system monitored and maintained by non-local labor *may* be more reliable than local labor working with manual or mechanical control systems, there remain concerns about the reliability of highly automated systems in remote rural settings.
SCADA Systems	Medium to large communities served by regional utilities tend to have some form of SCADA system in place. Nonetheless, improvements in the system to speed data collection and analysis may enable additional, albeit smaller percentage, efficiency opportunities to be identified	Many smaller communities do not appear to have SCADA systems in place. Improved management information may help both the local managers better understand their own system and enable technical assistance from outside the community to more quickly troubleshoot and resolve problems without requiring on-site travel.
AMR Systems	AMR systems are beginning to be deployed in large to medium sized communities.	Many smaller communities do not appear to have AMR systems in place.

1.9.2.4 Description of Market Reconnaissance Models

Introduction

Several Excel spreadsheet models were developed to analyze diesel generating units, controls, and operating regimes and their respective impacts on diesel system fuel efficiency—kWh generated per gallon of fuel and kWh sold per gallon of fuel (taking into account "line loss" plus "unaccounted for" losses).

These include:

1. **DieselBC**[28]

    1.1. This model uses community specific data (kWhs sold, gallons used, kWh sold per gallons used, fuel storage information) as inputs to estimate the potential fuel, capital and maintenance cost differences that may result from:

    1.1.1. Replacing an existing diesel prime mover with a new, more efficient prime mover given a specific set of assumptions about how much *system fuel efficiency* might be improved with a new unit.

    1.2. This model also contains sub-models to estimate the potential fuel, capital and maintenance cost differences that may result from:

    1.2.1. Installing a new automated control system

    1.2.2. Installing a new SCADA system

2. **DieselDispatch778**

    2.1. This model looks in detail at comparing one diesel unit to another over a given load curve and assumptions about how closely the operating regimes follow the load.

    2.2. Note well: This model also contains a module to estimate the value of outages when the load-following capability of a particular operating regime is unable to keep up with a rapid change in load—an occasional early weekday morning happening for some small community operations where the school comes on line quickly.

3. **SimpleModel27May02**[29]

    3.1. This model is a case study of a particular diesel efficiency proposal involving replacement of an existing diesel prime mover gen set with a new, more efficient gen set and the replacement of the existing controls with a new control system for all of the diesel gen sets.

    3.2. The model separates the projects for comparison purposes and provides a total project comparison as well. The model enables one to quickly examine the effects of changing efficiency improvement assumptions and includes a spinner to enable a rapid change in the attribution of efficiency benefits between the new diesel unit and the new controls to assess the relative importance of each.

    3.3. Sensitivity analysis is performed on a number of parameters and presented in the tab labeled "Sensitivity Runs."

---

[28] **DieselBC** and **DieselDispatch778** are available on-line at: http://www.aidea.org/RuralEnergyPlan.htm

[29] This model and the next three models listed: **Load778, DieselPerformanceData921**, and **Generators**, are available from the author at mafa@alaska.net

In addition, several databases and associated analysis were performed using Excel spreadsheets. These include:

1. **Load778**
   1.1. Contains an actual load profile for a rural Alaska village at 15-minute increments over the course of one 365-day year. Separated into monthly and daily load profiles. Summary of peak to average loads for days, months, day/night is provided.
   1.2. Portions of this load profile data are used in the DieselDispatch788 model. This enabled a rough check on the ability of the model to track actual results under one set of field conditions.
2. **DieselPerformanceData921**
   2.1. Contains a wide variety of manufacturer, field verified, and "synthetic" (data smoothed curves) diesel gen set fuel consumption vs. load performance.
   2.2. Many of these performance curves have been loaded into the DieselDispatch778 model.
3. **Generators**
   3.1. Contains the data and data analysis from the Rural Alaska diesel utility plant field condition survey work from 2000.

Avoided Costs (Benefits):

The models assume that the benefits of a project include the fuel, capital and maintenance costs that would occur under a continuation of current operating characteristics. These avoided costs are the benefits that are attributed to the new project.

New Efficient Diesel Measure Costs (Costs):

The models assume that the costs of the new project include capital, maintenance (overhaul), and fuel costs.

The total present value of benefits is divided by the total present value of costs to determine a *net* present value and a benefit/cost ratio.

If benefit/cost > 1.0, then the amounts are entered in the "Attractive Community" columns. Those benefits and costs are added up for a total market estimate of the benefits and costs.

1.9.3 Description of Diesel Technologies

1.9.3.1 Background[30]

For an introduction and background on diesel engines used in electric power generation, please see the Catepillar Product Information Manual for Electric Power Generation, available on-line and in CD-ROM format from the Catepillar dealer. This is not an endorsement of Catepillar products. This is

[30] Please see the Catepillar Product Information Manual for Electric Power Generation, available on-line and in CD-ROM format from the Catepillar dealer. This is not an endorsement of Catepillar products. This is an endorsement that the CAT manual is worth having as a reference.

an endorsement that the CAT manual on Electric Power Generation is an invaluable industry reference.

1.9.3.2 Diesel Generating Units

Diesel compression ignition engines are not throttled, but are controlled by regulating the amount of fuel injected and the injection timing. Because of the required high injection pressures, almost all diesel engine fuel injectors are mechanically rather than electronically driven.

The injection start and duration are varied according to engine load and operating conditions. In the past, control was generally accomplished through purely mechanical means and consisted mainly of increasing the injection duration in response to increased torque demand. In recent years, electronically controlled injector pumps have become common. In these units, the power is supplied mechanically, but fuel delivery is controlled by unloading solenoids. Electronic control allows fuel delivery to be adjusted in response to engine operating conditions and is useful in obtaining low emissions.

Relative to spark ignition engines, compression ignition engines have higher thermal efficiency at full load and much higher thermal efficiency at part load.

Diesel engine manufacturers package diesel engines together with generators and sell them as gen sets.

See **DieselDispatch778**[31] to compare a few diesel gen set performance curves.

Diesel & Gas Turbine Worldwide Monthly Magazine reported that over the past 25 years, diesel generator sets experienced a 25 percent increase in fuel efficiency. This was mostly attributed to fuel and air injection and combustion chamber improvements that resulted from a desire to reduce emissions. The increase in fuel efficiency was not an increase in peak efficiency, but measured over a range of unspecified load conditions.

Going forward, participants at the MIT Symposium on the Future of Diesel suggested that worldwide markets were driving future improvements toward decreasing diesel engine emissions and that, unlike the past several years, many of the future improvements may come at the expense of fuel economy.

In short, the historic trend toward increased fuel economy in new diesel units over a wider range of performance may not continue at the same pace.

1.9.3.3 Control Systems

Diesel generators are controlled by a governor which controls engine speed and generator frequency. Governors may be mechanical, hydromechanical, hydraulic, and electronic.

Standard industry advice is:

> *When selecting a governor, always use the simplest governor that will adequately satisfy the application.*

An electronic governor is recommended if the following are critical:

- Automatic paralleling
- Isochronous load sharing

[31] Available on-line at: http://www.aidea.org/RuralEnergyPlan.htm

- o Improved response time

Which unit or units get used at any given time may be controlled manually, mechanically, or electronically.

Manual and mechanical governors allow for manual parallel operations.

An operator may wish to be on hand in the morning when the school comes on line between 7 am and 9 am to oversee manual parallel operations if required.

Alternatively, electronic governors and programmable logic controllers may be deployed to automatically sense load changes and provide for automatic parallel operations. For even more sophisticated applications, operators can attempt to figure out which units provide the best fuel economy and reliability performance and dispatch those units in various individual and parallel configurations. This is not typically a trivial task.

Capital Cost Estimates for the installation of automatic (electronic) control systems that enable automatic paralleling and economic dispatch range widely.

AVEC reports total capital costs in the range of $300,000 for a typical village with three gen sets running around 2,000,000 kWh a year.

While the Screening Report includes automated control system estimates of less than $100,000, MAFA's interviews with AVEC and APT personnel support estimates in the $200,000 to $300,000 and over range for electronic control system applications for systems in the 3,000,000kWh a year and smaller size. This includes labor required to dial-in the system to local conditions and to enable the system to function reliably.

Smaller, less complicated control schemes, or power plants with multiple gen sets that can be run in parallel on a manual basis may be more cost effective in a number of locations where local operators are familiar with the procedure.

1.9.4 Characterization of Existing Technology Deployed in Alaska

On the electric supply side, individual electric utilities have made significant gains in the efficient delivery of diesel-fired electrical service over the last 25 years. As Meera Kohler, President & CEO of Alaska Village Electric Cooperative (AVEC) documents in a letter of January 15, 2001:

> *Our [AVEC] average annual generating efficiency has been raised from less than 7.1 kWh generated per gallon of fuel in 1975 to over 13.4 kWh in 1998.*
>
> *During the same time period [1975-1998], our system losses have been reduced from over 13% to less than 5.4%.*
>
> *The net result has been to more than double actual energy sales [efficiency] from under 6 kWh per gallon of fuel in 1975 to nearly 12.4 kWh in 1998.*

It appears that rural electrical usage as measured by total mWh sold by PCE utilities, rose from 293, 086 mWh in FY90 to 391,454 in FY00, a 33 percent increase in ten years, with 2/3 of the increase coming in the first five years.

Meanwhile, fuel consumed went from 24.8 million gallons to 27.7 million gallons over the same time period, an 11.7 percent increase.

Thus, fuel efficiency improvements (19.7 percent) offset roughly 2/3 of aggregate energy consumption— saving rural Alaskan electric utilities roughly *5.5 million gallons of fuel per year*.

Interviews with utilities that have reported significant fuel efficiency gains strongly support the proposition that fuel efficiency gains require a combination of factors need to work together including:

- Management focus on efficiency
- Management information to enable measurement of efficiencies
- Effective operations, maintenance and management to get the most out of existing infrastructure
- Access to financing to replace capital equipment with new more energy-efficient equipment

1.9.5 Market Penetration Considerations

Local utilities are likely to continue to replace diesel gen sets with new gen sets based on the availability of financing from internally generated funds, bank loans, low interest loans from former rural utility service programs, and equipment leasing available from diesel generator set manufacturers.

The replacement can come after a unit has been overhauled as many as three times and has 100,000 hours. Alternatively, the replacement can come when the oil is beginning to indicate the need for an overhaul.

As it turns out, running units until they need replacing rather than performing major overhauls may be more economical in some circumstances. See for example, Excel Spreadsheet Model **DieselBC**, Tab "UnitSubNPVSensitivity."

It appears from the diesel fuel system efficiency data analyzed as part of the Efficient Operations, Maintenance, and Management Study, that systems of all sizes have experienced efficiency improvements over the past decade or so.

Nonetheless, some smaller systems appear to continue to lag behind the larger market trend.

1.10 Appendices

APPENDIX A

Rural Alaska Utilities Standards—Review of the Power Cost Equalization Efficiency and Staffing Standards

APPENDIX B

Cost/Reliability Profiles – Utilities & Households

1.11 Appendix A: Rural Alaska Utilities Standards—Review of the Power Cost Equalization Efficiency and Staffing Standards

Introduction

The purpose of this appendix is to describe the history and implementation of standards by the APUC/RCA in its review of allowable costs under the State of Alaska Power Cost Equalization (PCE) Program.

Based upon the mixed success of the history and implementation of prescriptive standards for rural utilities in the PCE program, it may be useful to consider alternative approaches including:

- Descriptive standards similar to the American Public Works Association accreditation program
- Performance based regulation where utilities are provided with incentives to improve efficiency—allowing the utility to share a portion of the cost savings it achieves

PCE Program

The Power Cost Equalization Program was established in 1984 to equalize the electricity cost per kilowatt-hour statewide. The program was designed to pay a significant portion, 95 percent, of the APUC/RCA approved costs between the urban average cost of electricity of then 8.5 cents per kWh and a ceiling of 52.5 cents for rural Alaskan utilities.

As of July 1999, the urban average floor was set at 12 cents per kWh, subject to annual upward revision by the Regulatory Commission of Alaska in the event the weighted average cost of electricity in urban areas exceeds 12 cents per kWh.[32]

Residential customer PCE support is limited to the first 500kWh per month of consumption.[33]

Local community facilities are eligible to receive PCE support for actual consumption of not more than 70 kilowatt-hours per month for each resident of the community. Community facility means a water and sewer facility, public outdoor lighting, charitable educational facility, or community building whose operations are not paid for by the state, the federal government, or private commercial interests.[34]

As noted by the State Division of Energy on its web page describing the PCE program, PCE is a core element of the financial viability of centralized power generation in rural communities.[35]

Promulgation of PCE Efficiency Standards

In 1988, through legislative intent language, the Fifteenth Legislature required the Alaska Public Utilities Commission, the APA, and the Department of Community and Regional Affairs to:

> *Review and evaluate possible modifications to the Power Cost Equalization Program and Report to the Legislature. Specific consideration should be given to the establishment of*

---

[32] See AS42.45.110(c)(1)

[33] See AS42.45.110(b)(2)

[34] See AS42.45.110(b)(1)

[35] see http://www.aidea.org/pce.htm

guidelines or standards for participation in the program including fuel efficiency and administrative expenses. Specific consideration should also be given to the restructuring of PCE payments in order to provide incentives to make efficiency improvements.

In October 1988, the APUC issued a notice of inquiry and proposed regulations for comment.

After receiving oral and written comment and allowing time for feedback from the legislative staffers involved in the drafting of the legislative intent language, the Commission issued an order in April 1989 adopting regulations that, among other things:[36]

1. Demand, facilities, and customer charges were excluded in calculating average electric rates for the purpose of a state funded power cost equalization program
2. In determining electric utility fuel costs for purposes of a state funded power cost equalization program, (1) an inventory capacity of 10 percent was found appropriate; (2) labor, dock, storage, and wharf costs were excluded; and (3) a market standard was applied to purchases from affiliated suppliers.
3. Generating efficiency standards for electric utilities generating with diesel fuel for all power requirements and separate standards for partial diesel or power purchase utilities were adopted reflecting consideration of the efficiency of the generator, transmission and distribution line loss, and station power needed to run the power house.
4. Allowable line loss standards for electric utilities were adopted.
5. Standards for limiting personnel and consultant costs in determining power cost equalization were rejected in favor of a "reasonableness" standard.

In short, the Commission established standards for some areas (fuel inventory capacity, local fuel handling costs, generating efficiency, and line loss) and declined to set standards for personnel and consulting costs in favor of ad-hoc "reasonableness review."

Minimum Efficiency Standards

The fuel efficiency standards were designed to set a target that should have been achievable for "the vast majority of the utilities by adhering to reasonable operating and maintenance practices."[37]

Table 1-7. Minimum Efficiency Standards for Utilities that Rely on All-Diesel Generation (Annual kWh sold per gallons consumed)[38]

	Less than 100,000 kWh sold annually	100,000 to 499,999 kWh sold annually	500,000 to 999,000 kWh sold annually	1,000,000 to 9,999,999 kWh sold annually	10,000,000 or more kWh sold annually
Beginning October 1, 1990	6	7	8	9	10
Beginning October 1, 1991	7	8	9	10	11
Beginning October 1, 1993	8	9	10	11	12

[36] See APUC Order No. R-88-6(5), dated April 13, 1989.

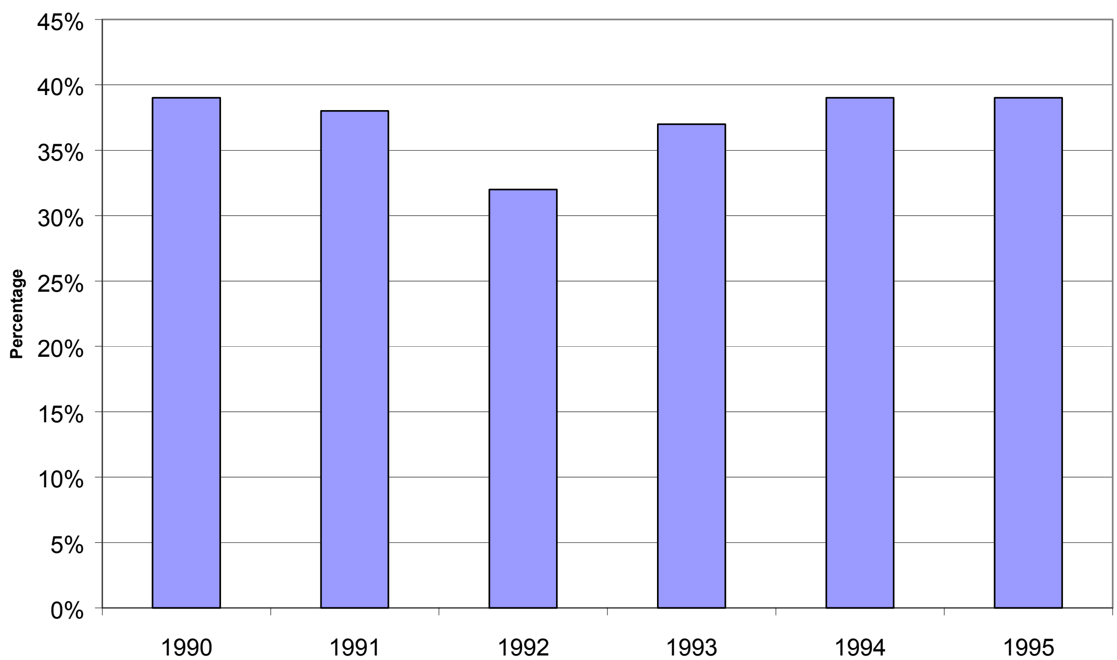
[37] As articulated by Commissioner Sokolov in a separate statement to APUC Order No. R-88-6(5), April 13, 1989.

[38] See 3 AAC 52.620.

As it turned out, roughly 1/3 of the all-diesel generation utilities that applied for PCE in the years 1990 through 1995 did not meet the generation efficiency standards adopted in 1989.

There does not appear to be a discernable trend over the period 1990 to 1995 among those all-diesel generation utilities that failed to meet the generation efficiency standards.

Figure 1-5. Percentage of Utilities NOT Achieving Generation Efficiency Standards



Source: Barb O'Hara Fuel Efficiency Database (1990-1995)

Perhaps as Commissioner Sokolov noted:[39]

> *The regulations by themselves, however, will not succeed in achieving their intended goal. They must be supplemented by a comprehensive program which addresses small utility operations. Routine maintenance and other operating practices of many village utilities should be improved; inefficient and unsafe plant should be upgraded or replaced. Power system parameters may forewarn of major breakdowns. Systematic engine oil sample testing and incentive programs directed at improving maintenance may also provide some answers in bettering power plant operations.*

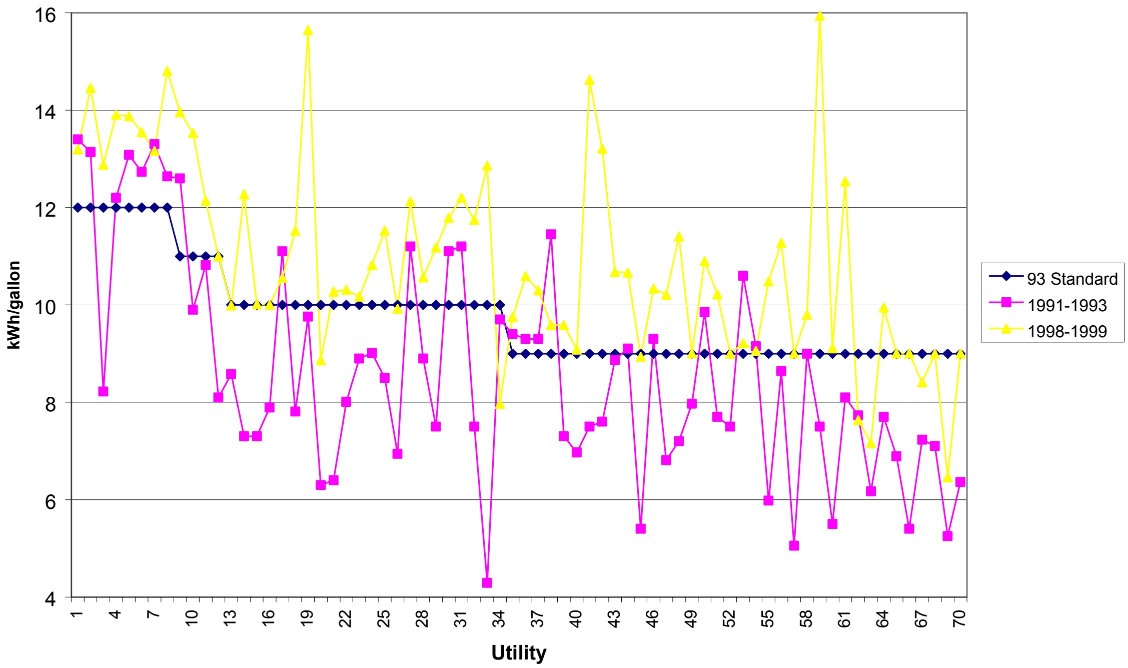
Review of the Data from the 1990s (See Chart Below):

A decade after adoption of the efficiency standards, roughly 23 percent of the all-diesel utilities still failed to meet the standards. In short, a net of 15 utilities moved into compliance over the decade out of a total of roughly 90 utilities that were not in compliance at the beginning of the decade.

With the exception of the 10,000,000 kWh a year or larger size category where all utilities are now in compliance, the remaining size categories contain non-compliant utilities.

[39] Ibid.

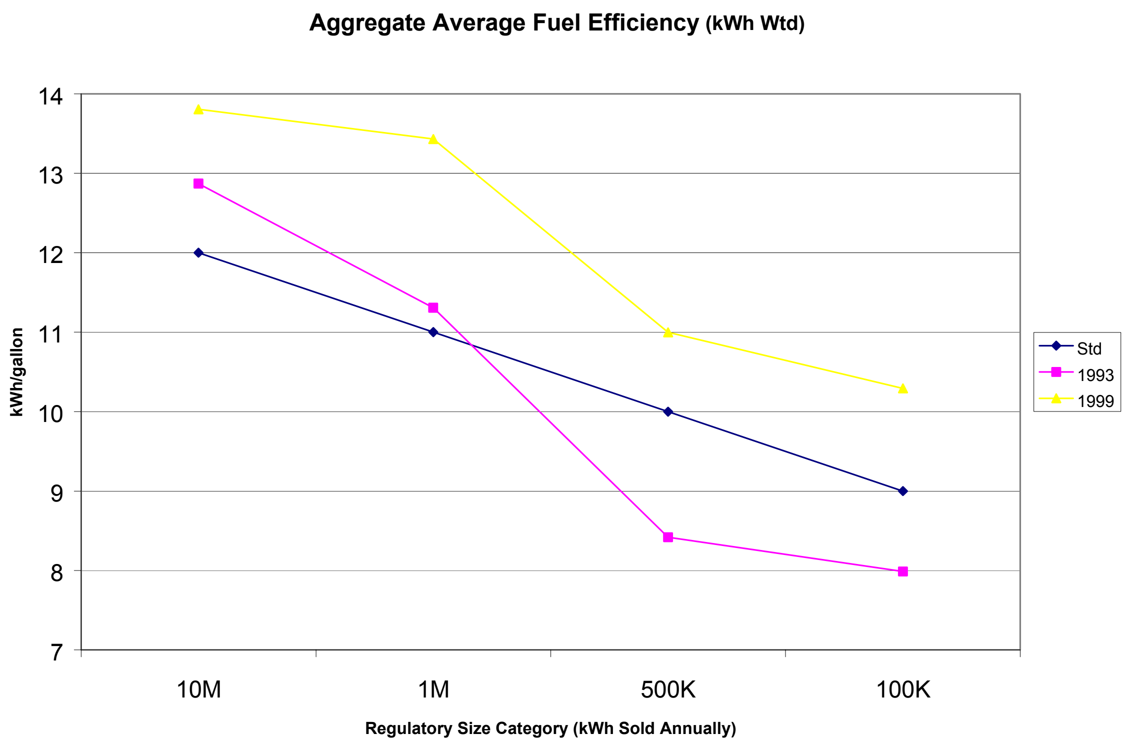
Figure 1-6. Generation Fuel Efficiency



Noncompliance has moved from being distributed among all size levels toward further concentration in the less than 500,000 kWh a year group. Thus, questions remain about whether the standard is set too high for this size category, or whether the standard is about right, but that the tools (capital, management, operations, information) necessary to meet the standard are not in sufficient supply.

Nevertheless, overall, the kWh weighted average fuel efficiency for each size category has clearly moved upward over the period 1993-1999.

Figure 1-7. Aggregate Average Fuel Efficiency (kWh Wtd)



It appears that the smaller size utilities (less than 1,000,000 and 500,000 kWhs a year) have experienced dramatic improvements in aggregate efficiency over the previous decade.

Anecdotal evidence suggests that improved load matching practices combined with the installation of new generating units with overall higher efficiencies and improved partial load efficiencies have been major contributors to the overall fuel efficiency improvements.

Efficacy of standard vs. Newer, efficient and better matched generating units

In the two largest size categories, the number of utilities that did not meet the standard was de minimus and yet the aggregate fuel efficiency improved significantly in both categories over the 1990s—suggesting that the fuel efficiency standards, in and of themselves were not a significant factor contributing toward improvements.

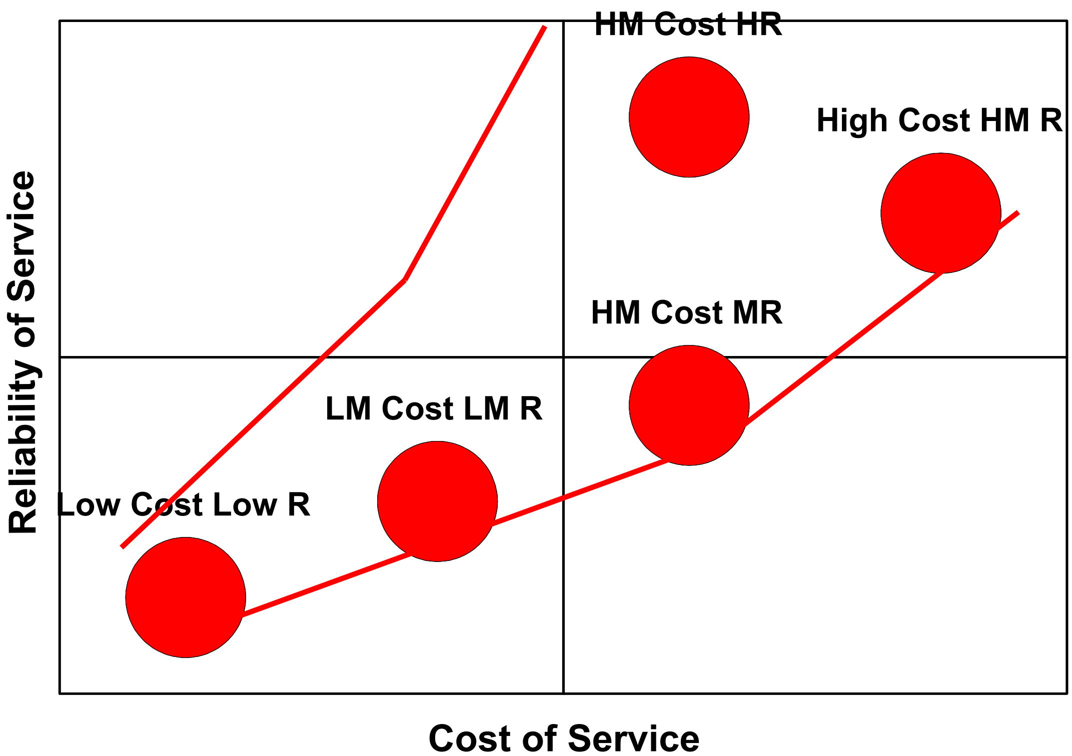
Summary

Fuel efficiency standards, in and of themselves, do not appear to have been a significant contributing factor to the efficiency improvements that the PCE utilities experienced in the 1990s.

It appears likely that the replacement of older generating units with newer, often smaller generating units that were more efficient and more closely matched with system loads may be a more significant factor contributing to aggregate efficiency improvements over the decade.

1.12 Appendix B: Cost/Reliability Profiles—Utilities & Households

Figure 1-8. Cost of Service vs. Reliability of Service Value Profiles



In general, cost and reliability tend to be related—it costs more to get more reliability. In addition, it tends to cost a lot more for the last few increments of reliability compared to the first few. For example, the cost to improve reliability from 99.9 percent ("three nine", 8 hours a year of outage) to 99.99 percent ("four nines", 53 minutes a year) *may* be more than the cost to go from 99 percent ("two nines", 88 hours of outage a year) to 99.9 percent ("three nines", 8 hours of outage a year).

On the ground, cost and reliability of service in rural Alaska do **not** follow a neat line based on a review of available data, recognizing the available data is relatively poor. The PCE filings provide some cost data (but typically not all costs, especially contributed capital from grants), and reliability data are sparse and do not appear to be consistently recorded or reported. Alaska Power & Telephone provides a notable exception with respect to reliability data— it files detailed reliability data with its annual reports as a regulated utility that enable some insights into outages.

There remains a deal of variability in costs (even after adjusting for contributed capital) and the costs do not appear to be *well* correlated with reliability. Reliability appears to be more closely *related to whether the utility management has a high reliability expectation of its operations.* Some high reliability expectations do appear to drive higher costs and result in improved reliability compared to lower reliability expectations—where costs may be low, but may also be high.

What is a reasonable reliability expectation for a rural village? Should the reliability expectation be the same for all rural villages?

It may be interesting to note that a key difference in the *cost* structure between Alascom and GCI in Alaska goes to how they approach reliability and robustness in their design and operations. The *cost* differential between the incumbent monopoly and the new competitive entrant may be on the order of 25 to50 percent, depending upon the particular infrastructure or service being analyzed. The relative difference in reliability and quality of service tends to be less. One designs "fool-proof" systems; the other designs systems that fools can crash, but monitors those systems so that lesser fools can fix them quickly.

Taking the analogy to rural electric markets, some villages may be served by incumbent utility managers who come from a tradition of high reliability and robustness that aims to build and manage "fool-proof" systems. These systems tend to be relatively high cost.

Other villages may be served by utility managers who have found their local circumstances appear to allow for less rigorous capital infrastructure reliability and operations, and some of these have relatively lower overall cost structure as a result. Some of these less reliable systems may also have a relatively high cost structure—potentially due to some combination of labor, fuel efficiency, or frequent large capital improvement requirements.

MAFA notes that a key element in the success of the lower cost structure approach is active monitoring and maintenance of systems which allows a more tailored approach to reliability and quality of service rather than a "one fool-proof size fits all" approach.

Finally, it may be interesting to note than in an informal survey of Tuntutuliak residents during the winter of 2000/2001 (after a morning where their electric utility power was off for about an hour) most residents reported that they *no longer had* an operational back-up generator. While many found the somewhat regular morning outages inconvenient, the outages were not sufficiently inconvenient to cause a number of households to keep their old light plants (back-up generators) going. Those with a higher need for reliability had purchased or borrowed back-up generators—smaller, quieter and more fuel efficient new light plants—that often doubled as portable light plants for trips around and outside of the village.

Curiously enough, a similar dual use of light plant phenomenon appears to have emerged in some West Anchorage neighborhoods following the high windstorm on March 12th. Some households who needed electricity to maintain heat and avoid freezing pipes were able to use their own or their neighbor's "motor home" light plant to enable the heating system to operate.