

Contents

Section	Page
3	Wind-Diesel Hybrid Systems..... 3-1
3.1	Introduction..... 3-1
3.2	Recommendations – Summary..... 3-5
3.3	Recommendations – Portfolio of Policy Options..... 3-8
3.4	Analysis..... 3-10
3.4.1	General Market Considerations..... 3-10
3.4.2	Specific Market Triggers..... 3-14
3.4.3	Market Intervention Program Design Considerations..... 3-15
3.4.3.1	Program Goals..... 3-15
3.4.3.2	Market Trends Absent Intervention..... 3-15
3.4.3.3	Market Intervention Program Alternatives..... 3-27
3.5	Recommended Market Intervention Alternatives..... 3-35
3.5.1	Market Reconnaissance..... 3-36
3.5.1.1	Introduction..... 3-36
3.5.1.2	Results of Market Reconnaissance Study..... 3-38
3.5.1.3	Analysis of Market Reconnaissance Study Results..... 3-41
3.5.1.4	Description of Market Reconnaissance Model..... 3-45
3.5.1.5	Market Reconnaissance Assumptions..... 3-47
3.6	Description of Wind System Technology..... 3-48
3.6.1	Background..... 3-48
3.6.2	Wind/Diesel Hybrids: Low, Medium and High Penetration Systems..... 3-50
3.6.3	Wind/Diesel Systems with Storage: Batteries and Secondary Loads..... 3-52
3.6.4	Characterization of Existing Technology Deployed in Alaska..... 3-53
3.6.4.1	The Kotzebue Project..... 3-55
3.6.4.2	The St. Paul Project – POSS Camp Industrial Facility..... 3-59
3.6.4.3	The Wales Project..... 3-63
3.6.4.4	Selawik Project..... 3-65
3.6.4.5	High Wind Potential Sites..... 3-66
3.6.5	Potential Savings from Existing Technology Deployed..... 3-67
3.6.6	Potential Net Benefits and Likely Market Penetration Absent Intervention..... 3-72
3.6.7	Market Penetration Considerations..... 3-76
3.7	Appendices..... 3-77
3.8	Appendix A: Highly Attractive Wind Opportunities in Rural Alaska..... 3-78
3.9	Appendix B: Wind Power in selected Rural Alaskan Communities..... 3-79
3.10	Appendix C: Low Sulfur Fuel Requirements..... 3-81
3.11	Appendix D: Texas Deliberative Polling Renewable Energy Results..... 3-83
3.12	Appendix E: Potentially Attractive Wind Opportunities in Rural Alaska..... 3-84
3.13	Appendix F: Simplified Break-Even Analysis..... 3-85

Table	Page
Table 3-1. Wind Resource Market Potential Study – Attractive Opportunities.....	3-3
Table 3-2. Policy Options for Rural Energy Plan – Economic Measurement Considerations.....	3-8
Table 3-3. Policy Options for Rural Energy Plan – Implementation Considerations.....	3-9
Table 3-4. Wind System Cost Range – Rural Alaska Reconnaissance.....	3-22
Table 3-5. 2002 Real Discount Rates for OMB Circular No. A-94 (January 29, 2002)	3-24
Table 3-6: “Approximate Recommended” Sliding-Scale Discount Rates	3-25
Table 3-7. Wind Resource Market Potential Study – Attractive Opportunities.....	3-39
Table 3-8. Wind Resource Market Potential Study – Potentially Attractive Opportunities.....	3-40
Table 3-9. WIND FARM: Average Wind Speed Required to Break Even with Diesel (mph).....	3-41
Table 3-10. WIND GARDEN: Average Wind Speed Required to Break Even with Diesel (mph).....	3-42
Table 3-11. Rural Alaska Wind Market Reconnaissance Medium Wind Penetration Scenario Number of Communities with B/C > 1.0.....	3-45
Table 3-12. Utility Price per Gallon for Delivered Diesel Compared to Benchmark Price of Oil	3-45
Table 3-13. Wind Power Class and Net Power Production Estimates	3-47
Table 3-14. Classification of Wind Hybrid Systems by Wind Penetration	3-52
Table 3-15. Summary Description of Wind Demonstration Projects in Alaska.....	3-54
Table 3-16. Performance Summary of the Kotzebue Project.....	3-56
Table 3-17. Actual Capital Costs for Phase I	3-58
Table 3-18. Expected Annual Operations and Maintenance Costs for Kotzebue	3-58
Table 3-19. System Performance of the St. Paul Project during the First Two Years of Operation ...	3-61
Table 3-20. Summary of Poss Camp Energy Production and Consumption from January to September 2001.....	3-62
Table 3-21. Actual Capital Expenses of the St. Paul Project.....	3-62
Table 3-22. Total Estimated System Costs of the Wales Project.....	3-65
Table 3-23. Estimated Project Costs for the Selawik Project.....	3-66
Table 3-24. Assumptions Used in Estimating Avoided Costs of Different Hybrid Systems	3-67
Table 3-25. Calculated Avoided Cost without Storage in Dollars per Kilowatt Hour (\$/kWh).....	3-68
Table 3-26. Calculated Avoided Cost with Storage in Dollars per Kilowatt Hour (\$/kWh).....	3-68
Table 3-27. Total Avoided Cost without Storage for Retrofits and New Diesel Generator sets.....	3-69
Table 3-28. Total Avoided Cost with Storage for Retrofits and New Diesel Generator sets.....	3-69
Table 3-29. Wind Energy (kW) Generated.....	3-70
Table 3-30. Total Added Costs of Hybrid Systems in Alaska.....	3-71
Table 3-31. Net Present Values of the Different Hybrid Systems.....	3-72
Table 3-32. Net Present Values of the Different Systems (without avoided costs from diesel generation)	3-76
Table 3-33. Minimum, Maximum, and Average Wind Power Classes of Selected Communities in Rural Alaska.....	3-79
Table 3-34. Wind Resource Reconnaissance Model Sensitivity Analysis: Eight Percent Diesel Fuel Increase	3-82
Table 3-35. Central Power & Light, Corpus Christi	3-83
Table 3-36. West Texas Utilities, Abilene	3-83

Figure	Page
Figure 2-1. Rural Alaska Wind Energy Development	3-2
Figure 2-2. Wind Market Potential Study – Benefit/Cost/Risk Profiles.....	3-4
Figure 2-3. Wind Resource Assessment Program	3-6
Figure 2-4. Wind Resource Assessment Program	3-7
Figure 2-5. Estimated Cost of Capital for Various Utility Ownership Models	3-26
Figure 2-6. Rural Alaska Wind Energy Development	3-38
Figure 2-7. An AOC 15/50 Turbine Assembly.....	3-51
Figure 2-8. Hybrid System with Battery Storage.....	3-53
Figure 2-9. St. Paul Wind Diesel System Architecture System	3-60
Figure 2-10. Wind Diesel System Architecture in Wales	3-63
Figure 2-11. Wales Wind Diesel System Communication and Control.....	3-64
Figure 2-12. Net Present Values: With Cost Savings from Storage, 5 percent Discount Rate.....	3-73
Figure 2-13. Net Present Values: With Cost Savings from Storage, 15 percent Discount Rate.....	3-73
Figure 2-14. Net Present Values: Without Storage, 5 percent Discount Rate.....	3-74
Figure 2-15. Net Present Values: Without Storage, 15 percent Discount Rate.....	3-74

3 Wind-Diesel Hybrid Systems

3.1 Introduction

The preliminary screening analysis identified wind-diesel hybrid electric power systems as one of a number of alternatives that have potential economic benefits compared to diesel systems due to diesel fuel savings and the potential to avoid costs associated with new or expanded diesel fuel tank farms and diesel systems.

The objective of this study is to refine the evaluation of the costs and benefits of wind-diesel hybrid 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.

The key parameters driving the economic assessment of wind-diesel hybrid systems include:

- Abundance of usable wind (steady and frequent) available at a local site
- Price of displaced diesel fuel
- Installed capital cost of towers, wind turbines, associated energy storage and new control systems (which are sensitive to scale economies and efficient rural logistics)
- Economic value of potentially delayed or avoided costs associated with reducing diesel fuel storage needs and diesel generating requirements

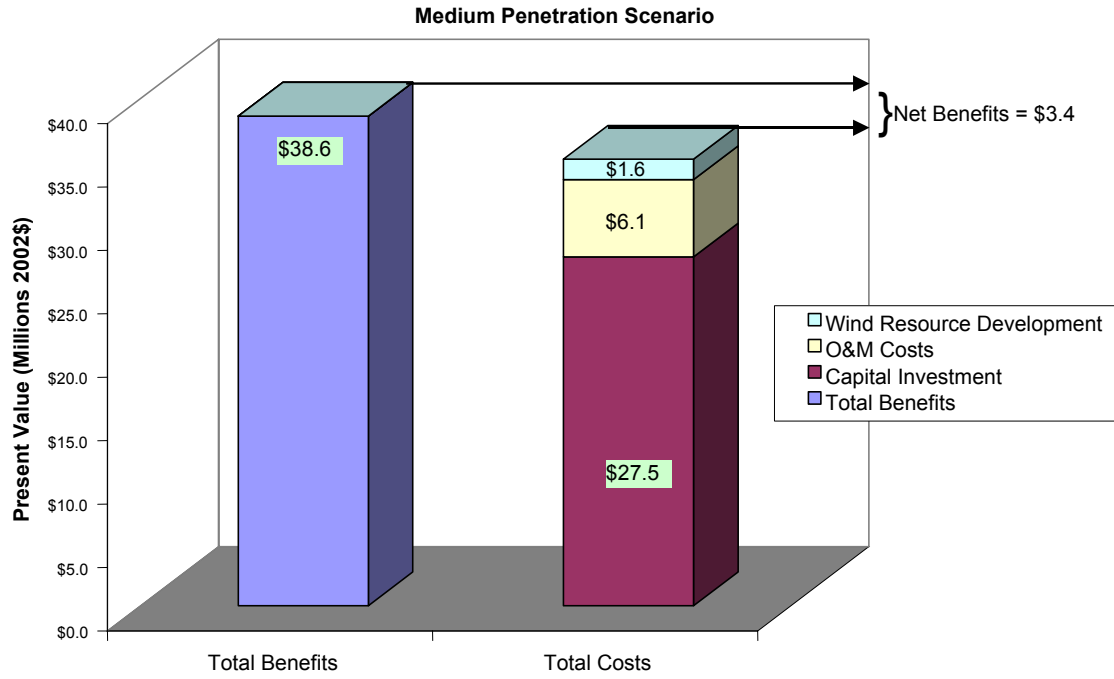
Attractive Wind Opportunities:

Based on an economic analysis of currently available individual PCE eligible communities, roughly 31 rural Alaska communities representing 15,000 residents, present **attractive** opportunities for wind resource development—with reconnaissance level benefit/cost ratios ranging from 1.0 up to 1.7. These communities represent, in aggregate, a total present value benefit of \$38.6 million and a total present value cost of \$35.2 million.¹ The potential net economic benefits from these communities are sufficient to justify a wind resource development program on the order of \$35 million—including \$1.6 million for detailed reconnaissance, preliminary design, and final feasibility, plus \$27.5 million for final design and construction contingent upon a finding of net economic benefits at the final feasibility analysis stage.²

¹ Total Cost = Capital + O&M + Wind Development Program Costs = \$27.5M + \$6.1M + \$1.6M = \$35.2M. All figures are expressed in present value 2002\$, based on cash flow estimates over a 15 year life using a 5% real discount rate.

² See Figures 3-3 and 3-4: Wind Resource Assessment Program

Figure 3-1. Rural Alaska Wind Energy Development



Source: Wind Resource Reconnaissance Model, Version 1.3, Medium Penetration Scenario (MAFA, 2002)

Table 3-1. Wind Resource Market Potential Study – Attractive Opportunities

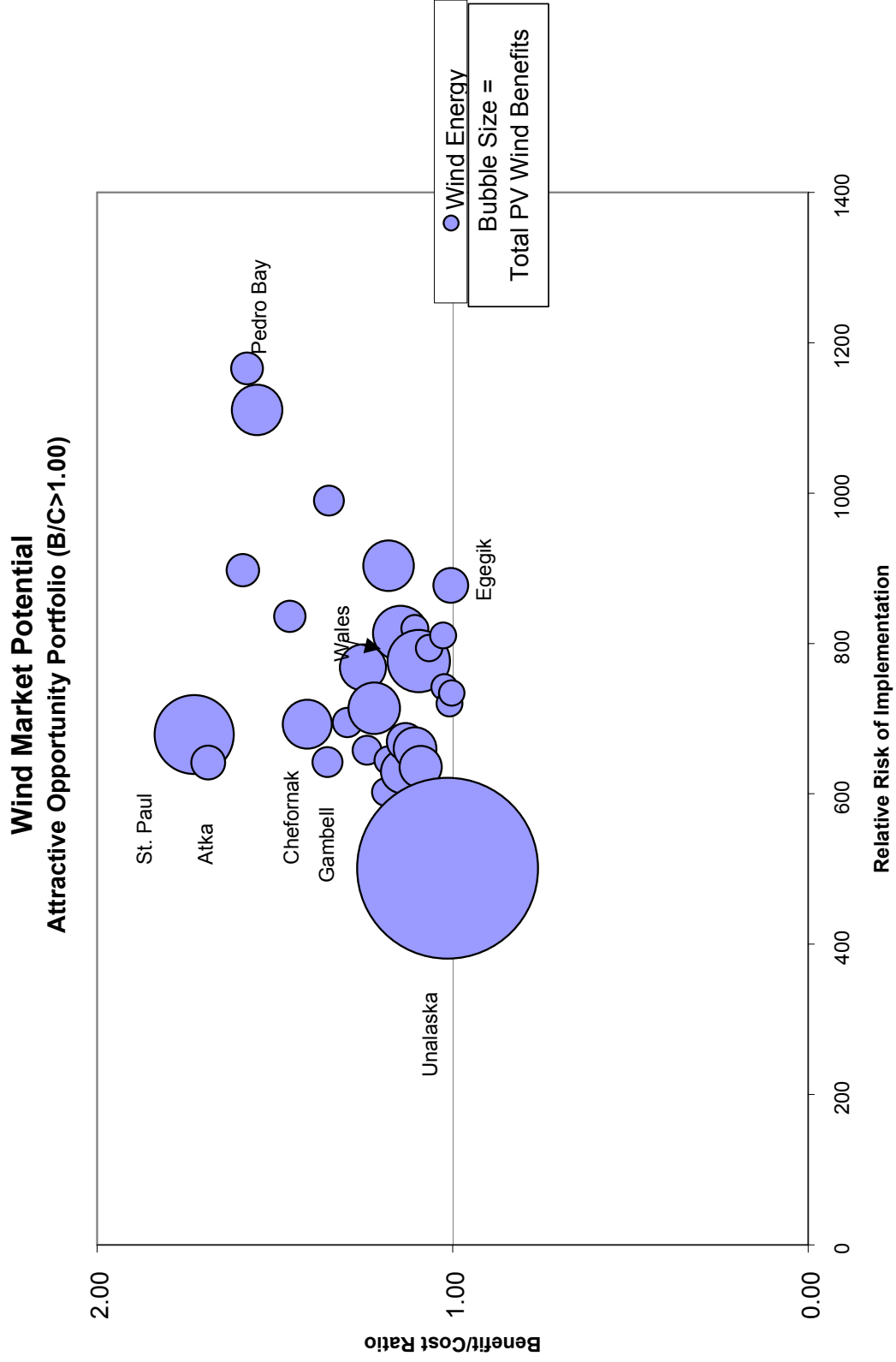
Community	Population	Wind Benefits (PV 2002\$)	Wind Costs (PV 2002\$)	Benefit/Cost Ratio
1 St. Paul	532	\$2,999,207	\$1,736,894	1.73
2 Atka	92	\$550,296	\$326,113	1.69
3 Pedro Bay	50	\$504,504	\$317,319	1.59
4 Platinum	41	\$496,160	\$314,400	1.58
5 Deering	136	\$1,239,215	\$799,781	1.55
6 Chefornak	394	\$473,785	\$325,063	1.46
7 Gambell	649	\$1,151,536	\$817,697	1.41
8 False Pass	64	\$438,825	\$324,611	1.35
9 Akutan	713	\$437,244	\$324,514	1.35
10 Nightmute	208	\$420,263	\$324,281	1.30
11 Kipnuk	644	\$1,021,549	\$815,891	1.25
12 Kwig	338	\$401,829	\$324,041	1.24
13 Kongiganak	359	\$394,250	\$319,830	1.23
14 Hooper Bay	1014	\$1,284,827	\$1,052,828	1.22
15 Perryville	107	\$376,719	\$317,304	1.19
16 Savoonga	643	\$1,222,002	\$1,035,531	1.18
17 Wales	152	\$382,008	\$323,732	1.18
18 Nunapitchuk	466	\$1,444,802	\$1,260,358	1.15
19 Chevak	765	\$928,455	\$814,585	1.14
20 Toksook Bay	532	\$673,775	\$594,993	1.13
21 Kokhanok	174	\$348,507	\$315,045	1.11
22 Akiachak	585	\$872,608	\$789,210	1.11
23 Point Lay	247	\$1,853,265	\$1,692,643	1.09
24 Kwethluk	713	\$859,661	\$789,011	1.09
25 Mekoryuk	210	\$344,587	\$323,200	1.07
26 St. George	152	\$326,586	\$318,105	1.03
27 Brevig	276	\$330,412	\$322,980	1.02
28 Unalaska	4283	\$15,595,178	\$15,375,554	1.01
29 Tununak	325	\$325,808	\$322,938	1.01
30 Egegik	116	\$583,940	\$581,032	1.01
31 Atmauluak	294	\$319,491	\$318,773	1.00
TOTALS	15,274	\$38,600,000	\$33,600,000	1.15

Source: MAFA Recon Model Ver 1.3 (2002), see also Appendix A: Market Potential Estimate, Medium Wind Penetration, Medium Avoided Diesel Cost Scenario; Population (2000 Census)

The relative benefit/cost and estimated implementation risk associated with each of the attractive opportunities is graphically depicted in Figure 2.1. The size of the bubble is proportional to the total present value of wind benefits. The y-axis represents the benefit/cost ratio and the x-axis represents the relative risk of implementation as measured by the relative size of the community—a surrogate measure for the availability of labor either skilled or readily trainable in the new technology.³

³ The underlying assumption is that the local labor market in smaller communities is more limited and the risks of outages and reduced reliability associated with a new technology that requires local operating and maintenance personnel are higher. This assumption is generally supported by an analysis of the efficiency performance of diesel generating systems (kWh sold per gallon of fuel). With additional time, a relative risk measure based on a more direct field performance measure (i.e., predicted vs. actual diesel fuel efficiency) could be developed. The relative risk could be mitigated if the utility can contract for specialized labor that travels around region to provide services.

Figure 3-2. Wind Market Potential Study – Benefit/Cost/Risk Profiles



Potentially Attractive Wind Opportunities:

Another 17 communities representing 16,000 residents represent **potentially attractive** opportunities for wind resource development, with reconnaissance benefit/cost ratios ranging from 0.85 to 1.0. These communities represent, in aggregate, a total benefit of \$53 million and a total cost of \$58 million under the medium wind penetration scenario. While the benefit/cost estimate ratios for these communities are less than one in the preliminary reconnaissance for medium wind penetration, they are within the margin of uncertainty associated with the market reconnaissance and warrant additional in-depth record and on-site reconnaissance to reduce the uncertainty of the potential value of wind resource development in these communities.

Please note that wind development has already begun in Kotzebue—a community with a benefit/cost ratio of 0.86 in the market reconnaissance study under the medium wind penetration case. An investment in additional reconnaissance in these communities is roughly equivalent to buying an option on the potential that the B/C for wind resource development in these communities will exceed one after further reconnaissance.

3.2 Recommendations – Summary

Based on the initial market reconnaissance study, MAFA recommends a wind resource development program on the order of \$30 million over roughly five years.

The program includes detailed site-specific reconnaissance, preliminary design, final feasibility, and, contingent upon a final feasibility determination, is expected to reach roughly 31 rural Alaska communities representing 15,000 rural residents.

In order to maximize the economic value of wind resource development, the recommended program focuses on systematically reducing the uncertainty associated with the initial market value estimates. As an industry best practice, the National Wind Coordinating Council recommends that construction funds should not be committed until a final project feasibility assessment is made based upon detailed site specific reconnaissance and *at least* two to three years of detailed local wind data at the proposed site.⁴ Please see Figure 3-3 below for a description of the wind resource development program.

Key questions for policy makers to consider include:

1. *What* is the appropriate basis for evaluating government funded energy sector capital investments, especially time frame, discount rate, and risk assessment
2. *How* to implement—large scale public/private partnership vs. individual community projects funded by government program

⁴ See National Wind Coordinating Council, Wind Energy Series No. 4, January 1997.

Figure 3-3. Wind Resource Assessment Program

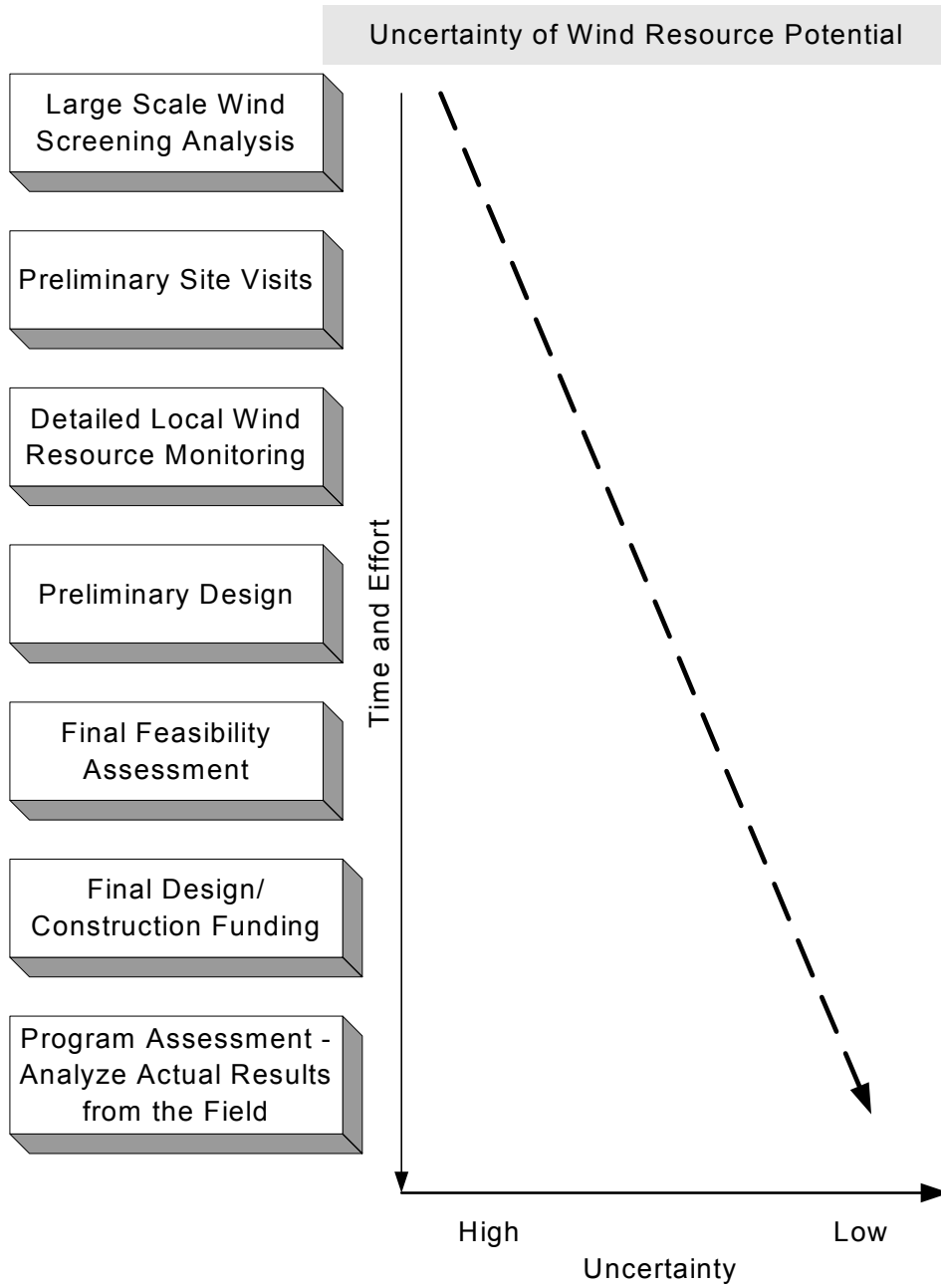
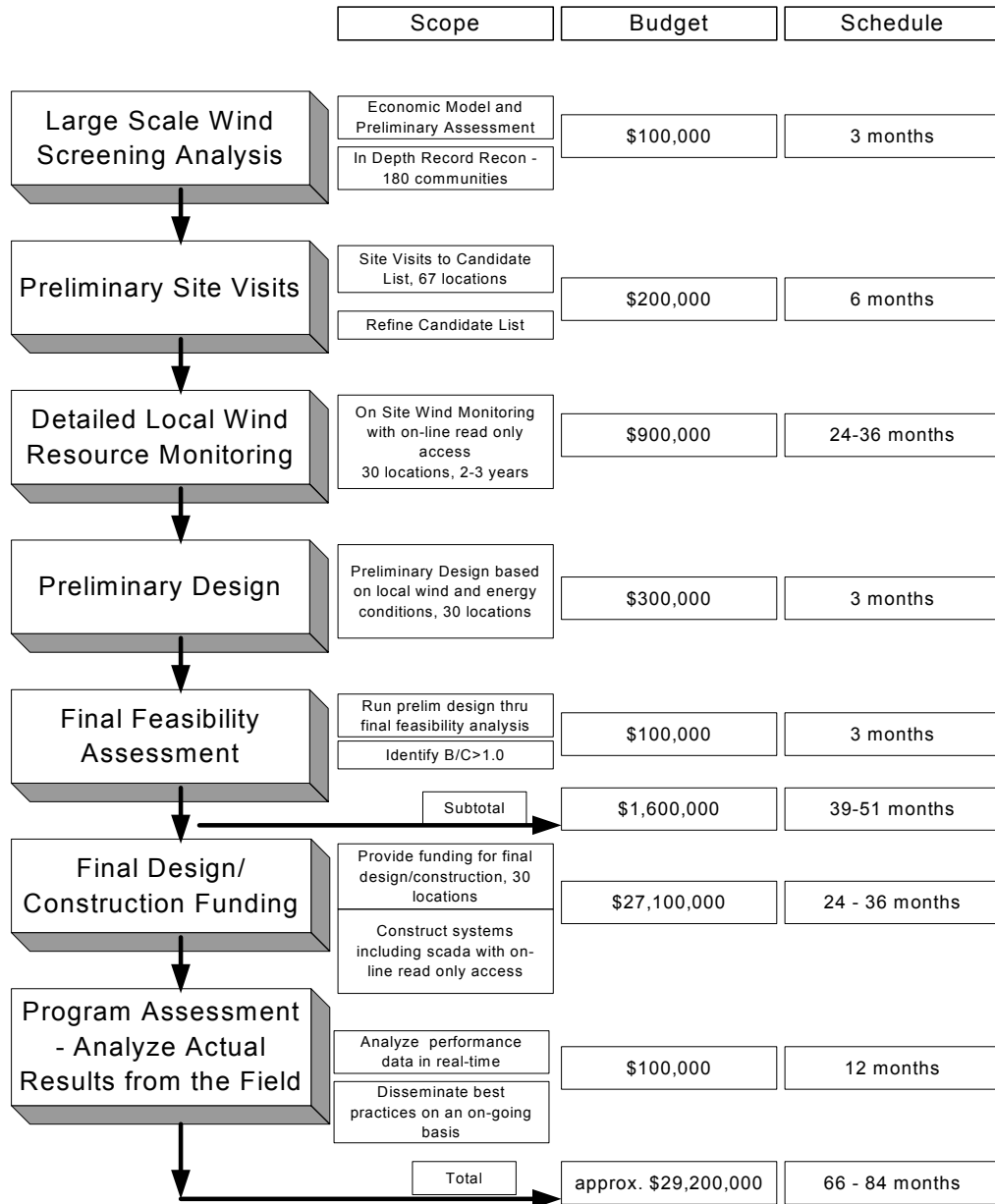


Figure 3-4. Wind Resource Assessment Program



3.3 Recommendations – Portfolio of Policy Options

The following policy options merit consideration in the Wind Resource Development Program (see Table 2.2 and 2.3 below).

Table 3-2. Policy Options for Rural Energy Plan – Economic Measurement Considerations

Reduce Cost of Capital			
Provide government funding of wind resource development 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*	Allows explicit risk trade-offs	Requires relative risk assessment metrics	Qualitative relative risk assessment may be biased.

* See Figure 2.1 for an example of Bubble Chart presentation of B/C, Present Value opportunity and relative risk assessment.

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

Reduce Cost of Capital				
Provide government funding of wind resource development where positive economic benefits are likely				
Alternatives	Benefits	Costs	Risks	
Detailed Reconnaissance Phase:				
A.	Contract for Large Scale Multi-Year Detailed Wind 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 wind design/build phase for communities who wish to participate	Consolidated procurement for \$25 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

3.4 Analysis

General Market Considerations

Specific Market Triggers

Market Intervention Program Design Considerations

- Program Goals
- Trends absent Government Intervention
- Program Alternatives
- Recommendations

Market Reconnaissance

- Introduction
- Analysis of Results

3.4.1 General Market Considerations

Factors favoring wind power as an attractive cost effective alternative to an all diesel system include:

- *High Energy Costs associated with Diesel Systems.* Currently, eighty-six percent of the power generated in rural Alaska is generated by diesel fuel (10 percent is generated by natural gas and 4 percent by hydropower) (AIDEA, 2001). The estimated total cost of producing electricity in rural Alaska can be as high as \$1.00 per kilowatt hour (kWh) (RUS Rural Utility Study, 2001).⁵ The total cost of diesel fuel is a significant portion of the cost of electricity—averaging roughly one-third of the total cost of electricity, ranging from 20 to 70 percent of the total cost of electricity depending upon community.⁶ The principal drivers of the high cost of diesel fuel include:
 - High transportation costs of fuel to small, remote communities—especially upriver—make their cost of energy significantly higher compared to other cities in Alaska. While fuel is usually shipped by barge in the summertime, small quantity delivery far upriver, low water requiring air delivery, and general non-accessibility by barge requiring standard air delivery all contribute to higher prices. The total price of flown-in fuel can be high—exceeding \$3.00 per gallon under some instances.
 - High costs of diesel fuel storage facilities due in part to the remoteness of sites (requiring larger storage capacity and driving higher construction costs) combined with increasing levels of environmental regulation are driving requirements for new facilities

⁵ Please note that the typically reported high price range of 50¢ per kWh for Rural Alaska does not include the costs of grant-funded improvements (diesel generators, power houses, tank farms) and subsidized loan programs.

⁶ The FY00 PCE Report indicates \$30.4 Million in direct fuel expense, not including grant funded capital costs associated with tank farms. This represents roughly one-third of the *total direct reported* cost of electricity. This does not include the government costs associated with grant funded capital or subsidized loans for diesel equipment and facilities.

- There is a relative lack of competition in fuel supply alternatives to serve small remote markets
- *Volatility of Diesel Fuel Prices.* The price of diesel fuel delivered to rural Alaskan communities may vary by as much as \$0.25 per gallon (as much as 40 percent) from year to year, presenting many local communities with a tremendous challenge to pay their annual fuel bill. For example, the PCE reported price of fuel rose \$0.27 from \$0.61 to \$0.87 from FY99 to FY00 in Tok (over 40 percent).⁷ It is important to note that the utility is able to pass on *much* of the diesel fuel price increase to end-use customers through fuel price adjustment clauses (limited by time lags and an increase in receivables typically associated with fuel price increases). Thus, shifting to alternative energy sources with less annual price volatility may be very valuable to end-use consumers in many communities, especially those with limited cash resources and volatile seasonal industries such as fishing and tourism.⁸
- *Wind Technology Learning Curve Driving Unit Costs Downward Faster than Diesel.* Wind Power appears economically attractive today under many circumstances and appears to be on a steeper learning curve for efficiency improvements compared to diesel.
 - Small-scale diesels in the 1920's 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.⁹ 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 percent improvement *in peak performance* over 80 years.
 - The 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.¹⁰ However, continuing efforts to reduce particulate and NO_x emissions may come at the expense of diesel fuel

⁷ See also Brevig Mission, Gambell, Hollis, Kasaan, Red Devil, Circle, Cordova, Gustavus, St. Paul, Tenakee, Unalaska, and Yakutat for communities that experienced significant (~20 percent) increases in fuel price from FY99 to FY00.

⁸ Thus, the utility has much less incentive to diversify its energy portfolio relative to end-use customers who feel the volatility most directly and dramatically in their bills. In order to help create a more efficient market structure, the end-users, who pay the bills, should be given an opportunity to place competitive pressures on the utility to adopt alternative energy services that may be relatively more valuable to end-users compared to utilities. In short, to align consumer and utility interests more closely, it may be prudent for utilities to hold a community meeting and endure feedback from their customers concerning whether or not to pursue alternatives to diesel (when the economics are at least potentially attractive). In this environment, a wind energy service company could also present itself as a viable alternative to the existing diesel system used by the utility.

⁹ See The Modern Diesel: Development and Design, Edited by Williams, Revised by Williams, 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 Show in December 1924.

¹⁰ 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 percent 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 to 60 percent of its rated capacity, presumably because most units are not run for a large number of hours at these low levels.

efficiency improvements and are likely to require post-combustion treatment systems increasing unit costs.¹¹

- In contrast, wind technology continues to experience significant efficiency gains that are reflected in downward trending unit costs.
 - Improved technology has significantly reduced the cost of energy from wind turbines since the early 1980s. In 1992, wind turbines were producing electricity for about 7-9¢/kWh at 16 mph sites, compared with more than 30¢/kWh in 1980.¹² This amounts to a 70 percent increase in overall system efficiency over a little more than a decade.¹³
 - Furthermore, wind system efficiencies are projected to continue to realize efficiency gains due to better equipment design, reduced operations and maintenance requirements, improved control and system integrations, and improved energy storage technologies to enable more efficient storage and use of the wind energy that is not immediately consumed.¹⁴
- *Availability of “Free” Wind Resources.* Many Alaskan coastal regions appear to have excellent wind resources year round. The Wind Energy Resource Atlas of the United States identified the major areas of wind resource in Alaska.¹⁵ The Wind Power Survey of AEA (2001) indicates that there are over 100 communities in rural Alaska with wind resources in the range of wind class three and above, equivalent to roughly 11 mph to 20+ mph average annual wind speeds.¹⁶ When the cost of developing these wind resources is compared to the benefits associated with avoided diesel systems costs, roughly 30 communities appear to have favorable economics based on a reconnaissance-level market assessment.
 - *Environmental Concerns Driving Cost of Diesel Energy Upwards.*
 - *Fuel Handling.* The major environmental concerns associated with diesel fuel energy systems include fuel spillage during transportation, fuel seepage around the tanks, and emissions from diesel generator sets. The fuel is stored in bulk fuel tanks, and some of these tanks have deteriorated with age and are leaking, and may have contaminated surrounding soil. Many storage tanks are 20 years old and need to be replaced. In some areas, new diesel storage facilities may cost as much as \$8.00 per gallon of storage to build (Denali Commission [www.denalicommission](http://www.denalicommission.gov), Department of Energy: www.eren.doe.gov). After taking into account the capital and additional operating and insurance requirements, the cost of new diesel fuel storage

¹¹ Massachusetts Institute of Technology, Energy Laboratory, MIT EL 00-007, Symposium Summary, The Future of Diesel: Scientific Issues, December 2000, pp. 16-17, John Heywood, MIT, Pat Flynn, Cummins.

¹² The EPRI/DOE Wind Turbine Performance Verification Program, NREL/CP-440-22486, January 1997.

¹³ The Royal Dutch/Shell Group of Companies web site (<http://www.shell.com/royal-en/>) reports that between 1980 and 1995, the *real cost of wind-generated electricity fell by 10 percent per year* in Europe.

¹⁴ See U.S. Department of Energy Wind Energy Program, Wind Turbine Technology & Research at <http://www.eren.doe.gov/wind/wtrr.html>.

¹⁵ See <http://rredc.nrel.gov/wind/pubs/atlas/>

¹⁶ See Appendix B: Wind Resources.

facilities in a remote rural village may add as much as another third to the price per gallon of delivered fuel.¹⁷

- *Air Quality.* In addition, concerns with diesel emissions continue to attract increasing environmental regulation that may increase the price of fuel. Most recently, air quality concerns are driving national requirements to lower the sulfur content for *on-road* diesel fuel to 500 ppm. Depending upon specific geographic markets and their associated supply and demand considerations, this may shift the market price for *off-road* diesel fuel as well.¹⁸

In summary, the potential benefits of wind-diesel hybrid systems include:

- 1) Wind-diesel hybrid power may be less expensive than diesel-only energy where the wind resource is substantial;
- 2) Wind is a free local energy source providing diversification for local Alaskan communities and hedging against volatile diesel prices;
- 3) Wind is a relatively clean source of energy compared to diesel systems;
- 4) Maintenance and repair procedures on wind *turbines* may be better able to be handled by local labor;¹⁹ and
- 5) New wind energy technologies and associated control systems are continuing to demonstrate efficiency and reliability improvements.

However, potential limitations on the attractiveness of wind-diesel hybrids include:

- 1) The cost of integrating wind with the existing diesel systems can be significant—including the capital cost, and the labor to calibrate, operate, and maintain the control systems to ensure system performance at high efficiency levels. Trouble shooting wind systems faults also requires considerable skill and experience, including diligent record keeping.²⁰
- 2) The cost of developing a critical mass in the labor market of skilled maintenance workers to repair wind turbines and control systems can be significant.
- 3) Limited availability of cranes for tower erection and maintenance in rural Alaska can raise installation and maintenance costs or limit wind resource development due to erection height limitations.
- 4) The wind resource can be variable.
 - a. Wind resource may not closely match the local load over the course of the day or the year, often requiring an energy storage system to capture the benefits of the wind resource.

¹⁷ See Wind Reconnaissance Model, Avoided Cost Estimates, Diesel Fuel Storage Column [Excel Spreadsheet WindBCa.xls, Tab “WindBenefitModel”, Columns BQ, BR]. Note that the reconnaissance model base case assumption set assumes 15 percent of the capital cost of fuel storage is variable for those communities where a new tank farm has not been installed in the last five years.

¹⁸ See Appendix C – Low Sulfur Fuel Requirements.

¹⁹ There is an assumption that the maintenance items on the wind turbines themselves require less specialized skill than maintenance items on diesel units. While this may be a reasonable guess, this local labor advantage may be offset by increased levels of specialized skills required to operate and maintain high penetration wind systems with sophisticated controls and secondary energy conversion and storage systems.

²⁰ See Lessons Learned in the DOE-EPRI Wind Turbine Verification Program (TVP), p. 7 (2001).

- b. Wind resource may vary significantly from the “best guess” available, whether it is based on a wind atlas, a local weather station anemometer or a more detailed local reconnaissance.
- 5) Wind resource development, including reconnaissance, design, installation, operations and maintenance, may be conducted on a “one village at a time basis” leading to high unit costs compared to larger scale efforts.
- 6) The cost to secure an optimal wind farm location for a community (property site negotiation, neighbor considerations—noise, visual, etc.) may be high. Diesel systems in Alaska typically require between 1 to 3 acres per MW (including fuel storage).²¹ Wind farms in Alaska may require between 4 to 60 acres per MW.²² Local land ownership issues may limit the ability to build wind farms in optimal locations.
- 7) Concerns may be raised about potential wind turbine impacts on local and migratory bird populations.²³

3.4.2 Specific Market Triggers

In addition to the general economic conditions that favor wind, the following market conditions may trigger economic opportunities for wind-diesel hybrids:

- o Existing diesel(s) are at or near the end of their economic life (time between overhauls is becoming noticeably shorter, the cost of the most recent overhaul increased substantially, reliability of a diesel unit is degrading)
- o A significant new demand for electricity, associated with new or upgraded sewer/water facilities; a new housing project; and/or a 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 wind energy are likely to be found at the confluence of:

- o Abundance of usable wind (steady and frequent) available at a local site
- o Moderate to High Cost of Diesel Fuel (Price of fuel plus potential cost of storage and handling requirements)
- o Moderate to high O&M Sophistication and a desire to learn new things (“early adopters” of new technologies or access to skilled contract labor)
- o Existing diesel(s) are becoming expensive to operate and maintain
- o A significant new demand for electricity is imminent in the community
- o A community where consumers who pay the bill for electrical energy have an opportunity to express their collective choice about whether they wish to continue their dependence on diesel compared to other energy technologies (like wind) that reduce their exposure to variable diesel fuel prices.

²¹ See for example the recent tank farm and new powerhouse project in Tuntutuliak.

²² Kotzebue’s current wind site is roughly 148 acres. The current installation of ten wind turbines (10X66kW = 0.66 MW) requires approximately ¼ of the total site, or $(148/4)/(0.66) = 56$ acres per MW. In contrast, a single 255kW wind turbine, like the installation in St. Paul, may only require 1 acre or roughly 4 acres per MW.

²³ See for example American Wind Energy Association, Wind Energy & Birds.

3.4.3 Market Intervention Program Design Considerations

3.4.3.1 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.²⁴

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?

3.4.3.2 Market Trends Absent Intervention

- What's happening?
- What cost effective resource development should be happening?
- What are the barriers to cost effective resource development?

Within the last few years, there has been an increase in interest in developing wind resources to generate electricity for electrical and heating end-use energy demand in rural Alaska. The most recent wind resource developments appear to be the result of:

- Publicly supported partnerships with highly motivated and relatively sophisticated rural Alaskan utilities (Kotzebue, Wales)
- Private capital attracted to high potential value opportunities (St. Paul POSS Industrial Facility Camp)

Based on a market reconnaissance of individual PCE eligible communities, wind resource development appears to be an attractive alternative to existing diesel generation in roughly 31 communities—with a total benefit on the order of \$38 million for the medium wind penetration case.²⁵

Without additional government funded market intervention, individual firms and communities are unlikely to pursue opportunities that are likely to provide net economic benefits to the citizens of the State of Alaska.

²⁴ See Alaska Energy Authority Statutes.

²⁵ See Appendix A: Market Reconnaissance

In short, a number of barriers significantly reduce the incentives of utility managers and energy service companies to invest in wind power.

Key barriers to consider include:

- Scale Economies
- Learning Curve/Minimum Sustainable Scale
- High Transactions Costs
- Wind Resource Variability and Uncertainty—How much wind is there?
- Wind System Cost Uncertainty—How much does wind energy cost?
- High Cost of Capital
- Artificial Market Structure Impediments

Scale Economies:

“The High Cost of “Small Scale” and “One-At-A-Time” Projects in Rural Alaska”

For example, the capital cost associated with the installation of three AOC 15/50 wind turbines (66kW Rating) and towers in Kotzebue was approximately \$600,000, or roughly \$2990 per kW. Installing an additional seven turbines cost an additional \$1,000,000, bringing the total capital cost to \$1.6 million or around \$2440 per kW – roughly a 20 percent reduction in unit costs.²⁶

Similarly, 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. Kotzebue is reported to have hired two full time people to work on wind—a wind engineer and a wind technician. If the costs associated with these specialists were spread over the anticipated wind production in Kotzebue alone, this could amount to as much as \$0.11 per kWh in labor costs.²⁷ However, if cost effective wind energy opportunities were developed throughout Northwest and Western Alaska, Kotzebue could provide technical support in a “wind circuit rider” fashion and drive unit costs for operations and maintenance labor down toward \$0.02 per kWh.

For example, while AVEC may not be able to afford to hire a full time wind engineer and wind technician for their wind operations in Wales, they may be able to obtain adequate operations and maintenance support from a contract with the experienced Kotzebue wind personnel.

²⁶ This is roughly consistent with prior EPRI Research Findings (Cost Estimates for Large Wind Turbines, EPRI Report AP-3276, November 1983). Single Wind Turbine costs were in the range of \$3,700 to \$4,800 per kW. Wind farm costs were estimated to cost 17 to 27 percent less to install on a \$/kW basis than a single machine. These turbines were in the 2.5MW to 4MW range.

²⁷ Kotzebue reports that these positions work on other than wind related activities, so that the actual cost per kWh is considerably less. This example is cited to illustrate the fundamental management program of acquiring specialized labor resources in rural Alaska: while you can buy specialized contract help that can be flown in from Fairbanks, Anchorage or outside, reliability requirements—especially during extreme weather conditions—often drive the need to have some local knowledge and expertise. You might be able to buy this local service on a part-time basis, but more often than not, you pay for a full time position (including retirement benefits if you want to keep your trained person from jumping ship and taking the next school district maintenance opening). The full time position needs to be spread out over as many activities as practical to keep costs reasonable while balancing the need for consistent reliable performance.

Learning Curve/Minimum Sustainable Scale

High penetration wind systems require sophisticated control systems. Efficient *reliable* operations of these systems require time for experienced control systems engineers and technicians to “dial-in” the control systems to local conditions. Efficient *reliable* operations also require well documented systems data to enable experienced control systems personnel to troubleshoot problems. The level of operations and maintenance sophistication required to reliably operate today’s wind-diesel hybrid systems (especially high penetration systems) is not necessarily typical of remote rural settings.

In order for the wind market to generate sufficient *demand* for specialized experienced labor to *sustain a supply* of experienced O&M labor at a reasonable cost, wind energy may have to achieve sufficient market penetration to support at least a half dozen personnel statewide, which requires a minimum sustainable scale of around 18 million kWh per year of wind energy.²⁸

Thus, for wind to provide reliable energy service in the rural Alaska energy market, it may have to achieve cost effective reliability in several communities including St. Paul, Gambell, *Kotzebue*, Hooper Bay, Savoonga, Chevak, Kipnuk, Kwethluk, and *Unalaska*.

In addition, even if the operations and maintenance knowledge and experience can be imported, it will take time for that knowledge to be efficiently transferred to local personnel in the key anchor tenant utilities or their service providers—local knowledge being required to maintain remote system reliability given current system performance levels.

Alternatively, the manufacturers of wind turbines and wind-diesel control systems may be able to drive reliability standards into a large worldwide market for cost effective small scale wind-diesel hybrid systems, producing simple, robust “plug and play” components that may theoretically reduce the need for local training and knowledge.²⁹

Both of these learning curves (people and robust product development) require time. While turbine manufacturers and control systems vendors may be making progress on product development, conditions in the near future seem to favor a focus on creating local self-sustaining clusters of expertise.

High Transaction Costs

Some of the “best practices” wind procurement contracting lessons learned from the EPRI/DOE Wind Turbine Verification Program include:

- Tight turbine purchase contracts to keep projects on schedule and within budget
- Site visits to inspect turbines during manufacture

²⁸ Example calculation: 6 people X \$60,000/year / \$0.02/kWh (O&M Labor) = 18 million kWh per year.

²⁹ This is somewhat analogous to the “black box” syndrome in transport vehicle engines. There was a gradual change in automobile, ATV, and outboard motors where fuel injection (fuel economy and performance), replaced carburetors (you could see and understand what was happening). Engine fuel economy, performance, reliability, and ease of use gradually improved (with the notable exception of whenever the manufacturer decides to improve things and changes something that degrades performance, reliability or ease of use). When the fuel injection doesn’t work, you don’t open it to see what was happening and tinker; you get a new black box. This might work OK when there is a repair shop with electronic diagnostics and a good selection of replacement parts in town and you have cash or credit cards. It might not be so convenient if between you and the nearest diagnostics and part store is a couple of plane flights and some inclement weather. Efficient, just in time inventory in this context may mean recycling old motors and locally maintainable parts in the community back yard.

- Ensuring all expectations are addressed in procurement, O&M, and equipment, performance, and availability warranty agreements with wind turbine vendor and other equipment suppliers and contractors (EPRI/DOE, 2001)

Individual utility managers in remote rural communities may not have the time and resources necessary to track down this list of best practices and the knowledge and experience that underlie it. Nor are individual utility managers likely to have the time and resources individually to acquire a “tight sample contract” or find a qualified person to administer the contract and conduct the site visit to inspect the turbines.

It is more effective for a larger regional organization to contract with knowledgeable and experienced personnel in the procurement of capital resources in order to manage the tradeoffs between capital and operating costs and reliable operations.

The Alaska Native Tribal Health Consortium (ANTHC) is an instructive model that acts on behalf of and works in a partnership with local communities to help reduce transaction costs and improve the overall quality of rural utility systems. It can be viewed as a statewide organization designed to consolidate specialized technical knowledge that has been used to reduce the overall transaction costs involved in the process to plan, design and construct sewer and water facilities for villages across rural Alaska.

Wind Resource Variability and Uncertainty

In the design of a wind resource development, there are two separate sources of variability or uncertainty associated with the wind resource.

The first element to consider is that the wind resource has an inherent natural variability. In short, the weather changes from day to day, week to week, season to season, year to year. This *resource variability* is something we accept as a natural variability that cannot be directly influenced by the recommendations from this report. It is analogous to variability associated with the snow and rain that may accumulate in any given year in the watersheds feeding the hydroelectric projects in the Western U.S. In some years, the snow is less than normal and there is less power than normal. When capacity margins are thin, this natural variability may create shortages and precipitate a “California Style” energy crisis. Similarly, wind-hybrid systems continue to require “capacity margins” from diesel or other energy storage means in order to avoid shortages if the wind does not show up in any given time period.

The second element to consider is that our knowledge of the wind resource may be uncertain. In other words, our measurement of the wind resource may not be accurate. In rural Alaska, much of our centralized knowledge of the wind resource appears to be based on interpolations between meteorological data and map reading (NREL Wind Resource Maps), this *measurement uncertainty* can be significantly reduced by following standard industry processes to more precisely quantify the wind resource.

Wind Resource Measurement Uncertainty

What can be done to reduce the uncertainty in our estimate of the wind resource? The following program is recommended to reduce the uncertainty of the wind resource and provide the basis for a final feasibility study prior to the commitment of capital expenditures.

Development of wind energy depends upon a clear understanding of the wind resource that is very dependent upon local conditions. Wind potential is often characterized by seven wind classes, each representing a range of wind power densities or wind speeds at a specified height above the ground.

In the lower 48, areas suitable for wind turbines are ranked as class 5 or above.³⁰ Due to the high cost of diesel-fired electrical generation in rural Alaska, wind turbines may be economical in some rural Alaskan communities with a wind power class of 3 or above.³¹

To predict wind turbine and associated wind system performance, one must know the aggregate average wind speed at a particular location and how wind speed varies at different heights and during different lengths of time. Variations during a short time period (seconds to minutes) have little significance for wind resource evaluation unless the wind is extremely turbulent or frequently changes direction. Information about variations over hours to days is essential because wind speeds typically persist for several days, reflecting weather conditions, and often exhibit daily patterns. Monthly, seasonal and annual variations also have significant impacts on a wind power plant's performance and how well that performance matches the energy requirements of the specific community.

The amount of usable energy from wind depends upon three basic variables:³²

- o Wind Speed
- o Length of Wind Turbine Blades
- o Air Density (cold winter air may have a density factor up to 20 percent greater than warm summer air)³³

Available Electrical Power = $C \times D \times A \times E \times V^3$

A key aspect of wind power density is the amount of usable energy varies with the cube of the wind speed. This means that a small change in wind speed results in a large change in available power. For example, if the average wind speed is 12 mph at the first site and 15 mph at a second site, the power available at the second site *may be* as much as twice as much as at the first site.³⁴ Conversely, if you estimate the aggregate average wind speed at 15 mph and it only turns out to be 12 mph, the power available may be half of your expectation. A critical determinant of the economic value of wind power is the aggregate average wind speed at the proposed site.

³⁰ See National Wind Coordinating Council, Wind Energy Resources, Issue Brief No. 4 (1997).

³¹ See Appendix A: Market Assessment of Wind Resource Potential

³² Available Electrical Power = $C \times D \times A \times E \times V^3$. Available Electrical Power = watts. C = constant = 0.5 in theoretical derivation for "kinetic energy in wind", 0.6125 in some "electrical power calculations" which take into account some losses. D = air density ratio (Standard sea level air density at 15 C = 1.225kg/m³. Average annual air density in Kotzebue = 1.32 kg/m³ based on -5.8 C with -25 C winter air density in excess of 1.40kg/m³). A = swept area in square meters = blade length(meters)² X 3.14159. E = blade efficiency (typically in the 0.3 range – consult your manufacturer). V = wind speed in meters per second. To convert from meters per second to miles per hour multiply by 3600 seconds per hour and divide by 1609 meters per mile. Exercise caution when converting from metric to U.S. measures.

³³ The increased air density with cold air is both a blessing and a curse as Kotzebue has discovered. More "free" wind energy is good for each wind turbine, until it is too much and it leads to a shorter gear box life on the over-worked turbines. Variable pitch turbine blades (with higher operations and maintenance costs) are a trade-off to consider to better match turbine performance to wind conditions.

³⁴ Under actual field conditions, the relationship between the power output of a wind turbine and wind speed does not follow a cubic relationship over the entire range of wind speeds. Below a certain minimum, the turbine does not have enough wind to operate, whereas above a certain speed its output levels off or begins to decline. In very high winds the turbine may even be shut down to prevent damage to it. Furthermore, the power output performance curve of a particular wind turbine over a range of wind speeds may not follow the theoretical wind output due to the losses associated with turbine blade design, turbine gear box, etc.

Thus, a key first step in developing wind energy is to conduct a survey of available wind resource data.³⁵ The National Renewable Energy Laboratory (NREL) Wind Energy Resource Atlas of the United States is a useful resource for initial examination of estimated wind energy resources.³⁶ For this report, the information from the NREL Wind Energy Resource Atlas has been translated into some basic wind power estimates in spreadsheet **Alaska Wind Resource Reconnaissance**, available online at <http://www.aidea.org/RuralEnergyPlan.htm>.

The degree of certainty with which the wind power class is specified in the NREL Wind Resource Atlas depends upon three factors: the abundance and quality of data, the complexity of the terrain, and the geographical variability of the resource. Over Alaska, certainty ratings are mostly low due to the complexity of terrain and scarcity of data in many areas. However, some areas have been identified with high wind resource and *relatively* high certainty where representative surface data, typically from anemometers at weather stations (meteorological or “met” data).³⁷ Even this so-called “relatively high” certainty appears low given the Kotzebue experience to date.

Thus, an individual utility manager may not have the time, energy and easy access to expertise to research available documentation and meteorological data for an individual community to refine wind resource estimates. In contrast, a coordinated statewide reconnaissance of existing documentation may cost about \$100,000, or roughly \$500 per community.

To further reduce the uncertainty associated with the wind resource, site visits by wind experts to communities with a “documented” wind power class of 3 or more *that also demonstrate the potential for net economic value* may be conducted to verify the “documentation” effort. Another purpose is to check for potential siting constraints. A site may prove inaccessible, there may be competing land uses, it may be difficult to obtain permits for the wind turbine farm or its transmission lines, or local land owners may express resistance to selling the necessary land and easements. A third purpose of the site visit is to select possible locations for detailed wind monitoring. (\$3000 per community; approximately \$3000 X 67 sites = \$200,000)

Once a set of promising sites has been identified through large-scale screening and follow-on site visits, equipment should be installed to monitor wind speeds for one to three years. The site chosen for the equipment should be as representative as possible of the locations that might actually be developed for wind power. Two or three anemometers should be placed on each tower to measure wind shear. Anemometers should be designed to transmit data to a central computer, where the data can be stored and analyzed. Extreme care must be taken throughout the process to ensure accurate measurements and to keep to a minimum any data loss caused by equipment failures. The approximate cost of installing and operating a single site for two to three years may be on the order of \$40,000. With a large-scale rural Alaska deployment of monitoring equipment and operations, the cost per site may decline to \$30,000.³⁸ (\$30,000 X 30 sites = \$900,000)

³⁵ See for example, American Wind Energy Association, Wind Energy Fact Sheet, “10 Steps in Building A Wind Farm”. Step Number One is to “Understand Your Wind Resource.” The most important factor to consider in the construction of a wind energy facility is the site’s wind resource. While the AWEA’s generic advice is that “a site should have a minimum annual average wind speed in the range of 11 mph to even be considered,” it appears that the high cost of fuel in rural Alaska may make wind economically attractive at even slower speeds compared to the lower 48.

³⁶ See <http://rredc.nrel.gov/wind/pubs/atlas>

³⁷ See NREL Wind Energy Resource Atlas of the United States, Chapter 2: The National Wind Resource, Subheading “Certainty of the Resource Estimates.”

³⁸ In addition, the National Renewable Energy Laboratory has a Native American Anemometer (and tower) Loan Program with equipment currently loaned out to Fort Yukon, Tanana, and Ugashik Traditional Village. There is some potential that equipment and monitoring costs could be reduced for this phase of the wind resource

Finally, after the detailed on-site wind resource assessment is conducted, preliminary design and final feasibility can be performed. Individual community preliminary design and final feasibility may cost on the order of \$30,000. A large-scale deployment effort may drive unit costs to under \$15,000. (\$13,333 X 30 sites = \$400,000)

At that point, it would be appropriate for the local community to participate in a “town hall” meeting to consider whether it wants its utility to invest in a particular form of power (wind, energy efficiency, new high efficiency diesels, etc) or not.

In summary, the detailed wind reconnaissance, preliminary design and final feasibility program is likely to cost around \$1.6 million over three or four years.

The project should be eligible for design and construction funding, if:

- o The wind resource is sufficient to justify an investment ($B/C > 1.0$, at discount rate of 5 percent over 15 years),
- o The community has expressed a commitment to wind energy (local community resolution, local community grant application), and
- o The local utility has either signed a long term contract for wind energy services or has provided a resolution that it will build and operate a wind system.

The funding should be made available to local communities.³⁹ The local community may contract the design/build activities to a utility or energy services company.

Based on current rural Alaska market reconnaissance, this may amount to a statewide design/construction effort on the order of \$27 million over a two- to three-year period (roughly \$1 million per community). Consolidated procurement with turbine manufacturers, control systems vendors, communications systems, tower vendors, and construction contractors and equipment should significantly drive down capital costs.

Thus, while an individual utility manager may not find a significant incentive to invest in the reconnaissance, the collective potential value of wind in the class 3 or above communities would appear to support a *total investment* approaching \$30 million, including roughly \$1.6 million in wind resource assessment.

Wind System Cost Uncertainty

In addition to the uncertainty associated with the wind *resource*, there remains uncertainty over the capital and operating costs and the reliability of wind system.

The costs to consider include:

- o Equipment Costs: Wind turbines (high wind/small rotor vs. low wind/large rotor), towers, manufacturer volume discount for wind farm contract, price and reliability competition in kW size range, first cost vs. quality trade-offs
- o Installation Costs: Site lease or purchase, foundation requirements, transformer and line extension to connect to existing system, control and communications systems, dump load/energy storage systems, wind-diesel control system integration, freight for all capital and

assessment by working with NREL to expand and extend their national program. Furthermore, once the towers and equipment are done with their Alaska reconnaissance, they can be passed on for use in other States.

³⁹ See U.S. Senate Bill 517, SA 2996.

construction equipment (crane) to site, installation crew mobilization and productivity, economies of scale for wind farm, multiple projects in one season

- Testing/turn-up/dial-in of system to local conditions
- Maintenance, surveillance, trouble-shooting (economies of scale in wind farm, regional circuit rider program)
- Reliability of system (Percent of time that the turbines are available to produce electricity)
- Turbine reinvestment/refurbishment/major overhauls cost and frequency (rotor blades, gearbox, generator— in the order of magnitude of 20 percent of the price of the turbine plus freight and labor)

In short, the costs for an installed system in rural Alaska may vary over a wide range due to potential variance across many factors.

Based on recent experiences in rural Alaska, one can expect the levelized cost per kWh to run from a low of under \$0.10/kWh to a high of over \$0.20/kWh. Key assumptions include: 15 year time horizon, 5 percent real discount rate, capacity factor 20 to 70 percent, communities ranging in size from under 500,000 kWh/year to those with around 20-30 million kWh/year, wind turbine performance match to wind resource and electric loads.

Table 3-4. Wind System Cost Range – Rural Alaska Reconnaissance

	Capital Cost (\$/kW)		Operating Cost (\$/turbine/yr)		Total Cost (\$/kWh)	
	Low	High	Low	High	Low	High
Low Wind Penetration	\$2200		\$2600		\$0.10	
High Wind Penetration		\$3600		\$60,000		\$0.28
DOE Small (< 40kW) Wind Turbine Verification Project Cost Targets ⁴⁰					\$0.38	\$0.60

Source: Section 2.1.6 Characterization of Existing Technology Deployed in Alaska

High Cost of Capital

Cost of Capital Background⁴¹

Cost of capital is the expected rate of return that the market requires in order to attract funds to a particular investment.

The cost of capital for a particular investment is an opportunity cost—it is the cost of foregoing the next best alternative investment.

The “market” is the universe of investors who are reasonable candidates to provide funds for a particular investment.

The opportunity cost of capital is equal to the return that would have been earned on alternative investments at a *comparable level of risk*.

The cost of capital for any given investment is a combination of two basic factors:⁴²

⁴⁰ See <http://www.eren.doe.gov/wind/small.html>

⁴¹ See for example, Brealey & Myers, *Principles of Corporate Finance*, 4th Edition, 1991, McGraw-Hill.

- *Risk free rate*: rate of return available in the market on an investment that is free of default risk, usually the yield to maturity on a U.S. government security, e.g., 10 year treasury note
- *Premium for risk*: an expected amount of return over and above the risk-free rate to compensate the investor for risk, which is often divided into three components:
 - Maturity risk (a.k.a. horizon risk or interest rate risk)
 - Systematic risk (a.k.a. market risk, i.e., S&P 500)
 - Unsystematic risk (a.k.a. company risk, specific risk, or residual risk), much of the company risk may be captured in the size premium – the concept that smaller size is associated with higher risk and therefore a higher cost of capital⁴³

High Cost of Capital for Private Sector in Alaska

The private sector in Alaska starts with a relatively high cost of capital compared to lower 48 markets due to:

- Relatively less liquidity—relatively fewer investment dollars available in-state to chase in-state investment opportunities
- Small size effect—many private sector firms in Alaska are “micro-cap” in size (Market Capitalization in the range of \$25 million or so and below); micro cap firms traded on the NYSE suggest a size premium on the order of 3 to 4 percent⁴⁴;

Cost of Capital for Government-Supported Utilities in Alaska

The federal and state governments have partially compensated for the high cost of capital in Alaska by providing grants and low interest loans for infrastructure development of various forms.

These subsidies have historically been available to government-owned entities and cooperatives and government-sanctioned authorities. Over the last twenty years, the government subsidies have become less generous as state capital grants have declined and the gap between subsidized interest rates and market rates for state and federal programs has narrowed. On the other hand, government subsidies have been made available to private investor-owned utilities in some instances, lowering the aggregate average cost of capital for investor-owned utilities.

For larger railbelt utilities with access to low interest loans and high debt/equity ratios, the weighted average risk adjusted *real* cost of capital may be on the order of 8 percent.

For energy service companies without easy access to low interest loans and capital grants, and typically with higher equity/debt ratios, the weighted average *real* cost of capital may be on the order of 12-15 percent.

As one compares urban to rural Alaska, the micro-micro size and limited liquidity in rural areas may add considerable risk to investments, creating circumstances that present a *real* cost of capital in excess of 15 percent.

⁴² A third factor is liquidity, which typically arises in the buying and selling of a company or minority interest in a company. It is normally treated as a separate adjustment in a valuation. See for example, Shannon P. Pratt, Cost of Capital: Estimation & Applications, 1998, John Wiley & Sons.

⁴³ See Pratt, Cost of Capital, (1998), pps.37, 89.

⁴⁴ See Stocks, Bonds, Bills and Inflation, 2000 Yearbook, Ibbotson Associates.

Government Funds Discount Rate—State of Alaska

In contrast, many State of Alaska-funded projects compare the cost of the investment to the expected returns from the State of Alaska Permanent Fund as one measure of the opportunity cost for State of Alaska government money. The expected forward-looking returns from the Permanent Fund were estimated at a 4.95 percent *real* discount rate in the most recent quarterly report (Second Quarter FY 2002, December 31, 2001).

Government Funds Discount Rate—Federal Government

On the federal side, the Office of Management and Budget annual discount rate memorandum issued on January 29, 2002 provides the following guidance for “cost-effectiveness” analyses:⁴⁵

Table 3-5. 2002 Real Discount Rates for OMB Circular No. A-94 (January 29, 2002)

3 year	5 year	7 year	10 year	30 year
2.1	2.8	3.0	3.1	3.9

These discount rates for “cost effectiveness” analyses are also referenced in the National Institute for Standards and Technology (NIST) Annual Supplement to the NIST Handbook 135, *Life Cycle Costing Manual for the Federal Energy Management Program*, entitled “Energy Price Indices and Discount Factors for Life Cycle Cost Analysis,” though their time frame for applicability varies slightly.

For benefit cost analyses of public investment, OMB Circular Number A-94 specifies the use of a 7 percent real discount rate, but allows for alternative cost of capital estimates if they can be justified.⁴⁶

In addition, OMB “Guidelines to Standardize Measures of Costs and Benefits and the Format of Accounting Statements provides the following:⁴⁷

The Circular [OMB Circular A-94] specifies the use of a 7 percent real rate to discount the constant dollar estimates. The 7 percent rate is an estimate of the opportunity cost of capital, as measured by the before-tax rate of return to incremental private investment. We revised Circular A-94 in 1992 based on extensive review and public comment. It reflects the rate of return on low-yielding forms of capital, such as housing, as well as the higher rates of return on corporate capital.

In the A-94 guidance, we encourage you to present sensitivity analyses using other discount rates if you can justify the use of such alternative rates. An alternative that we often see used is the “social rate of time preference.” The social rate of time preference reflects the discount rate at which society is indifferent between a payment now and a correspondingly larger payment in a future year. It may be lower than the average real return on investment because, as a result of taxes and other distortions, individuals do not receive the full return on their investment. The economic literature identifies the government borrowing rate as a good measure of the social rate of time preference and most analysts use the average rate on long-term Treasury bonds. In recent years, this rate has been roughly 3 percent.

You may also use an alternative method based on the “shadow price” of capital [the opportunity cost of diverting capital from one use to another].

⁴⁵ See <http://www.whitehouse.gov/omb/memoranda/m02-03.html>. January 29, 2002.

⁴⁶ See <http://www.whitehouse.gov/omb/circulars/a094/a094.html>. Revised October 29, 1992.

⁴⁷ See <http://www.whitehouse.gov/omb/memoranda/m00-08.html>. March 22, 2000.

Finally, a large survey of economists and subsequent analysis by Martin L. Weitzman suggests that the effective social discount rate should decline over time as follows:⁴⁸

Table 3-6: "Approximate Recommended" Sliding-Scale Discount Rates

Time Period	Name	Marginal Discount Rate (%)
Within 1 to 5 years hence	Immediate future	4
Within 6 to 25 years hence	Near future	3
Within 26 to 75 years hence	Medium Future	2
Within 76 to 300 years hence	Distant Future	1
More than 300 years hence	Far-distant future	0

State & Federal Funded Projects

For the purpose of this report, where the policy analysis appears likely to involve both state and federal funds and investments with a life of 10-20 years in many cases, a “base case” with a real discount rate of 5 percent is used. The results can be supplemented with sensitivity analysis of 3 percent and 7 percent in an attempt to capture the range of the opportunity cost of capital for state and federal policies and investments.

In many cases, relatively low up-front capital with high annual costs alternatives are being compared to relatively high up-front capital with low annual costs. As a result, modest changes in the assumptions about the discount rate and the choice of a 15-year time frame can make a significant difference in which alternative is most economically attractive.

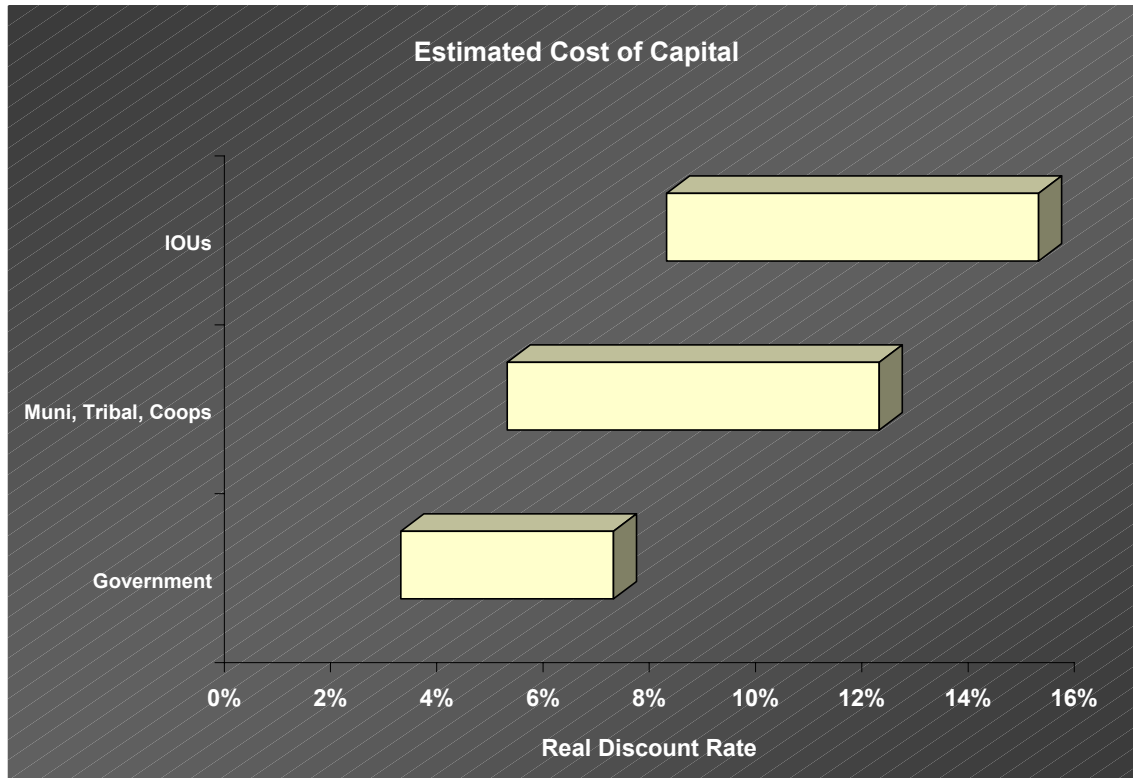
Government vs. Non-Government Sector Discount Rates

Thus, the risk adjusted cost of capital for the private sector (i.e., energy service companies and investor-owned utilities), is likely to be *considerably higher* than the cost of capital for state and federal government— resulting in less rural energy sector investment than is optimal from the point of view of the citizens of the State of Alaska.

In addition, the cost of capital for cooperatives, public authorities, municipalities, and tribal utilities may also be higher than for the State of Alaska due to loan interest rates increasingly tracking market rates and debt covenants requiring equity in the capital structure with equity’s relatively higher opportunity cost. In addition, many government and quasi-government sponsored utilities have to wait in line for low-cost government capital and have a difficult time obtaining private sector financing, thus driving their cost of capital upwards.

As a result, absent government funding (grants/loans), the high cost of capital in rural Alaska is likely to continue to significantly limit otherwise cost effective energy infrastructure investments.

⁴⁸ See Martin L. Weitzman, “Gamma Discounting”, American Economic Review, Volume 91, No. 1, March 2001, p. 270.

Figure 3-5. Estimated Cost of Capital for Various Utility Ownership Models

Institutional Market Imperfections

The incentives for utilities and their consumers to adopt a particular cost-effective technology may not be the same.⁴⁹ A classic example involves fuel price volatility. Utility regulators have traditionally protected utilities, but not their ratepayers, from fuel price volatility. Thus, when it comes to selecting the most cost-effective energy service to provide customers, the utility is much less sensitive to fuel price swings than the end-use customer.

This effect can be mitigated somewhat by budget billing—where customers are billed a levelized monthly amount based on an estimate of annual energy consumption. The overage or underage at the end of the year is applied to next year’s estimated monthly amount (similar to a mortgage escrow). Unfortunately, this fix still leaves customers relatively vulnerable to price swings that occur “between years” and across multiple years compared to the utility.

⁴⁹ This is often referred to as a “principal-agent” problem. Essentially consumers expect utilities to act on their behalf to obtain reliable low cost energy. And to protect against profit maximization incentives inherent in the grant of a monopoly service, a regulatory body may have jurisdiction to look out for the customers to make sure they are not paying more than they should for the service. But alas, the customer finds that the utility and the regulator have rationalized that since the utility management is not responsible for fuel price changes per se, fuel price changes should be passed through directly to consumers. On a day-to-day basis, this argument might have some limited merit. But over time the utility management can exercise control over the magnitude of fuel price changes through improved fuel efficiency and through managing their demand and supply resources to minimize the impact of fuel price swings on consumers. But with fuel price adjustment clauses and cost of power adjustment clauses, the utility management has little incentive to seek fuel efficiency and fuel diversification relative to consumers who pay the bill.

Finally, the power cost equalization (PCE) program insulates rural residential customers from seeing the full effect of fuel price swings, adding a further market impediment to rational economic choices.⁵⁰

How might incentives between the customer and its agents (utility and regulator) be better aligned? It may be prudent to require both the utility and the regulators to actually talk to real customers in a modern systematic way to ascertain the needs of the otherwise largely captive customer market.

In the late 1990s in Texas, eight regulated public utilities conducted deliberative polling on energy planning in their service territories in cooperation with the Texas Public Utilities Commission (PUC). The success of these polls led the PUC to require that the public be consulted on public utilities issues *after it has had an opportunity to be informed on the issues*.⁵¹

In a similar approach aimed at listening to local customers, ANTHC has placed a great value on “local community involvement” in the selection of utility infrastructure appropriate to that community. Rather than making assumptions about what a community needs, the staff of ANTHC has worked with communities to reach informed decisions about costs, benefits, risks, and quality of service. It is hoped that by building community support for the infrastructure that is installed, there will be a heightened desire to take ownership of the facilities and provide appropriate maintenance to ensure long-lived facilities.

3.4.3.3 Market Intervention Program Alternatives

The basic market intervention alternatives available to the state/federal government policy makers include:⁵²

❖ Investment Incentives

○ Investment Tax Incentives

Investment tax credits usually lower an investor’s capital expenditures by allowing the investor to reduce his tax burden by a portion of the amount that was invested. This lowers the investor’s cost in making the investment through the savings in tax expenditures.

This option favors the for-profit over non-profit management structure. Given the larger number of non-profit utilities operating in Alaska, the short term impact of an investment tax incentive would be narrowly confined to those areas currently served by for-profit entities.

○ 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’s’ 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 accelerated depreciation of wind equipment (for example, allowing 100 percent depreciation

⁵⁰ See Government Programs Chapter for a discussion of the PCE program.

⁵¹ See The Center for Deliberative Polling, University of Texas, Blue Book, Executive Summary. See also American Wind Energy Association public polling on renewable energy.

⁵² See also American Wind Energy Association web page for a discussion of wind energy policy. For a more complete discussion of government policy options, see “Strategies for Supporting Wind Energy: A Review and Analysis of State Policy Options”, Nancy A. Rader, Ryan Wisser, National Wind Coordinating Committee, prepared for the National Conference of State Legislatures, 1999.

of a wind turbine 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 depreciation expense could be paid for by the PCE program. The attractiveness of this solution is limited since depreciation on capital that was funded by grants has not been 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 are including 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.

- o Grants

Direct cash payments can be a very efficient way to promote cost-effective wind energy services. Many times, a direct cash payment for the installation of a wind energy system 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.⁵³

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.⁵⁴

⁵³ SA 2996, Subtitle A: Rural and Remote Community Development Block Grants

⁵⁴ SA 2996, Subtitle B: Rural and Remote Community Electrification Grants

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.⁵⁵ 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 non-metropolitan average, and the area does not include a city with a population of more than 15,000.

The administration of grant programs could be efficiently delegated to the Denali Commission and Alaska Energy Authority given the grant administration infrastructure in place.

❖ Production Incentives

○ Production Tax Credit

A production tax credit provides the generator or owner of a wind facility an annual tax credit based on the amount of energy that the particular facility produced. At the federal level, the production tax credit is inflation adjusted from a base of 1.5 cents per kWh in 1993 dollars for the first ten years of a qualifying facilities operation subject to availability of appropriation. The 2001 credit was 1.7 cents per kWh.⁵⁶

Enacted as part of the Energy Policy Act of 1992, the credit, which had expired at the end of 2001, was extended in March 2002 as part of H.R. 3090, Job Creation and Worker Assistance Act of 2002. The credit is set to expire at the end of 2003.

Tax credit is available for taxable entities, and a cash payment is made to non-taxable entities (municipalities and cooperatives).

Kotzebue received \$14,403 in 2001 for FY2000 production and any prior year unpaid production it may have had.⁵⁷

○ Direct cash payments per kWh produced

These payments are similar in nature to investment grants; however, the government pays the generator a certain amount of money per kWh produced. This incentive not only encourages a potential developer to build a wind farm, but also to produce as much electricity as possible to obtain the production benefit. An advantage of direct cash payments is that they would not favor one management structure (non-profit vs. for-profit) over another and would provide widespread benefits fast.

To maintain a semblance of economic efficiency, the direct cash payment could be designed to be roughly proportional to the avoided cost of existing electrical generation of the particular community.

The program overhead could be held down by tying the calculation to an existing calculation methodology—the avoided cost calculation required by PURPA and reviewed by the RCA. However, these avoided costs have typically been calculated assuming a very small decrement in output. The calculation typically includes the avoided price of fuel and does

⁵⁵ SA 2996, Subtitle C: Rural Recovery Community Development Block Grants. The phrase “designated industrial park” is not defined in SA 2996.

⁵⁶ See IRS Form 8835 Renewable Electricity Production Credit (2001).

⁵⁷ See Renewable Energy Production Incentive (REPI), U.S. Department of Energy, Office of Power Technologies.

not tend to capture the likely avoided costs of a medium-penetration wind system—the avoided cost of fuel storage capital and O&M, the avoided/delayed cost of diesel overhauls, the avoided or delayed cost of diesel capacity additions.

A more accurate avoided cost methodology would require additional information that is not typically captured at present and would entail additional program overhead.

❖ Other Fiscal Incentives

○ Property Tax/Land-Use Fee Waivers

Property tax/land-use fee waivers or reductions also can be used to reduce the costs involved with the entire investment of a wind farm. A significant amount of land is necessary for the development of any wind project. Large amounts of land are associated with higher taxes or fees for the use of that land. In addition, in many instances, property taxes are based on the value of the facilities on the property. Compared to fossil fuel plants, wind plants are valued at a much higher rate, i.e., installed \$/kW, and therefore, are subject to higher property taxes. Eliminating or reducing fees or taxes on the land where the wind farm is built would lower the costs of the entire project.

○ Financing

Renewable energy, to many commercial lending institutions, is considered a high risk due to the intermittent nature of the energy source and the “newness” of the technology. Therefore, if financing is available at all, the terms are not as beneficial as those provided to conventional developments. Many governments either guarantee the loans, provide subsidies which effectively lower the interest rates developers must pay, or offer low-interest loans. These financing incentives for capital investments can help offset the payments wind farm operators must pay in the early years of their project.

The administration of a loan program could be efficiently handled by the Rural Utility Service given its loan administration program currently in place.

❖ Environmental Regulations

○ Emissions Standards

Many countries that have populations concerned about environmental degradation have instigated a series of emissions standards to raise the air quality throughout their prospective countries. These standards often come in the form of emissions caps where a certain level of polluting emissions are allowed by law and anything beyond that will result in some kind of punitive action enforced by a governmental regulating agency. In the United States, for example, emissions caps are enforced by the Environmental Protection Agency. These caps are coupled with marketable permits that are tradable on the free market much like what is described in the renewable portfolio standard section below.

In addition, the requirement for on-road vehicles to use low sulfur (500ppm) diesel fuel may drive the price of diesel fuels in the Alaska market upward in the range of 10 to 25 cents per gallon. This may raise the cost per kWh for many rural Alaska utilities in the range of 0.8 to 2.0 cents per kWh, shifting the economics away from diesel and in favor of wind and energy efficiency.⁵⁸

⁵⁸ See Appendix C: Low Sulfur Fuel Requirements

The continuing trend toward increased environment regulation of oil exploration, oil production and transportation, petroleum refining, petroleum transportation and storage, and petroleum combustion appears likely to contribute to upward pressure on the cost of petroleum based energy. While this cost pressure may be offset by technology improvements, it appears that the net effect is to increase the relative cost of petroleum-based energy compared to end-use energy efficiency and non-diesel fuel energy sources (wind, hydroelectric).

❖ 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)

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 1/10th 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.

○ Customer Information Regarding Line Extension Alternatives

In cases where a utility requires a customer to pay a contribution toward the construction of extending utility power lines to a remote location, the utility must provide information about on-site renewable energy technology options. This line extension rule is part of Texas's integrated resource planning requirements.

Given the small size and wide variety of line extension policies in non-regulated rural Alaskan electric utilities, it may not be cost effective to implement this approach here.

○ Customer Disclosure

Requiring that a generator disclose to its consumers the source from where its power is produced can be a very powerful market mechanism. Generally, this policy is utilized in a

market system where competition is allowed in the electricity market. In an environmentally conscious society, disclosure can raise the concerns of a generator's customer base and therefore, pressure the generator to produce more environmentally benign energy.

While this system may be effective in the urban, suburban or rural lower 48, it does not seem well suited to rural Alaska communities where: (1) a great deal of information still flows through more traditional oral channels, and (2) competition is not typically between firms serving a customer. The competition is between demand and supply side alternatives for customers and between supply side alternatives for the utility (diesel, wind, etc.).

- o Reduction or elimination of subsidies for conventional fuel

Most governments subsidize, in one form or another, conventional fuel such as diesel.⁵⁹ These subsidies artificially lower the costs associated with conventional power generation and are likely unsustainable over a long term. By eliminating these subsidies, renewable energy will become more competitive, and in many instances in the relatively high cost environment of rural Alaska, be less expensive than conventional energy.

- o Green pricing

The idea of green pricing is relatively new in the electricity industry. These programs are typically associated with the development of a competitive electricity market similar to what is emerging in many lower 48 states. Green marketing allows the consumer to freely choose where he gets his energy source. Utilities or other independent power producers market their energy product to meet the customer's demands. In a market with a high propensity to consume "environmentally friendly" products and services, a utility might opt to offer wind energy and charge a slightly higher price for it. Conversely, the energy services company may target a low price point for its consumer and price closer to marginal cost for older, conventional power plants. However, this type of program is not likely to be successful without credible consumer disclosure. If the consumer does not know from where the power is coming, then he would most likely choose the apparent lower price because he would not understand the benefit of paying for a differently priced product.

An interesting example can be found in Austin, Texas. You can choose between the standard, typically volatile fuel price adjustment on your monthly bill or you can choose a flat wind renewable price adjustment on your monthly bill.⁶⁰ When consumers are given an opportunity to vote with their pocketbook, it appears that many choose the predictably priced wind alternative.

- o Net Metering

Net metering can only be used if a customer or independent power producer is allowed to sell power to the grid. Generally, net metering benefits both small-scale and large-scale operators. This policy would allow a generator to interconnect his turbine so that the electric meter would essentially run backwards when the generator utilizes energy produced from the turbine. If the generator produces more energy than the operator uses, the excess power is sold to the utility at the lower, "avoided cost" rate. Power the operator purchases from the utility is purchased at the higher, typically average retail rate from the utility. This helps offset the initial capital cost while simultaneously lowering the customer/generator's electricity bill.

⁵⁹ Diesel subsidies include: capital grants, low interest loans, power cost equalization, bulk fuel storage facility grants.

⁶⁰ See <http://www.austinenergy.com/greenchoice/>

Texas and Vermont have instituted net metering programs. Based on initial research, while this approach does appear attractive for some relatively sophisticated do-it-yourself customers, the market penetration rates are quite low.⁶¹

- Renewable Portfolio Standards (RPS)

The Renewables Portfolio Standard (RPS) is a flexible, market-driven policy that can ensure that the public benefits of wind, solar, biomass, and geothermal energy continue to be recognized as electricity markets become more competitive. A requirement for the RPS is specified as a certain percentage of renewable energy in a generator's power portfolio by a certain date. Requirements are usually quantified amounts of energy. For example, a government can set a requirement of 100 MW of wind by the year 2000. In the U.S., the RPS would require that 10 percent of a generator's entire portfolio be supplied by renewable energy by the year 2000. In addition, the RPS allows renewable energy credits to be traded on the free market. If a generator deems that owning a renewable energy power plant is too expensive, he can buy credits from a generator who has an excess of renewable energy. This ensures that the mandated percentage of a country's power mix will be renewable energy. This policy usually benefits wind energy over other sources of renewable energy because wind is the most cost-competitive source of non-hydro renewable energy.

After a series of deliberative polls in Texas by utilities with the support of the Texas Public Utilities Commission that found considerable support for renewable energy, legislation was passed and signed into law by Governor Bush that required Texas utilities to implement a renewable portfolio standard.⁶²

The current Energy Bill (S.517) pending before the U.S. Senate contains provisions concerning a national renewable portfolio standard.⁶³

As of early April 2002, the bill provided exemptions from the renewable portfolio standard for non-profit utilities, thus providing a potential competitive advantage to non-profits.⁶⁴

- Requiring Utilities to Purchase Cost Effective Wind Power

In many instances, utilities and power bureaus throughout the world are reluctant to buy wind power from Independent Power Producers (IPPs). Requiring that utilities provide long term contracts for energy purchased from wind farms may give confidence to potential developers worried about whether or not they will be able to sell their power. Then the debate can shift to what is an appropriate avoided cost over a ten year period. Many of the

⁶¹ See Nancy A. Rader, Ryan H. Wisser, Strategies for Supporting Wind Energy: A Review and Analysis of State Policy Options, National Wind Coordinating Committee, p.68. They found Indiana, New Hampshire, Oklahoma, and Texas, representing the high end of the market penetration, have between 15 and 25 net metering customers, most of whom are using small wind systems.

⁶² See <http://www.puc.state.tx.us/rules/rulemake/20944/20944arc/20944arc.cfm>. See also Appendix D: Renewable Energy Polling Data.

⁶³ See Wall Street Journal, March 22, 2002, "Senate Weighs 'Green' Energy Quota Despite Utilities' Fears About Costs." The WSJ report cites an Energy Department study indicating that the resulting electricity price increases are "projected to be small" [less than 5 percent], partly because natural-gas prices could drop with more use of energy from renewable sources – for both a 10 percent and a 20 percent renewable portfolio standard with an implementation deadline of 2020.

⁶⁴ This differential treatment of for-profit and non-profit energy service providers remains a significant issue for the for-profit energy sector, i.e., Edison Electric Institute. The recent experience in the California Energy Crisis has raised awareness of this issue in the for-profit sector. While the non-profits complained about the adverse effects of competition in that market, many of the non-profits made record margins on sales of electricity to for-profit *retail* energy service providers during periods of high prices and shortages in the summer of 2000.

avoided cost formulae and calculations conducted for the Regulatory Commission of Alaska do not examine avoided costs over a ten year time horizon or at a level of supply side technology substitution association with a medium or high wind penetration system.

The cost to develop site-specific avoided cost estimates that include more than just the avoided *price* of fuel times the estimated avoided number of gallons, which in turn depends upon a forward-looking estimate of efficiency, may be fairly high in rural Alaska unless it is part of a large scale program.

In rural Alaska, rather than attempting to impose ten year term contracts requirements on small rural utilities (or even regional utilities) it may be more cost effective to facilitate the development of a market by providing a RFP for a firm to do the wind resource reconnaissance, preliminary design and final feasibility. The wind resource reconnaissance firm could also develop a consolidated procurement template in order to obtain volume discounts and to lower the transaction costs of individual communities and their respective utilities seeking to join the consolidated procurement. The wind resource reconnaissance firm could then market wind energy projects to local communities and their utilities—with the understanding that the more that sign up the lower the cost. The local community could then apply for wind energy development grants using an economic valuation template to provide some insurance that the $B/C > 1.0$ ⁶⁵

- o Premium Pricing & Indexing

Some countries go a bit further and require that not only must the utility purchase all the power from wind farms, but they also must pay a premium price for that power. Usually, the required price ensures profitability of the power plant. In countries where the utility is state-owned, the government may simply offer premium prices for wind power. This encourages wind power development since initial capital costs are high and therefore, need a higher power price for the plant to remain solvent during its first few years of operation. Many developing countries have highly fluctuating currencies and rising inflation due to their rapidly expanding economies. To alleviate the concerns of those developers who sign power purchase agreements over a prolonged period, indexing is allowed where power prices are adjusted periodically for inflation and/or currency devaluation.

While this may be one way to overcome the perceived hurdles of wind power, it may be more cost effective to use an economic benefit cost model (see Rural Alaska Market Reconnaissance Model) for rural Alaska to identify opportunities where wind is likely to be economical.

- o Banking

Banking is a unique policy used in India where a wind plant operator is allowed to deposit a certain percentage of his power production and withdraw that power during a certain time frame. The idea here is to compensate for the problem of the intermittent quality of wind power. This allows a wind plant operator to “store” power during a very good wind period and withdraw it during a low-wind period. In addition, the industrial host is allowed to withdraw this power as well in times of need.

The essential point of this process—storing wind energy—can also be accomplished by integrating the wind-diesel system with an energy storage system or load (including batteries,

⁶⁵ It would be in the interest of the wind energy development company to improve the chances of the local utility's grant application by using a common template to streamline processing. GCI's sales and marketing of the rural schools, libraries, and telemedicine telecommunications programs is an interesting case study in this regard.

heating loads, ice making loads, etc.). Incorporating the costs of these systems into the benefit/cost analysis is more likely to capture all of the costs and all of the benefits for a particular project and thus improve the chances that the overall program will be cost effective.

3.5 Recommended Market Intervention Alternatives

Given the potential availability of rural community grants for energy projects, the most cost effective program may be to provide direct grants to those communities where the wind energy potential is likely to yield net economic benefits.

This requires local communities to take initiative to put together grant proposals. Given the potential availability of grants, local utilities, regional utilities and energy service companies have an incentive to assist local communities with grant applications.

In order to enhance the potential to realize scale economies and learning curve cost and quality benefits, an RFP for a wind resource development service company may be an efficient way to facilitate larger-scale, cost-effective development of the rural Alaska wind resource.

The basic outline of the Wind Resource Development Partnering Plan Procurement would contain the following elements:

- Phase I Reconnaissance:
 - Review of existing records, including local meteorological data
 - Site visits to ascertain viable sites (adequate acreage under reasonable terms, identify and mitigate migratory bird concerns, site access, etc.)
 - Detailed on-site collection of wind resource data (wind speeds at specific heights at specific site over sample period)
- Phase II Preliminary Design, Final Feasibility
 - Develop preliminary design based on reconnaissance phase. For those communities where $B/C > 1.0$, encourage local communities to apply for final design/build grants.
- Phase III Grant Application Technical Assistance & Consolidated Procurement
 - Provide technical assistance to communities to assist them with grant applications to the funding agencies.
 - Provide local communities with an option for a consolidated procurement for the acquisition, installation and testing and turn over of wind-diesel hybrid systems (towers, wind turbines, foundations, foundation contractor, line extensions, control systems, etc)

To the extent possible, require all data collected in each phase of the project to be posted on a publicly accessible web site, i.e., Alaska Energy Authority.

For example, during the reconnaissance phase, all detailed site-specific wind speed data should be posted to the web. During the wind turbine test phase, all detailed operational data should be posted to the web. Similarly, a wind service contract could require at least the first two to three years of operational performance data to be posted to the web.

Procurement Considerations:

- 1) Reconnaissance
 - a) Paper reconnaissance could be performed by a combination of Alaska Energy Authority and contractors
 - b) Detailed site reconnaissance could be performed under a consolidated procurement where at least 20 potentially attractive sites are bundled together to take advantage of economies of scale and logistical efficiencies
- 2) Final Feasibility/Preliminary Design
 - a) Final feasibility assessments could be performed under a consolidated procurement to ensure consistency in analysis
 - b) Preliminary design could be performed under a consolidated procurement where feasible sites are bundled together to take advantage of a common design template to the extent practicable
- 3) Wind Services Procurement
 - a) Wind services (design/build/initial trial period to demonstrate compliance with performance specifications) could be sought under a consolidated procurement to take advantage of common mobilization and logistical considerations
 - b) In order to be eligible to participate in a consolidated procurement, a local community must have:
 - i) A final feasibility assessment indicating a positive benefit/cost ratio
 - ii) A design using design elements common with other designs in the region to the extent practicable
 - iii) A resolution demonstrating community support for the project

Individual communities and their utilities have an incentive to participate in a consolidated procurement given 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.⁶⁶

3.5.1 Market Reconnaissance

3.5.1.1 Introduction

The basic economic analysis compares:

- o The additional capital and operating costs of installing and integrating a wind system with an existing diesel system (wind-diesel hybrid)
to
- o An existing all diesel system

⁶⁶ See S. 517, **SA 2996**, TITLE IX--RURAL AND REMOTE COMMUNITY DEVELOPMENT BLOCK GRANTS, SEC. 906. ALLOCATION AND DISTRIBUTION OF FUNDS.

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

A real discount rate of five 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.⁶⁷ An additional sensitivity analysis is conducted to reflect a potential range of the real discount rate for government funded projects from three percent to seven percent.⁶⁸

The key parameters driving the differences between the wind-hybrid and all-diesel alternatives include:

- Abundance of usable wind (steady and frequent) available at a local site
- Availability of wind energy to displace diesel fuel, which in turn is a function of:
 - The match between the wind resource and the energy demand (hourly, daily, weekly, seasonal), which can be enhanced in part by adding energy storage capacity to the wind-hybrid system that can displace diesel fuel heating systems, and
 - The reliability of the wind system, which in turn is a function of:
 - Wind Power equipment reliability for site-specific conditions (including icing)
 - Control system integration reliability (including time to “dial in” the controls and the robustness of the controls, i.e., the ability of the system to adjust to changes in operating regime)
 - O&M Personnel desire to learn “new technology” (including climbing towers in winter)
- Price of displaced fuel
- Value of potentially delayed or avoided capital *and* operating costs associated with reduced diesel fuel storage needs
- Avoided or delayed diesel operations, maintenance and capital capacity costs
- Installed capital cost of towers, wind turbines, associated energy storage and new control systems

The analysis is based on:

- Two case studies of wind demonstration projects in Alaska (Kotzebue, St. Paul)
- Two feasibility studies of two wind hybrid systems (Selawik, Wales)
- Development and application of an economic model comparing wind/diesel hybrids to existing diesel systems
- Application of economic model to reconnaissance-level, community-specific data to identify magnitude of wind-diesel economic opportunity
- Sensitivity analysis of economic model
- Review of NREL Wind Resource Reports

⁶⁷ See Alaska Permanent Fund Second Quarter, 2002 report, dated December 31, 2001. The forward looking real rate of return is estimated at 4.95%.

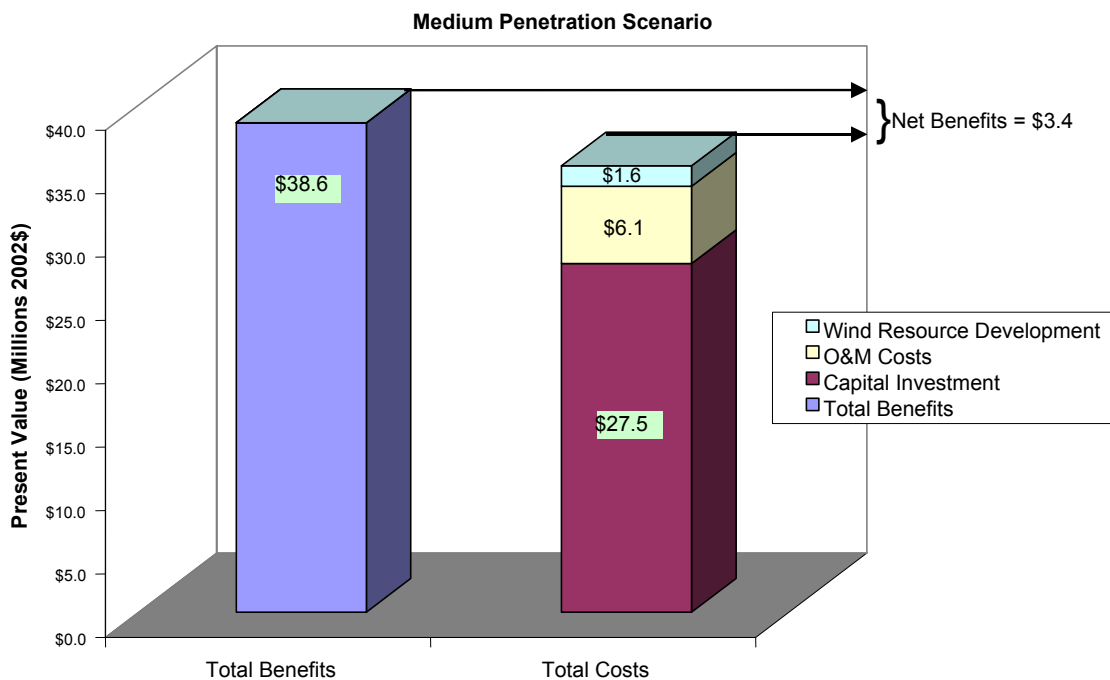
⁶⁸ See Sections “High Cost of Capital” and “Government Funded Discount Rates”

- Review of DOE Wind Energy Program Best Practices
- Review of American Wind Association Best Practices
- Review of Canadian and European Wind Energy Market Best Practices
- Identification of key market failures which prevent or impede wind resource development relative to socially optimal economic investment, defined here as $B/C > 1.0$, 15 years, 5 percent real discount rate.

3.5.1.2 Results of Market Reconnaissance Study

Based on an economic analysis of individual PCE eligible communities, roughly 30 rural Alaska communities representing 15,000 residents, present **attractive** opportunities for wind resource development, with reconnaissance benefit/cost ratios ranging from 1.0 up to 1.7. These communities represent, in aggregate, a total benefit of \$38.6 million and a total cost of \$35.2 million.⁶⁹ The potential net economic benefits from these communities are sufficient to justify a wind resource development program on the order of \$35 million – including \$1.6 million for detailed reconnaissance, preliminary design, and final feasibility plus \$27.5 million for final design and construction contingent upon a finding of net economic benefits at the final feasibility analysis stage.⁷⁰

Figure 3-6. Rural Alaska Wind Energy Development



⁶⁹ Total Cost = Capital + O&M + Wind Development Program Costs = \$27.5M + \$6.1M + \$1.6M = \$35.2M. All figures are expressed in present value 2002\$, based on cash flow estimates over a 15 year life using a 5% real discount rate.

⁷⁰ See Figures 3-3 and 3-4: Wind Resource Assessment Program

Table 3-7. Wind Resource Market Potential Study – Attractive Opportunities

Community	Population	Wind Benefits (PV 2002\$)	Wind Costs (PV 2002\$)	Benefit/Cost Ratio
1 St. Paul	532	\$2,999,207	\$1,736,894	1.73
2 Atka	92	\$550,296	\$326,113	1.69
3 Pedro Bay	50	\$504,504	\$317,319	1.59
4 Platinum	41	\$496,160	\$314,400	1.58
5 Deering	136	\$1,239,215	\$799,781	1.55
6 Chefornak	394	\$473,785	\$325,063	1.46
7 Gambell	649	\$1,151,536	\$817,697	1.41
8 False Pass	64	\$438,825	\$324,611	1.35
9 Akutan	713	\$437,244	\$324,514	1.35
10 Nightmute	208	\$420,263	\$324,281	1.30
11 Kipnuk	644	\$1,021,549	\$815,891	1.25
12 Kwig	338	\$401,829	\$324,041	1.24
13 Kongiganak	359	\$394,250	\$319,830	1.23
14 Hooper Bay	1014	\$1,284,827	\$1,052,828	1.22
15 Perryville	107	\$376,719	\$317,304	1.19
16 Savoonga	643	\$1,222,002	\$1,035,531	1.18
17 Wales	152	\$382,008	\$323,732	1.18
18 Nunapitchuk	466	\$1,444,802	\$1,260,358	1.15
19 Chevak	765	\$928,455	\$814,585	1.14
20 Toksook Bay	532	\$673,775	\$594,993	1.13
21 Kokhanok	174	\$348,507	\$315,045	1.11
22 Akiachak	585	\$872,608	\$789,210	1.11
23 Point Lay	247	\$1,853,265	\$1,692,643	1.09
24 Kwethluk	713	\$859,661	\$789,011	1.09
25 Mekoryuk	210	\$344,587	\$323,200	1.07
26 St. George	152	\$326,586	\$318,105	1.03
27 Brevig	276	\$330,412	\$322,980	1.02
28 Unalaska	4283	\$15,595,178	\$15,375,554	1.01
29 Tununak	325	\$325,808	\$322,938	1.01
30 Egegik	116	\$583,940	\$581,032	1.01
31 Atmauluak	294	\$319,491	\$318,773	1.00
TOTALS	15,274	\$38,600,000	\$33,600,000	1.15

Source: MAFA Recon Model Ver 1.3 (2002), see Appendix A: Market Potential Estimate, Medium Wind Penetration, Medium Avoided Diesel Cost Scenario; Population (2000 Census)

Another 17 communities representing 16,000 residents represent **potentially attractive** opportunities for wind resource development, with reconnaissance benefit/cost ratios ranging from 0.85 to 1.0. These communities represent, in aggregate, a total benefit of \$53 million and a total cost of \$58 million under the medium wind penetration scenario. While the benefit/cost estimates for these communities are less than one, they are within the margin of uncertainty associated with the market

reconnaissance and warrant additional in-depth record and on-site reconnaissance to reduce the uncertainty of the potential value of wind resource development in these communities.⁷¹

Table 3-8. Wind Resource Market Potential Study – Potentially Attractive Opportunities

Community	Population	Wind Benefits (PV 2002\$)	Wind Costs (PV 2002\$)	Benefit/Cost Ratio
Kasaan	48	\$311,238	\$314,620	0.99
Sand Point	842	\$2,634,315	\$2,675,209	0.98
Anaktuvuk	314	\$2,581,917	\$2,630,706	0.98
Pilot Point	92	\$309,671	\$316,369	0.98
Craig ⁷²	2809	\$1,601,484	\$1,647,319	0.97
Port Heiden	116	\$557,638	\$580,645	0.96
Quinhagak	595	\$733,077	\$792,739	0.92
Bethel ⁷³	5471	\$27,691,114	\$30,257,244	0.92
Newtok	284	\$294,578	\$322,478	0.91
Nelson Lagoon	87	\$287,696	\$318,349	0.90
Goodnews Bay	256	\$284,779	\$316,002	0.90
Tenakee Springs	93	\$275,948	\$314,056	0.88
Shishmaref	556	\$1,082,609	\$1,234,753	0.88
St. Mary's	442	\$1,598,195	\$1,848,304	0.86
Kotzebue	2932	\$10,498,880	\$12,142,765	0.86
Old Harbor	276	\$489,485	\$576,007	0.85
Take	745	\$1,758,797	\$2,080,121	0.85
Total	15,958	\$52,991,423	\$58,367,686	0.91

Source: MAFA Recon Model Ver 1.3 (2002), see Appendix E: Market Potential Estimate, Medium Wind Penetration, Medium Avoided Diesel Cost Scenario

⁷¹ It is interesting to note that subsidized wind development has already begun in Kotzebue—a community with a benefit/cost ratio of 0.86 in the market reconnaissance study under the medium wind penetration case. An investment in additional reconnaissance in these communities is roughly equivalent to buying an option on the potential that the B/C for wind resource development in these communities will exceed one after further reconnaissance. The potential value of the option is not just that the wind resource may turn out to be sufficient to produce a project with a B/C>1.0. Scale and scope economies may be a consideration. For example, a particular community may be a regional center that is capable of servicing other communities with higher B/C ratios, bringing regional efficiencies to those communities and itself. Potential sources of regional efficiencies include on-site wind resource assessment, micro-siting considerations, knowledge of arctic design trade-offs, foundations, towers, wind turbines, controls and installation contracting, etc.

⁷² Please note that the wind resource market potential is based on potentially displacing less than half of the roughly 150,000 gallons of diesel fuel a year that is used to complement hydropower.

⁷³ This is a particularly interesting case of a regional center with a significant diesel based cogeneration system. Given the potential economies of scale for development of a wind hybrid system with dump loads that could be used for the district heating system, further investigation may yield additional insight into the trade-offs and potential integrations between wind-diesel hybrids with cogenerated energy from both wind and diesel sources. In addition, Bethel's potential to provide regional wind energy services to other communities in the delta warrants additional investigation.