Distributing Alaska's Power:

A technical and policy review of electric transmission in Alaska

Prepared for:

Denali Commission

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Denali Commission Intertie Study
Prepared for the Denali Commission
By NANA Pacific

I am pleased to present a copy of *Distributing Alaska's Power: A Technical and Policy Review of Electric Transmission in Alaska* prepared at our request by NANA Pacific. This report examines the role that intertie lines could play in meeting the critical need for low cost, reliable electrical power throughout Alaska.

This report originated at the request of the Commission's Energy Advisory Committee who recognized the key role connectivity between communities could play in the State's energy future. I would especially like to thank committee members for their innovative ideas and dedication on behalf of all Alaskans. They are:

- John MacKinnon, Denali Commissioner and Executive Director, Associated General Contractors of Alaska
- Vince Beltrami, Denali Commissioner and Executive President, Alaska AFL-CIO
- Nels Anderson, Jr.
- Eric Marchegiani, P.E., U.S. Department of Agriculture Rural Development
- Bob Martin, Goldbelt Corporation
- Brad Reeve, Kotzebue Electric Association
- Dr. Buck Sharpton, Ph.D., University of Alaska Fairbanks

This year marks the 10th anniversary of the Denali Commission. The Commission works with tribal, state, federal and local partners to improve infrastructure and the quality of life in rural Alaska. This report will serve as an important tool and resource as we move forward with our mission.

Thank you for your interest in the Denali Commission. Please visit our website at www.denali.gov where you can learn more about our programs or sign up for our monthly e-newsletter to receive updates on our progress on finding solutions to the challenges of Alaska.

Sincerely,

George J. Cannelos

George J. Cannelos
Federal Co-Chair

Executive Summary

In 2008, energy costs in Alaska skyrocketed. This is particularly true in rural areas of Alaska where fuel costs often exceed $8.00 a gallon. One way to reduce these costs and potentially spur economic development is diversifying power and energy by producing renewable energy in combination with conventional energy sources. This could facilitate the phasing in of renewable energy and reduction in reliance on fossil fuels. To bring this energy to market- be it a small rural Alaskan community or the Railbelt- it is vital to wisely plan, develop, implement and operate effective electrical transmission systems.

The Denali Commission commissioned NANA Pacific to prepare this report to examine the role that intertie lines could play in addressing the critical need for low cost reliable electrical power throughout Alaska. NANA Pacific assembled a team of engineers and policy analysts who completed the following work:

- Examined the mission and history of energy management agencies, such as the Tennessee Valley Authority or the Bonneville Power Administration (BPA),
- Reviewed about 70 existing reconnaissance or feasibility-level intertie studies,
- Reported on interviews from Alaskan policy makers and experts in the field of transmission,
- Reviewed the current state of the electrical intertie technology,
- Provided an overview of environmental considerations,
- Examined the role of anchor tenants or “value hubs”, and

From this data, the team formulated several conclusions. The team found that:

Transmission Lines enable renewable energy development. Transmission lines allow for the movement of energy and capacity between geographic locations. They can, therefore, present a solution to the “energy/capacity shortfall” challenge by bringing renewable energy from the energy source to the consumer.

Transmission lines should be incremental. In the majority of cases, transmission lines should be constructed incrementally so as to optimize the generation-load profile of existing communities and their resources. However, these incremental projects should be vetted against broad regional and statewide transmission plans so as to insure growth of an integrated electrical grid over time.

Transmission lines should consider intangible criteria such as quality of life and economic development. The benefits and costs of transmission lines, often unforeseen, accrue over time frames much longer than most local or regional interests are capable of identifying and analyzing. Therefore, evaluations of the benefits and costs related to transmission systems must consider, in an integrated fashion, the multiregional effects of energy costs on quality of life and distant economic development.

There may be opportunities for co-development (gas pipeline, transmission lines, and other regional development initiatives). Significant benefit may be accrued by co-developing regional interties. Benefits will be accrued in terms of economies of scale in areas such as right-of-way acquisition, construction costs as well as provision of energy and capacity to meet the demand of these projects.

For example, a gas pipeline and an electrical transmission line could share the same right-of-way, go through permitting concurrently, and utilize much of the same equipment, thus reducing costs.

Opportunities exist for improved statewide coordination. More could be accomplished by a higher level coordinating entity that can capably work across jurisdictions and promote policy criteria such as economic development, quality of life, and other factors.

Interties in Alaska should consider national and international (through Canada) connection. While the mission of Alaska Energy Authority (AEA) is to reduce the cost of energy in Alaska, there are several noteworthy international considerations.

Value hubs are an important consideration in planning intertie projects. Electricity-hungry industries often locate their facilities in areas with cheap power, even if these locations are remote**.** These operations could become "value hubs," or large energy users, which can economically justify the interties for electrical distribution to nearby communities. They could also create a sufficient demand to justify large power generation projects.

There are several possible roles for a Joint Commission. Many of the conclusions in this report could be managed by an organization composed of federal state and local partners but does not have the responsibility for implementing an existing portfolio of projects. Such an organization would have, at the core of its mission, responsibility for providing a forum for the discussion of complex projects of statewide and perhaps international interest. The following suggestions for a possible agenda for such an organization are derived from lessons learned in the preparation of this report.

- Work with relevant stakeholders to develop "the big picture."
- Serve as "point agency" for discussions with international neighbors
- Provide a bridge between overlapping international, federal, state, regional and local jurisdictions
- Facilitate complex discussions on the trade-offs between cultural integrity and traditional lifestyle and economic development
- Help sustain and expand technological gains in power generation and distribution
- Facilitate the identification and development of transportation/utility systems (TUS) as defined in ANILCA, Article 11

Foreword

This report presents the results of NANA Pacific's review and analysis of current transmission historical and policy developments in Alaska.

NANA Pacific appreciates the assistance and contributions of many individuals and agencies involved in the development of this report.

Due to the reconnaissance nature and literature of this study, the technical team and authors should be considered impartial regarding the relative value of proposed and existing transmission lines. Recommendations on infrastructure development, technology, and projects should be left to public policy agencies and their respective engineers.

Due to the multi-disciplinary nature of transmission, a team made up of engineers, planners, policy specialists, and socio-economic experts were assembled to address the transmission study.

- Principal Investigator, Brian Hickey, PE, PMP- NANA-Colt
- Project Manager & Rural Infrastructure Specialist: Jay Hermanson- NANA Pacific
- Senior Policy Analyst/Specialist, Brian Saylor- NANA Pacific
- Project Engineer: Brian Yanity, MS- NANA Pacific
- Rural Infrastructure Specialist & Project Management Support: Nicole McCullough- WHPacific
- GIS Designer/Planner: Kelly Singh- WHPacific
- Planner/Technical Writer: Suzanne Taylor- WHPacific

Acronyms

AAC	All-Aluminum Conductor
AC	Alternating Current
ACC	All-Copper Conductor
ACSR	Aluminum Conductor/Steel Reinforced
AEA	Alaska Energy Authority
AK-BC	Alaska-British Columbia
ANILCA	Alaska National Interest Lands Conservation Act
AP&T	Alaska Power and Telephone
ARDOR	Alaska Regional Development Organization
b/c	benefit/cost
BESS	Battery Energy Storage System
BPA	Bonneville Power Administration
CEQ	Council on Environmental Quality
CHP	Combined Heat and Power
CVEA	Copper Valley Electric Association
DC	Direct Current
DSM	Demand Side Management
FAA	Federal Aviation Administration
FACTS	Flexible AC Transmission System
FEIS	Final Environmental Impact Statement
FERC	Federal Economic Regulatory Commission
GVEA	Golden Valley Electric Association
HVDC	High-Voltage DC
IPP	Independent Power Producers
kV	Kilovolt
MW	Megawatt
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NOAA	National Oceanic and Atmospheric Administration
O&M	Operations and Management
PARC	President's Appalachian Regional Commission
PHEV	Plug-in Hybrid Electric Vehicle
PV	Photovoltaic
RCA	Regulatory Commission of Alaska
REGA	Railbelt Electrical Grid Authority
ROM	Rough Order of Magnitude
RUBA	Rural Utility Business Advisor
SCADA	Supervisory Control and Data Acquisition
SMES	Super-Conducting Magnetic Energy Storage (System)

SWGR	Single-Wire Ground Return
SWER	Single-Wire Earth Return
TUS	Transportation/Utility System
UAA	University of Alaska Anchorage
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
VAR	volt ampere reactive
WIA	Wyoming Infrastructure Authority
4S	Super Safe, Small and Simple

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1 Introduction

As fuel costs remain high, the need for alternative means of producing and delivering energy has become critical. This contributes to an increasing interest in interties as a means of promoting rural, regional, and statewide infrastructure development.

Over the years, a variety of electric transmission (intertie and tieline) technical studies have been completed for various regions of Alaska. These were commissioned by public sector entities, utilities, and other interested parties. While dated, these studies are important and hold beneficial information.

The Denali Commission has participated in energy infrastructure projects targeting the rural sector, including bulk fuel, rural power systems upgrades, and other types of energy infrastructure. The Denali Commission requested NANA Pacific to undertake a review of past intertie studies to be presented in a format for public, agency and stakeholder review that addresses policy needs today.

The study is made up of the following sections:

1. ***Literature Review.*** The literature review identifies and summarizes known and appropriate electric transmission studies done to date. This entailed a review of archives at Alaska Energy Authority (AEA), utilities, and state and local governments, and a concise summary assessment of these documents.

2. ***Professional Knowledge Review.*** This step entails interviews with professionals knowledgeable on the intertie infrastructure development issue, including public, utilities, and private sector representatives.

3. ***Technological Assessment***. The technological assessment includes a review of technological innovations that could drive or hinder intertie development for Alaska conditions. There are emerging technologies currently in the development stage that could create new opportunities for intertie development by helping to drive down development costs and making interties more commercially viable.

4. ***Discussion of Value Hubs*.** Value hubs are defined as large users of energy that can economically justify the creation of interties to supply that energy to the hub and the surrounding area. This section includes an analysis of the concept and mapping of plausible value hubs in Alaska.

5. ***Cost Scenarios.*** Different types of tieline/intertie scenarios were developed with the objective of developing cost metric ranges (cost/mile or other) for various regional and topographical anomalies. These cost scenarios address intra-regional projects (i.e. micro-grids, community to community; or community to hub) only.

2 Policy Environment of Interties

Private and public agencies are organized for specific purposes. These purposes can be found in articles of incorporation, authorizing legislation or other policy documents. These statements of purpose help organizations remain focused on the specific policy objectives that they were initially intended to address.

This section summarizes the Denali Commission's policy objectives. These objectives are then used as criteria to determine the extent to which intertie projects support the Commission's purpose and policy objectives.

2.1 Denali Commission Purpose

According to the Denali Commission website, the Denali Commission Act of 1998 defines its specific purposes as follows:

- To deliver the services of the Federal Government in the most cost-effective manner practicable by reducing administrative and overhead costs.
- To provide job training and other economic development services in rural communities particularly distressed communities (many of which have a rate of unemployment that exceeds 50 percent).
- To promote rural development, provide power generation and transmission facilities, modern communication systems, water and sewer systems and other infrastructure needs.

Intertie projects distribute electrical energy among rural Alaskan communities. These projects appear to be an effective way of meeting two of the three specific purposes of the Denali Commission's enabling legislation. The 1998 Denali Commission Act specifically addressees transmission in Alaska as a policy and programmatic focal point.

In addition, the act established economic development committees to consider and approve applications which promote economic development and private sector investment to reduce poverty in economically distressed rural villages. This objective appears to be supported by the rural communities it serves. A recent edition of the commission's newsletter recounted the opinion of one Alaska native leader urging the commission to build infrastructure that allows rural Alaskans to focus on creating economic opportunities for residents of rural Alaska.

The Denali Commission recognizes the importance of this economic development policy objective. The Commission's Investment Guidance re-emphasizes its commitment to accelerating the building of sustainable infrastructure in rural Alaska to enhance the health and safety of rural residents and to provide the underpinnings for economic opportunity. Further, the policy states that the Commission will invest the limited funds with which it is entrusted in the most conscientious and sustainable manner possible with the objective of maximizing the benefits to rural Alaskans.

2.2 Experience of Other Development Entities

The Denali Commission is a federal agency formed by the government to accomplish specific policy objectives. This section examines the way in which policy objectives have been included in the authorizing legislation which created a number of the Denali Commission's predecessors. The purpose of this section is to better understand how basic policy objectives are embedded in these agencies, and to clarify the specific objectives which may influence the nature and scope of electrical transmission projects supported by the Denali Commission.

2.2.1 The Appalachian Regional Commission

The authorizing legislation for the Denali Commission is reportedly modeled on the successful Appalachian Regional Commission, a federal-state partnership that works with the people of Appalachia to create opportunities for self-sustaining economic development and improved quality of life.

In 1963, President Kennedy formed a federal-state committee that came to be known as the President's Appalachian Regional Commission (PARC), and directed it to draw up "a comprehensive program for the economic development of the Appalachian Region." In its report to the President and the Congress, the Commission emphasized the importance of addressing human needs of residents of the Appalachian region as well as economic development. Subsequent updates of the Appalachian regional commission's authorizing legislation have provided an even greater emphasis on regional economic development and the quality of life.

Specifically, the 1998 reauthorization language stated that the purpose of the Commission was to assist the Appalachian region in:

- Providing the infrastructure necessary for economic and human resource development;
- Developing the region's industry;
- Building entrepreneurial communities;
- Generating a diversified regional economy; and
- Making the region's industrial and commercial resources more competitive in national and world markets.

In addition, the enabling language was to provide a framework for coordinating federal, state, and local initiatives to respond to the economic competitiveness challenges in the Appalachian region through:

- Improving the skills of the region's workforce;
- Adapting and applying new technologies for the region's businesses, including eco-industrial development technologies; and
- Improving the access of the region's businesses to the technical and financial resources necessary to development of the businesses;

Furthermore, the Appalachian Regional Commission's objective is to address the needs of severely and persistently distressed areas of the Appalachian region and focus special attention on the areas of greatest need so as to provide a fairer opportunity for the people of the region to share the quality of life generally enjoyed by citizens across the United States.

The Commission used this expanded charge in its energy goals:

> Develop the Appalachian Region's energy potential to increase the supply of locally produced, clean, affordable energy, and to create and retain jobs.

2.2.2 Bonneville Power Administration

Another major energy management agency, the Bonneville Power Administration (BPA) developed Transmission Adequacy Guidelines to guide the selection of energy transmission projects. They stated:

> One of the challenges facing the electric utility industry today is how to balance reliability, economic, environmental and the other public purpose objectives to optimize transmission and resources to meet the needs of the region. These critical issues must be addressed to move the Northwest electrical system into the 21st century. BPA is initiating the development of transmission adequacy standards because BPA needs to find a better way to determine how much transmission it needs, the solutions to be deployed, and the criteria to be applied to guide prudent investment decisions consistent with its obligations.

2.2.3 Wyoming Infrastructure Authority

According to the Wyoming Infrastructure Authority website, the Wyoming Infrastructure Authority (WIA) was created in June 2004 by the state legislature, tasked with diversifying and growing the state's economy through the development of electric transmission infrastructure. The Authority is responsible for planning, financing, building, maintaining and operating interstate electric transmission and related facilities.

In passing the legislation, the Wyoming Legislature found that:

> (iv) It is in the public interest of the citizens of this state to promote the economic welfare of the state and its residents by increasing employment, stimulating economic activity, augmenting sources of tax revenue, fostering economic stability and improving the balance of the state's economy;
>
> (v) This article constitutes a valid public purpose of primary benefit to all citizens of this state.

Wyoming state statute describes the policy objectives of the Authority. It states:

> 37-5-303. Purposes.
>
> (a) The purpose for which the authority is created is to diversify and expand the Wyoming economy through improvements in the state's electric transmission infrastructure and to

> facilitate the consumption of Wyoming energy by planning, financing, constructing, developing, acquiring, maintaining and operating electric transmission facilities and related supporting infrastructure and undivided or other interests therein to facilitate the transmission of energy. In order to provide for the financing, construction, development, maintenance, upgrade and operation of existing and new electric transmission facilities, the authority may own, lease or rent facilities constructed pursuant to the authority conferred herein, and all facilities, structures and properties incidental and necessary thereto, to facilitate the transmission of energy.

In the 2006 session, the legislature expanded the Authority's role to become directly involved in financing and promoting advanced coal technologies related to electric generation. The Authority will be seeking partnerships to demonstrate the commercial viability of advanced coal technologies.

The Wyoming Infrastructure Authority was created, in part, to promote economic development.

2.2.4 The World Bank

International programs have multiple policy objectives including improvements in the quality of life and economic development. The World Bank (formally known as the International Bank for Reconstruction and Development) and The International Development Association are committed to fighting global poverty. Their efforts are focused on reaching Millennium Development goals. Countries borrow for poverty reduction programs as well as to promote economic growth to improve the standard of living, social services and environmental programs.

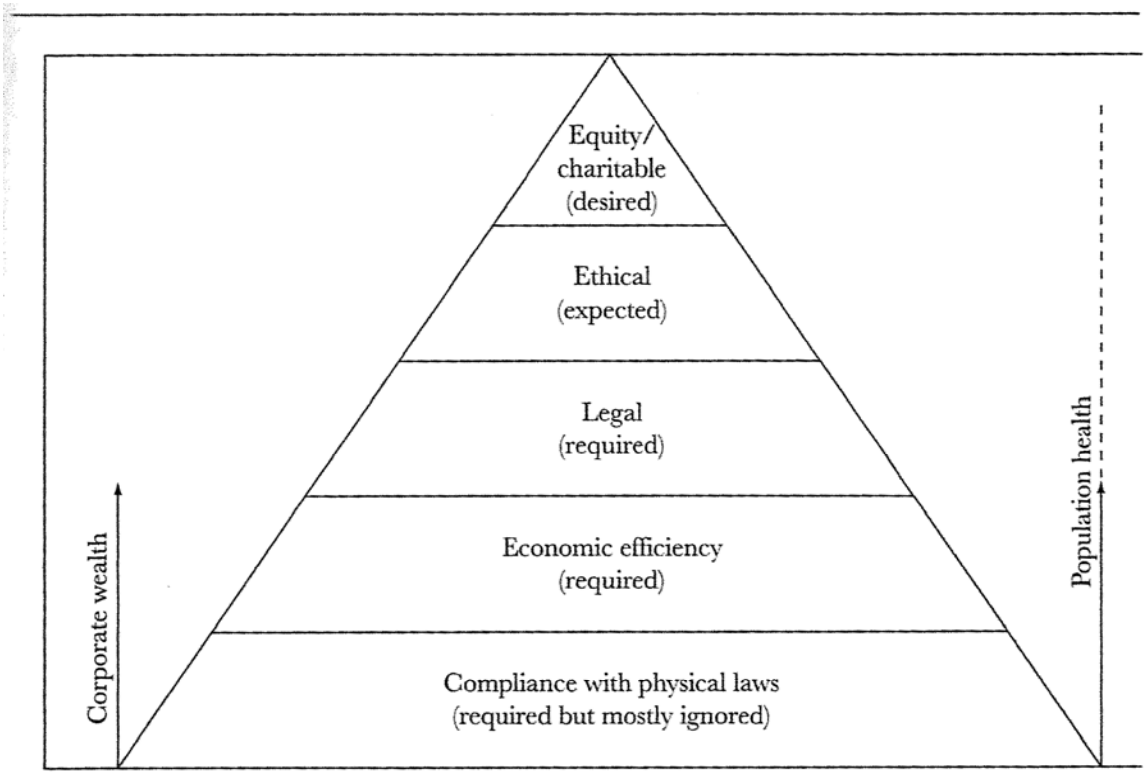
2.3 A Policy Framework for Denali Commission-sponsored Transmission Projects

The policy challenge is to develop a strategy for electrical transmission project development that will reduce conflicts among policy goals and alternative methods of energy production and distribution, economic development, and health and welfare of rural Alaskan populations. Sustainable development can be evaluated in terms of economic efficiency, ecological, effectiveness, and environmental equity, according to L.A. Aday, in *Reinventing Public Health: Policies and Practices for a Healthy Nation.*

The term economic development refers to the growth of the economy as well as broader concept-encompassing factors that reflect on the population's quality of life. Research has shown that health improves with income and vice versa in developed or developing countries. Policies that affect income will have a substantial influence on health, which in turn will influence income and related indicators of economic development.

The policy criteria that are proposed here are consistent with the Denali Commission's policy objectives and are organized according to a policy framework developed by A.B. Carroll (Figure 1.). Carroll's original conception contained a pyramid of social responsibility organizes multiple factors into four components: economic, legal, ethical and charitable responsibilities.

Figure 1 Pyramid of Social Corporate Responsibility



Note. Adapted from "The Pyramid of Corporate Social Responsibility: Toward the Moral Management of Organizational Stakeholders—Balancing Economic, Legal, and Social Responsibilities," by A. B. Carroll, 1991, *Business Horizons, 34,* p. 42, fig. 3. Used with permission of Elsevier.

2.3.1 Policy Criteria #1: Economic Efficiency

Economic efficiency is the extent to which the allocation of resources results in maximum benefit at minimum cost. With respect to interties, economic efficiency has been one of the dominant policy objectives. Many of the discussions, however, have been limited to the cost per kilowatt hour and the capital costs of construction. These discussions could be enhanced by adding additional criteria regarding regional economic development potential and the extent to which reduced energy costs can create more disposable household income which could be used for entrepreneurial business development or the purchase of local services.

Sustainable development suggests that profits resulting from enhanced economic efficiency may not be the only aspect of economic efficiency which might be applied to funding decisions for electrical transmission. An additional and important aspect is the extent to which management and production systems can help promote quality of life in the affected population.

Additional considerations also include the extent to which the proposed project impacts the natural ecosystem. These include environmental protection and the mitigation of natural system changes. They seek to minimize the incidence of regional, local and global consequences of economic development and include minimization of equal ecological hazards and health risks emanating primarily from economic activities. These considerations are especially important in evaluating intertie projects in rural Alaska.

2.3.2 Policy Criteria #2: Legal Responsibility

Legal responsibilities include social expectations of businesses to comply with federal, state and local laws and regulations that are the ground rules under which they must operate. These laws coexist with economic responsibilities as a fundamental component of the free enterprise system. All projects promoted by the Commission must meet this basic threshold. Therefore, it is important to recognize the responsibility of intertie projects to conduct their business in a legal manner and in compliance with applicable local, state and federal laws and regulations.

2.3.3 Policy Criteria #3: Ethical Responsibility

Ethical responsibilities include those activities and practices that society expects or prohibits, but has not yet codified into law these include environmental issues, civil rights and consumer movements. Changing ethics and social values precede and motivate the establishment of new laws and regulations.

Chief among these is the obligation of any organization proposing to construct an intertie to demonstrate ongoing conversations with affected communities. These discussions must be honest and thorough, alerting communities regarding the costs and benefits of electrical distribution systems.

2.3.4 Policy Criteria #4: Equity and Charitable Responsibility

Equity and charitable responsibilities include the requirement of being a good corporate citizen. They include discretionary or voluntary donations and participation in humanitarian programs. Regulations that govern the operation of energy providers make their potential role as a philanthropic entity extremely difficult. Many of these organizations are publicly supported. Their ability to donate cash or services to a local community could be a transfer of resources from the state to a local government or agency without appropriate legislative oversight. For those organizations that are owned as a cooperative, donating to charitable organizations increases the operating budget of the organization, therefore increasing the cost of energy production or distribution. For this reason, expecting organizations which generate or distribute power to exercise charitable or a philanthropic activities is probably unrealistic.

3 Transmission Literature Review

The purpose of this section is to identify and synthesize studies plans and commentary regarding the development and implementation of intertie projects in Alaska. The authors quickly discovered the lack of a coordinated approach to the development and implementation of transmission infrastructure. With one exception, the studies reviewed in this section addressed local and regional projects. This led to the development of a statewide map of existing and proposed intertie projects.

Since the early 1970s, about 70 reconnaissance or feasibility-level studies have been conducted on Alaska electric transmission line proposals. Seven general **regional themes** were covered in the literature:

- Central Alaska, including the Railbelt and Copper Valley Electric Association
- Southeast Alaska
- Southwest Alaska
- Northwest Alaska
- North Slope

The overwhelming majority of the intertie literature available dealt with the Railbelt and Southeast Alaska regions. The only inter-regional connection described in the literature was the Copper Valley to Railbelt Interconnection. A truly state-wide Alaska power grid was not addressed in any of the literature reviewed.

It must be stressed that proposed interties on the maps in this report only reflect lines which were discussed in the literature review. Communities in large regions of the state, such as the Seward Peninsula/Norton Sound region, the upper Yukon River area, and much of the Interior, are not shown connected to any proposed intertie. It is recommended that future intertie studies cover these areas not previously studied and expand on these topical areas.

The only statewide assessment of rural Alaska intertie projects is the 1997 report Rural Alaska Electric Utility Interties: A Comprehensive Survey of Existing and Proposed Transmission Lines Serving Utilities Participating in the Power Cost Equalization Program, prepared for the Alaska Department of Community and Regional Affairs, Division of Energy. The methodology for this study was a survey letter, literature review, and telephone survey. In total, 34 proposed interties between rural Alaska communities were identified in the telephone survey, in addition to 83 "conceptual" interties mentioned. In this 1997 report, existing interties were identified in rural Alaska communities participating in the Power Cost Equalization program: Bethel-Napakiak, Bethel-Oscarville, Dot Lake-Tok, and Shungnak-Kobuk. The Dot Lake-Tok intertie is a 40-mile, 7.2-kV line which functions more as a distribution line. Other existing electrical interties connecting rural Alaska communities include the Naknek-King Salmon-South Naknek, and Iliamna-Newhalen-Nondalton lines in the Bristol Bay region. The Interior Alaska communities of Alatna and Allakaket are connected by a submarine cable under the Koyukuk River.

Three general technical themes were discussed in the literature:

- Conventional alternating current (AC) transmission lines (overhead and submarine cables)
- Direct Current (DC) submarine transmission lines
- Single Wire Earth Return (SWER), also called Single Wire Ground Return (SWGR), was a technology proposed in several studies during the 1970s and 1980s, for both overhead and submarine cables. A lower per-mile cost was expected with SWER transmission lines, and the technology notably featured in 1975 and 1980 intertie studies for the Lower Kuskokwim region by Robert W. Retherford Associates. An experimental, 8.5-mile SWER transmission line was built between Bethel and Napakiak in 1980 at a cost of $280,000. This line has been deteriorating in recent years, resulting in line loss, poor reliability and higher energy costs, and is presently being upgraded to a standard three-phase line. An experimental, 10.5-mile SWER line was also constructed between Shungnak and Kobuk in 1980. In 1991, this line was rebuilt as a conventional 14-kV, three phase line for a cost of $1,350,000.

It was noted that few significant technical advances in electric transmission line technology have occurred over the past several decades.

Engineering and construction metrics dominate the economic feasibility criteria of the literature reviewed. Until the early 1980s, environmental concerns were not discussed in the literature in any detail. However, the economic and financial assumptions used in these studies varied widely (variable discount rates, etc.). As a result, it is not meaningful to compare the economics of the different intertie proposals discussed in different reports or publications.

The general criteria for measuring economic feasibility, or 'categories of possible benefit', for an electric intertie were identified below by the 1989 Railbelt intertie economic feasibility study by Decision Focus:

- **Reliability**
  Intertie projects can improve total system reliability, which is measured by the number, duration, and magnitude of power outages for electric customers.
- **Economy energy transfer**
  Savings are realized when higher cost energy in one area can be displaced with lower cost energy imported from another area via an intertie.
- **Transmission efficiency**
  Savings result from reduction of transmission energy losses with new and improved interties.
- **Capacity sharing**
  An intertie project may allow different areas to share generation capacity and, as a result, an increment of future investment in generation capacity could be deferred or avoided.
- **Operating reserves sharing**
  Similar to capacity sharing, an intertie project may allow different areas to share operating (or "spinning") reserve capacity, which are typically maintained to help avoid outages.

3.1 Interties and Economic Development

There was little mention in most of the literature reviewed of new economic development opportunities associated with the construction of new interties. The exceptions to this were the several regional intertie studies for Southeast Alaska, which discussed a variety of economic development possibilities enabled by new electric transmission infrastructure, such as "value hubs" in the form of large remote mining operations, revenue from power export to Canada, and the construction of new generation facilities. This concept of economic value hubs are discussed below in section 6. However, the only existing "value hubs" identified in Alaska associated with a new electric interties is the Greens Creek Mine near Juneau, and the Pogo and Fort Knox mines near Fairbanks. A new submarine cable intertie was constructed specifically to serve the remote mine. Other key industrial facilities in Southeast Alaska, such as wood and pulp mills, tend be located in or near existing population centers.

If Southeast Alaska were to be connected to the greater North American power grid via British Columbia, the "value hub" could be in the form of bulk power sales to very large external power markets. Renewable energy generated in Alaska could be exported to western parts of Canada and the contiguous U.S. The construction of new hydroelectric, tidal, or geothermal power plants, along with new transmission lines, could serve as a major economic stimulus to Southeast Alaska as a region.

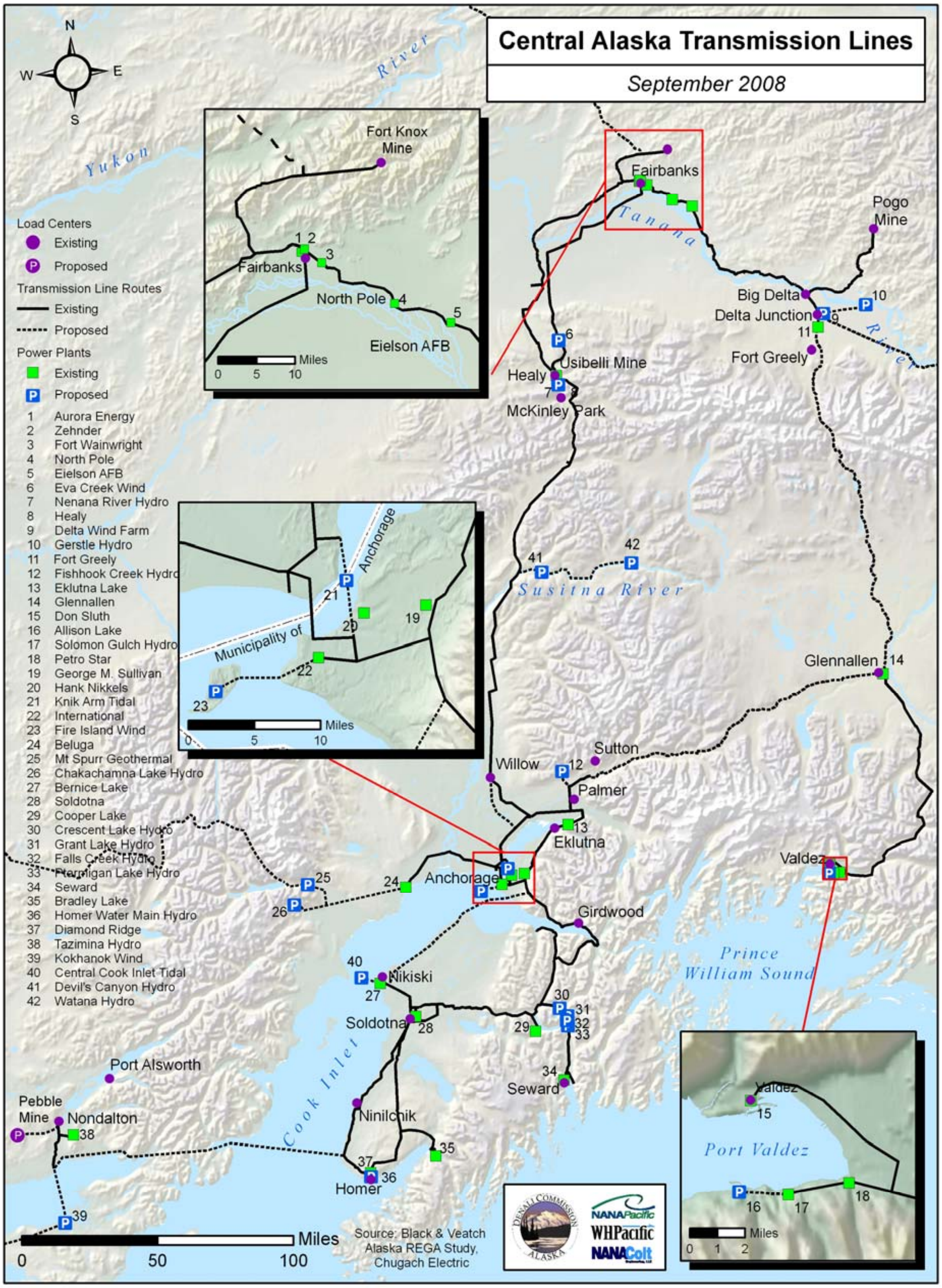
3.1.1 Central Alaska

3.1.1.1 Railbelt

The Railbelt Intertie system connects the utilities of Homer Electric Association, Chugach Electric Association, the Seward Electrical System, Anchorage Municipal Light and Power, Matanuska Electric Association, and Golden Valley Electric Association. The Railbelt Intertie system, also called the Railbelt Interconnection or grid, serves the majority of Alaska's population.

A 2008 Black & Veatch report for the Alaska Energy Authority, the *Alaska Railbelt Electrical Grid Authority (REGA) Study,* recommended the creation of a new state power authority to own and operate the Railbelt transmission system, with the six existing utilities serving the purpose of local distribution. Such a regional entity would have the following functional responsibilities:

- Independent, coordinated operation of the Railbelt transmission system
- Economic dispatching of the region's generation facilities
- Regional resource and transmission expansion planning
- Joint development of new generation and transmission facilities.


Central Alaska Transmission Lines
September 2008
Load Centers
Existing
Proposed
Transmission Line Routes
Existing
Proposed
Power Plants
Existing
Proposed
1 Aurora Energy
2 Zehnder
3 Fort Wainwright
4 North Pole
5 Eielson AFB
6 Eva Creek Wind
7 Nenana River Hydro
8 Healy
9 Delta Wind Farm
10 Gerstle Hydro
11 Fort Greely
12 Fishhook Creek Hydro
13 Eklutna Lake
14 Glennallen
15 Don Sluth
16 Allison Lake
17 Solomon Gulch Hydro
18 Petro Star
19 George M. Sullivan
20 Hank Nikkels
21 Knik Arm Tidal
22 International
23 Fire Island Wind
24 Beluga
25 Mt Spurr Geothermal
26 Chakachamna Lake Hydro
27 Bernice Lake
28 Soldotna
29 Cooper Lake
30 Crescent Lake Hydro
31 Grant Lake Hydro
32 Falls Creek Hydro
33 Ptarmigan Lake Hydro
34 Seward
35 Bradley Lake
36 Homer Water Main Hydro
37 Diamond Ridge
38 Tazimina Hydro
39 Kokhanok Wind
40 Central Cook Inlet Tidal
41 Devil's Canyon Hydro
42 Watana Hydro
Fort Knox Mine
Fairbanks
North Pole
Eielson AFB
Pogo Mine
Big Delta
Delta Junction
Fort Greely
Usibelli Mine
Healy
McKinley Park
Susitna River
Glennallen
Willow
Sutton
Palmer
Eklutna
Anchorage
Girdwood
Valdez
Prince William Sound
Port Valdez
Nikiski
Soldotna
Seward
Cook Inlet
Port Alsworth
Pebble Mine
Nondalton
Ninilchik
Homer
Municipality of Anchorage
Yukon River
Tanana River
Miles
0 50 100
Source: Black & Veatch Alaska REGA Study, Chugach Electric

3.1.1.1.1 Anchorage-Fairbanks Intertie

The 345-kV Anchorage-Fairbanks Intertie, also called the Alaska Intertie, was completed in 1985, with a maximum transfer capacity of 70 MW (due to system operating constraints, not design limitations). The 170-mile line between Healy and Willow was built with a capability to handle 345-kV, though currently is operated at 138-kV.

The Anchorage-Fairbanks Intertie was found to be feasible by a 1981 study for the Alaska Power Authority by Gilbert/Commonwealth, which concluded that its operation will result in significant economic benefits to both areas. The chief economic benefit of the Anchorage-Fairbanks Intertie was the assumption that the Fairbanks power generated by oil fuel would be substantially more costly than gas-fired generation in Anchorage. The report recommended the construction of approximately 160 miles of new transmission line designed for future operation at 345 kV. This recommendation assumed that the Susitna hydroelectric project would be built; otherwise, the recommended voltage for the line was 138 kV.

According to the 1989 report *Economic Feasibility of the Proposed 138 kV Transmission Lines in the Railbelt* by Decision Focus, the overall benefit/cost (b/c) of a "limited upgrade of the Anchorage-Fairbanks Intertie" was estimated to be 4.4, and a b/c ratio of 1.6 for the Healy-Fairbanks (northern line) intertie.

The 11-volume *Railbelt Intertie Reconnaissance Study*, prepared for the Alaska Energy Authority by various consultants, is described in table below:

Table 1 - Railbelt Intertie Reconnaissance Study Summary

Volume	Title	Author	Date	Description
1	*Economic and Demographic Projections for the Alaska Railbelt: 1988-2010*	UAA Institute of Social and Economic Research	1988	There is a 66% chance that Railbelt employment growth between 1987 and 2010 will be between 0.9 to 1.9 percent annually, while the number of households will increase by 1.1 to 2.0 percent annually.
2	*Forecast of Electricity Demand in Alaska Railbelt Region: 1988-2010.*	UAA Institute of Social and Economic Research and Adams, Morgenthaler & Co.	1989	There is a 66% chance that Railbelt demand for electric energy will grow at an average annual rate between 0.2 and 1.3% during the period 1988-2010.
3	*Analysis of Electrical End Use Efficiency Programs for the Alaska Railbelt*	UAA Institute of Social and Economic Research	1989	Energy efficiency measures, assuming 100% participation by electric customers in the efficiency programs, could save 9% of the total Railbelt electric load in 2010.
4	*Fuel Price Outlooks: Crude Oil, Natural Gas, and Fuel Oil*	ICF Incorporated	1988	Predicted 2010 price of crude oil to be $40/barrel (consensus) or $20/barrel (low), in 1987 dollars.
5	*Anchorage-Kenai Transmission Intertie Project*	Power Engineers, Inc. and Hart-Crowser Inc.	1987	Proposed increasing the Anchorage-Kenai the intertie transfer capacity to 125 MW by 2000, including three alternate routes for a new "Southern Intertie".
6	*Anchorage-Fairbanks Transmission Intertie Expansion and Upgrade Project*	Harza Engineering	1987	Recommended new Healy-Fairbanks, and Douglas-Lake Lorraine 345 kV transmission lines be constructed for a cost of $118 million (1987 dollars)
7	*Railbelt Stability Study*	Power Technologies, Inc.	1988	Recommends alternative equipment additions to facilitate delivery of Bradley Lake power to Anchorage.
8	*Northeast Transmission Intertie Project*	Power Engineers, Inc. and Hart-Crowser Inc.	1989	Recommended an intertie connecting the Matanuska Valley to Glennallen following the Glenn Highway, and from there following the Richardson Highway to Delta Junction. This intertie would connect Copper Valley Electric Association to the Railbelt power grid.
9	*Estimated Costs and Environmental Impacts of Coal-Fired Power Plants in the Alaska Railbelt Region*	Stone and Webster Engineering Corp.	1988	Estimates of construction and O&M costs and environmental impacts of coal power plants 150, 100 and 50 MW in capacity on the Alaska Railbelt.
10	*Estimated Costs and Environmental Impacts of a Natural Gas Pipeline System Linking Fairbanks with the Cook Inlet Area.*	Stone and Webster Engineering Corp.	1989	The total cost of a gas line between Cook Inlet and Fairbanks is estimated at $190 million in 1988 dollars. The purpose of such a line would chiefly be to supply Fairbanks with Cook Inlet gas.
11	*Benefit/Cost Analysis*	Decision Focus, Inc.	1989	Benefit/cost analysis recommended a limited upgrade of the Anchorage-Fairbanks intertie from 70 MW to 100 MW, construction of a gas line to Fairbanks, and electric end-use conservation programs.

In 1987, Volume 6 of the Alaska Energy Authority's *Railbelt Intertie Reconnaissance Study* recommended that new Healy-Fairbanks and Douglas-Lake Lorraine 345-kV transmission lines be constructed for a cost of $118 million (1987 dollars). The purpose of these two new lines would be to augment the existing Anchorage-Fairbanks Intertie. The 1990 report by the North American Electric Reliability Council, *Reliability Assessment of the Railbelt Interconnected Electric Utility Systems of the Alaska Systems Coordinating Council 1990-1999,* examined peak demand and generation adequacy, transmission adequacy, operations, and reliability issues.

The final report of the 1991 Alaska Energy Authority *Railbelt Intertie Feasibility Study*, examined the feasibility of two new 138-kV intertie projects to augment the existing Railbelt grid system: the northern line (between Healy and Fairbanks) and the southern line (between Soldotna and Anchorage). Based on the work of the reconnaissance studies on the Railbelt Intertie, this final report is a description and analysis of preliminary engineering design, capital and operating costs, environmental impacts, and economics (benefit/cost) of the proposed intertie projects. The benefit-cost (b/c) ratio of the Soldotna-Anchorage "southern" intertie was estimated to range between 0.7 and 1.5, with a construction cost ranging between $64 million and $126 million in 1991 dollars. The b/c ratio of the Healy-Fairbanks "northern" intertie was estimated to be 1.3, with a total construction cost of $78 million in 1991 dollars.

3.1.1.1.2 Northern Intertie

The 1988 report *Preliminary Review: Northeast Transmission Feasibility Design and Cost Estimate* by Power Engineers, Inc. and Hart-Crowser Inc. recommended a new 345-kV Healy-Fairbanks transmission line. The 1991 Alaska Energy Authority *Railbelt Intertie Feasibility Study*, proposed two alternatives for the Northern Intertie: preferred "south route" and alternative "north route". The purpose of the project is to supplement the existing 138-kV line between Healy and Fairbanks. Expected project benefits are mostly due to "economy energy" of increased substitution of gas generation from oil-fired generation and reduced transmission losses, but also reliability and capacity-sharing benefits.

The Northern Intertie, a 97-mile-long, 230-kV transmission line serving as second-circuit intertie between Fairbanks and Healy, was completed by Golden Valley Electric Association in 2003.

3.1.1.1.3 Anchorage-Kenai Peninsula (Southern) Intertie

The 115-kV Quartz Creek intertie between Anchorage and the Kenai Peninsula, completed in 1960, has a maximum transfer capacity of 75 MW. However, approximately 245 MW of generation capacity exists on the Kenai Peninsula. Therefore, the Quartz Creek Line is considered the weak link in the Railbelt transmission system, and parts of it are difficult to access for repairs, especially for avalanche damage. By providing a second circuit between Anchorage and the Kenai Peninsula, the 138-kV Southern Intertie was proposed to help improve the reliability of power supply to the entire Railbelt region.

In 1987, Volume 5 of the Alaska Energy Authority's *Railbelt Intertie Reconnaissance Study* recommended increasing the overall Anchorage-Kenai intertie transfer capacity to 125 MW by 2000, and proposed three alternate routes for a new "Southern Intertie". According to the 1989 report *Economic Feasibility* *of the Proposed 138 kV Transmission Lines in the Railbelt* by Decision Focus, the overall benefit/cost (b/c) ratio of the new Kenai-Anchorage (southern line) intertie was estimated to be between 1.3 and 1.8. The 1991 Alaska Energy Authority *Railbelt Intertie Feasibility Study*, concluded that the preferred route for the Southern Intertie is the "Enstar route" through the Kenai National Wildlife Refuge following the same path as the existing Enstar gas pipeline right-of-way; the alternate route is the "Tesoro route", following the west coast of the Kenai Peninsula near the existing Tesoro pipeline right-of-way. Both of these route alternatives would involve a submarine cable under Turnagain Arm. Project benefits listed were reliability, generation dispatch and efficiency, and generation reserve requirements.

A 1996 route selection study for Chugach Electric Association described in more detail these two route alternatives, with proposed alternative voltages of 138 kV or 230 kV. The 1998 report *Ratepayer Impacts of Proposed Transmission Projects: Final Report* by DFI/Aeronomics concluded that the Southern Intertie would be beneficial to Chugach Electric Association ratepayers. This conclusion was re-evaluated in 2002 by Chugach staff. The 2002 document *Records of Decision: Southern Intertie Project, Kenai Peninsula to Anchorage, Alaska*, by the USDA Rural Utilities Service, U.S. Fish and Wildlife Service, and U.S. Army Corps of Engineers states that the Tesoro Route can be built and concludes the Environmental Impact process. This line has not been constructed.

3.1.1.1.4 Kenai Peninsula

A 1983 report by Ebasco Services Inc., *City of Seward: Transmission System Alternatives*, recommended a 115-kV transmission line from the Chugach Electric Association substation at Dave's Creek to the City of Seward, upgrading an older 24.9-kV line. The 115-kV Dave's Creek-Seward intertie was completed in the 1990s and is owned by the City of Seward.

A 138-kV transmission line from Bradley Lake hydroelectric plant to Soldotna (the Soldotna-Fritz Creek Circuit) was recommended in a 1983 report by Commonwealth Associates for Homer Electric Association. The Soldotna-Fritz Creek intertie, providing a second circuit to connect the Homer/Bradley Lake and Soldotna/Kenai areas, was completed in 1996.

3.1.1.1.5 Matanuska Electric Association

The 2004 Dryden & LaRue study on the proposed 230-kV Teeland-Douglas transmission line, within the service area of Matanuska Electric Association, estimated construction costs for each of the alternative routes ranging between $12 million and $16 million in 2004 dollars.

3.1.1.1.6 Future Railbelt Generation and Load Centers

Proposed new generation for the Railbelt should include in long-term transmission line planning: the Chackachamna hydroelectric project, four proposed hydro projects in the Moose Pass area, and the Fire Island wind project. Other natural gas, coal, wind, hydropower, geothermal or tidal power developments in the Railbelt area are possible. In addition to population growth, proposed new 'load centers' connected to the Railbelt should also be anticipated, in particular large-scale mining projects.

3.1.1.2 Copper Valley Electric Association

3.1.1.2.1 Glennallen-Valdez Transmission Line

The Glennallen-Valdez intertie was first described in detail by a 1978 report by Robert W. Retherford Associates, for Copper Valley Electric Association (CVEA): *The Proposed Glennallen-Valdez Transmission Line: An Analysis of Available Alternatives.* This was followed by a 1981 report by the International Engineering Company, *Transmission Line Design Review of the Glennallen-Valdez 138 kV Transmission Line.* The 106-mile-long Glennallen-Valdez transmission line was completed in 1982. The main purpose of the line is to displace diesel generation in Glennallen with hydropower generated at the Solomon Gulch plant near Valdez.

3.1.1.2.2 Copper Valley-Railbelt Intertie

Over the years, several studies have proposed an intertie to connect the CVEA system to the Railbelt power grid. Volume 8 of the 1989 Alaska Energy Authority's *Railbelt Intertie Reconnaissance Study* recommended an intertie connecting the Matanuska Valley to Glennallen following the Glenn Highway, and from there following the Richardson Highway to Delta Junction. The estimated cost of construction for the suggested route was about $156 million in 1989 dollars. The 1991 Alaska Energy Authority report, *Glennallen to Fairbanks Intertie: Preliminary Assessment,* estimated a construction cost of $92.5 million in 1991 dollars, and concluded that the proposed Glennallen-Fairbanks intertie would be uneconomic.

Also during the early 1990s, a transmission line was proposed to connect Matanuska Electric Association in the Railbelt region to the CVEA system in Glennallen. In 1993, the Alaska State Legislature appropriated $35 million for a zero-interest, 50-year loan to pay for construction of the Copper Valley Intertie. A 1993 POWER Engineers report on the proposed 138-kV Sutton-Glennallen transmission line estimated the total construction cost to be $40.4 million in 1992 dollars.

The 1994 feasibility study of the Copper Valley Intertie by R.W. Beck and Associates for the DCRA Division of Energy proposed a 138-kV transmission line proposed between Sutton and Glennallen, a distance of approximately 135 miles. Study includes a feasibility-level design of the preferred Intertie alternative, construction cost estimate and schedule, environmental study, electric systems analysis, forecast of electric power requirements, and an economic analysis. The 1994 study estimates the construction cost of the Intertie to be $46.7 million in 1993 dollars. A 1994 report for the Alaska Department of Community and Regional Affairs, Division of Energy, Copper Valley Intertie Plan of Finance, provided a more detailed financial analysis of the project. A 1995 CH2M Hill study updated the resource cost analysis and cost of the power supply alternatives. Data from the 1994 Intertie Study were reviewed and updated to reflect these changes.

3.1.2 Southeast Alaska

Utilities in Southeast Alaska have long proposed a variety of electrical interconnections between communities and hydroelectric plants as part of a comprehensive regional electric power system. The region also has a large amount of untapped hydroelectric potential, and export of this hydropower to

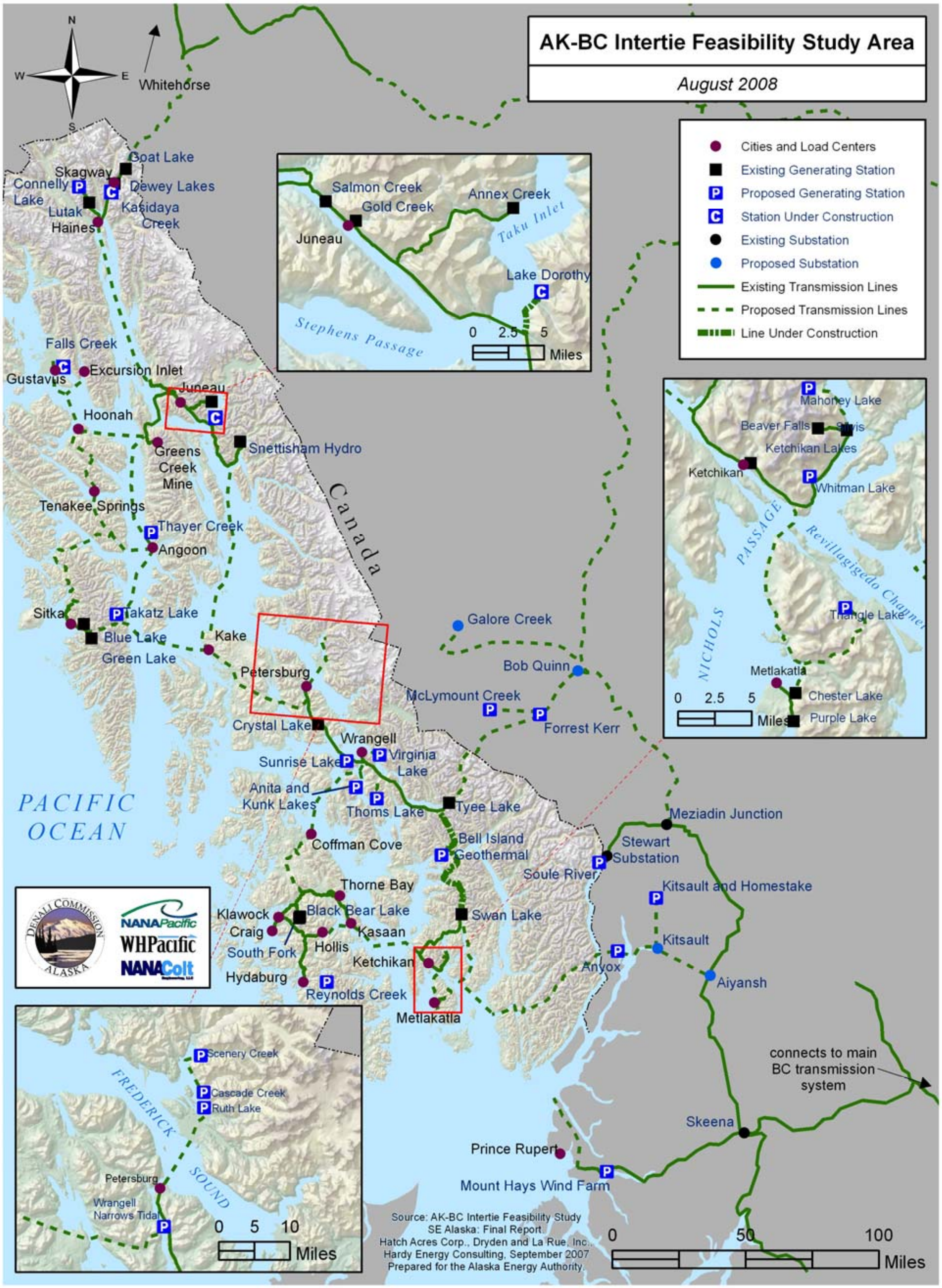
British Columbia is a possibility. The purpose of new electric transmission lines, along with new hydroelectric projects, would be to reduce the need for diesel generation, stabilize and equalize power rates, better coordinate the efficient use of the region's water resources for hydropower generation, increase regional electric system reliability, and create revenue from the export of power.

Economic development opportunities associated with a regional transmission system include the utilization of Alaska-generated hydroelectric power for mining operations in both Southeast Alaska and Northwestern British Columbia. A surplus of hydroelectric power in Southeast Alaska would enable a transition from fuel oil to electric heating for homes and buildings, as well as future applications of electric vehicles and hydrogen production. New interties will make many more potential hydroelectric sites economic to build, along with possible tidal and geothermal sites.

The Swan-Tyee Intertie, to connect the electric utilities of Petersburg and Wrangell to Ketchikan, is presently under construction.

Chief Proposed Interties within SE Alaska*:*

- Juneau-Greens Creek-Hoonah
- Kake-Petersburg
- Metlakatla-Ketchikan
- Ketchikan-Prince of Wales Island
- Kake-Sitka
- Juneau-Angoon-Sitka
- Hoonah-Gustavus
- Juneau-Haines


AK-BC Intertie Feasibility Study Area
August 2008
Cities and Load Centers
Existing Generating Station
Proposed Generating Station
Station Under Construction
Existing Substation
Proposed Substation
Existing Transmission Lines
Proposed Transmission Lines
Line Under Construction
Whitehorse
Skagway
Goat Lake
Connelly Lake
Dewey Lakes
Lutak
Kasidaya Creek
Haines
Falls Creek
Gustavus
Excursion Inlet
Juneau
Hoonah
Greens Creek Mine
Snettisham Hydro
Tenakee Springs
Thayer Creek
Angoon
Canada
Sitka
Takatz Lake
Blue Lake
Green Lake
Kake
Petersburg
Crystal Lake
Wrangell
Sunrise Lake
Virginia Lake
Anita and Kunk Lakes
Thoms Lake
Tyee Lake
PACIFIC OCEAN
Coffman Cove
Bell Island Geothermal
Soule River
Thorne Bay
Klawock
Black Bear Lake
Craig
Kasaan
South Fork
Hollis
Ketchikan
Hydaburg
Reynolds Creek
Metlakatla
Swan Lake
Galore Creek
Bob Quinn
McLymount Creek
Forrest Kerr
Meziadin Junction
Stewart Substation
Kitsault and Homestake
Kitsault
Anyox
Aiyansh
connects to main BC transmission system
Skeena
Prince Rupert
Mount Hays Wind Farm
Salmon Creek
Gold Creek
Annex Creek
Taku Inlet
Lake Dorothy
Stephens Passage
0 2.5 5 Miles
Mahoney Lake
Beaver Falls
Silvis
Ketchikan Lakes
Whitman Lake
Revillagigedo Channel
Triangle Lake
Nichols Passage
Chester Lake
Purple Lake
Scenery Creek
Cascade Creek
Ruth Lake
Frederick Sound
Wrangell Narrows Tidal
0 5 10 Miles
Denali Commission Alaska
NANAPacific
WHPacific
NANAColt
Source: AK-BC Intertie Feasibility Study SE Alaska: Final Report
Hatch Acres Corp., Dryden and La Rue, Inc.,
Hardy Energy Consulting, September 2007
Prepared for the Alaska Energy Authority.
0 50 100 Miles

3.1.2.1 Southeast Alaska Regional Transmission Line Studies

A preliminary regional intertie study was a 1980 report by Harstad Associates for the Alaska Power Administration, *Snettisham-Ketchikan Transmission System Preliminary Feasibility Design.* This report concluded that a transmission system connecting Juneau-Snettisham with Petersburg, Wrangell and Ketchikan was technically feasible.

Harza Engineering Company's 1987 *Southeast Alaska Transmission Intertie Study* for the Alaska Power Authority, was a reconnaissance-level study on new transmission links in Southeast Alaska. Perhaps the most important single study on interties possibilities in the region, it included systems studies, route selection, engineering studies, and economic analysis. The chief findings and recommendations of the *Southeast Alaska Transmission Intertie Study* are for more detailed feasibility/design studies of the following interconnections:

- Juneau-Greens Creek Mine-Hoonah-Tenakee Springs-Angoon-Sitka
- Swan-Tyee Intertie (to connect Petersburg/Wrangell to Ketchikan)
- Quartz Hill Mine, Alaska to Kitsault, British Columbia

The estimated construction cost of these three interconnections, at the January 1987 price level, was $153 million, with an overall benefit/cost (b/c) ratio of 1.26. Without the Quartz Hill Mine line and load, the overall cost of the plan was estimated to be $112 million and b/c ratio to be 1.12. If the proposed Quartz Hill Mine was not to be connected to the BC Hydro system in Canada, and instead have its power supplied by hydroelectric generation within Alaska, the cost of constructing the needed transmission lines was estimated to be $167 million in 1987 dollars, with a b/c ratio of 1.21. Power systems studies in the 1987 report indicated that a transmission grid for the region should be a predominantly 138-kV AC system with DC transmission for submarine cable segments exceeding 25 miles in length. The proposed regional system would also utilize the existing Snettisham-Juneau, Tyee Lake-Wrangell-Petersburg and Swan Lake-Ketchikan transmission lines at their present design voltage levels.

The Southeast Conference's 1998 *Southeast Alaska Electrical Intertie System Plan*, by Acres International, proposed a five-phase approach to new intertie construction:

Table 2- Southeast Alaska Summary of Interties

Timeline	*Intertie*, Voltage	Estimated Cost (millions in 1996 dollars)	Transmission Line Length (miles)		
			Submarine Cable	Overhead	Total
Phase I (1995-2010)	*Swan-Tyee*, 138 kV	$69.8	0	57	0
	Metlakatla-Ketchikan, 34.5 kV	8.8	1	14	15
Phase II (2010-2015)	*Kake-Petersburg*, 69 kV	19.7	2	45	47
	Kake-Sitka, 138 kV	45.5	33	22	55
Phase III (2015-2020)	*Sitka-Tenakee Springs/ Angoon- Hoonah-Greens Creek-Juneau*, 69-kV	173.8	28	121	149
Phase IV (2020-2025)	*Juneau-Skagway*, 69 kV overhead, 100 kV DC submarine	79.2	64	7	71
Phase V (2025-2030)	*Ketchikan-Prince of Wales*, 69 kV or 115 kV	39.1	18	1	47
	Total System	**$ 435.8**	**146**	**246**	**392**

The 1998 report presents a proposed system plan for an integrated electrical intertie system in Southeast Alaska, a proposal for joint system operation and planning, and for development of a 20-year power grid plan for Southeast Alaska responsive to each community's needs. The report draws on the content of existing state and federal reconnaissance-level investigations on potential hydroelectric sites and transmission line corridors, and does not include original research. The two-part 2003 report *Southeast Alaska Intertie System Plan,* by D. Hittle & Associates for the Southeast Conference, proposed a regional intertie system in eight phases, described in the table below, with a total system cost estimated to be $316 million in 2003 dollars:

Table 3- Southeast Alaska Intertie System Plan

	Intertie	Estimated Cost (millions in 2003 dollars)	Transmission Line Length (miles)		
			Submarine Cable	Overhead	Total
SEI – 1	Juneau-Greens Creek-Hoonah	$ 37.1	34.5	18.7	53.2
SEI – 2	Kake-Petersburg	23.1	1.7	49.9	51.6
SEI – 3	Metlakatla-Ketchikan	6.0	1.0	16.0	17.0
SEI – 4	Ketchikan-Prince of Wales	31.7	17.2	18.0	35.2
SEI – 5	Kake-Sitka	50.3	35.0	24.0	59.0
SEI – 6	Hawk Inlet-Angoon-Sitka	81.2	82.0	22.0	104.0
SEI – 7	Hoonah-Gustavus	26.4	29.1	1.0	30.0
SEI – 8	Juneau-Haines	69.8	2.8	82.5	85.3
	Total System	**$ 316.0**	**203.2**	**212.1**	**415.3**

The 2007 *AK-BC Intertie Feasibility Study* further examined Southeast Alaska regional transmission intertie development scenarios with the possibility of power exports. The 2007 study discussed many specific hydroelectric projects which, when combined with new interties, would be made economical by an interconnection with Canada.

3.1.2.2 Swan-Tyee Intertie

The Swan-Tyee Intertie, between the existing Tyee Lake and Swan Lake hydroelectric plants, will electrically connect Ketchikan to Wrangell and Petersburg. The primary purpose of the Swan-Tyee Intertie is to transmit excess energy from the Tyee Lake plant to Ketchikan. The transmission line is presently under construction and is scheduled for completion at the end of 2009. Both the Swan Lake and Tyee Lake hydroelectric plants are owned by the Four Dam Pool Power Agency.

The 1987 regional intertie reconnaissance study recommended further evaluation of a 138-kV Swan-Tyee transmission line. Following the completion of a new electric load forecast for several Southeast Alaska electric utilities in 1990, the Alaska Energy Authority commissioned a preliminary assessment of financial and market feasibility of the Swan-Tyee Intertie. The purpose of the 1991 report *Lake Tyee to Swan Lake Intertie: Preliminary Market and Financial Assessment* was to determine the amount of debt that the Swan-Tyee Intertie could support and the amount of additional funding required for construction. The study also estimated the amount of surplus power generation from the Tyee Lake hydroelectric plant, the potential savings to Ketchikan Public Utilities of using this power compared to other supply alternatives, and the amount of debt the intertie project could take on without affecting customer power rates.

The 1992 feasibility study of Swan-Tyee Intertie, commissioned for the Alaska Energy Authority, includes a review of Intertie route options, preliminary engineering design, environmental assessment, construction and O&M cost estimates, economic analysis, and review of power supply options. The Intertie was judged to be economically feasible, with a primary benefit of displacing future diesel generation in Ketchikan.

3.1.2.3 Kake-Petersburg Intertie

According to the 1981 reconnaissance report by Robert W. Retherford Associates for the Alaska Power Authority, the proposed intertie would connect the town of Kake to the interconnected Petersburg/Wrangell/Tyee Lake system. The route selected resulted in a proposed 45 miles of new overhead lines and 2 miles of submarine cables, using 40-kV Single Wire Earth Return (SWER) or 34.5-kV, three-phase tieline, with a transfer capability of 1.35 MW. The SWER alternative was recommended. A Kake-Petersburg Intertie feasibility study completed by Ebasco Services Inc. in 1984 for the Alaska Power Authority concluded that the transmission line was economically feasible, with a benefit/cost (b/c) ratio estimated to be between 1.0 and 1.24.

The 1987 regional intertie reconnaissance study indentified a transmission line between Kake and Petersburg as having long-term benefits by using surplus generation at Tyee Lake to offset diesel generation in Kake. A 1996 feasibility study by R.W. Beck for the Alaska Department of Community and Regional Affairs, Division of Energy, evaluated several possible route/design alternatives, and concluded that the Kake-Petersburg Intertie was not economic compared to the base-case of diesel generation in Kake, with an Intertie b/c ratio estimated to be between 0.50 and 0.95. However, the rising cost of diesel-powered generation in Kake may warrant re-evaluation of the intertie under today's economic conditions.

The 2003 regional intertie report by D. Hittle and Associates estimated the cost of the Kake-Petersburg Intertie to be $23.1 million in 2003 dollars. Based on a 2005 report by D. Hittle and Associates, the 2007 AK-BC intertie report estimated the construction cost of the line to be $31 million in 2007 dollars, and that the Kake-Petersburg Intertie would be economic starting in 2011. An extension of the Kake-Petersburg line would be to the Takatz site on Baranof Island. The 2007 report estimated the construction cost of a 45-mile-long, submarine 138-kV DC transmission line between Kake and Takatz to be $160 million in 2007 dollars. Takatz is the site of a proposed hydroelectric plant about 20 miles east of Sitka.

3.1.2.4 Thomas Bay Hydroelectric Projects

The Thomas Bay Energy Development near Petersburg is a proposal for the three hydroelectric projects at Cascade Creek (30 to 70 MW of potential), Scenery Creek (30 to 60 MW), and Ruth Lake (20 to 40 MW). The Thomas Bay hydropower complex is being proposed by Tollhouse Energy Company, which is based in Bellingham, Washington. The three potential hydroelectric sites of Cascade Creek, Scenery Creek, and Ruth Lake have received preliminary permits from the Federal Energy Regulatory Commission (FERC). The 2007 AK-BC intertie report estimated the construction cost of a Thomas Bay-

Petersburg transmission line to be $66 million in 2007 dollars, with a total length of 22 miles (9 submarine, 12 overhead).

3.1.2.5 Metlakatla-Ketchikan Intertie

Originally identified in the 1987 regional intertie study, the 17-mile Metlakatla-Ketchikan Intertie was evaluated in a 2000 reconnaissance report by R.W. Beck. The 2007 AK-BC intertie report estimated the construction cost of a 34.5-kV Metlakatla-Ketchikan transmission line to be $14.9 million in 2007 dollars, and that the line would be economic starting in 2013.

3.1.2.6 Prince of Wales Island

On Prince of Wales Island, the interties of Alaska Power & Telephone (AP&T) Company connect Black Bear Lake and the South Fork hydroelectric plants to the communities of Klawock and Craig, with later extensions to Thorne Bay (1999), Kasaan (2001), Hollis (2003), and Hydaburg (2004). A 7-mile-long, 24.9-kV intertie connecting Craig and Klawock was constructed in 1987 for a cost of $869,000. The 4.5-MW Black Bear Lake plant was completed in 1995, and the 2-MW South Fork plant was completed in 2006. Together, these two hydroelectric plants provide the majority of power for Prince of Wales Island, and have reduced the cost of electricity compared to diesel generation. For example, a 1997 report for the Alaska Department of Community and Regional Affairs, Division of Energy, *City of Thorne Bay, Electricity Sales Agreement and Intertie Evaluation,* indicated that the ten-year AP&T power purchase agreement (and new intertie) would reduce the cost of energy in Thorne Bay by approximately 1.7 cents/kWh. Future expansion of the Prince of Wales Island power grid is planned to include the load centers of Naukati and Coffman Cove. From Coffman Cove, a 50-mile-long DC submarine cable to Wrangell was estimated by the 2007 AK-BC intertie report to cost $170 million in 2007 dollars. The 1998 and 1987 regional intertie reconnaissance studies recommended a Prince of Wales-Ketchikan intertie as one of the last phases of the regional intertie system. The 2003 regional intertie report by D. Hittle and Associates estimated the cost of the Prince of Wales-Ketchikan Intertie to be $31.7 million in 2003 dollars. The 2007 AK-BC intertie report concluded that a Prince of Wales-Ketchikan intertie was uneconomic.

3.1.2.7 Juneau-Greens Creek Mine-Hoonah Intertie

Two reconnaissance-level studies conducted in 1981 on the Juneau-Hoonah Transmission Line Evaluation for the U.S. Dept. of Energy, Alaska Power Administration concluded that a 50.4-mile-long 69-kV transmission line between Juneau and Hoonah would be economic. The construction cost was estimated to be $20.6 million in 1981 dollars. The majority of the power demand to be served by the Juneau-Hoonah Intertie was expected to be from the then-proposed Greens Creek Mine on Admiralty Island and new timber industry facilities in the Hoonah area on Chichagof. The overall feasibility of the intertie was dependent on the expected load of the Greens Creek Mine, and service only to Hoonah was not economically feasible. The 1998 and 1987 regional intertie reconnaissance studies recommended the Juneau-Hoonah intertie as part of a longer connection including Tenakee Springs, Angoon, and Sitka. Phase 1 of the 2003 regional intertie study by D. Hittle and Associates recommended a line from Juneau to Greens Creek Mine, and continuing on to Hoonah. The report estimated the cost of a Juneau-Greens Creek-Hoonah Intertie to be $37.1 million in 2003 dollars

A 9.5-mile submarine cable transmission line, connecting Juneau to the Greens Creek Mine, was completed in 2006. The Kennecott Greens Creek Mining Company purchases power from Alaska Electric Light and Power, the Juneau utility, which is in the process of building the first (15 MW) phase of Lake Dorothy hydroelectric plant to help serve the mine's energy demand. An extension of this line to Hoonah was estimated to cost $30 million in a 2006 study for the Alaska Energy Authority by Emerman Consulting. This reported concluded that intertie extension to Hoonah would not have access to any surplus hydropower generation in the Juneau area as long as the Greens Creek Mine is in operation. Thus the generation capacity of the regional electric grid would not be large enough to provide tangible economic benefits to Hoonah.

3.1.2.8 Alaska-Canada Interconnection Proposals

The proposed Bradfield Intertie would connect the existing hydroelectric plant at Tyee Lake, Alaska to neighboring British Columbia. A 1988 report by Harza Engineering Company for the Alaska Power Authority, *Southeast Alaska Transmission Intertie Study: Addendum 1, Tyee/Johnny Mountain Transmission Line Study*, was a preliminary investigation of a proposed transmission line between the existing Tyee Lake hydroelectric plant in Alaska and gold mining operations at Johnny Mountain, British Columbia. The line was proposed by Bradfield Electric, Inc., an independent concern based in Wrangell. The 1988 report recommended a 69-kV line, though it also recommended the transmission line and required substation facilities at Tyee Lake be built to 138 kV. A 41.5-mile, 138-kV Bradfield Intertie was estimated to cost $16.7 million in 1988 dollars. The Johnny Mountain gold mine only operated briefly between 1988 and 1990, though may be reopened in the future.

The mining company NovaGold is also developing the Galore Creek gold mine in the same area of British Columbia. Nearby, Calgary-based Alta Gas is proposing the 195-MW Forest Kerr hydroelectric project on the Iskut River. Plans for the Forest Kerr project include a 138-kV line to be connected to the lines of the British Columbia Transmission Corporation (formerly the BC Hydro transmission system), which in turn is part of the greater North American grid system, connected to the contiguous United States. The Bradfield Intertie connected to the Forest Kerr project could in turn enable the export of hydroelectric power from Southeast Alaska into Canada or to the U.S. Pacific Northwest. According to an article in the July/August 2008 issue of the publication *IEEE Power and Energy*, British Columbia's domestic consumption of electricity has begun to outstrip its supply. Although for many years the province had a surplus of power, it is now a net importer of electricity. Demand for electricity in British Columbia is expected to increase as much as 45% by 2025.

The 2007 Alaska Energy Authority study, *AK-BC Intertie Feasibility Study SE Alaska: Final Report*, by Hatch Acres and Dryden & LaRue, concluded that the export of energy after the year 2015 to British Columbia via the Bradfield Intertie appears to be economic at discount rates of 6%. Construction of the Alaska section of the Bradfield AK-BC Intertie (Tyee Lake to U.S./Canada border) was estimated to cost

$32 million in 2006 dollars, and the British Columbia section of the AK-BC Intertie (U.S./Canada border to Forest Kerr) was estimated to cost $36 million.

A transmission intertie from the Haines/Skagway area to Whitehorse, Yukon was examined in the early 1980s by the Alaska Power Administration and the Northern Canada Power Commission. A 1983 report by FWS Engineers to the Northern Canada Power Commission estimated that the 148-km-long Canadian section of the intertie (Whitehorse-White Pass) would cost between $10.5 million to $11.5 million in 1983 Canadian dollars. This was followed by a 1984 study by R.W. Beck and Associates for the Alaska Power Administration and the Northern Canada Power Commission: *Economic and Financial Analysis of a Proposed Transmission Intertie between Whitehorse, Yukon Territory and Haines, Skagway and Juneau, Alaska*. The 1984 report estimated a construction cost for the U.S. section of the intertie (White Pass-Skagway) to be $7.3 million in 1983 U.S. dollars, as well as Skagway-Juneau intertie to cost $35.8 million in 1983 dollars. The report concluded that the proposed intertie would only be economic under the conditions of low load growth in the Yukon and high or extra high load growth in the Juneau area. In other words, if excess hydroelectric power generated in the Yukon would be exported to Alaska.

A 1983 report by B.C. Hydro's Systems Engineering Division analyzed a proposed electric transmission line between Whitehorse, Yukon and British Columbia, and briefly discusses possible Alaska-Canada interties.

The 1987 regional intertie study for the Alaska Energy Authority proposed an intertie from the proposed molybdenum mine at Quartz Hill in Alaska to Kitsault, British Columbia to import power from Canada. However, the mine site at Quartz Hill, about 50 miles east of Ketchikan, has yet to be developed due to global molybdenum prices over the past 20 years.

3.2 Southwest Alaska

3.2.1 Southwest Alaska Regional Interties

The 1975 Robert W. Retherford Associates regional study for the Alaska Power Administration, *A Regional Electric Power System for the Lower Kuskokwim Vicinity: A Preliminary Feasibility Assessment,* concluded that a regional electric power system of lines interconnecting the ten villages within a 40-mile radius of Bethel is a feasible project. Most of the transmission interconnections proposed use conventional 3-phase, 4-wire electric lines. A 70-mile transmission line to the proposed 36-MW Golden Gate hydroelectric site on the Kisaralik River is also described. The report recommends more in-depth study of this and smaller hydropower sites in the region.

Included in 1975 study was a preliminary assessment of Single Wire Earth Return (SWER), which promised lower transmission line costs. Both conventional 4-wire and SWER regional power lines were estimated to be more economical than village power systems. SWER/SWGR technology is discussed in greater detail below in section 5.1.4.

SWER in the region was further examined in 1980 in the *Lower Kuskokwim Single Wire Ground Return Transmission System, Phase I Report,* by Robert W. Retherford Associates for the Alaska Division of

Energy and Power Development. This study included preliminary field investigations, design, routing and cost estimates, and recommended a SWER prototype transmission line be built between Bethel and Napakiak. The phase I report was followed in 1982 by the *Lower Kuskokwim Single Wire Ground Return Transmission System, Phase II Report (Bethel to Napakiak SWGR System Design Manual and Construction Summary)*. The Bethel-to-Napakiak SWER demonstration project extends 8.5 miles over tundra.

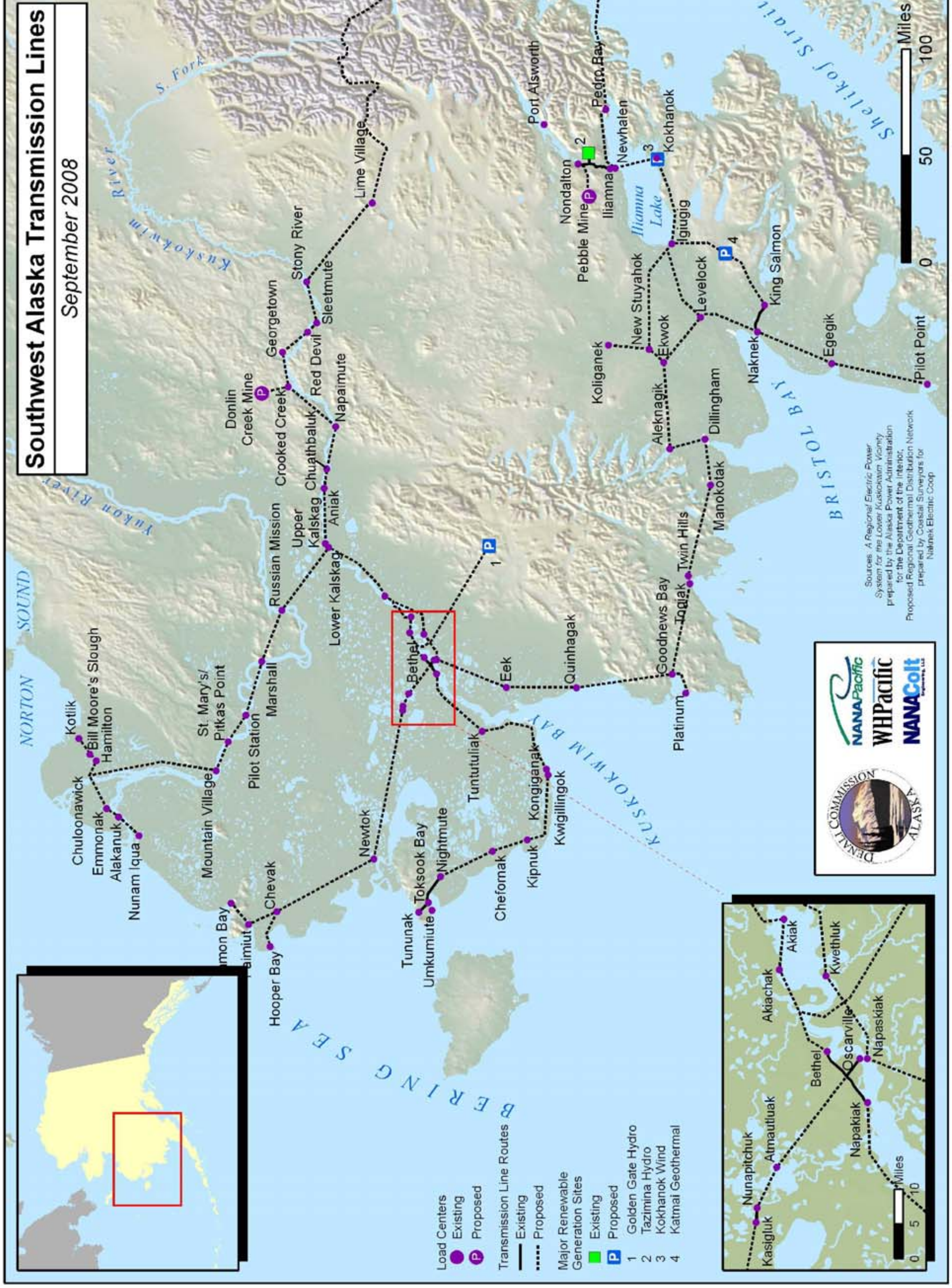


Figure 4 Southwest Alaska Transmission Lines

The purpose of the 1982 report is to consolidate information concerning the final design, general construction techniques and construction cost data of the 15-kV Bethel-to-Napakiak SWER Transmission

System, which became operational in October 1980 at a total construction cost of about $280,000 in 1980 dollars. This line has been deteriorating in recent years, resulting in line loss, poor reliability and higher energy costs, and is presently being upgraded to a standard three-phase line. The Bethel-Oscarville Intertie is a 5-mile, 15-kV, conventional single-phase line that was constructed in 1988 at a cost of $281,000.

3.2.1.1 Bethel-Nyac Intertie

Nyac is a community more than 60 miles east of Bethel. A 1995 feasibility study, design and cost estimate of the Bethel-Nyac transmission intertie was prepared by FPE Roen Engineers for the Alaska Dept. of Community and Regional Affairs, Division of Energy. A 1996 cost estimate on the Bethel-Nyac Intertie by Dryden & LaRue estimated a total project cost of $46.8 million in 1995 dollars. A 1996 amendment to Bethel-Nyac intertie study provided updated technical design and cost information. It was proposed that this intertie connect to the proposed Golden Gate hydroelectric site forty miles south of Nyac.

3.2.2 Other Southwest Alaska Intertie Studies

Outside of the Bethel area, five existing interties between rural communities in Southwest Alaska were identified:

- Naknek-King Salmon-South Naknek
- Iliamna-Newhalen-Nondalton
- The Toksook Bay to Tununak intertie is a 6.6-mile-long electric line energized in 2006. The total project cost was $2,049,494, according to the Denali Commission's June 2008 project closeout summary.
- Kasigluk-Nunapitchuk
-
- St. Mary's-Andreafski/Pitkas Point, line completed in 1985.

A 1985 feasibility study on the Kokhanok-Newhalen electrical tie line was conducted by Dryden & LaRue for the Kokhanok Village Council. The study concluded that it would be technically feasible to connect Kokhanok to the Newhalen-Illiamna-Nondalton system, an existing intertie completed in 1982.

In 1986, Polarconsult Alaska studied the feasibility of a Manokotak-Dillingham transmission line for the Alaska Power Authority. This study recommended a SWER system to connect Manokotak Heights to the Nushagak Electric Cooperative in Dillingham.

Naknek Electric Association has proposed a regional electric interconnection plan centered on a possible 25 MW geothermal power plant near Katmai National Park. As proposed, such a scenario would involve the construction of about 450 miles of new electric intertie/transmission lines.

3.3 Northwest Alaska

A 1984 final report on the Kobuk-Shungnak SWER transmission line was done by the Thomas D. Humphrey Company for the Alaska Department of Commerce and Economic Development. An SWER transmission line was constructed in 1980 between Shungnak and Kobuk, with a total length of 10.5 miles. In 1991, this line was rebuilt as a conventional 15-kV, three-phase line for a cost of $1,350,000. A Shungnak-Ambler intertie is being investigated by the NANA Regional Corporation, as is an intertie connecting Kivalina, the Port of Red Dog Mine, and Noatak. Several possibilities exist in the region for connecting electric loads and generation capacity of both local communities and mining operations.

3.4 North Slope

A 1981 report by Robert W. Retherford Associates for the North Slope Borough examined the feasibility of a Barrow-Atqasuk-Wainwright transmission line, recommending a 70-mile line between Barrow and Atqasuk, and a 67-mile line between Barrow and Wainwright. The total project cost was estimated to be $16 million in 1980 dollars.

The following year, in 1982, the U.S. Dept. of Energy, Alaska Power Administration, studied a proposal for an 8000-MW high-voltage DC transmission line between proposed coal and gas-fired power generation on the Alaska North Slope to Canada and the Pacific Northwest. This 1982 report was an update of the 1972 North Slope Transmission Study, and concluded that further study of the concept was not warranted.


Proposed Transmission Lines
North Slope and Northwest Arctic Borough
September 2008
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
BERING SEA
GULF OF ALASKA
Barrow
Atqasuk
Wainwright
Point Lay
Point Hope
Nuiqsut
Prudhoe Bay
Anaktuvuk Pass
Wiseman
Bettles
Evansville
Ambler
Kiana
Selawik
Noorvik
Kotzebue
Noatak
Red Dog Mine
Kivalina
Shishmaref
Dease Inlet
Smith Bay
Teshekpuk Lake
Harrison Bay
Colville River
Noatak River
Kobuk River
Transmission Line Routes
Existing
Proposed
Source: North Slope Borough Planning Department
0
50
100
150
Miles

4 Professional Opinion Survey

The objective of the previous section was to provide an historical perspective of electrical transmission through a review of existing literature.

The purpose of this section is to synthesize the opinions of professionals involved in the development, planning, engineering, construction and management of energy transmission systems regarding the extent to which these systems address the policy objectives of the Denali Commission. Furthermore, efforts were made to explore policy criteria beyond the traditional criteria of reliability, economic energy transfer, transmission efficiency, capacity sharing, and operating reserves sharing.

Fifteen Alaskan experts were interviewed. Their responses are synthesized below. All comments are anonymous by agreement with the respondents; no comments are attributable to any individual respondent.

4.1 What do you see as the value of intertie projects? Why do we build them?

The following five reasons for building intertie projects were given:

1. Excess stranded capacity is available in one area and can be transmitted to an area that has insufficient capacity, thus increasing systems efficiency.
2. Power is cheaper in one area than in another area.
3. Linking numerous communities to different sources of power will improve power systems reliability.
4. Increased transmission lines reduce line loss, and improve economies of scale.
5. Additional lines can add more capacity to existing lines.

Interties create options for communities. They can help reduce the cost of energy for connected communities and help to promote economic development. Communities can make their own decisions about their futures if an intertie project is available.

Many of the respondents emphasized the importance linking newer low-cost power sources to power users. Most thought that continuing reliance on diesel fuel as the basic fuel stock was unsustainable. Connecting communities which rely on diesel-fueled power generation is delaying efforts to develop and transmit renewable energy such as geothermal, wind, hydropower and biomass.

One respondent emphasized the importance of the intertie as a "two-way street," meaning that there should be opportunities for the sharing of power costs and improvements in reliability for all communities linked by an intertie. It should not benefit only one community.

Another respondent emphasized the importance of building institutional capacity for managing complex energy distribution. He believed that supervisory control and data acquisition (SCADA) is an essential ingredient in the development of any intertie project. Institution development is critical in Alaska because our knowledge base is about 20 years behind that of many other communities.

4.2 Most of these projects are paid for, in part, using public funds. What do you see as the public policy objectives that these projects are trying to realize?

As one respondent said, “Electricity is the key to life and the economy. Energy is the lifeblood of the modern human lifestyle. Interties are a part of this.” Therefore, it is the government's responsibility to promote this essential, basic service through power provision, policy, and financing mechanisms. Interties can be part of “taking care of Alaskans, not of making money.”

Respondents also voiced general concerns about the impact of high energy costs on the sustainability and viability of rural communities. One respondent posed the question “where do people go if energy costs get too high? I think that, without power, villages will disappear. People will probably go to Anchorage or Fairbanks.”

Many respondents emphasized the importance of local energy production in retaining wealth in local communities. The use of local labor and the opportunity to develop local economic enterprise are both directly related to the availability of low-cost power. Interties are an important part of this system if they reduce the cost of power or mitigate the extent of cost increases

A few respondents mentioned the importance of the logical clusters of communities which could create enough critical mass to justify an inter-village energy distribution system. The natural alliances among adjacent communities can help in the development and organization of an intertie system. Not only are the communities in close geographic proximity, but in many cases share some of the same cultural values and community histories. This common ground could help reduce some of the conflicts and organizational issues that surround regional utility projects.

While energy is an essential ingredient, the availability of low-cost energy does not necessarily result in economic development. The cost of electricity is probably a small component of the total cost of production. Therefore, without all of the other production ingredients in place, businesses would not be attracted solely on the basis of low-cost energy.

The continued operation of basic public services, on the other hand, could be greatly affected by the continued rise in the cost of energy. Schools, health clinics, public offices and other elements of the public infrastructure could become too costly to operate. Without these basic services, some communities will have difficulties. If an intertie can help prevent this situation, it is in the public's interest to build it. This relates directly to the Denali Commission’s policy objective of helping to sustain rural Alaskan communities

4.3 To what extent should publicly-funded intertie projects promote community or regional economic development? How can these impacts be measured?

Available energy and economic development are closely intertwined. One respondent called the lack of energy “the number one impediment to economic development around the world.” However, even with interties, the high cost of electricity may not promote community economic development.

Reducing the cost of electricity through interties may promote economic development by reducing the proportion of the family budget that is allocated to heating and electric energy, thus increasing the amount of family discretionary income. These funds could be used by local entrepreneurs to develop small community businesses, such as crafts, local businesses and fish processing. One respondent suggested that there could be dramatic improvements in value added fish processing in the Bristol Bay region if there were adequate power. He noted that potential hydroelectric power generation sites in the Woods River/Tickchick Lakes area could be linked to Bristol Bay fish processors through interties. He also cited examples of potential improvements in value added fish processing in the Chignik area from local hydropower, and salmon processing in Holy Cross using wind and a hydropower shared it with the Donlin Creek project.

Large scale economic enterprises, such as mining, fish processing, smelting and value added timber products, require substantial amounts of energy. Interties are required if there is no on-site power source. Small and medium scale hydroelectric projects can generate enough power for local fish or timber processing. However, most mining operations require huge amounts of electricity. The power sources must be large scale, geothermal or fossil fuel. Respondents strongly suggested that diesel-fueled electricity generation is not economically feasible for large economic development projects.

Large economic development projects, particularly mines, have proposed being energy producers and sellers. The proposed Donlin Creek and Pebble mines require at least 600 MW of electricity to operate. These operations could become “value hubs,” or large energy users, which can economically justify the interties for electrical distribution to nearby communities. They also create a sufficient demand to justify large power generation projects, such as the Susitna hydroelectric project, the Mt. Spurr geothermal project or the potential for a large-scale regional gas power generation plant.

Most respondents agreed that public funding of intertie planning and construction could make the difference between an economically feasible and infeasible project.

Most respondents argued that the economic impacts of intertie projects could be measured by the net improvement in the price of energy. However, economic planners suggested that successful intertie proposals include documented interactions with regional economic developers or sponsors, such as Alaska Regional Development Organizations (ARDORs), Rural Utility Business Advisors (RUBAs), the Department of Transportation and Public Facilities, and local community leaders demonstrating planning activities linking efficient energy production (perhaps involving interties) and economic development.

Fueling Development: Energy Technology for Developing Countries, a report by the Office of Technology Assessment noted that securing higher standards of living for increasing populations requires rapid economic growth. This further increases the demand for energy services. The demand for increased energy could be even greater in supplying the needs for a growing economic engine. This creates a potential dilemma. On one hand the rapid rates of economic growth necessary to provide rising standards of living for growing populations require sharp increases in energy services. The cost of building the infrastructure, however, could divert available investment funds, thus limiting the economic development itself. This could stifle economic growth and the quality of life in rural communities.

4.4 Intertie proposals often suggest that the project will lower the cost of electricity in participating communities. Have you found this to be true in the long-term?

There was some disagreement among respondents about the long-term impact of interties in reducing electrical costs. One respondent suggested that the Railbelt and Northern interties have reduced energy costs in Fairbanks or at least eliminated or tempered steep cost increases. On the other hand, interties that link renewable energy, such as the Toksook Bay/Tununak wind project, have dramatically reduced costs to all participating communities.

4.5 To what extent do these projects impact the quality of life of Alaskans, especially rural Alaskans? How can these impacts be measured?

Intertie projects enhance the quality of life in rural Alaska to the extent that they make energy affordable. As one respondent said, "the cost of heat and lights in a cold and dark place is a top priority in community sustainability, ahead of health and education." As mentioned earlier, continued high energy costs could severely threaten the stability of rural Alaskan communities. The resulting outmigration could affect the stability of hub communities or larger Alaskan cities such as Anchorage Fairbanks and Juneau.

The quality of life can also be enhanced as reduced energy costs allow more discretionary spending in the family budget. The NANA region's Red Dog Mine is evidence that large economic enterprises enhance the quality of life in rural Alaska. Therefore, to the extent that interties support regional economic development, the quality of life is enhanced

4.6 The notion of an "anchor user" has been discussed more frequently in recent years. How does this arrangement work? To what extent is an anchor user a valuable addition to an intertie project?

All respondents agreed that anchor tenants, also called "value hubs," were a critical, but not a required, part of any transmission system. Value hubs are critical because they may provide the critical mass necessary to justify an efficient energy transmission system. They are not required, because it is important to produce and deliver low-cost energy for rural Alaskan communities to sustain them, regardless of the presence of an anchor tenant. Examples of successful anchor tenants include the Red

Dog and Fort Knox mines. Economies of scale are shown by the cost savings and improved reliability of power within the Railbelt interconnection. Other anchor users have been proposed linking economic development and power distribution systems.

The most common examples of industries that could be anchor tenants are fish plants and mining operations. They would provide the “economic engine” for the region, and allow for the economies of scale that would help reduce the cost of power in local communities.

Local communities must be in charge of their own destinies, including the ability to accept or reject a transmission project. This suggests that intertie projects must involve regional and local governments. Communities are becoming more sophisticated in negotiating with larger corporations. In this way, they are increasing their own real and perceived sense of empowerment in dictating their own futures. In some cases, the future may involve major economic development initiatives, such as mining, fish processing, smelting or timber products. In other cases, these economic development initiatives may be rejected. By themselves these initiatives are an insufficient rationale for developing and intertie.

Most interties follow established communication routes. Traditional interactions and personal and family alliances appear to drive the establishment of communications among villages. We see these communication patterns today in the organization of air traffic among local communities, attendance at sports tournaments and traditional gatherings, and the organization of mutually beneficial projects. Trust is an essential element in developing the ongoing relationship among communities which must exist in order to justify an intertie.

Local communities must have an economic incentive to interconnect. For each community on both sides of an interconnection, there must be mutual benefits in the reliability of electrical power and a reduction in its cost. The cost of operating and maintaining the interties must also be taken into account.

A successful intertie proposal should demonstrate that the proposers have “explored” engaging a potential anchor user.

4.7 In the overall scheme of things, how important are the environmental impacts of these projects? How can these impacts be measured?

In the 1940s, there was a drive to distribute electric power to communities as quickly as possible. Most environmental concerns surrounded construction and systems maintenance challenges. Times have changed. An in-depth literature review revealed increasing attention to environmental factors associated with energy distribution, starting in the early 1980s.

Now, environmental concerns about the effect of interties on environmental aesthetics, the impact on flora and fauna, and the pollution produced in the power generation phase are all extremely important. Mitigation of these impacts has caused the permitting process to extend for as long as seven years. This adds to the cost of intertie construction.

People do not want to "see the wires" of transmission lines. Some feel that it compromises the beauty and pristine character of the Alaskan environment. Utility corridors which cross environmentally sensitive areas must demonstrate minimal impact on the environment through the preparation of Environmental Impact Statements.

The source of power is also a major concern. Coal is considered a "dirty" fuel by certain segments of the population. It was recently rejected as the principal feedstock for the generation of electrical power in the Mat-Su Valley. Some also consider the coal-to-liquids and Fischer-Tropsch conversion processes environmentally objectionable. There continue to be concerns about the proposed nuclear generation facility in Galena. Concerns with the use of fossil fuels, especially diesel fuel, are repeatedly raised.

The construction of transmission lines also requires the use of costly metals (copper and steel) which require substantial energy to refine.

4.8 To what extent are intertie sponsors expected to be "good corporate citizens"? Should they be active in the communities they serve? Are they expected to become philanthropists?

There was little support among respondents for intertie sponsors to be "good corporate citizens" beyond their diligence in making electrical power cheaper, more reliable, and accessible. Some noted that power co-ops are measured according to the cost of the power that they generate. These costs of doing business include public participation and socially responsible development. However, philanthropy is not expected.

The Regulatory Commission of Alaska (RCA) could make it difficult for private sector economic development projects, such as mines or natural resource processors, to sell low-cost energy to local communities. One respondent urged the review and modification of RCA regulations for independent power producers which could reduce impediments for entry into the market. He believed that the REGA recommendations would support such changes in utility regulations in Alaska.

4.9 Is there anything else that you would like to share with the Denali Commission about intertie projects?

Many respondents believed that the Denali Commission could play an important role in energy production and distribution. One respondent said that "no single institution has all the resources" required to manage the energy generation and distribution portfolio. The Commission can organize and coordinate teams which could accomplish these larger goals. They can help decide "what projects we can accomplish together."

One specific recommendation was that the commission addresses the provisions of Article 11 of the Alaska National Interest Lands Conservation Act (ANILCA) of 1981, which discusses the transportation/utility system (TUS). In passing the legislation, Congress recognized that Alaska's transportation and utility network was largely undeveloped and future needs would be best identified and provided through an orderly process involving the state and federal governments and the public.

Agencies would have to determine whether a proposed TUS project is “compatible” with the purposes for which a conservation system unit was established. If an agency denies an application for a TUS, the president of the United States can reverse the denial. Congress must agree with the president's recommendation by passing a joint resolution within 120 days. Many of the respondents suggested that the commission assist in identifying several key corridors and obtaining Congressional support.

One respondent said that Alaska could use some help in sustaining and expanding gains in energy generation and distribution technology. We tend to train people “on the job.” These people often leave their positions, leaving little enhanced institutional capacity behind them. One respondent said, “The people who make it work are making big bucks.” He argued for increased workforce development in planning and management of energy generation and distribution systems.

The Commission should become more involved in helping to advance intertie technology, including demonstrations of wave, current and tidal energy generation. This should emphasize the integration of operations and management with the marketing of technological advances. These advances should have at least a 30-year planning and implementation horizon. An organization that has a clear mandate to do this without extensive shortsighted political interference could have a positive effect on Alaska's ability to develop, operate and market new technology.

It could also help fund research to improve intertie construction technology, the development of hydrogen fuels, and the monitoring of the nuclear demonstration site at Galena. One respondent said “we should be an example to the world about how to do it right. We should develop our technology and export knowledge to the world.” Others disagreed, arguing that this was more appropriately the role of the University.

Respondents in the energy sector believed that the efforts to modernize Alaska’s bulk fuel storage system were brilliant. Now, however, other alternative fuels need to be explored. The Commission could serve a valuable role in assisting rural communities in infrastructure development. This role could be uniquely filled by the Commission. Because it is a partnership among federal and state agencies, it is one of the few groups that have the ability to bridge overlapping jurisdictions. This role could be invaluable in facilitating the resolution of Agency conflicts.

5 Electric Utility Technology Review

The purpose of this section is to review the current state of the technology for developing constructing and implementing efficient electrical intertie systems. The information presented here is intended to help identify strengths and weaknesses in our understanding of these critical technologies.

The technology assessment is broken down into three categories: generation, transmission and distribution, and energy end-use. The electric transmission and distribution technology assessment is obviously the most directly relevant focus for this study, but generation and end-use of energy are also vital parts of the energy supply chain.

Over the next two decades, the replacement of ageing electrical infrastructure will be needed. Most of Alaska's existing electrical infrastructure was built during the three-decade period spanning the 1960s to the 1980s.

5.1 Power Generation

5.1.1 Central-Station Power Plants

The status quo of electric power generation is relatively large, three-phase alternating current (AC) generators. The vast majority of standard three-phase generating capacity is owned and operated by established electric utilities or independent power producers (IPPs). Commonly referred to as 'central station' generation plants, the 'prime-mover' energy sources for standard three-phase generation range from steam turbines (fueled by coal, natural gas, oil, nuclear, or renewable heat sources such as biomass, geothermal, or solar thermal), natural gas turbines, diesel engines, and renewable sources such as hydroelectric or tidal turbines, and wind turbines, or even wave energy converters. A common type of generation unit in Alaska's Railbelt region is the natural gas fired combustion turbine. The most efficient of these units is the natural gas fired combustion turbines operated as a combined-cycle plant, which utilizes the waste heat from a gas turbine to power a steam turbine. These combined cycle plants make up about 30 percent of the installed thermal generation in the Railbelt region. Throughout most of the rest of Alaska generation consists primarily of small diesel fired reciprocating engines and hydro electric plants with a smattering of wind powered units. Most hydro generation outside of the Railbelt is located in the southeastern region of the state, however several small hydro units exist in other areas Most electric generators produce AC power, but photovoltaic (PV) solar panels and hydrogen fuel cells (see below) generate power by direct current (DC) only, and wind system operate asynchronously. For grid-tied systems, such generating units are connected to DC-AC or AC-DC-AC power conversion equipment.

5.1.2 Distributed Generation Technology

Distributed generation consists of relatively small generation units located closer to, or co-located with, the end user. Distributed generation is possible both at the scale of individual homes, as well as at large commercial or industrial users such as office buildings and factories. Distributed generation technology offers opportunities for small-scale renewable energy applications, such as roof-top solar PV installations. Distributed generation can also be done with fossil fuels, such as natural gas micro-turbines or combined heat and power (CHP) applications using natural gas, as in fuel cells, or with oil, or even coal.

The future mix of power generation resources will likely be composed of both large, central station power plants and various, small-scale distributed generation plants. In effect, a decentralization of power grids around the world is a possible outcome; however, economically it is difficult to overcome the economies of scale found in central station power generation. With proper real-time control and protection systems, distributed generation could offer greater power grid flexibility.

Net-metering, or allowing very small-scale power plants to sell power back to the grid, is allowed under the utility regulatory structure in the majority of U.S. states. Net-metering is typically done with small-scale renewable energy installations at homes, such as roof-top solar panel installations, and usually has a maximum capacity limit (typically under 100 kW) of how much power can be exported to the local distribution grid. Net-metering legislation is being considered in Alaska.

5.1.3 Future Power Generation Possibilities

In addition to the renewable energy sources described above, other emerging technologies offer future possibilities for Alaska power generation.

5.1.3.1 Fuel cells

Fuel cells convert pure hydrogen and oxygen directly into electricity, with a byproduct of heat, and emitting only water vapor as exhaust. Fuel cells utilize a number of technologies to produce electricity, Solid Oxide, Phosphoric acid, Proton Exchange Membrane to name a few. Fuel cells can run off of any hydrocarbon-based fuel source, for example, natural gas, methanol or even gasoline. A natural gas-based fuel cell with a reformer attached can extract the hydrogen from the natural gas before it enters the cell. However, the hydrogen reformation process takes time, and cannot be done rapidly for large quantities of gas. Reforming hydrogen from natural gas also emits carbon-based air pollutants and the hydrogen gas is highly explosive.

Although fuel cell technology has been in existence since the 1800s, the commercial use of fuel cells has so far been limited to small-scale, specialized applications. Over the short to medium term, natural gas is the most practical feedstock in Alaska for fuel cells. For pure-hydrogen fuel cell use to become widespread, a comprehensive hydrogen delivery infrastructure needs to be developed (read below). Also, the performance of fuel cells in cold temperatures is an important technical concern for Alaska.

5.1.3.2 Small-scale nuclear

Historically, the practicality of nuclear energy has been dictated by economies of scale. Typically, nuclear power plants are built with capacities of 1000 MW or more. The smallest commercial nuclear power plant in the U.S. has a capacity of 478 MW, which is larger than any single generation facility existing in Alaska today. However, emerging small-scale reactor technology, if proven safe and reliable, could find various applications for Alaska.

At present, the only proposed Alaska nuclear installation is for the town of Galena on the Yukon River. The proposed power plant would be a 10-megawatt (MW) 4S reactor (Super Safe, Small and Simple) reactor under development by the nuclear power systems division of Toshiba. The 4S modular "battery" design is a sodium-cooled fast reactor operating at atmospheric pressure with 'modular' construction, and would be housed in a sealed, cylindrical vault 30 meters underground, while the building above ground would connect to the town's electrical distribution system. The reactor will run on highly-enriched uranium or uranium-plutonium alloy fuel rods, with no refueling for 30 years, after which time the entire reactor will be replaced, presumably with a new 4S unit. Other than electric power production, the proposed end-uses of the surplus nuclear energy in Galena include heating for city buildings, schools, the public swimming pool, and the health clinic. However, the Galena 4S project is years away from regulatory approval, and may not turn out to be economically viable. If this project succeeds, Toshiba plans to sell other 4S reactors to other towns in rural Alaska and around the world. Alaska's mining industry has already expressed interest in small reactors powering remote, large-scale operations.

In addition to electricity production and district heating, other uses have been proposed for small nuclear reactors including hydrogen production and saltwater desalination. Perhaps hydrogen could be produced using surplus electricity from the small reactor, and this hydrogen could in turn power vehicles such as trucks or snow machines.

5.1.4 Power Transmission and Distribution

The transmission system efficiently carries large amounts of electric power from generating stations to end-users. Electricity *transmission* lines are generally defined as have a voltage greater than 35 kV. Electricity *distribution* lines are generally defined as having a voltage less than 35 kV, with line voltages between 34.5 kV and 138 kV, sometimes defined as *sub-transmission*. However, in Alaska, 15 kV interties between small communities may be called "transmission", while falling under the standard industry definition of distribution voltage. Common electric intertie voltages in Alaska include 230 kV, 138 kV, 115 kV, 69 kV, 34.5 kV, and 15kV lines. In rural Alaska, 'islanded micro-grids' are the rule for electric power on the village scale, with only a handful of existing village-to-village interties.

Toksook Bay to Nightmute 13.8kV intertie. Photo courtesy of Alaska Village Electric Cooperative.

Toksook Bay to Nightmute 13.8 kV intertie. Photo courtesy of Denali Commission.

Quartz Creek 115kV transmission line along the Seward Highway near Girdwood. Photo by Brian Yanity.

Linemen working on tower of Beluga-Anchorage 230-kV transmission line. Photo courtesy of Chugach Electric Association

Almost all power generation and transmission/distribution lines are three-phase AC, while electric systems within homes are generally single-phase AC. Three-phase generators are much simpler and more efficient than singe-phase machines. Also, compared to single-phase lines, three-phase power lines require less copper to carry the same amount of power. Supplying single-phase power from three-phase lines is a simple process. Transmission and distribution line voltages are classified in two ways, first based on the IEEE standard voltage insulations classifications i.e. 15kv, 25kv, 48kv, 69 kv 120kv 145kv etc. Lines insulated for a particular voltage class meet certain minimum standards and can be operated at any voltage below the rated insulation value. Second, lines are sometimes identified based upon actual operating voltages which generally following the IEEE standard transformer voltages, although transformers of non-standard voltage output can be constructed. For distribution class voltages these operating voltages are generally referred by the combination to the three phase and single phase operating voltage i.e. 12.470/7.2 kV or 24.9/14.4kV and by the three phase operating voltage for transmission level voltages, 115kV or 138kv.

Electricity flows through the path of least resistance, or in the case of AC power, impedance (or total opposition to current flow from the combined resistance, capacitance, and inductance). Due to the complex network of elements which make up the power grid, this path of least impedance may not take the most direct route geographically. Modifying grid impedances to control actual power flows in real-time is expensive and complex therefore, in grid system energy sales are generally defined in terms of contract paths with variations in actual flows accounted for through an energy accounting mechanism known as “inadvertent payback”. The practical realization of this physical phenomenon is that without careful real-time monitoring and exhaustive long term planning, unintended flows across transmission lines can lead to system collapses or “black-outs”.

Besides the construction of new transmission lines, other options for improving electric transmission capacity include the upgrade of existing lines, control system and substation improvements, and the installation of transformers or compensation devices (reactors or capacitors). Compensation systems (which change impedance) such as static volt-ampere reactive (VAR) compensators and Flexible AC Transmission Systems (FACTS) use high-voltage semiconductors. Such devices improve grid flexibility, power transfer capability and reliability maximizing line capacity or by enabling rapid routing of power to different locations; however, as discussed above these systems are complex and costly. With more advanced computing and communication technologies, so-called “smart-grid” technology may add more intelligent control to power system operation, but will require a significant upgrade to the existing Supervisory Control and Data Acquisition (SCADA) systems capabilities

Three-phase AC overhead transmission and distribution line technology has remained basically unchanged for over a century. Few significant technical advances in overhead electric transmission line technology have occurred over the past several decades. More notable are the improvements in underground/submarine AC cable technology, such as the introduction of solid dielectric insulation materials which eliminate the need for costly and complex liquid oil dielectric insulating systems.

5.1.4.1 High Voltage DC (HVDC) Overhead Lines

Overhead high-voltage DC (HVDC) transmission lines are practical for very large scale applications, most notably for long-distance bulk power transmission. HVDC lines require DC/AC converter stations on each end of the line to connect to the standard AC power grid, which greatly add to the capital expense of the transmission line. However, due to the physical limitations of AC systems, HVDC lines are the only viable option for high-capacity overhead transmission lines more than several hundred miles in length. Over 100 HVDC bulk overhead long-distance transmission systems exist in the world today, with notable examples including the Pacific Intertie from Celilo, Oregon to Sylmar, California (846 miles, 500 kV HVDC, 3100 MW transfer capacity), and the Itaipu-Sao Paulo line in Brazil (2000 km, 600 kV HVDC, 6300 MW transfer capacity).

5.1.4.2 DC Submarine/Underground Cable

For submarine or underground cables longer than a distance of about 40-50 miles, AC transmission lines reach their physical limit of capacitance. On small, lightly interconnected, systems the acceptable length for AC cables can be much shorter due to the system's ability to withstand switching of the cable's capacitive charging current. Direct current (DC) electric transmission eliminates this problem, although it requires DC/AC converter stations on each end of the cable. Unlike AC underground/submarine cables, there is no physical limit for the distance or power level for DC underground/submarine cables. At present, existing DC transmission technology is far too large in scale for consideration in Alaska, except for a select few possible applications with submarine cables. Applications for conventional HVDC in Alaska might include a connection between the proposed Pebble Mine in southwest Alaska and the Railbelt energy grid, or between proposed major hydroelectric projects in southeast Alaska such as the Yukon-Taiya and the Canadian/ Lower 48 energy grids.

5.1.4.3 Single Wire Earth Return (SWER)

Single wire earth return (SWER), also referred to single wire ground return (SWGR), is a technology that was proposed for use in Alaska in several studies during the 1970s and 1980s, for both overhead and submarine cables. A lower-per mile cost was expected with SWER transmission lines, and the technology was notably featured in 1975 and 1980 intertie studies for the Lower Kuskokwim region by Robert W. Retherford Associates.

SWER consists of using an overhead (or submarine) wire for the high voltage ('hot') leg of a transmission circuit, and using the earth as a return pathway ('neutral') instead of a separate dedicated conductor to complete the transmission circuit. Conceptually, a SWER circuit is very similar to the electrical system of a car, which uses the vehicle's chassis as a return pathway to the battery's negative terminal instead of a separate dedicated wire. SWER systems can be used for single phase AC transmission or for monopolar DC transmission. The primary rationale for using a SWER circuit in a rural area is to reduce the cost of the transmission line by eliminating multiple conductors and thereby allowing the use of lighter and less costly structure installations.

One of the primary technical considerations with SWER circuits is the intentional routing of electrical currents into the earth to complete a transmission circuit. Proper design is necessary to safely transfer these currents into the ground so they are dispersed and to adequately protect the public in situations where short circuits to ground occur. Also, DC earth currents have the capability to cause accelerated corrosion of buried metallic objects, such as pipelines and similar metallic infrastructure. In areas with a significant buried metallic infrastructure, SWER circuits require special design or may not be appropriate due to this phenomenon.

The unique technical considerations of SWER circuits need to be addressed by proper field investigations and design. The two documented SWER circuits in Alaska demonstrated that the technology is feasible in Alaska, although both systems have since been replaced by conventional three-phase AC circuits.

The National Electric Code (NEC) has not allowed SWER circuits for non-emergency use since 1961. Similarly, the National Electric Safety Code (NESC) also does not allow SWER circuits for non-emergency use. The State of Alaska has adopted both of these codes. Future SWER systems in Alaska could be allowed either through a project-specific code variance from the Alaska Department of Labor and Workforce Development, or a future state amendment to these codes.

5.1.4.4 Alternating Current (AC) SWER

Single-phase AC SWER systems are used in rural parts of Australia, New Zealand, South Africa, and other nations with significant rural populations. The two documented SWER circuits built in Alaska have both been single phase AC circuits. Brief descriptions of these follow.

An experimental, 8.5-mile SWER transmission line was built between Bethel and Napakiak in 1980 at a cost of $280,000. This line employed several innovative design elements intended to lower the cost of rural transmission lines, including SWER and low-cost bipod poles. Portions of this line fell down at least once due to conductor breaks that allowed several of the bipods to fall over. This line has been deteriorating in recent years, resulting in line loss, poor reliability and higher energy costs, and is presently being upgraded to a standard three-phase line at a budgeted cost of approximately $2.8 million.

An experimental 10.5-mile SWER line was also constructed between Shungnak and Kobuk in 1980. In 1991, this line was rebuilt as a conventional 15 kV, three phase AC line for a cost of $1,350,000.

These early experimental SWER interties in Alaska used single-phase AC power. The primary perceived economic benefit of such construction techniques is the use of fewer conductors allowing for fewer and lighter transmission structures resulting in reduced installation costs both in terms of labor and materials. While other international jurisdictions may have accepted SWER as an acceptable rural transmission technology, the actual life cycle cost data to either confirm or refute the hypothesized savings from SWER systems in Alaska was not found in our research.

5.1.4.5 Direct current (DC) SWER

A more recent proposed variation of the SWER concept is DC SWER, with proponents claiming that such a system would be less costly to install than conventional AC. Similar to AC SWER, most of the cost savings proposed from this system are derived from the fact that one wire can be used instead of four, simplifying the structural loads and design considerations for poles. This would allow fewer poles per line mile, and would allow the use of lighter fiberglass poles with less costly foundations. The cost savings associated with such construction must be evaluated against the lifecycle costs of the line, including converter and line maintenance, system efficiency, and similar cost considerations.

Direct current SWER circuits are rather common. For example, many of the HVDC submarine cables operating in northern Europe are or were originally monopolar circuits utilizing a single submarine cable and earth return. The 500 MW, 400 kV Fenno-Skan link between Finland and Sweden, commissioned in 1989, is a monopolar system with an anode in Sweden and cathode in Finland. Some of the original monopolar SWER circuits have been upgraded to bipolar circuits to increase their capacity.

In 2007, the Denali Commission funded the first phase of a research and development project to assess the feasibility and construct a prototype small scale HVDC converter that would be appropriate for use in rural Alaskan transmission grids. This converter is designed for a power throughput of one MW and nominal operating voltage of 60 kV DC. The intent of this Denali Commission project is to develop an HVDC SWER transmission system that will be less costly to build and maintain than the existing three phase AC lines currently used for transmission in rural Alaska.

The technology being developed in this project would also be applicable for submarine or overland cable transmission connections. The availability of a small-scale HVDC technology would allow consideration of numerous rural interties that are not currently technically viable, such as between communities in southeast Alaska. This is because direct current can be transmitted via cables of unlimited length, whereas cable applications using alternating current are limited to approximately 30 miles depending on configuration and voltage.

This HVDC study is currently under way, and is scheduled for completion by the end of 2008.

5.2 Future Electric Energy Transmission and Storage Technologies

5.2.1.1 Power grid telecommunication applications

In addition to moving electric energy, another possible application for electric transmission and distribution lines is sending telecommunications signals. A power line's "carrier signal" of 60 Hz can be used to send broadband telecommunications signals in a manner which does not interfere with the energy carrying function of the same line. Power line carrier telecommunications technology, which possibly involves applications ranging from phone to broadband internet, has been implemented in several U.S. cities, most notably Manassas, Virginia. Power line carrier telecommunication systems may add economic value to a new electric intertie project. For rural Alaska, such developments may provide new telecommunications links and reduction in the number of overall satellite uplinks, as a side benefit to new village-to-village electric interties.

5.2.1.2 Superconducting cables

Cables made from superconducting materials could greatly reduce, or perhaps virtually eliminate, transmission line losses over long distances. The technology could make it much more practical to move larger amounts of electric energy over longer distances, and allow greater grid flexibility over short line distances. Superconductors are already used for electric power grid applications in the form of short-range underground cables in dense, urban areas. One of the major challenges with the technology is that superconducting cables need to be cooled by liquid nitrogen to temperatures of around -200^{o} C. In the future, improved superconductors may be able to operate at much higher temperatures, and not require cooling systems. Additionally, carbon nano-fiber technology has been shown to be superconducting in some situations and may provide a practical solution to lossless overhead line conductors, in terms of both strength weight and conductivity. Such improvements could make superconducting transmission lines practical between Alaska communities.

5.2.1.3 Storage of electrical energy

Electricity is unique among commodities in that it cannot practically be stored in significant quantities. Therefore electricity, though treated as a commodity, is in practice generated and delivered in real time. Practically speaking this means that virtually all electricity generated is consumed as soon as it is produced by power plants. However, the storage of electrical energy may become more important in the years ahead with improved technology.

A conventional hydroelectric reservoir is a form of energy storage, as is the storage of hydrocarbon power-generation fuels such as natural gas and coal. However, these forms of energy are stored before being converted into electricity. Long-term hydro-thermal optimization of generation resources includes the scheduling of reservoir water, fossil fuels, and equipment maintenance as a form of “energy storage”. In the example of the grid system in Southcentral Alaska, such operational planning involves the storing of water in a hydroelectric reservoir until it is most valuable: when natural gas-fired generation is most expensive.

Pumped-storage hydropower, which requires a specially-designed hydroelectric plant that can also pump water to a higher reservoir, is the most common large-scale form of electric power storage. Pumped-storage hydroelectric plants thus convert surplus power that is available during low-demand periods into prime power to serve system needs during periods of peak-demand. Until the late 1970s, pumped-storage hydropower was the only bulk energy storage technology available to electric utilities. Pumped-storage plants typically are only built as part of very large-scale grids, and there are no existing pumped-storage hydropower plants in Alaska. The number of sites available for pumped-storage hydro facilities is very limited due to geographic, geologic, and environmental constraints.

The storage of electricity in batteries has long been practical on the small scale, but has proven difficult and expensive on a large scale. However, the utility-scale battery storage of electricity is an emerging technology which has improved considerably over the past decade. Such systems are presently limited in capacity to about 50 MW or less in output, and can discharge power only for a period of seconds or minutes. The most notable Alaskan example of a large-scale electric storage battery is Golden Valley Electric Association’s Battery Energy Storage System (BESS) installation in Fairbanks, operating successfully since 2003. The BESS was designed for a discharge capacity of 46 MW, with a specified run time of about 15 minutes before the batteries are exhausted. The BESS currently has batteries installed to provide 25 MW of electric power for about 15 minutes. However, this short amount of time which stored energy is available is enough to act as spinning reserve, or allow sufficient time to start a gas turbine, and improves overall grid reliability.

Other existing technologies used to storage electric energy over a short time period (seconds or minutes), include mechanical flywheels, and compressed air storage. More experimental electric energy storage technologies under development include super-capacitors, superconducting magnetic energy storage systems (SMES), and hydrogen (see below).

5.2.1.4 Hydrogen production and storage

Although the vast majority of hydrogen used in the world today is produced by reforming natural gas or other hydrocarbon fuels, electricity can be used to produce hydrogen from water via electrolysis. The use of hydrogen from hydrocarbon sources such as gas or coal results in pollution from the carbon and other chemical components of these feedstocks. However, since the burning of pure hydrogen emits only water vapor as a byproduct, hydrogen can be a genuinely clean fuel when it is made from electricity generated by non-polluting sources. Hydrogen thus offers much promise for the storage of electric energy generated by variable renewable sources, such as solar and wind. Hydrogen can in turn be stored, power fuel cells to generated electricity, or be burned as a fuel in a manner similar to natural gas.

Hydrogen technology is presently very expensive, and is still in the pre-commercial stage for large-scale power applications. Hydrogen storage is still an unresolved problem, which has so far proven to be difficult and very expensive. Various experimental large-scale hydrogen storage technologies include high-pressure and cryogenic tanks, as well as the use of advanced solid state and liquid materials.

Hydrogen fuel cells (see generation section above) can produce on-site electricity and heat. Hydrogen fuel-cell, or hydrogen-electric, vehicles use hydrogen to produce electricity, which powers an electric motor. However, the inherent inefficiencies of the primary energy source-electricity-hydrogen-electricity energy conversion chain make 'renewable-electric' hydrogen costly as a vehicle fuel. Other types of experimental hydrogen vehicles can burn hydrogen gas directly has a turbine/engine fuel.

A comprehensive hydrogen distribution infrastructure would in many ways be similar to today's existing natural gas pipeline and distribution system, with the addition of hydrogen fueling stations for vehicles. Fueling stations could possibly have hydrogen production on-site, either in the form of electrolysis units or natural gas reformers. In Alaska, the most likely source of hydrogen over the short to medium-term is reformed natural gas or coal. Long-term sources of hydrogen would include electricity produced from Alaska's abundant renewable resources.

5.3 Energy End-Use

In addition to changes in the number of customers (for example, population growth or decline in a particular area), the overall demand for electricity can be influenced by other developments in how electricity customers use energy.

5.3.1 Energy Efficiency and Demand-Side Management

Reducing the per-capita demand for electricity is common way to displace the need for the construction of both new generation plants and transmission lines. In particular, it is often more economical for energy efficiency measures to reduce demand, than having the same amount of electricity demand be met by building new generation capacity. In addition, energy efficiency offers the environmental benefits of providing the same service with less electricity generation.

Demand-side management (DSM) is the planning and implementation of utility activities designed to influence customer use of electricity. These DSM activities will produce desired changes in the utility's overall 'load shape', or the timing and magnitude of the overall electricity demand. The fundamental objective of DSM is to reduce overall demand and flatten, as much as possible, the peaks and valleys of electricity demand. This flattening of the overall demand curve is desirable, and a function of the "real-time commodity" nature electricity. Due to its real-time production, electricity generation must equal electricity demand at every moment of the day. Therefore, electricity demand curves with steep peaks and valleys result in significant capital and O&M investment in under-utilized generation assets. This under-utilization is also one of the key drives in intertie construction, i.e. the sharing of capacity. DSM systems can enable the utility to automatically switch off loads, for customers who volunteer or are provided incentives to do so, during periods of peak demand. Often, interruptible electric service is offered to large power users at a discounted price. Large industrial customers willing to participate are usually needed for DSM programs to be feasible. Power-line telecommunication technology (see above) can be employed by a utility to activate DSM systems of residential users.

5.3.2 Electric Heating

With the rising cost of hydrocarbon heating fuels such as natural gas and oil, the use of electric heat will become more economic in Alaska. This is particularly true in Southeast Alaska, where abundant electricity generated by hydropower facilities is available. Many utility customers in Southeast Alaska have already starting converting their heating systems to all-electric. Electric heating on a community scale can also be implemented with an intelligently controlled 'managed electric heat' strategy, which would fall under the category of demand-side management (see above). It should be noted that widespread use of electric heating may require upgrades to a community's power distribution systems at the neighborhood-level.

5.3.3 Electric Vehicles

Electric vehicles can charge their batteries using grid power, even from a standard home electric outlet. Such vehicles can take the form of either all-electric vehicles relying on storage batteries, or plug-in hybrid electric vehicles (PHEVs), which combine a battery-electric drive-train and a gasoline engine. Although all-electric vehicles typically have a driving range (between battery charging) of only 100 miles or less, many Alaska cities and towns have 'islanded' road networks where daily driving distances are well within this constraint.

As electric vehicles become more widespread, they could become a significant portion of the overall load of electric utilities. Demand-side management strategies can be employed by encouraging electric vehicle owners to charge their batteries at night, or the time of day with the lowest energy demand. This balancing out of load demand throughout the 24-hour day could provide economic benefits to the power grid as a whole.

6 Environmental Considerations

Environmental concerns remain a principal concern in the development of transmission lines throughout Alaska and warrant further discussion and analysis. Environmental concerns should be a focal point of the policy review and criteria of a given project. The following section outlines a plausible permitting process and a discussion on potential environmental benefits.

6.1 The Permitting Process

Development proposals such as transmission lines are subject to varying degrees of environmental documentation regardless of length, size or location. Typically, an environmental document is created that complies with the National Environmental Policy Act (NEPA) and Council on Environmental Quality (CEQ) guidelines.

Complying with NEPA involves agency and public involvement. Scoping activities require public notice and invitations to comment early on a development proposal. More than one scoping meeting may be prudent if the proposed transmission line is particularly long and/or crosses multiple jurisdictions.

Complex or possibly controversial proposals warrant multiple ways of involving resource agencies and the public. Web sites and newsletters/post cards and other media should be used.

Specific resource categories need to be researched such as Threatened and Endangered Species. The United States Fish and Wildlife Service (USF&WS) and the National Oceanic and Atmospheric Administration (NOAA) must be consulted for both on and off shore species. The Magnuson-Stevens Act requires that all impacts to open water include an Essential Fish Habitat consultation.

Animal migration routes, known spawning, rearing and other fish habitat must be mapped. Denning sites, traditional calving sites and other types of habitat need to be assessed. Wetlands will need to be delineated and those delineations coordinated with the United States Army Corps of Engineers (USACE).

Section 106 consultation with the State Historic Preservation Office is required. Archaeological survey and investigation may be necessary as well as Determinations of Eligibility and Determinations of Effect. A Memorandum of Agreement may need to be worked out to insure impacts to cultural resources are mitigated.

Multiple local jurisdictions will need to be consulted as well as local planning and zoning regulations, where applicable. Local jurisdictions may have permitting requirements and other land use controls that will impact an intertie proposal

Telecommunications in primarily urban areas can be impacted. Any environmental documentation will have to include an analysis of intertie impacts to the telecommunications network, in any. Air space conflicts with airports, air strips, float plane lakes etc. must be avoided. The Federal Aviation Administration (FAA) has strict regulations regarding air space conflicts.

Viewsheds in Alaska are dramatic reminders of the vastness of our State. However, any intertie proposal will need to analyze and be sensitive to the appearance of the line with respect to aesthetic values.

Of particular note for an intertie proposal is the possibility of needing access through national parks or wildlife refuges. Federal and State agencies in charge of these types of resources will need to be consulted early and often. Local tribal governments and Native Corporations will also play a large role in any environmental documentation required for an intertie proposal.

6.2 Environmental Benefits of Interties

If the environmental impact concerns discussed above are adequately addressed, the construction of new electric transmission lines can lead to net environmental benefits. The environmental benefits of interties include the enabling of the use of more renewable energy generation, in order to displace fossil fuel generation sources such as diesel, coal, or natural gas. Renewable energy generation sites are often located in remote areas distant from population centers, and thus require adequate transmission infrastructure to be practical. In other words, a new transmission line often serves as the enabler of a new renewable generation project such as a wind farm, hydroelectric or geothermal power plant.

Also, the capital-intensive nature of renewable energy projects means that the more electric customers can be served by a particular project, the more favorable the economics will be for that particular renewable energy installation. For example, several wind energy projects recently completed, or under development, in Southwest Alaska are being pursued jointly by several communities which are interconnected, or have plans for interties between them. The interties allow the costs and benefits of the installed wind turbines to be shared between several communities.

In addition to renewable development, environmental benefits can also be realized by operating fossil fuel generation sources more efficiently due to the capacity-sharing benefits of an electrical intertie. Electric interties between communities in rural Alaska can also enable the consolidation of fuel storage and diesel generation facilities. This consolidation can reduce the number of remote tanks farms and diesel power plants which need to be maintained, and decrease the risk of fuel spills. Fewer power plants also mean fewer locations to deal with used diesel engine filters, used oil and other contaminants. Small fuel farms across rural Alaska present serious environmental risk due to potential spills and the lack of enough qualified/trained fuel farm employees.

While the primary environmental complaint of electric transmission lines is subjective aesthetic impact of "visual pollution", oil spills present the risk of concrete, non - subjective water and ground pollution, including destruction of wildlife habitat and local food sources. Where renewable power generation is feasible, electric interties also could allow for the conversion of oil heating to electric heating, further reducing the need for distributed oil storage.

7 Value Hubs

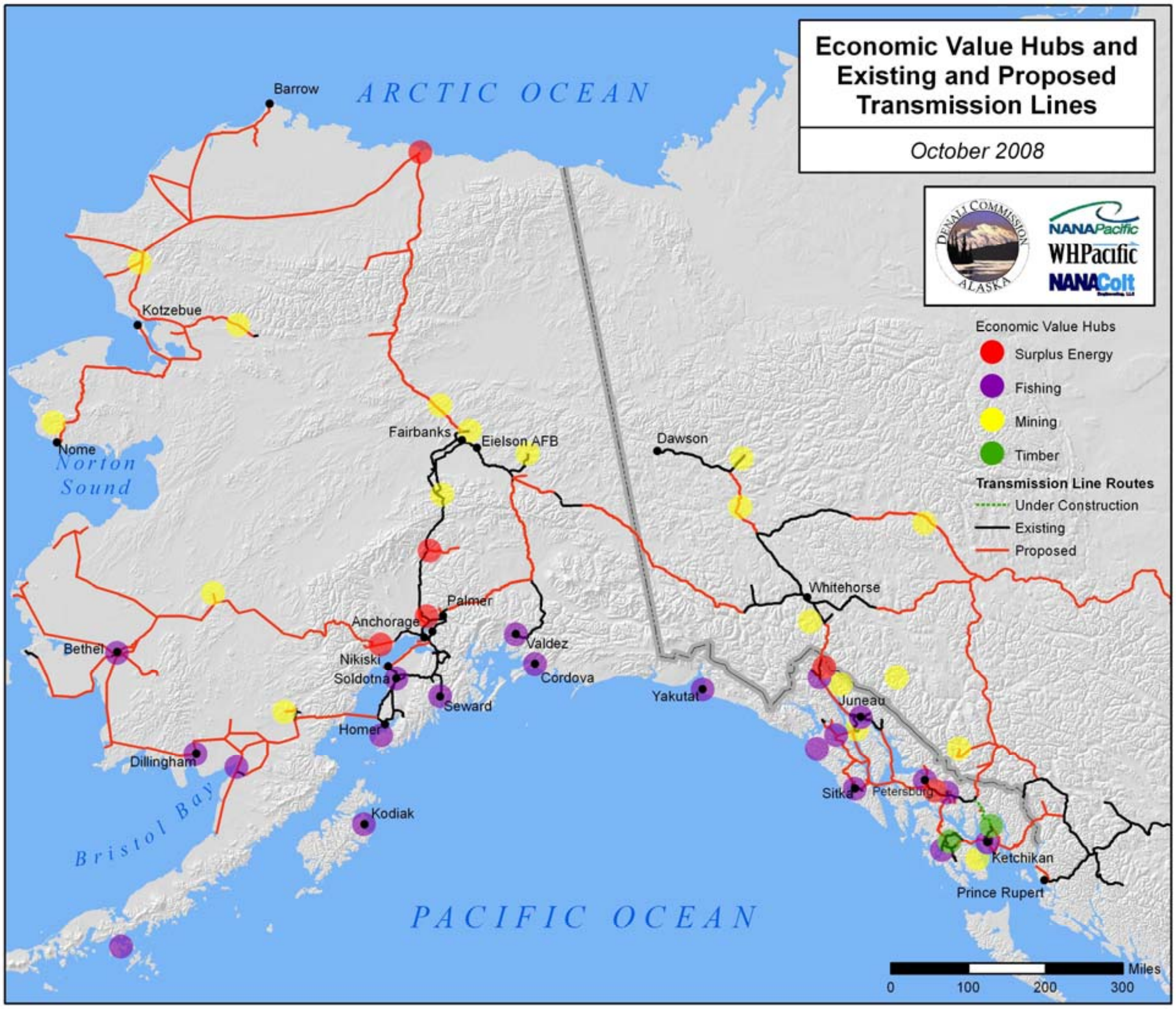
Four categories of economic *value hubs* were identified for this study:

- Surplus Energy
- Fishing
- Mining
- Timber

These four categories were based on major resource extraction industries that tend to be located in rural areas, and were chosen to reflect economic value hubs that are not in Alaska's population centers. However, the fishing and timber value hubs on the map are located in cities and towns where these industries have long been established. With fishing in particular, the hubs shown on the map do not show all the important fishing industry centers in the state, such as Unalaska. The mining value hubs on the map reflect both existing and proposed major mining sites, in various stages of development, some of which (i.e. Pebble and Donlin Creek) have yet to receive regulatory approval.

The value hub category of "surplus energy" is far more speculative than mining, fishing, or timber, and reflects possible locations where excess electricity supply would provide opportunities for energy-intensive industries. Electricity-hungry industries often locate their facilities in areas with cheap power, even if these locations are remote. Examples of these industries include established industries as metals processing (aluminum smelting in particular), contemporary internet 'server-farms' or data centers, or even proposed future industries such as hydrogen production from electricity. Alcan's aluminum smelter in Kitimat, British Columbia is a prime example of a large industrial facility located in a remote area due to its proximity to cheap power from a nearby hydroelectric plant. No such surplus energy value hubs yet exist in Alaska.

The surplus energy value hubs on the Alaska statewide intertie map include locations where a surplus of electricity generation capacity does not yet exist, but has the potential to exist due to nearby potential for renewable or natural gas power generation. In particular, the surplus energy hub shown at Skagway reflects the huge potential for large-scale hydropower generation from the speculative Yukon-Taiya project, and the hub shown on the Parks Highway near Talkeetna is adjacent to the large hydroelectric potential of the Susitna River. The surplus energy hub shown at the western shore of upper Cook Inlet (around Tyonek) is a unique location where significant coal, natural gas, petroleum, hydropower, geothermal, tidal, and wind energy resources all exist within about a 30-mile radius.



7.1 Value hubs in Canada with connections to Alaska:

Two major mining prospects in northwestern British Columbia were shown on the statewide economic value hub map, due to their proximity to Southeast Alaska and the proposed AK-BC intertie.

Many untapped hydroelectric sites exist in the Yukon Territory, along with various proposals for large-scale mines. In 2006, the Yukon Energy Corporation published a 20-year resource plan, which identifies potential industrial development opportunities, or value hubs, in the form of potential mine developments and gas pipeline compressor stations. TransCanada's proposed natural gas pipeline route parallels the Alaska Highway through the territory, and the pipeline needs compressor stations at key locations in order to operate. These compressor stations are major electric loads in their own right, and may have power demands of up to 30 MW each.

8 Rough Order of Magnitude Cost Comparisons

This section has been developed as a relative analysis of the cost drivers associated with electrical transmission. While many of the Denali Commission's infrastructure projects can be put into a cost benchmark framework, electrical transmission does not lend itself to benchmarking in the manner that the Commission has traditionally benchmarked its projects.

The cost of constructing an electrical transmission line in Alaska is dependent on several variables and cost drivers, including the following:

- Material Costs including Transportation
- Project Size and Bidding Environment
- Permitting
- Project Life Expectancy
- Construction

8.1 Material Costs

Materials for transmission lines are dependent on the amount of transmission line construction taking place elsewhere and the health of the raw materials markets, specifically the steel and aluminum markets. At times of heavy transmission construction activity, material costs and delivery schedules will increase due to supply and demand. Transportation costs from the west coast will also vary with demand and generally will push Alaskan delivered prices higher than anywhere else in the country.

8.2 Project Size and Bidding Environment

Alaska has a limited number of skilled line workers that can build transmission lines and rarely has the manpower to build more than one major project in any given year. This limited labor pool has very significant impacts of the cost of a given project. Major transmission projects in the lower 48 will also draw workers from Alaska. There are a limited number of qualified line contractors in the state and this limited competition also impacts costs. Due to high mobilization/demobilization and general condition costs, the average cost per mile for long lines will be less than for shorter lines. Projects large enough to attract the attention of outside contractors usually result in more competitive prices.

8.3 Permitting

All transmission lines in Alaska will require permits from the various agencies that are affected. The permitting process can take from months to years, depending impediments or opposition to the project. The cost of this effort is completely dependent on the particular line and the lands crossed.

8.4 Project Life Expectancy

Projects with short life expectancies, such as those serving mines with life expectancies of 20 years or less, can be designed and constructed for lesser climatological conditions than lines with greater life expectancies. Line materials with shorter anticipated lives but more economical costs such as wood poles and composite insulators, are better choices for lines with limited live expectancies.

8.5 Construction

The line routing will determine many aspects impacting cost including: access, clearing, foundation types, etc. The climatological conditions (ice, wind, etc.) that the line must withstand are completely dependent on the local weather conditions along the route. Heavy ice and or wind will determine many of the design components including; tower weights, span lengths, conductor type, etc.

Access will dictate the construction method. If the line can be constructed adjacent to an existing road and built from the road the cost is considerably less than areas that are inaccessible and may require helicopter or ice road construction. Permitting stipulations will limit construction activities such as requiring winter only construction. Winter construction in Alaska will cost considerably more than summertime. Similarly, foundations to fit the various soil conditions and tower loadings will greatly impact construction costs. A simple augured hole with a direct embedded pole is much less costly than a driven pipe pile.

The attached table is intended to provide a "Rough Order of Magnitude" (ROM) relative cost for a transmission line in Alaska in 2008. These estimates were prepared to allow us to compare various transmission lines within the study group on an apples-to-apples basis, and are not intended to reflect absolute cost of any given project. All of the above variables will contribute to the actual line cost.

Table 4- Rough Order of Magnitude Costs of Transmission

	Category 1	Category 2
69kV	$200,000/mile	$500,000/mile
115/138kV	$300,000/mile	$1,000,000/mile
230kV	$500,000/mile	$1,500,000/mile

Category 1 = Primarily favorable conditions

- Good Material Costs
- Good Bidding Environment
- Normal Permitting & Stipulations
- All-Season Road Access
- Favorable geotechnical and clearing conditions

Category 2 = Mostly unfavorable conditions

- Competing transmission projects in Alaska or outside
- Extended permitting – EIS
- No road access – helicopter or frozen ground construction required
- Poor geotechnical conditions

Category 2 is most of rural Alaska.   The lower voltage lines used for in rural Alaska roughly correspond with the category 2 69-kV line as show in the table above.

9 Conclusion

Modern life and commerce as we know it cannot exist without adequate supplies of electric energy at acceptable prices. Without electric energy, there can be no telecommunications systems, no Internet, no cell phones; no television or cable TV, more fundamentally no electric lights, traffic lights or cash registers, and in some areas no heat. Further, this implies no access to credit or debit cards, no interbank electronic transfers or financial infrastructure. Essentially without electricity life as we know it would revert back to that found in the pre-industrial era. Therefore, it is imperative that we understand maintain and improve this basic infrastructure component that has become such an integral part of modern society.

9.1 Transmission Lines enable renewable energy development

Due to the "real-time commoditized" nature of electricity it is technically necessary that sufficient generation be available at each moment of the day to serve connected electric load demand. Often emerging renewable technologies (as well as more mainstream technologies) are limited in their ability to provide either energy or capacity or both in the quantities required on demand. Therefore, spare capacity or energy from a different region with a different generation-load profile could be used to make up such energy to capacity short falls. Fundamentally, transmission lines allow for the movement of energy and capacity between geographic locations they can, therefore, present a solution to the "energy/capacity shortfall" challenge. A good example is a wind-hydro optimization system. Lake-tap and reservoir hydro-plants (and to a lesser degree run-of-river hydro plants) have assured capacity, but may not have sufficient stored water to provide this capacity year-round. Wind projects produce energy when the wind blows, but have no assured capacity. However when a wind project is connected to a grid with a hydro plant via a transmission lines, the wind energy can be used to offset or conserve water usage. This effectively stores the wind's potential energy in the form of conserved water, and allows the hydro plant to provide assured capacity for a greater portion of the year.

Renewable energy generation sites are often located in remote areas distant from population centers, and thus require adequate transmission infrastructure to be practical. In other words, a new transmission line often serves as the enabler of a new renewable generation project such as a wind farm, hydroelectric or geothermal power plant. Also, the capital-intensive nature of renewable energy projects means that the more electric customers can be served by a particular project, the more favorable the economics will be for that particular renewable energy installation. Interties thus enable more electric consumers to share the costs and benefits of a single power plant.

9.2 Transmission lines should be incremental

Although in some cases, in order to promote future growth, backbone transmission lines must be constructed in advance of the availability of connected generation or load; in the majority of cases the transmission lines should be constructed incrementally so as to optimize the generation-load profile of existing communities and their resources. However, these incremental projects should be vetted against broad regional and statewide transmission plans so as to insure growth of an integrated electrical grid over time and in a manner congruent with the sustainability of a particular region or community.

9.3 Transmission lines must consider intangible criteria such as quality of life and economic development

Transmission lines are community, regional and statewide infrastructure development projects much like state and federal interstate highway projects, international airports and marine ferry systems. Transmission interties facilitate the movement of a commodity between regions and, as such, generate both costs and benefits that often reach far beyond regional and local interests. These benefits and costs, often unforeseen, accrue over time frames much longer than most local or regional interests are capable of identifying and analyzing. Therefore, evaluations of the benefits and costs related to transmission interties must consider in an integrated fashion the multiregional effects of energy costs on quality of life and sometimes far-distant economic development.

9.4 There may be opportunities for co-development

When regional or interregional infrastructure projects are taken on, such as natural gas and oil pipelines or major highways, significant benefit may be accrued by co-developing regional interties. Benefits will be accrued in terms of economies of scale in areas such as right-of-way acquisition and construction costs. Also, there is a need for the provision of energy to meet the demands of these projects – in the case of pipelines, the pumping and processing requirements, and in terms of highways, to facilitate economic growth along these corridors.

Co-mobilization of remote infrastructure projects creates opportunities for cost savings if construction execution schedules can be coordinated.

9.5 Opportunities exist for improved statewide coordination

The literature review suggested that the concept development associated with transmission and interties occurred either at the regional or community level, often times by an entity that was not looking at a broader context. While recent initiatives associated with the Southeast Conference and the proposed Railbelt Electrical Grid Authority are indeed noteworthy, more could be accomplished by a higher-level coordinating entity that can capably work across jurisdictions and promote policy criteria such as economic development, quality of life, and other factors.

This statewide coordinating entity could encourage and coordinate regionalization/batching of projects, management, purchases, and design, thereby creating some economies of scale in the development of transmission systems. This entity could also be responsible for documenting lessons learned, continuous programmatic improvements, risk management and tolerance, and could improve coordination between various governmental levels.

9.6 Interties in Alaska should consider national and international (through Canada) connection

The development of transmission projects in Southeast Alaska is already being influenced by the Canadian electric power entities of BC Hydro, BC Transmission Corporation and Yukon Energy. While the mission of Alaska Energy Authority (AEA) is to provide safe, reliable, and affordable power to Alaskans, these international considerations are noteworthy in that they have economic and regional development potential. This is potentially outside of AEA's frame of reference. The economies of scale involved with bi-national hydroelectric and transmission line projects could result in significant electricity cost savings for Southeast Alaska residents. In particular, if the massive Yukon-Taiya hydroelectric project is resurrected in the future, it could become economic to build comprehensive transmission links between Alaska, the Yukon, and BC.

Many untapped hydroelectric sites exist in the Yukon and northwestern BC, as well as various proposals for large-scale mines. TransCanada's proposed natural gas pipeline route parallels the Alaska Highway through the Yukon and part of northern BC, and the pipeline needs compressor stations at key locations in order to operate. These compressor stations may require up to 30 MW power each, and could justify an electric transmission line along the length of the gas pipeline. Combined with Yukon-Taiya and other proposed and existing projects in BC and the Yukon, hydropower could be used to power the gas line's compressor stations. However, this hydroelectric energy would have to be cost-competitive with gas-fired generation. Another possibility enabled by a gas pipeline route along the Alaska Highway would be to electrically connect Interior Alaska (and perhaps the Railbelt) to the main BC grid system via the Yukon.

9.7 Value hubs are an important consideration in planning intertie projects.

Four categories of economic *value hubs* were identified for this study: surplus energy, fishing, mining, and timber. These categories were chosen to reflect natural-resource-based industries that are not in Alaska's major urban centers, and comprise only a partial, simplified list of all the economic development possibilities in rural Alaska. The fishing and timber hubs shown on the value hub map in section 6 are located in cities and towns where these industries have long been established. The mining value hubs on the map reflect both existing and proposed major mining sites, in various stages of development, some of which are in the proposal phase and have not been yet been permitted by regulatory agencies. The value hub category of "surplus energy" is far more speculative than mining, fishing, or timber, and reflects possible locations where excess electricity supply would provide opportunities for energy-intensive industries. Electricity-hungry industries often locate their facilities in areas with cheap power, even if these locations are remote. Examples of these industries include established industries such as metals processing (aluminum smelting in particular), contemporary internet 'server-farms' or data centers, or even proposed future industries such as hydrogen production from electricity. No such surplus energy value hubs yet exist in Alaska.

9.8 A Joint Commission is needed

Many of the recommendations presented in the previous paragraphs could be managed by an agency or organization, composed of federal, state and local partners, that does not have the responsibility for implementing an existing portfolio of projects. Such an organization would have, at the core of its mission, responsibility for providing a forum for the discussion of complex projects of statewide and perhaps international interest. The following suggestions for a possible agenda for such an organization are derived from lessons learned in the preparation of this report.

9.8.1 Work with others to develop "the big picture."

During the literature review, NANA engineers identified and compiled numerous intertie engineering studies and plans. Some of these plans have been implemented. Others remain "discussion pieces," and await further detailed review. Many will be found to be practically or economically unsound, and will never be implemented. The synthesis of all of these studies and plans, however, presents a picture of a probable future for energy distribution in Alaska.

This future is fragile. In order to avoid regional competition and develop the most effective intertie system possible, some single agency could be assigned the role of stewardship of "the big picture."

9.8.2 Serve as "point agency" for discussions with international neighbors

The aim of the Yukon-Taiya project (1951) was the utilization by industrial developments in Alaska of power generated by a US/Canadian bi-national project. The proposed Alaska gas pipeline presents additional opportunities for collaboration with Canada in energy distribution. Other plans describing the distribution of hydroelectric power generated in Southeast Alaska to British Columbia industries and communities are worthy of consideration. In addition, futurists see strengthening of relationships with the Russian Far East. These may also involve the distribution of energy resources.

Some organization, other than the Alaska State Government, could provide a focal point for international discussions on energy generation and distribution.

Provide a bridge between overlapping international, federal, state, regional and local jurisdictions

Large scale energy generation and distribution efforts involve all levels of government. As described above, strong relationships with neighboring countries are an essential ingredient in the development of an efficient energy distribution system. Statewide interests must also be addressed, as some interties will surely cross regional boundaries. Regional involvement is critical to the successful implementation of an integrated statewide system. This involves intense interaction with regional corporations and borough governments. Last, local jurisdictions, including cities and villages, are the important users of the energy which could be distributed using an efficient intertie system.

It is critical to assign some organization the role of a facilitator of the discussions and negotiations among all of these levels of government. Without this critical role, serious and prudent distribution system issues could be overcome by regional competition.

9.8.3 Facilitate complex discussions on the trade-offs between cultural integrity, traditional lifestyle and economic development

These discussions are extremely sensitive. The cultural identity of rural Alaskan communities must be maintained. At the same time, our modern lifestyles rely heavily on the availability of affordable energy.

These crucial discussions of the trade-offs between cultural integrity and traditional lifestyle and economic development (including energy generation and distribution) must be conducted in a professional and respectful way. A joint commission with no vested interest in any particular outcome could provide an important service in facilitating these critical discussions.

9.8.4 Help sustain and expand technological gains in power generation and distribution

There was a general sense that Alaska could be a world leader in the environmentally responsible energy generation and distribution. Some cited the important technological gains that came from the design, construction, operation and maintenance of the trans-Alaska oil pipeline. They argued that we should show the same international leadership in the technological development of power generation and distribution systems.

While there was some compelling argument that this role should be retained by the University of Alaska, all agreed that a joint commission could, at least, be a valuable participant in helping to establish and maintain a fully funded research agenda.

9.8.5 Facilitate the identification and development of transportation/utility systems (TUS) as defined in ANILCA, Article 11

In passing this legislation, Congress recognized that Alaska's transportation and utility network is largely undeveloped and future needs with best be identified and provided through an orderly process involving the state and federal governments and the public. In an attempt to minimize the adverse impacts of locating transportation and utility systems (TUSs), the act established a single statutory authority to approve or disapprove such systems the process support obtaining permission to build a TSU across or within a conservation systems unit in Alaska is complicated and difficult.

A joint commission with some statutory responsibility to coordinate the activities of state and federal agencies could provide a valuable service in providing an orderly and continuous decision-making process involving all levels of government.

9.8.6 Encourage research and development of new energy technology applicable to rural Alaska and Arctic Environments

A joint commission should encourage research and development on new energy technology applicable to rural Alaska, in particular that relating electric energy transmission, distribution, and storage. Perhaps a model for this effort would be the now-defunct Alaska Science and Technology Foundation. This organization was a public corporation established in 1988 to provide small grants to support basic and applied research to enhance technological innovation in the state. Projects involving emerging energy technologies are inherently risky, and applications involving rural Alaska require specialized knowledge of local conditions.

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Intertie/Tie Line Reconnaissance Study

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2008 Rural Alaska

Energy Conference

Girdwood, Alaska

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Methodology

- ❑ Literature Review
- ❑ Targeted Interviews
- ❑ Technological Assessment
- ❑ Market Assessment
- ❑ Costs Scenarios

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Why Build an Intertie?

- ❑ To promote energy efficiency by sharing available capacity.
- ❑ To increase the reliability of electrical power.
- ❑ To help reduce the cost of electricity through the use of more efficient fuels or renewable resources.

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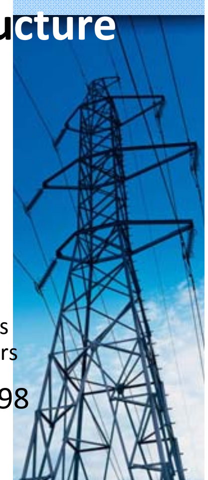
History of other public infrastructure development agencies

- ❑ Tennessee Valley Authority, 1930s
  - Revitalized the economy of the Tennessee River region.
  - Emphasized physical, economic and social development
- ❑ Bonneville Power Authority, 1930s
  - Focused on balancing reliability, economic development environmental concerns and other public objectives.
  - Organized the sale and distribution of hydroelectric dams built by the Bureau of Reclamation and Corps of Engineers
- ❑ Appalachian Regional Commission, 1963, 1998
  - Emphasizes self-sustaining economic development
  - Promotes improved quality of life



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Public Benefits of Interties

- ❑ Natural resource industries rely on cheap power.
- ❑ Large consumers (mines, fish processors or value-added timber products) could help increase economies of scale and reduce energy costs.
- ❑ Public funding can help transmit low cost energy to rural communities.

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Electrical Power & Quality of Life in Rural Alaska

"Electricity is the key to life and the economy. Energy is the lifeblood of the modern human lifestyles."

"The cost of the heat and light in a cold and dark place is a top priority, maybe ahead of health and education."

2008 Intertie Interviews

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Intertie/Tie Line Reconnaissance Study

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Brian Saylor

Electrical Power & Quality of Life in Rural Alaska

- Interties are useful if they reduce the cost of heat and lights.
- The high cost of energy threatens the sustainability of rural Alaskan communities.
- Lower energy costs result in more discretionary income to spend locally.

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Interties & Economic Development

- Low-cost energy is an important input into some large production process (mining, smelting, and fish and timber processing.)
- Emerging industries are an important partner in energy generation and distribution planning.
- Cheap power does not guarantee economic development.

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Intertie/Tie Line Reconnaissance Study

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Brian Saylor

Literature Review

- **Technological Assessment**. Conventional alternating current (AC) transmission lines, direct current transmission lines, and single wire ground return.
- **Regional Themes**. Railbelt, Southeast Alaska, Copper Valley Electric Association, Southwest Alaska, Northwest Alaska, and the North Slope.
- **Criteria for measuring economic feasibility.** Reliability, economic energy transfer, transmission efficiency, capacity sharing, and operating reserve sharing.

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Technological Assessment

- **Power Generation**. New technologies include distributed fuel cells and expanded alternative energy sources. Improvements to existing technologies, gas turbine, clean coal, and coal gasification.
- **Power Transmission and Distribution**. The power transmission and distribution technology has not significantly changed over the years.
- **Disruptive Technologies- Electric Energy Transmission and Storage.** Advances in storage technologies will drive technology change and transmission/distribution development.

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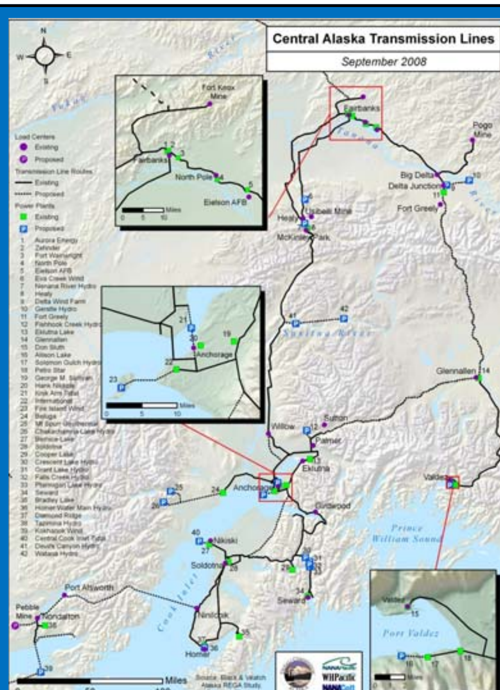
AK-BC Intertie Feasibility Study Area
August 2008
PACIFIC OCEAN
Canada


Central Alaska Transmission Lines
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Fairbanks
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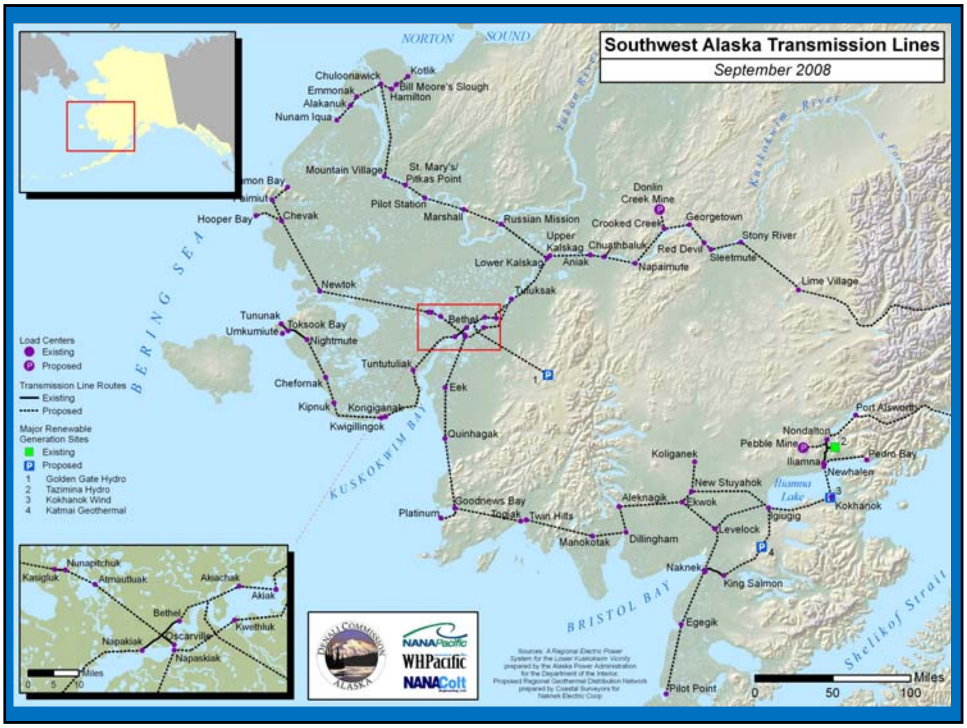
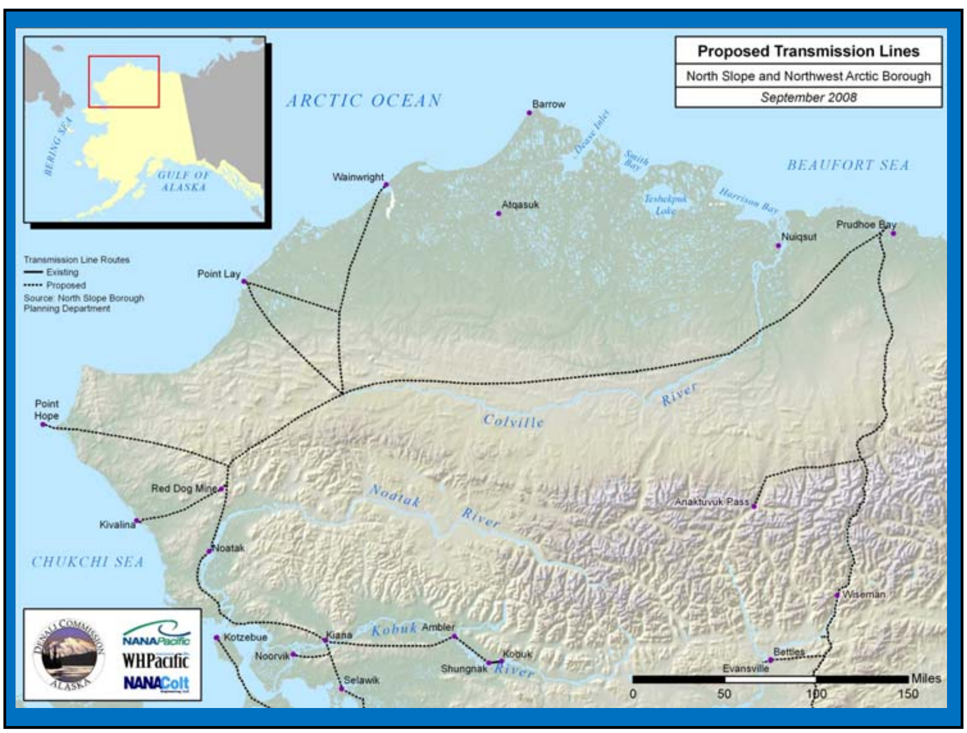
Glennallen
Valdez
Homer


Southwest Alaska Transmission Lines
September 2008
Load Centers
Existing
Proposed
Transmission Line Routes
Existing
Proposed
Major Renewable Generation Sites
Existing
Proposed
1 Golden Gate Hydro
2 Tazimina Hydro
3 Kokhanok Wind
4 Katmai Geothermal
NORTON SOUND
BERING SEA
KUSKOKWIM BAY
BRISTOL BAY
Shelikof Strait
Yukon River
Kuskokwim River
Iliamna Lake
Chuloonawick
Kotlik
Emmonak
Bill Moore's Slough
Hamilton
Alakanuk
Nunam Iqua
Mountain Village
St. Mary's/Pitkas Point
Pilot Station
Marshall
Chevak
Hooper Bay
Russian Mission
Donlin Creek Mine
Crooked Creek
Georgetown
Upper Kalskag
Chuathbaluk
Red Devil
Stony River
Aniak
Sleetmute
Napaimute
Lower Kalskag
Lime Village
Newtok
Tuluksak
Tununak
Toksook Bay
Umkumiute
Nightmute
Bethel
Tuntutuliak
Chefornak
Eek
Kipnuk
Kongiganak
Kwigillingok
Quinhagak
Goodnews Bay
Platinum
Togiak
Twin Hills
Manokotak
Dillingham
Aleknagik
Koliganek
New Stuyahok
Ekwok
Levelock
Igiugig
Nondalton
Pebble Mine
Iliamna
Newhalen
Pedro Bay
Port Alsworth
Kokhanok
Naknek
King Salmon
Egegik
Pilot Point
Nunapitchuk
Kasigluk
Atmautluak
Akiachak
Akiak
Oscarville
Napakiak
Napaskiak
Kwethluk
Miles
0 5 10
Miles
0 50 100
Sources: A Regional Electric Power System for the Lower Kuskokwim Vicinity prepared by the Alaska Power Administration for the Department of the Interior. Proposed Regional Geothermal Distribution Network prepared by Coastal Surveyors for Naknek Electric Coop
Denali Commission Alaska
NANA Pacific
WHPacific
NANA Colt


Proposed Transmission Lines
North Slope and Northwest Arctic Borough
September 2008
Transmission Line Routes
Existing
Proposed
Source: North Slope Borough Planning Department
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
BERING SEA
GULF OF ALASKA
Colville River
Noatak River
Kobuk River
Teshekpuk Lake
Harrison Bay
Smith Bay
Barrow
Wainwright
Atqasuk
Nuiqsut
Prudhoe Bay
Point Lay
Point Hope
Red Dog Mine
Kivalina
Noatak
Anaktuvuk Pass
Wiseman
Kotzebue
Kiana
Ambler
Noorvik
Kobuk
Shungnak
Selawik
Bettles
Evansville
Miles
0 50 100 150
Denali Commission Alaska
NANA Pacific
WHPacific
NANA Colt

Intertie/Tie Line Reconnaissance Study

Presented By:
Jay Hermanson, NANA Pacific
Brian Hickey, P.E., NANA Colt
Brian Saylor

Anchoring interties through “value hubs”

- ❑ Value hubs are clusters of consumers.
  - Villages
  - Individuals
  - Economic development projects.
- ❑ Reflect historical communications patterns.
- ❑ Grow organically.
- ❑ Must have an economic incentive to interconnect.

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Anchoring interties through “value hubs” (Continued)

- ❑ Mining
- ❑ Fish Processing
- ❑ Timber
- ❑ Energy Surplus

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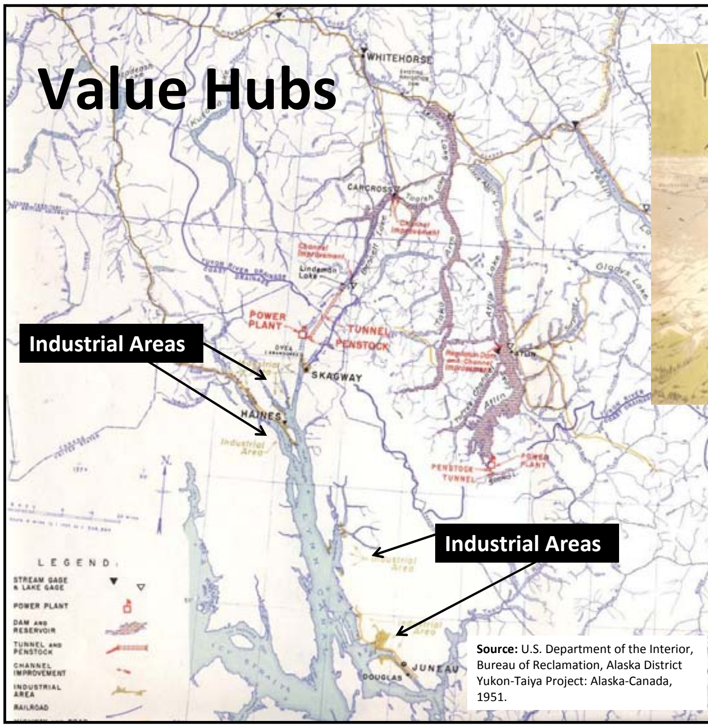
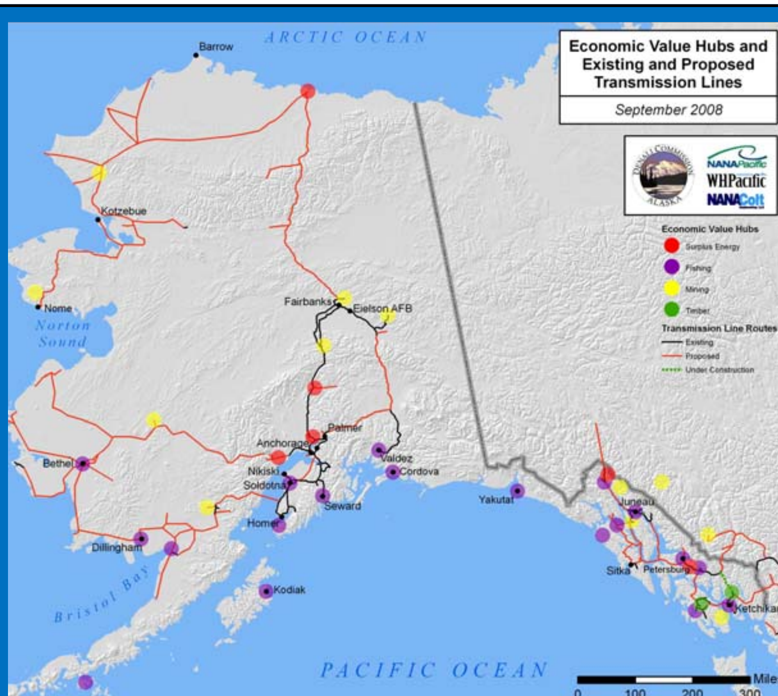
Value Hubs



Source: U.S. Department of the Interior, Bureau of Reclamation, Alaska District Yukon-Taiya Project: Alaska-Canada, 1951.



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Comparative Costs

The cost of constructing an electrical transmission line in Alaska is dependent on:

- ❑Material Costs(including Transportation)
- ❑Project Size and Bidding Environment
- ❑Permitting
- ❑Project Life Expectancy
- ❑Construction

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Comparative Costs

	Category 1 Primarily Favorable Conditions	Category 2 Mostly unfavorable conditions
69kV	$200,000/mile	$500,000/mile
115/138kV	$300,000/mile	$1,000,000/mile
230kV	$500,000/mile	$1,500,000/mile

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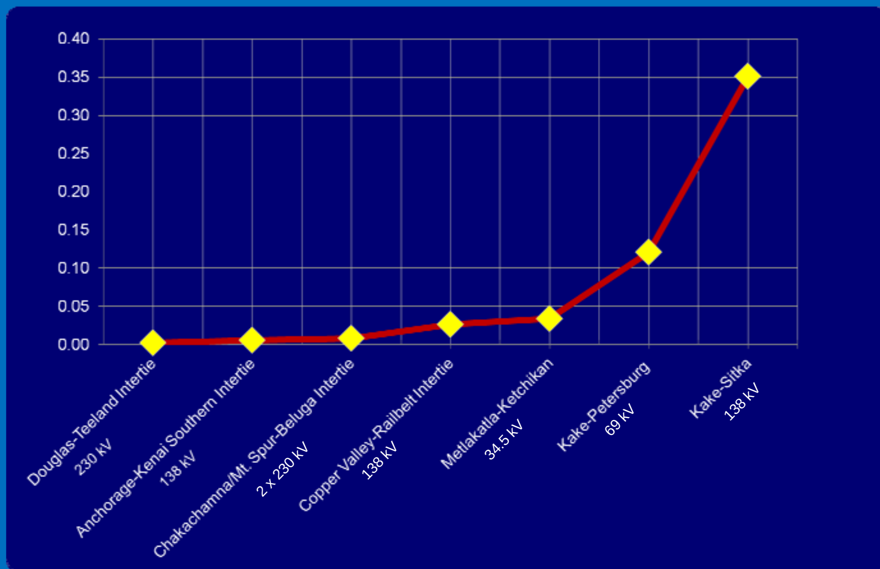
Relative Ranking of Interties

Relative Capital Costs on a per unit basis



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Possible Roles for a Joint Commission

- ❑ Work with others to develop “the big picture.”
- ❑ Serve as “point agency” for discussions with international neighbors.
- ❑ Provide a bridge between overlapping international, federal, state, regional and local jurisdictions.
- ❑ Facilitate complex discussions on the trade-offs between cultural integrity and traditional lifestyle and economic development.
- ❑ Help sustain and expand technological gains in power generation and distribution.
- ❑ Facilitate the identification and development of transportation/utility systems (TUS) as defined in ANILCA, Article 11.

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Questions?

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