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April 11, 1980

APR 17 RECD

Mr. Vic Fischer
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221 East 7th, #204
Anchorage, Alaska 99501

RE: Final Report on Alternate Energy Resources.
Alaska's Railbelt

Dear Vic:

Transmitted herewith is our final draft of the subject report. Please add Rich Seifert's Solar Report, previously transmitted as an appendix to our report. Looking forward to your comments.

Sincerely,

FRYER, PRESSLEY: ELLIOTT

Mark Fryer

Mark Fryer

Copies to: Jim Babb
Brian Rogers
Mark Wittow
Rich Seifert
Eric Meyers
Scott Goldsmith

# ALTERNATIVE ENERGY RESOURCES OF ALASKA'S RAILBELT

Prepared for

Alaska Center for Policy Studies

as part of a study for

House Power Alternatives Study Committee

BY:

FRYER : PRESSLEY : ELLIOTT, INC.
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Anchorage, Alaska 99504

April, 1980

OUTLINE OF ALTERNATE ENERGY SOURCE

## ACKNOWLEDGEMENTS

Fryer : Pressley : Elliott, Inc., was assisted in the preparation of this work with substantive contributions from Skip Roy and Bruce Melzer concerning wind power, Will Theuer concerning wood resources and Richard Seifert of the University of Alaska concerning solar resources. Roy Barkwell of Fryer : Pressley : Elliott, Inc., was responsible for a good share of documents research and micro-hydro potential analysis.

## 1.0 SUMMARY:

The magnitude of the annual energy consumption for use in space heating and electric power production for the Railbelt Region of Alaska is about 53 trillion BTU's per year.[1] If the range of values expressed in Table 1 is acceptable, the maximum practical exploitation of alternative energy resources could conceivably provide up to perhaps 10% of current energy use, or perhaps 5 trillion BTUs per year. Further, if steps as significant in scope as those suggested for exploitation of alternative energy were taken in the area of energy conservation and, as a result, energy use were decreased (on a per capita basis) by say 17%, then alternative energy resources could serve as much as 12% of the Railbelt Region's electric and thermal energy requirements.

Table 1 lists "reasonable levels" of alternative energy use expressed as a percent of the total raw energy potential currently consumed in the Railbelt Region for electric power generation and for space heating. Fuels used in transportation and industrial processes are neglected in the analysis. The values shown in the table are meant more as an aid to ranking the potential use of the various alternatives, than as an accurate quantification of the resources potential.

The term "reasonable level" is subjective, and is based on engineering judgment rather than laws of physical science or explicit economic equations (see 3.0 methodologies).

Table 1 indicates that the most promising alternative resources are solid waste used as electric generation plant fuel, fuel wood for residential heating, and waste heat recovery from electric generation plants.

In order to achieve these levels of alternative energy utilization, some environmental effects would be realized. For example:

° Wood Resource:

From this resource, to obtain 10% of the 1980 home heating fuel requirements 3,000 acres of virgin forest land would be logged for firewood each year.[2]

° Micro-Hydro Resource:

To provide the equivalent of 1 1/2% of electric generation fuel, the precipitation from about 134 square miles located in the center of the railbelt would be collected. To accommodate continous, year round generation, some of this water would be impounded. Such storage will extend over perhaps 22 square miles of new and existing lakes. If 25% of this lake surface is newly created to accommodate the development of micro-hydro, 3,520 acres of land will be flooded by such development.[2]

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[1]At the time this paper was written "End Use" analysis portions of this project were not complete. The value given in the text is therefore an estimate made by the authors. See appendix of calculations.

[2]See appendix of calculations.

TABLE 1. Summary of Alternative Energy Potential

| Resource | Potential Fraction of 1980 Energy Consumption | | Rank |
|---|---|---|---|
| | Thermal | Electric | |
| ° Solid waste combustion as a co-generation fuel. | Included in Waste Heat | 6% to 7% | 1 |
| ° Wood Resources | 3% to 4% | -- | 2 |
| ° Waste heat recovery from electric generation plants | 1 1/2% to 2% | -- | 3 |
| ° Solar Energy (year 2000) (includes Passive Solar) | 0.3% to 1 3/4%* | Photovoltaic ? | 4 |
| ° Micro-Hydro (end use) | -- | 1 1/2% | 5 |

* Upper limit includes possible contribution of passive solar design techniques which could be incorporated in future building construction.

## 2.0 INTRODUCTION:

The information contained herein has been compiled specifically for use by the Alaska Center for Policy Studies as background information for a broader study. This work is not at all intended to be comprehensive; it is intended rather, to place the alternative energy resources that are accessable within Alaska's Railbelt, into perspective with both current technologies and the physical environment of the region.

In order to discuss alternative energy, and related technologies, it is necessary to first define some terms. In this area many popularly used terms are frequently misused; for the purposes of this work, we wish to narrowly define the terminology.

Alternative Energy refers to an energy source or energy technology that is not expected to significantly use non-renewable energy resources. An energy resource that is renewable, or an energy technology that deals with such renewable energy resources.

Micro-Hydro means a hydroelectric facility capable of producing 500 kilowatts or less at peak output.

Solar Energy means that energy contained in the rays of sun used for space heat or photovoltaic conversion to electric energy. (Note: Specifically omitted from this definition are hydro, wind, biomass, etc.)

The objective of this paper is to place some alternative energy resources and technologies into the technical and economic perspectives of the late twentieth century, and into the physical environment of the Railbelt Region of Alaska.

The scope of our work has been limited to a "survey" that specifically excludes transportation, communication and developmental technologies such as fusion, orbital solar power stations, and ocean thermal, etc.

### ALTERNATIVES SURVEYED

During the course of this work, six alternative energy resources were examined:

- Micro-Hydro
- Wind
- Solid Waste
- Solar
- Waste Heat
- Wood

The surveys undertaken are qualitative and geographic; however, no distinction as to land ownership, covenant or legal restriction has been made. Obviously, land disposition and ownership have significant impact on resource availability. Thus, the abundance of such resouces as wood and micro-hydro are necessarily overestimated.

## 3.0 METHODOLOGIES:

### 3.1 Micro-Hydro:

Micro-hydro feasibility is dependent upon a number of factors. Most prominent however are the quantity of water available and the head, or vertical distance, the water may fall.

For example, a lake of elevation 150 feet and located near the sea, containing 5 million cubic feet of water will possess a potential energy of 46.8 billion foot-pounds. Were that lake to be drained over the period of a year, the potential work available would be a continuous 2.7 horsepower or about 2 kilowatts (Note: Machine efficiencies, and friction, etc., neglected).

If that lake is the low point of a 10 square mile basin that experiences an average rainfall of 20 inches per year, about 15 cubic feet of water each second will leave the lake making a potential for work of a continuous 250 horsepower or 187 kilowatts of electricity.[1]

As the imaginary lake is moved further and further away from the site of the power plant, the longer the pipe required to carry water from the lake to the power plant. The lengthening of the pipeline has two effects:

a. The cost of the project is increased because of the longer pipeline and required right of way on which to lay pipe, and

b. More inefficiencies will characterize the system because of frictional losses as the water flows through the pipe.

The relationship between horizontal distance and elevation change is defined as the "slope." The slope of the terrain plays an important part in assessing the feasibility of micro-hydro potential. Rainfall also influences the energy potential; obviously, if the rainfall is cut in half, the theoretical potential will also be halved.

The method used herein to survey the potential for micro-hydro was to construct a slope map of the railbelt, overlay a precipitation map for the region and combine the two parameters to obtain a "potential index."

This potential index neglects such effects as seasonal flow variations which are very important in the feasibility of micro-hydro potential. Such factors are, however, site specific and cannot be quantitive in this overview paper. Furthermore, the annual freezing index (a parameter used to estimate depth of frost penetration and thickness of lake ice, etc.) affects the annual variation in flow of streams. We have neglected this factor as well, since the relationship between the variation in the flow of small streams and the freezing index is poorly known and is also site specific.

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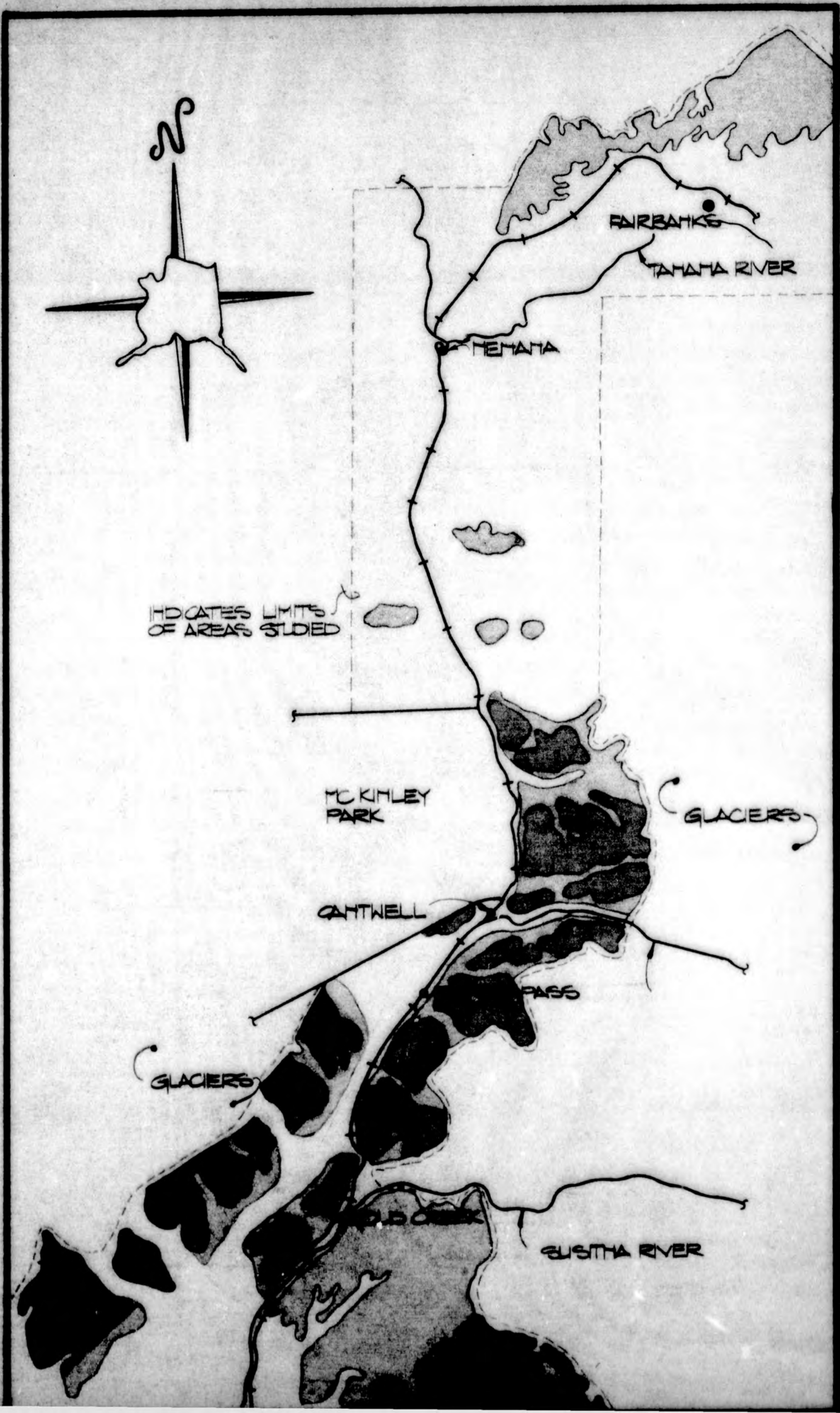
[1]See appendix of calculations.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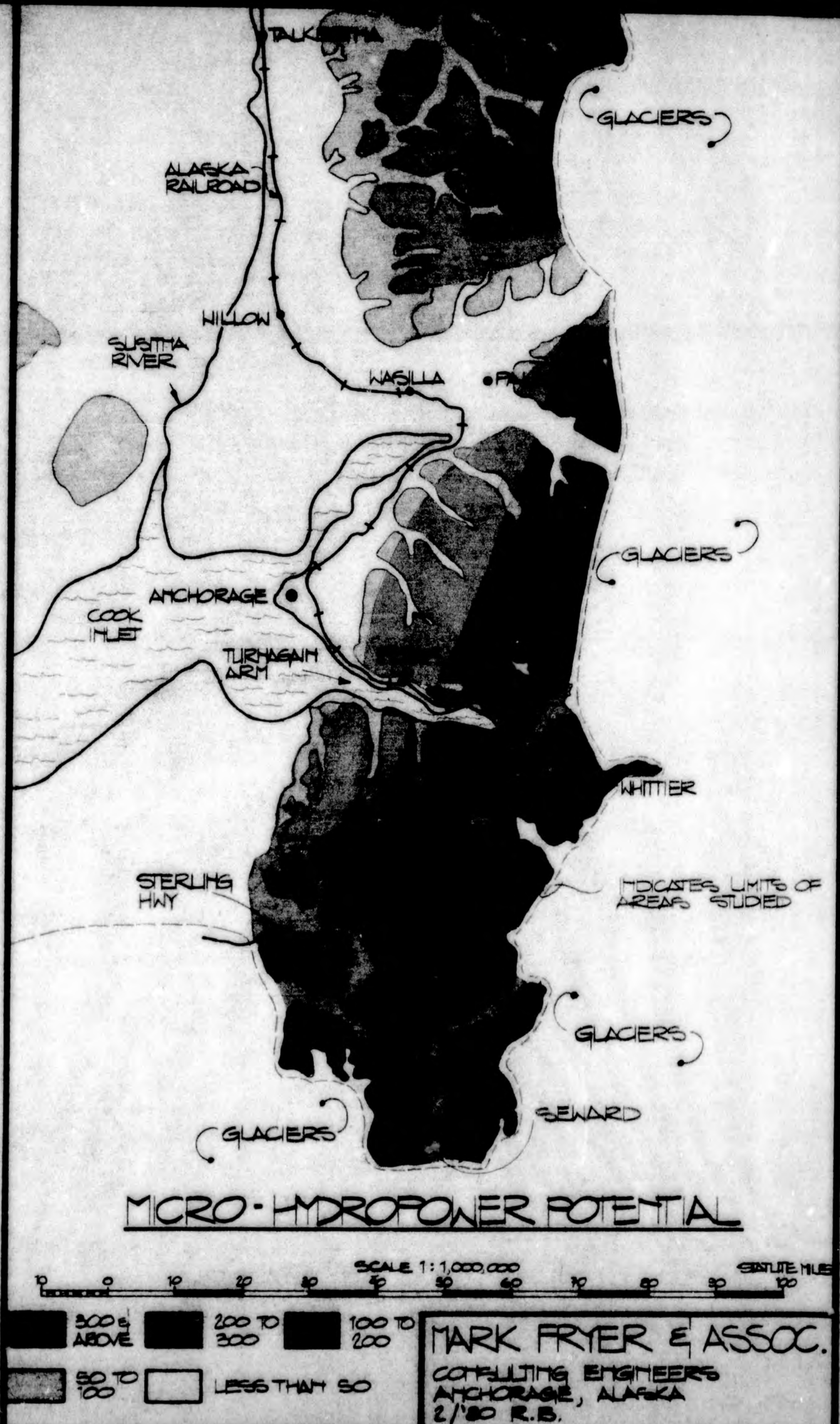
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A micro-hydro potential map has been constructed by plotting and contouring the potential index data derived by overlaying a slope map of the Railbelt Region with a precipitation map. This potential map compares well with run-off maps constructed by the U.S. Geological Survey.

The potential map could be used to estimate approximate potential of a micro-hydro site. The potential index is derived such that for every 100 square miles of watershed area, the index approximates the continuous kilowatt production potentially available from that area. A reasonable length of penstock is assumed and a potential head of 50 vertical feet used as a basis of calculations.

For potential indexes below 50, it is assumed that penstock length would be too great for gravity head dependent micro-hydro schemes. It is assumed that hydro power for these smaller potential ranges would be developed from stream velocity head only.

For the purposes of estimating micro-hydro potential, the authors have assumed that the development of 50 micro-hydro projects averaging 50 kilowatts of continuous output each is probably an upper limit to the exploitation of this technology. This assumption is made presuming that the current economic and land disposition environment is static. The assumed development would require between 10 million and 20 million 1980 dollars for capital investment.

Should economic and social conditions cause hydroelectric projects to become more attractive than they are today, emphasis should move away from micro-hydro to larger hydro projects because of their obvious cost and environmental advantages, thus limiting the expansion of the use of micro-hydro technology.

Considering the above noted assumptions, it is the judgment of the authors that an aggregate of perhaps 2.5 megawatts of installed micro-hydro is a reasonable upper limit to the expanded use of this technology.

3.2 Wood Resources (Fuel Use):

Under contract arrangements with Fryer : Pressley : Elliott, Inc., Will Theuer undertook a survey of wood as a fuel resource. The following is a resume of that survey.

Landsat satellite imagery in black and white as well as multi-spectral color reconstituted imagery were analyzed in order to estimate the extent of the fuel wood resource. Seven land categories were developed for the purpose of the analysis as follows:

1. Non Forest Land
2. Urban Areas
3. Water
4. Commercial Forests
   (defined as containing 2,000 cubic feet of wood or more per acre)

5. Fuel Wood Type 1
   (Land containing up to 1000 cubic feet
   of wood per acre)
6. Fuel Wood Type 2
   (Land containing 1000 to 2000 cubic feet
   of wood per acre)
7. Sparsely Covered Ground
   (Containing about 500 cubic feet per acre)

As in the hydro work, political boundaries were disregarded.

Table 2 summarizes the fuel wood potentials. In total, at this time, the energy equivalent of about 180 million barrels of oil is determined to be contained within an area approximately 30 miles wide from Seward to Fairbanks. The amount of this energy obtainable on a sustained annual basis would be the subject of an extensive study. However, as a general observation the actual productivity is invariably different from potential productivity. It is theoretically attractive to use a scheme based on assumed potential of land; however, actual productivity will be largely determined by current vegetation and management methods. Forestry in this regard is unlike agriculture, where productive potential is quickly realized.

Mr. Theuer as well as others point out that progressive management of this resource could, over the study period substantially increase the yield of our timber stands. For example, thinning some stands to acquire fuel wood could, if managed properly, result in the promotion of commercial stands of timber at a later date.

The potential for the use of wood as a heating fuel was determined through the consideration of several assumptions as follows:

1. Extensive use of fuel wood will meet price competition with coal.

2. The equipment required to burn wood efficiently is not substantively different than coal burning equipment.

3. The inconvenience of wood burning as opposed to other sources of thermal energy will limit the use of wood fuels to the residential sector.

4. The aesthetics of wood burning, as well as the low cash cost to the individual of the harvest (and to a degree the personal pleasure the individual may experience during wood harvest) will act to promote the use of wood as a fuel.

5. Most multi-family dwelling units are not equipped to burn wood with convenience, thus limiting the use of wood to single family dwellings.

Therefore, even though the fuel wood resource is extensive, economic lifestyle and convenience will limit the use of this resource to the roll of a secondary fuel source for single family dwelling units.

Table 2: Estimate of Fuel Wood Potential Located In Alaska's Railbelt

| STUDY AREA | FUEL WOOD LANDS (MILLIONS OF ACRES) | | | ESTIMATED RESERVE (MILLIONS CUBIC FT.) | THERMAL POTENTIAL $10^{12}$ BTU | EQUIVALENT/ BARRELS OF OIL (MILLIONS) |
|---|---|---|---|---|---|---|
| | Fuel Wood Type 1 | Fuel Wood Type 2 | Fuel Wood Total | | | |
| Fairbanks | 0.54 | 0.26 | 0.80 | 415 | 111 | 19.1 |
| Nenana | 1.57 | 0.55 | 2.12 | 1,600 | 430 | 73.5 |
| Talkeetna | 0.50 | 0.47 | 0.97 | 950 | 256 | 44.1 |
| Cook Inlet | 0.52 | 0.52 | 1.04 | 1,000 | 279 | 47.6 |
| Seward | 0.04 | -- | 0.04 | 210 | 5.56 | 0.9 |
| TOTALS | 3.17 | 1.80 | 4.97 | 4,175 | 1081.6 | 185.2 |

NOTE: Fuel wood type one contains up to 1000 cubic feet per acre.
Fuel wood type two contains between 1000 and 2000 cubic feet of wood per acre.

## 4.0 THERMODYNAMIC MACHINES:

The second law of Thermodynamics (credited to Rudolf Clausius, a 17th century German physicist) is the law that stops most "Perpetual Motion" machines from being workable. In practice the second law of thermodynamics requires coal, oil and gas fired, electric generation plants to reject heat to the environment. Large coal fired power plants reject heat into rivers or use cooling towers. Smaller power plants usually reject heat directly to the air (small diesel plants for example).

Modern electric generation plants (such as supply the Railbelt's electric needs) range in efficiency between 20% and 30%. That is to say that for every unit of chemical energy delivered to the electric generation plant, only 0.2 to 0.3 units of electric energy leave the plant, the remaining energy is rejected in the form of "waste heat". Since the efficiency of conversion of chemical energy to electric energy characterized by the electric power generation plant is frequently much poorer than the conversion efficiency of chemical energy to thermal energy of the residential furnace or water boiler, electric heat is not typically energy conservative. The residential natural gas or oil fired burner typically operates between 60% and 80% efficient, while electric heat is probably less than 20% fuel efficient.

When power plants are designed to recover and use waste heat for process energy requirements or for space heat, the plant so designed is termed a co-generation plant. Such plants are now in use at Fairbanks and on some Alaska Military bases.

It is obvious that two features of the thermodynamic, electric generation process can be addressed as a topic of alternate energy discussion. First, the fuel used to fire the plant could be a fuel derived from renewable resources and second, the heat wasted from the thermodynamic process could be used as a part of the heating energy required of the region.

### 4.1 Electric Power Plant Fuels:

The capital cost of electric power generation plants is governed to a large degree, by the character of the raw fuel it relies on for its basic energy supply. On the one end of the spectrum, natural gas and high quality fuel oils can be burned directly. Gas turbines are probably the cheapest electric generator prime mover for commercial sizes of electric generation plants.

As the quality of the primary fuel is reduced, steam is generated to drive the turbine, which in turn drives the electric generator. The steam is produced by boilers which are designed to convert the chemical energy of the primary fuel to thermal energy. The equipment required to store, process and convey the primary fuel is more or less elaborate depending again on the quality and consistency of the primary fuel.

Further, the need for environmental plant features, bag houses, flue gas scrubbing, etc., and the cost of those features is dependent upon the quality of the primary fuel. Thus the processing and burning equipment required for solid waste fuel costs more than that required of wood burning, which costs more than coal burning equipment, which in turn costs more than heavy oil burning equipment, which costs more than light oil burning equipment, which costs more than natural gas burning equipment.

For use in electric generation plants, coal is a superior fuel to wood or solid waste (the two most obvious alternative chemical fuels). The environmental impacts of large scale harvest of wood fuels are in some ways, probably comparable to open pit coal mining. This statement is based on the assumption that a thousand acres of forest land would yield about the same energy as mining a single acre of coal.[1]

Furthermore, coal, though nonrenewable is an abundant resource of Alaska. However, once coal became a readily exportable resource, natural price pressures could conceivably rise to a level that would make wood a valuable electric generation fuel. Until that time, however, wood used as an electric generation fuel will be limited to areas of the state that harvest lumber and pulp wood and incidentally create quantities of slash or sawdust, and perhaps rural areas where wood is a readily available local resource. This waste wood has a negative value, since it must be disposed of in an environmentally acceptable way; a way that generally creates costs to the timber or mill operations. In these cases electric generation from mill wastes appears to be potentially feasible.

Similarly, solid waste materials so profusely generated by urban communities, have a negative value. Since landfills require expensive real estate, and acceptable disposal thereon generates additional costs, use of solid waste as a fuel for electric generation becomes interesting.

The solid waste materials currently generated by the Greater Anchorage Area contain enough chemical energy to fire a 20 megawatt power plant. The economics of using this fuel rather than coal have been examined and found to be marginal; however, new technology, or a marked increase in coal prices could make such an option attractive.

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[1]See appendix of calculations.

The economical use of solid waste as a fuel for electric generation plants is dependent upon the scale of operation. Currently, maintenance intensive equipment is used to condition the waste materials into a fuel. Further, the burner equipment required must be suited to the fuel (fluidized bed burners for example), and conditioning of the gases that result from the combustion process is required for obvious environmental requirements. All of these elements of the process demand full time operators to attend to the facility. The labor costs of such attendance are only warranted when basic economics of scale are met. Coal generation plants of traditional design are subjected to most of the same sort of economic limitation as have been described for solid waste fired plants. Thus, solid waste fuel becomes an option to coal.

### 4.2 Waste Heat

Over the period of a year the average railbelt resident consumes about 5000 kilowatt-hours (17 million BTU's) of electric energy and about 69 million BTU's of space heating energy. In order to produce the electric energy, the electric utility consumes nearly 85 million BTU's of fuel. The difference between the 17 million BTU's and the 85 million BTU's (68 million BTU's) is typically lost as: a) "Second law" heat (50 million BTU's), b) stack and plant losses (17 million BTU's) and c) electric transmission losses (1.7 million BTU's). The 50 million BTU's of "second law" heat is of high enough quality (temperature) to be used for ordinary space heating or process heat.

It is obvious that the waste heat could go a long way in the supply of space heating energy requirements of the residents if, somehow, it could be made available for such use.

Modern waste heat space heating systems use hot water, pumped from a co-generation plant to the building spaces. Since such systems require large insulated water pipes to supply heat to various buildings, the beneficial use of this energy resource becomes more and more expensive the further from the generation plant the point of use becomes. Studies produced by the new Capital Site Planning Commission suggest that the ratio thermal load to distance for the economical service with district hot water space heat, is about 30 million BTU's per foot of distance from power plant to heat consuming space. Thus, to transmit waste heat from a power plant to a point of use five miles away, for example, the annual thermal load would have to be about 800 billion BTU's or the equivalent of the thermal consumption required of a 12,000 population community.

In the recent past, power generation plants have been located away from densely populated areas because of the noise and pollutants produced by such plants. Thus, adding waste heat recovery features to existing power plants is often difficult to justify from a cost view; the transmission of waste heat becomes too costly.

For the purposes of this work, the Fairbanks Municipal Utilities downtown power generation facility, the University of Alaska's co-generation plant located in Fairbanks and a new, solid waste fired plant designed to consume the solid waste co-generated by the City of Anchorage were surveyed as being potential sources of waste heat.

Other plants in Anchorage and at Healy, Alaska may show promise upon indepth study, however the limited resources of this survey precluded analysis of any but the obvious schemes.

The estimated "second law" heat available from the options briefly examined during this work amounted to an additional 0.5 trillion BTUs annually that could be collected and used for space heat.

In the case of Fairbanks, the bulk of this conserved energy could be used to heat spaces currently electrically heated. Thus, the savings would be marked by affecting the peaking generation problems Fairbanks has suffered in the past.

## 5.0 OTHER TECHNOLOGIES

Geothermal energy, tidal power and wind power are energy resources properly termed "alternative." We are unable to find substantial application for any of these resources except by application of unproven technology such as "hot rock" geothermal or the very large tidal project proposed for Knik Arm. Some estuaries along the Cook Inlet could be used for smaller tidal power projects; however, it is the opinion of the authors that such projects would prove financially unfeasible, if not environmentally unacceptable.

At the outset of this project, it was assumed that some wind power potential would be identified. However, examination of 19 weather stations indicate but marginal potential for only two locations (Gulkana and Homer) one of which actually falls outside of the study area.

## 6.0 CONCLUSIONS:

Perhaps ten percent of the energy budget accounted to residential, institutional and commercial buildings, located within the study area, could be provided through alternative energy sources examined during the course of the work reported upon herein. Of the resources surveyed, use of solid waste fuel, wood fuel, and waste heat rejected from electric generation plants, appear to hold the greatest promise.

Solid waste fuel and waste heat recovery potentials are primarily located in the Anchorage and Fairbanks areas and lend themselves well to large demonstration type projects.

The competition of coal as a fuel for electric power generation will limit the use of wood to residential heating, primarily supplemental to electric, oil and gas fired systems. Most single family residences, however, could be fitted with efficient wood fuel heating equipment; thus this potential seems an attractive alternative.

A potential savings of up to 30% of the heating fuels could theoretically be achieved with passive, solar design; provided that the home was not located on a shady site (i.e. northern slope or heavily "treed" location). Such benefits are only practically achieved (on a large scale) with new construction. Assuming 30% of new construction were designed to exploit this resource, by the year 2000, the annual savings realized through application of this technology is probably on the order of $10^{12}$ BTU's per year, (equivalent of 170,000 barrels of oil) or about 1% of the year 2000 energy requirements of the residential, institutional, and commercial building energy needs of the Railbelt. Active solar could also contribute to domestic water heating.

Benefits from micro-hydro are somewhat small. Not that the resource is itself small but, rather, energy from micro-hydro must be used close to the point of generation. The demand for such power in areas removed from densely populated areas is small compared to the demands of the whole. Large capital costs considerations together with regulatory costs and competition from electric utilities also discourage the exploitation of this resource. By the year 2000, if 50 micro-hydro sites were developed to deliver an aggregate of 2.5 megawatts of continuous output, perhaps, $0.3 \times 10^{12}$ BTU's annually of electric generation fuel could be saved. This amount of fuel is about one percent of the residential commercial and institutional electrical energy budget.

Benefits from tidal, electrical, wind power, and geothermal are negligible.

## 7.0 RECOMMENDATIONS:

It is recommended, that the state set up a program that could:

1. Streamline the permit acquisition process for small and micro-hydro site development.

2. Arrange for the management of the railbelt wood resources so as to encourage harvest of fuel wood at locations near to densely populated areas. Such management may require the development of access roads as well as the selection of suitable lands and management of the harvest itself.

3. Develop a program that would assist the layman in the technical aspects of solar design, micro-hydro feasibility analysis and energy products selection.

4. Encourage municipal and borough governments in the assessing of feasibility of solid waste fuel potentials and waste heat capture and distribution schemes.

   NOTE: Significant opportunities exist for large scale energy conservation demonstrations at both Anchorage and Fairbanks International Airports -

   - The airport at Fairbanks is electrically heated to avoid air pollution.

     The facility was designed during a time of cheap energy, thus not only the heating, ventilation and air conditioning systems but the building envelope as well could be upgraded for conservation purposes. District heat concepts with heat pump and heat storage could significantly reduce non-renewable energy consumption.

   - Another project that could yield benefits is the upgrade of the district heating system currently serving the core area of Fairbanks. Not only would this project result in substantial economic savings to the people of that community, it could potentially reduce the fuel oil consumption of that community by perhaps a million gallons of oil per year.

   - The electric and thermal energy loads required of the Anchorage International Airport are of such a character that a solid waste fired co-generation plant with waste heat and heat pump features could reduce the need to consume non-renewable fuels to zero.

     The projects cited above will demonstrate payback periods for capital investment attractive to the institutional owners, while demonstrating alternative energy technology and reducing our dependence upon oil and natural gas fuels.

- The requirements of these projects suggest a comprehensive solution which would include the University of Alaska's co-generation plant as well as the Municipal Utilities facilities located near downtown Fairbanks.

- The non-renewable resource aggregate savings of these projects suggested above are perhaps 0.5 X $10^{12}$ BTU's per year (on the order of 1% of the total energy consumed by the residential, commercial and institutional buildings of the Railbelt area).

RECOMMENDED WORK TO BE DONE

7.1 Engineering Data:

There does not now exist adequate engineering data on the environment of the Railbelt. The following information should be collected on a regular basis at every proposed project or population growth site along the Railbelt:

1. Population
2. Wind profiles in three components: direction, height and velocity
3. Stream gauging and hydrology, periodically throughout the year
4. Temperature
5. Precipitation
6. Solar measurements periodically throughout the year (Both diffuse and incident normal)
7. EPA base line air quality
8. EPA base line water quality

In order to accomplish this accumulation of information a scientific group consisting of the following expertise should be formed:

- Solar Specialist
- Hydrologist
- Environmental Engineer
- Weather Specialist
- Data Collection Coordinator

These specialists should select specific sites and design standard data collection stations.

Other probable groups to involve in project planning:

- University of Alaska
    - Institute of Water Resource
    - Arctic Environmental Information and Data Center
    - Geophysical Institute

- State of Alaska
  - Division of Energy & Power Development
  - Department of Environmental Conservation
  - Department of Transportation
  - Alaska Power Authority
  - Department of Natural Resources
  - Department of Environmental Conservation

- Federal Government
  - U. S. Geological Survey
  - U. S. Department of Environmental Quality

- Private Consultants

- Other Interests
  - Local Governments
  - Local Utilities
  - Local business interests, such as Usibelli Coal Co.
  - Native Corporations

The idea suggested here is that the groups cited would develop a comprehensive project plan and budget and select individuals to represent the specific technologies required of the project. One group would be named project coordinator. That group would be charged with the responsibility of carrying out the data collection, analyzing the data and making the results of analysis available to the public.

This project should be thought of as a long-term commitment of the State; a commitment to the development of alternate energy resources as well as collecting information required of resource development in general.

7.2 Waste Heat Studies:

A comprehensive study of waste heat utilization and district heat transmission and distribution should be undertaken for the Railbelt Region of Alaska. Such an effort should result in the documentation of feasability and recommended capital projects. Further, the study should address the local political realities of current utilities management and make appropriate recommendations.

7.3 Technology Availability:

The technologies dealing with both solar and micro-hydro are difficult for the lay citizen to grasp. Because of the small scale of projects that exploit these technologies, the cost of professional expertise may, in many cases, be prohibitive. Thus, the appropriate technology could be made available through some sort of "energy extension service."

This concept is not at all new. The Federal Government now promotes such a program. The State, however, could augment Federal efforts and cooperate with various Federal programs and the State University to deliver the required technology to the individual citizen.

Should such a program be developed, the administrator that heads it must be an experienced engineer. The problems to be dealt with, though superficially informational, are founded in applied engineering science, not political policy, nor developmental science. Hydro projects frequently require impoundment of water for the storage of potential hydro energy. The untimely release of that stored energy can obviously devastate property and populace located down stream of the impoundment site. The risk of poor professional consulting to builders of hydro projects, large or small, is a risk to human life.

In addition to assisting the citizen to design and construct solar or hydro energy facilities, the "energy extension" should "approve" or "endorse" various products available to the public. These products include:

- Solar panels
- Wood burning stoves
- Hydro turbines and wheels
- Electric generators
- Solid state control accessories
- Storage systems
- Thermal insulations
- Thermally resistive building products such as windows, doors, weatherstripping, etc.

Some products that purport to save energy for the home owner are of marginal value. The lay citizen has little or no basis for selection among the profusion of products now on the market. Experts in the field could help the citizen to sort through the various products and recommend a variety for the consumer's choice, a variety that is well-conceived, of recognized quality, and most importantly, fits the application for which it is intended.

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RAILBELT ALTERNATE ENERGY SURVEY
Appendix of Miscellaneous Calculations

1. Population

- 1980 = 285,000 (Assumed)
- Growth = 3% (Assumed)
- 2000 = 515,000

2. Built Space

- Residential = 350 sq. ft. / capita (Assumed)

- Non-Residential = 150 sq. ft. / capita (Assumed)

| | 1980 | △ | 2000 |
|---|---|---|---|
| Residential sq. ft. | 99,750,000 | 80,500,000 | 180,250,000 |
| Units | 95,000 | 76,667 | 171,667 |
| Non-Residential sq. ft. | 42,750,000 | 34,500,000 | 77,250,000 |

3. Energy Use (Assumed)

| | Unit Consumption (sq. ft./yr.) | |
|---|---|---|
| | Thermal | Electrical |
| Residential | 120,000 BTU | 5.5 KWH |
| Non-Residential | 185,000 BTU | 20.0 KWH |

## THERMAL ENERGY CONSUMPTION

($10^{12}$ BTU)

| | 1980 | | $\Delta$ | | 2000 | |
|---|---|---|---|---|---|---|
| | Use | Raw | Use | Raw | Use | Raw |
| **Residential** | | | | | | |
| Non-electric | 11.06 | 15.80 | 8.93 | 12.76 | 19.99 | 28.56 |
| Electric | 0.91 | 3.65 | 0.73 | 2.93 | 1.64 | 6.58 |
| Total | 11.97 | 19.45 | 9.66 | 15.69 | 21.63 | 35.14 |
| **Non-residential** | | | | | | |
| Non-electric | 7.19 | 10.27 | 5.80 | 8.29 | 12.99 | 18.56 |
| Electric | 0.5 | 2.00 | 0.41 | 1.64 | 0.91 | 3.64 |
| Total | 7.69 | 12.27 | 6.21 | 9.93 | 13.90 | 22.20 |
| TOTAL | 19.66 | 31.72 | 15.87 | 25.62 | 35.53 | 57.34 |

Assuming no change in basic approach to space heat generation.

## ELECTRIC ENERGY CONSUMPTION

UNITS ARE $10^6$ KWH

| | 1980 | | $\Delta$ | | 2000 | |
|---|---|---|---|---|---|---|
| | Use | Raw | Use | Raw | Use | Raw |
| Residential | 548.6 | 2,194 | 442.8 | 1,771.5 | 991.4 | 3,965.5 |
| Non-residential | 855.0 | 3,420 | 690.0 | 2,760.0 | 1,545.0 | 6,180.0 |
| TOTAL | 1,403.6 | 5,614 | 1,132.8 | 4,531.5 | 2,536.4 | 10,145.5 |

## RAW ENERGY PROFILE

($10^{12}$ BTU)

| | 1980 | Δ | 2000 |
|---|---|---|---|
| Residential | | | |
| ° Fuel Thermal | 15.80 | 12.76 | 28.56 |
| ° Electric Thermal | 3.65 | 2.93 | 6.58 |
| ° Other Electric | 7.49 | 6.04 | 13.53 |
| Subtotal | 26.94 | 21.73 | 48.67 |
| Non-residential | | | |
| ° Fuel Thermal | 10.27 | 8.29 | 18.56 |
| ° Electric Thermal | 2.00 | 1.64 | 3.64 |
| ° Other Electric | 11.67 | 9.42 | 21.09 |
| Subtotal | 23.94 | 19.35 | 43.29 |
| Other Electrical | 0.47 | 0.37 | 0.84 |
| Electrical Losses | 1.51 | 1.23 | 2.74 |
| GRAND TOTAL | 52.86 | 42.68 | 95.54 |

Assume electric generation efficiency @ 25% and
6% transmission and distribution losses

WOOD USE CALCULATIONS:

1. Assumptions:

   a. 10% of all residences rely on wood as a fuel source.

   b. The average home is occupied by 2 1/2 people.

   c. The average home is 900 sq. ft.

   d. The average home consumes 90,000 BTU's per square foot per year (without domestic hot water).

   e. The average home heating system is 45% efficient.

   f. Utilization of wood as a primary fuel source is 50%.

2. Annual Chemical Energy Requirements =

$$285{,}000 \text{ population} \times 10\% \times \frac{\text{Home}}{2.5 \text{ people}} \times 900 \text{ ft.}^2 \times 90{,}000 \text{ BTU/ft.}^2$$

$$\times\ 1/45\% \times 50\% = 1.03 \times 10^{12} \text{ BTU's/yr.}$$

3. Wood Harvest Requirement

$$\frac{\text{Ft.}^3}{31\#} \times \frac{\text{Acre}}{1325 \text{ ft.}^3} \times \frac{\#}{8{,}500 \text{ BTU}} \times 1.03 \times 10^{12} \text{ BTU} = 2950 \text{ acres.}$$

COAL-WOOD EQUIVALENCE:

1. $70\#/\text{ft.}^3 \times 8000 \text{ BTU}/\# \times 20' \text{ seam} \times 43{,}560 \text{ ft.}^2/\text{acre} = 0.48 \times 10^{12}$ BTU's

2. $0.48 \times 10^{12} \text{ BTU} \times \#/8{,}500 \text{ BTU} \times \text{ft.}^3/31\# \times \text{acre}/1325 \text{ ft.}^3 = 1374$ acres

Notes on wood calculations: See "Alaska's White Spruce" by Forests, North, Ltd. (Prepared for Alaska Department of Commerce and Economic Development) 1979.

CALCULATIONS FOR SOLAR ENERGY USE IN HOT WATER HEATING:

1. Assumptions:

   a. Active solar panels.

   b. Solar energy accounts for 30% of residential hot water heat in 10% of all residences.

   c. Per capita daily hot water use is 20 gallons/day.

d. "R" chart methods are acceptable.

$$285{,}000 \text{ population} \times \frac{20 \text{ gal.}}{\text{capita}} \times \frac{8.3453\#}{\text{gal}} \times \frac{1 \text{ BTU}}{\#\text{-}^\circ\text{F}} \times (100^\circ\text{F})$$

$$\times (365 \text{ days/yr.}) \times 30\% \times 10\% = 0.05 \times 10^{12} \text{ BTU's/yr.}$$

WASTE HEAT RECOVERY CALCULATIONS:

1. Assume:

   An additional 20% of heat wasted from the Fairbanks municipal utilities power generation plant is captured for uses as space heat.

2. $$\frac{130{,}000 \text{ tons of coal}}{\text{year}} \times \frac{16.0 \times 10^6 \text{ BTU}}{\text{ton}} \times 0.7 \times 0.75 \times 0.20 =$$

   $0.22 \times 10^{12}$ BTU/YR.

3. Assume a solid waste fired co-generation plant producing 20 megawatts should be installed and the waste heat thereby generated, consumed for waste heat use.

   $$20{,}000 \text{ kilowatts} \times \frac{3413 \text{ BTU}}{\text{KWH}} \times 0.8 \times 0.75 \times 0.75 \times \frac{8760 \text{ Hrs}}{\text{Yr.}} =$$

   $$0.27 \times \frac{10^{12} \text{ BTU}}{\text{Yr.}}$$

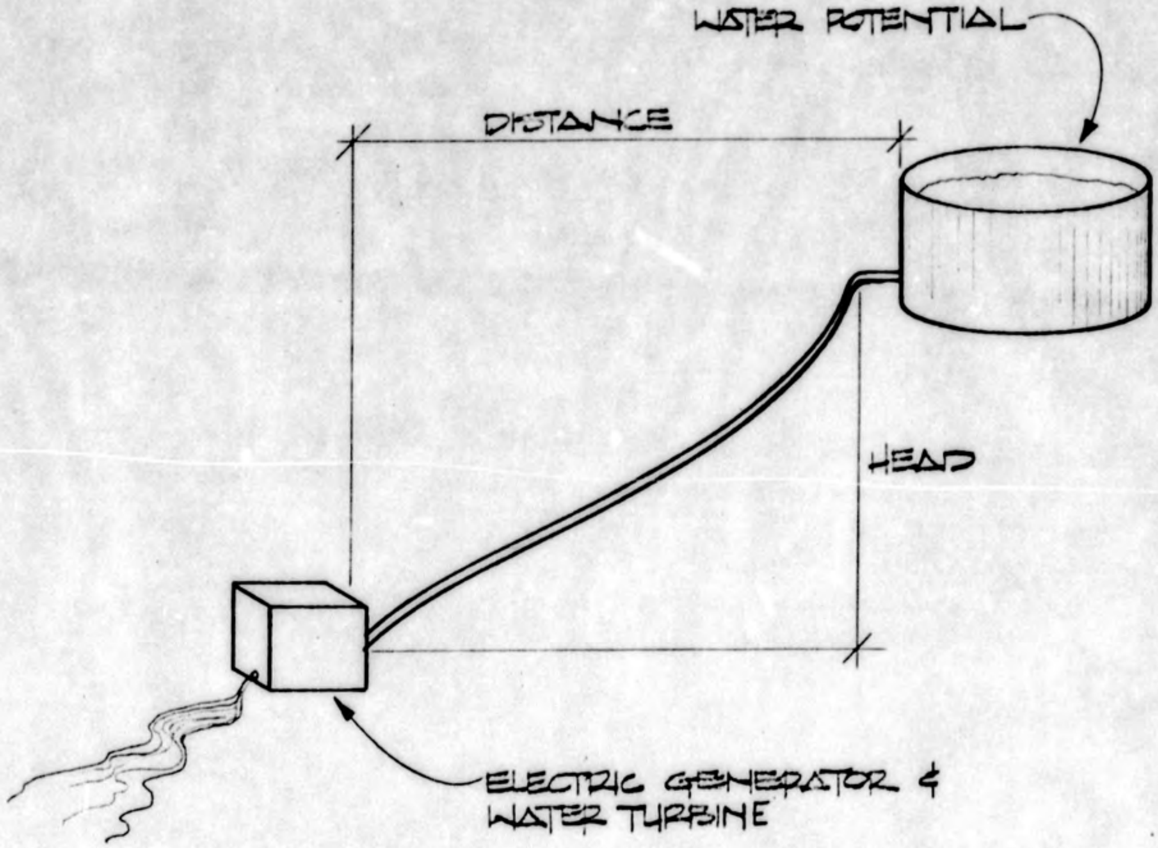
   $$\text{Total waste heat capture} = 0.49 \times \frac{10^{12} \text{ BTU}}{\text{Yr.}}$$

SOLID WASTE AS AN ELECTRIC POWER PLANT FUEL

Assume 75% of sold waste in Anchorage may be utilized plus solid waste from surrounding areas.

190,000 tons X 2000 #/ton X 5,000 BTU/# = $1.9 \times 10^{12}$ BTU's of raw energy for electric power plant fuel.

MICRO-HYDRO POTENTIAL INDEX:




$$\text{Potential Energy} = \text{Weight of Water} \times \text{Head}$$

$$\text{Potential Power} = \frac{\text{Potential Energy}}{\text{Time of Release}}$$

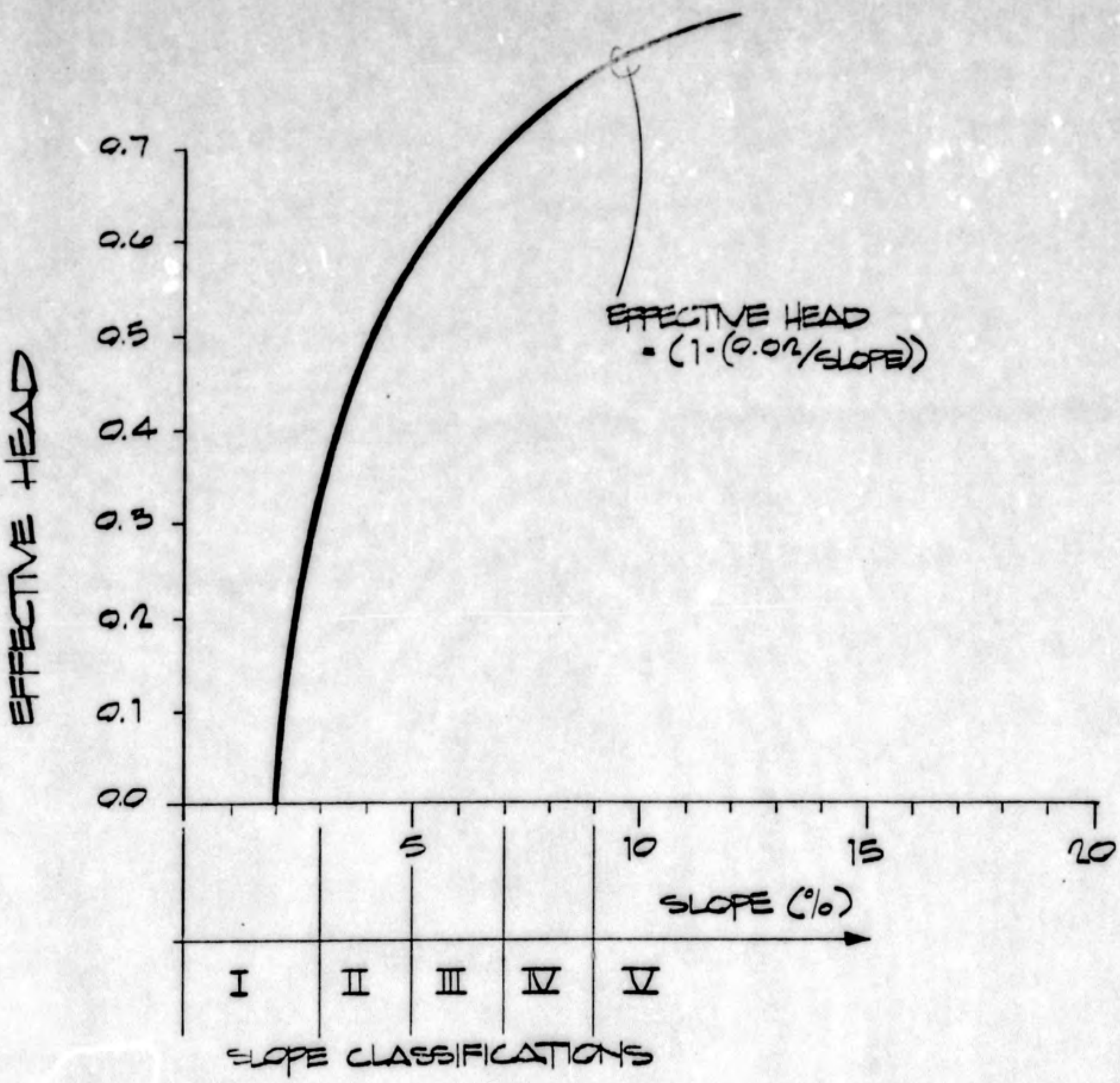
Friction Loss in Pipe = 0.02 Ft./Ft. (assumed)

$$\text{Slope} = \frac{\text{Head}}{\text{Distance}}, \quad \text{Head} = (\text{Slope}) \times (\text{Distance})$$

Effective Head = (Head - Friction Losses)

Assume Head = 1 Ft.

$$\text{Effective Head} = \left(1 - \frac{0.02}{\text{slope}}\right)$$




| SLOPE RANGE | EFFECTIVE HEAD |
|---|---|
| 0 - 3 | 0.20 |
| 3 - 5 | 0.50 |
| 5 - 7 | 0.65 |
| 7 - 9 | 0.75 |
| Greater than 9 | 0.80 |

Assuming (for example)

1. Basin Area = 10 sq. mi.
2. Precipitation = 24"/yr.
3. Slope Range = 0 - 3%
4. Head = 50'

Continuous power generation potential =

$$24''/\text{Yr.}\left(\frac{62.4\ \#/\text{Ft}^3}{12''/\text{Ft.}}\right)(20\ \text{Ft.})\left(\frac{\text{HP-MIN}}{33{,}000\ \text{Ft-\#}}\right)\left(\frac{0.75\ \text{KWH}}{\text{HP}}\right)\times$$

PRECIPITATION; HEAD

$$(0.33)\left(\frac{\text{YR}}{525{,}600\ \text{MIN}}\right)(10)(5280^2) = 9.92\ \text{KW}$$

EFFECTIVE HEAD

Example #2

Slope greater than 9%

Precipitation 50"/yr.

Continuous power generation potential =

$$50\left(\frac{62.4}{12}\right)(20)\left(\frac{1}{33\times10^3}\right)(0.75)(0.8)\left(\frac{1}{525{,}600}\right)(10)(5280^2) = 50\ \text{KW}$$

If system efficiency = 40% and the assumed head for a facility is 50', the indices would relate to:

| Potential (KW) | Penstock Length |
|---|---|
| Less than 50 | N/A |
| 50 - 100 | Greater than 1500' |
| 100 - 200 | 1000 to 1500 |
| 200 - 300 | 700 to 1000 |
| Greater than 300 | Less than 700' |

Basin is 100 sq. miles in extent.

MICRO-HYDRO

50 plants @ 50 kw each = 2,500 kw.

$$2{,}500 \text{ X } (365 \text{ days/yr.}) \text{ X } (24 \text{ hrs./day}) = 21.9 \text{ X } 10^6 \text{ kwh}$$

EFFECTED LAND AREA:

Precipitation collected, $(6.22 \text{ X } 10^9 \text{ Ft.}^3/1.67')/27{,}878{,}400 = 134$ square miles

20" precipitation zone

Average micro-hydro head, 150'

$21.9 \text{ X } 10^6$ kwh X $2.66 \text{ X } 10^6 = 5.83 \text{ X } 10^{13}$ Foot-Pounds

$(5.83 \text{ X } 10^{13}/150')/62.4 = 6.22 \text{ X } 10^9 \text{ Ft.}^3$

Assume average impoundment to be 10' in depth.

$(6.22 \text{ X } 10^9/10')/27{,}878{,}400 = 22$ square miles

22 square miles X 25% = 5.5 sq. mi.

5.5 X 640 = 3520 acres

POWER POTENTIAL:

15 $\text{ft.}^3$/sec. X 62.4 #/$\text{ft.}^3$ = 936 #/sec. = 56,160 #/min.

56,160 #/min. X 150' = 8,424,000 ft. - #/min.

= 8,424,000/33,000 = 250 HP = 186 Kw

****PLEASE NOTE****

THE ORGINAL FILE CONTAINS AN OVERSIZED DOCUMENT THAT IS UNSUITABLE FOR FILMING. PLEASE REFER TO THE ALASKA STATE ARCHIVES TO VIEW THE ORIGINAL.

Description:

Diagram/map

Micro-hydropower potential

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