

Assessment of Feasibility of Biomass Fuel Conversion in Interior Villages

Is it feasible to convert diesel electrical systems in Interior Alaska villages to wood biomass systems?

How would this type of project impact the relationship between fire, ecosystems, and people?

An Opportunity to Solve Multiple Problems?

Interior Alaska communities maintain strong cultural traditions with mixed economies

- Economic viability threatened by high fuel costs
- Physical viability threatened by matrix of flammable fuels near villages
- Social viability threatened by lack of local employment

Energy Systems in Rural Alaska

- 200 off-grid villages use diesel generators
- High fuel prices and storage prices
- Large state subsidies for diesel power



Old tank farm, Anvik

Biomass Investment and Technology

Boilers, wood gasification, or
pyrolysis

Existing combined heat and
power systems



Federal and state grant
money available

Forest Ecology and Ecosystem Services

Fire is a
crucial
component of
ecological
succession
but poses an
unacceptable
risk to
communities



Fire fighting
provides local
employment

System Sub-models

1) Ecological:

What is the maximum travel distance needed to sustainably harvest black spruce to meet village electrical energy needs?

2) Economic:

How many years would it take, based on annual savings, to pay back infrastructure costs?

3) Social:

What social factors are crucial to the success of a biomass conversion project?

Ecological Sub-model

Maximum travel distance to obtain wood fuel =
$$\sqrt{\frac{P \times Epc \times Eo \times R \times 0.01}{Bd \times Ad \times Ew \times Ee \times Fc \times \pi}}$$

Where:

P = Village population

Epc = Per capita energy use

Eo = Energy offset

R = Rotation length for forest harvest

Bd = Biomass density for black spruce

Ad = Correction factor for converting green to air-dried wood

Ew = Energy available from air-dried wood

Ee = Electrical efficiency

Fc = Forest cover

Ecological Sub-model

Nominal values and ranges

- ***Village population = 21 to 1439***
- ***Per capita energy use = 3758 kWh/yr***
- ***Rotation length = 110 years (80-200)***
- ***Biomass density = 28 t/ha***
- ***Energy available = 5480 kW/t***
- ***Electrical efficiency = 28%***
- ***Forest cover = 44% (10%-75%)***

Technical Issues

- Multiple technologies are available
- Combined heat and power would double the efficiency

Type of process	Electrical efficiency	Combined heat and power efficiency	Source
Hot gasification/fuel cell	0.23	0.6	<i>Osmosun et al.</i>
Downdraft gasification	0.4	0.9	<i>Zerbin</i>
gasification		0.7	<i>Wu et al.</i>
gasification	0.35		<i>Willeboer</i>
gasification/fuel cell	0.24	0.6	<i>Wright et al.</i>
combustion	0.25		<i>USDA</i>
biomass integrated gasification	0.33		<i>Haq</i>
gasification	0.21		<i>Somashekhar et al.</i>
combustion	0.2	0.6	<i>Bain et al 2003</i>
mean	0.28	0.68	

Economic Sub-model

Years to pay back investment in biomass system =

$$\frac{\text{Capital Costs}}{\text{Annual Savings}} = \frac{I_c \times E_l}{[(A_o \times D_e \times D_p) + (N F_o \times N F_c)] - (B_g \times B_c) + (D_e \times A_o \times C_c)}$$

Where:

I_c = installed cost of a biomass power system, per kW

E_l = electrical load

A_o = actual offset

D_e = diesel efficiency

D_p = diesel price

NF_o = non-fuel offset

NF_c = non-fuel costs

B_g = Biomass energy generated

B_c = Biomass energy costs

C_c = carbon credits available due to fuel offset

Economic Sub-model

Nominal values and ranges

- Installation cost = \$1849/kW
- Biomass energy costs = \$.16/kWh
- Compares with current residential rates of \$.17-\$.56/kWh (\$.23-\$.80 unsubsidized)



Firebreak project at Tanacross – work done by hand by local residents

Harvest Costs = Local Benefits

Fuels treatment project site	Type of treatment	Overhead and equipment cost per acre	Wages per acre	Total cost per acre	Cost per metric ton ¹	Operating cost per kWh ²
Healy Lake ³	Fire break	\$640	\$2,560	\$3,200	\$282	\$0.22
Tanacross ³	Parklike clearing to spacing of ~12'	\$800	\$3,200	\$4,000	\$353	\$0.27
Delta Junction ⁴	Fire break	N/A	N/A	\$1,100	\$97	\$0.07
Stevens Village ³	Light thinning of spruce understory	\$100	\$400	\$500	\$44	\$0.03
Fairbanks ⁵	Fire break	N/A	N/A	\$2,700	\$238	\$0.18
mean		\$513	\$2,053	\$2,300	\$203	\$0.16

1 Assuming 28t/ha, .405ha/acre

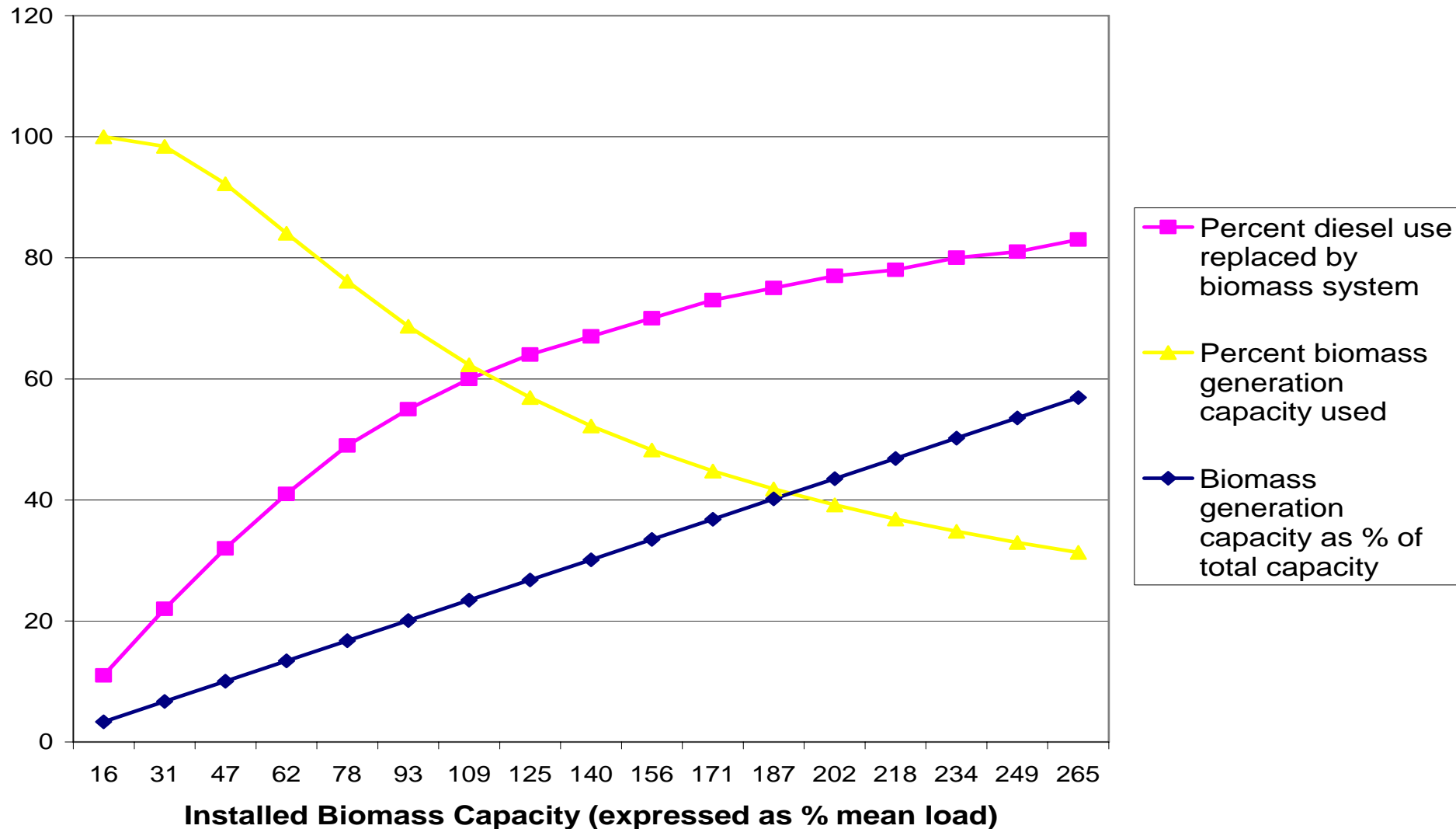
2 Assuming 5480*0.85= 4658 kWh/t (green weight)

3 Data from Hanson 2005 Pers. comm.

4 Data from BLM 2005

5 Data from Lee 2005, hand-felling method only

Biomass Generation Capacity and Diesel Fuel Savings

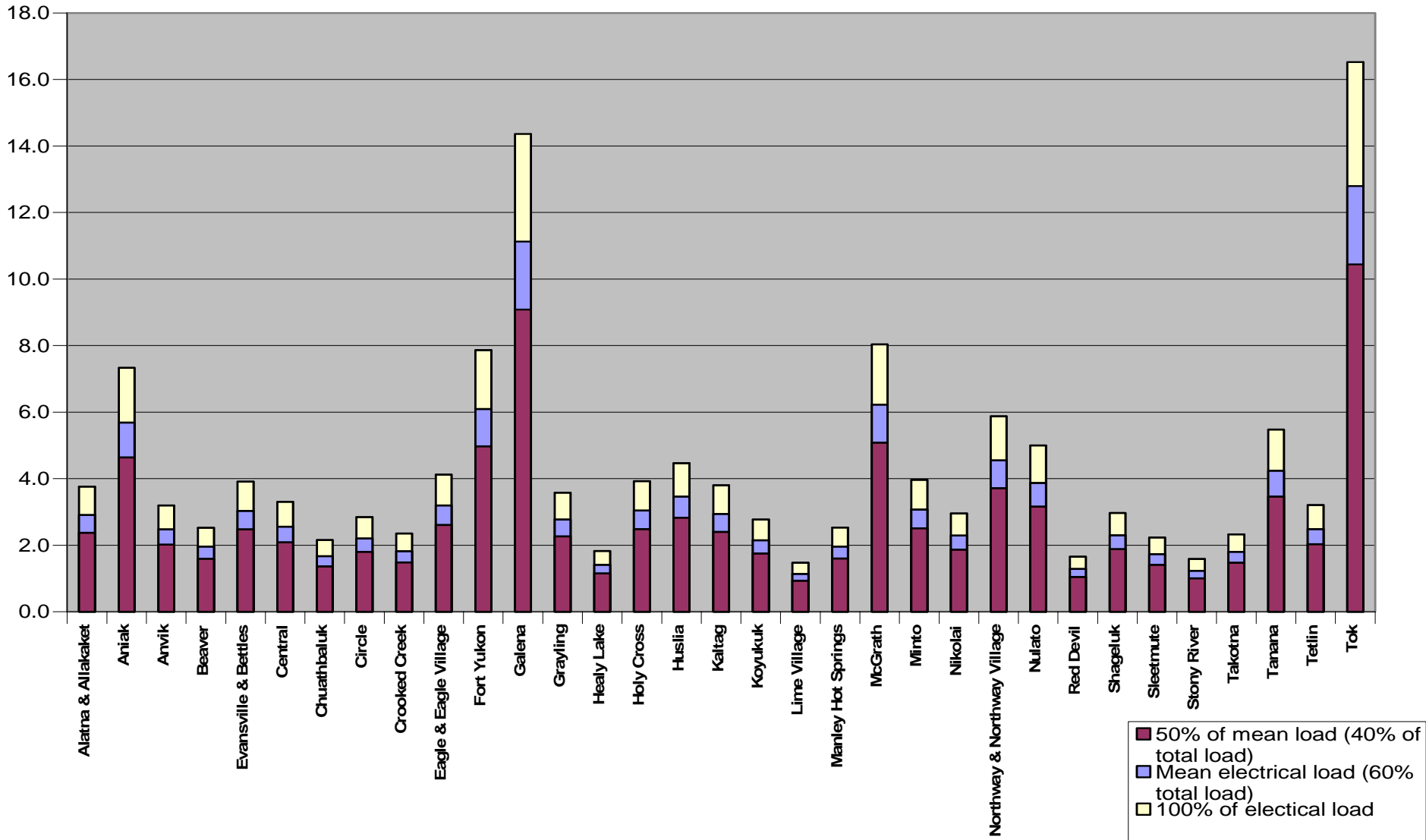


Social Sub-model

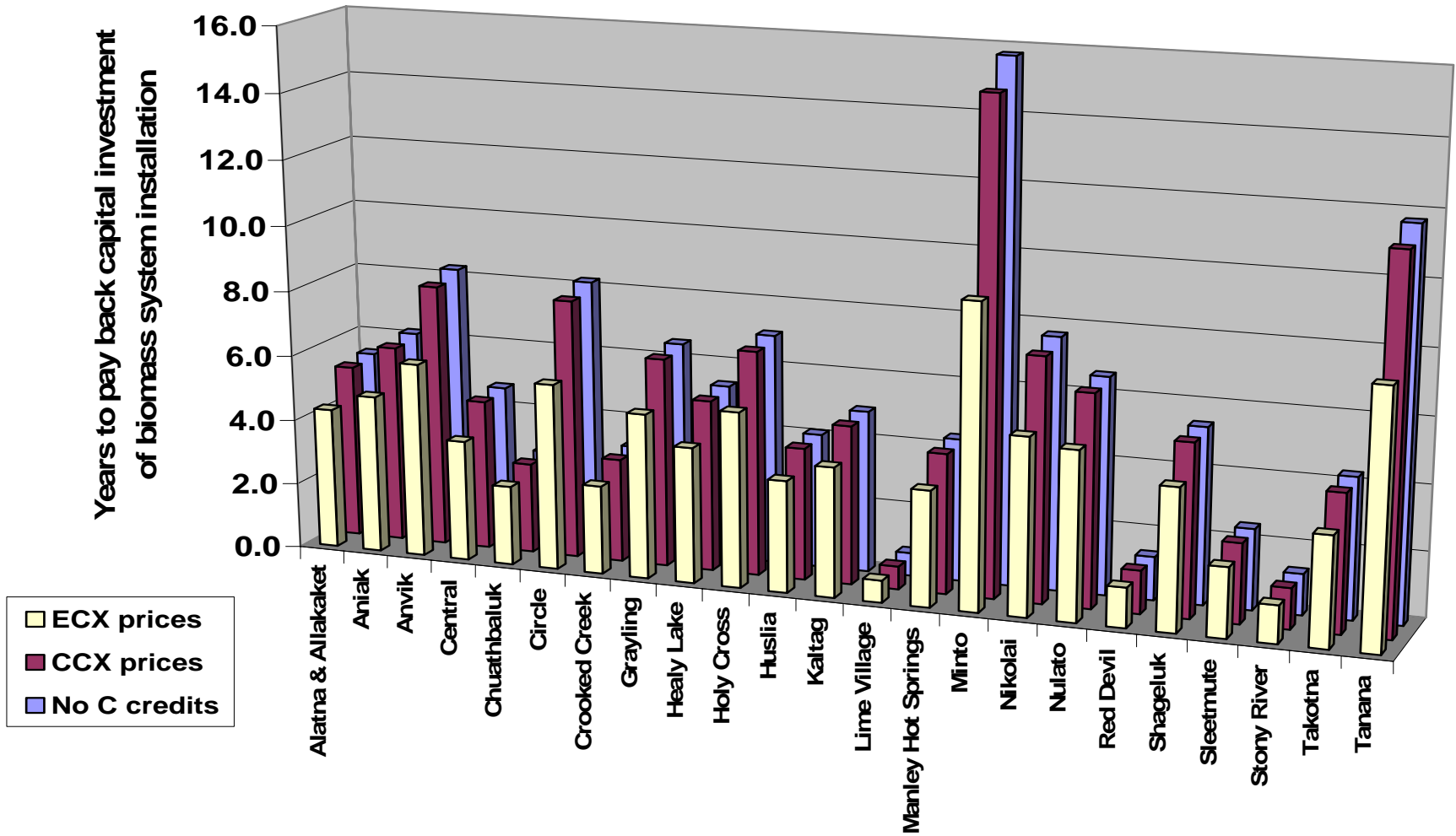
Factors Assessed:

- Existing social and technical capacity
- Threshold requirements
- Existing institutional barriers to change
- Potential positive and negative social feedback
- Lessons learned from existing biomass projects in rural Alaska

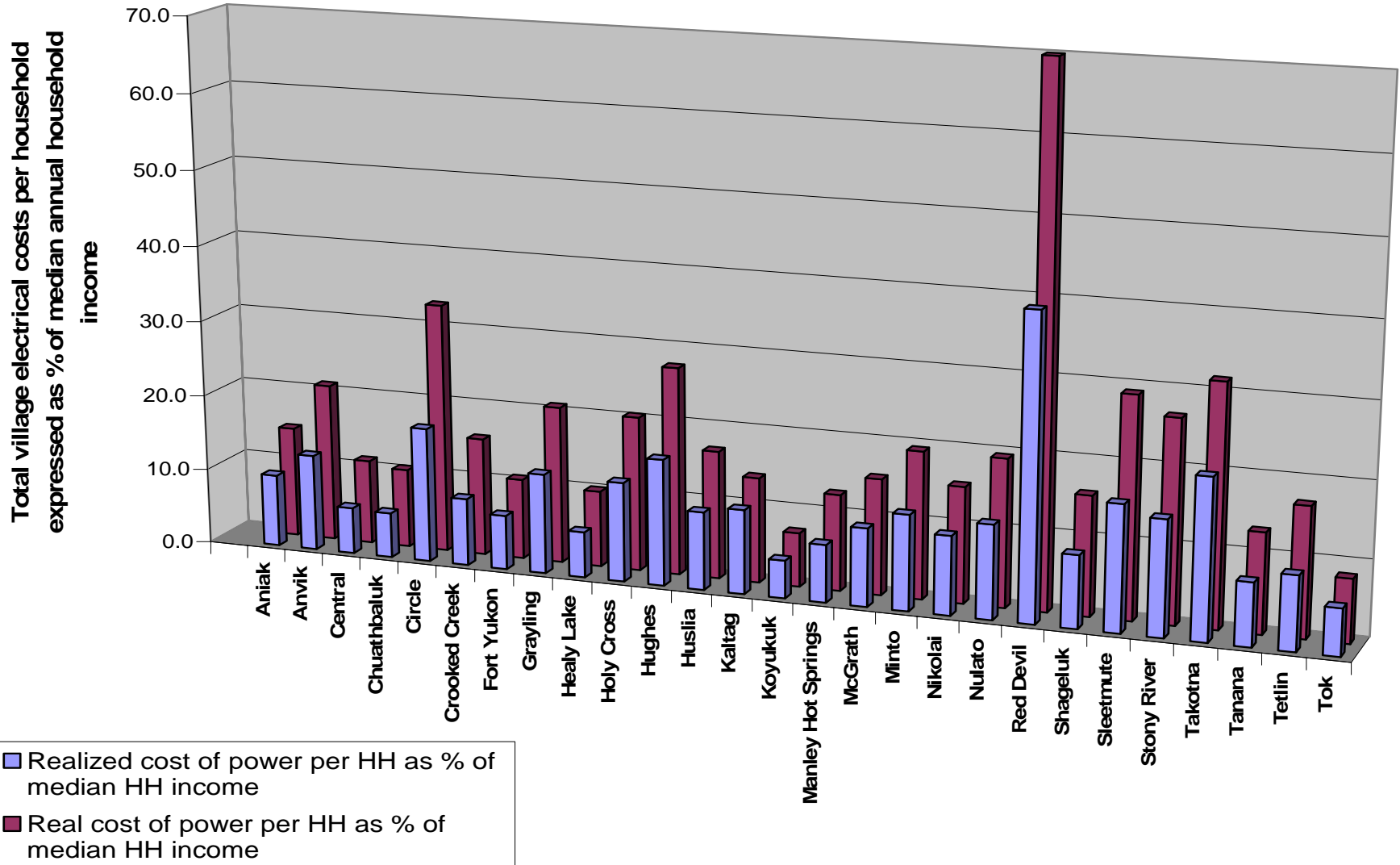
Maximum Travel Distance Required to Supply Fuels Sustainably



Years to Recoup Initial Investment



Cost of Electrical Power (% of household income)



Barriers to Implementation

- AEA funding allocated to diesel power
- State electrical subsidies favor status quo
- Many power cooperatives managed regionally

Thresholds to Feasibility

- Development of necessary leadership and technical skills in villages
- Formation of effective collaboration between agencies, power industry, and villages

Potential Hurdles and Benefits

	Hurdles	Benefits
Economic	Cost of new infrastructure	Wages from fuel gathering
	Cost of biomass harvest	Reduced cost of diesel
	Certification for sustainable wood harvest	Reduced cost of subsidies
		Market value of carbon credits
Social/Political	Political buy-in from agencies and power companies	Health benefits from reduced pollution
	Ensuring local involvement and continuity	Greater autonomy of local communities
Technical/Ecological	Technical challenges of biomass energy generation	Reduced fire risk
		Greater landscape diversity
	Ensuring long-term sustainability of harvest	Creation of diverse wildlife habitat

Pilot Projects

Dot Lake

- wood-fired boiler to heat and power 8 residences and washeteria
- economic savings to the community
- currently in operation

McGrath

- combined heat and power system
- based on analysis prior to increase in fuel prices
- not yet installed



photo by Dan Swift 2005

Dot Lake boiler

Conclusions

- Fuel conversion is likely to be economically and ecologically viable in small remote villages, including 22 villages studied
- Fire protection through fuel harvest might provide a valuable additional benefit for these communities
- Employment in fuel harvesting could potentially complement subsistence lifestyles and/or firefighting jobs
- Social feasibility requires case studies