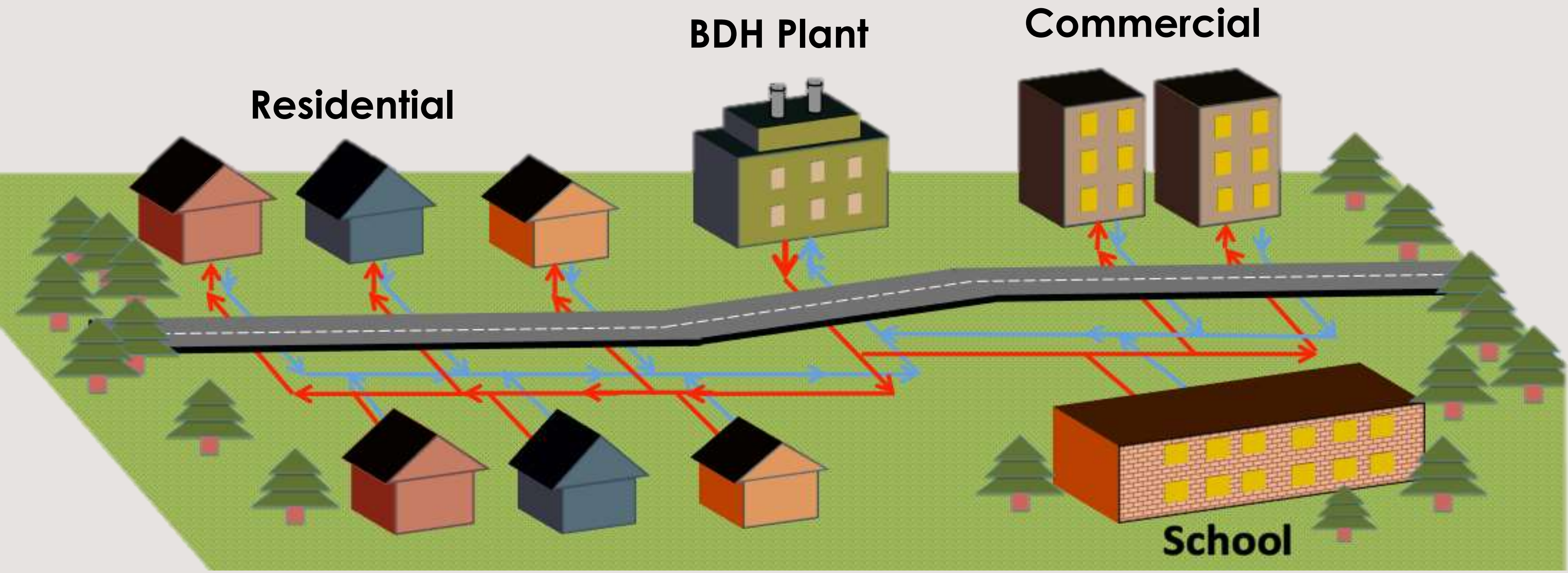
Biomass District Heating in the Tug Hill, New York

Feasibility and Regional Economic Impacts



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Purpose

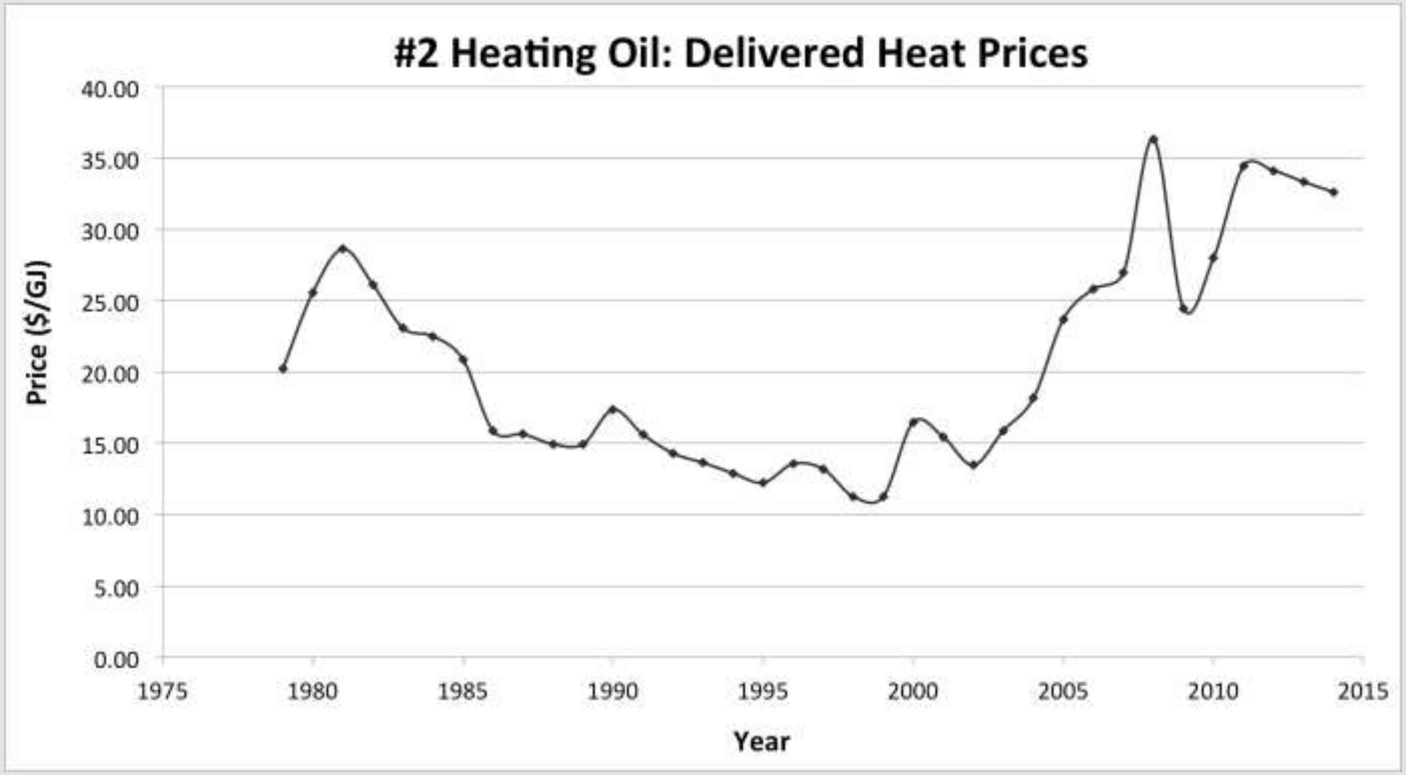
- Look for new ways to utilize the abundant forest resources of the Tug Hill to stimulate the economy

Village	Population	Village Area (km^2)
Barneveld	284	0.49
Camden	2,231	6.34
Castorland	351	0.83
Cleveland	750	2.94
Copenhagen	801	3.07
Holland Patent	458	1.33
Parish	450	4.19
Prospect	291	0.55
Remsen	508	0.99
Sylvan Beach	897	1.79

Problem 1: Economic Conditions

- **Declining forest harvests**
  - 1/3 of the state's sawmills have closed over past 15 years
  - 40% reduction in sawtimber harvests over past 15 years
  - Since 1990, 50% reduction in employment in the Pulp and Paper sector
- **Low industrial presence**
  - Market fluctuations have stronger impact
- **County-wide poverty rate of 15.6%**

Problem 2: Heat Demand



- High annual heat demands
- Erratic Oil Prices
- Annual expenditures for oil leave region (78%)

Opportunity

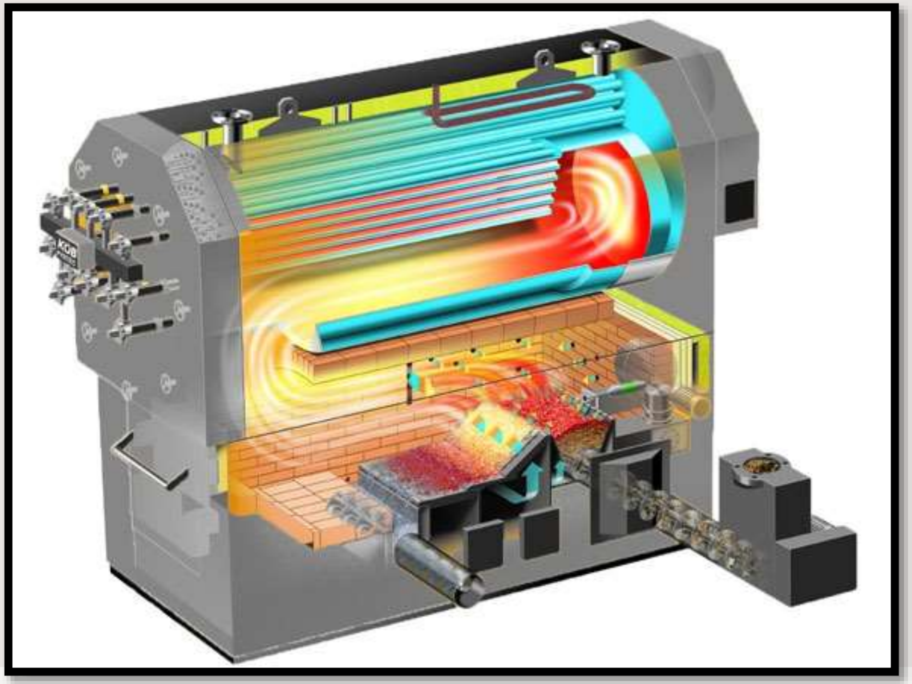
- High abundance of low grade wood
  - Potential to establish secondary market
  - Promote better silviculture

- Wood energy is a predominantly local resource
  - Annual heating expenditures remain in local economy

Opportunity

- Recently improved biomass combustion technologies
  - Allows for greater utilization of wood resources
  - More efficiently meets annual heating demands

Two-stage combustion boilers



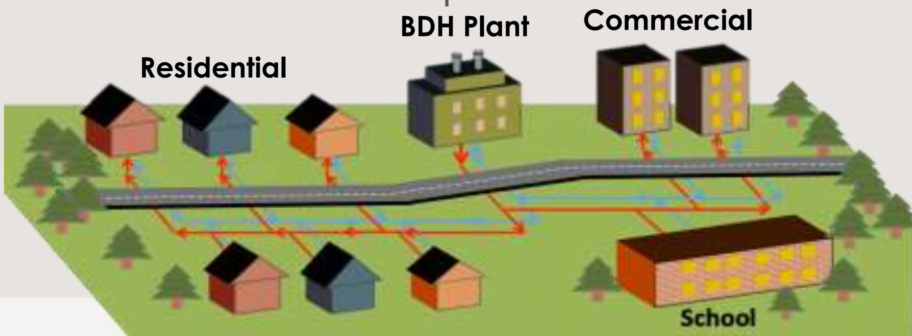
Biomass District Heating

Benefits

- Aggregates Heat Demand
- Allows for utilization of low cost wood chips
  - Low heat density
    - High traffic volume
    - Storage limitations
- Convenience
- Establishes local industry

Drawbacks

- Low heat density in rural areas
  - Distribution network costs can be limiting factor
- High capital costs
- Cost of delivered heat?
- Social acceptance?



Determining Feasibility

METHODS

Annual Village Heat Demands (Q_s)

- Used specific building heat demand data from US EIA following Gils et al. (2013)
  - 78% energy conversion efficiency used (assumes #2 fuel oil use)
- Tax parcel GIS data determined specific buildings present in each village
- 75% village connection rate to the BDH network

Energy Center (Boiler)

- **Peak sizing**

  (Q_s) * (Efficiency losses) * [(Highest Daily HDD / Total yearly HDD) / 24]

  - 75% boiler efficiency
  - 85% distribution network efficiency
  - 64% overall BDH system efficiency

- **Cost estimates**
  - $1,000/kW – $1,700/kW

Picture taken from Becker et al. (2014)

Distribution Network

- **Network Size**
  - Pipe Length

    $L_{spec} = 1207.36 * p_{building}^{-0.5894}$ (m)
  - Pipe Diameter

    $d_a = 0.0486 * \ln(Qs/L) + 0.0007$ (m)

Photos from: Community Energy Association (2014)

- **Cost estimate**

  $C_d = a \cdot (C1 + C2 \cdot da) / (Qs/L)$ (\$/GJ)

Energy Transfer Stations

- **Sized for peak demands**

  (specific building heat demand) * [(Highest Daily HDD / Total yearly HDD) / 24]

- **Costs estimates**
  - $300/kW to $500/kW

Photo from: Community Energy Association (2014)

Biomass Demands

- **Annual Wood Chip Demand**
  - Q_s * Efficiency Losses * 11.5 GJ/tonne
- 64% overall BDH system efficiency
- **Wood Chip Costs**
  - Regional price ranged from $26.50/tonne to $46.25/tonne
  - Price of $42/tonne used

Determining Feasibility

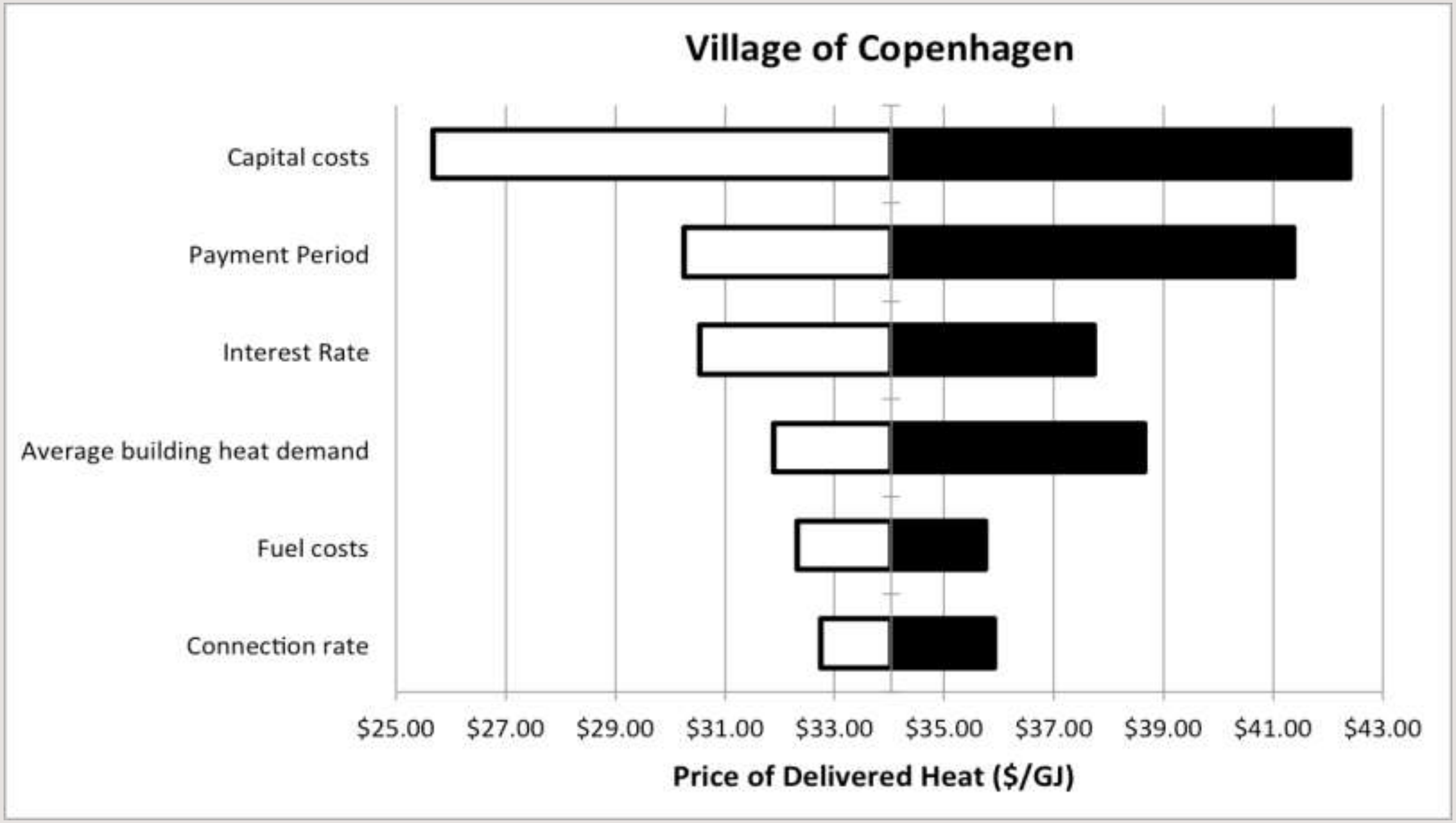
RESULTS

Price of Heat

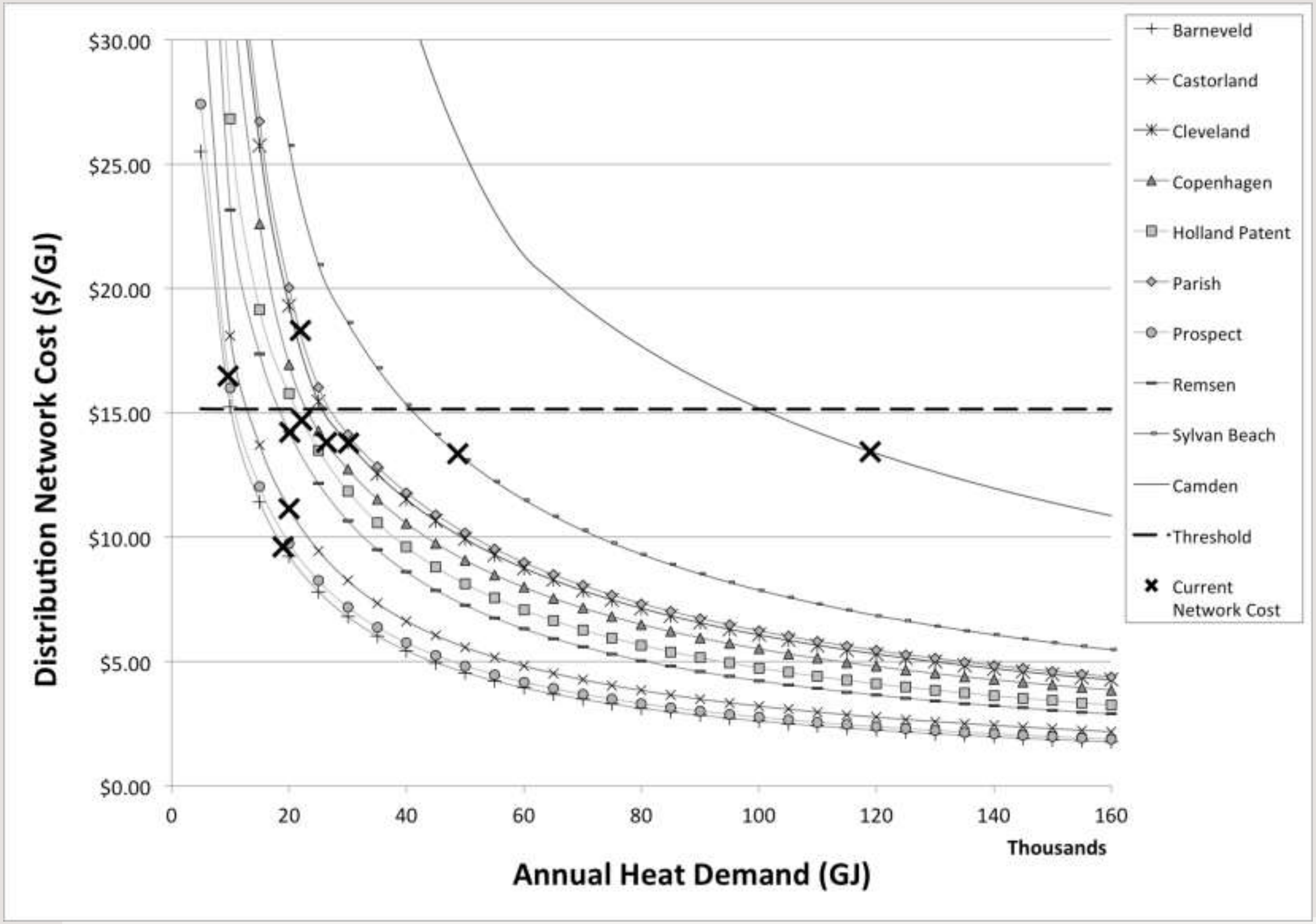
Village	Annual Heat Demand (GJ)	Annual Wood Chip Demand (Metric Tonnes)	Total Annual Cost	Price of Delivered Heat ($/GJ)
Parish	21,904	2,984	$844,568	$38.56
Prospect	9,575	1,304	$351,702	$36.73
Price of Heat Derived from #2 Fuel Oil = $35.22				
Holland Patent	22,160	3,019	$773,741	$34.92
Remsen	20,080	2,735	$691,201	$34.42
Copenhagen	26,330	3,587	$895,979	$34.03
Cleveland	30,126	4,104	$1,024,172	$34.00
Camden	119,008	16,211	$4,005,245	$33.66
Sylvan Beach	48,673	6,630	$1,634,146	$33.57
Castorland	20,016	2,727	$627,127	$31.33
Barneveld	18,960	2,583	$564,813	$29.79

- **Oil derived heat does not include capital**
  - Every $1,000 invested raises oil fired heat price $1.05/GJ
- **Results comparable to other studies**
  - Gils et al (2013): Natural gas CHP networks delivered heat for NYS region between $20.81/GJ-$37.01/GJ
  - Sherman (2013): Feasibility assessment for Fleischmanns, NY generated estimates of $37.47/GJ-$38.83/GJ
- **45,883 tonnes of wood chips demanded annually**
  - Represents <5% of harvests residues available each year in Lewis, Oneida, and Oswego Counties
  - Equivalent to 1.1% annual NYS pulpwood, chip, and firewood harvests

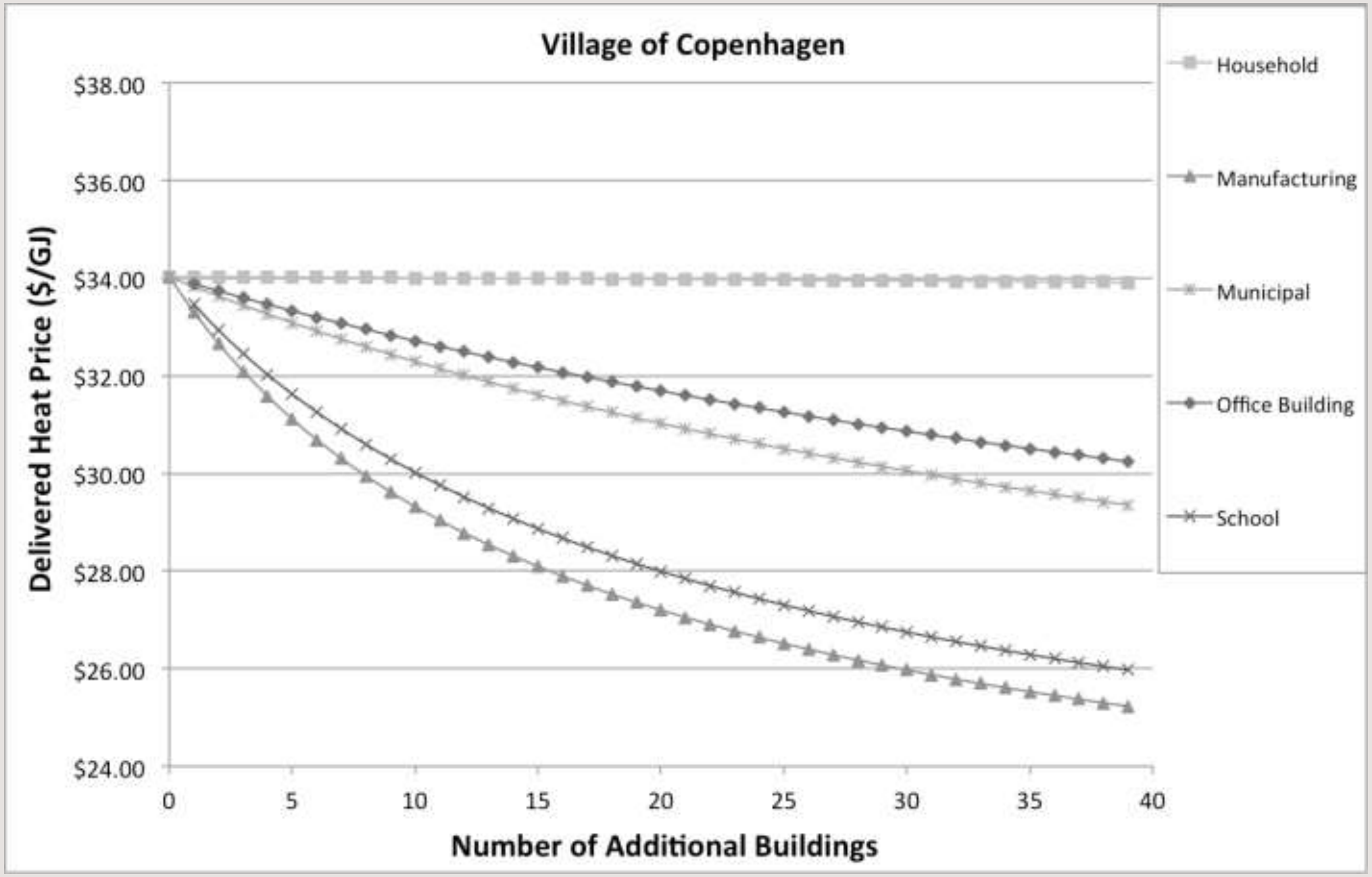
Factors Influencing Heat Price



Factors Influencing Heat Price

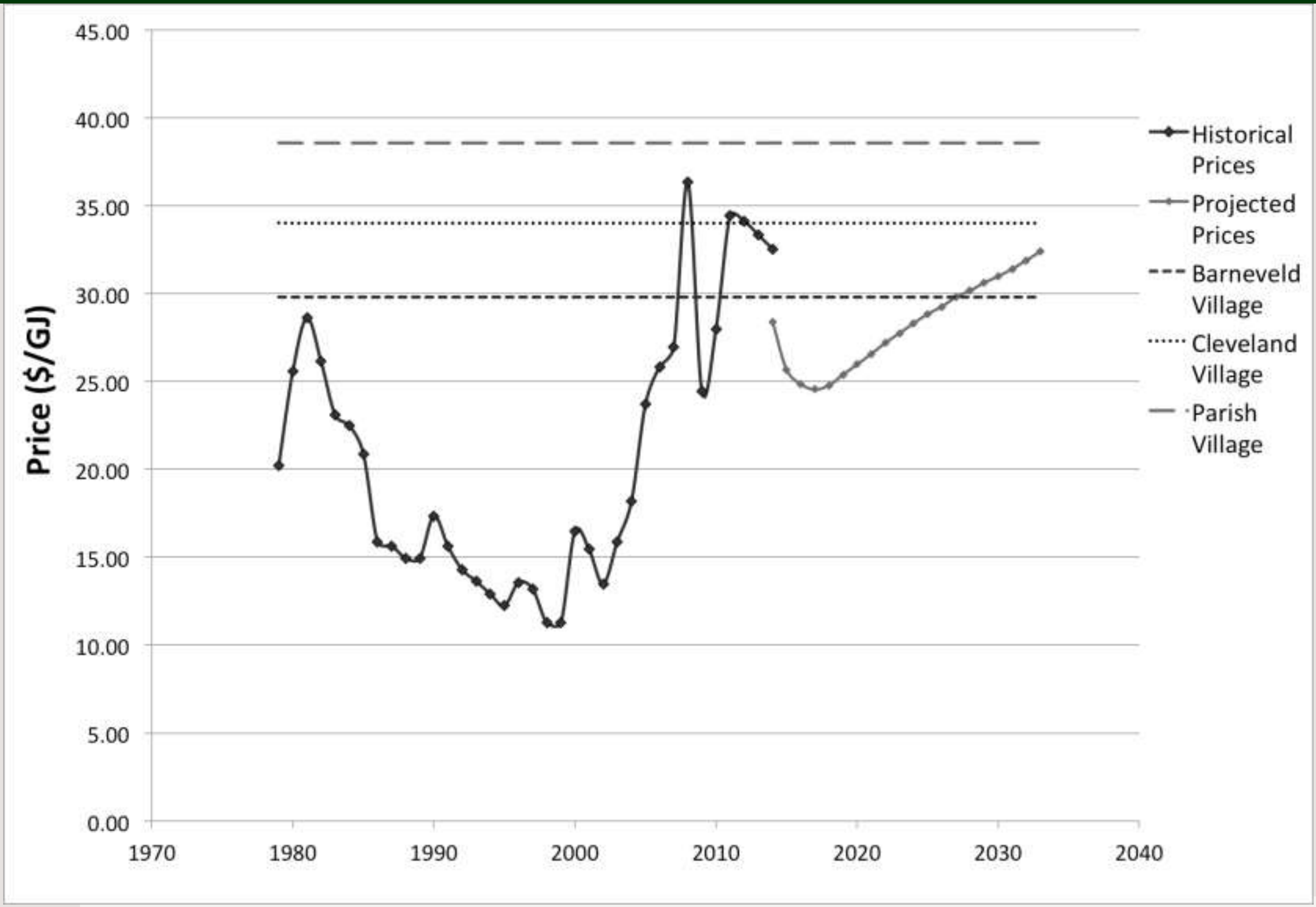


Specific Building Heat Demands



- Roughly 100 GJ/building needed for profitable marginal connection (Average across all villages)
- Although not beneficial at the margin, households add to overall village heat density necessary for a village level network

#2 Fuel Oil Price Projections



Economic Impact Analysis

THEORY AND METHODS

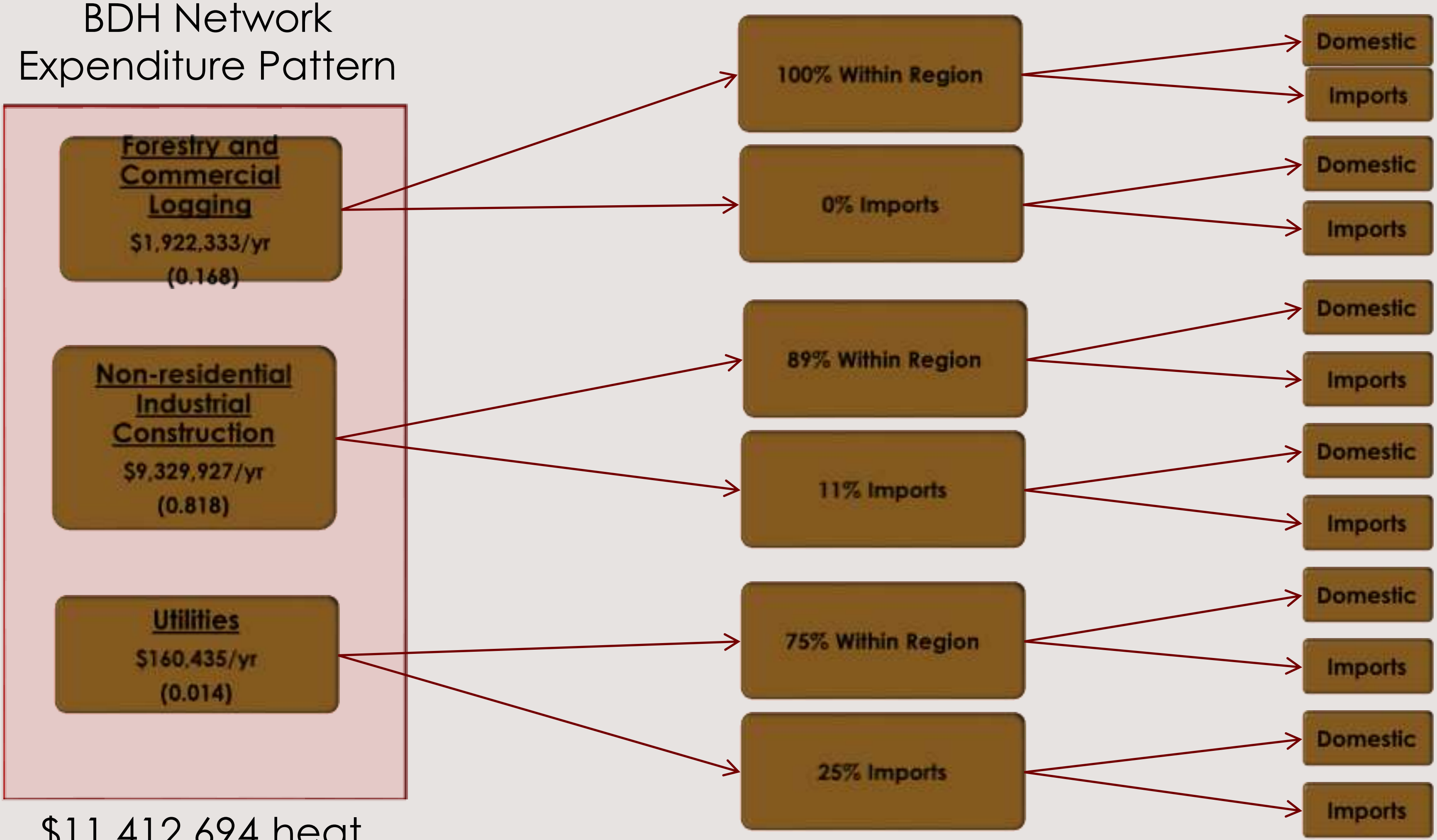
Economic Impacts of BDH

- The goal is to capture the "total effect" of BDH on the regional economy
- "You've got to spend money to make money"
  - Following the dollars through the regional economy

The economic ripple effect

Following the Money:
The expenditure pattern approach

BDH Network Expenditure Pattern



$11,412,694 heat delivered annually

Modeling Economic Impact

RECEIPTS	EXPENDITURES				
	Activities	Factors	Inst	Exports	Total Output
Activities Ind 1 Ind 2 . . . Ind n	T_{11}	0	T_{13}	T_{14}	q_1
Factors EC PI OPI	T_{21}	0	0	T_{24}	q_2
Inst HH Cap Ent Govt	T_{31}	T_{32}	T_{33}	T_{34}	q_3
Imports	T_{41}	T_{42}	T_{43}	T_{44}	q_4
Total Outlays	q'_1	q'_2	q'_3	q'_4	

$$x = [(I-A)^{-1} d_i]\beta = Lf$$

Economic Impact Analysis

RESULTS

Economic Impacts of BDH

Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	N/A	N/A	N/A	N/A
Indirect Effect	98.0	$4,029,382	$6,019,005	$13,137,926
Induced Effect	45.3	$1,814,746	$3,495,822	$5,531,880
Total Effect	143.3	$5,844,128	$9,514,827	$18,669,806

Each $1 million invested:

- 12.5 jobs
- $1.64 million in output

Major industries affected

1) Construction of new non-residential industrial (63 jobs, $9.2 million output)
2) Forestry and Logging (23 jobs, $2.2 million output)
3) Real Estate (2.3 jobs, $1 million output)

Tax generation

- $809,656 in state and local taxes
- $1,293,834 in federal taxes

Heat cost savings ($500,000/yr across region)

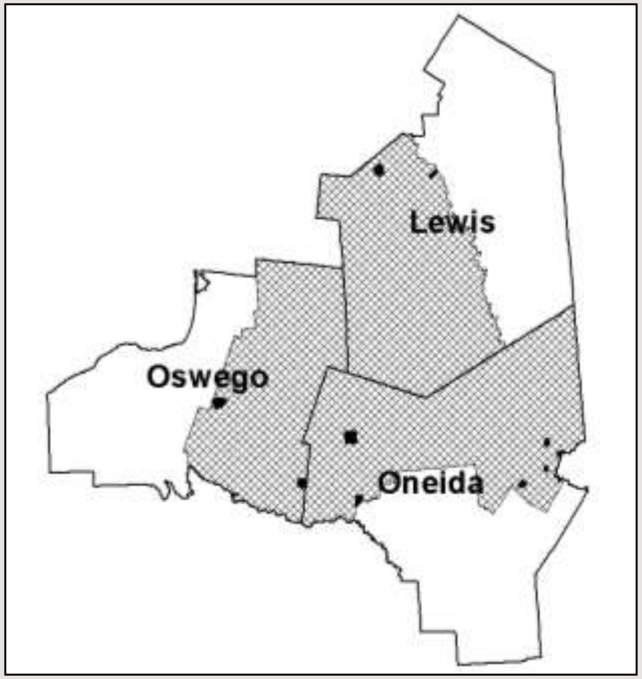
- Significant in comparison to total village assets (11% - 32%)
- Small at income level: $375/person/year

Limitations

- **Expenditure Pattern Approach**
  - No BDH networks to model expenditure pattern after
  - Loss of endogenous impacts
- **Model scale**
  - Larger areas expand inter-industry connections, thus increasing economic impact
  - What portion of the economic impact is centered around study villages?
    - Oswego? Utica?

Villages vs. Model Region

7,021 people vs. 272,899 people
23 km^2 vs. 8,939 km^2



Further Considerations

Implications

- **Pre-feasibility tool for policy analysis**
  - Easily replicable, remote study
- **BDH and Rural development**
  - Silver buckshot, not silver bullet
- **Focus on specific applications**
  - Downtown areas, school and surrounding neighborhood
- **Other renewable energy technologies?**
  - Citing appropriate technology
  - Comparing efficiency and efficacy

Future Research

- **Sizing boiler, determining costs**
- **Need for more empirical data on BDH**
  - Network, boiler, ETS cost
  - Establishing expenditure pattern
- **Modeling economic impacts in rural regions**
- **Comparison to other renewable energy incentives**
  - Efficacy? Efficiency?
  - Appropriate technology?

Conclusion

- BDH can provide stable, low cost heat and stimulate the economy of the ten study villages and the surrounding region.