



Geothermal-Enabled Zero Energy Electric Community

An Integrated System Design Study

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The Cold-Climate Zero Energy Problem

Zero Energy construction is defined by a mix of efficiency and renewable generation, so that annual primary/source energy use is offset by on-site production.

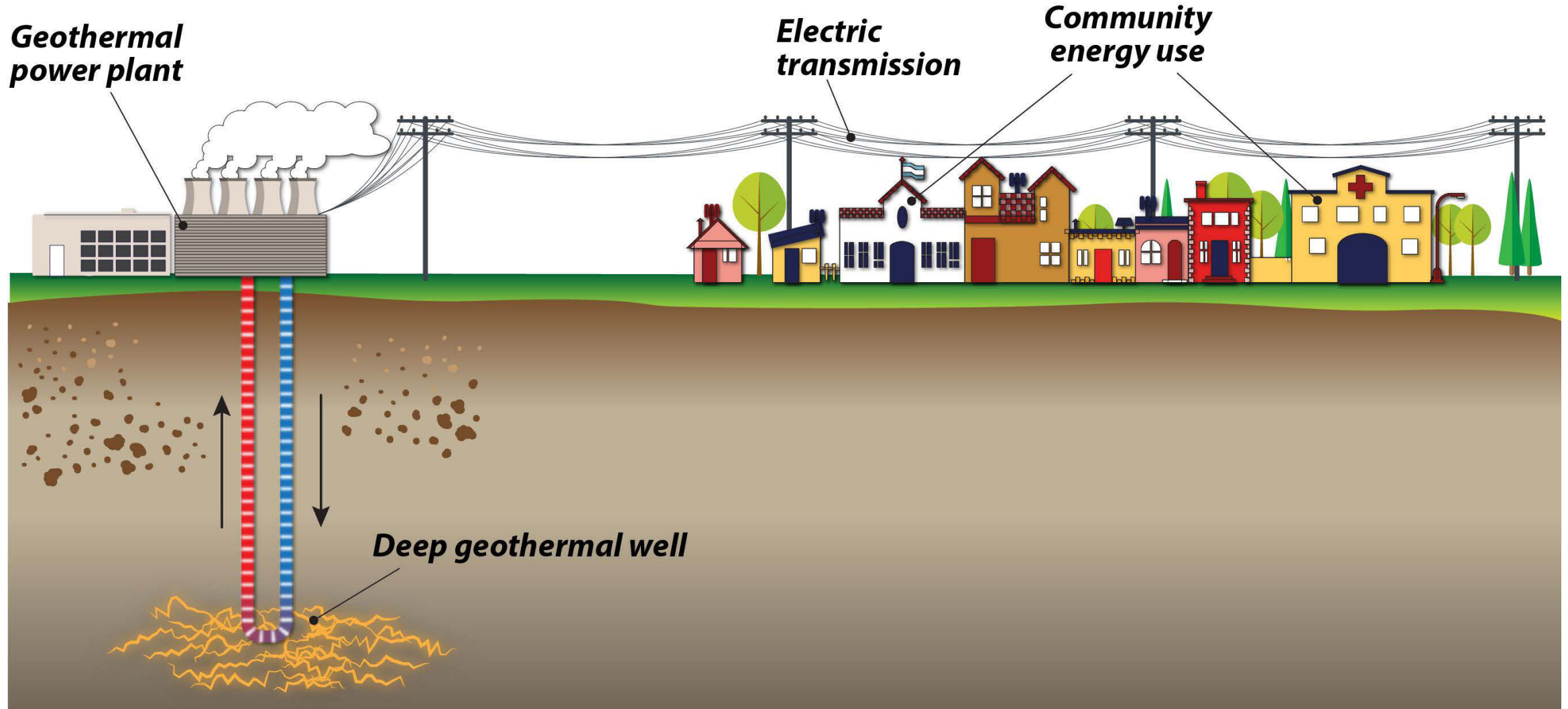
In cold climates:

- Very cold weather = High heating load
- High heating load = Efficiency gets expensive
- Lower solar resource = PV economics are worse
- High solar generation in summer (poorly aligned with winter energy demands) = energy storage is not economically feasible

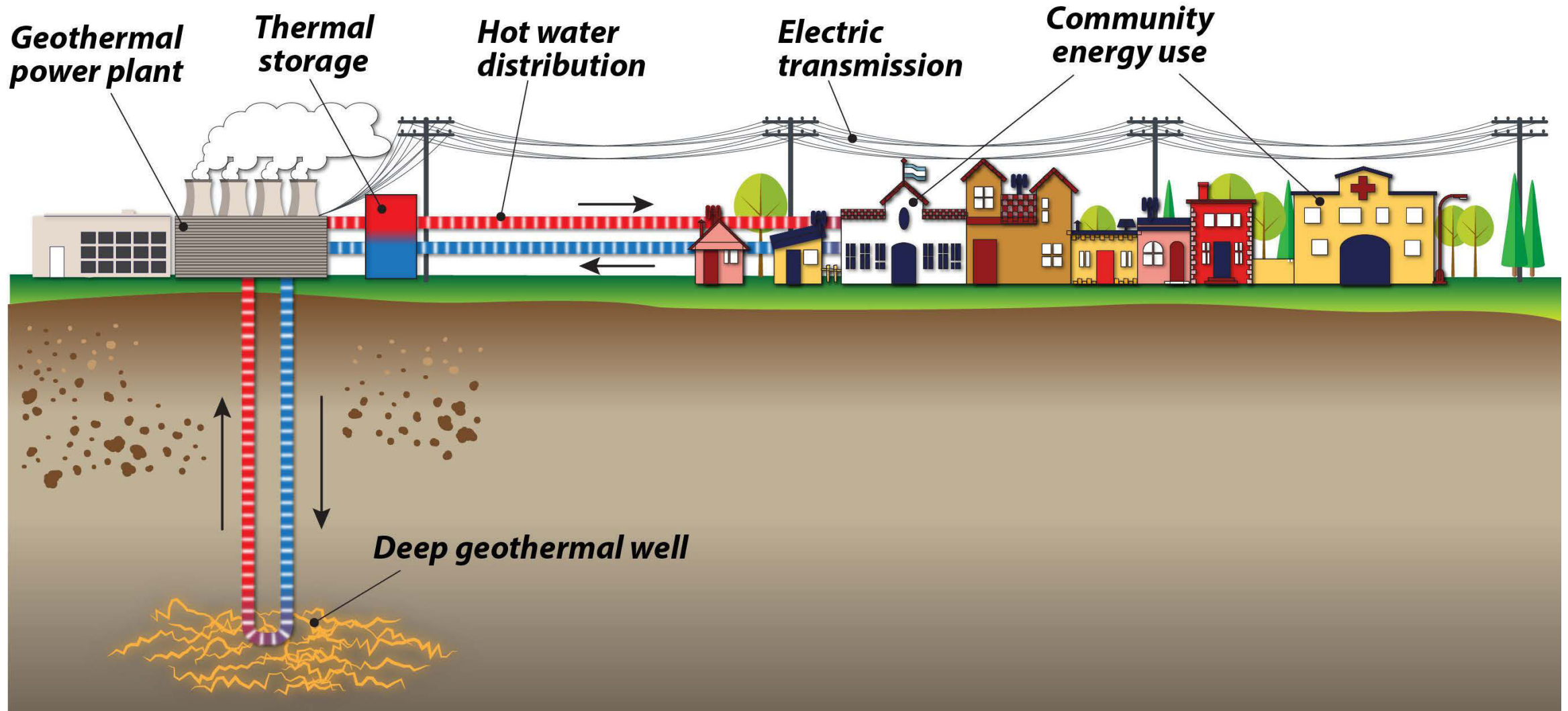


Key research question: Can geothermal resources cost-effectively support the energy needs (electric and thermal) of a cold-climate community? If so, what are the governing parameters—and technoeconomic limitations which could be overcome—to enable this market for geothermal?

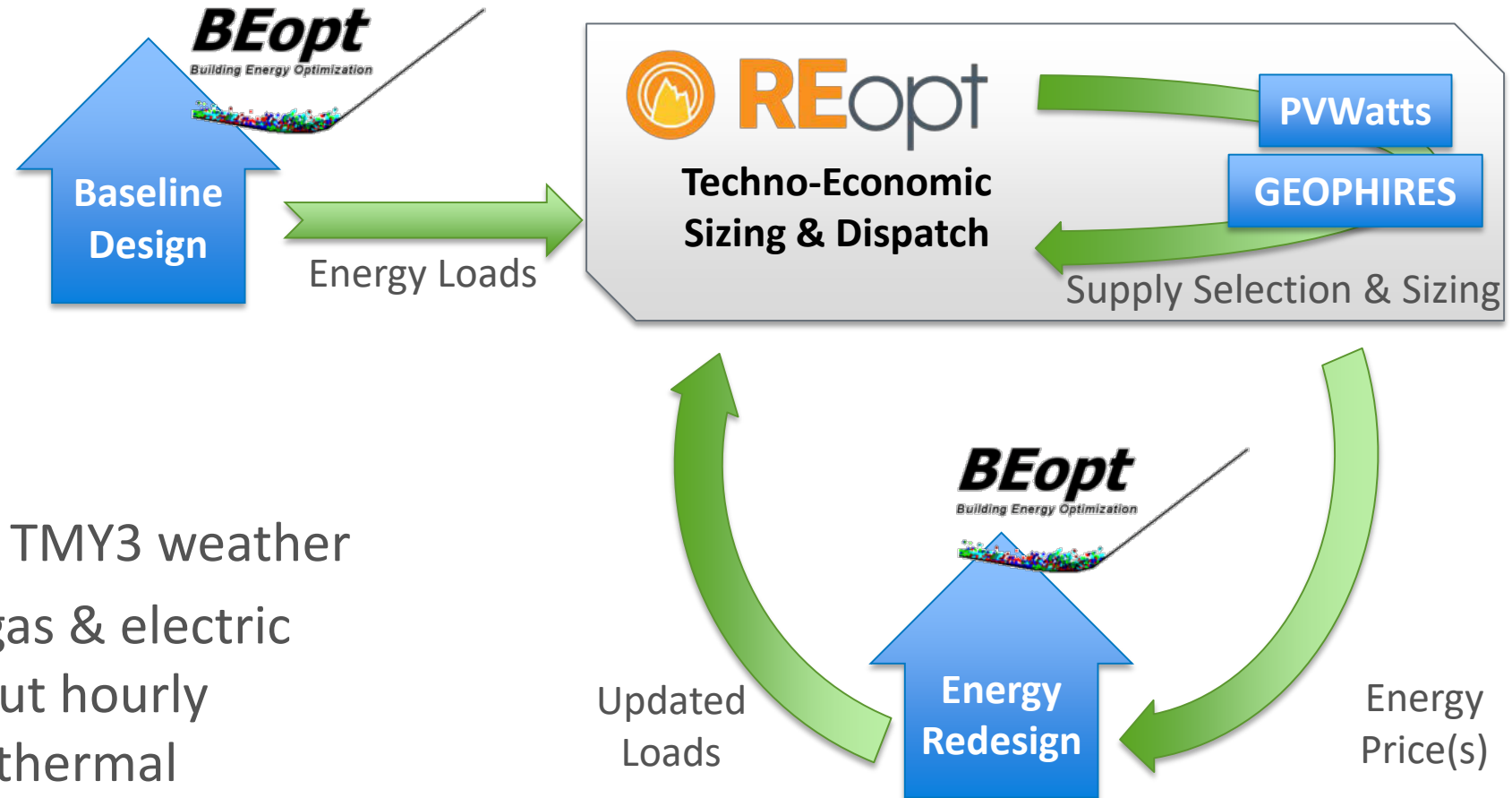
All-Electric Load and Supply Diagram



Electric + Thermal Supply and Load Diagram

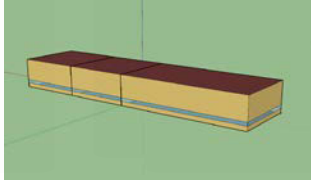
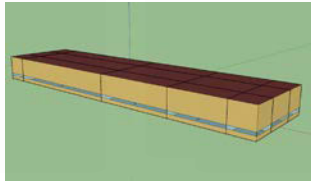
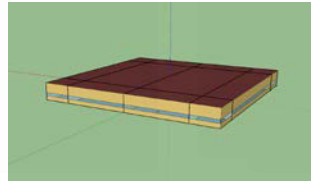
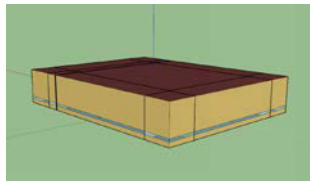


Research Process








- Pocatello, ID TMY3 weather
- All electric, gas & electric cases – output hourly electric and thermal demand

Suburban Community Design

Commercial	Building	Retail Strip Mall 1	Retail Strip Mall 2	Retail + Restaurant	Retail Standalone
	Area/Building (ft ²)	5,000	10,000	10,000	10,000
	Count	1	1	1	1
	Area %	1.4%	2.9%	2.9%	2.9%
	Electric Load (MWh/yr)	47.83	101.53	459.89	95.07
	Electric Load %	1.8%	3.8%	17.4%	3.6%
					

Commercial

- 7 building archetypes (retail, food, office)
- Started with pre-built models from a NZE community currently in construction in Denver, CO (climate zone 5b)

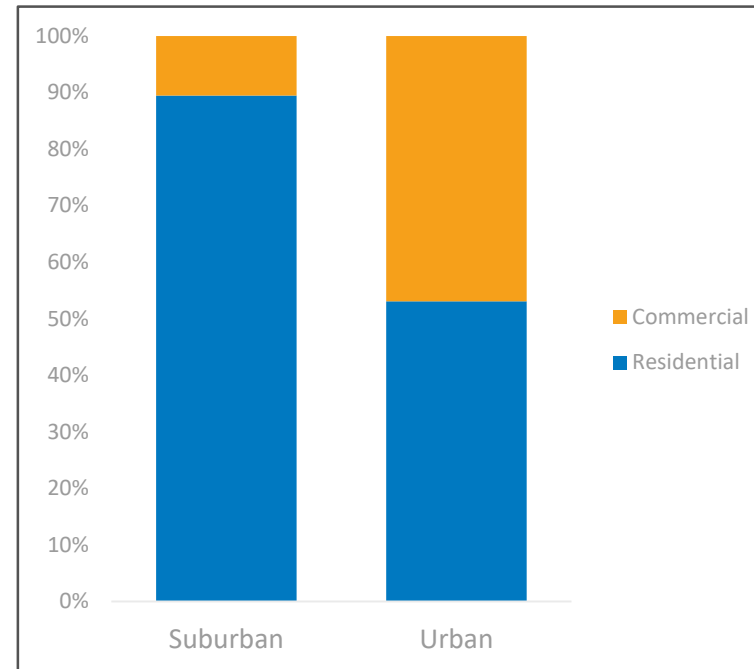
Residential	Building	Large Home	Mid-Sized Home	Small Home	Duplex	Townhome
	Area/Building (ft ²)	3,024	2,016	1,020	2,040	9,000
	Count	30	30	30	20	10
	Area %	26.1%	17.4%	8.8%	11.7%	25.9%
	Electric Load (MWh/yr)	425.36	389.95	291.63	330.38	499.27
	Electric Load %	16.1%	14.8%	11.0%	12.5%	18.9%
						

Residential

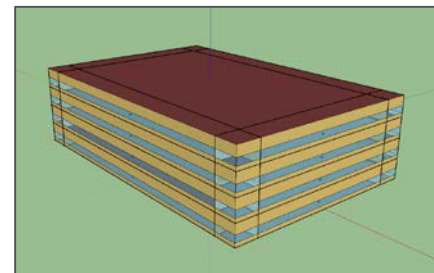
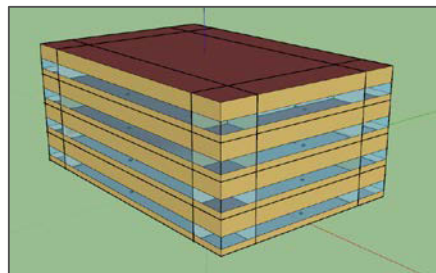
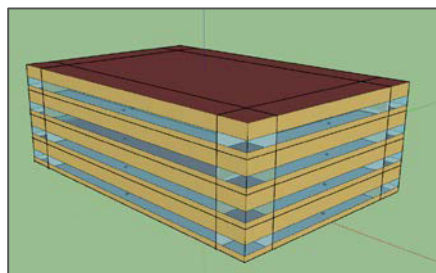
- 5 building archetypes (detached, attached, multifamily)
- Starting point: IECC 2012 – adopted code in Idaho
- Optimized with **BEopt** to determine net-zero energy buildings' energy demand

Suburban vs Urban Communities

		Suburban	Urban
Commercial	Retail Strip Malls	5%	2%
	Retail Standalone	3%	1%
	Retail + Restaurant	3%	2%
	Office Space	0%	41%
Residential	Single-Family Detached	52%	0%
	Single-Family Attached	38%	11%
	Multifamily Apartment	0%	42%

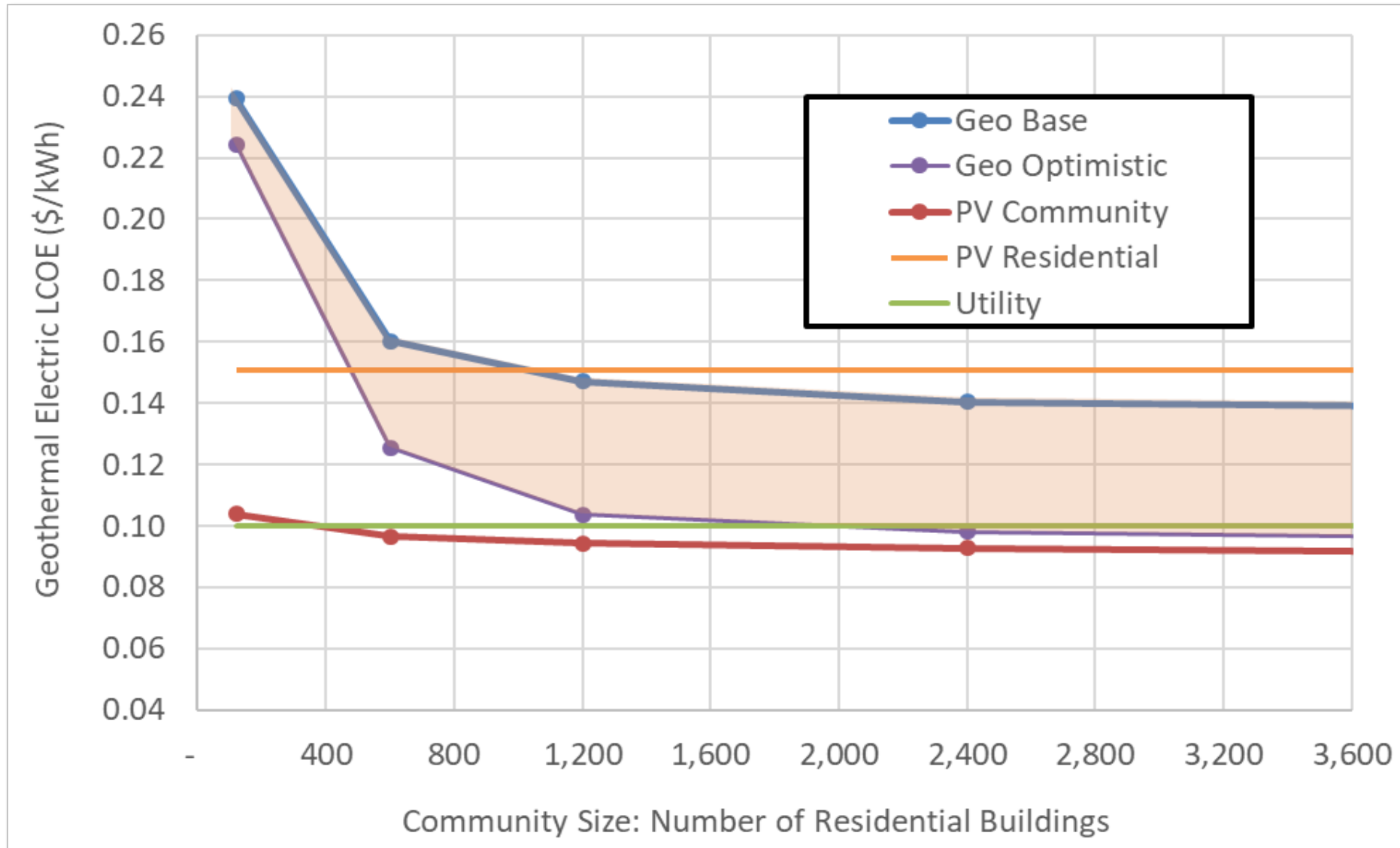


Urban community includes office buildings:



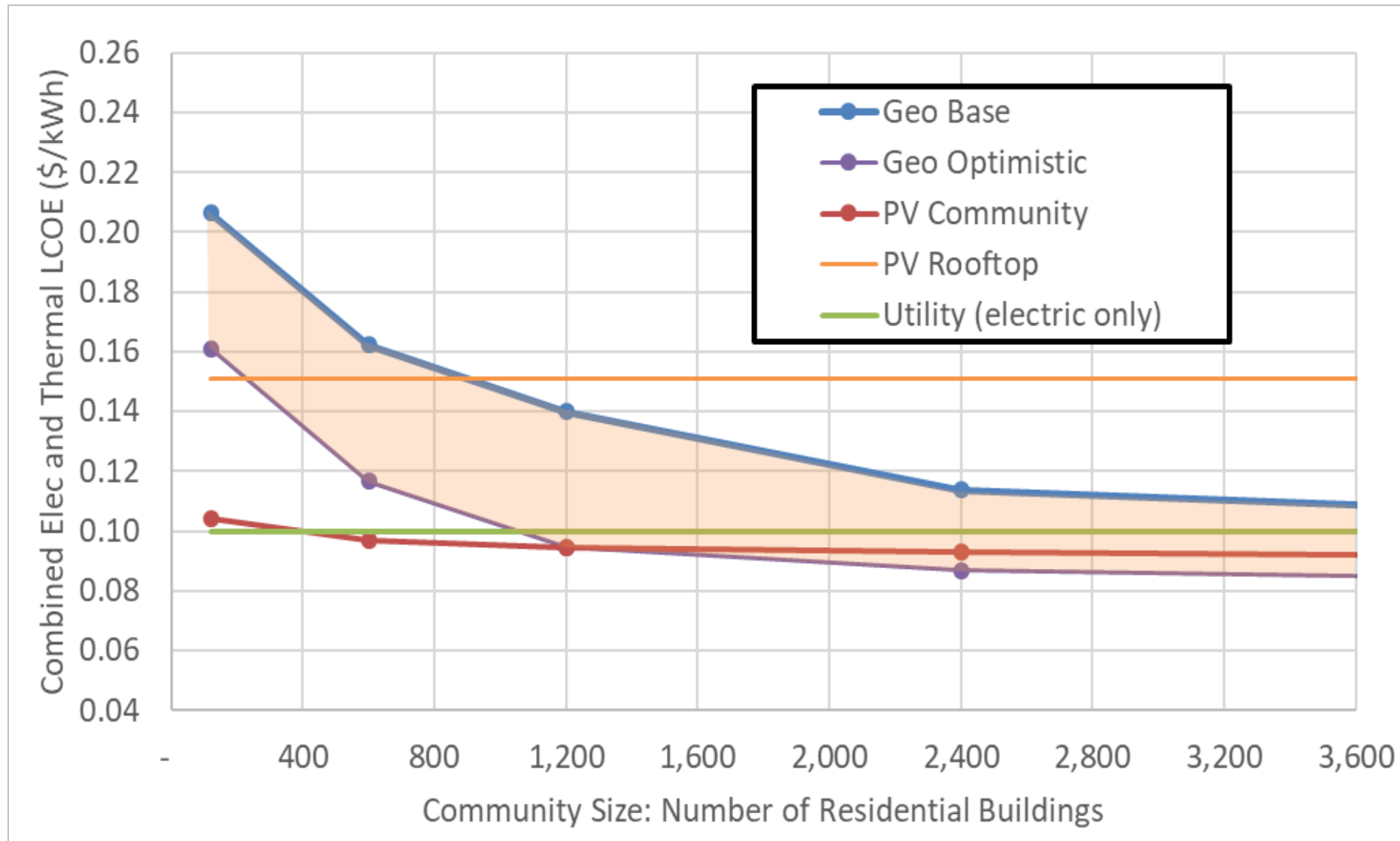
Results: Levelized Cost of Energy

Electric Utility, no Direct Use



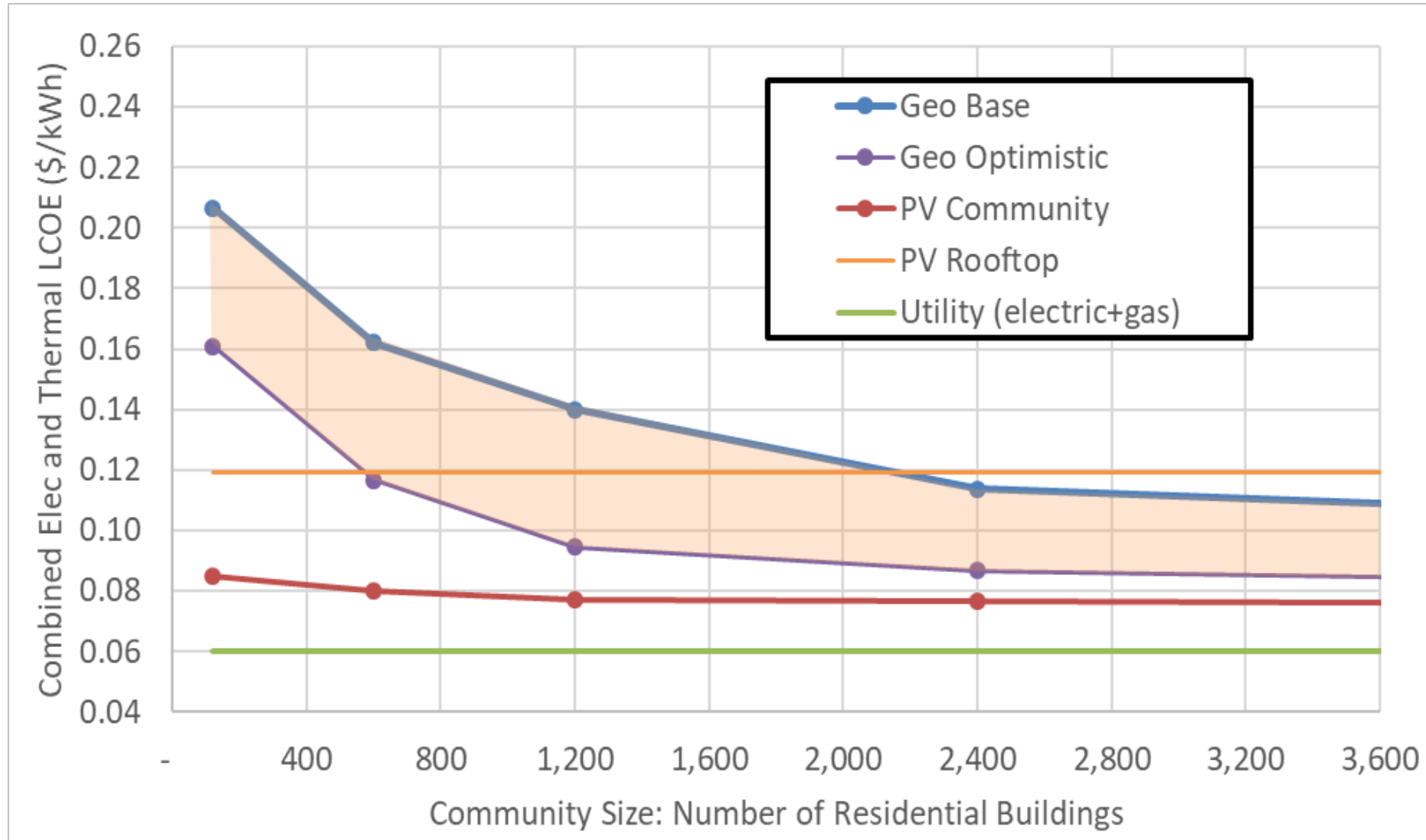
Results: Levelized Cost of Energy

Electric Utility, with Direct Use



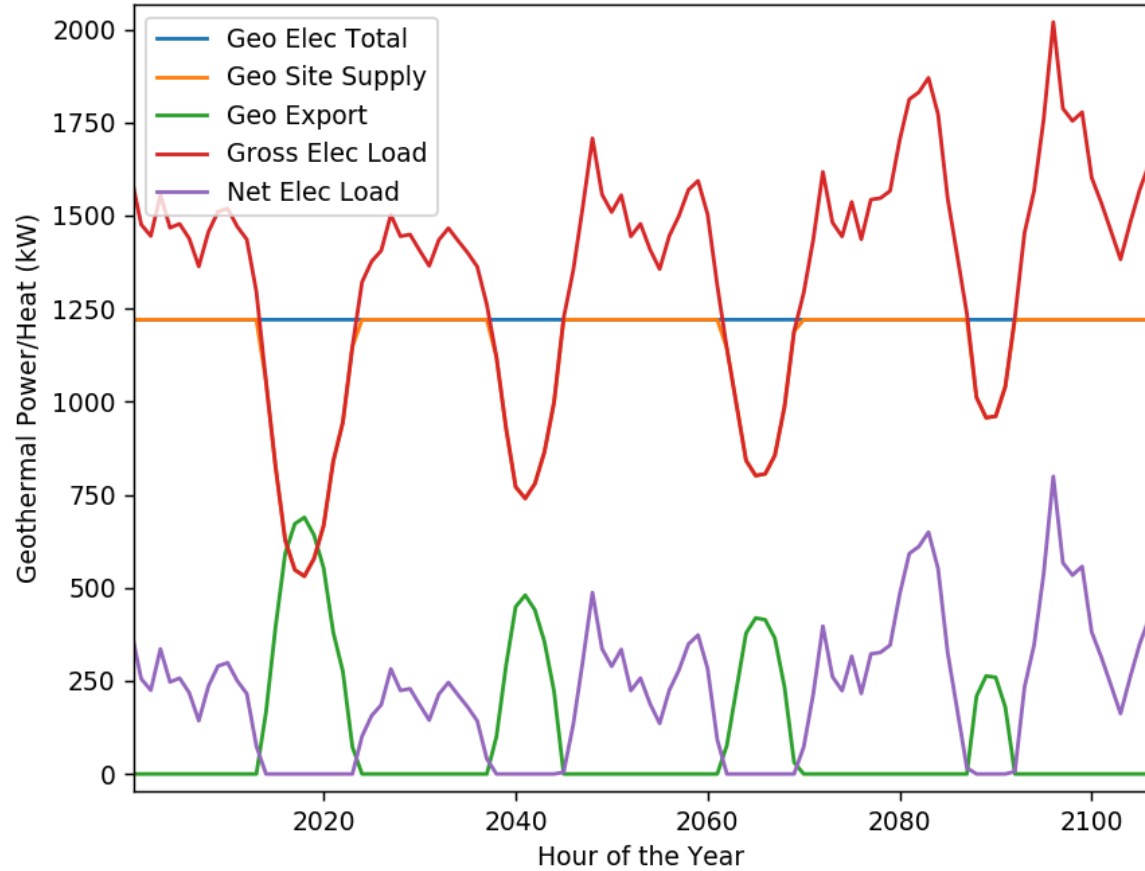
Results: Levelized Cost of Energy

Electric+Gas Utility, with Direct Use

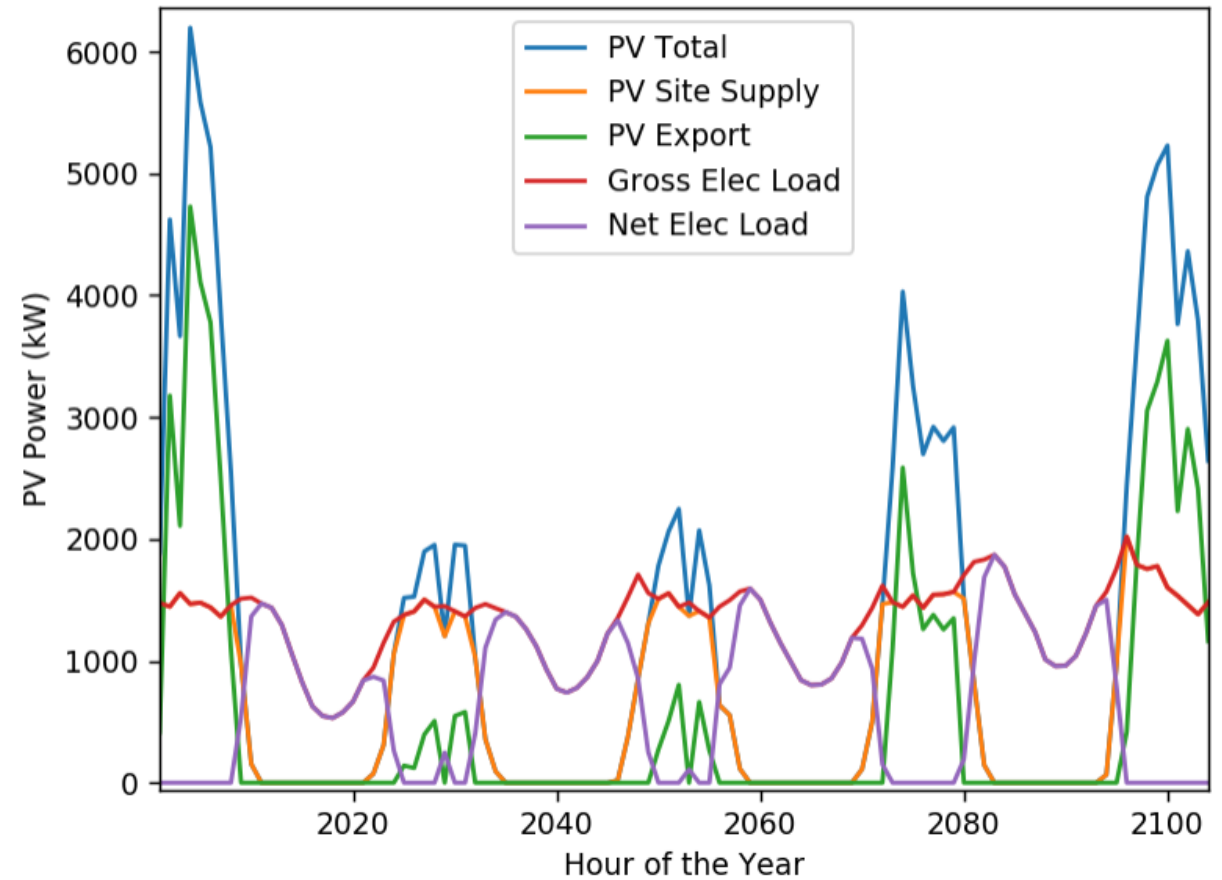


Dispatch Examples

Geothermal Dispatch

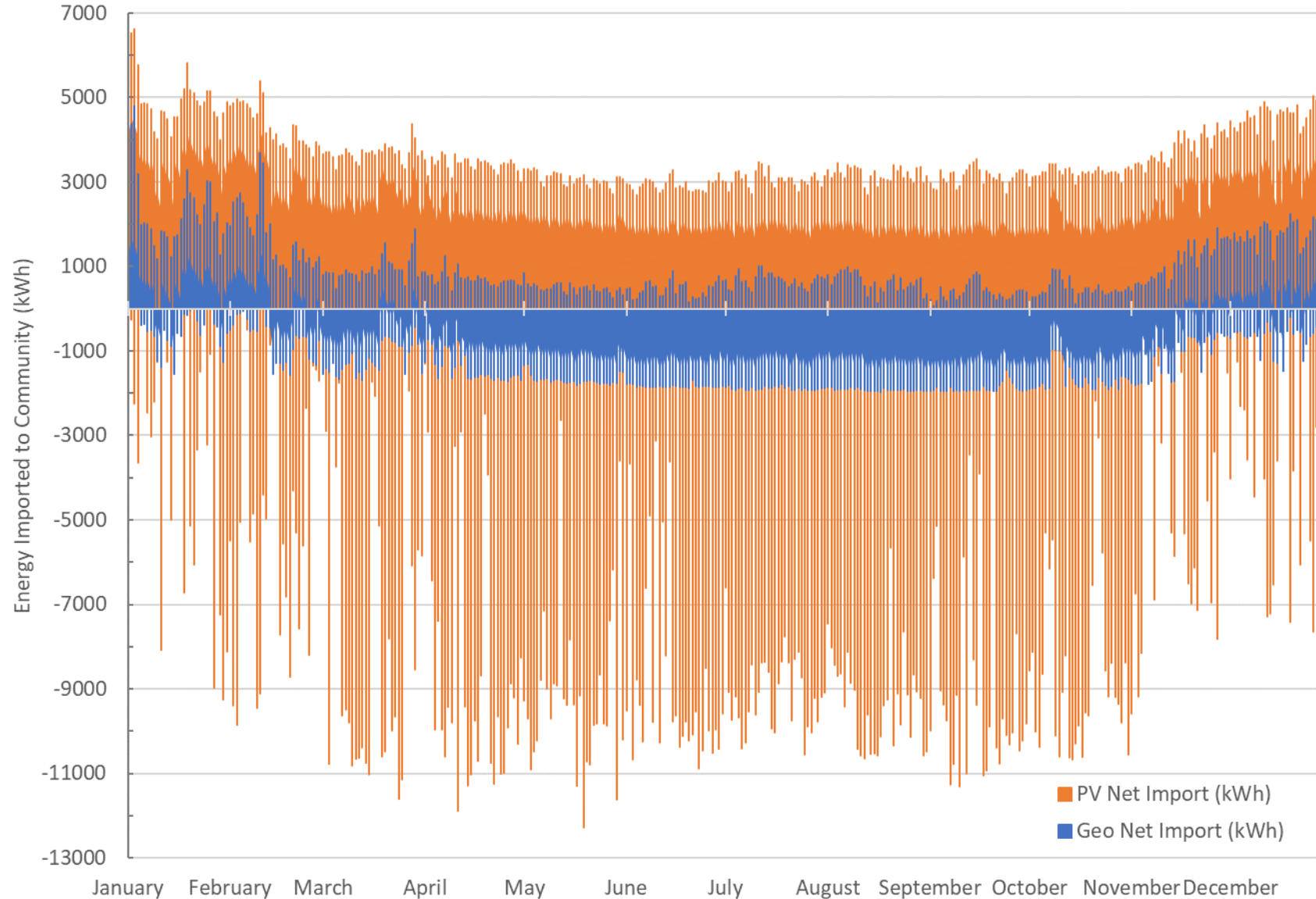


PV Dispatch



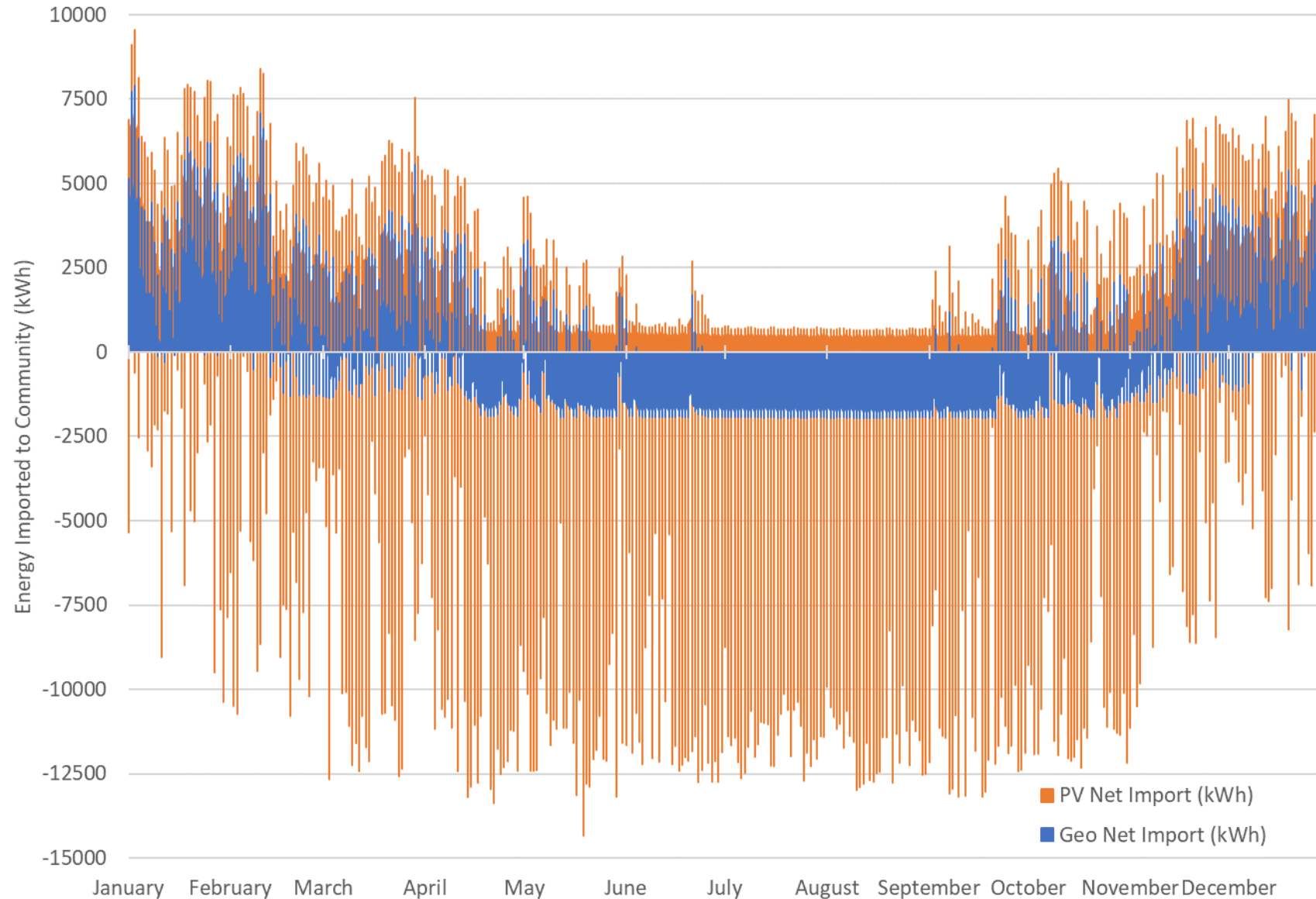
Grid Impacts – Annual Import/Export Comparison

Electric Utility, no Direct Use



Grid Impacts – Annual Import/Export Comparison

Electric+Gas Utility, with Direct Use



Summary of Findings

All-Electric Community

- At ZNE community sizes above 1,100-homes, geothermal is more cost-effective than rooftop PV
- With excellent reservoir conditions, geothermal power can be competitive at smaller delivered capacities

Grid Impacts

- Geothermal power supply is a much better match to energy demands of a community, reducing impacts on power grid

Electric+Direct Use Community

- Geothermal is still challenged to compete with natural gas for building heating
- If gas supply is not available, geothermal cogeneration can be very cost-competitive
- Community sizes above 2,200 still show benefit from using geothermal power and thermal generation, vs. rooftop PV
- Thermal energy storage is beneficial for reducing well sizes

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Thank you!

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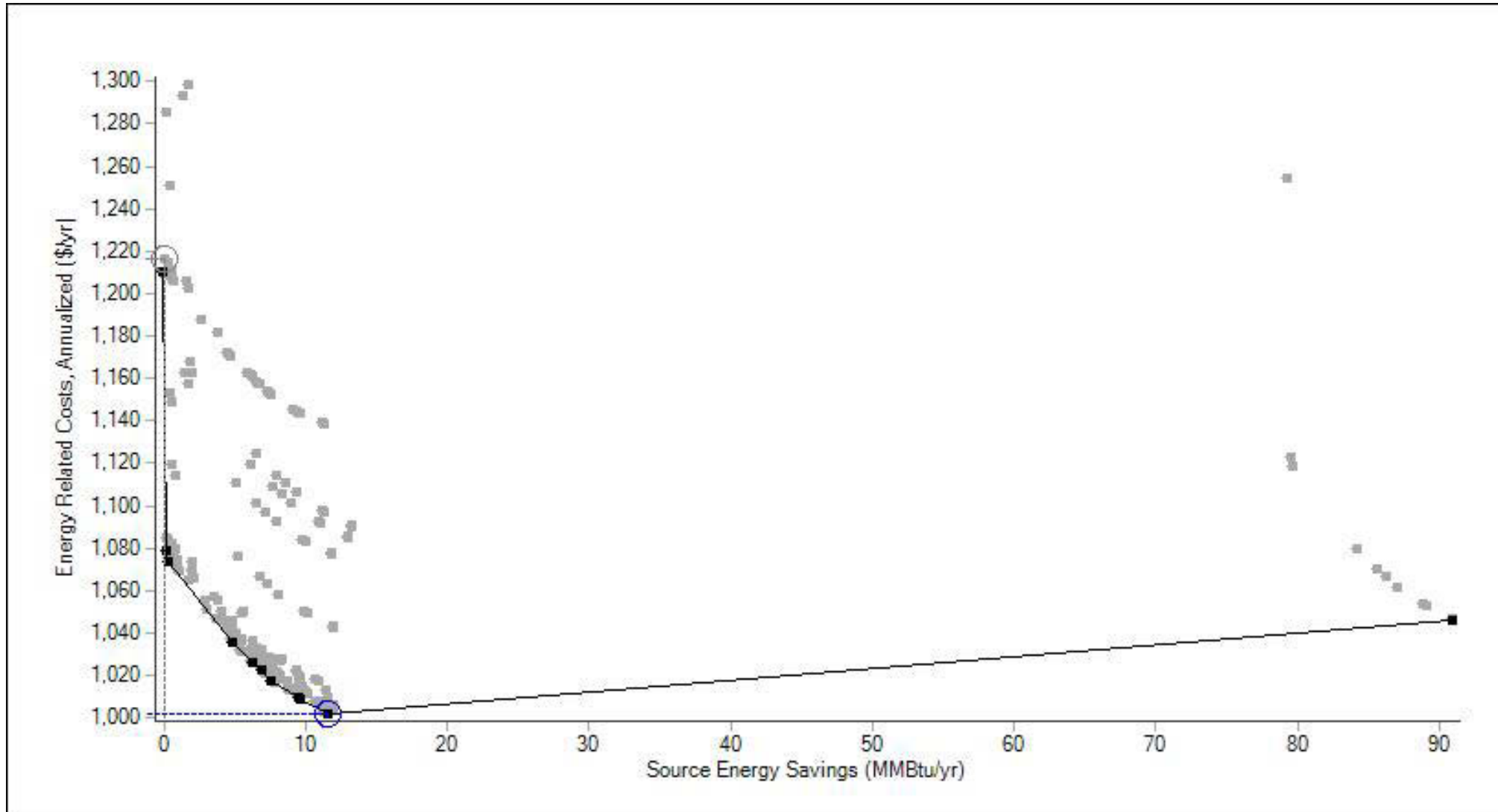
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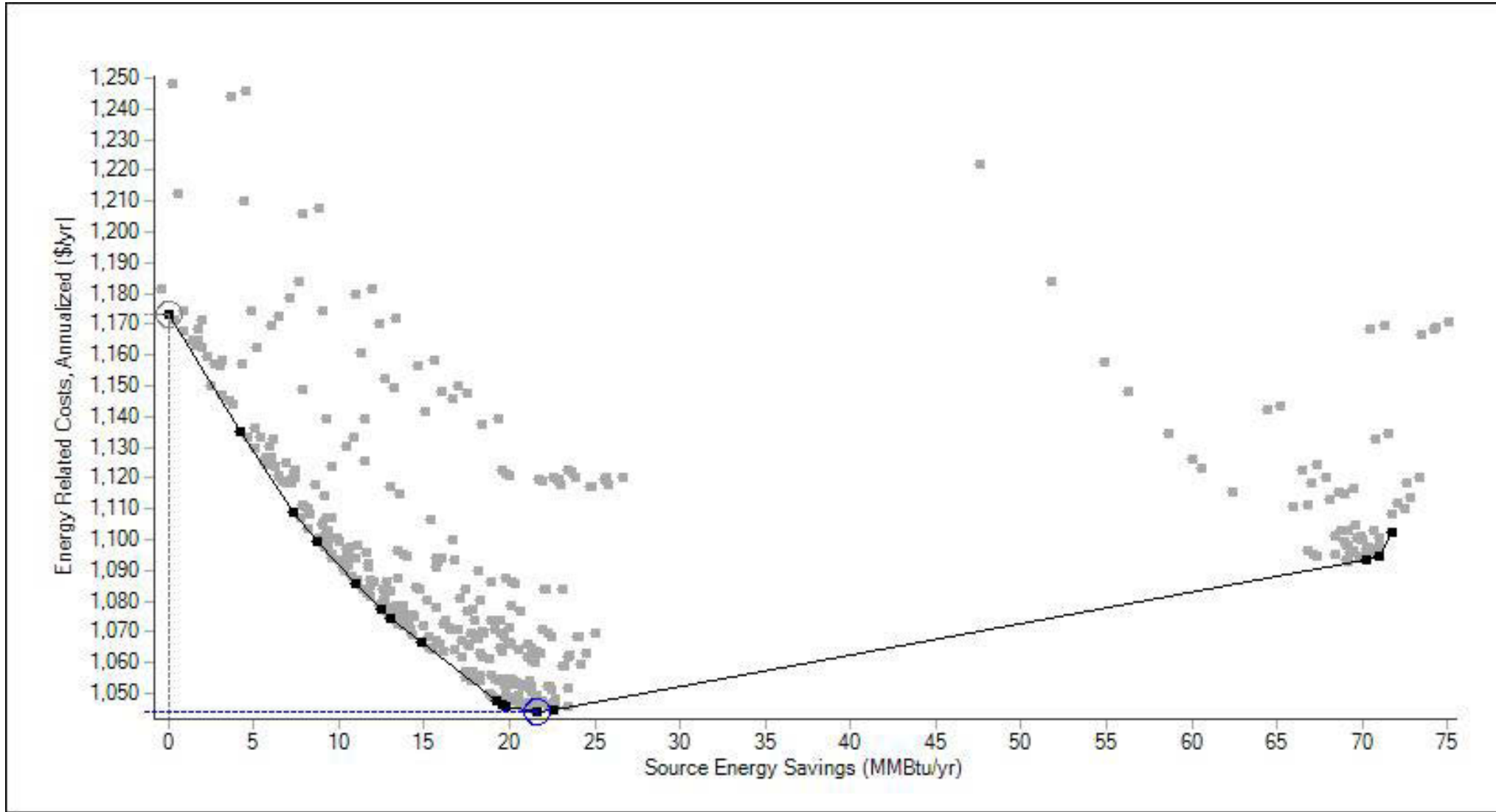


Supplementary Material

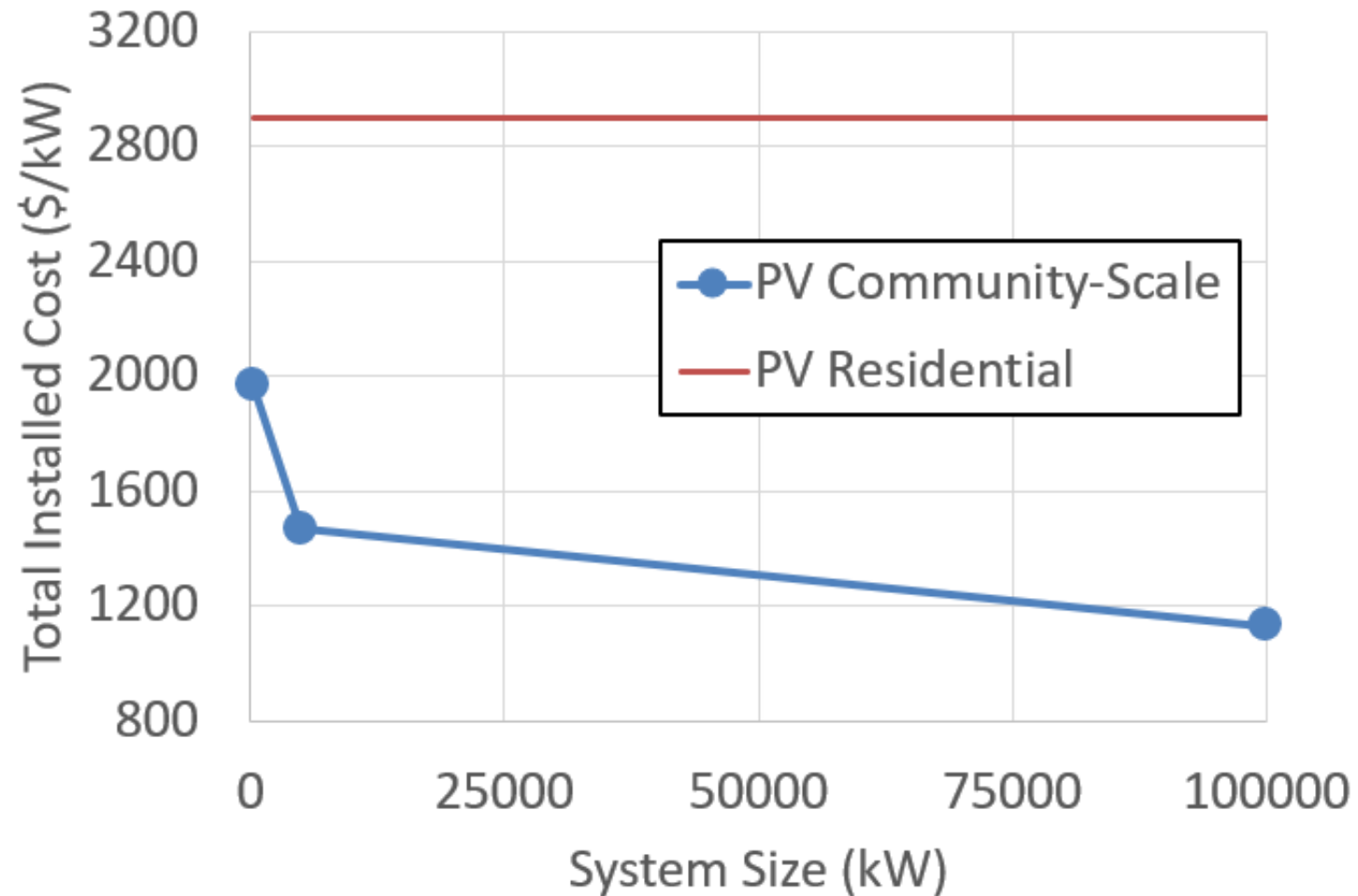
BEopt Efficiency Optimization: All-Electric



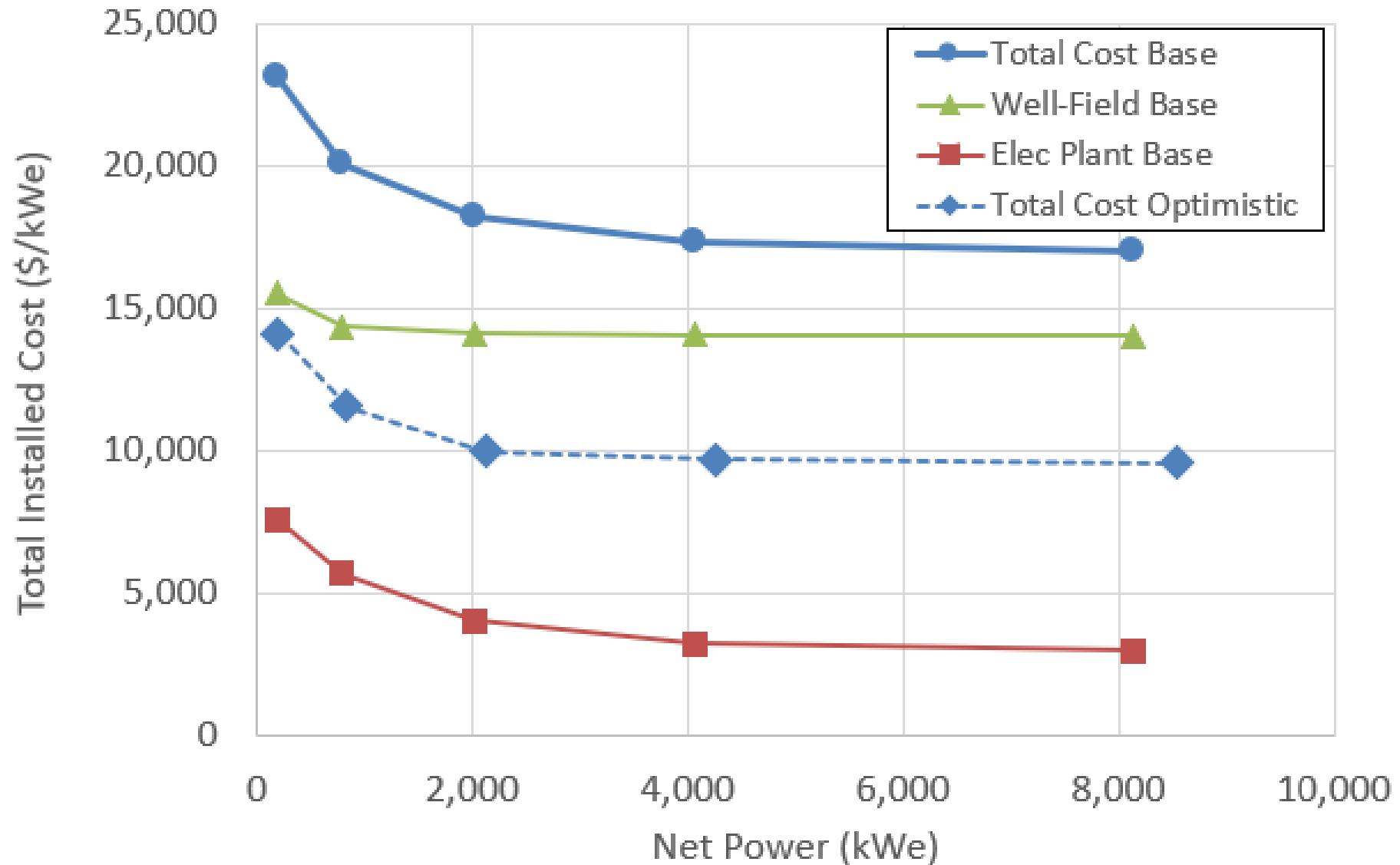
BEopt Efficiency Optimization: Dual Fuel



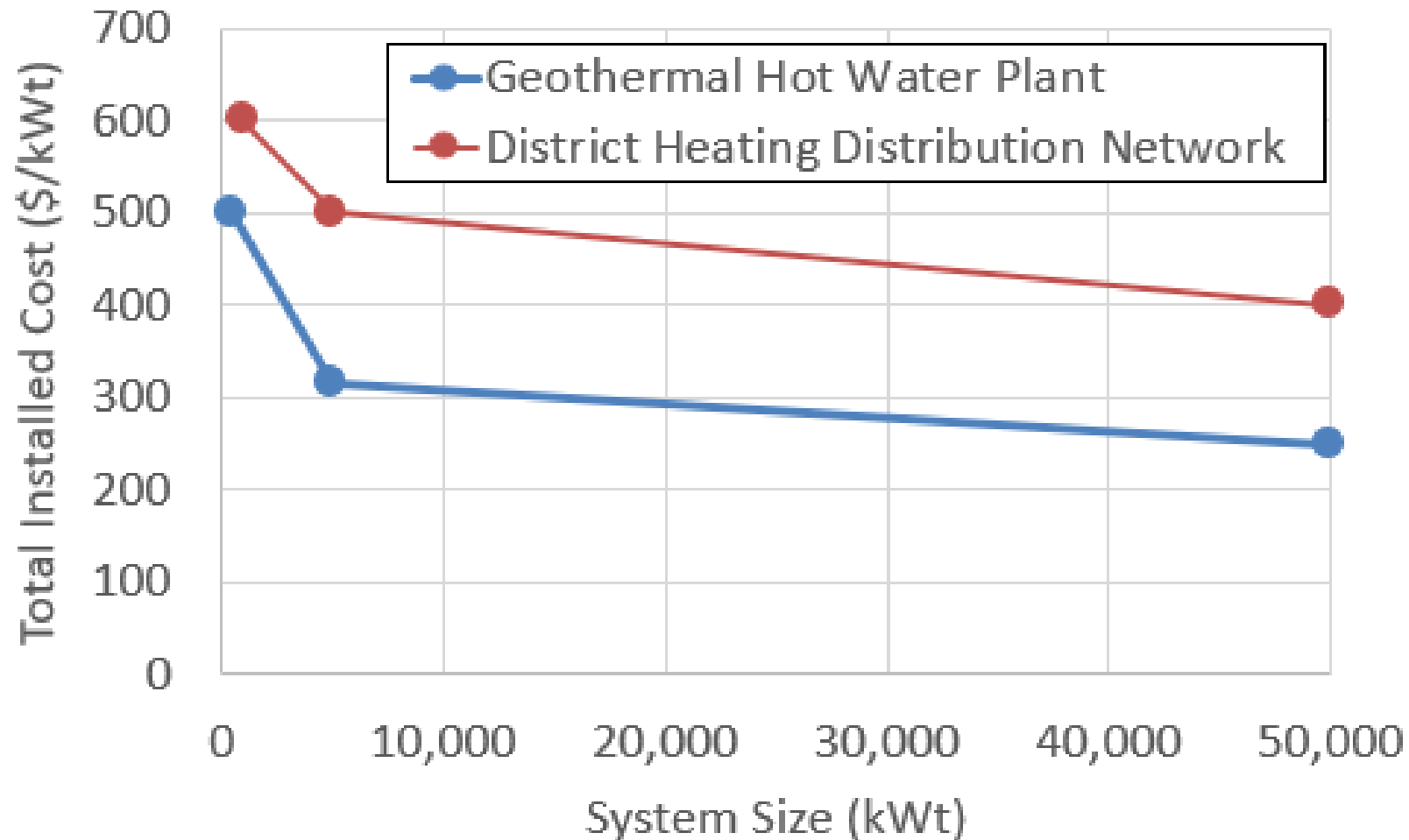
PV Capital Cost



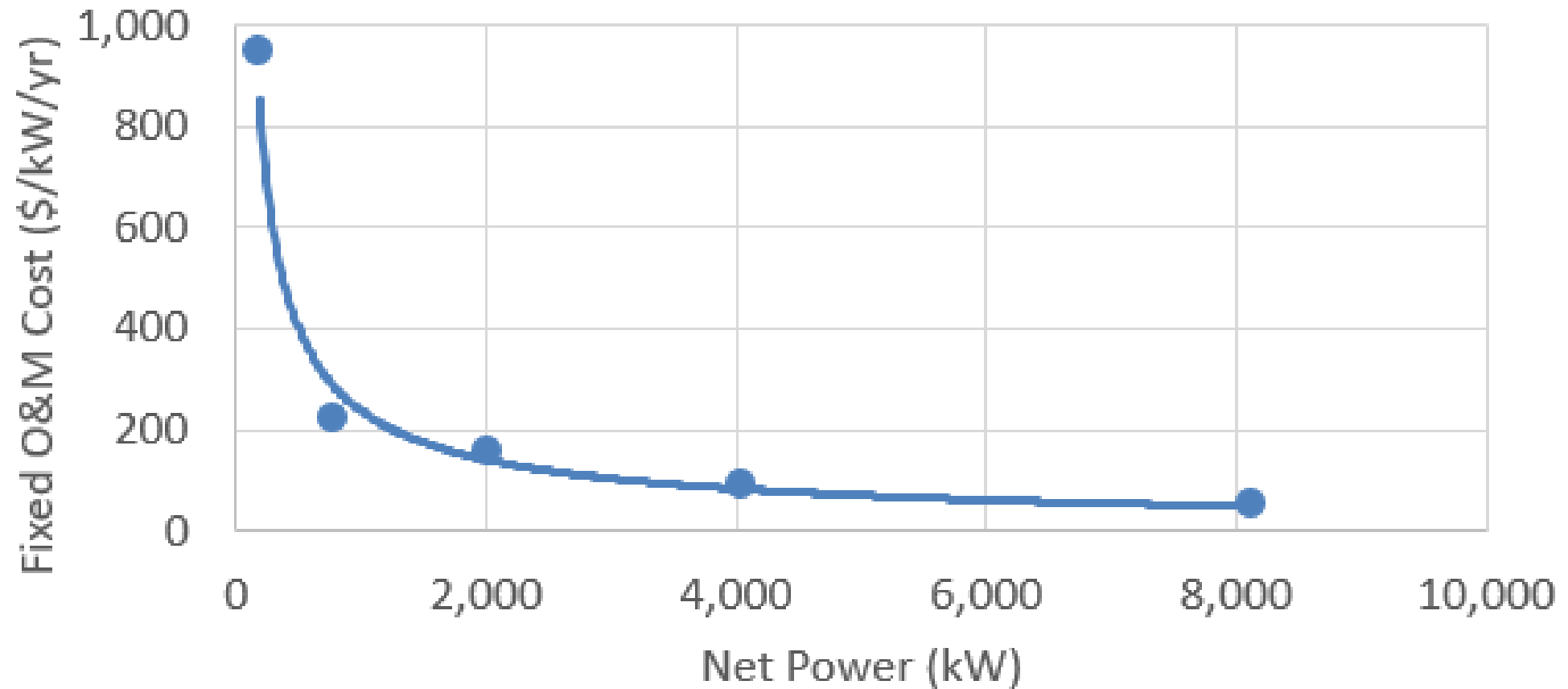
Geothermal Electric Plant and Well Cost



Geothermal Direct Use Plant Cost




Geothermal Plant O&M Cost



Idaho Power Commercial Electric Rate

Tiered Energy Usage Charge Structure


Period	Tier	Max Usage ?	Max Usage Units ?	Rate \$/kWh ?	Adjustments \$/kWh ?
1	1	2000	kWh	0.095161	0.0100655
	2		kWh	0.044392	0.0081617
2	1	2000	kWh	0.105716	0.0104614
	2		kWh	0.048932	0.008332



	12 am	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 pm	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm
Jan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Feb	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Apr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
May	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jun	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Jul	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Aug	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Sep	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oct	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nov	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dec	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Idaho Power Residential Electric Rate

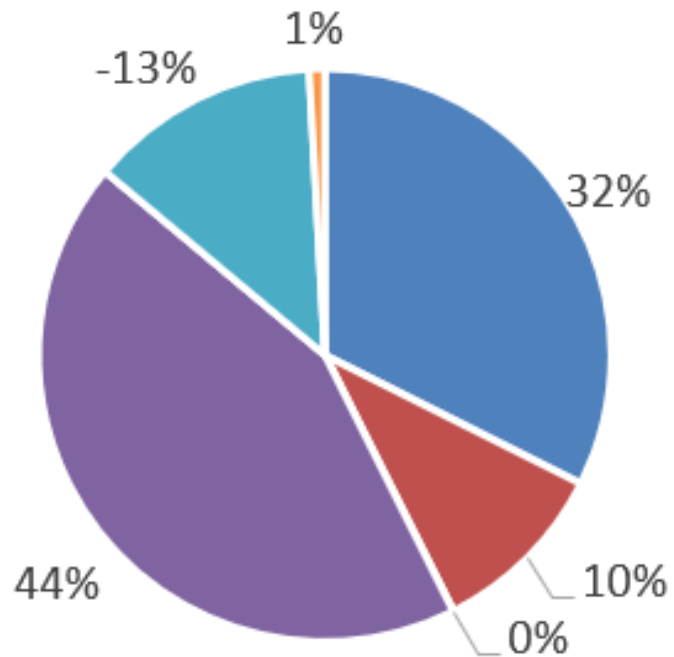
Period	Tier	Max Usage ?	Max Usage Units ?	Rate \$/kWh ?	Adjustments \$/kWh ?
1	1	800	kWh	0.086901	0.0161998
	2	2000	kWh	0.104494	0.0168595
	3		kWh	0.124132	0.017596
2	1	800	kWh	0.080746	0.015969
	2	2000	kWh	0.08902	0.0162793
	3		kWh	0.098588	0.0166381



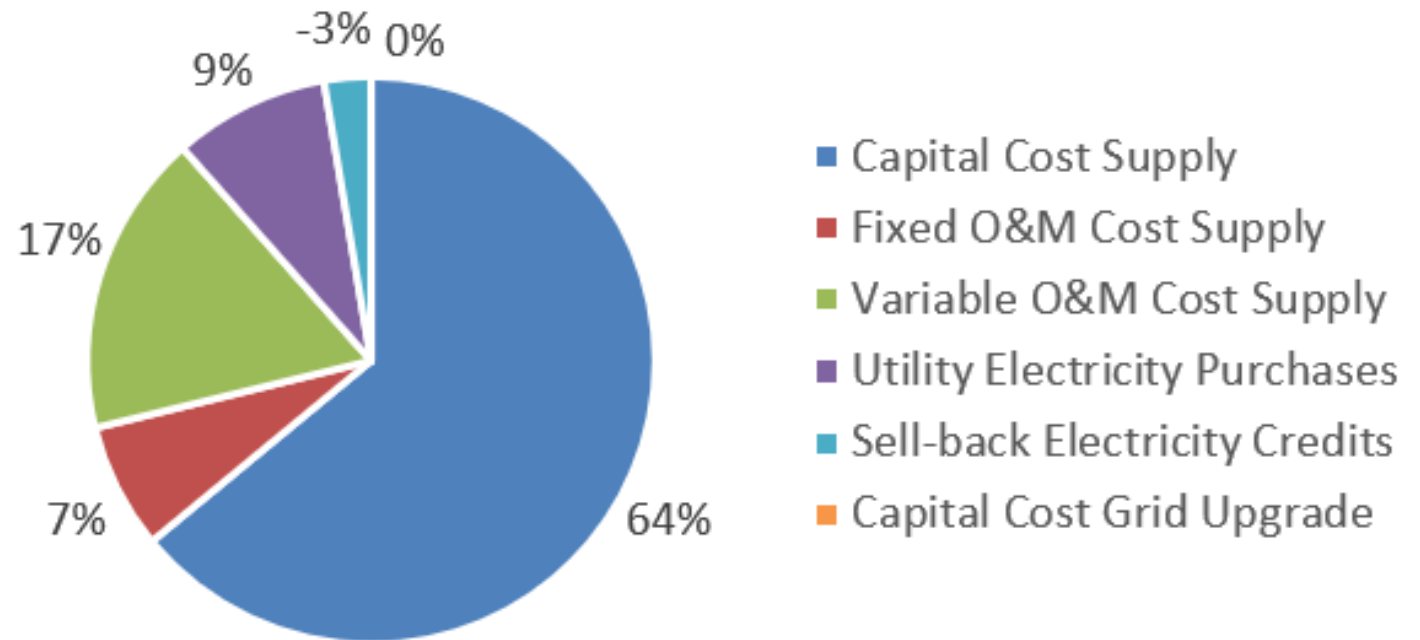
	12 am	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 pm	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm
Jan	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Feb	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
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Dec	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Cost Breakdown Comparison: All Electric

PV All-Electric Base Life Cycle Cost Breakdown



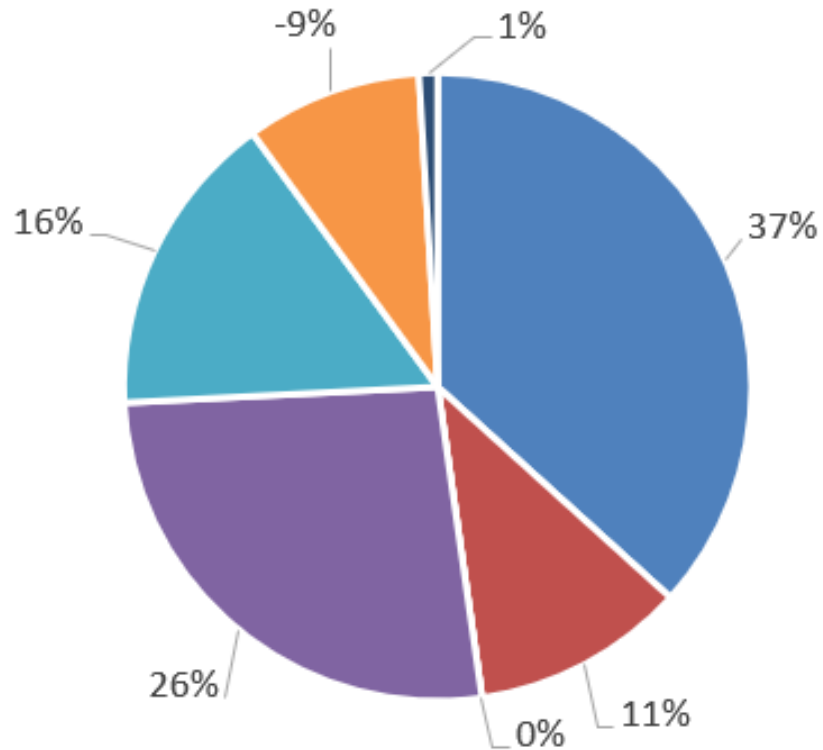
Geothermal Base Life Cycle Cost Breakdown



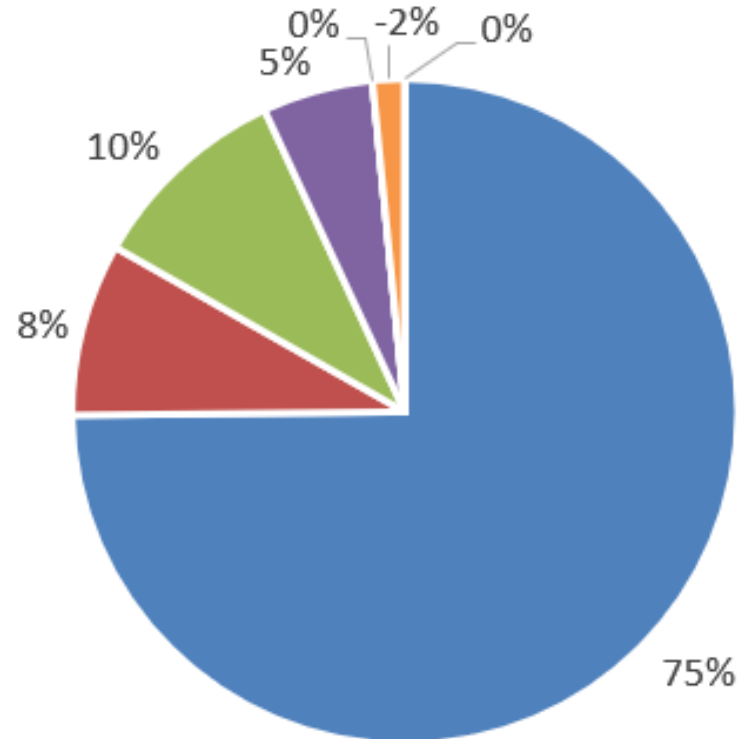
- Capital Cost Supply
- Fixed O&M Cost Supply
- Variable O&M Cost Supply
- Utility Electricity Purchases
- Sell-back Electricity Credits
- Capital Cost Grid Upgrade

Cost Breakdown Comparison: Electric+Gas

PV Life Cycle Cost Breakdown



Geothermal Direct Use Life Cycle Cost Breakdown



- Capital Cost Supply
- Fixed O&M Cost Supply
- Variable O&M Cost Supply
- Utility Electricity Purchases
- Utility Natural Gas Purchases
- Sell-Back Electricity Credits
- Capital Cost Grid Upgrade