HOW BIG IS YOUR THERMAL ENERGY NETWORK ?

What sounds like a very straightforward question for any engineer to answer is currently causing some confusion, even among the experts. After careful analysis and consideration HEET has determined that we must set a new standard and language for the reporting of size when considering true 'thermal energy networks'. Specifically those thermal distribution systems with ambient temperature, single pipe 'loop' design, and bidirectional energy flow.

Our initial recommended system size metrics are:

BUILDINGS LOAD MET - The peak load over a given year from the sum of all the individual building loads, before connected to a TEN. This can be measured or modeled, is non-coincident peak, and is for both heating and for cooling for that year: BLM_H & BLM_C

NETWORK LOAD MODELED$_{(1)}$ - The peak load over a given year from one 'anchor' network with all the buildings or customers connected. This requires a transient or semi-transient modeling tool that integrates the coincident peak load, the thermal inertia or flywheel effect of the network 'loop' itself, etc., for both heating and for cooling: NLM_{H1} & NLM_{C1}

NETWORK LOAD MODELED $_{(2, 3, 4...)}$- The peak load over a given year from one thermal network 'loop' interconnected to other 'loops', numbered 2, 3, 4 ... and so on, with the fourth network loop being NLM_4. Scaling through interconnection can increase load diversity and thermal inertia and stability while improving predictive accuracy, resulting in a lower loop load met than if islanded. Reported for heating and cooling: NLM_{H2} & NLM_{C2}

NETWORK LOAD ACTUAL $_{(1...2, 3, 4...)}$ - The actual measured peak load over a given year from an operating thermal network 'loop', either individual or interconnected: NLA_{H1} & NLA_{C1}

These definitions allow us to more accurately compare systems and understand costs, savings, scaling benefits, and minimum viable scale for investment.

- The BLM must be used for comparison to an alternative energy system & rates
- The NLM must be used for design and infrastructure investment
- Comparisons must consider the loads met for both heating and cooling
- The difference between BLM & NLM quantifies a new form of energy efficiency that includes a thermal storage component and changes calculation of efficiency[1]
- The difference between NLM & NLA can be reduced through learning, lowering costs
- All systems must report both clearly labeled. Abbreviations illustrated above.

[1] The 'Network' COP(coefficient of performance) equation is not the standard 'Box' COP as the boundaries are different

<u>HEET TECHNICAL NOTE</u>:

Framingham, MA as an example of understanding reported Loads, Capacities, and Costs through new load metrics 'BLM' & 'NLM'

Framingham as a Leading Example:

Eversource has been an industry leader on utility deployments of geothermal networks since 2019. Their Framingham Pilot went live in 2024 and the current expansion loop is awaiting regulatory approval. As these projects have progressed and the understanding of system modeling, performance, and loads have advanced, the reporting metrics have also subsequently adjusted.

As a result, project information from one phase to the next may not be reported from the same set of assumptions, and thus needs some additional context to be properly analyzed. This challenge can be further compounded by third party cost comparisons that may not always take into account different load methodologies, incentives, research funding outside of construction, and other project specific details. Which makes this Framingham project, as it often is, an excellent learning opportunity and a leading example to illustrate the need for an industry standard set of load metrics.

Barriers to Cost Comparison between First and Second Installations:

1. **The two projects have a different size basis.** Loop 1's 375-ton figure is a desktop summation of individual building peak loads produced via CDMSmith's original loop layouts with estimated building loads. Let's call this the '*Building Load Met*' or BLM_{H1}. Loop 2's 250-ton figure is a version of the network's simultaneous system load, or '*Network Load Met*', NLM_{H2} as stated directly in Eversource's DPU 26-83 testimony ("expand the system capacity by approximately 250 tons"). This is a coincident value that is post network effects and includes spare capacity on the original loop, not a summed building load as with the first project.
2. **The boreholes are of different types and designs.** The first installation has 'double U-Bend' angled boreholes and 'single U-Bend' vertical boreholes of varying depths, so borehole count would be a misleading metric. The originally designed system was 120 vertical bores, which would be a more accurate comparison to the filed expansion design.
3. **Incentives are not included in the same way, yet**. Loop 1's net cost reflects the IRA/ITC tax credit (-$7.29M) and MA Alternative Energy Credits (-$0.30M) already applied. Loop 2's ITC "has not yet been applied for", because that is not possible until system construction. An estimate of 30-40% of the construction costs, net of grant funding, is reasonable.
4. **Grant dollars for Loop 2 include non-construction spending** but could be easily misinterpreted as fully construction or design costs. Of Loop 2's $9.315M in DOE grant funding, $715,000 was awarded in 2023 specifically for design, engineering, and planning with, per Eversource's own testimony, "a portion of the grant dedicated to workforce development." The actual design costs totaled $500k. Similarly some of the down-select funding was allocated to non-construction costs such as workforce development as well as a large grid measurement and impacts research project. Treating the grant amount as construction cost overstates what it actually cost to build.

Adjusted CAPEX Comparison using BLM & NLM Metrics

Figures below are drawn from the DPU 21-53 Updated Pilot Budget (First Network Loop, 3/29/24) and Eversource's DPU 26-83 Exhibit ES-GEO testimony (Second Network Loop, 5/18/26)

Construction Cost Category	Network Loop 1 (installed)	Network Loop 2 (planned)
Borefield / Drilling	$9,626,105	$4,036,500
Mains / Loop Distribution	*(incl. above)*	$1,953,800
Pump House / Vaults / Civil	$5,036,482	$2,251,126
Design / Engineering Support	$1,610,156	$250,000
Monitoring & Controls	$796,950	$776,250
Fire Station Generator	$65,000	*n/a*
Contingency	$840,000	$245,000
Utility-Side Subtotal (pre-incentive)	$17,974,693	$10,012,676
Building Retrofits (Commercial + Residential + FHA)	$7,225,924	~$5,950,549
Buildings Included in Capacities 1&2	36 (22 residential + 9 FHA + Farley + 4 commercial)	44 (30 res., 13 FHA, 1 school)
Gross Construction Subtotal (system + retrofit, pre-incentive)	$25,200,617	$15,963,225
Less: IRA / ITC Tax Credit	-$7,288,685	-$3,805,070 (est.)†
Less: MA AEC / Other Credits	-$300,000	*Not modeled*
Total System and Building Cost (after incentives)	$17,911,632	$12,158,155 (est.)
Total Cost (after grant funds applied)	N/A	$5,507,606 (est.)
Capacity 1: *Building Load Met* ***BLM_H***	**~375 tons**	**~421 tons***
Capacity 2: *Network Load Met* ***NLM_{H1}***	**~217 tons****	**~295 tons****
Capacity 3: *Interconnected* ***NLM_{H2}***	n/a	**~250 tons****

† Estimated on utility system costs only. Loop 2's ITC is estimated at 40% of the $9,512,676 system-side construction subtotal, which is already stated net of DOE grant funding in the DPU 26-83 testimony for an estimated credit of $3,805,070. Loop 2's actual ITC has "not yet been applied for" per that testimony, so this is an estimate for comparison purposes; (For reference, Loop 1's filed ITC estimate of $7,288,685 was calculated against the budgeted system costs; MA AEC credits were not modeled for Loop 2 but should fall in the same range.

*DPU 21-53 - Eversource Phase II Quarterly Report (5-27-22) Appendix A: Site Plans
**Outputs from Transys modeling tool for each loop on its own vs. the interconnected load requirement

Conclusions based on use of the BLM & NLM Metrics:

Once the load basis is clarified by using BLM & NLM Metrics, and the incentive treatment and cost scope are normalized, we can safely conclude that the expansion network is substantially lower cost than the initial project.

1. Utility Infrastructure Cost, pre-incentives:

   First Network Loop ≈ $18M vs. Second Network Loop ≈ $10M:
   The second is roughly half the cost! (56%)

2. Per Eversource's testimony the expansion is characterized as "roughly doubling" the existing network's capacity, with: BLM_{H1} = 375 and BLM_{H2} -421:
   The expansion doubles the size! (112%)

3. Finally, the $/BLM heating ton goes from $48K to $23.7K, so . . .
   The expansion is half the cost/ton of the first install (50%)

   This expansion has a cost/ton per year (used & useful 50yrs) of $476, lower than gas.
   This does not include the tons of cooling provided, in this calculation cooling is free.

In conclusion, cost comparison methodology has been a frequent inconsistency across the growing new geothermal network or Thermal Energy Network (TEN) ecosystem. It must be a priority area for industry standardization, hence HEET's initial proposal of system size metrics. The use of these metrics in comparing between Framingham's first and second geothermal networks is a clear, concrete example of why the proposed standard is needed and illustrates why, absent it, well-intentioned cost transparency efforts may inadvertently draw a misleading conclusion. Widespread reassessment of existing projects to clarify the loads and capacity numbers used will help us all learn faster and better understand how best to improve performance and affordability rapidly.

COMMENT ON UNITS USED: In another brief, HEET will take on our strong recommendation to switch all use of 'TONS' and 'BTUs' measurement units to Kw and KwH thermal measurement units in order to better enable integrated planning and to improve widespread understanding of the thermal energy resources utilized.

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