Developing a software tool for discovery, sizing and sales of thermal energy storage systems SBIR Phase 1



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Project Summary

Objective and outcome

OptiMiser is building a simple-to-use TES-HVAC analysis tool to support TES adoption. We have completed detailed models of the TES-HVAC analysis and assembled a demonstration tool that integrates the model building loads and utility rates to produce a financial model.



Team and Partners

OptiMiser's team of scientists, developers, and managers has a 14 year history of developing successfully building energy analysis tools.

Primary contributors:

- Gamaliel Lodge
- Dr. Arthur Kariya

<u>Stats</u>

Performance Period: 06/27/2022 -06/27/2023 DOE budget: \$199k, Cost Share: \$0 Milestone 1: Develop TES-HVAC model Milestone 2: Integrate with building loads Milestone 3: Integrate with utility rates and produce net-savings analysis

Problem

- Heating and cooling of buildings accounts for 20% of use energy consumption and drives daily peaks in electricity demand.
- Thermal energy storage (TES) systems have the potential to lower the cost and GHG emissions related to heating and cooling buildings by shifting consumption to periods of lower demand.
- Quantifying site-specific benefits of TES requires an integration of multiple sources of complex info.
- Marketing this new technology requires being able to quantify the benefit and communicate it clearly to consumers and other stakeholders.
- No off-the-shelf tools are available to produce this type of analysis.



Solution Impact

- A successful solution to this problem will speed the adoption of TES systems, helping manufacturers achieve commercial success.
 - AC and Heat Pump shipments from US manufacturers hit 10.4 million in 2022
 - 14% of US population lives in AZ & CA where residential TOU rates are standard
 - Commercial TOU and demand rates are common across the US (5.9 million buildings)
- Broad adoption of TES systems will have several societal benefits
 - Reduced energy costs for consumers
 - Better grid resilience
 - Increased renewable energy penetration
 - Reduced greenhouse gas emissions

Why isn't the value of TES straightforward to calculate?



Electrochemical battery analysis is simple

- Charge and discharge when you want
- No change in efficiency

Constant round-trip efficiency = 90%





Constant round-trip efficiency = 90%

HVAC efficiency depends on weather

10 kWh in I

10 kWh in 9 kWh out

output depends

Example Integration of TES



Charging



Discharging



Modeling Approach



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Model Results - Load Shifting

- Los Angeles house on an August Day
- Peak / off-peak schedule per local utility (SoCal Edison)
 - Peak: 4-9 PM



Yearly Cost Savings - Ice based TES

- Los Angeles house
 - 2000 sq. ft.
 - Max. cooling load: 13.8 kW
 - AC Size: 14.1 kW (4 ton)

- Oversizing TES does not help savings
 - Diminishing returns (>50 kWh)
- Downsizing AC possible with TES
 - Downsizing requires minimum TES size



Lifetime Cost Savings - Ice based TES

- Los Angeles house
 - 2000 sq. ft.
 - Max. cooling load: 13.8 kW
 - AC Size: 14.1 kW (4 ton)
- Hypothetical TES cost assumed
 - Copper coil heat exchanger + ice tank
 - Similar to Thule's IceBear
- Optimum TES size around 40-50 kWh
 - Higher cost savings with downsizing in this case
 - Due to lower capital costs through downsizing



10 year Total Cost Savings

Comparison of different locations (2000 sq. ft. house)



Cost Savings vs HVAC Size (Building Size)

- TES savings are larger for bigger buildings
 - 4x increase in cooling load = 6x savings
- Commercial sector more favorable than residential
 - Commercial sector also has demand charges, which make peak electricity use more expensive



Demonstration Application

		•	Minimal user inputs
		•	Heating/Cooling loads
 Building 			
Year Built	2000 ≑	•	Utility rates from Oper
Has Basement			
Cond Area (Sq Ft)	2000 🜲	•	Automated scenario n
Building Type	Single-family Detached $ \smallsetminus $		
Zip Code	85003 🗸		
Cooling	Central Air Conditioner \smallsetminus		
Thermostat	Non-programmable \lor		
Home Temp	76 ≑		
Away Temp	80 🚖		

- s from EULP API or OptiMiser
- nEI USRDP API
- nodeling

Utility / Supplier	Arizona Public 🗸
Rate	Time-of-Use 3pm-t $ \smallsetminus $
	Load Rate
Override Schedule?	Charge/Discharge
	Run Scenarios

Results

	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
VCC (kW)	10.5	10.5	10.5	10.5	8.8	8.8
TES (kWh)	0.0	40.8	30.6	20.4	40.8	30.6
Load covered? (1=Yes)	1	1	1	1	1	0
Energy cost (\$/year)	\$625.27	\$457.38	\$538.70	\$578.22	\$456.41	\$550.66
VCC cost (\$)	\$3,235.46	\$3,053.83	\$3,053.83	\$3,053.83	\$2,665.33	\$2,665.33
TES cost (\$)	\$0.00	\$1,477.37	\$1,091.08	\$704.79	\$1,477.37	\$1,091.08
Total cost (\$/10 years)	\$9,488.17	\$9,105.04	\$9,531.91	\$9,540.79	\$8,706.79	\$9,263.03
Net Savings (\$/10 years)	\$0.00	\$383.13	-\$43.74	-\$52.62	\$781.38	\$0.00
Best Scenario? (1=Yes)	0	0	0	0	1	0

Phase II - Model Improvements

- Develop model for larger sizes (10-50 ton)
 - Rooftop units
- Different configurations
 - Water-source, ground source
 - TES configurations that boost HVAC efficiency rather than substituting for it



Phase II - Application Development

- Refine heating and cooling load generation
- Deploy integrated calculation application to existing API server infrastructure
- Build white-label web application that leverages our existing API services to allow end users to access TES modeling via standard web browser.
 - Work with TES manufacturers in beta-testing application

	Small Changes. BIO RESULTS.		Home	Take Action	Towns	Blog &	News Events Contact
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Thank You

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REFERENCE SLIDES

Project Execution

			FY2023			
Planned budget		\$199k				
Spent budget			\$103k			
	Q1	Q2	Q3	Q4		
Past Work						
Q1 Milestone: Technical and market research						
Q2 Milestone: TES-HVAC model						
Q3 Milestone: Building heating/coolng loads						
Q4 Milestone: Demonstration application						
Current/Future Work						
Q4 Milestone: Visualizations and reporting						

- While TES-HVAC model is complete for some configurations, we are working to add more.
- We also will continue to test and refine the demonstration application through Q4

Team

OptiMiser

- Gamaliel Lodge (PI) product roadmap, research agenda, stakeholder outreach, creation of demonstration application
- Dr Arthur Kariya (Lead Engineer) TES and HVAC technical research, market research, creation and testing of TES-HVAC model
- Larry Hausman-Cohen (Lead Developer) rapid application development platform
- Phen Canner (Data Analyst) ResStock/ComStock EULP data analysis, AWS Athena data queries and API endpoint for EULP data