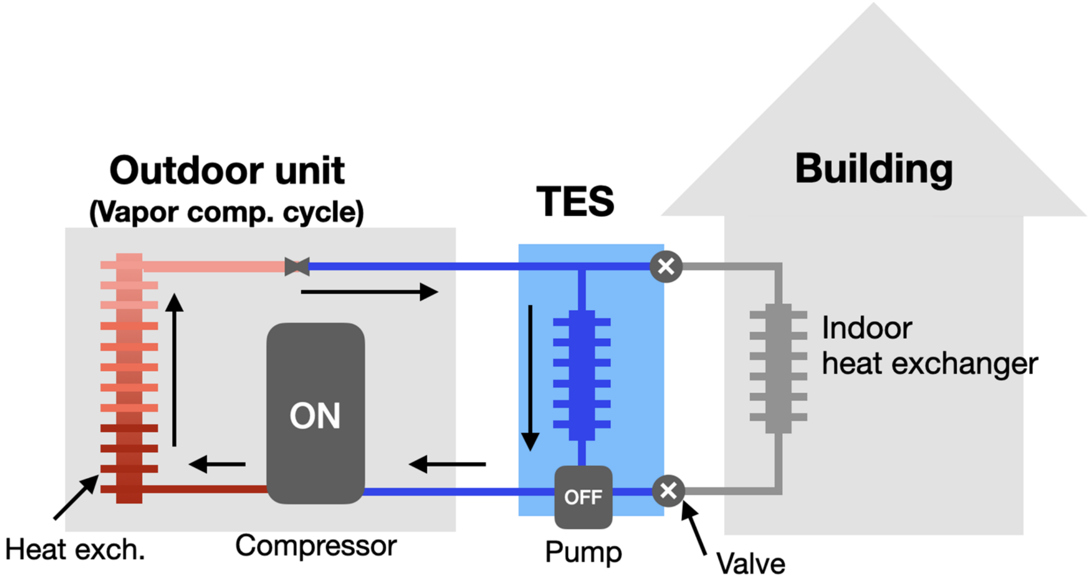
Developing a software tool for discovery, sizing and sales of thermal energy storage systems

SBIR Phase 1



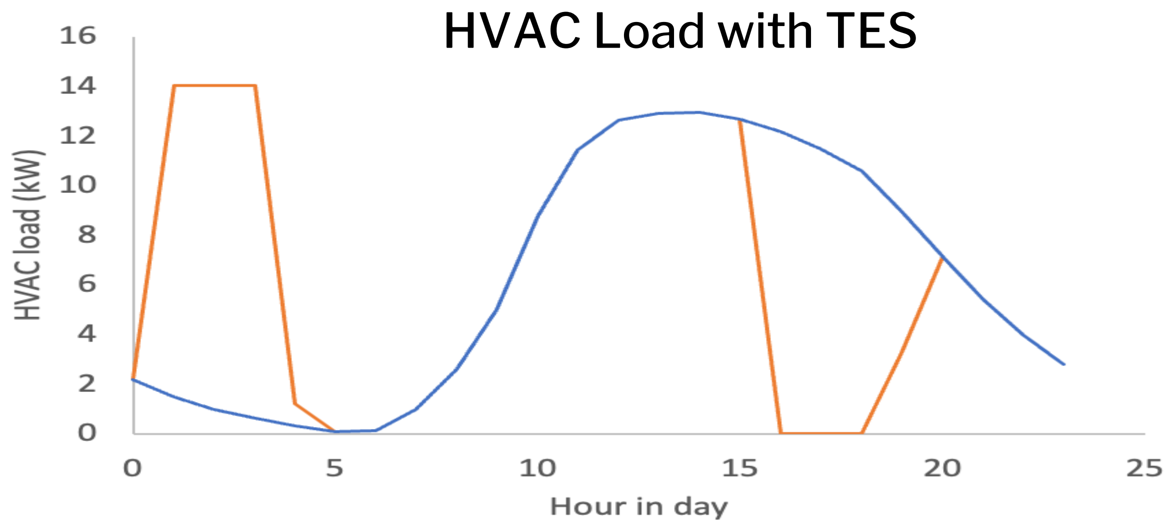
OptiMiser, LLC
Gamaliel Lodge, Director of Research
gamaliel@optimiserenergy.com
DE-FOA-0002555

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

Stats

Performance Period: 06/27/2022 -06/27/2023

DOE budget: $199k, Cost Share: $0

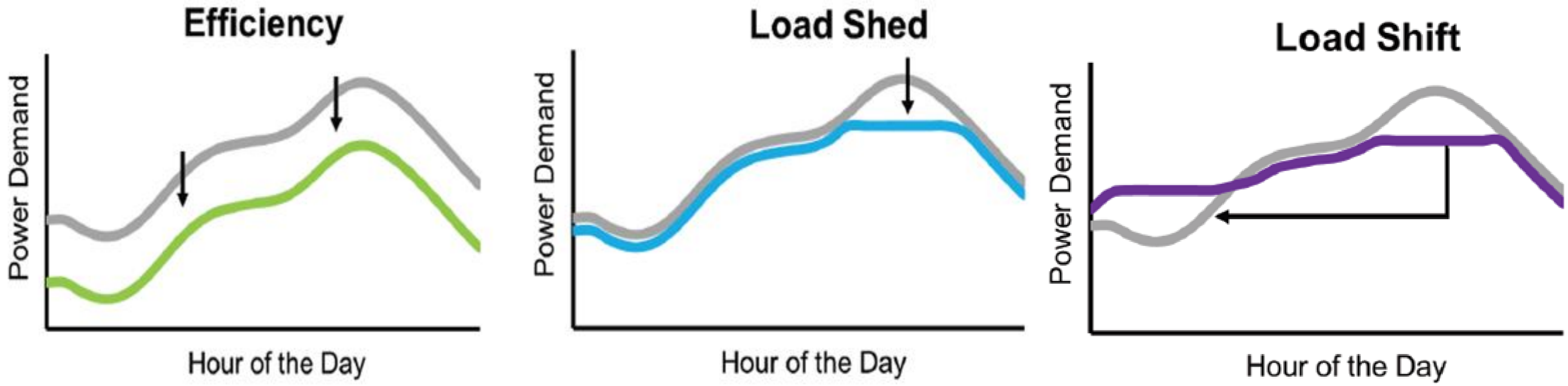
Milestone 1: Develop TES-HVAC model

Milestone 2: Integrate with building loads

Milestone 3: Integrate with utility rates and produce net-savings analysis

Problem

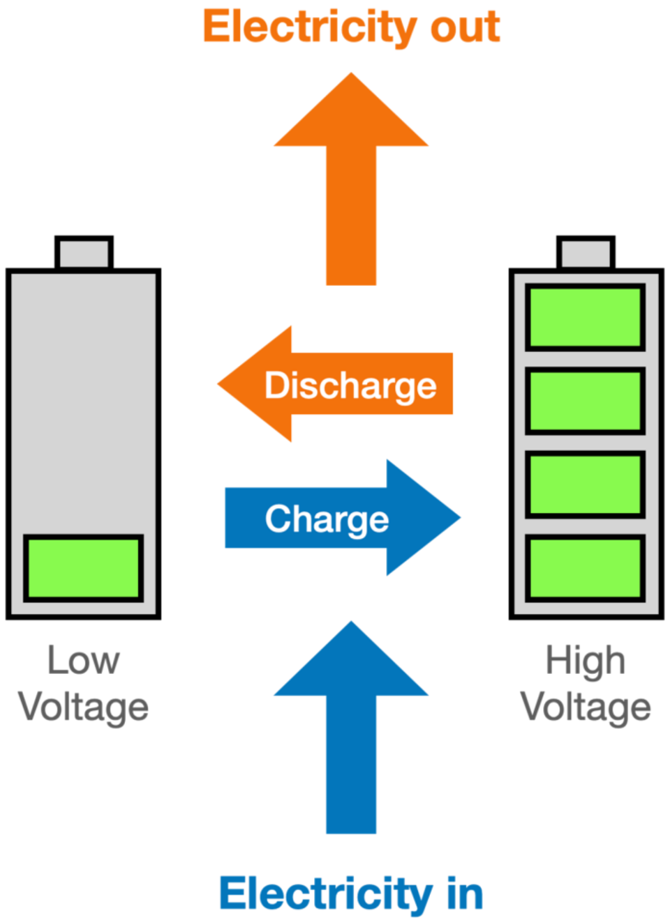
- Heating and cooling of buildings accounts for 20% of use energy consumption and drives daily peaks in electricity demand.
- Thermal energy storage (TES) systems have the potential to lower the cost and GHG emissions related to heating and cooling buildings by shifting consumption to periods of lower 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?



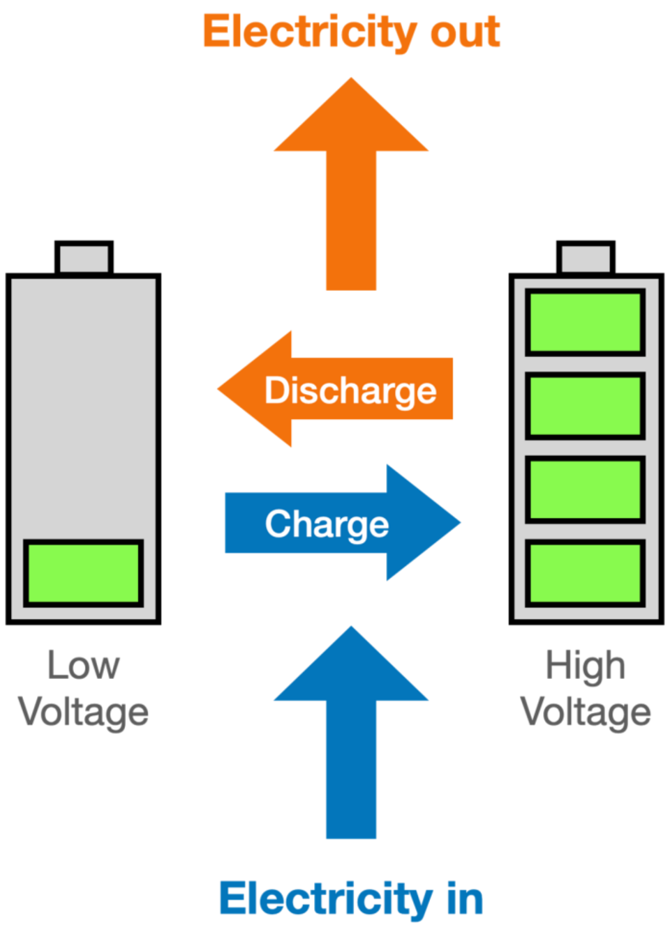
Electrochemical battery analysis is simple

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

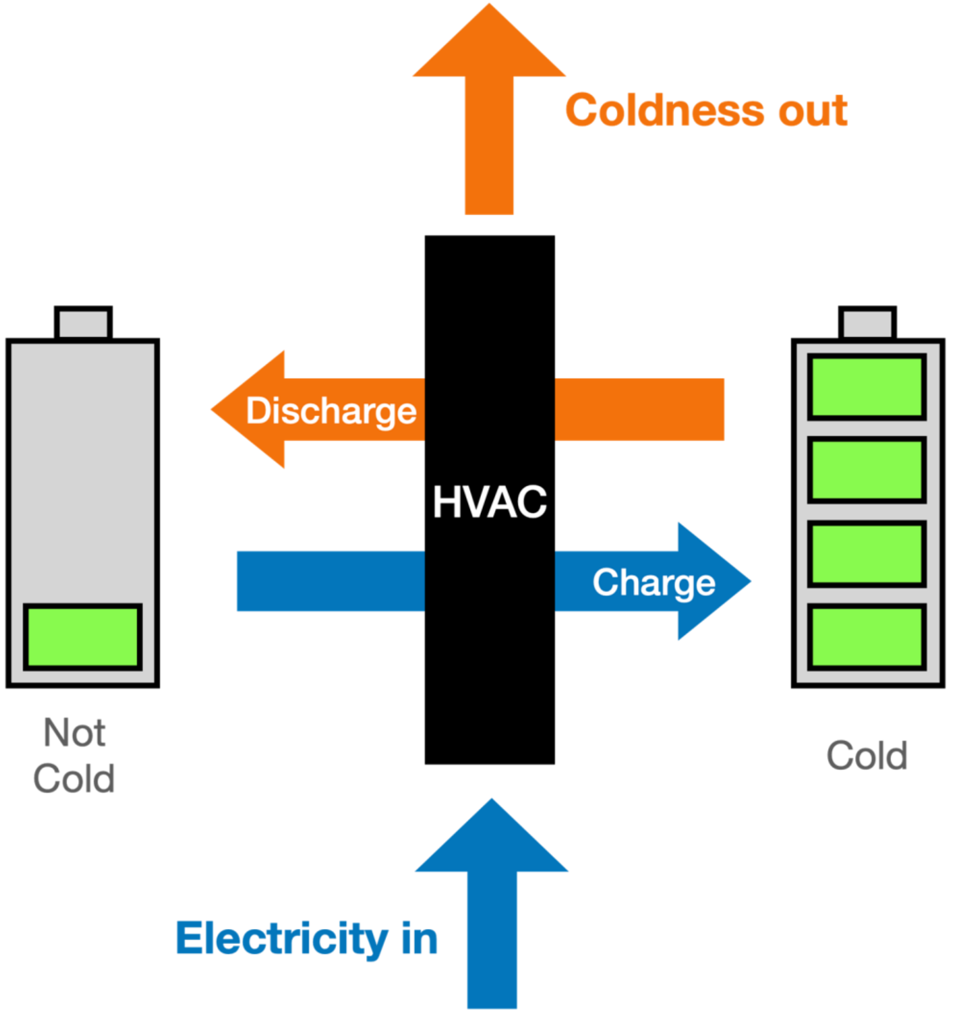
Constant round-trip efficiency = 90%

10 kWh in → 9 kWh out

Electrochemical Battery
(Lithium Ion)



Thermal Energy Storage
(Ice tank)



Constant round-trip efficiency = 90%

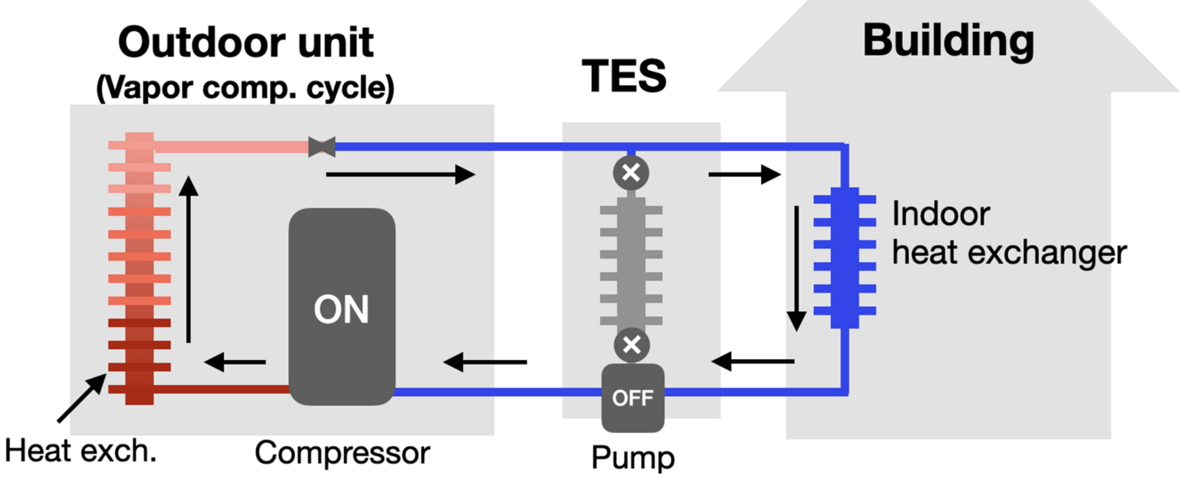
10 kWh in → 9 kWh out

HVAC efficiency depends on weather

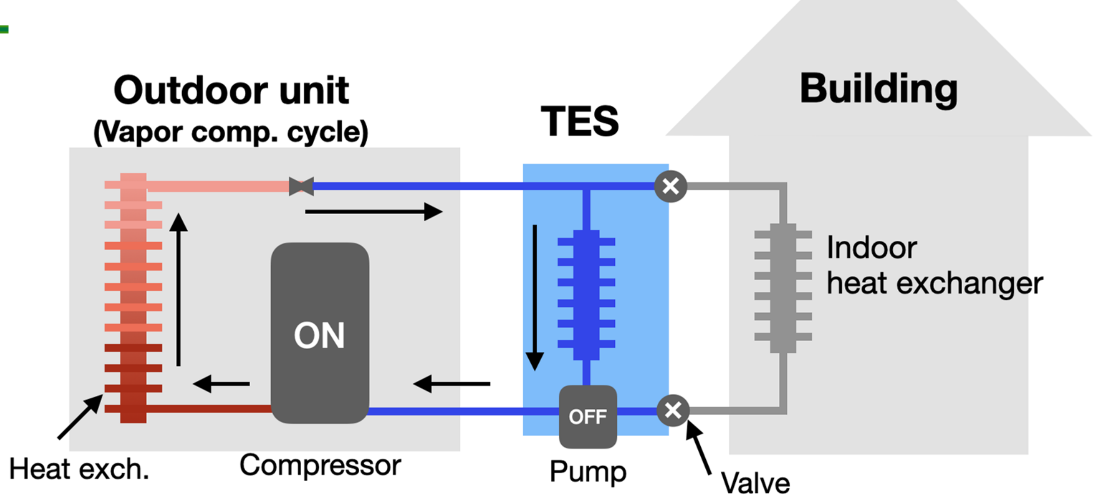
10 kWh in → output depends

Example Integration of TES

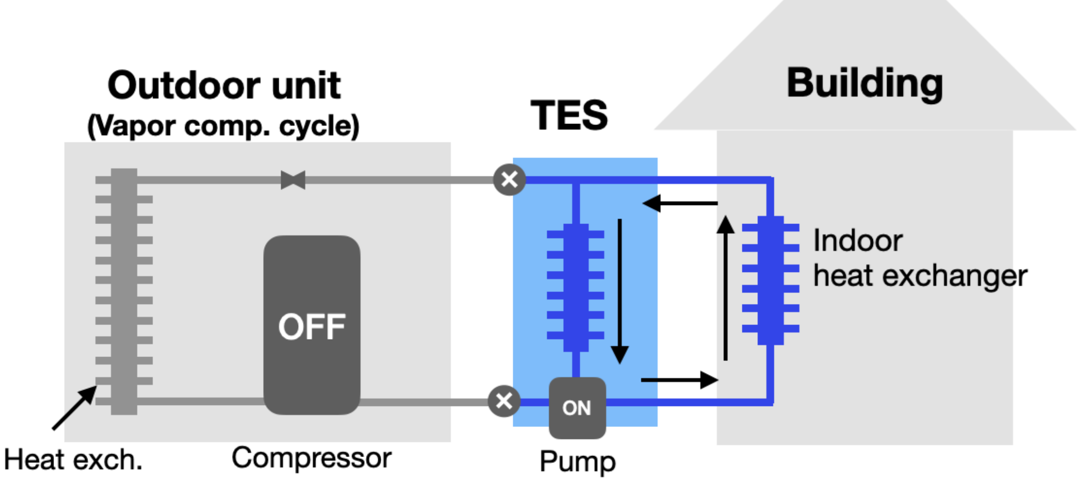
Normal operation
(TES bypass)



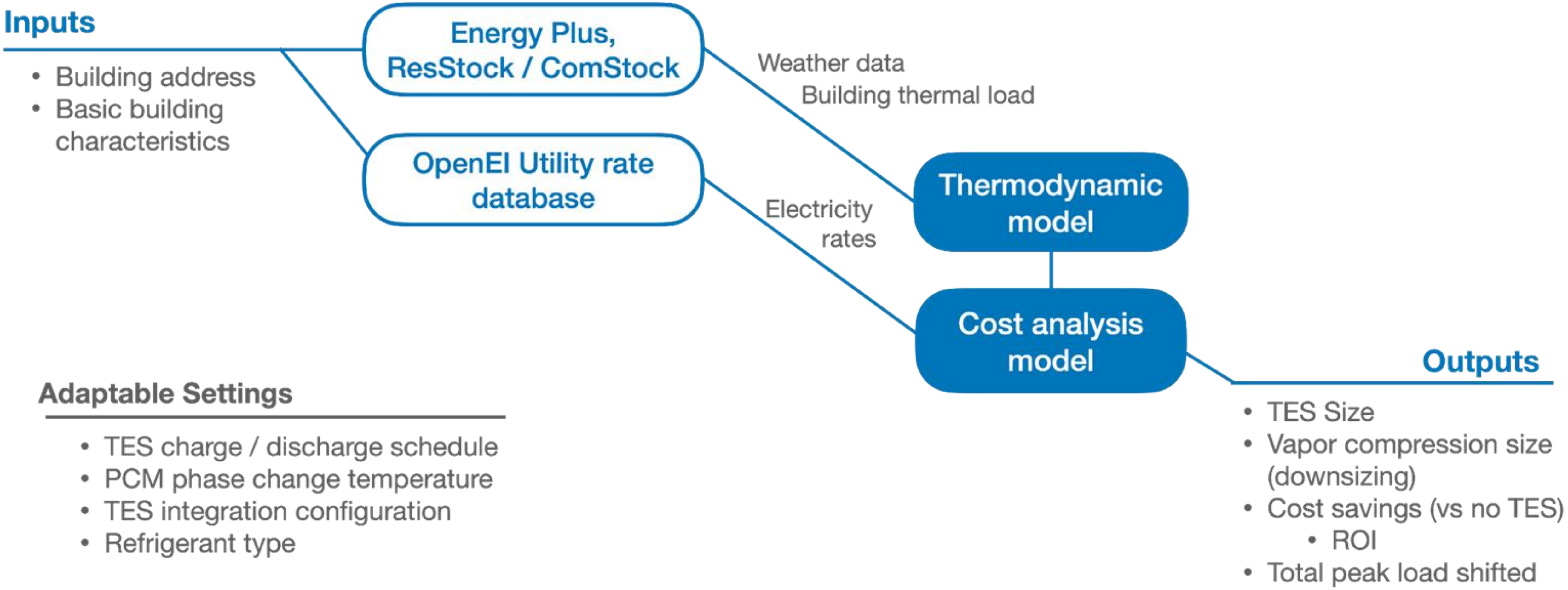
Charging



Discharging

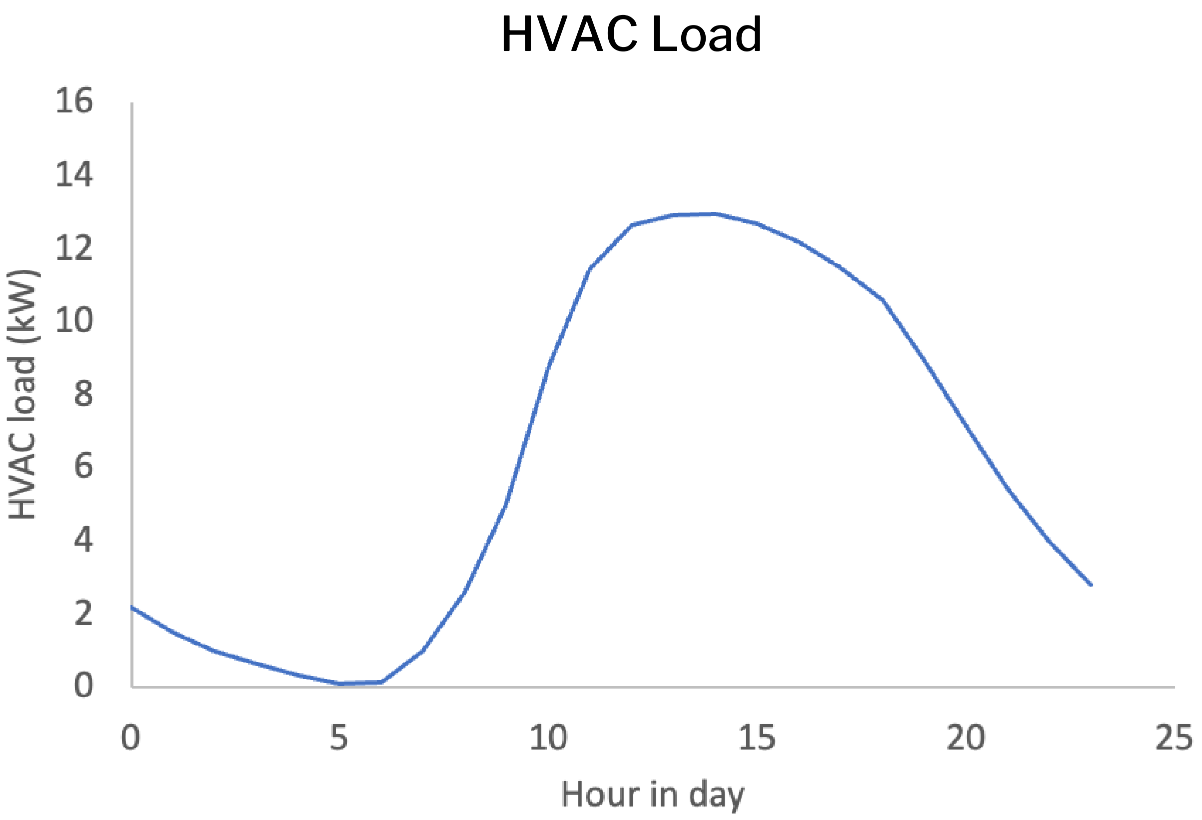


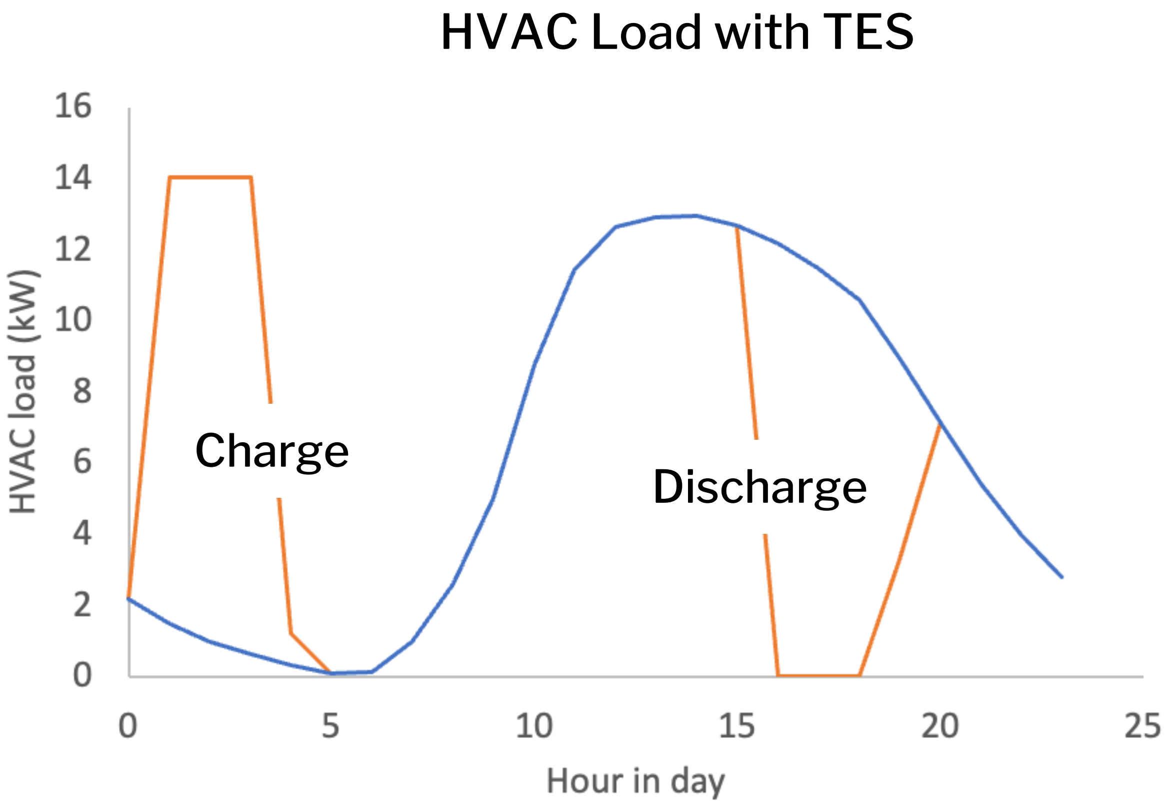
Modeling Approach



Model Results - Load Shifting

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

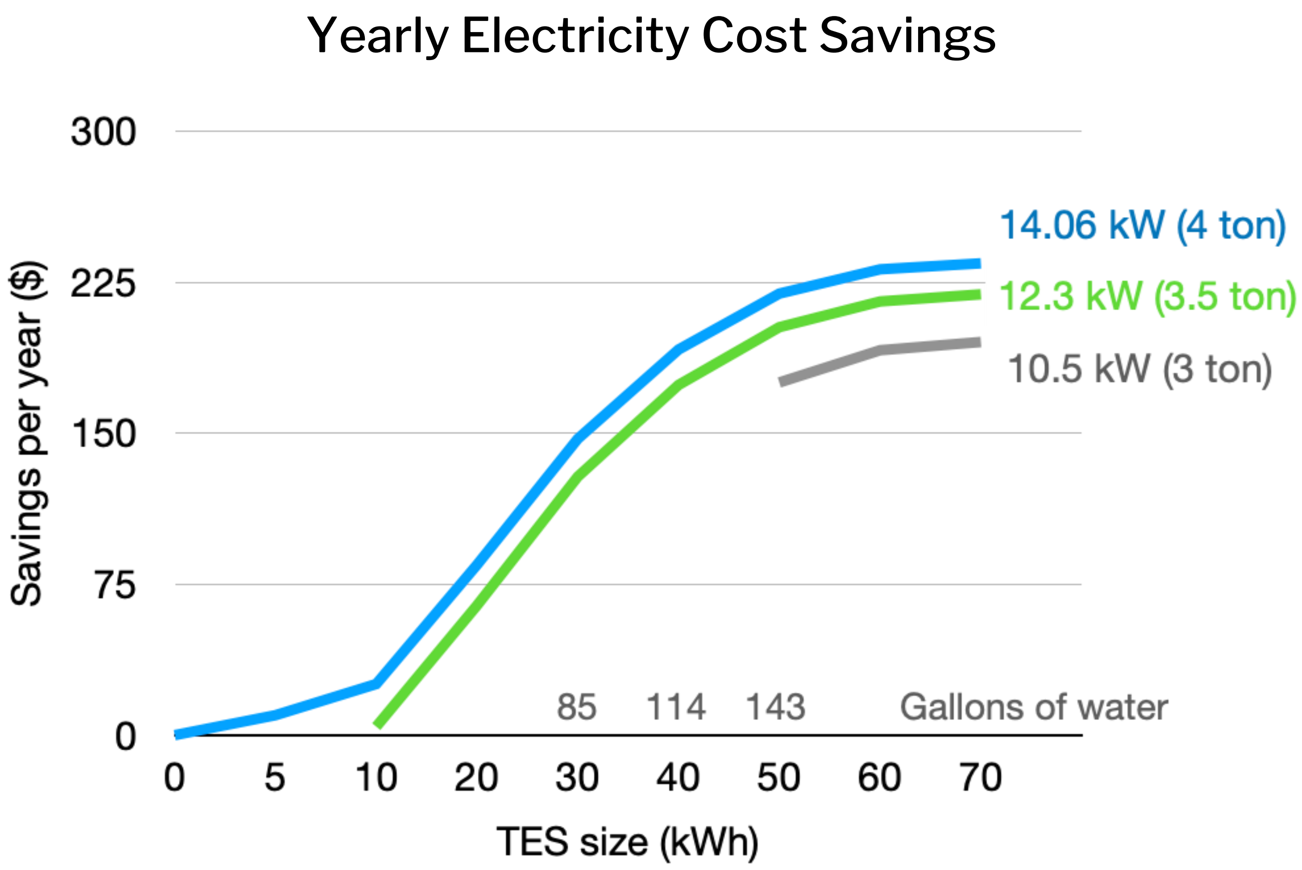




Yearly Cost Savings - Ice based TES

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

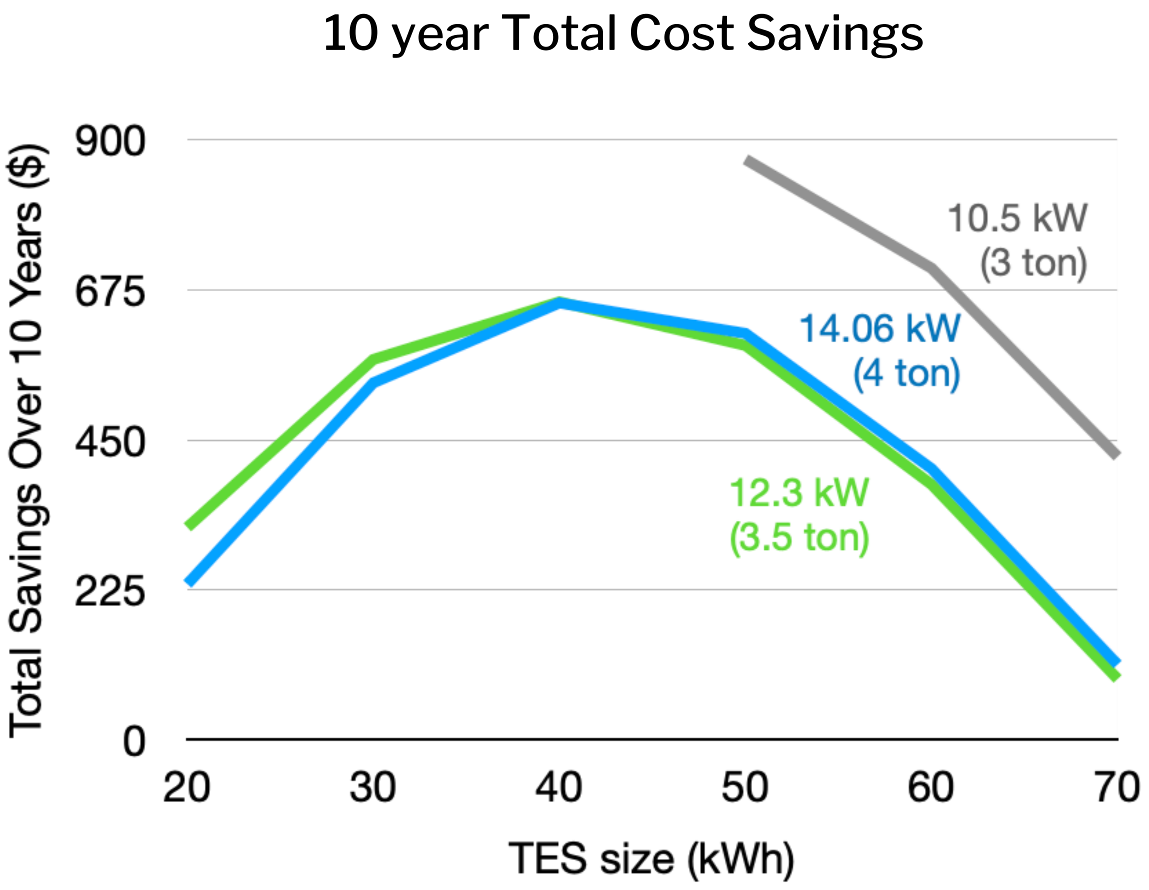
- Oversizing TES does not help savings
  - Diminishing returns (>50 kWh)
- Downsizing AC possible with TES
  - Downsizing requires minimum TES size



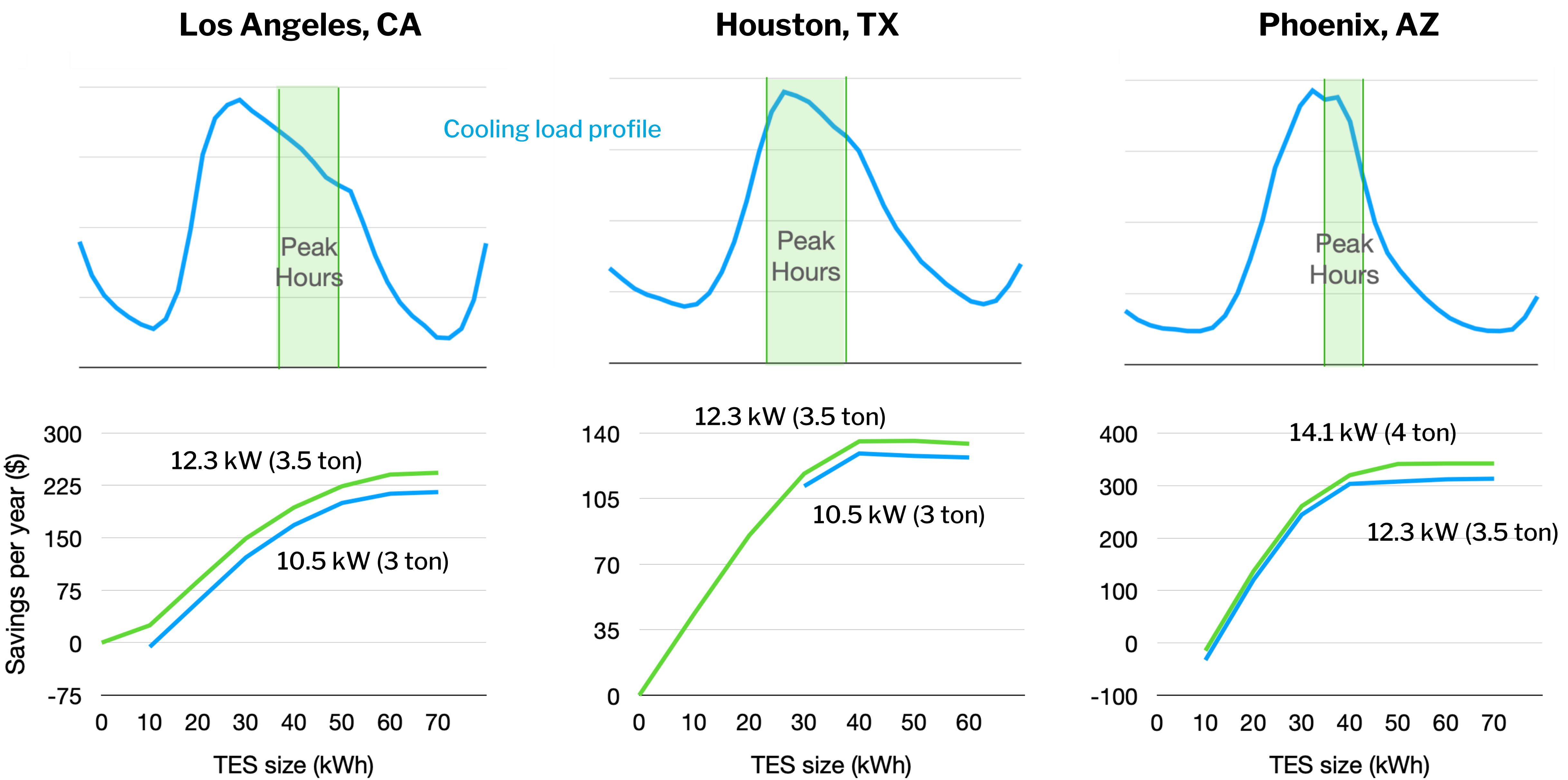
Lifetime Cost Savings - Ice based TES

- 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

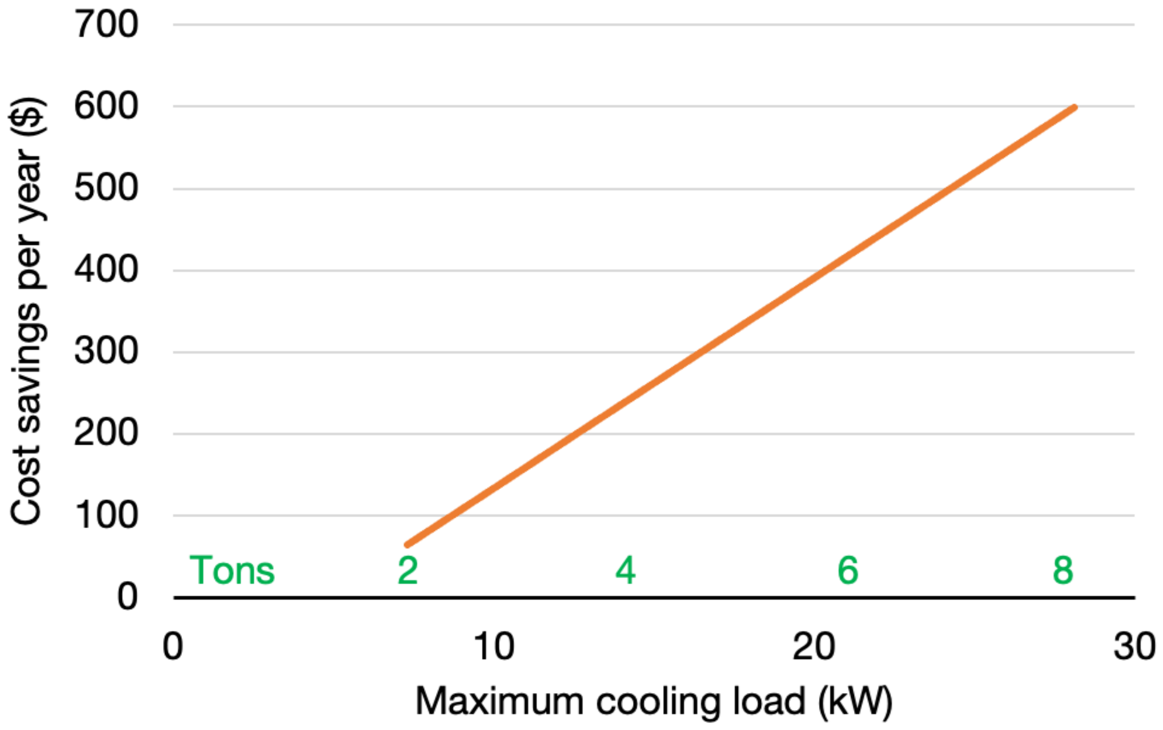


Comparison of different locations (2000 sq. ft. house)



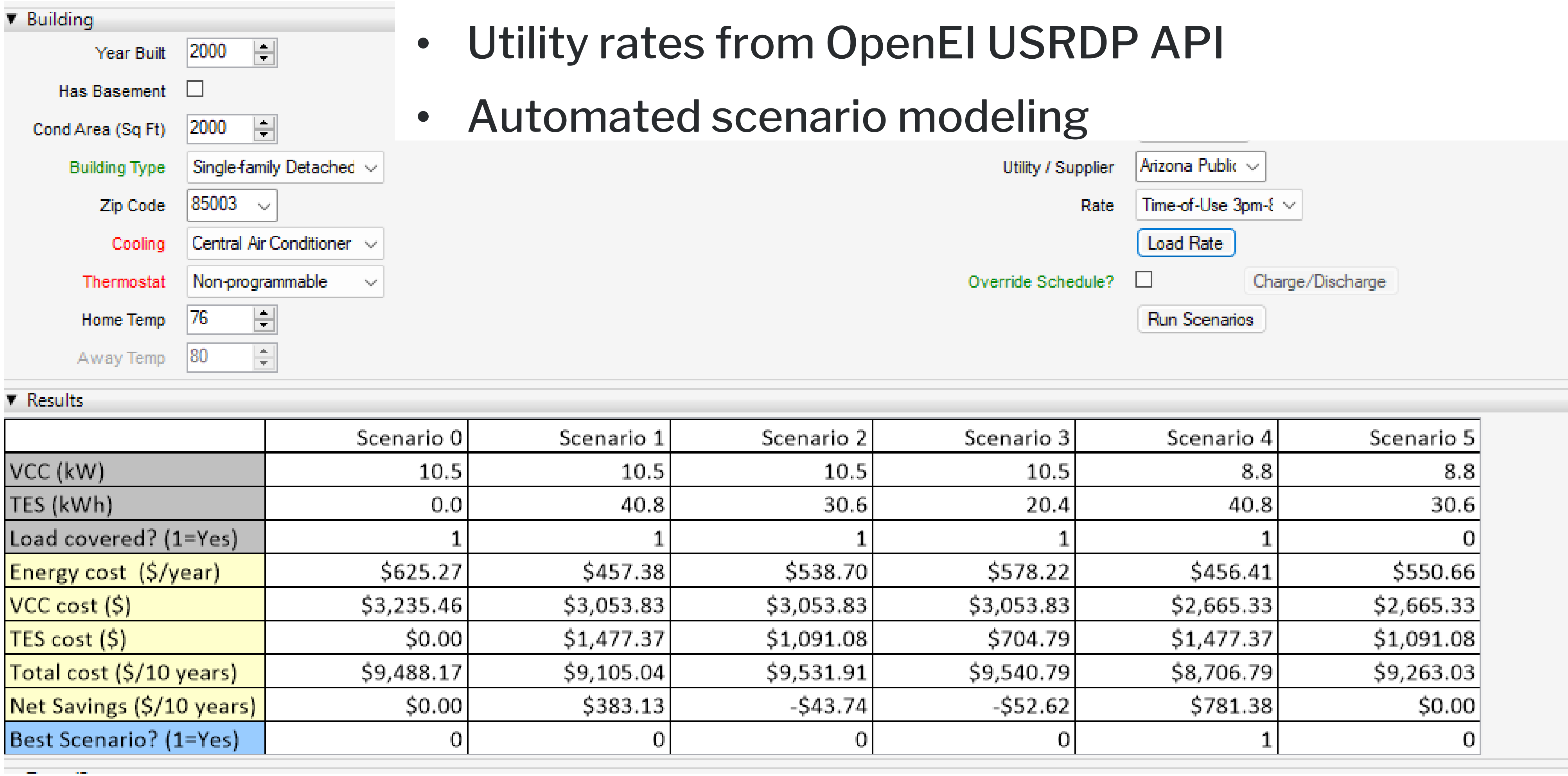
Cost Savings vs HVAC Size (Building Size)

- 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 from EULP API or OptiMiser
- Utility rates from OpenEI USRDP API
- Automated scenario modeling



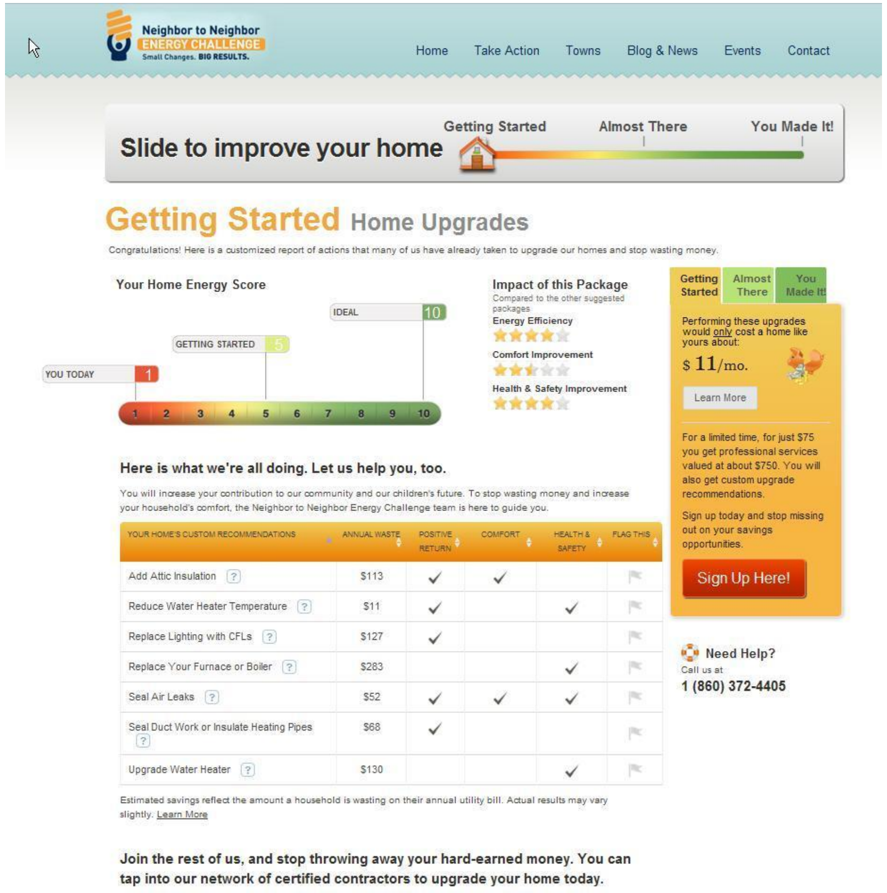
	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
VCC (kW)	10.5	10.5	10.5	10.5	8.8	8.8
TES (kWh)	0.0	40.8	30.6	20.4	40.8	30.6
Load covered? (1=Yes)	1	1	1	1	1	0
Energy cost ($/year)	$625.27	$457.38	$538.70	$578.22	$456.41	$550.66
VCC cost ($)	$3,235.46	$3,053.83	$3,053.83	$3,053.83	$2,665.33	$2,665.33
TES cost ($)	$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



Thank You

OptiMiser, LLC
Gamaliel Lodge, Director of Research
gamaliel@optimiserenergy.com
DE-FOA-0002555

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