DOER
Massachusetts Department of Energy Resources

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENERGY RESOURCES
Patrick Woodcock, Commissioner

Decarbonizing Massachusetts State Facilities

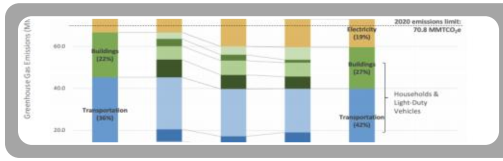
Better Buildings Summit
May 2022

Ryan Kingston
Ryan.Kingston@mass.gov
Sustainability Project Coordinator
Leading by Example Program

Commonwealth Climate Leadership

Massachusetts expected to achieve 25% emissions reduction target by 2020 (from 1990 baseline). This trend expected to continue with advancements in clean energy policy.

2021 Climate Law set aggressive GHG reduction targets: 50% by 2030, 75% by 2040, net zero by 2050, as well as sector-specific and 5-year interim targets



2050 Decarbonization Roadmap and 2025/2030 Clean Energy and Climate Plan prioritizing electrification of heating and transportation to meet climate goals

Three-Year Energy Efficiency Plan sets emissions reduction goals and incentivizes electrification

Over 3600 MW of solar PV installed, with SMART program furthering growth

3200 MW of offshore wind already procured, with authorization for another 1400 MW

179 MWh of energy storage installed (up from 0 in 2015), 874 MWh in the pipeline

LBE accomplishments are the result of the collective efforts of all state entities, who strive to meet the goals of applicable executive orders
while supporting long-term statewide policies and goals

Mission Statement

The LBE program aims to substantially reduce GHG emissions and environmental impacts of state owned and managed buildings, facilities, and campuses

State Footprint

Buildings

– 80 million square feet
– 29 college and university campuses
– 18 prisons, hundreds of armories
– 50+ state owned courthouses
– State hospitals, youth detention centers, office buildings, visitor centers, garages, parks

Vehicles

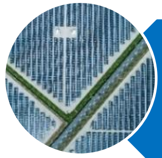
– 7,500+ light, medium, heavy duty

Impacts

– Over 1 billion kWh electricity
– 8 million gallons gasoline + diesel
– 870,000 tons GHG emissions

Key Portfolio Accomplishments


35% overall GHG emissions reductions*


30+ MW of solar PV at state facilities


85% reduction in heating fuel oil use*

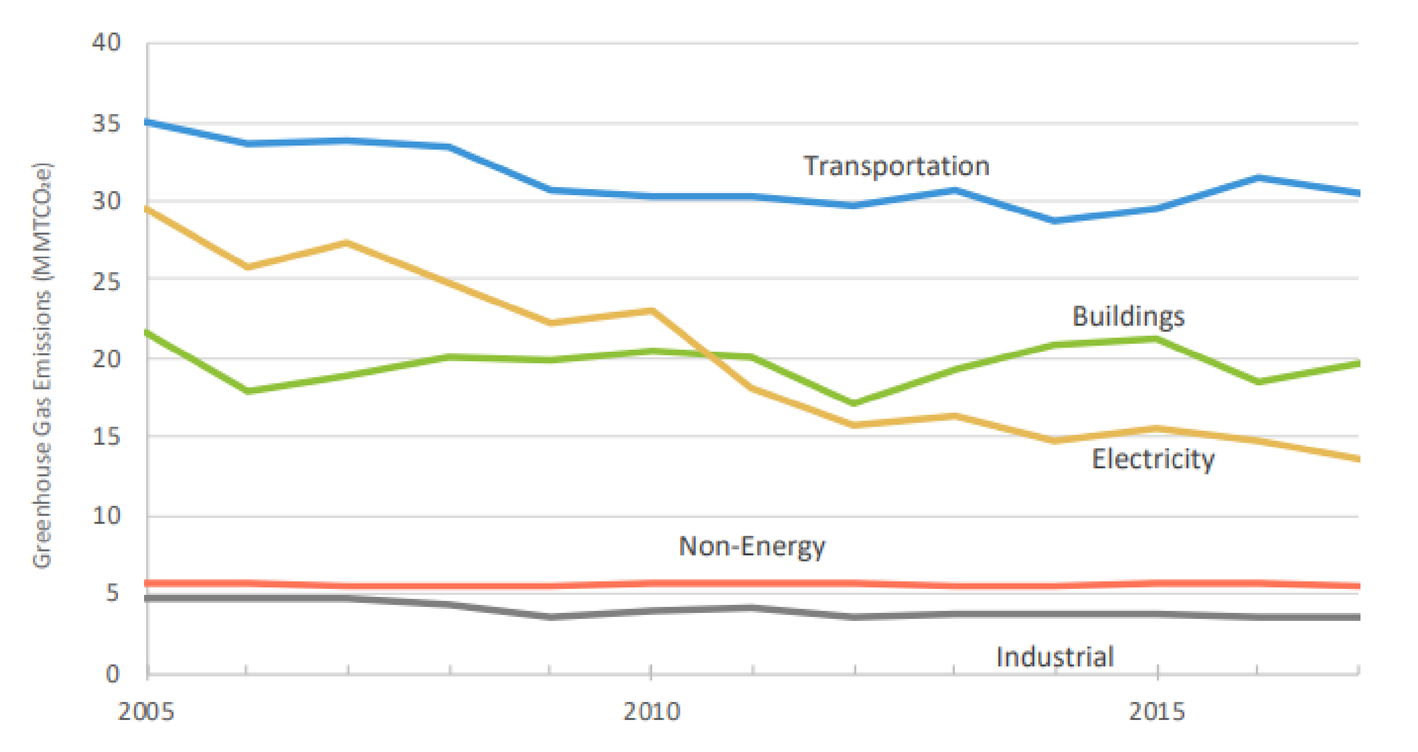

97 LEED buildings, 65% at highest certification levels


14% reduction in energy use intensity (EUI)*

*Over 2004 baseline

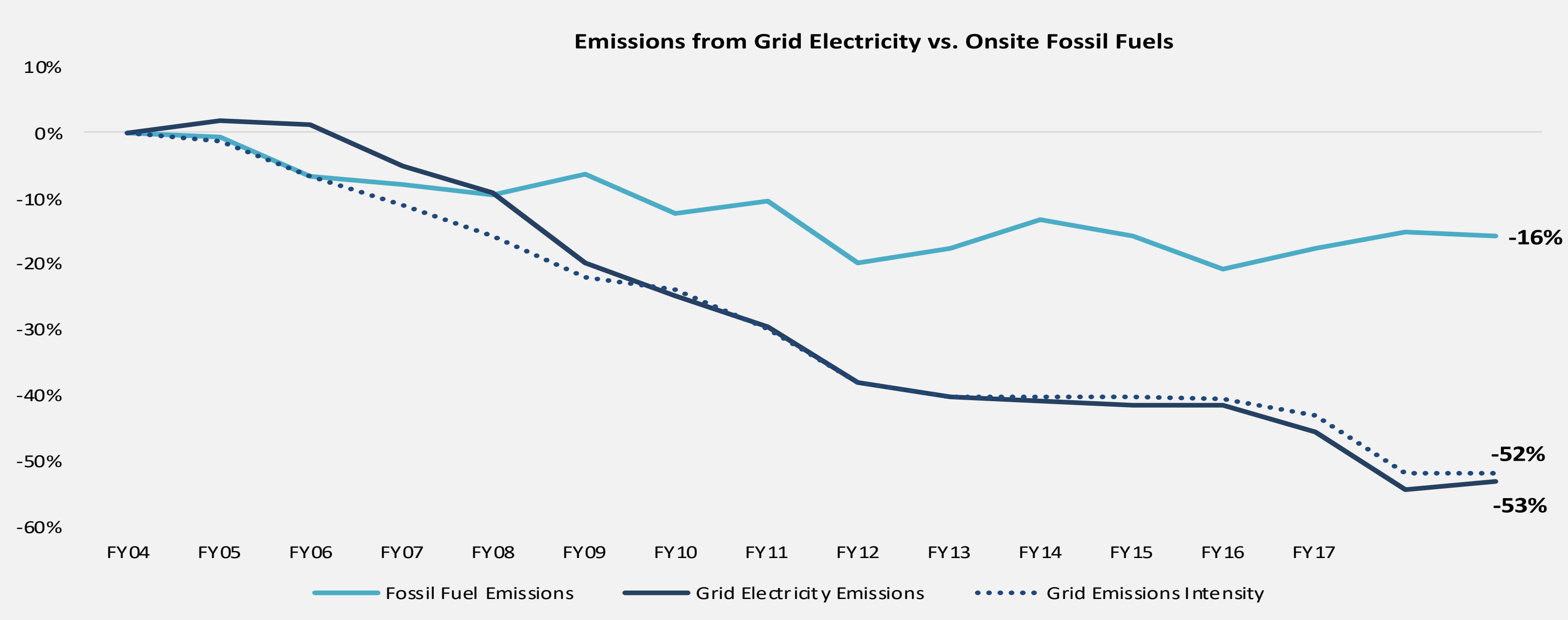
Setting the Context for Decarbonization Targets

❖ The grid is getting greener, while emissions from transportation and building sectors have seen smaller reductions in emissions



Setting the Context for Decarbonization Targets

- 75% of current state government emissions reductions can be attributed to changes in the grid emissions intensity
- Onsite fossil fuel emissions are most challenging to address, under the direct control of state action, and constitute the majority (and growing) portion of emissions within the state portfolio



2021: A Climate Odyssey

<u>Executive Order No.594</u>

Leading by Example: Decarbonizing and Minimizing Environmental Impacts of State Government

Signed by Governor Baker on Earth Day, April 22, 2021

Effective date: July 1, 2021

Supersedes LBE Executive Order 484

New targets focus on *onsite* fossil fuels at state facilities

<u>New Climate Law</u>

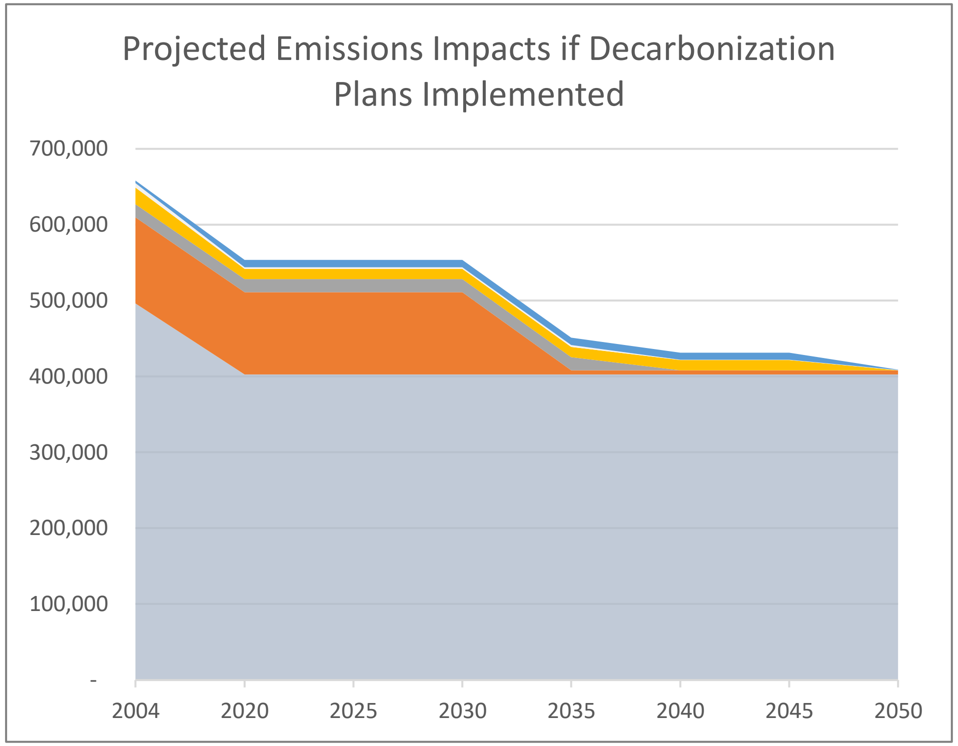
An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy

Signed by Governor Baker on March 26, 2021

New sector-specific targets and programs to support implementation

Targeting the Top: Campus Decarbonization Study Background

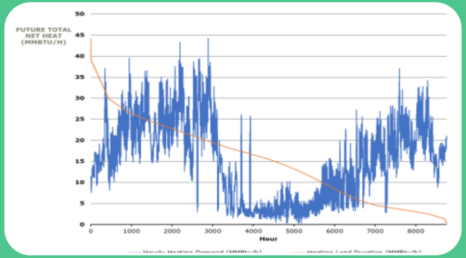
- Four campuses, varying in size from 685,000 sq ft to 12.8 million sq ft
- Responsible for ~25% of state portfolio emissions
- Buildings vary in age, condition, and type
- Heat and power provided by CHP, consumed combined 5 million therms of natural gas in FY21



Getting Started: Convening the People and the Data

Identify the Working Group

- Facilities, operations, fiscal, DOER, DCAMM
- Ensure leadership/stakeholder buy-in and support
- Incorporate into existing master planning efforts
- Some studies included extensive stakeholder outreach



Collect and Share Data

- Campus-wide and building-specific energy load and performance
- Seasonal and peak loads
- Forecasting through 2040 and beyond

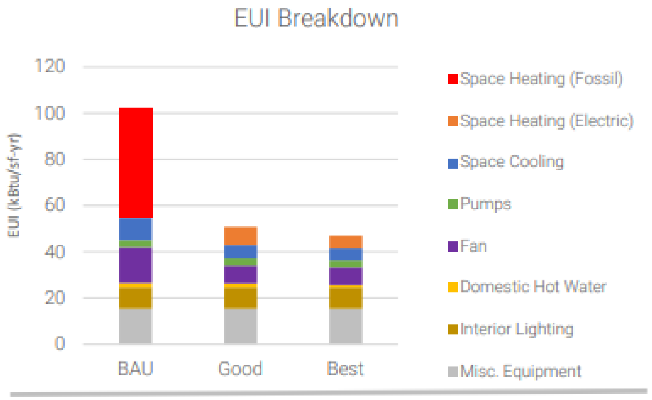
Identify Solutions

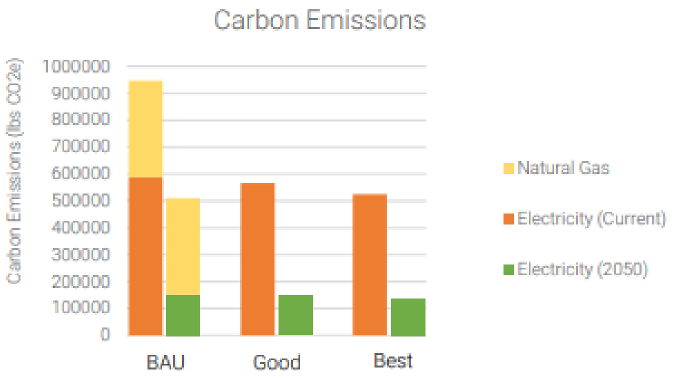
- Energy conservation measures
- Renewable technologies
- Phasing and cost-effectiveness

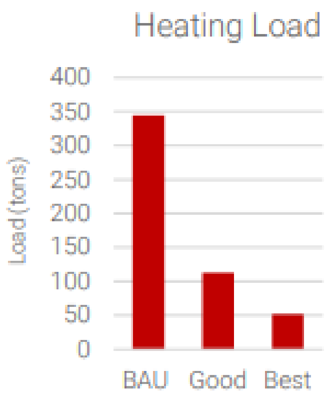
DOER Massachusetts Department of Energy Resources

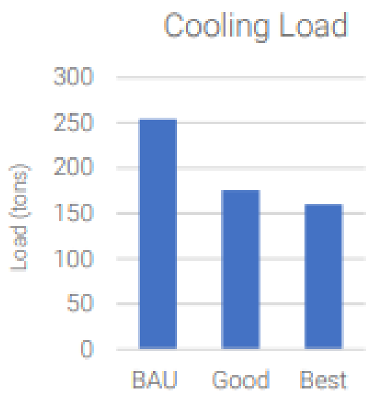
Energy Conservation Measures

- Multiple ECMs were considered with varying degrees of detail
  - ➢ Improve wall and roof insulation
  - ➢ Replace windows to achieve high U-value
  - ➢ Improve building controls
  - ➢ Upgrade air handling units
- ALL studies recommended conversion from steam to low temperature hot water for district heating system





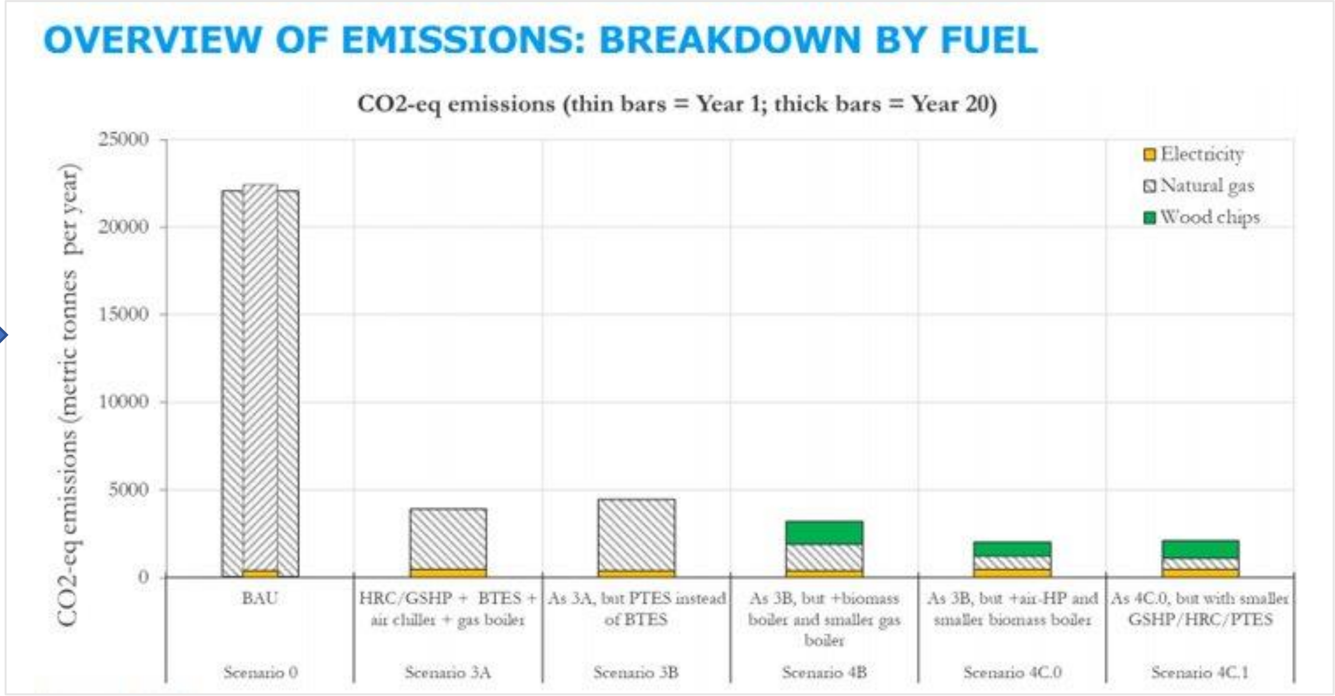




One study provided portfolio of options for every building based on energy demand modeling

Proposed Renewable Thermal Technologies

- Ground-source heat pumps
- Air-to-water heat pumps
- Solar thermal
- Wastewater heat recovery
- Heat recovery chillers
- Thermal energy storage
- Modern wood heating systems
- Renewable fuel oil boilers



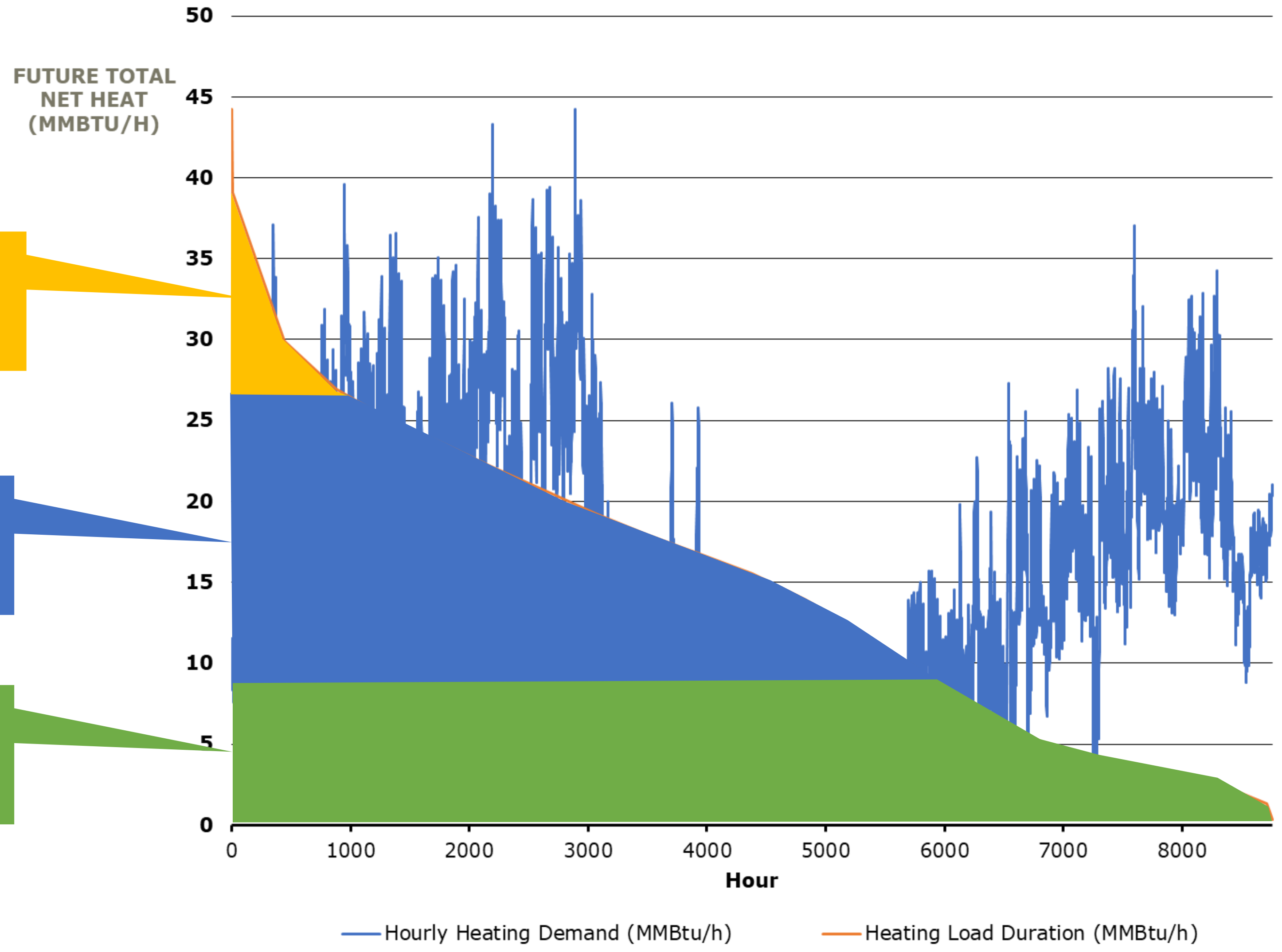
Various combinations of technologies assessed to determine GHG impact, cost, and overall feasibility

Meeting Demand with Multiple Technologies

Peak Load
- Renewable Combustion Fuel (Bio Diesel)

Intermediate Load
- Geothermal Heat Pump
- Air Source Heat Pump

Base Load
- Heat Recovery Chillers
- Geothermal Heat Pump



Meeting Demand with Multiple Technologies

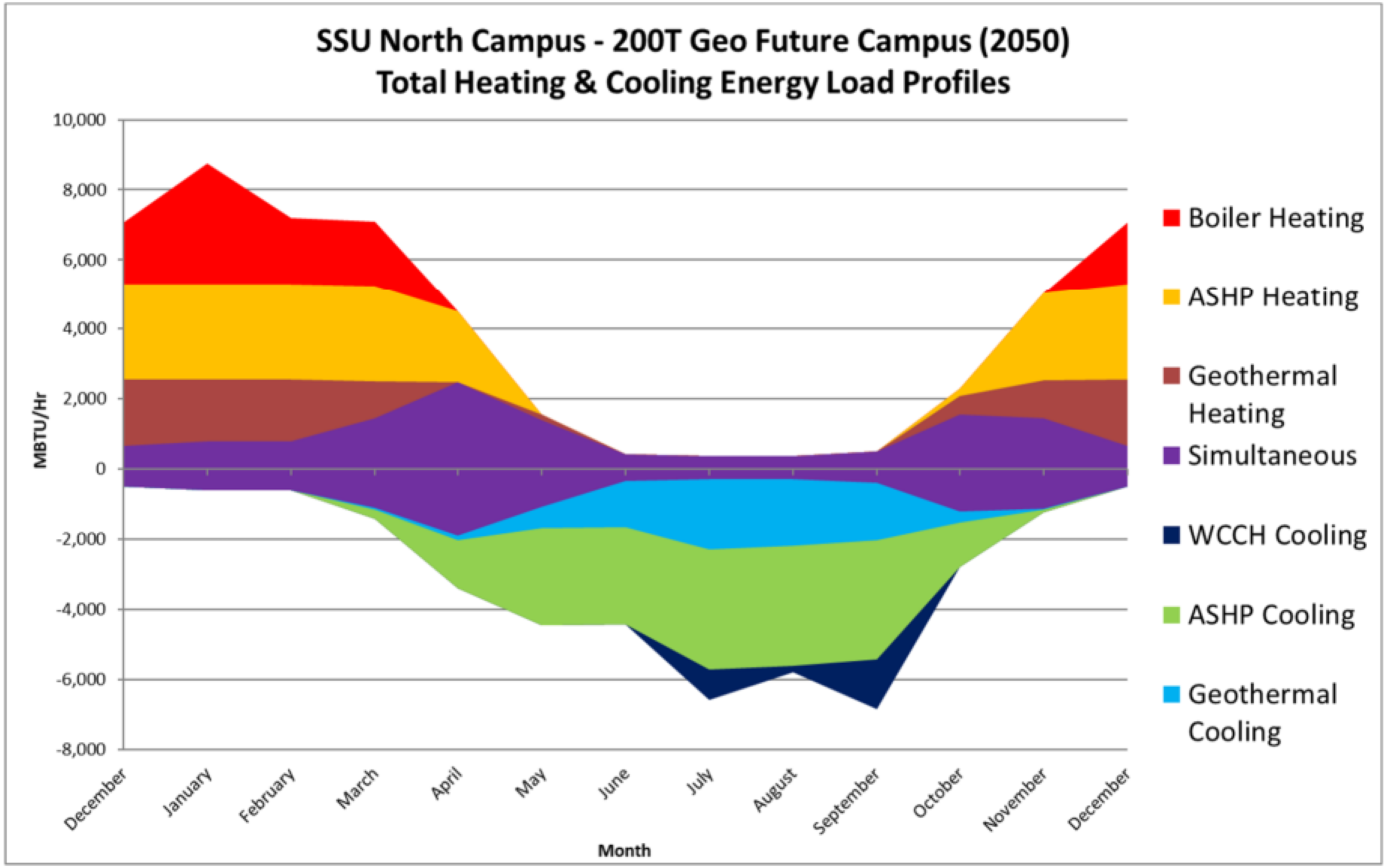
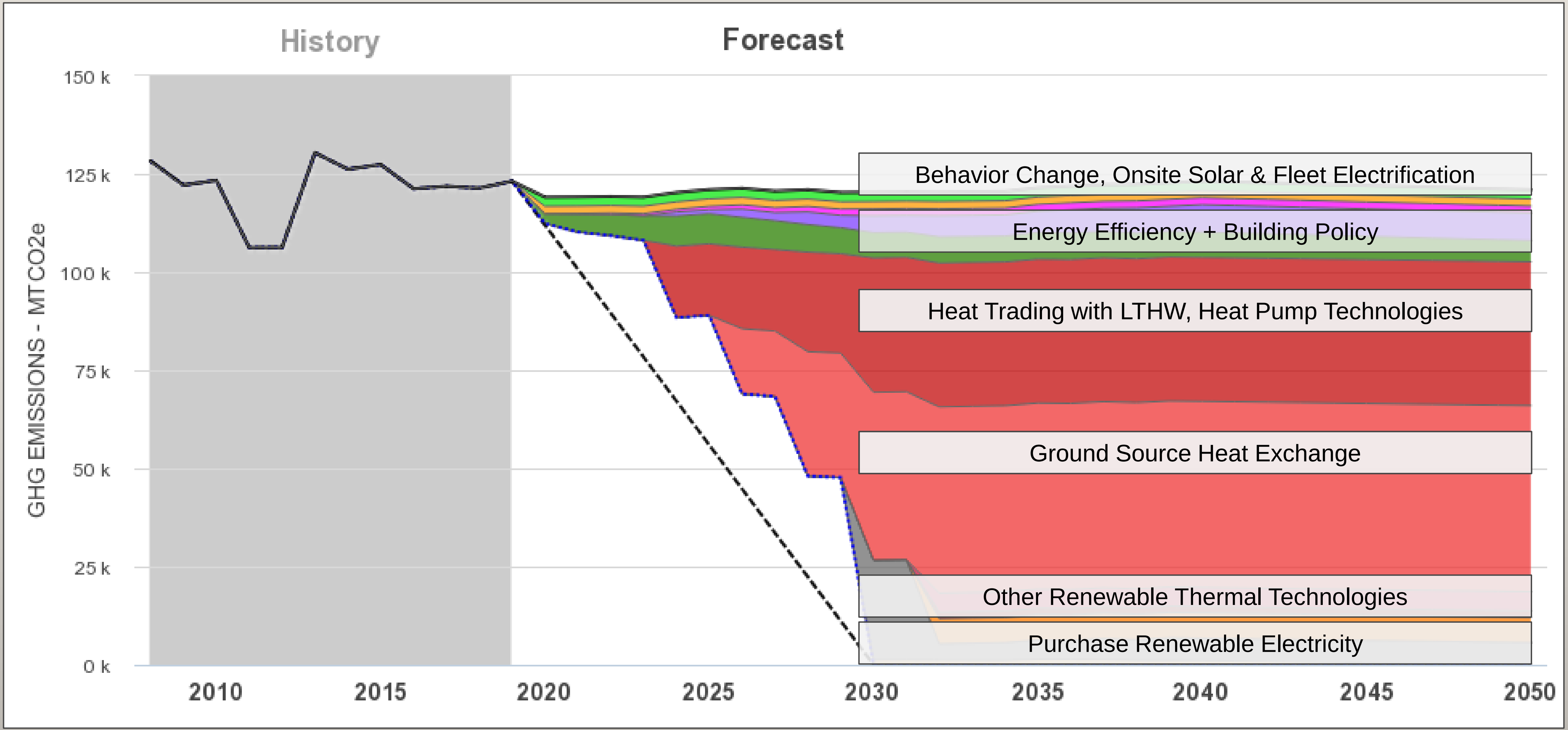


Figure 9: Centralized Option Thermal Profile

Massachusetts Department of Energy Resources

Projecting Impact of Multiple Technologies/Strategies



Key Solutions

Convert from steam to low temperature hot water

Reduce EUI across all buildings as much as possible

Transition central plant from gas to combination of renewable thermal technologies

Base	Intermediate	Peak	Other
Ground-source Heat Pumps	Air-Source Heat Pumps	Biofuels	Thermal energy storage
Heat Recovery Chillers			Wastewater heat recovery

Massachusetts Department of Energy Resources

Phases for Implementation

- Dividing work into phases provides guidance on work that needs to be done first
- Phase schedules intended to align with other plan schedules (e.g., master plan, energy retrofits, deferred maintenance)

Initiative	Phase 1	Phase 2	Phase 3	TOTAL
Year	(2025 – 2030)	(2030 – 2035)	(2035 – 2040)	-
Central Heating Plant Upgrades and Demolition/Replacement	$ 792,162	$ 954,000	$ -	$ 1,746,162
Distribution Network	$ 5,959,392	$ -	$ -	$ 5,959,392
NetZero Energy Plant	$ 14,474,445	$ 8,390,814	$ 408,875	$ 23,274,134
Geothermal Borings and BTES	$ -	$ 18,026,338	$ -	$ 18,026,338
Thermal Tank Energy Storage Installation	$ 2,108,026	$ -	$ -	$ 2,108,026
Building Upgrades and Conversions	$ 6,303,023	$ -	$ -	$ 6,303,023
Emergency Backup Generation	$ 1,861,364	$ -	$ -	$ 1,861,364
Solar PV Car Canopies	$ -	$ -	$ 10,625,000	$ 10,625,000
SubTotal	$ 31,498,412	$ 27,371,151	$ 11,033,875	$ 69,903,438
General Conditions	$ 1,522,498	$ 1,555,057	$ 31,451	$ 3,109,006
Contractor OH&P	$ 1,903,122	$ 1,943,821	$ 39,314	$ 3,886,257
Design Contingency	$ 6,984,806	$ 6,174,006	$ 78,628	$ 13,237,440
Change Order Contingency	$ 2,793,923	$ 2,469,602	$ 31,451	$ 5,294,976
GM Contingency	$ 873,101	$ 771,751	$ 9,828	$ 1,654,680
Engineering	$ 3,492,403	$ 3,087,003	$ 39,314	$ 6,618,720
Construction Management	$ 1,047,721	$ 926,101	$ 11,794	$ 1,985,616
Escalation	$ 12,328,532	$ 24,497,066	$ 10,542,737	$ 47,368,335
Total	**$ 62,444,518**	**$ 68,795,558**	**$ 21,818,392**	**$153,058,468**

*Costs here are high-level estimates, included for demonstrative purposes only

Lifecycle Cost Assessment: BAU vs Alternate Case

- NOT decarbonizing (business as usual) has a cost – fuel, maintenance, equipment replacement, etc
- Alternative case not always most cost-effective over lifetime, but there is other added value (e.g., adding cooling to new buildings, modernizing systems, full decarbonization…)

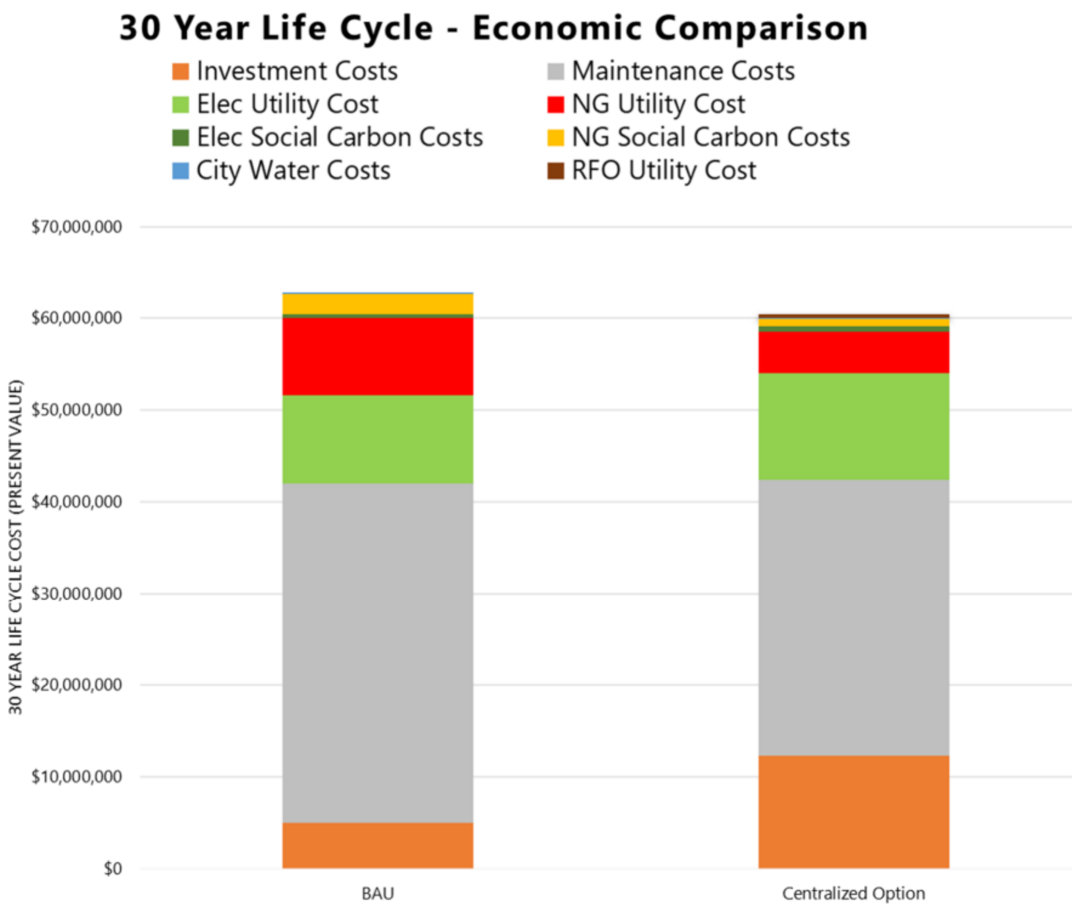
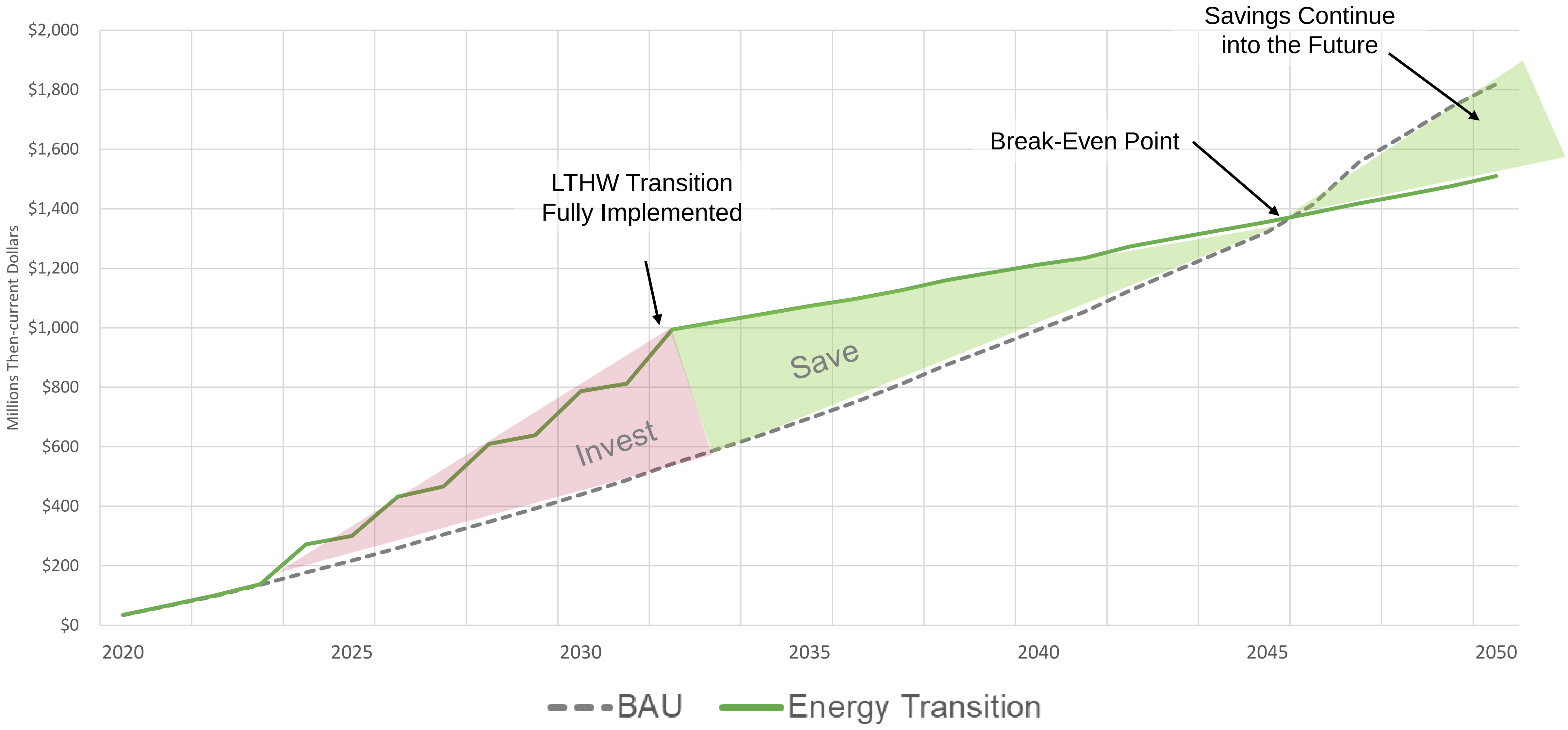


Figure 24: LCCA Present Value Comparison

Financial Implications

Cashflow - BAU vs Energy Transition Through 2050



To Recap…

- Convert to low-temperature hot water
- Reduce EUI
- Heat and cool with a combination of renewable thermal technologies
- Meet electric demand with onsite renewables and a grid powered primarily by renewables
- Implement across phases; conduct further study on technologies and financing

Implementation Challenges

- Investments will range from tens of millions to over $1 billion (~$128/sq ft on average)
- Recommended measures don't always pay for themselves under current financial models
- Systems will require substantial, disruptive infrastructure improvements
- Some technologies (e.g., air-to-water heat pumps, wastewater heat recovery systems) not yet commercially, cost-effectively available

Lessons Learned

- Value of multi-level buy-in for support of study and eventual implementation
- Reinforce goals by integrating ‘roadmaps’ into existing processes
- ECMs to downsize scale of proposed low-carbon technologies may or may not be cost-effective

Lessons Learned

These plans provide robust long-term roadmaps to decarbonization, equipping campuses with an understanding of the work and investments required to achieve our climate goals

What Comes Next?

- Integrate roadmaps into existing plans and protocols
- Granular feasibility studies for specific technologies
- Conduct similar studies at additional facilities, applying lessons learned
- Re-think and reframe financing challenge

Decarbonization is an investment to modernize our heating and cooling infrastructure, does it need a payback period?

Massachusetts Department of Energy Resources

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENERGY RESOURCES
Patrick Woodcock, Commissioner

Thank you!

Ryan Kingston
Ryan.Kingston@mass.gov
Sustainability Project Coordinator
Leading by Example Program