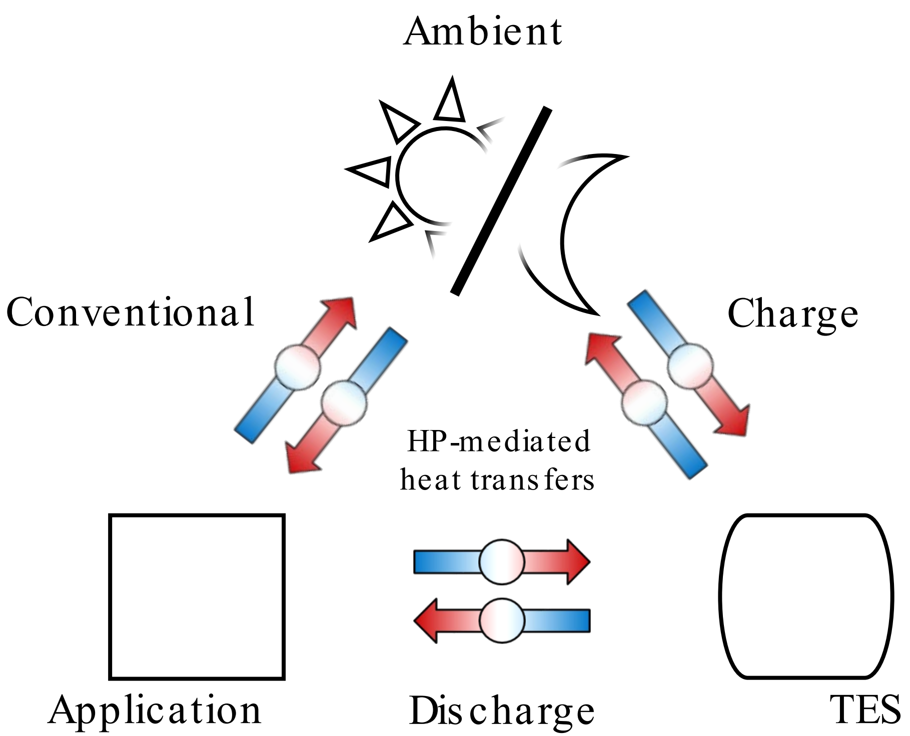
A proposed methodology to reduce heat pump size with integrated thermal energy storage

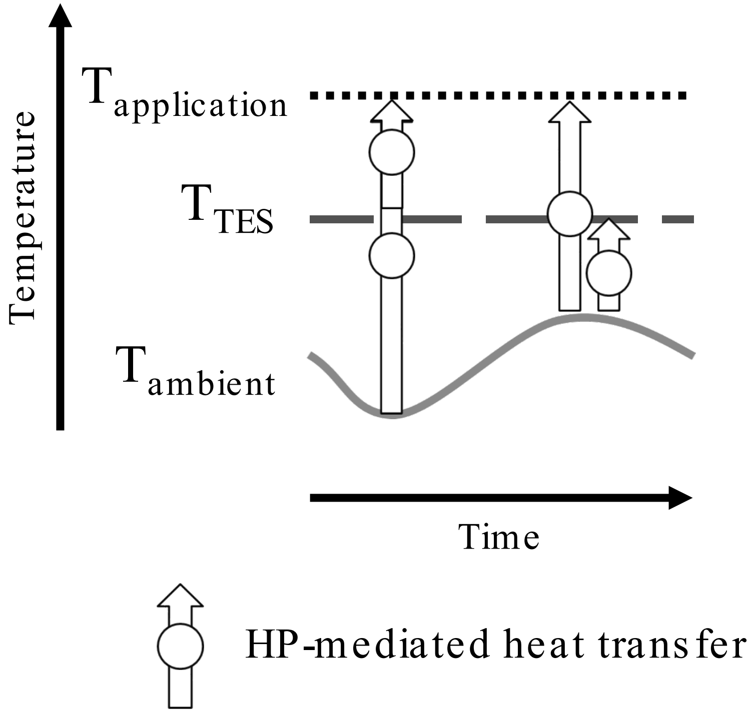
Jason Hirschey[a], Kyle R. Gluesenkamp[b], Bo Shen[b], Zhenning Li[b], Samuel Graham[a]

[a] Georgia Institute of Technology, Atlanta, GA, USA

[b] Building Technologies Research and Integration Center, Oak Ridge National Lab, Oak Ridge, TN, USA

TES Integrated Heat Pump





<u>Three temperature bodies</u>

1. Application (constant) 2. Ambient (time-varying) 3. TES (constant)

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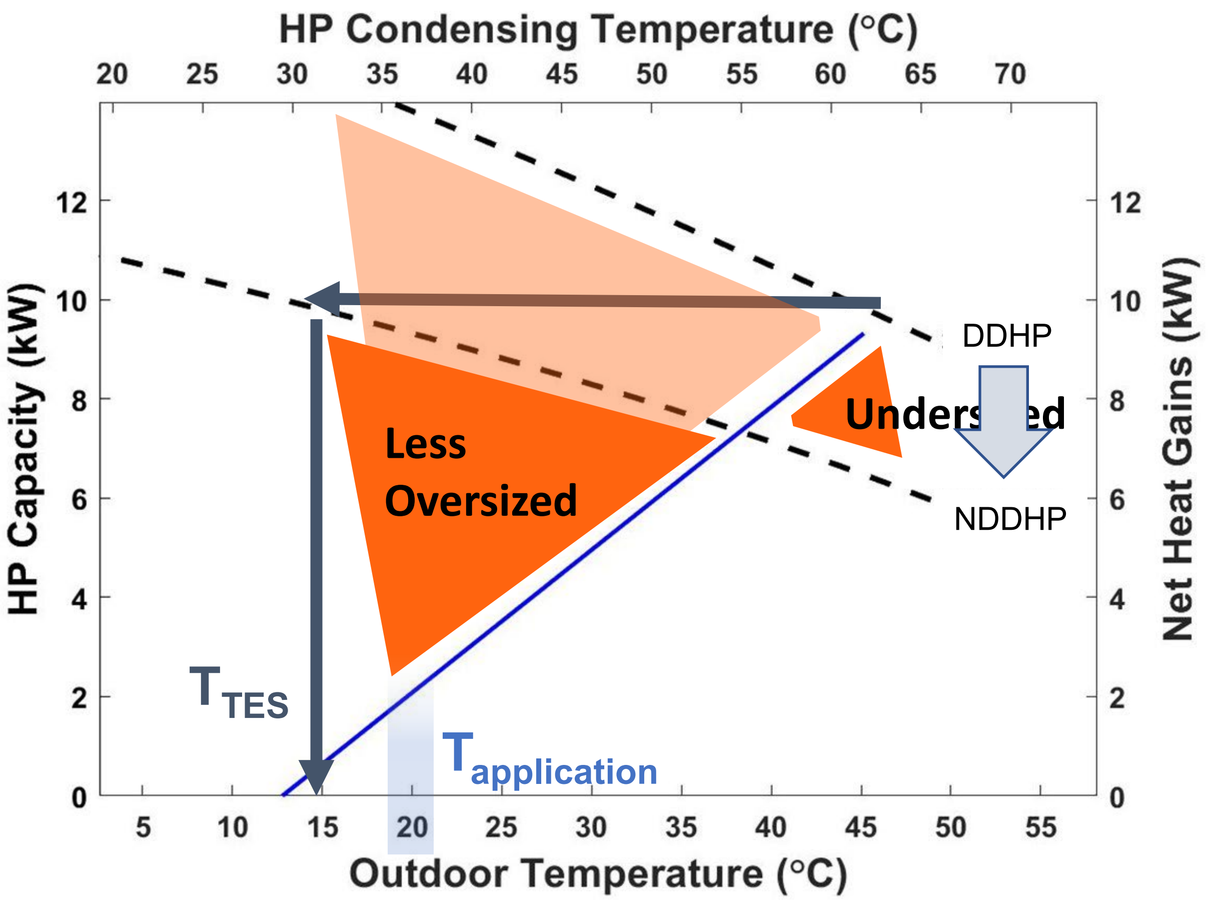
Can TES reduce the size of HP without sacrificing thermal comfort?

- Application heat load & HP capacity curves
- Imagined case study of downsizing HP-TES system
  - Parameters:
    - Indoor space cooling
    - Assumed heat load curve
    - Typical meteorological year (TMY) data
    - Phoenix, AZ
- Key takeaways & additional thoughts

Method to determine reduced HP and TES temperature



1. Determine application heat load at the Design Day (DD) condition

- ACCA Manual J, ASHRAE Standards, Building energy modeling

2. Select HP to meet DD conditions (DDHP)

- ACCA Manual S, Contractor oversize
- HP availability

3. Identify new DD (NDD) conditions –OR– Select smaller HP (NDDHP)

- Building energy calculations
- Climate consideration

4. Determine TES temperature

- NDDHP meets DD conditions

Apply Downsized HP-TES to Application

Determine TES capacity and HP-TES feasibility

1-4. Preceding method to identify reduced HP and TES temperature

- Iterate
- Develop set of possible configurations

5. Calculate all TES discharging and charging events with NDDHP

- Weather data
- Building energy modeling

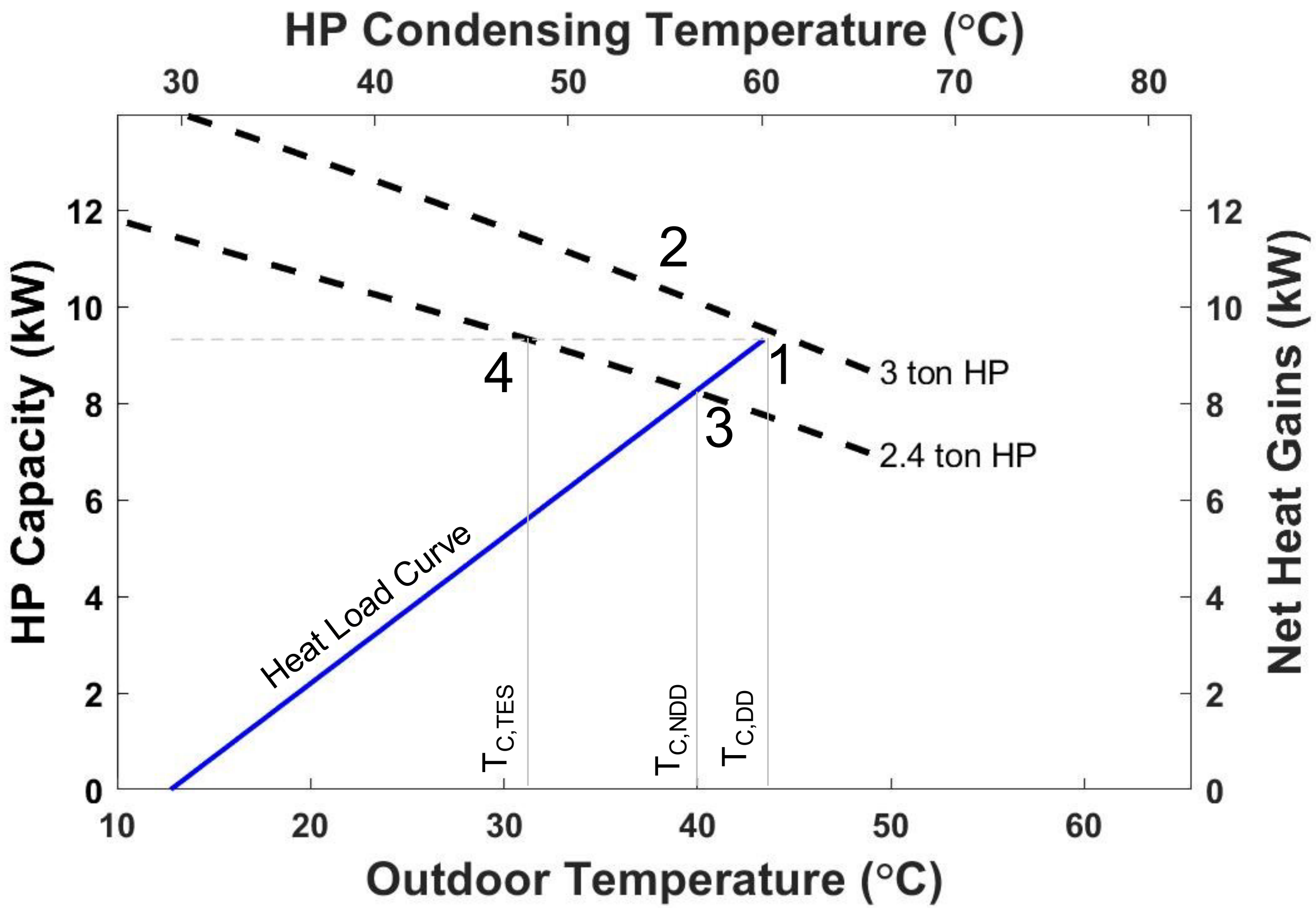
6. Determine necessary capacity of TES

- Maximum of all TES discharging events

7. Evaluate HP-TES configuration feasibility

- HP capacity to fully recharge TES and maintain application thermal comfort

Imagined Case Study | Phoenix, AZ
HP Downsizing Method



Determine Downsized HP

1. $T_{C,DD}$ = 45.2°C (0.4% design temperature)
2. DDHP = 3 ton nominal HP
3. NDDHP = 2.4 ton nominal HP (next smaller size from manufacturer)
   → $T_{C,NDD}$ = 41.8°C (3% design temperature)
4. $T_{C,TES}$ = 32.0 °C

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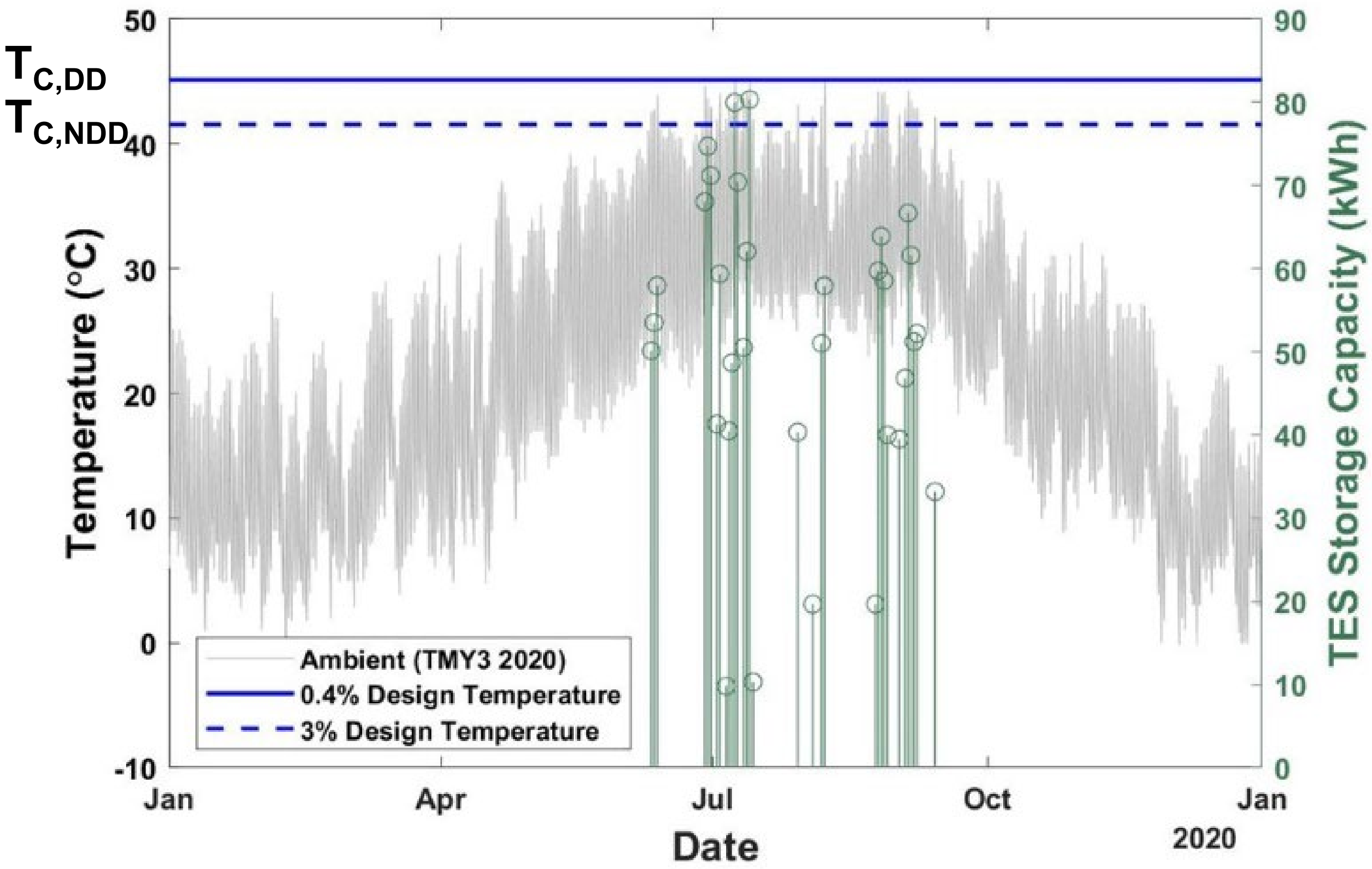
TES Capacity and HP-TES Feasibility

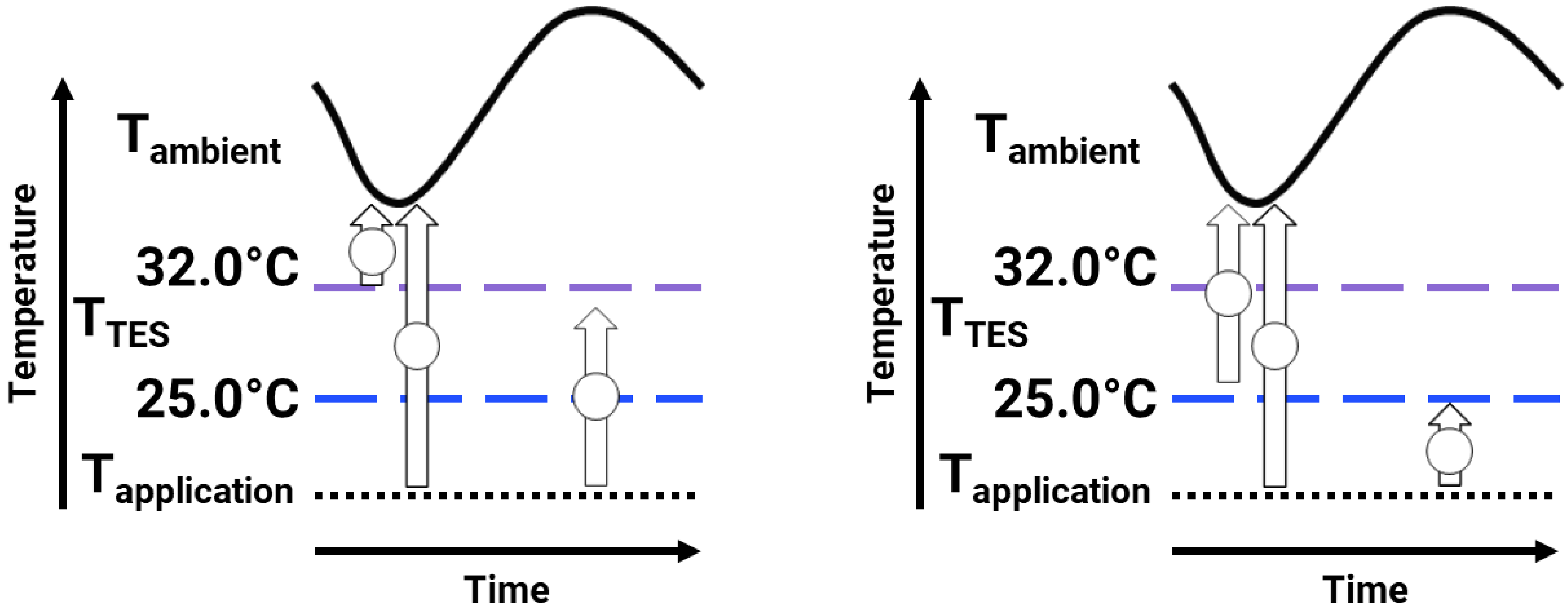


Apply Downsized HP-TES to Application

5. Calculate instances in which TES is active
    - $T_{ambient} > T_{C,NDD}$
6. Determine TES capacity (80.3 kWh)
    - Maximum supplied heat from all TES events
7. Evaluate feasibility
    - Can the downsized HP-TES provide the necessary thermal conditioning?

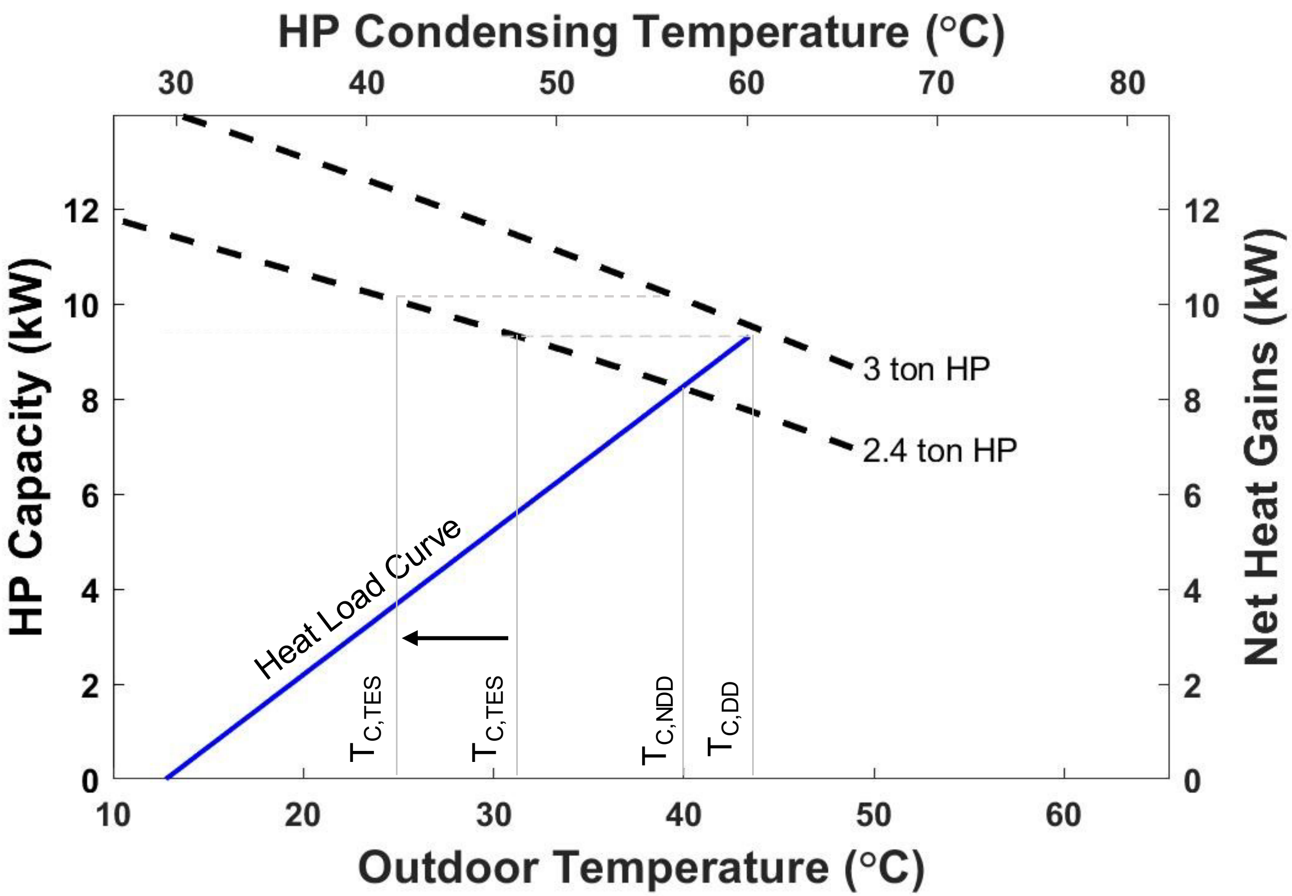
$T_{C,TES}$ = 32.0°C

Downsized HP | Sensitivity to TES Temperature



Downsized HP is responsible for simultaneous recharging and thermally conditioning the application

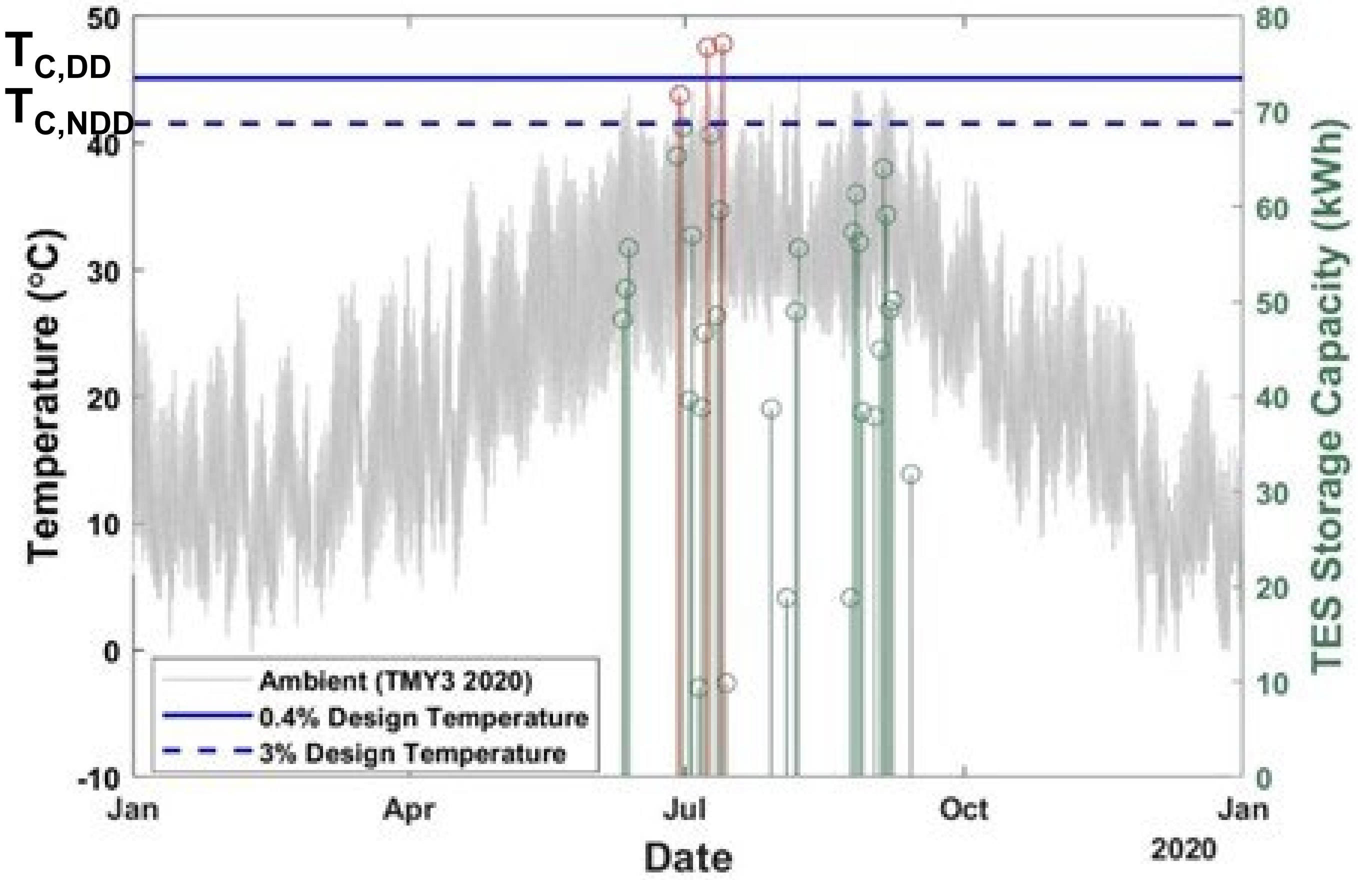
Downsized HP | Sensitivity to TES Temperature



Downsized HP | Sensitivity to TES Temperature

$T_{C,DD}$

$T_{C,NDD}$

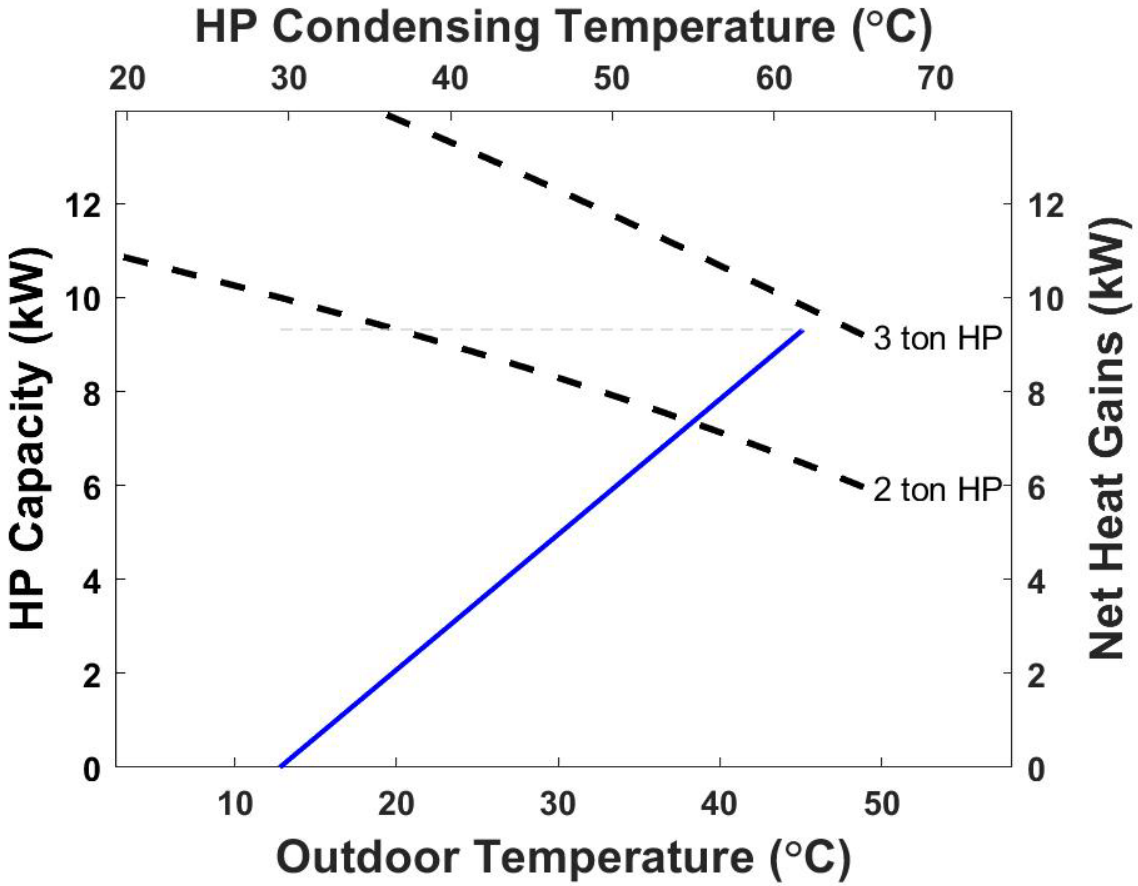


Apply Downsized HP-TES to Application

5. Calculate instances in which TES is active
   - $T_{ambient} > T_{C,NDD}$
6. Determine TES capacity (77.1 kWh)
   - 4% reduction from $T_{C,TES}$ = 32°C
7. Evaluate feasibility
   - Can the downsized HP-TES provide the necessary thermal conditioning?

$T_{C,TES}$ = 25.0°C

Sensitivity to Downsized HP



Determine Downsized HP

1. TC,DD = 45.2°C (0.4% design temperature)
2. DDHP = 3 ton nominal HP
3. NDDHP = 2 ton nominal HP
   → TC,NDD = 38.1°C (6% design temperature)
4. TC,TES = 15°C

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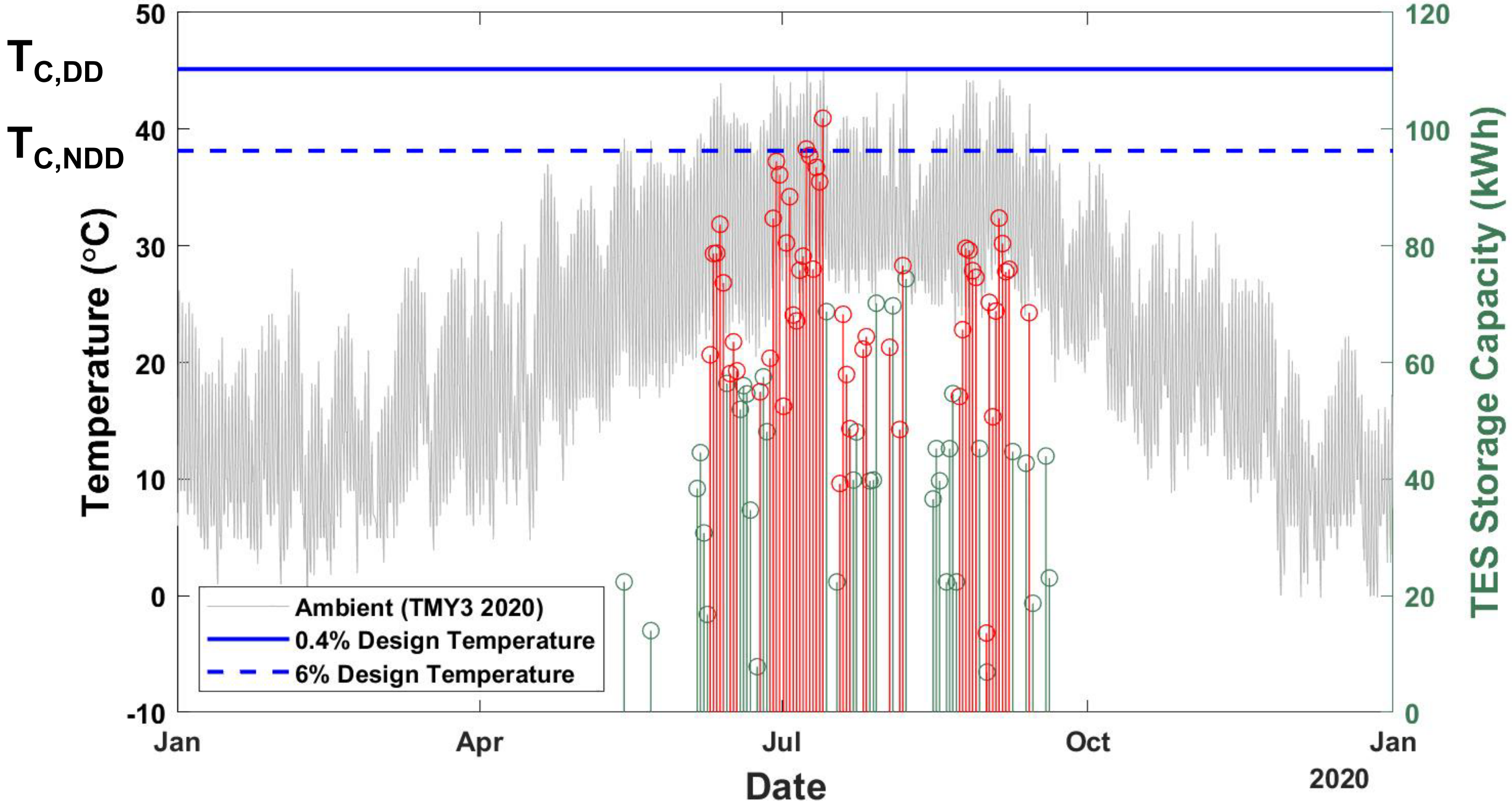

$T_{C,TES}$ = 15.0°C

Apply Downsized HP-TES to Application

5. Calculate instances in which TES is active
   - $T_{ambient} > T_{C,NDD}$
6. Determine TES capacity
   - 170 kWh
7. Evaluate feasibility
   - Can the downsized HP-TES provide the necessary thermal conditioning?

Key Takeaways

- Method proposed by which HP capacity can be downsized by integrating TES
  - Identifies new design conditions
  - Identifies necessary TES temperature
  - Calculates TES capacity
  - Tests viability to maintain thermal comfort and fully utilize TES
- Additional and future considerations
  - Different HP operation when interacting with TES
  - Setback temperatures
  - Variable speed compressors
  - Combined heating and cooling
  - Retrofit existing HPs

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Contact me to discuss more

Jason Hirschey, PhD
Post Doctoral Researcher
National Renewable Energy Laboratory

This work performed as:
ORNL GO! Fellow
George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology

Mail: jason.hirschey@nrel.gov
jason.hirschey@gmail.com
Web: https://www.jasonhirschey.com

Georgia Tech

Oak Ridge National Laboratory