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Modeling a Large Retail Center Using Energy Plus (E+)

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Energy Use In Commercial Buildings

- Use 18% of the nation's primary energy
  - 20% in "retail/service"
- E+ is a valuable tool for guiding energy-efficiency investments
  - New construction, retrofit
- E+ is constantly improved and expanded to include new efficiency technologies

ORNL's Contributions to the E+ Team

- Expanding capability to model energy savings options:
  - for refrigeration systems
  - for ground-coupled heat exchangers
- Working with Walmart to identify replicable opportunities

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ASHRAE cover article Sep07 on work with Wal-Mart (Part II Oct07)

- Daylight Harvesting
- "Cool" roofing
- Heat Reclaim
- High Efficiency HVAC
- Centralized EMS/Monitoring
- Exterior LED Signage
- Active De-humidification

Interior with sales floor lighting in "full off" mode

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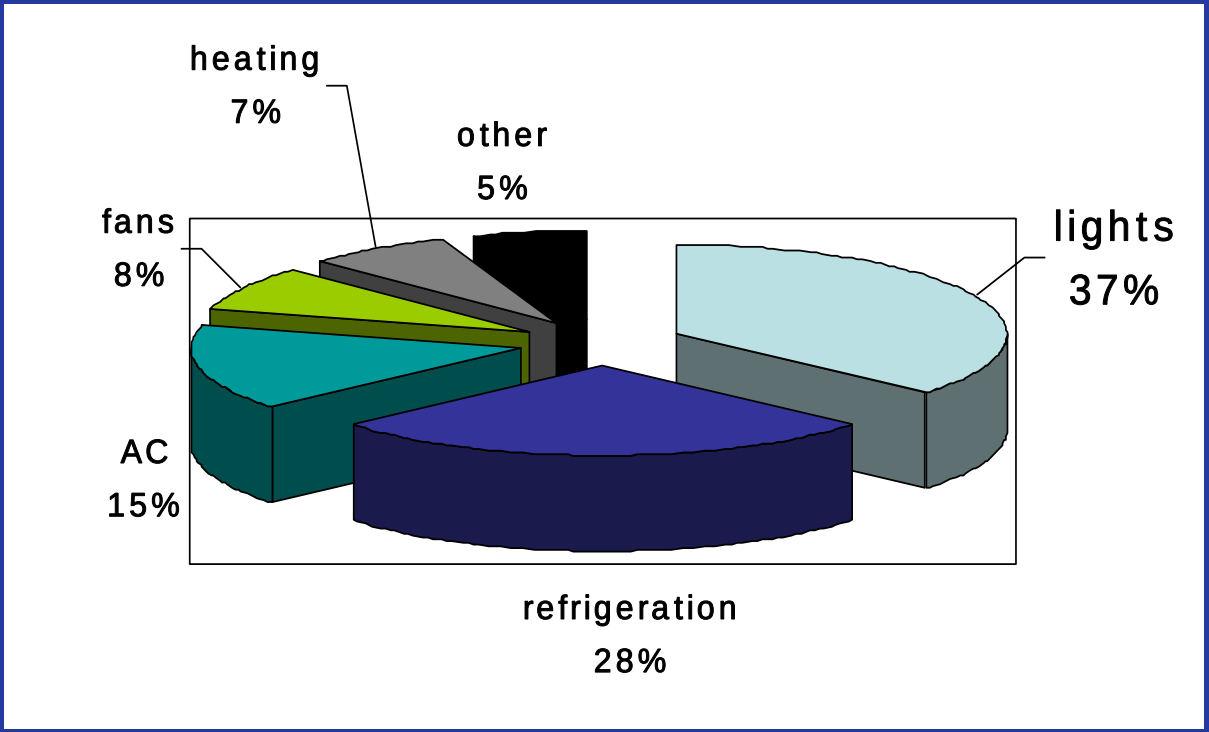
Describes results of what works and what doesn't at Super Centers

Refrigeration can account for 30% of a store's energy use.

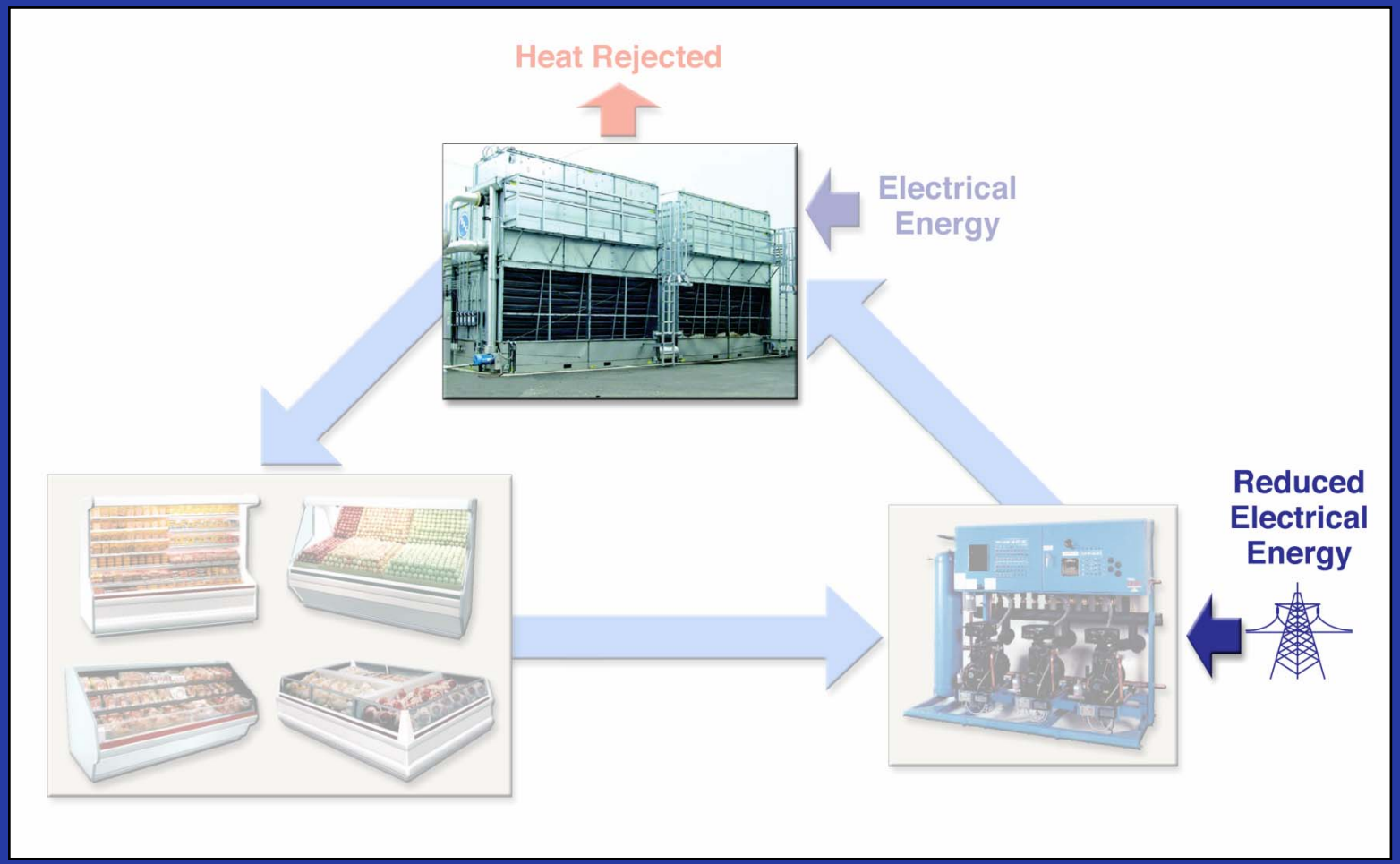


Typical Super Center Energy Use

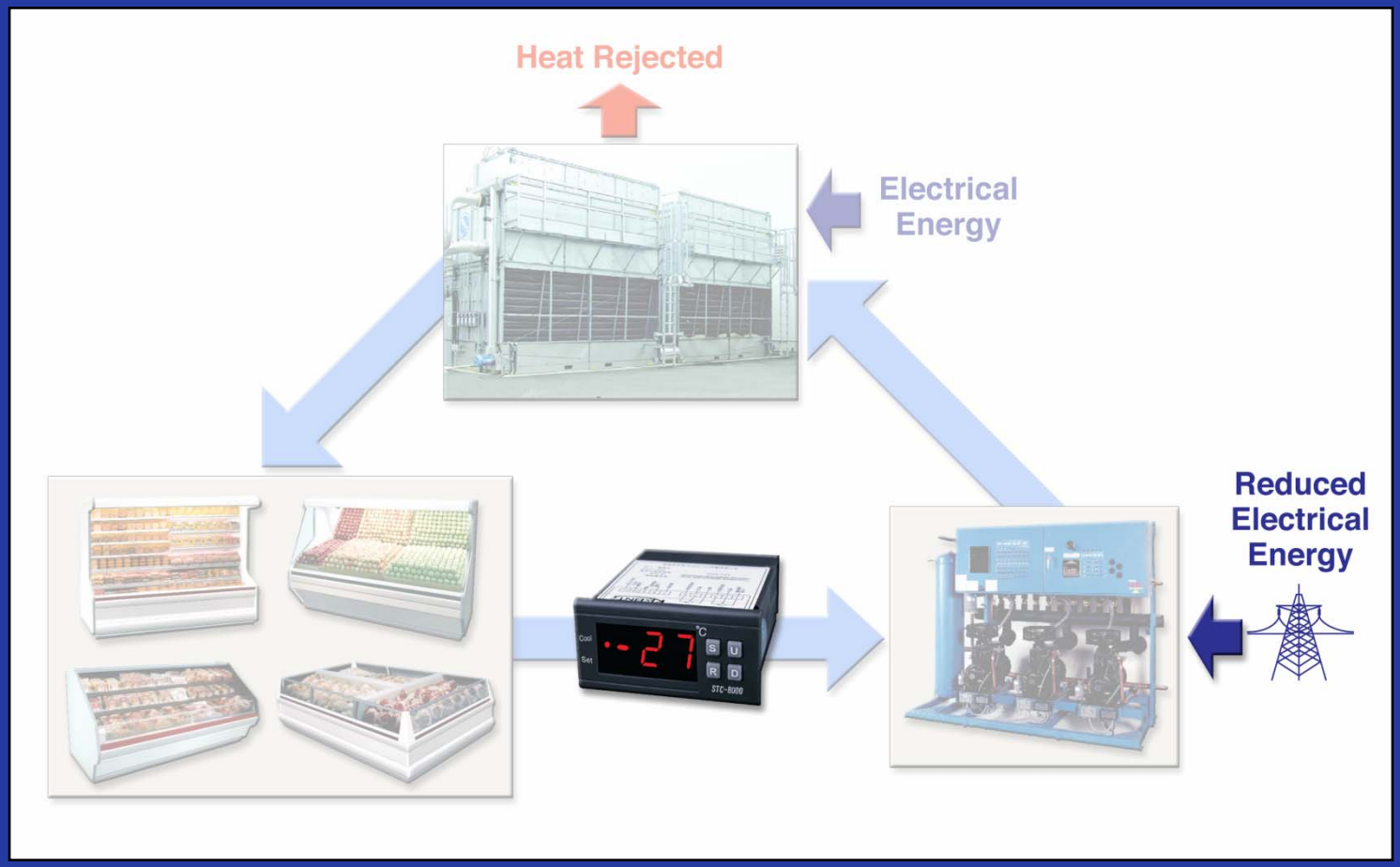
Expanding E+ Refrigeration Capabilities

- Increase model fidelity
- Some of the options for energy conservation recently added to E+:
  - Evaporative condensers
  - Water-cooled condensers
  - Variable suction pressures
  - Mechanical subcoolers

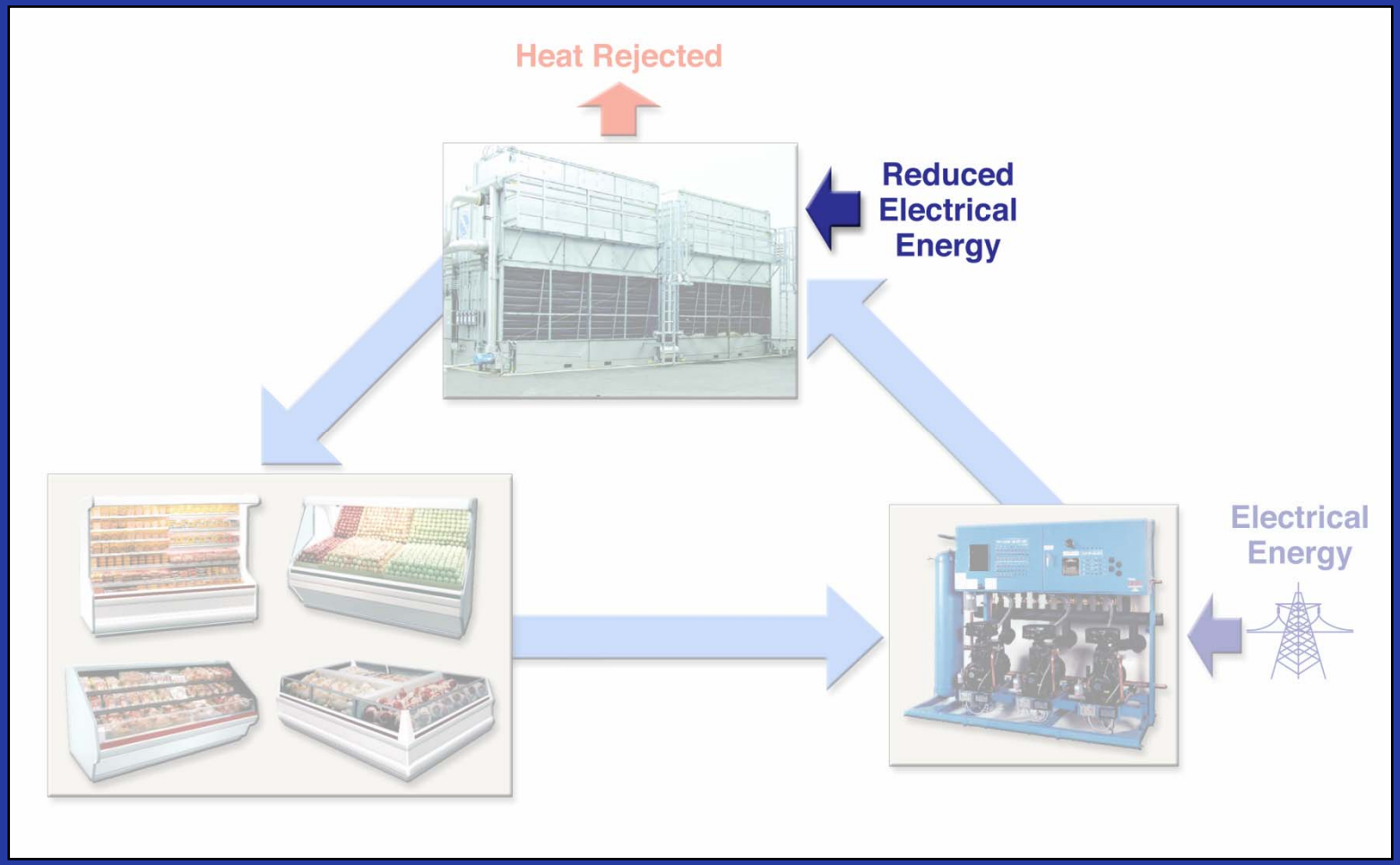
Evaporative and water-cooled condensers improve refrigeration system efficiency.



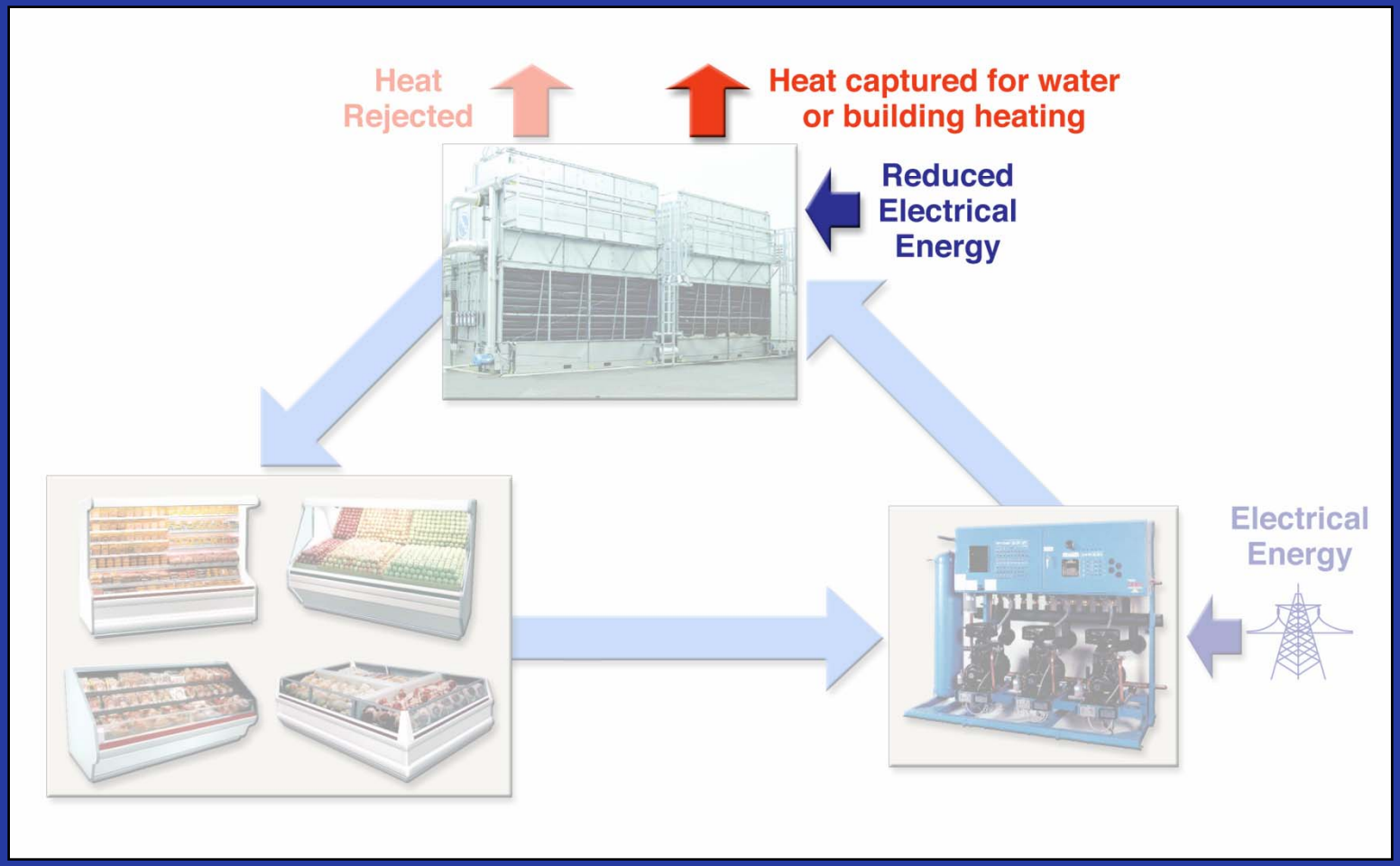
Meeting the refrigeration need at the highest possible evaporating temperature improves compressor efficiency.



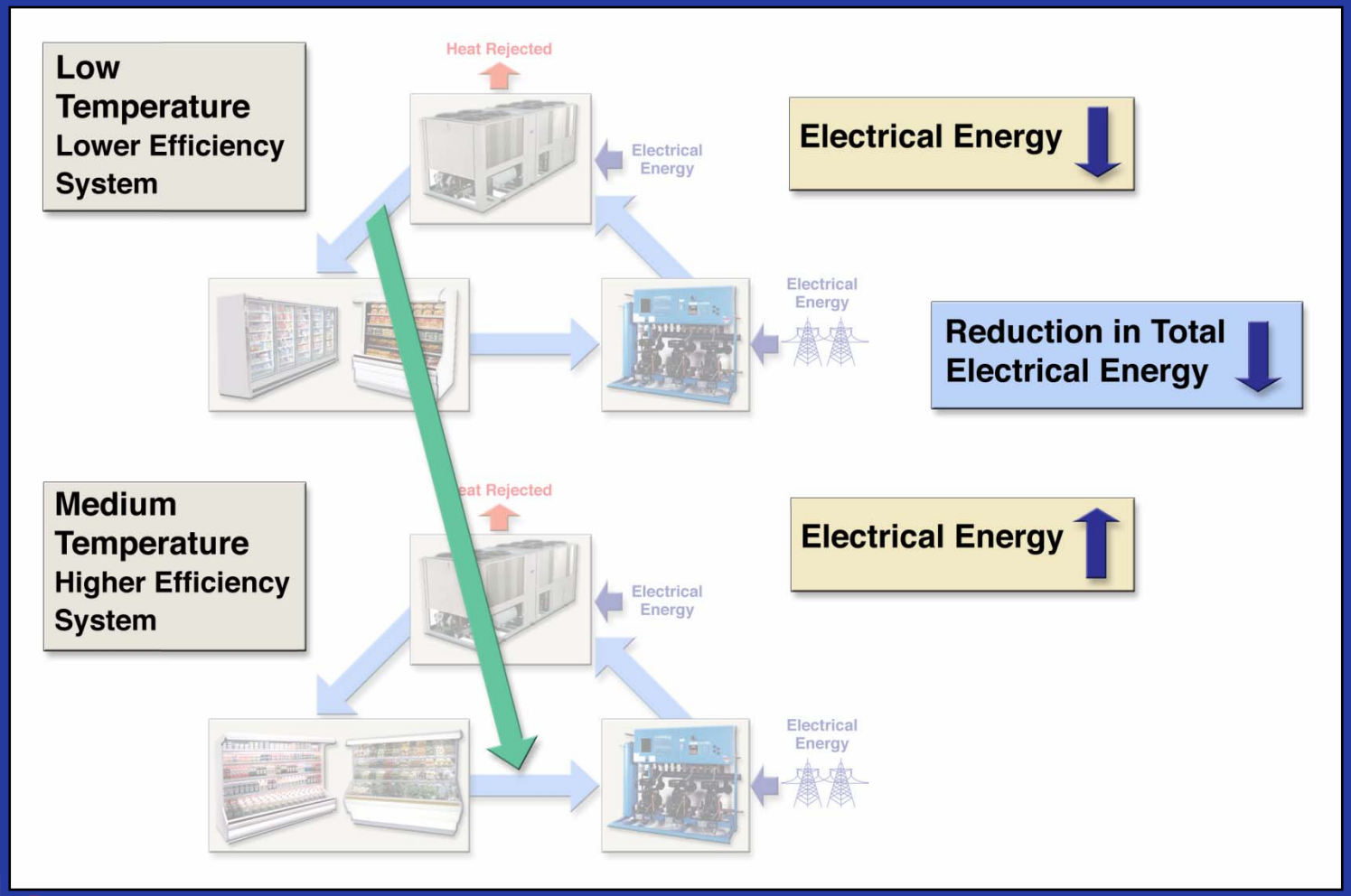
When system is running at half load, a variable-speed fan uses 1/8th as much power as at full load.



Recovering waste heat reduces fossil fuel use and reduces auxiliary energy for the condenser.



Using a higher-efficiency, refrigeration system to “sub-cool” a lower-efficiency system reduces net refrigeration energy use.



Walmart is considering many energy system options.

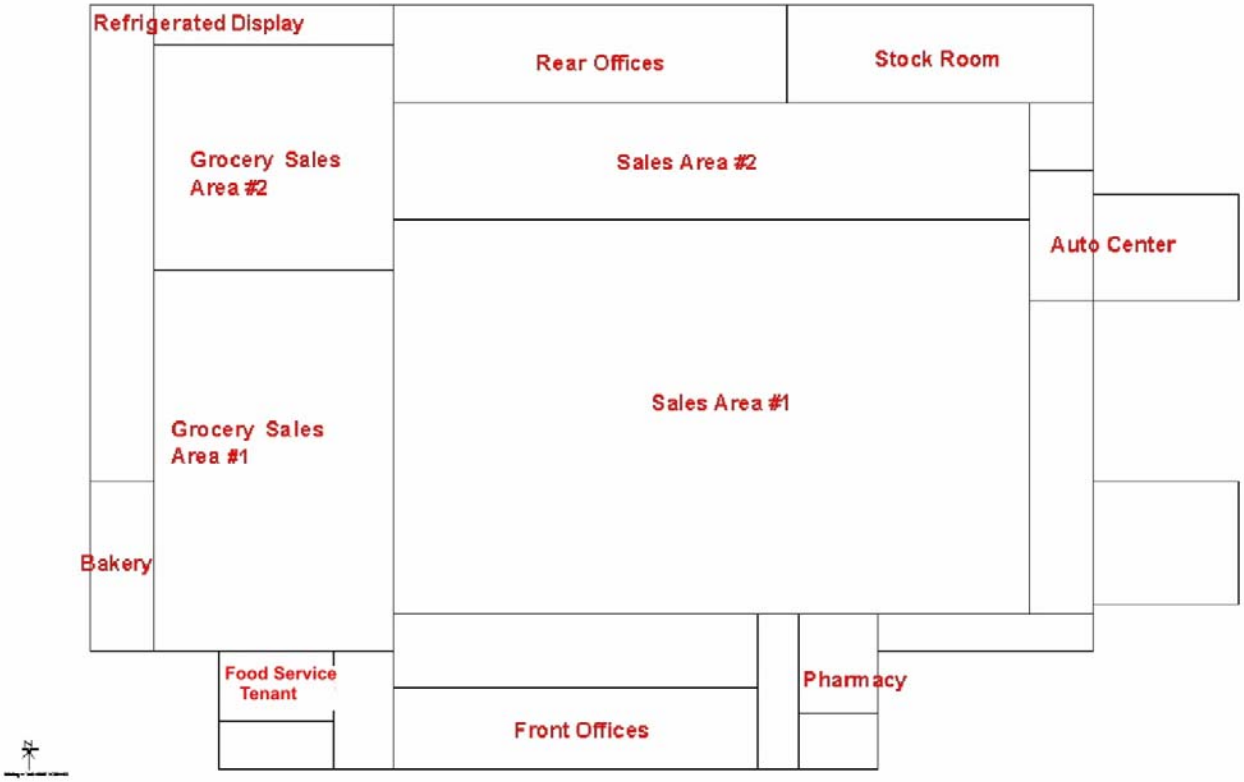
- Architectural
  - Reflective roofs, optimum insulation, daylighting, decreased wall areas
- Mechanical
  - Integrated HVAC and refrigeration, higher-efficiency display case options, water-source systems
- Lighting
  - Dimming controls, possible night dimming, T5 lamps
- Renewable systems, wind and solar

A particular store in North Texas was modeled.

- Single-story, 200,000 sq ft, 24/7 operation, block walls, metal roof
- Extensive daylighting
- White reflective roof
- Refrigeration systems on roof, water-cooled
- Gas boiler with water loop for heating
- DX cooling
- Dedicated outdoor air units for ventilation

This store has more than 50 energy meters and 200 data points monitored at hourly or one-minute intervals.

Specially metered data will be used to check model results.



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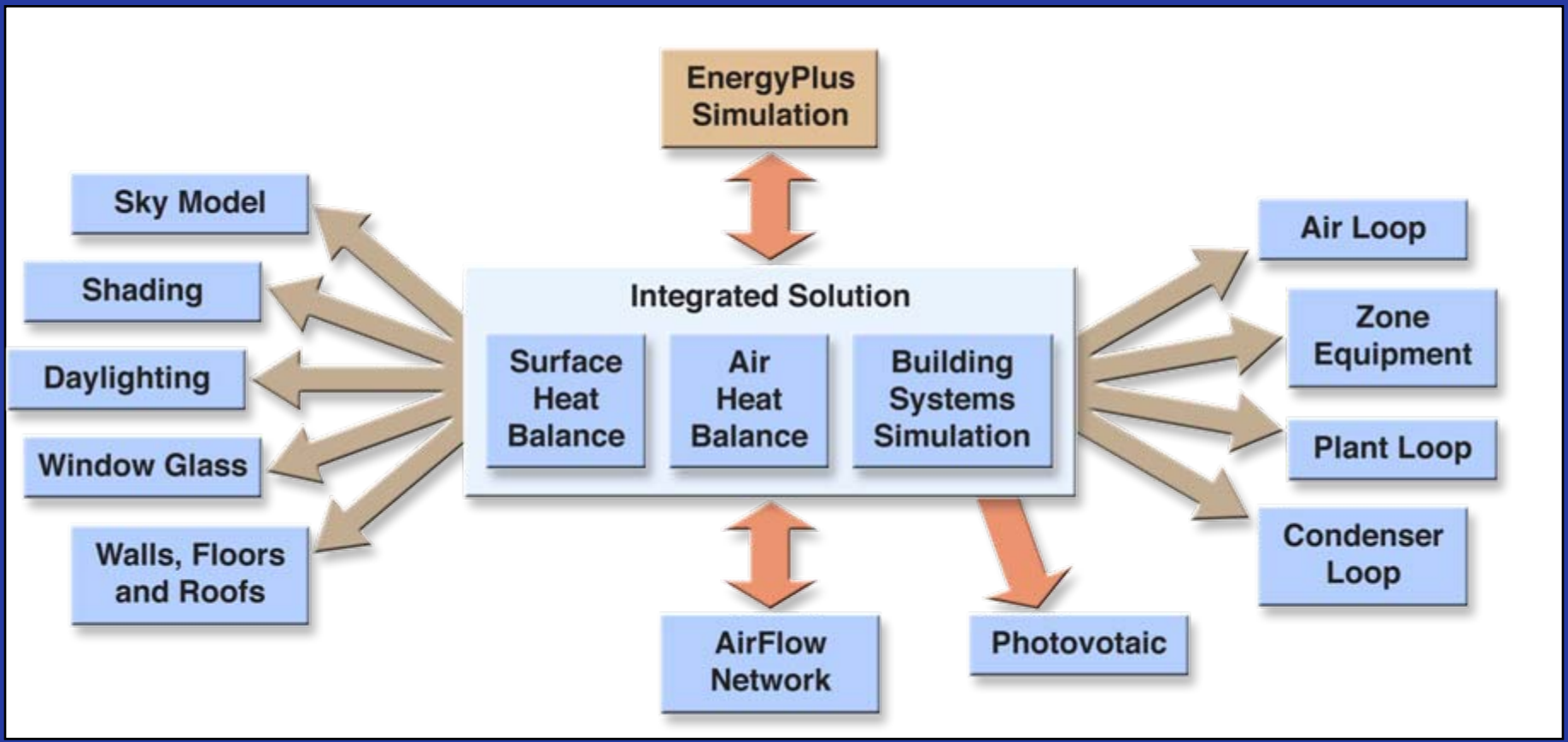
Major Mechanical Systems

- HVAC equipment
  - 32 rooftop units, 256 tons, heat recovery
  - 3 air-handling units, heat recovery, desiccant wheel dehumidification
- Hot water boilers – waste-oil fired and supplemented with gas as needed
- Hot water radiant floor panels
- Exhaust fans

Refrigeration Equipment

- Refrigerated display cases
  - Total of 47, capacity 73 tons
- Refrigerated case compressor racks, 5 groups
  - All water-cooled
  - Waste heat recovery

E+ Internal Elements —
Each component is modeled in detail.

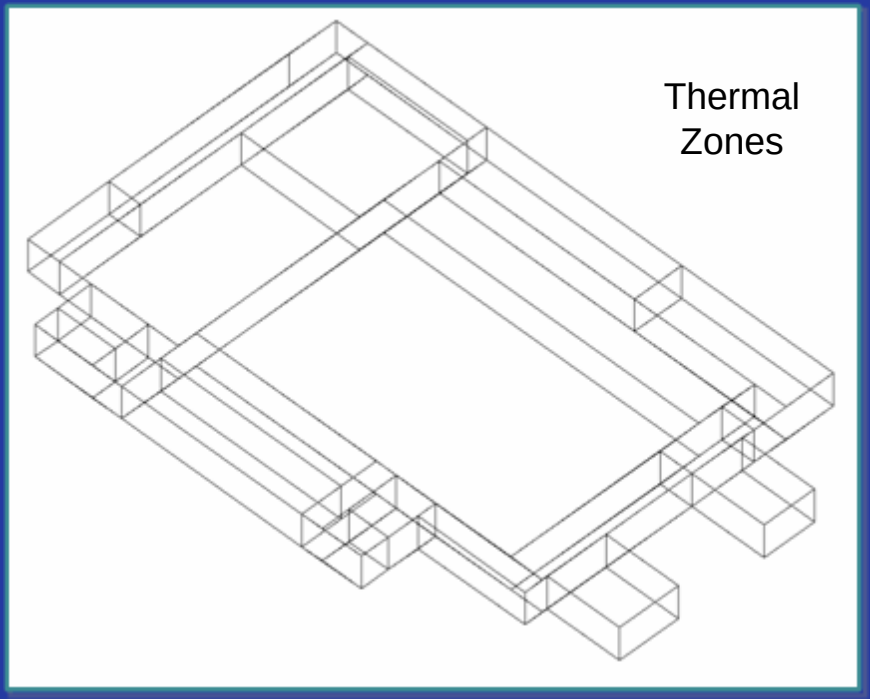


Detailed Component Modeling

- Provides ability to model real equipment
- Maximum versatility
- Expands opportunities to explore energy saving technologies
- BUT requires massive input
  - Retail center description is about 12,000 “lines” of input

The Building Model Includes:

- 12 thermal zones, e.g., bakery, refrigerated display, rear offices, stock room
- 112 heat transfer surfaces (e.g., walls, roofs, windows)



The Building Model (continued)

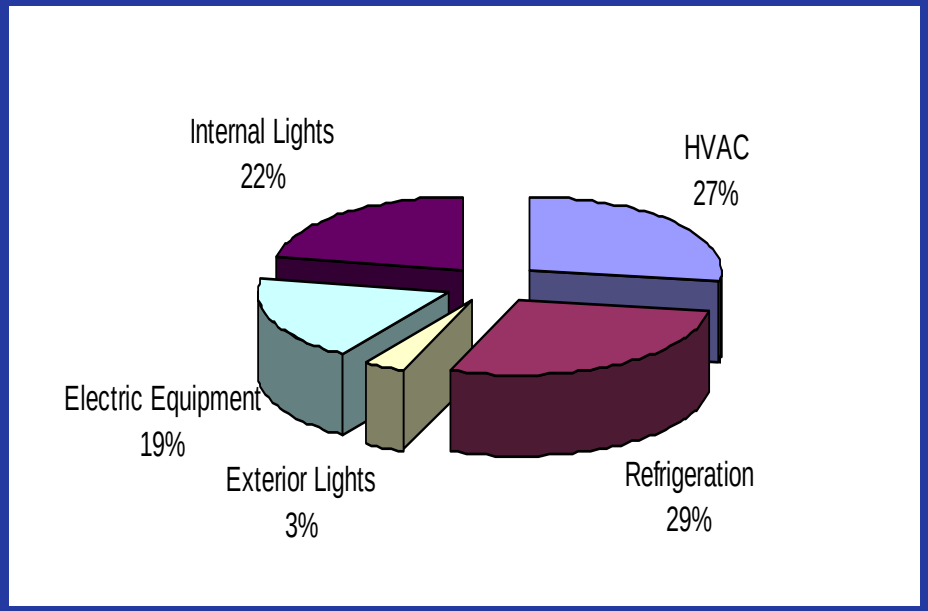
- Zone air mixing
- 12 air distribution loops (163 nodes)
- Zone equipment, e.g., air terminal units and water heating coil
- Plant water system, e.g., boilers, pipes (38 nodes)

Important Next Step – Benchmarking the Model

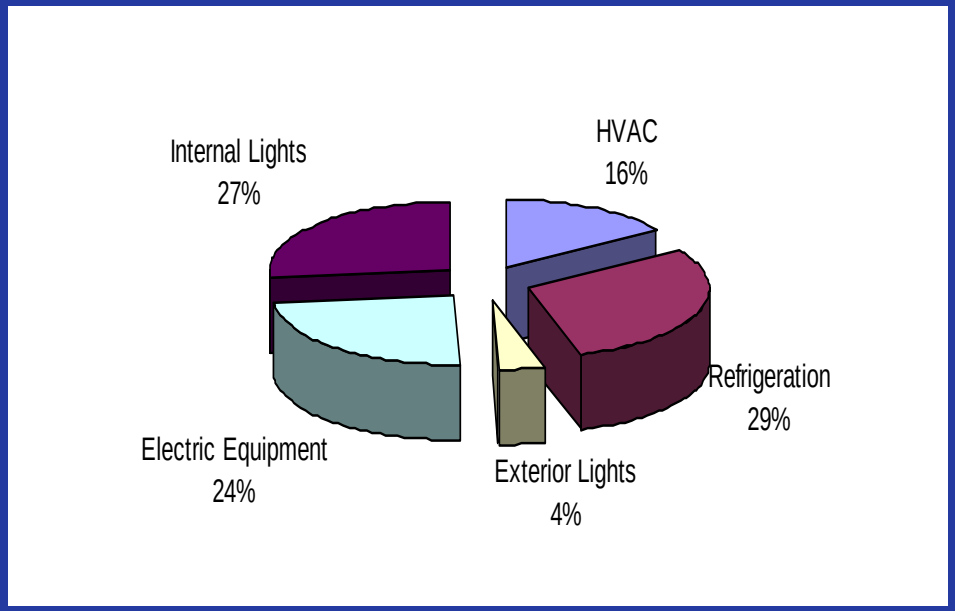
- Use 2007 TMY weather data and specially metered data to simulate store
- Compare results to metered data
- Calibrate model
- Use model to predict savings for similar systems in other locations

Comparing the original model to the measured results shows the importance of the calibration step.

Measured Data
Total 6,370,327 kWh

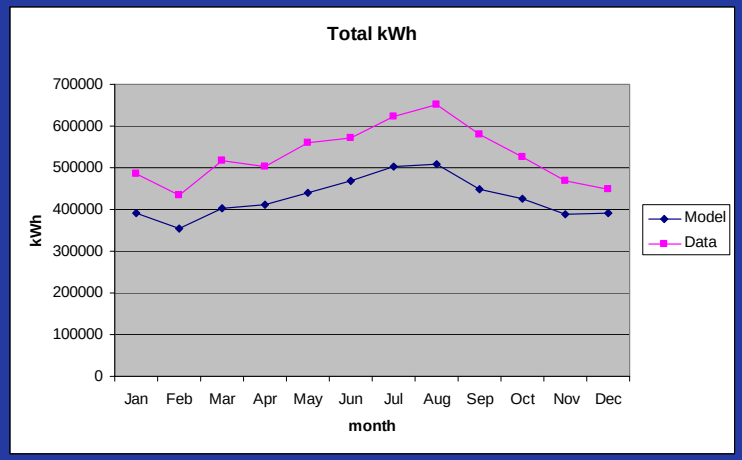


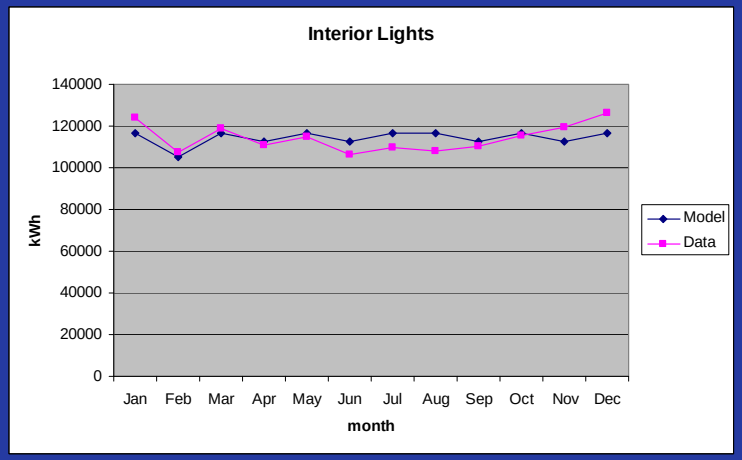
Model Predictions
Total 5,133,629 kWh

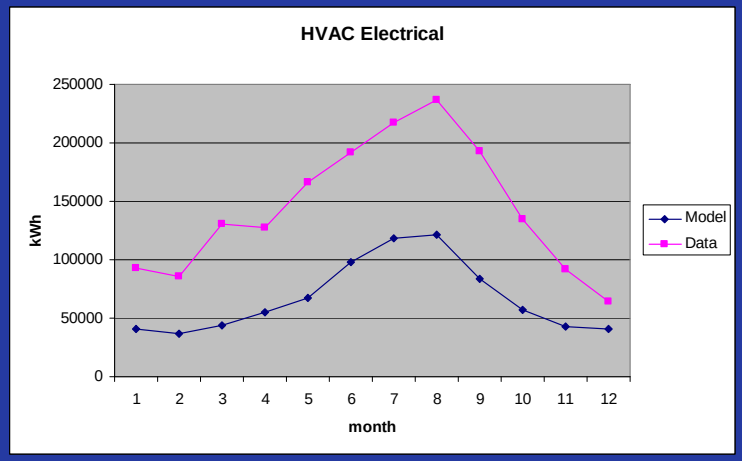


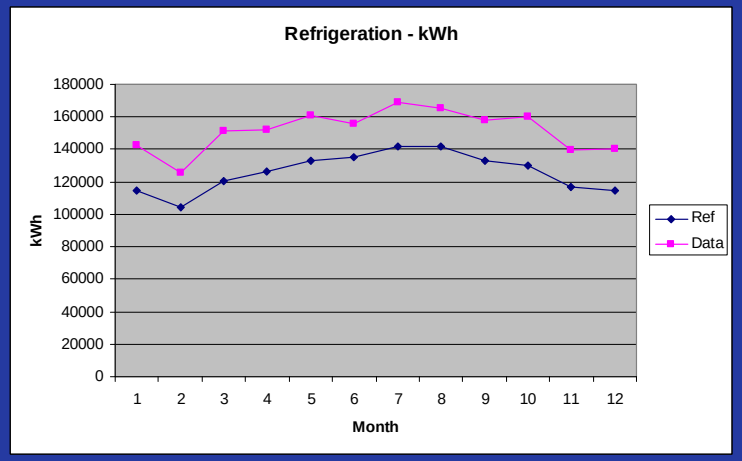
Initial prediction 81% of measured

The original model matched the lighting use well, but underestimated HVAC and refrigeration energy use.









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+/- 5% when calibration process completed

E+ Model Development Plans

- Add ground-loop heat exchanger model
- Benchmark ground-loop model with data from multiple buildings
- Add secondary refrigeration systems
  - Important tool in managing refrigerant leaks
- Improve walk-in cooler models

Conclusions

- E+ is a valuable tool for guiding energy decisions and investments.
- E+ is being used by owners whose buildings are variations of standard designs.
- Constant upgrades to E+ are adding capabilities to model equipment advancements and maximize savings.

For More Information

- Would you like to know more about this session?
- Patrick Hughes
- Oak Ridge National Laboratory
- Hughespj1@ornl.gov

Don’t forget to fill out and drop off your session evaluations!