



**ENGINEERING FUTURE FOCUSED SOLUTIONS**

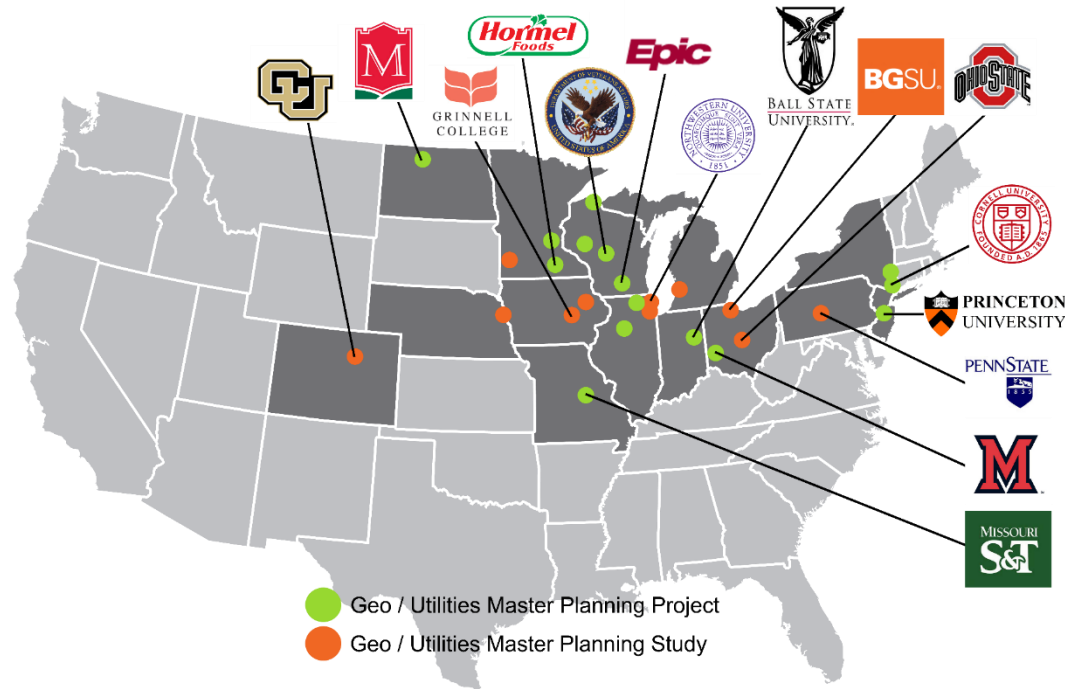
# PRESENTERS



**Andy LaFerriere, EIT, CEM**  
Energy Engineer  
[andy1@mepassociates.com](mailto:andy1@mepassociates.com)



**Dale Zank**  
Business Development  
[dalez@mepassociates.com](mailto:dalez@mepassociates.com)



## OUR MISSION



We continuously strive for excellence and **innovation** through **creative engineering solutions** to minimize environmental impact today and improve sustainable stewardship into the future.



Geothermal Heating & Cooling

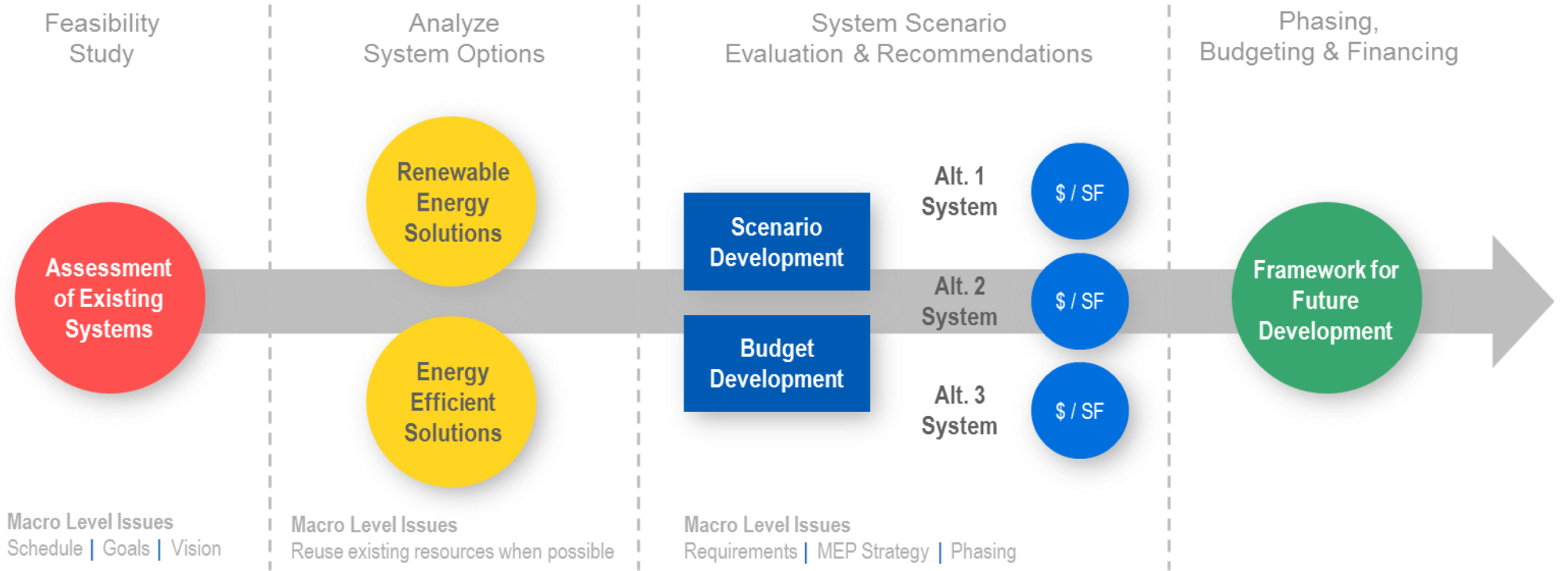
Solar PV



## Healthcare Facilities Energy Review

- Commercial Building Energy Consumption Survey (CBECS) lists healthcare facilities among highest annual energy consumers of all commercial building types
- Energy Use Intensity (EUI) can range from 50 to 250 kBtu/ft<sup>2</sup>/year depending on facility programming and age
- Goals of the presentation;
  - Assist in the identification of building systems and features that are high energy consumers
  - Identify energy conservation measures (small and large) that facility owners/management can implement to cost effectively lower site EUI
  - Discuss the importance of site energy reduction moving forward

# APPROACH



## Presentation Overview

- Small scale energy conservation measures
  - Lighting systems
  - Building envelope
  - Insulating exposed metal surfaces
  - Domestic hot water
  - Electric motors and drives
- Facilities retro commissioning
- Large scale energy conservation measures
  - HVAC systems and plants
  - On-site renewables
- Example healthcare projects
- Questions

## Lighting Systems

- Change Lighting Source
  - Replace existing fixtures with high efficiency CFL or LED
  - Higher capital cost, reduced operating and maintenance costs
  - Reduced maintenance from higher run hours
    - *LED typically rated for 50,000 hours*
    - *FL typically rated for 20,000 hours*

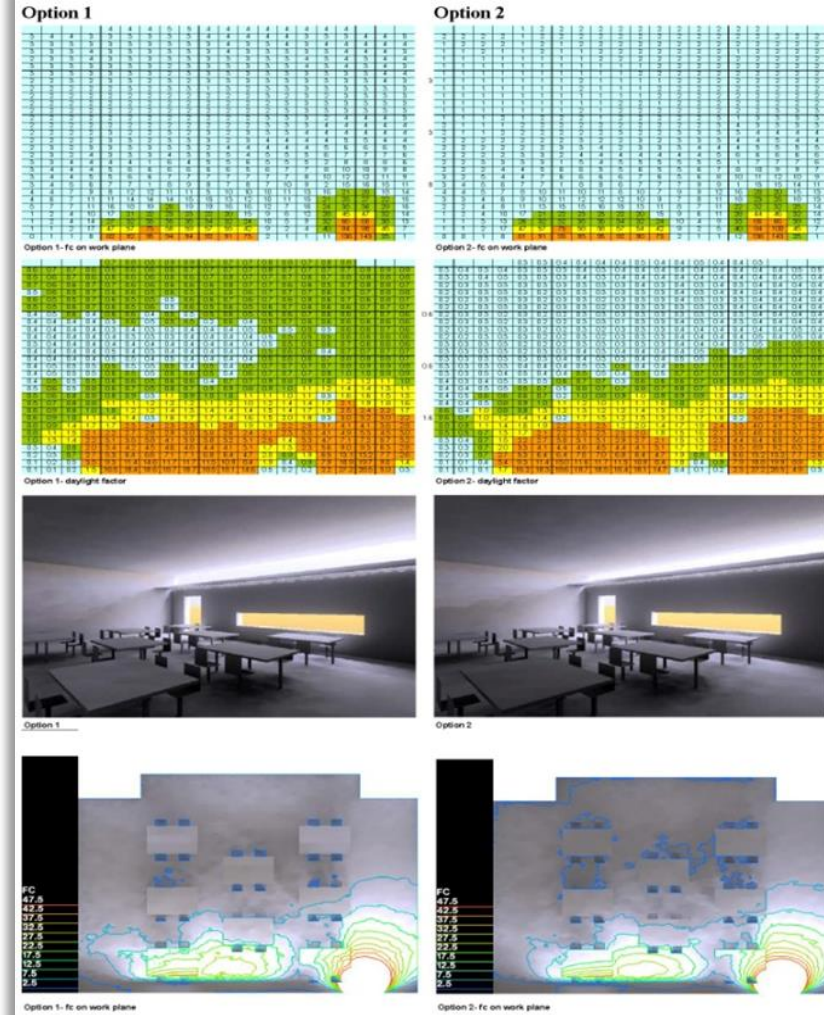


# ENERGY CONSERVATION MEASURES



## Lighting Systems

- Daylight Harvesting
  - Dictated by architectural design of the building
  - Commercial codes identify space types where required
  - Typically not economically viable in retrofit projects





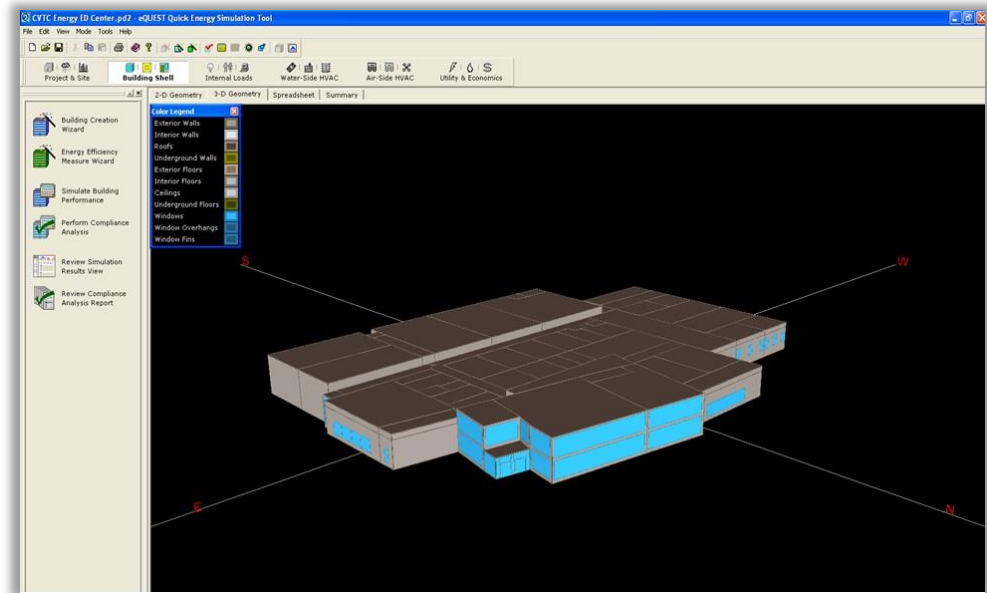
## Lighting Systems

- Automatic Shutoff and Dimming
  - Reduce lighting run time and energy consumption through timers, occupancy sensors, and photocells
  - Commercial codes identify spaces types where this is required and cannot be used
  - Typically not economically viable in retrofit projects



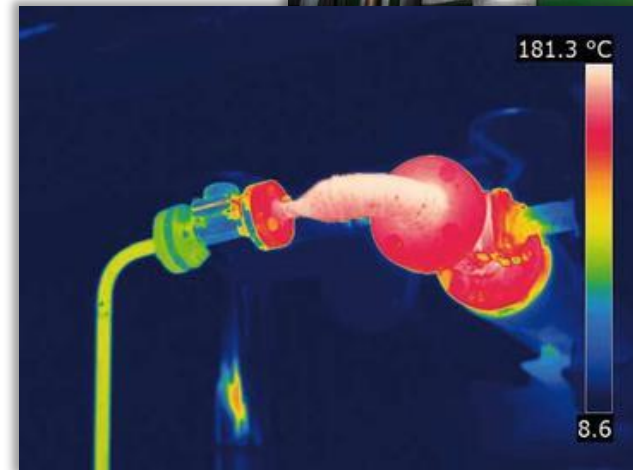
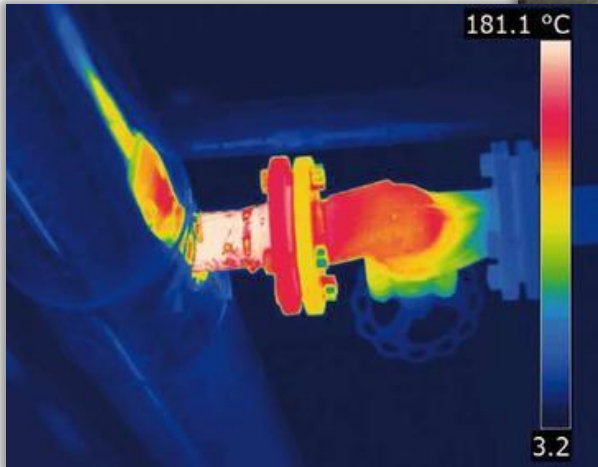
## Building Envelope

- General
  - Often difficult in building retrofit applications
  - Existing envelope typically does the job
  - Change is expensive
- Window upgrades
  - Significant contributor to envelope losses
  - Much easier to retrofit than roof and wall insulation
  - Typically will provide highest return on investment among envelope upgrades



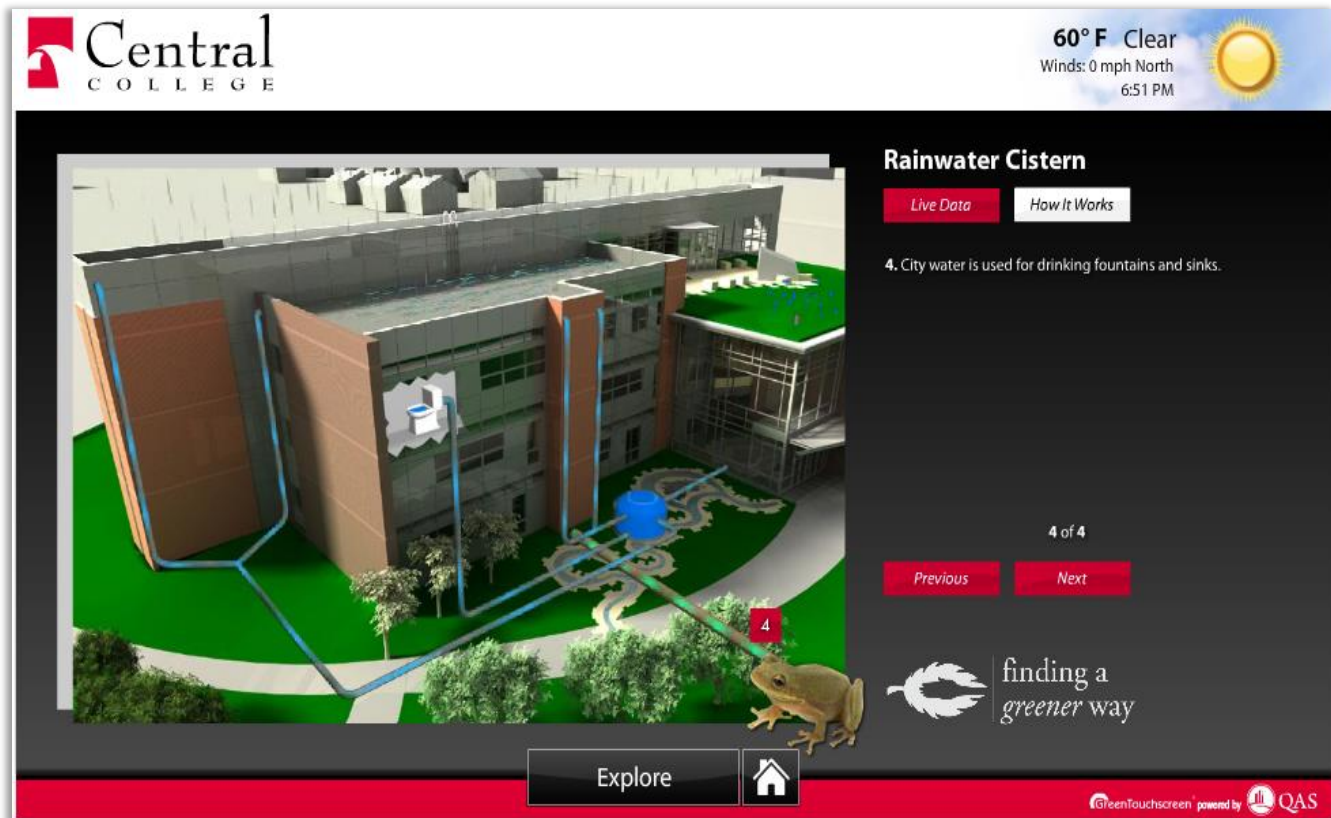
## Insulating Exposed Metal Surfaces

- Steam and hot water distribution piping
  - Systems losses and space conditioning
- Hot water storage tank(s)



## Domestic Water Systems

- Low flow fixtures
- Rain water capture
- Water re-use



The screenshot shows a digital interface for the Central College Rainwater Cistern system. At the top left is the Central College logo. The top right displays weather information: 60° F, Clear, Winds: 0 mph North, and 6:51 PM, accompanied by a sun icon. The main area features a 3D architectural rendering of a building with a rainwater cistern system. Blue pipes are shown running from the roof down to a cistern and then to various fixtures. A red number '4' is overlaid on the rendering. To the right of the rendering, the text 'Rainwater Cistern' is displayed, with buttons for 'Live Data' and 'How it Works'. Below this, a list item reads '4. City water is used for drinking fountains and sinks.' At the bottom of the rendering area, there are 'Previous' and 'Next' buttons, and a '4 of 4' indicator. A frog is shown in the bottom right corner of the rendering. At the bottom of the screen, there is an 'Explore' button, a home icon, and the text 'finding a greener way' with a leaf icon. The footer includes 'GreenTouchscreen powered by QAS'.

Central COLLEGE

60° F Clear  
Winds: 0 mph North  
6:51 PM

Rainwater Cistern

Live Data How it Works

4. City water is used for drinking fountains and sinks.

4 of 4

Previous Next

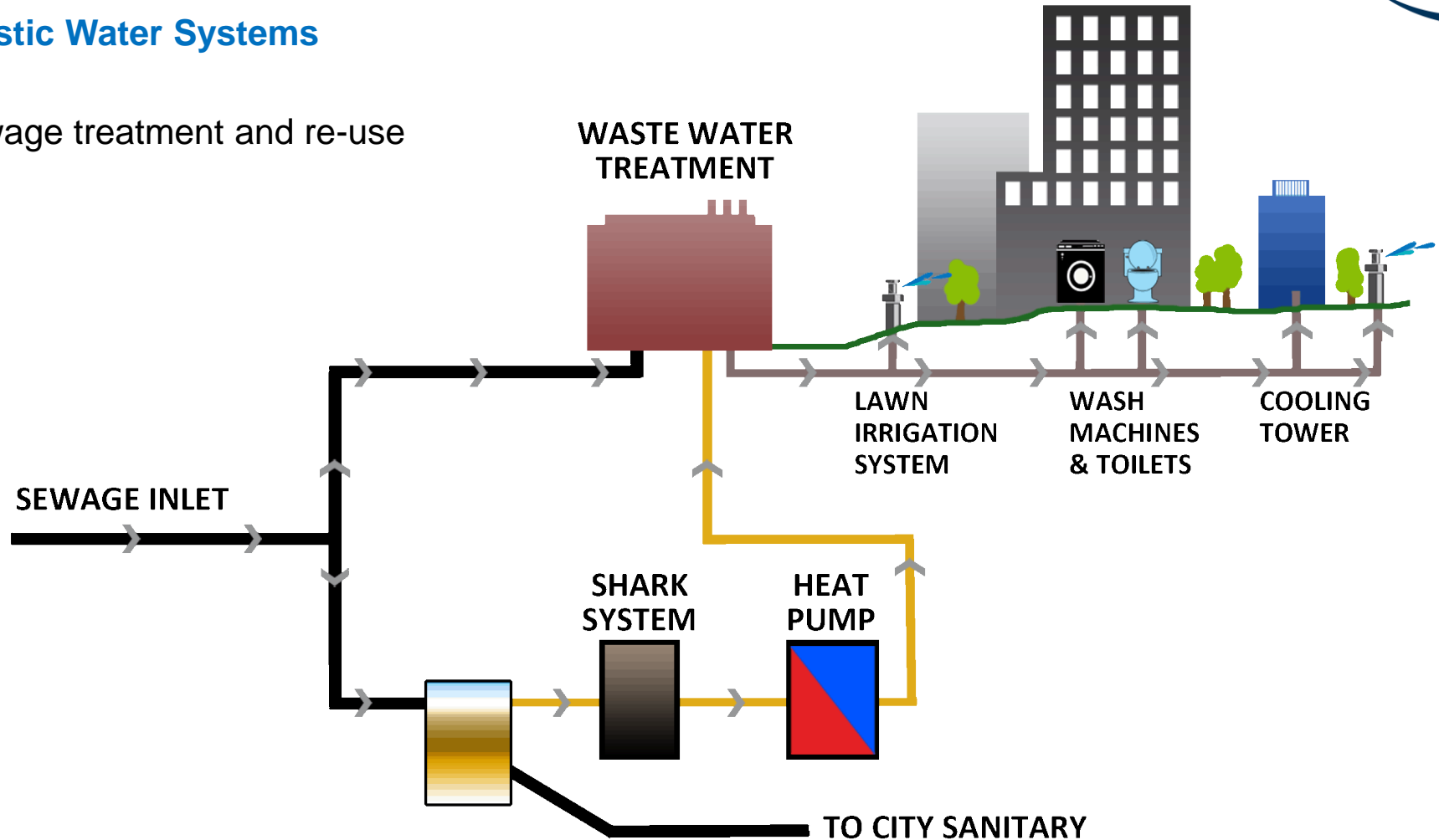
finding a greener way

Explore

GreenTouchscreen powered by QAS

## Domestic Water Systems

- Sewage treatment and re-use



# ENERGY CONSERVATION MEASURES



## Domestic Water Systems

- High efficiency condensing style storage units
- Process heat recovery for pre-heat
- Instantaneous (tankless) heaters
  - Advantageous from space standpoint
  - Reduces system standby losses and associated with storage tank
  - Little to no gain in efficiency
  - Not common in large scale applications
    - *Run multiple units in parallel to satisfy peak demand flow*

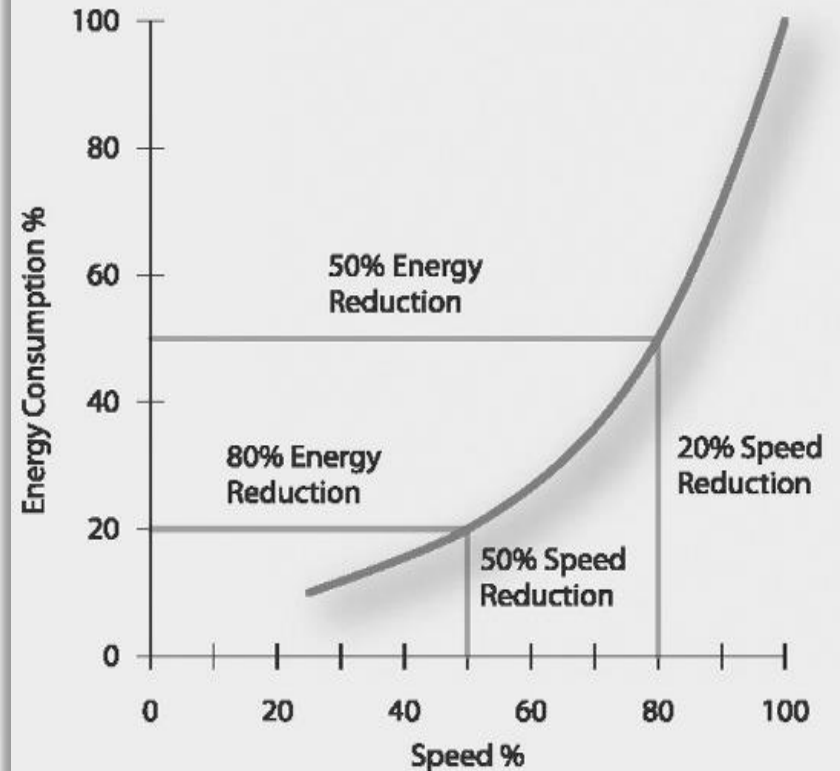


## Electric Motors and Drives

- Common types of drives
  - VFD drives
  - ECM motors
- Reduced energy and operational costs
  - Turn down to 20-30% of full load (ECM lower)
  - Eliminates cycling stresses



### Ideal Energy Consumption at Varying Speed



## Retro Commissioning - Buildings Have a Personality

- What is your building's personality?
  - How does it respond to internal conditions?
  - How does it respond to weather changes?
  - Do you know your balance points between heating and cooling?
  - Do you know it's flaws?
  - Do you know where you stand on energy cost?
    - What improvements have been made?
    - Do they continue to climb?
  
- **FIRST STEP IN RETRO COMMISSIONING IS TO KNOW YOUR BUILDING!** Perform a building walkthrough and look at each room, each piece of equipment, the building envelop and your overall operation.



## Retro Commissioning (RCx)

### ▪ FOCUS ON ENERGY RCx Definition

- Holistic approach to energy efficiency
- Targets building systems, energy using equipment and operating schedules
- Optimize how all of these elements work together

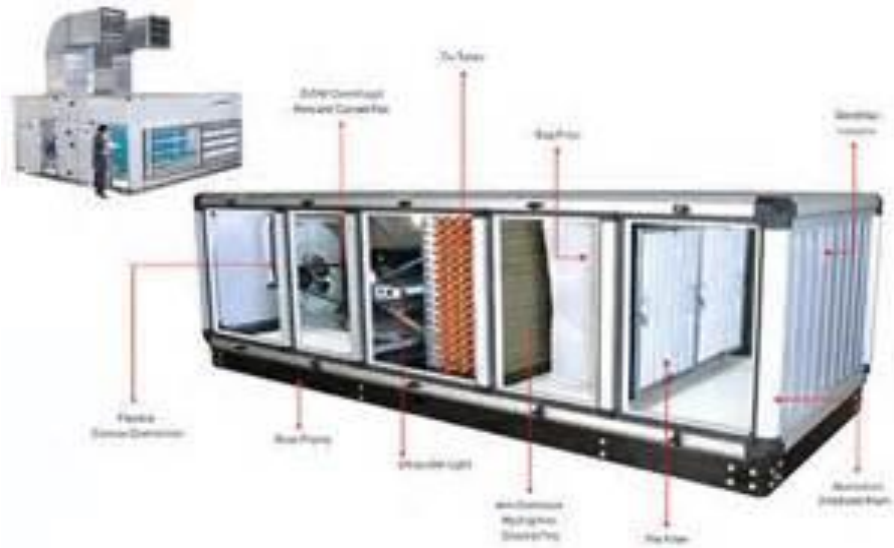
### ▪ RCx can produce a significant cost savings in buildings

- Biggest “Bang for the Buck” – up to 15% in savings is very attainable
- Normally lowest cost option for energy savings vs. major capital improvements

### ▪ Note

- Needed capital improvements may be discovered during the RCx process
- This is not test and balancing but T&B may be a part of overall RCx

## Air Handler Open Discussion



### Front to Back

### What can effect its operation?

## Air Handler Examples of Issues

- Outside air dampers
- Mixed air box
- Leaking ductwork
- Valves not opening/closing
- Outside, mixed, return air sensors
- Freeze stat malfunction
- Traps (steam and condensate)
- Controls (stats, actuators, program)
- Venting
- Overrides!
- Poor air circulation through the coil
- Plugged coils
- Filters, belts, bearings
- Dirty ductwork/fans
- Poor insulation
- Condensation
- Fan control
- Balancing – water and air side
- VAVs out of set parameters
- Usage change!

## Benefits of RCx

- Improved system(s) operation
- Improved equipment performance
- Longer life expectancy of equipment
- Increased asset value
- Energy savings
- Improved occupant comfort
- Improved indoor air quality
- Improved building documentation
- **It is truly a winning solution!**

## RCx Process

### Planning

- Determine the project
- Determine objectives
- Document current operation
- Site walk thru
- Determine your team

### Investigation

- Review available documentation
- Diagnostic monitoring
- Functional test
- Simple repairs
- Master list of findings
- Prioritize list of improvements

## RCx Process

### Implementation

- Develop plan
- Implement selected improvements
- Verify results

### Final

- Final report
- Systems manual
- Training
- Implement on-going maintenance plan and operational strategy

## Retro Commissioning

- **Additional considerations**
  - HW/CHW reset schedules
  - Air balancing for building zones
  - OQ and relief air dampers working correctly
  - Replacing faulty steam traps
  - Pneumatic valves working correctly
    - *Compressed air leaks are very costly*
  - Differential pressure sensors, airflow measure stations, and flow meters calibrated and working correctly
  - Can OA supply be reduced
    - *Renovations often miss ability to reduce OA based on utilization change*
  - BAS sequencing / schedule adjustments



## Building HVAC Systems

- **Chilled Beams**
  - Reduced fan energy consumption
  - Tighter constraints on space relative humidity
    - *Leaky envelopes might not be feasible*

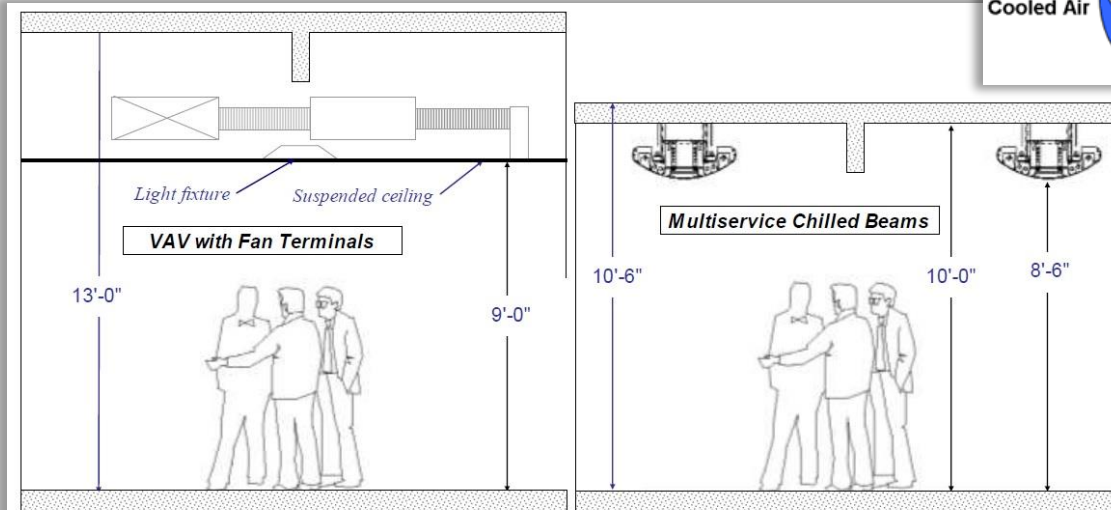
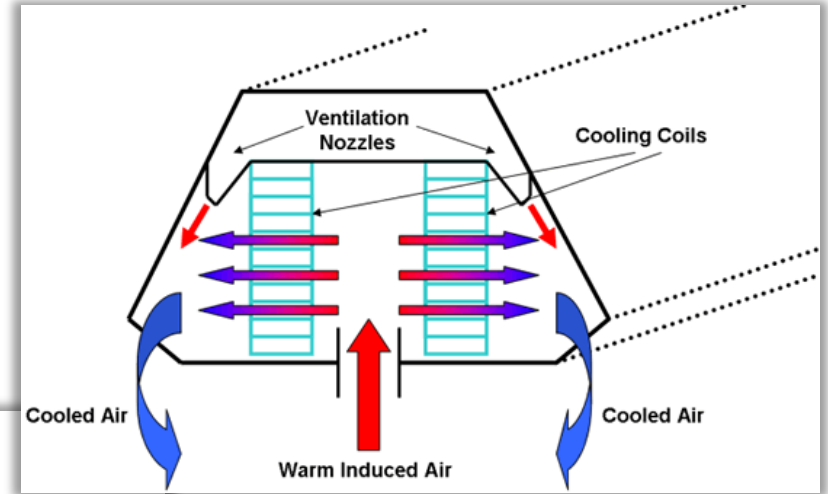
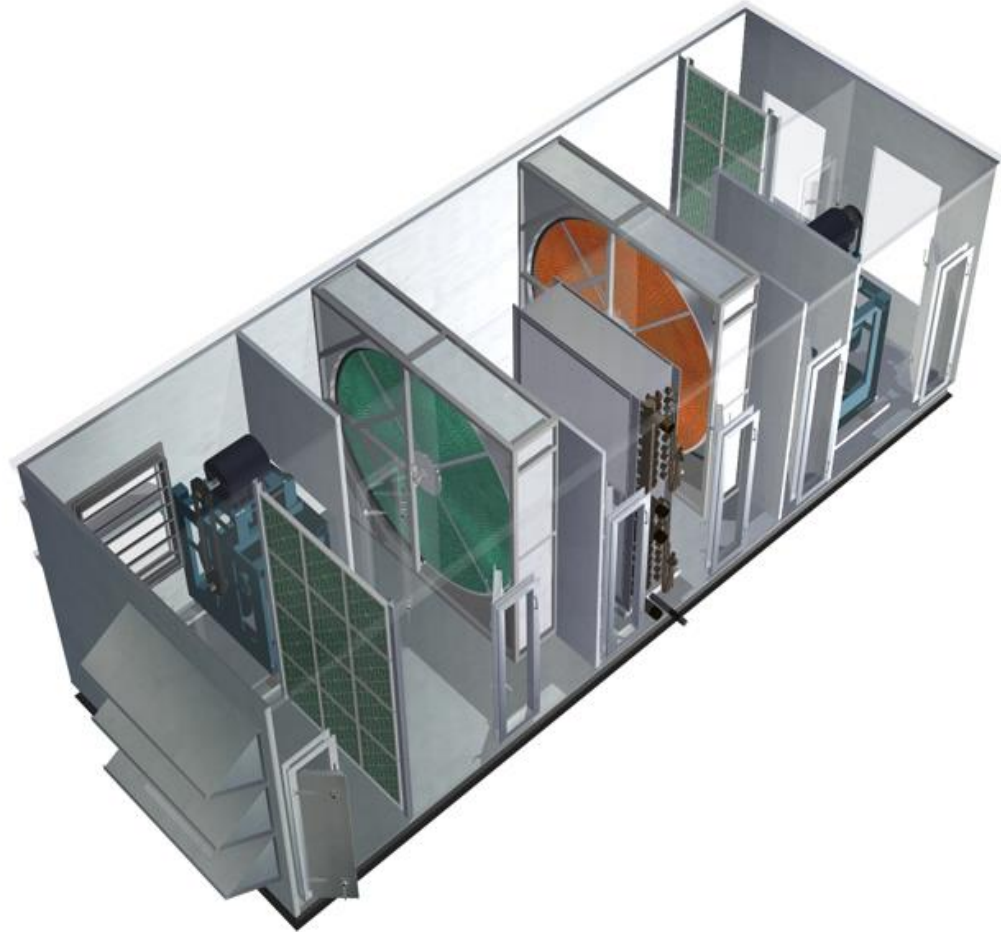


Figure 15: Slab Spacing Reduction with Multi-service Beams



## Building HVAC Systems

- **VAV Systems**
  - Reduced fan energy consumption
  - Increased occupancy comfort control
  - Expensive retrofit
- **Air side economizer**
  - Utilize ambient air for space conditioning instead of mechanical cooling
  - Dry-bulb or enthalpy controlled
  - Code required in many climate regions based on quantity of ventilation airflow



## Building HVAC Systems

- **Air side energy recovery**
  - Sensible and latent recovery
  - Control supply temperature and humidity
  - Significant savings for systems utilizing lots of ventilation air
  - Example application – OR supply temp
- **Process heat recovery (hydronic)**
  - Boiler flue (*non-condensing boilers*)
  - Kitchen
  - Laundry



*Energy recovery unit serving the demand based ventilation*

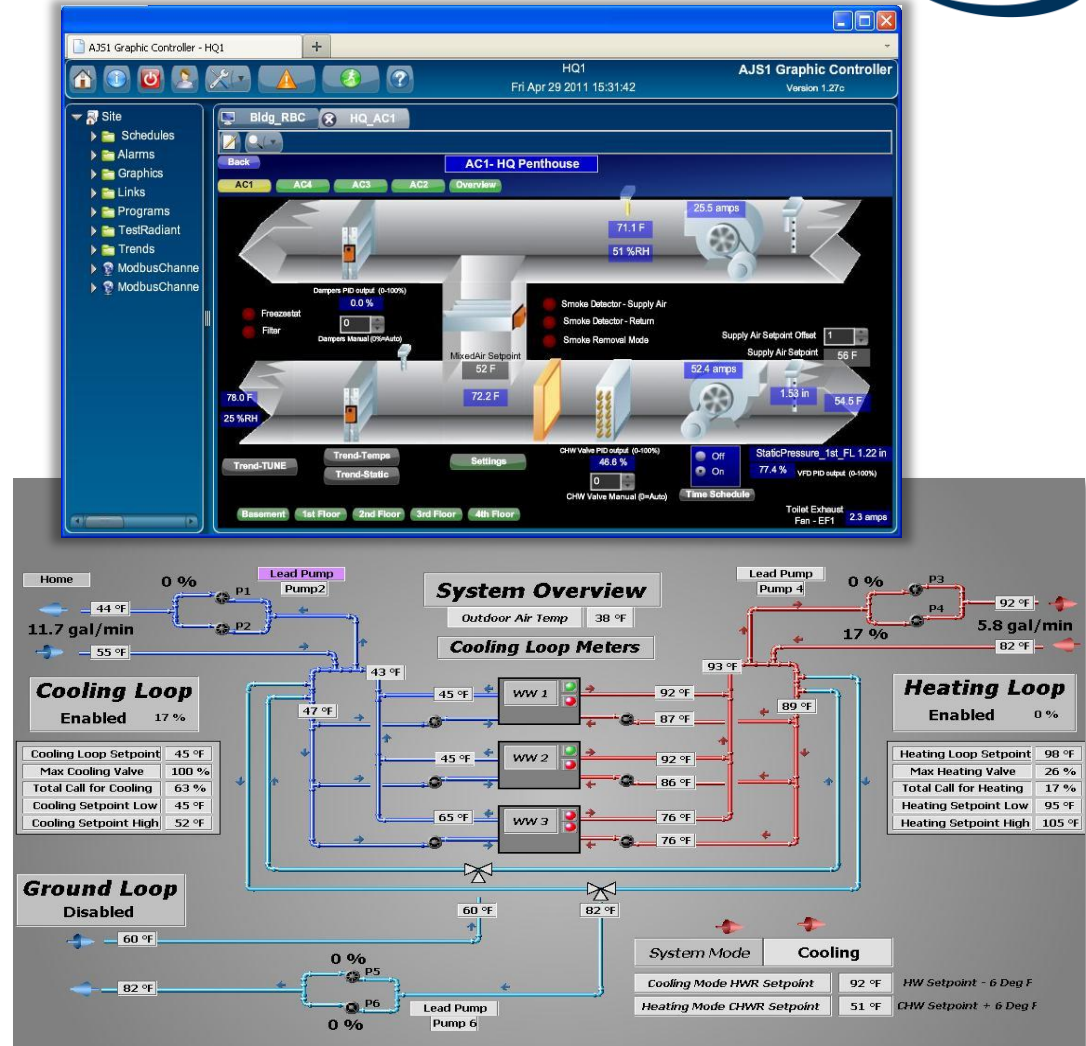
## Building HVAC Systems

- **Fluid (dry) coolers**
  - Utilize favorable ambient conditions to reject heat
  - Typically utilized during the heating season
    - Size to handle base cooling load
  - Close loop system
  - Can be retrofit into existing chilled water system
    - Operating temperatures may require glycol and heat exchanger to decouple building loop
  - Run fans instead of compressors



## Building HVAC Systems

- **Building Automation Systems (BAS)**
  - Complete upgrades are very expensive
  - How can we optimize current system?
    - Pneumatics
      - Valves working properly
      - Replace faulty control boxes
    - DDC
      - Adjust logic, schedules, set points, etc. to optimize systems operation



## Building HVAC Plants

- **High efficiency conventional plants**
  - Heat recovery chillers
    - Move energy between hot and chilled water loops
    - Requires base heating load for thermal rejection
  - Condensing boilers
    - Operate at lower supply temperatures
    - 93 - 98% efficient
  - Mag lev chillers
    - Very efficient (<0.5 kW/Ton)
- **Geothermal plants**
  - High operational efficiency
  - Thermal storage capability
  - Requires green space GLHE

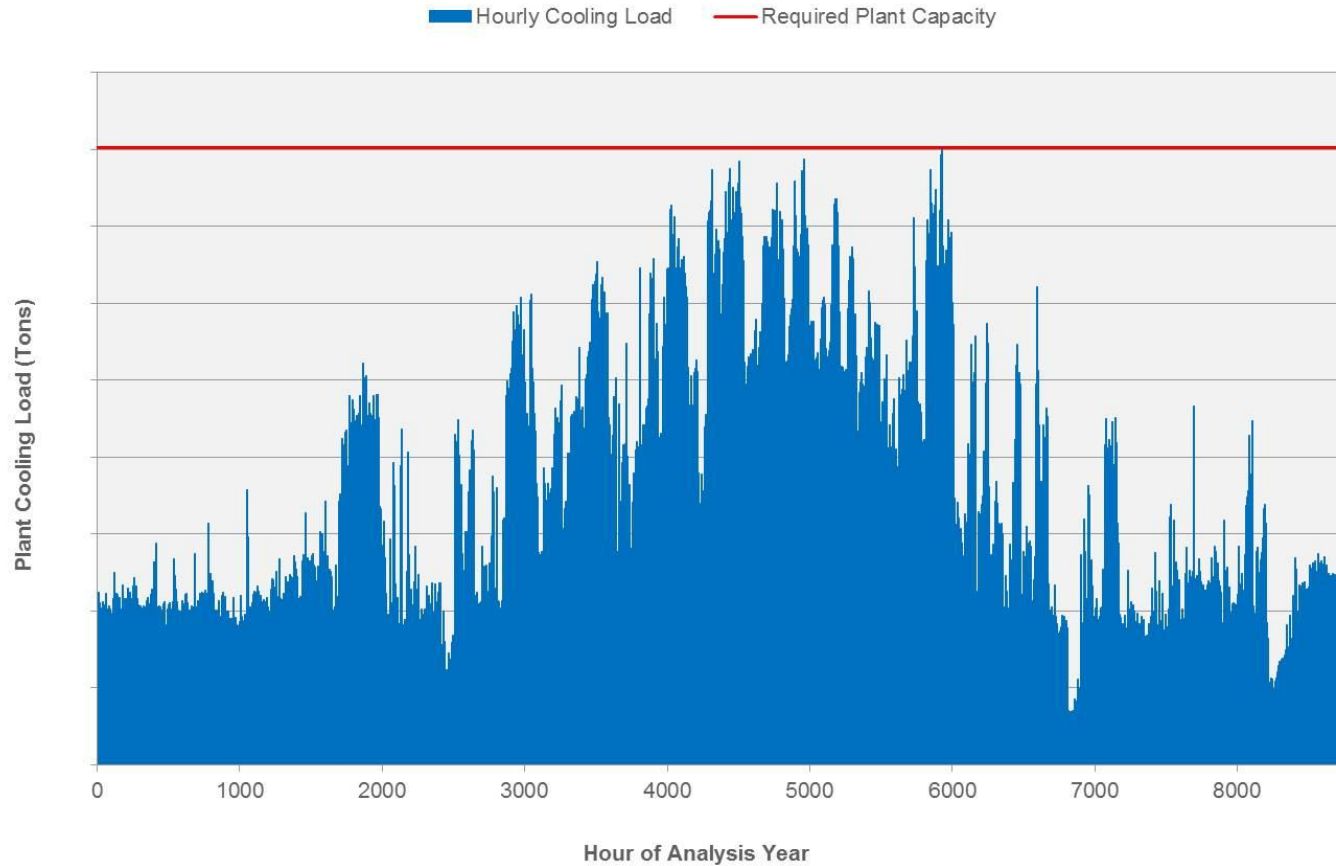


## Hybrid HVAC Systems

- **What is a hybrid system?**
  - Renewable coupled with conventional system
  - Not always constrained by this definition
- **Why are they beneficial?**
  - Capital cost reduction
  - Energy and operational cost reduction
- **Common examples of hybrid systems**
  - Solar supplementation
  - High efficiency base load equipment
  - Waste water and/or sewage systems
  - Geothermal hybrid

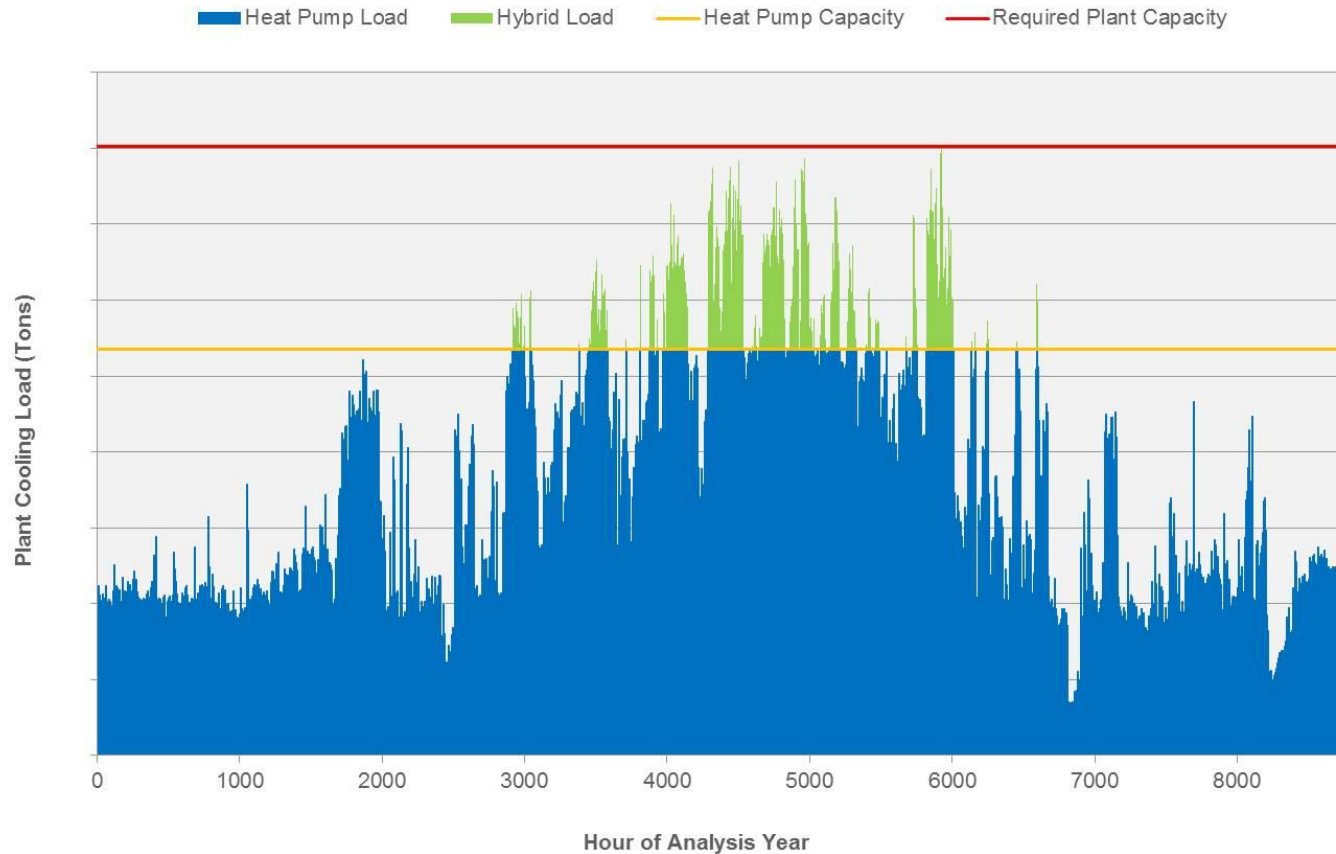
## Hybrid HVAC Systems

### Example Annual Cooling Load Profile



## Hybrid HVAC Systems

### Hybrid System Optimization - Heat Pump Sizing

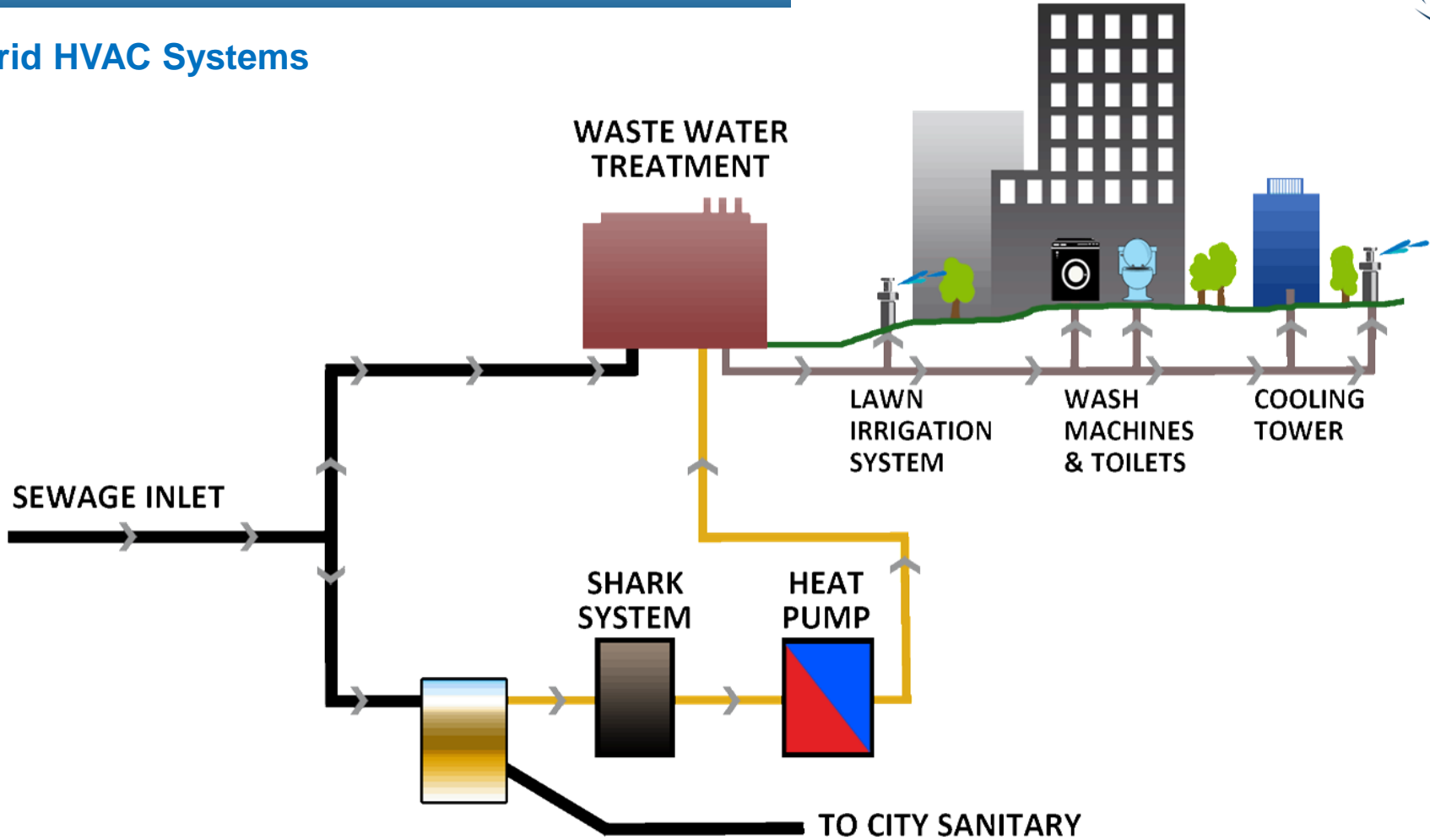




# ENERGY CONSERVATION MEASURES



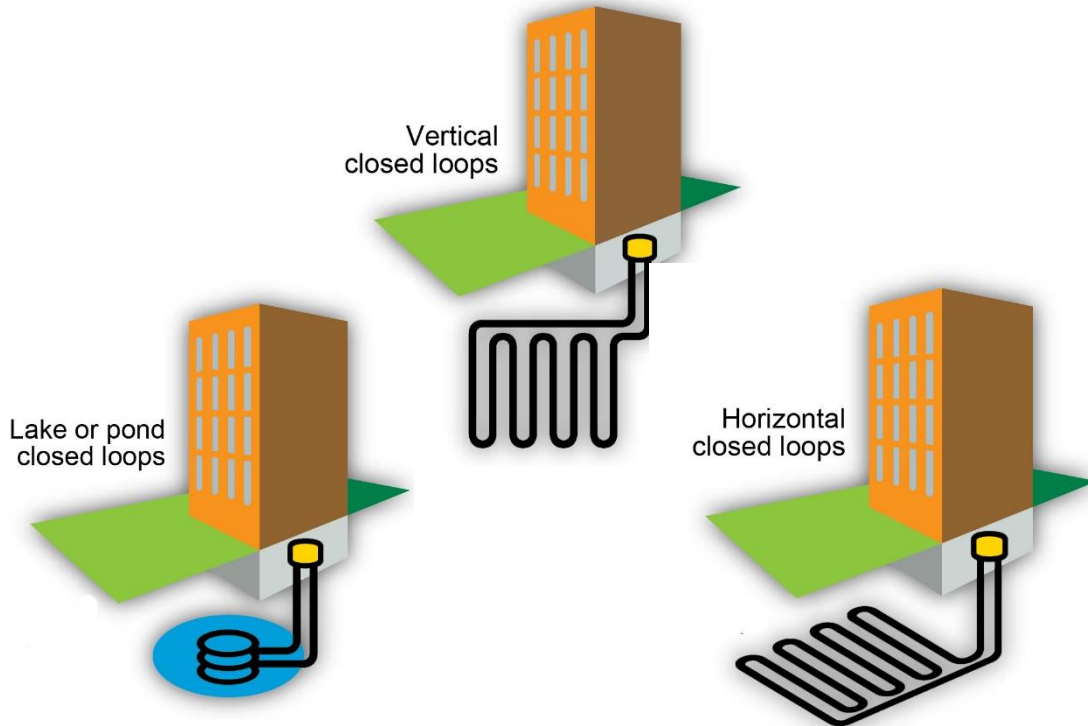
## Hybrid HVAC Systems



# ENERGY CONSERVATION MEASURES

## Geothermal

- Geothermal
  - Modular heat pump systems
  - Hybrid systems



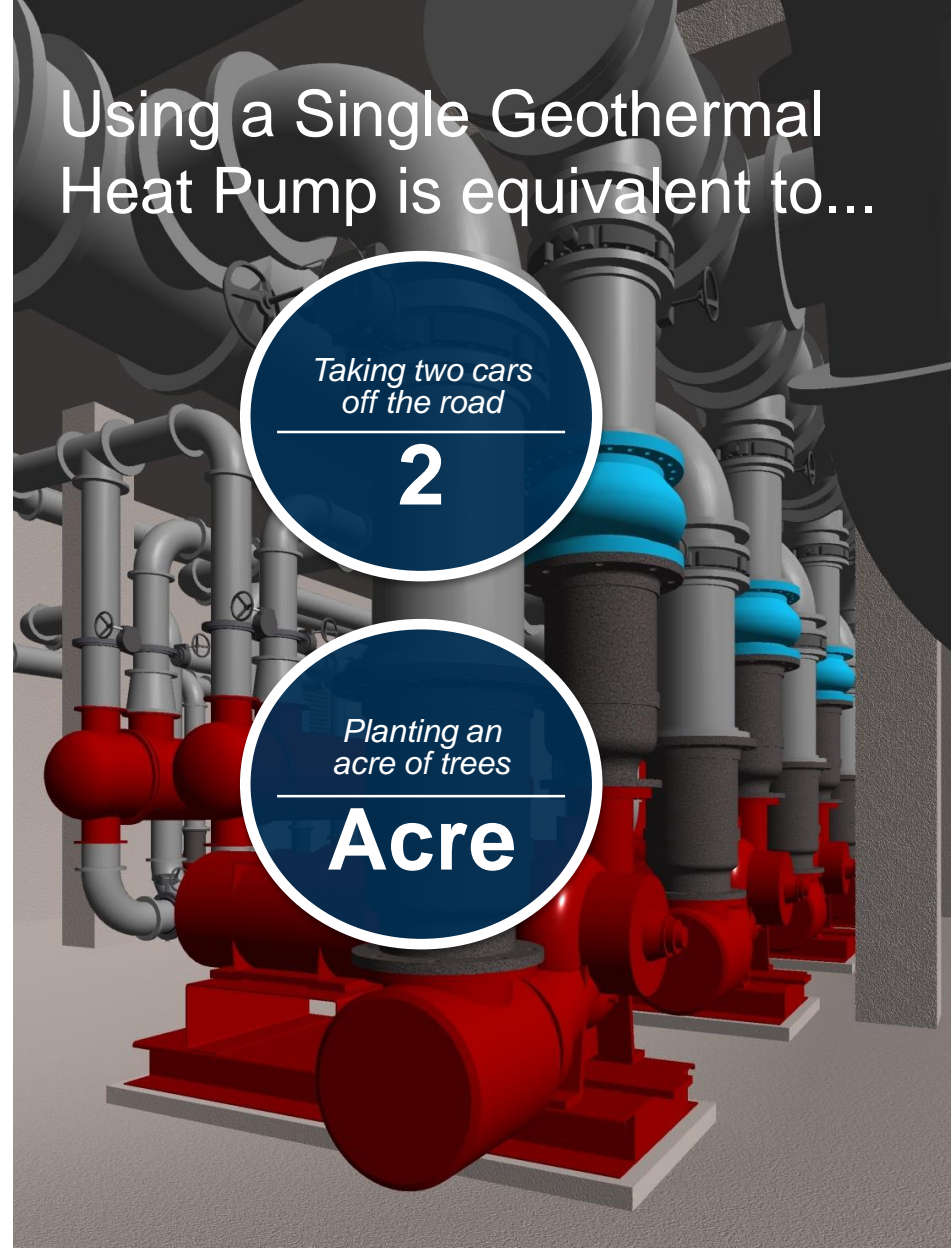
Using a Single Geothermal Heat Pump is equivalent to...

*Taking two cars  
off the road*

**2**

*Planting an  
acre of trees*

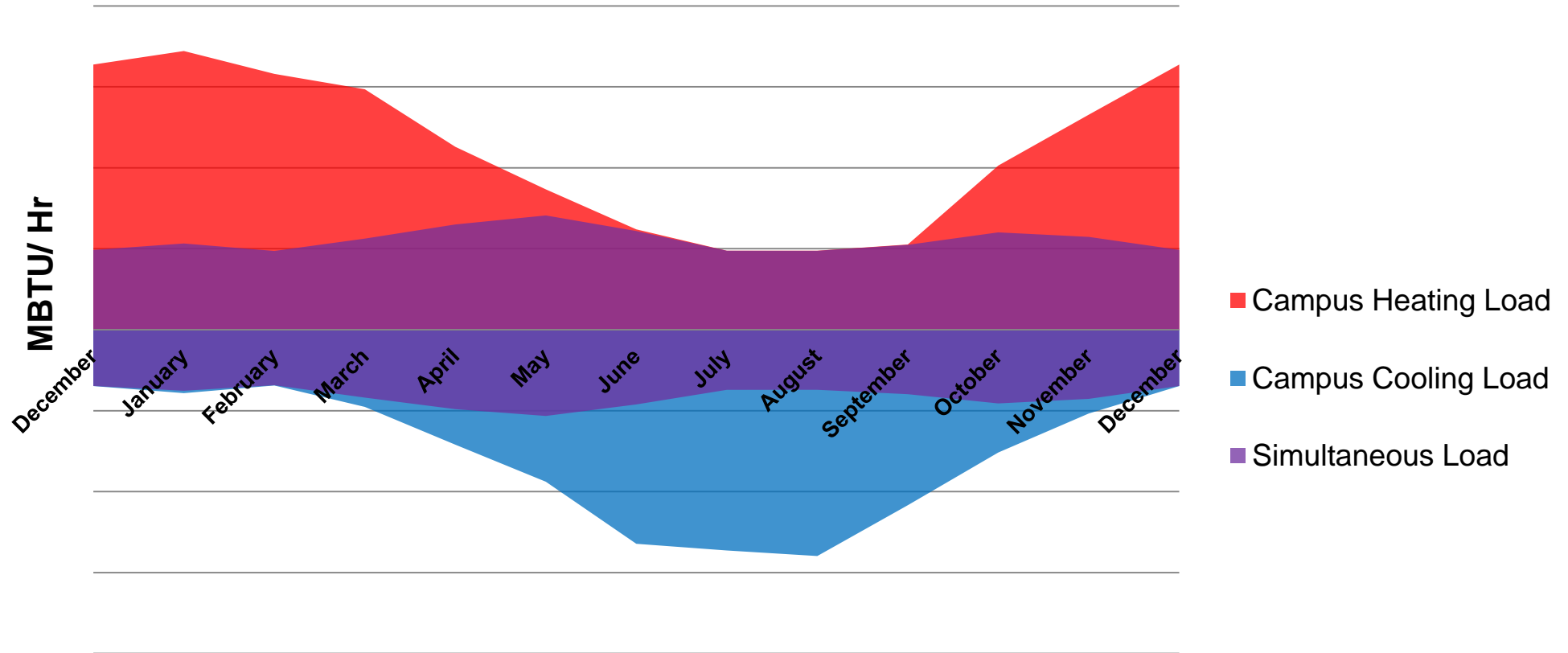
**Acre**



# ENERGY CONSERVATION MEASURES

## Geothermal

- Heating & Cooling Loads with **Simultaneous** Load



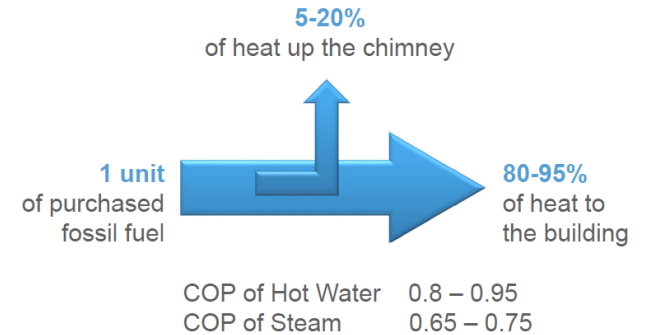
# ENERGY CONSERVATION MEASURES

## COP Comparison

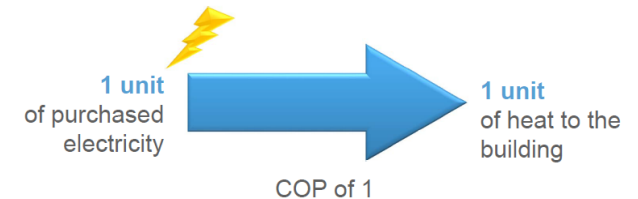
- **Heating Mode:**
  - *Electric Heat: 100% efficient has a COP = 1*
  - *Boiler: 85% efficient has a COP = .85*
  - *Steam Boiler burner efficiency COP = .85*
  - *Overall Steam systems efficiency COP = .65*
  - *Heat Pump Chiller with 32 F EWT has a COP = 3.3*
  - *Simultaneous Heating and cooling COP = 6 (min.)*

$$\text{COP (Coefficient of Performance)} = \frac{\text{Useful work}}{\text{Input work}}$$

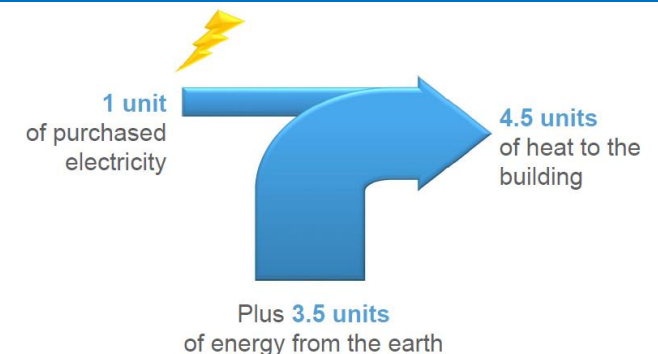
## Performance Measurement



## Electric Heat

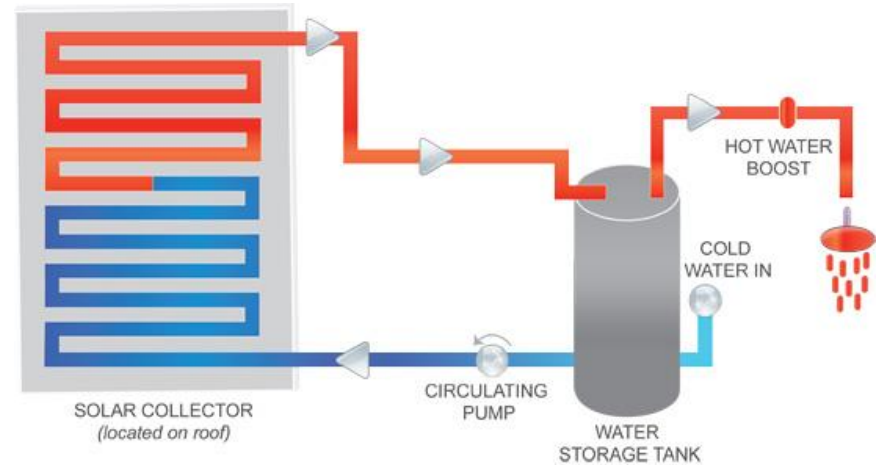


## Geothermal



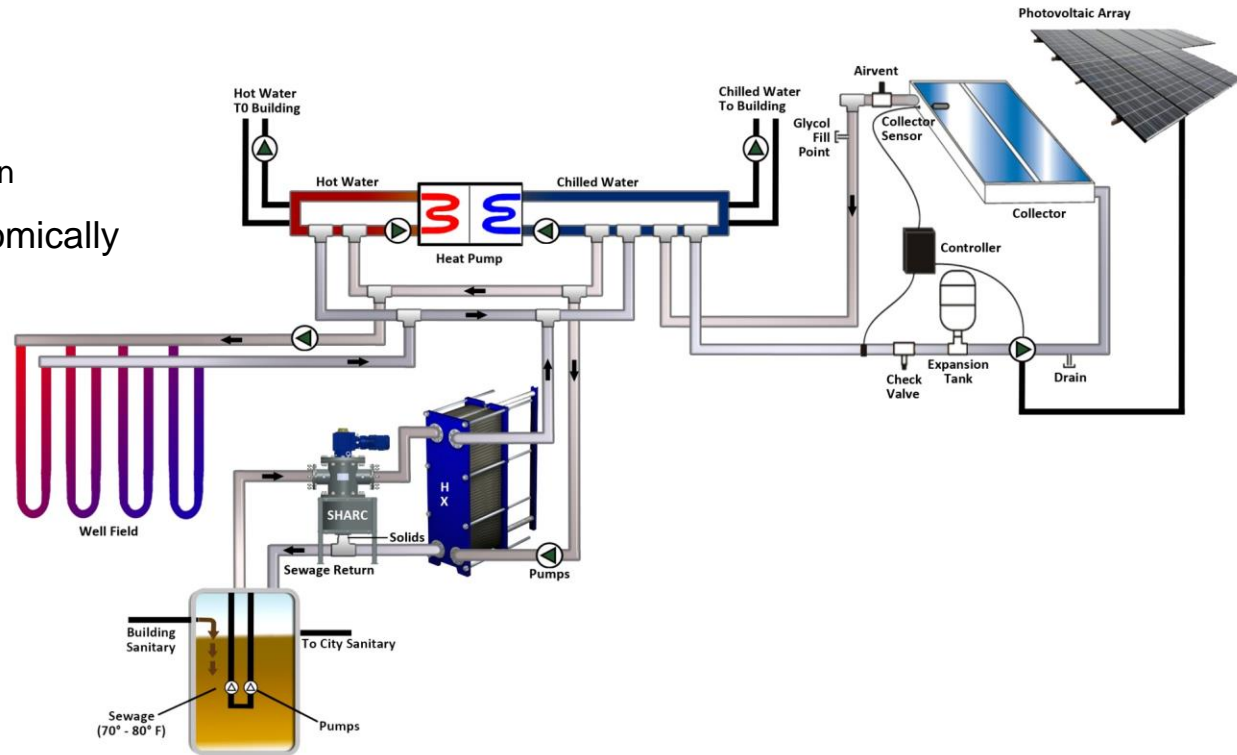
## On-site Renewables

- Solar Array Applications
  - Solar thermal collectors
    - More efficient than solar PV
    - Domestic hot water heating and/or preheat
    - Geothermal well field balancing/reduction
  - Solar photo voltaic (PV) panels
    - On site electrical generation
    - Provide source electric to interior systems
  - Combined solar PVT arrays
    - Produce both electrical energy and hot water
    - Increased efficiency from water cooling of panels
    - New technology, still developing, higher cost



## On-site Renewables

- Sewage Heat Recovery
  - How does it work?
  - Joint effort with municipality
  - System options
    - PIRANHA – heat recovery only
    - SHARC – heat recovery and rejection
  - Requires significant flow to be economically viable
  - Hybrid system implications
    - Capital cost reduction

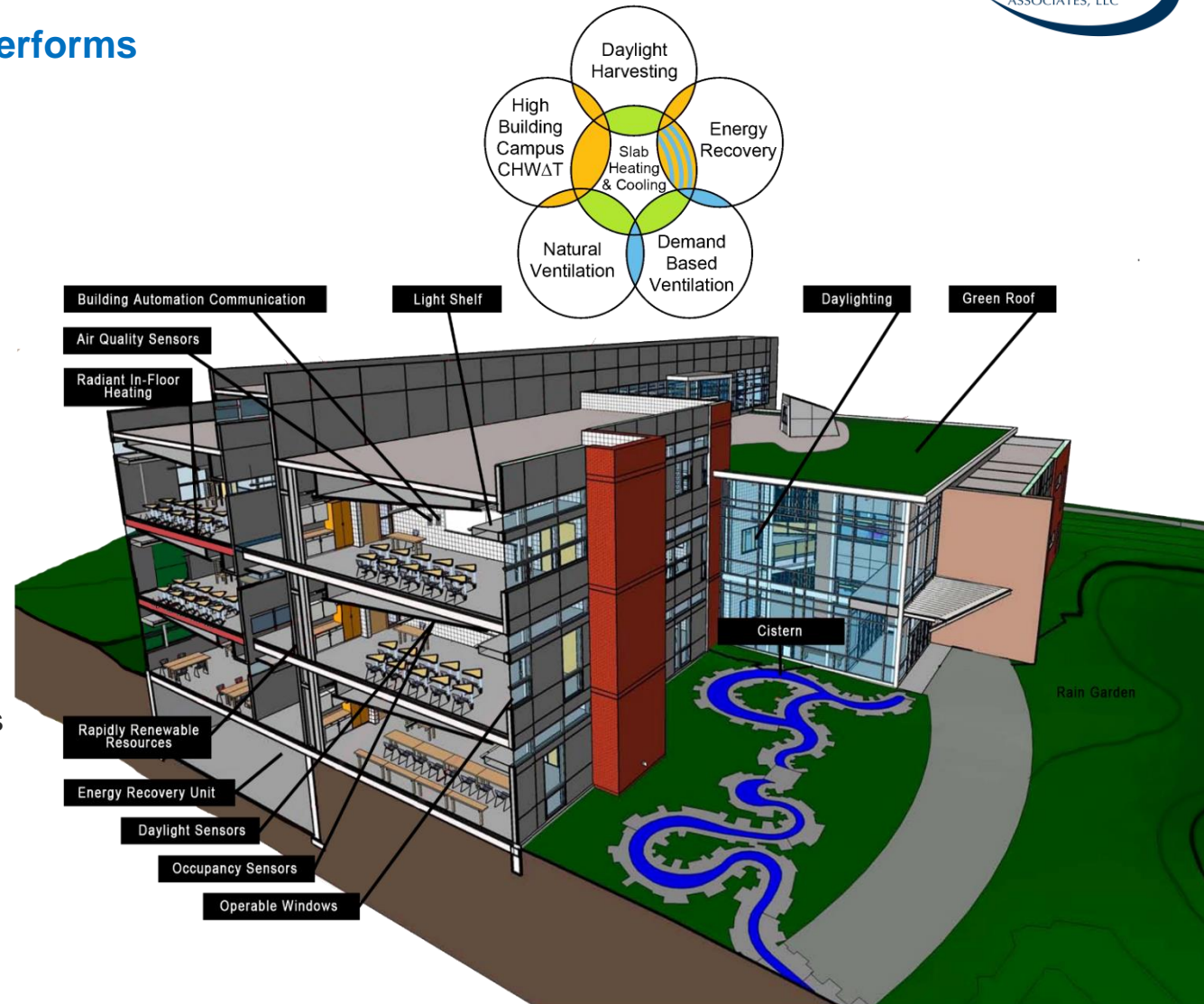


# ENERGY EFFICIENT SOLUTIONS FOR ALL FACILITIES

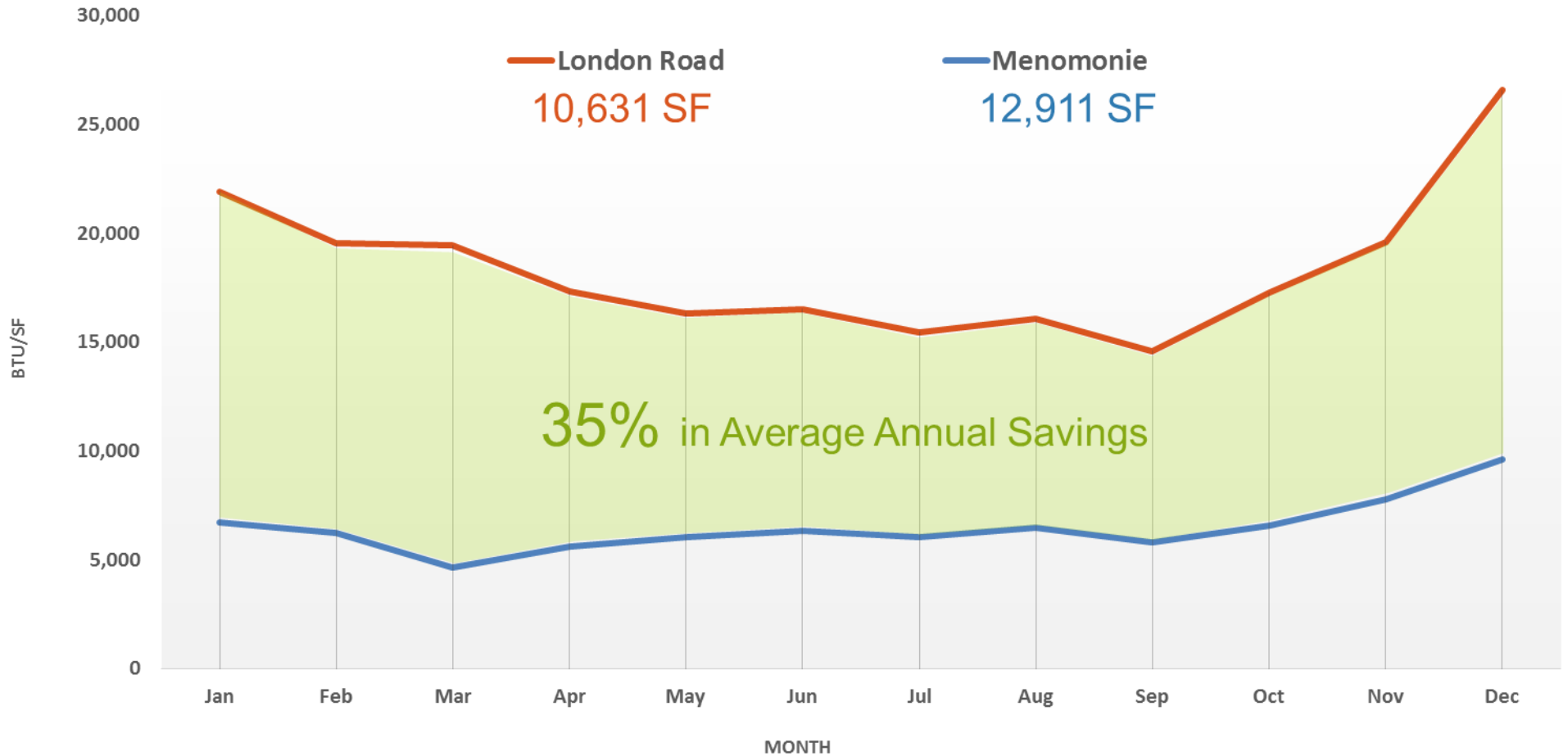


## A building is only as good as it performs

- Energy Recovery
  - *Dual Wheel Desiccant*
  - *Enthalpy Wheel*
  - *Fixed Plate*
- Solar Photovoltaics
- Solar Hot Water Heating
- Water Reduction
- Rainwater Reclamation
- Heat Pump Chillers
- Ice Storage Systems
- Demand Ventilation
- Daylight Harvesting
- DDC Building Control Optimization
- Air Flow Reduction in Unoccupied Rooms (*OR's, Cath Labs*)
- Sewage/Waste Water Heat Recovery



### 2012 Dialysis BTU/SF





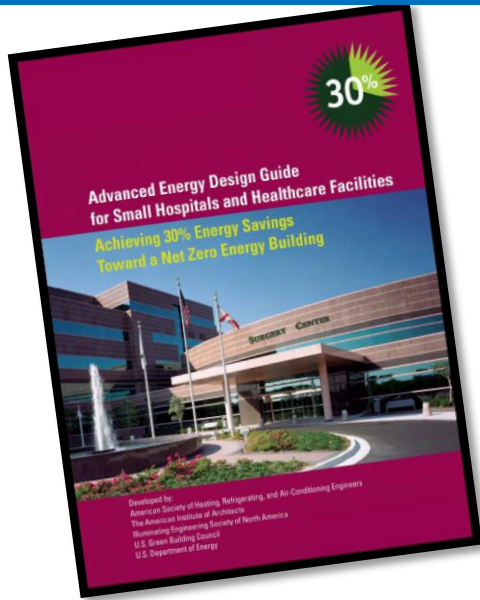
# SOLUTION EXAMPLE



## Regional Heart Doctors, Rapid, SD

- 34,000 SF
- 100 Ton W2W Heat Pump
- Operates at 47,000 btu/sf/year
- Dedicated outdoor air unit with energy recovery
- 4-pipe fan coil unit and in-floor heating in each patient room

Featured in ASHRAE Design Guide

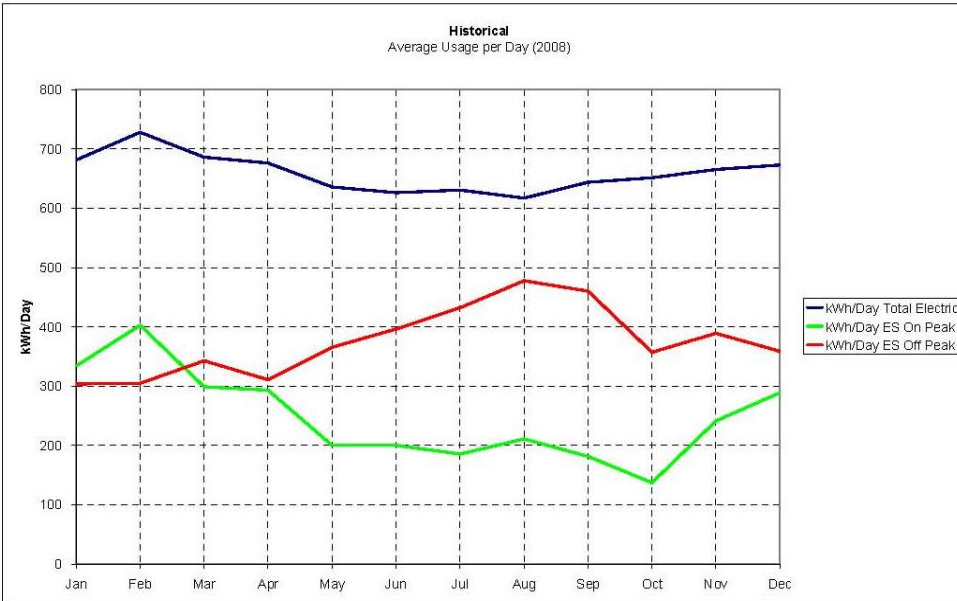


# SOLUTION EXAMPLE



## Regional Heart Doctors, Rapid, SD

**SQUARE FOOTAGE = 34,000**  
**ANNUAL ENERGY COST = \$31,132.54**  
**COST PER SQUARE FOOT = 91.6 ¢/sq ft.**  
**SAVINGS ON ENERGY STORAGE = \$4,269.02**



THE HEART DOCTORS HEART & VASCULAR INSTITUTE	
Energy Savings Measure	Description of Element
<b>Envelope</b>	
<i>Walls</i>	6 in. metal studs with R-19 batt insulation.
<i>Roof</i>	R-20.
<i>Vertical Glazing</i>	Center of glass U-factor of 0.29, SHGC of 0.28.
<b>Daylighting</b>	
<i>Windows</i>	In patient exam rooms.
<i>Skylights</i>	In building interior.
<b>Lighting</b>	
<i>Lighting Power Density</i>	1.12 W/ft <sup>2</sup> . 64 W 2x4 fixtures.
<i>Electric Lighting Design</i>	64 W 2x4 fixtures using T-8 lamps (includes parking lot lights).
<i>Controls</i>	Building energy management system.
<b>HVAC</b>	
<i>Equipment</i>	Water-to-water GSHP. Heat pump chiller with ice storage tank. Four-pipe fan-coils. Dedicated outdoor air unit with energy recovery.
<i>Humidification</i>	Humidifier control to minimize electrical demand load.
<b>Service Water Heating</b>	
	Preheat incoming water with waste heat from heat pumps.
<b>Energy Use Characteristics</b>	
<i>Estimated Annual Energy Index Savings</i>	17.1 kBtu/ft <sup>2</sup> /yr.
<i>Actual Energy Index</i>	47 kBtu/ft <sup>2</sup> /yr (2008 calendar year).
<i>Estimated Annual Cost Savings</i>	\$0.37/ft <sup>2</sup> /yr.
<i>Initial Investment Premium</i>	\$4.30/ft <sup>2</sup> /yr.
<i>Total Cost per Square Foot</i>	\$192/ft <sup>2</sup> /yr.
<i>Mechanical Cost per Square Foot</i>	\$23/ft <sup>2</sup> /yr.

Data and photographs provided by Cogdell Spencer ERDMAN.

# SOLUTION EXAMPLE



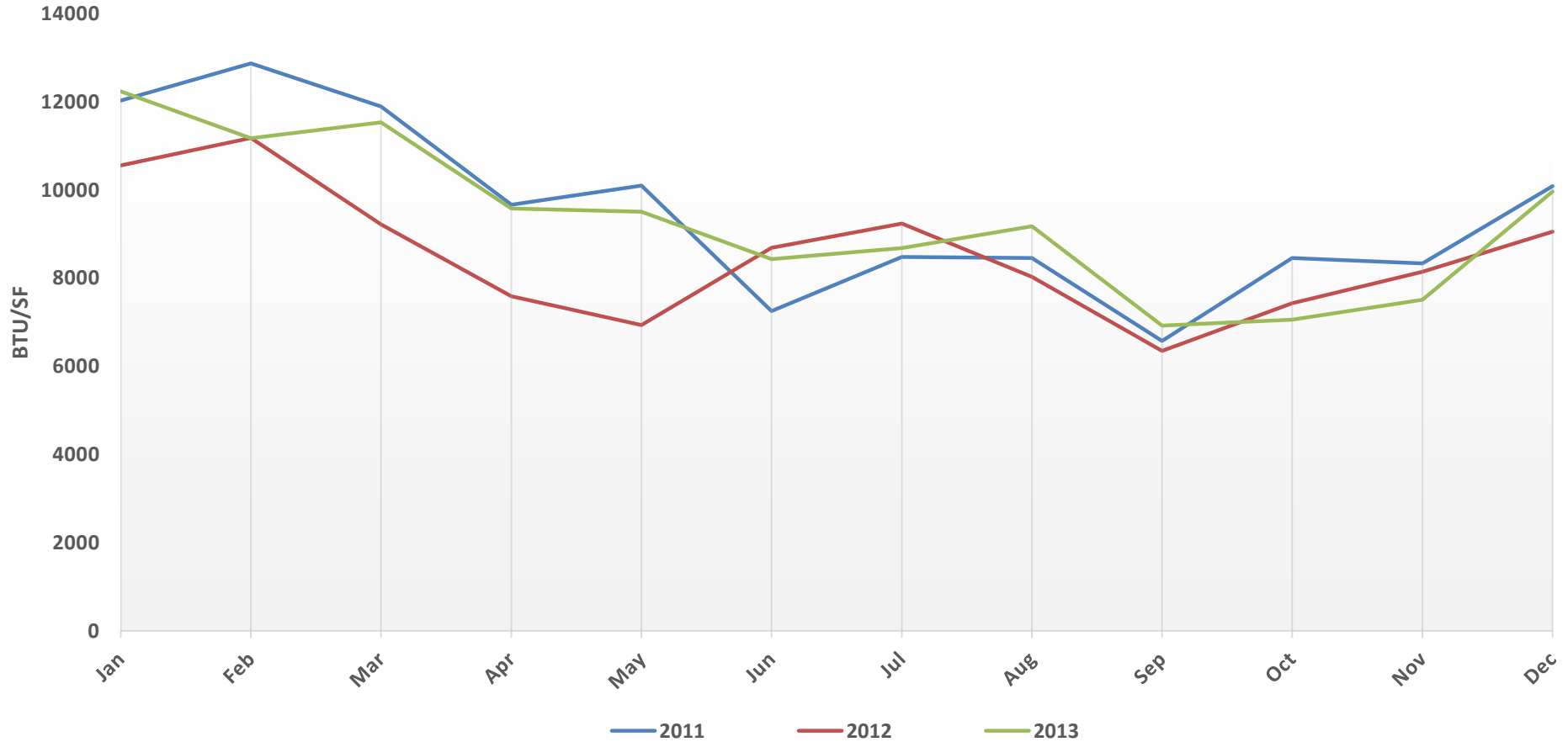
## Ortonville Area Hospital Services, Ortonville, MN

- 49,218 SF
- 350 Ton W2W Heat Pump
- Estimated Annual Savings: \$69,914

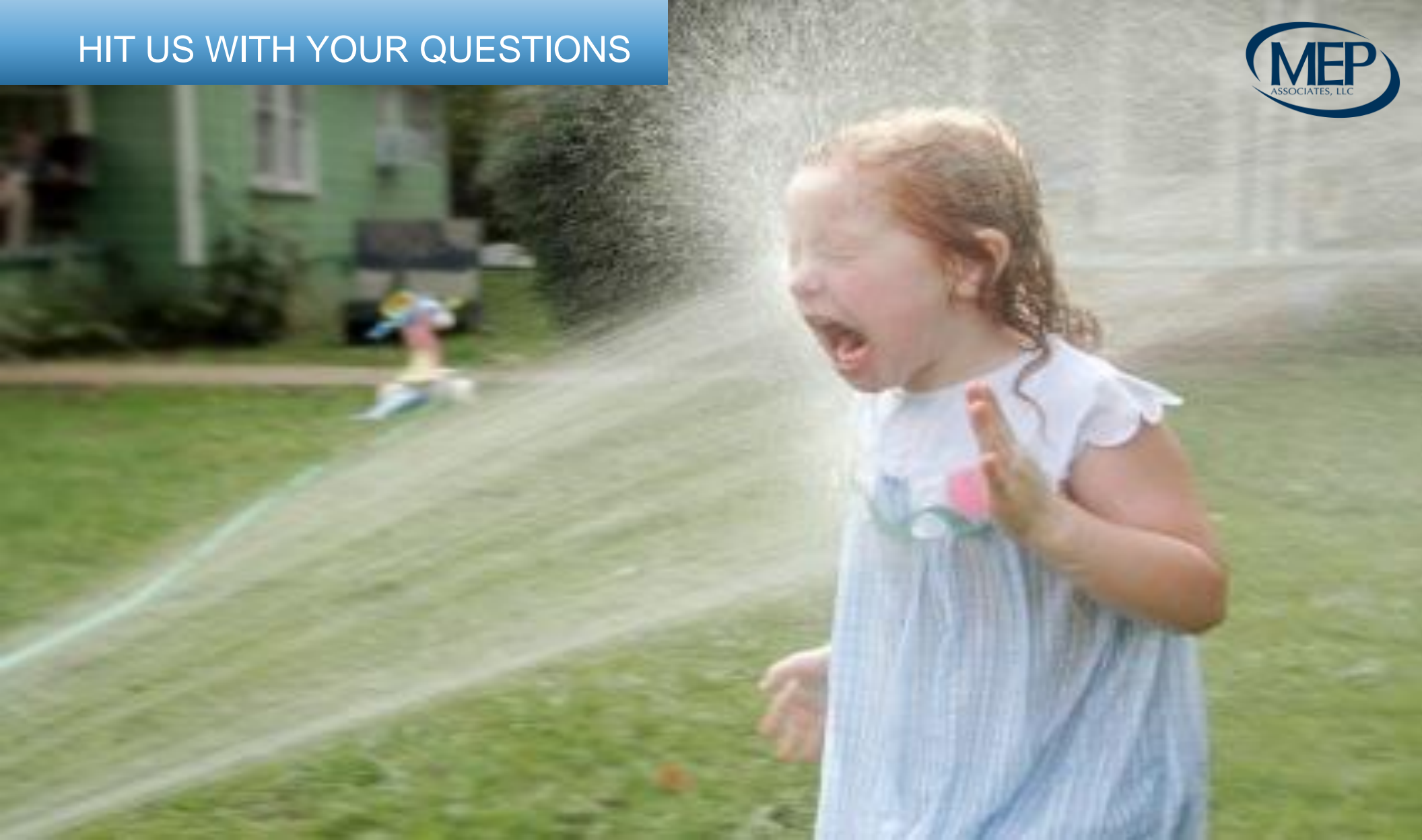


## Ortonville Area Hospital Services, Ortonville, MN

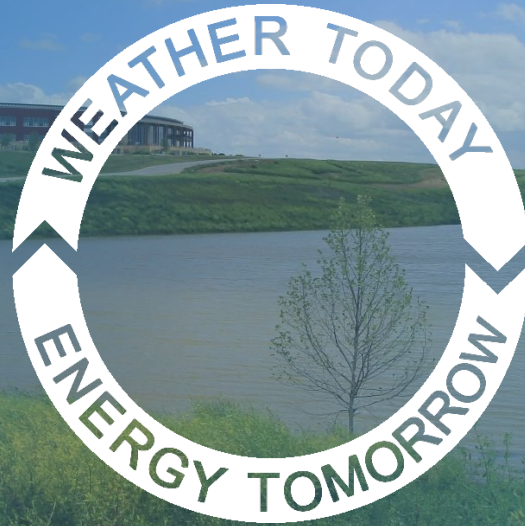
Total Monthly Energy Consumption (BTU/SF)



HIT US WITH YOUR QUESTIONS



Thank You!



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