AABC Commissioning Group

AIA Provider Number 50111116

Energy Modeling Tools – Solutions for Creating an Intelligent Building

Course Number: CXENERGY1601

Neil Maldeis, PE, CEM

TRANE

April 12, 2016

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES

for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Copyright Materials

TRANE®

Ingersoll Rand

CONTINUING EDUCATION AIA

Course Description

This session shows how energy modeling software tools can identify specific energy saving opportunities for existing and new buildings by using a sophisticated software tool to re-create building systems in a simulated environment. This provides a powerful resource for making infrastructure changes in a virtual environment and testing various solutions to determine which would function best in the building.

Learning Objectives

At the end of the this course, participants will be able to:

1. Learn how to apply modeling tools, methods and practices

2. Gain insights on what's required to set up an energy modeling system and learn how to perform a high-level cursory review of possible energy savings

3. Understand the factors that affect possible savings regarding the efficiency and operation of existing building systems.

4. Learn from success stories of how modeling was used to achieve intelligent building results

Agenda

- Why use modeling
  - Business drivers
  - Best practice
- How to use modeling
  - Assess and analyze
  - Adopt and implement
  - Measure and validate
- Keys to success
- Case studies

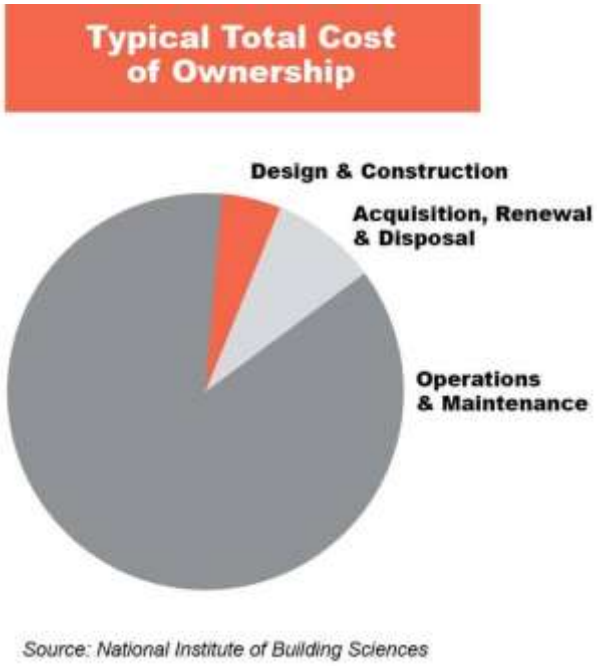
Why – Today's Environment

- The "new NORMAL" = doing more with less
- Economic and government/regulation uncertainty
- Technology-driven expectations and access to information (Internet of Things, cloud, mobility, social networking)

Organizations expect real, measurable return – tougher environment

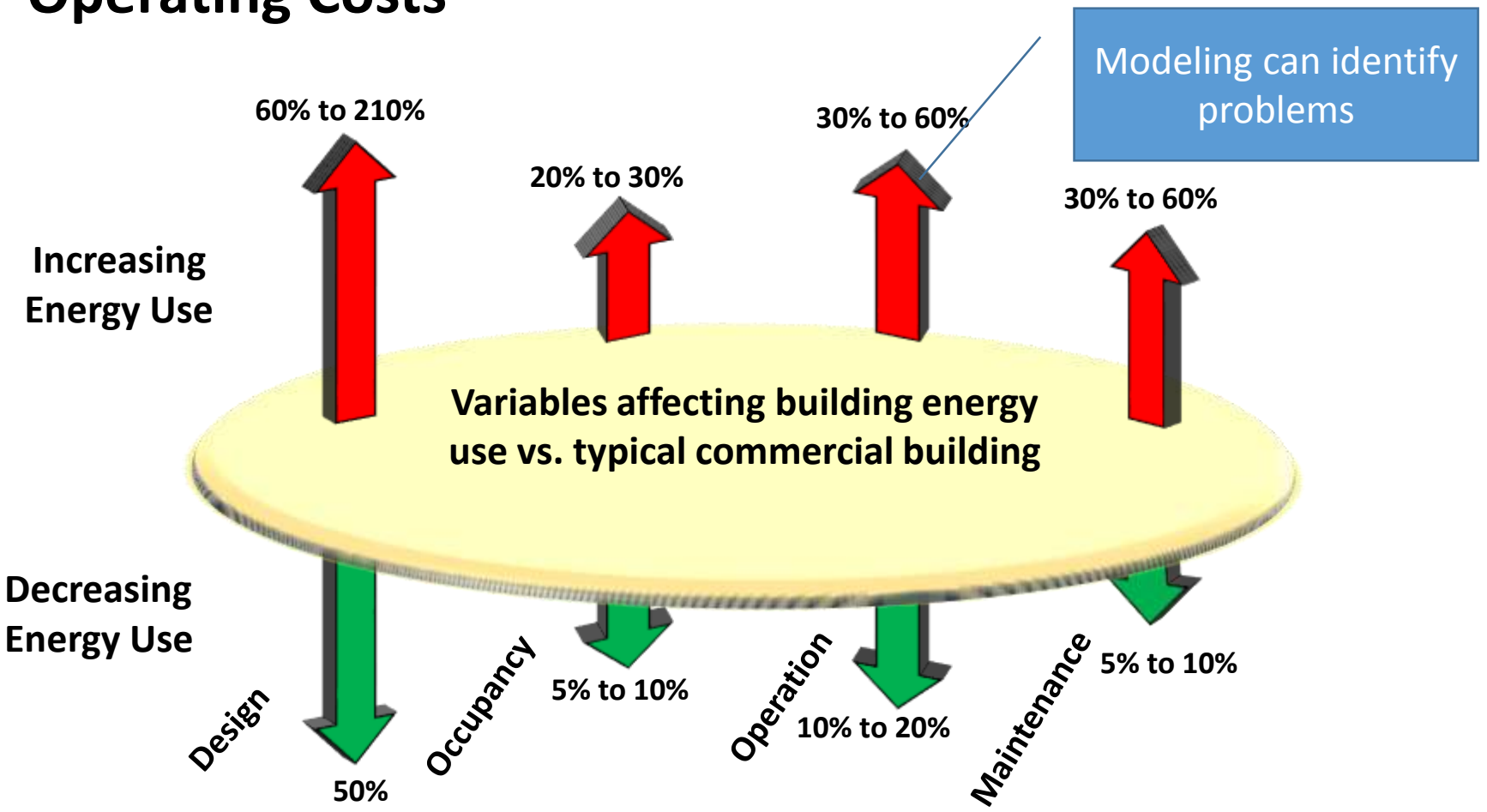
Why – Total Cost of Ownership

- Typical buildings have occupied lives of 50-75 years
- Operating costs typically account for 60-85% of building lifecycle costs – compared to 5-10% for design and construction costs
- Intelligent buildings reduce lifecycle costs so organizations can invest in other priorities and make buildings “assets” instead of “expenses”
- Areas of focus:
  - Energy and water consumption
  - System reliability
  - Environmental compliance
  - Occupant health, safety and comfort
- Energy has ties to/interfaces with all of these



Modeling is one of the best approaches to determine cost of ownership

Why - Addresses the Influences that Determine Life Cycle Operating Costs



Jonathan Heller and Morgan Heater, Ecotope Mark Frankel, New Buildings Institute, Sensitivity Analysis: Comparing the Impact of Design, Operation, and Tenant Behavior on Building Energy Performance; July 2012

Represents 70% of the commercial building stock in the U.S. -- P. Torcellini, M. Deru, B. Griffi th, K. Benne, DOE Commercial Building Benchmark; Models. ACEEE Summer Study on Energy Efficiency in Buildings, 2008.

Why - Enhance Operating Effectiveness

- Providing a safer, healthier, more comfortable (productive) environment
- Operating reliably with minimum unscheduled downtime and fast recovery
- Maintaining performance within acceptable tolerances throughout their lifespan

- Enhancing performance, retaining/increasing value and adding luster to the organization's brand and reputation
- Cost management and operating excellence

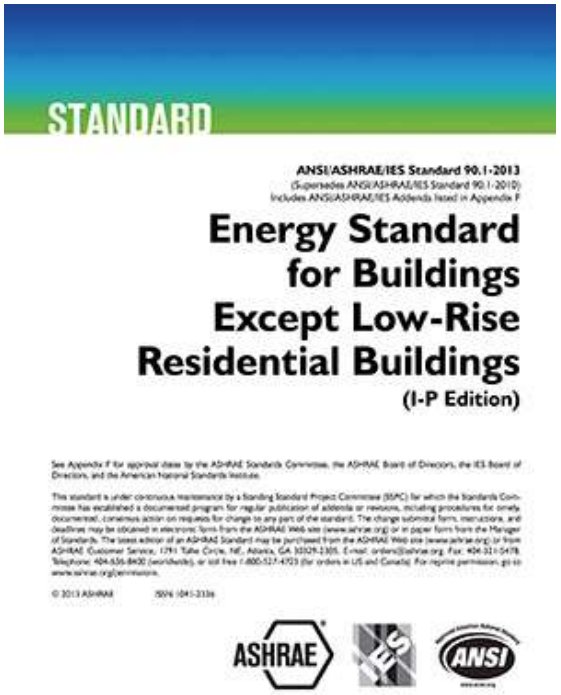
Why – Enhance Operating Effectiveness

- Need ways to manage efficiently
  - Make energy/operations visible
  - Identify and prioritize (by identified metrics) what projects to do next
  - An effective way to get things done and demonstrate the results

Why Use Modeling Tools

Best Practice

LEED® certification and ASHRAE standards



Why Use Modeling Tools

Best Practice

- 2009 ASHRAE Handbook-Fundamentals, Chapter 19 Energy Estimating and Modeling Methods
  - Forward (Classical) Approach – predict output of known design
  - Data-Driven (Inverse) Approach – input and output variable known, determine operation (i.e., have building information and utility bills get model output to match utility consumption)
    - Also use benchmarking information [CBECS, other] to compare existing energy consumption to buildings of same/similar function.

Why Use Modeling Tools

Best Practice

- Load design more straight science (still requires experienced engineering judgment)
  - Building envelope, location, orientation, people, lights, plug loads, schedules – look for peak for equipment sizing
- Energy simulation; an art based on science
  - Same building but get model to agree with utility bills
  - Existing building, audit (info, data mining) balance effort for results
    - Info can range from as-built electronic building information management documents to nothing (get out the tape measure and list of questions)

Why Use Modeling Tools

Best Practice

- Can Increase productivity to get desired results
  - Determine loads for equipment selection
  - Determine energy consumption
    - Design comparison
    - Budgets
    - Code Compliance (ASHRAE 90.1)
    - LEED
    - Energy conservation measure comparison
- Changing variables; weather, schedules (exhaustive calculations)

Why Use Modeling Tools - Advantages

Best Practice

- Allows you to look at many options
- Takes interactions into account
- Lets you try strategies without actually installing anything
- Creates a safe environment to fail
- Gives you the ability to project savings
- Helps determine economic feasibility

Many Tools Available

- DOE 2
- HAP
- eQUEST
- Trace 700
- EnergyPlus
- Many others (over 100)

Computer Simulation Tools Available

Best Practice

- Some load calculations
- Some energy simulations
- Combined tools
- Statistical database
- Office of Energy Efficiency & Renewable Energy
  - http://energy.gov/eere/buildings/analysis-tools
- EERE's home page, 2005 report comparing 20 major building energy simulation performance programs
  - http://apps1.eere.energy.gov/buildings/tools_directory/

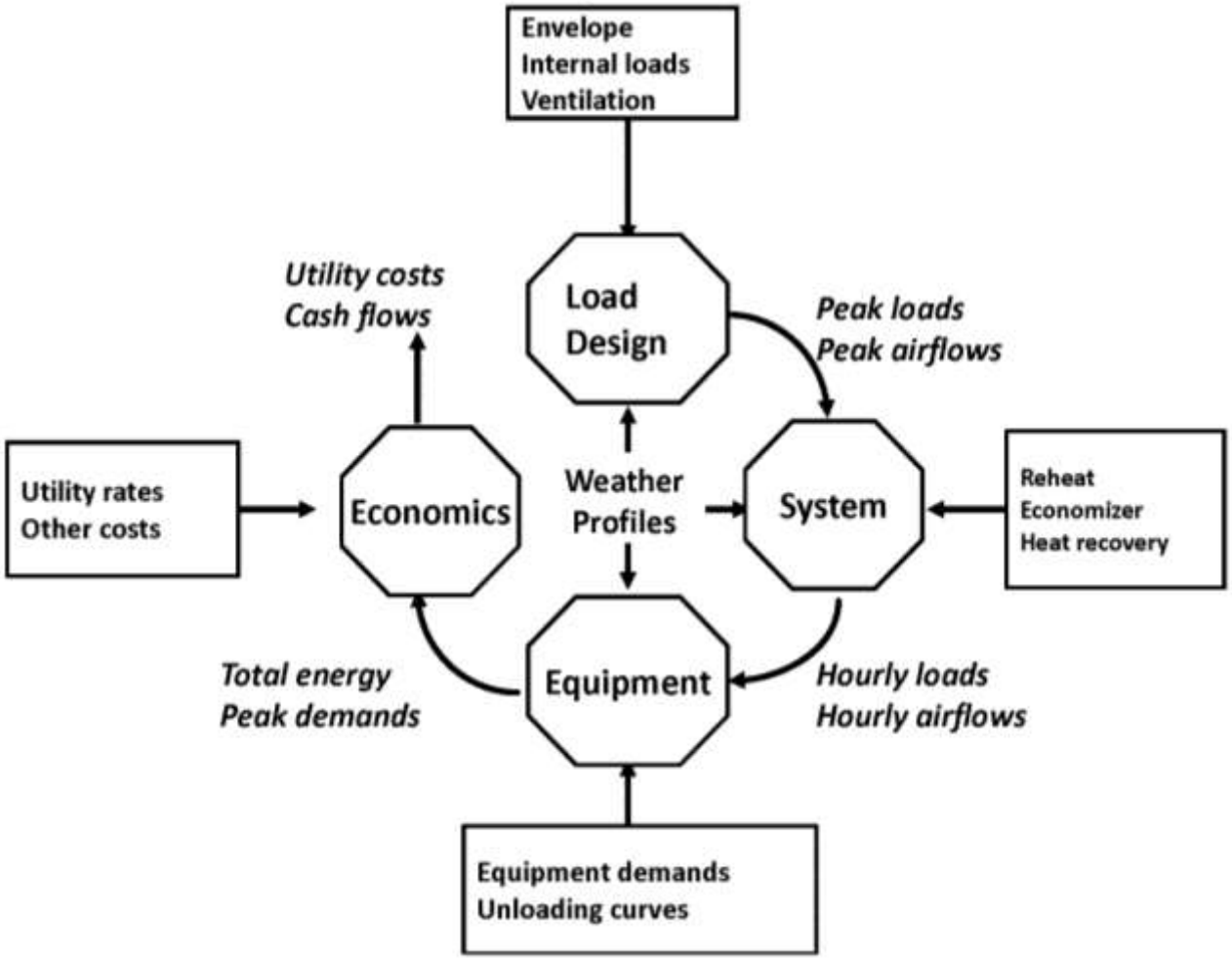
Sources

- eQuest, free http://doe2.com/
- EnergyPlus, free http://apps1.eere.energy.gov/buildings/energyplus/cfm/reg_form.cfm
- TRACE® 700 http://www.trane.com/Commercial/DNA/View.aspx?i=1136
- HAPhttp://www.commercial.carrier.com/commercial/hvac/general/0,3055,CLI1_DIV12_ETI495_MID1580,00.html
- Retroficiency www.**retroficiency**.com/

How to Use Modeling

Assess and Analyze

Modeling Methodology

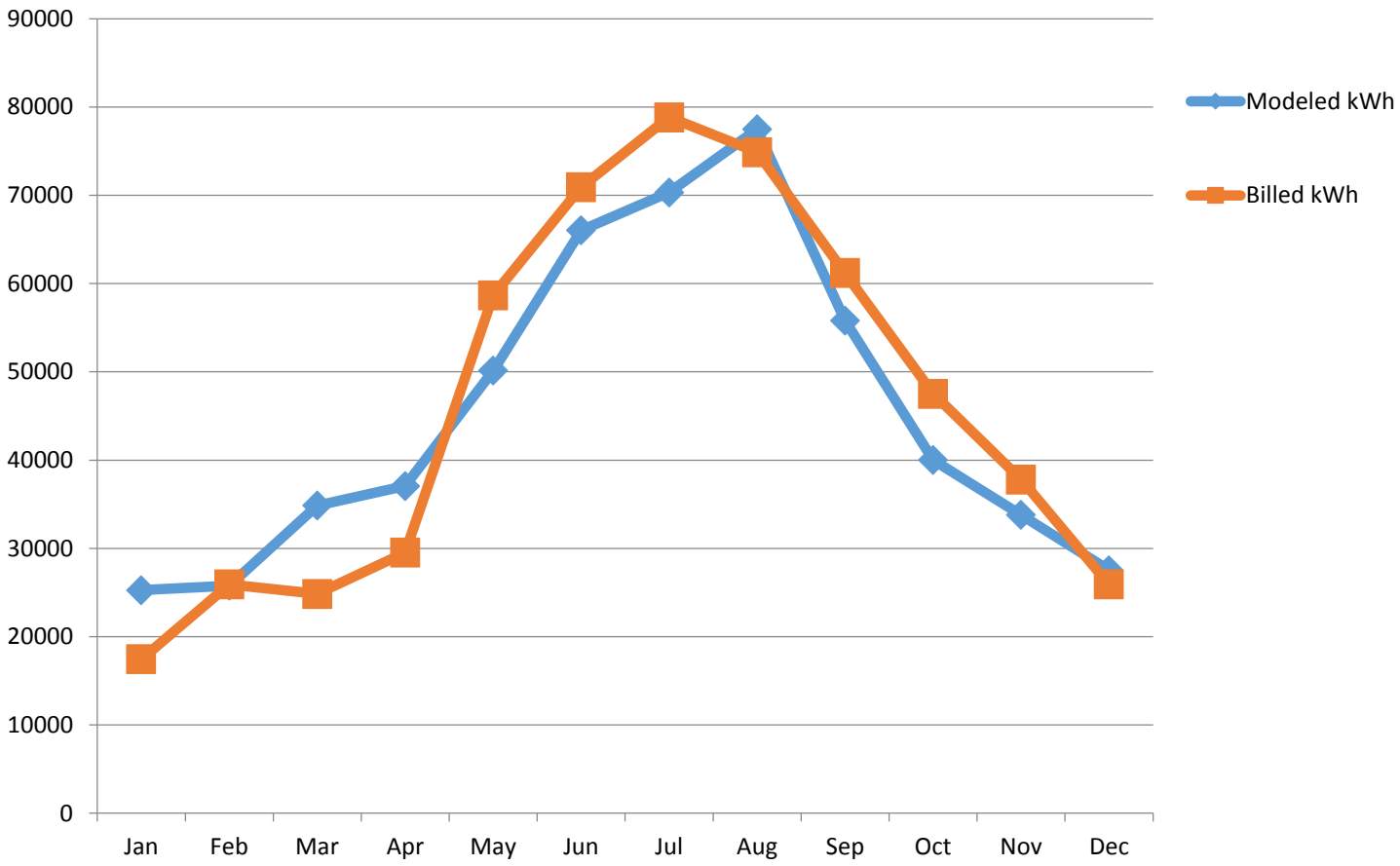


Modeling Execution – Key Considerations

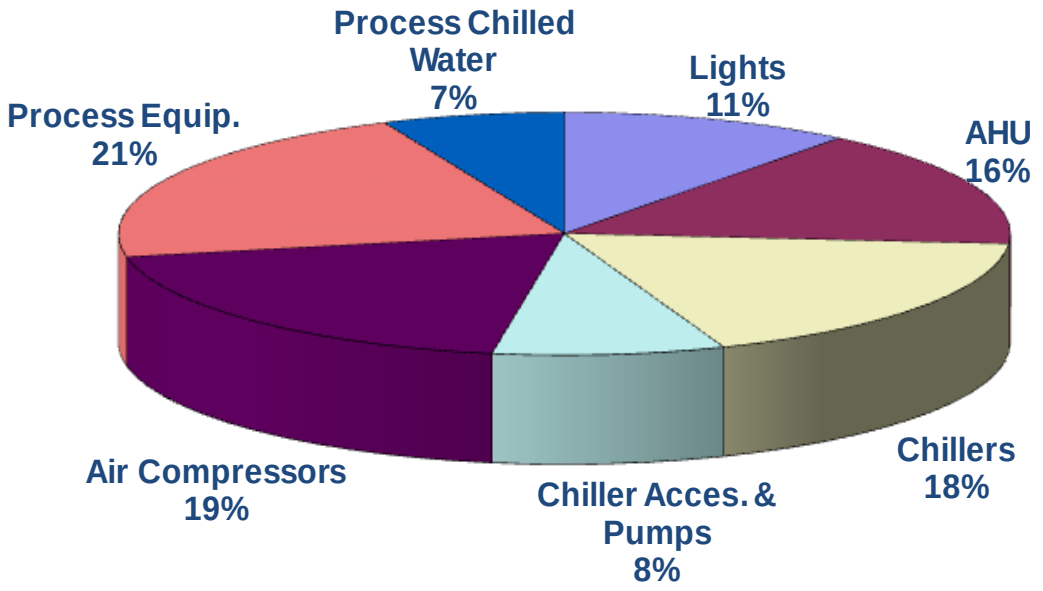
- Tuning is important to a high functioning model
- Existing buildings with utility history can be very accurate
- New construction requires sanity checking (sound engineering judgment)
- Garbage in = garbage out
- Accurate building asset data is important
- Monthly vs. annual tuning is best
- Manipulating model to drive expected results should be avoided
- Engage only experienced users of modeling tools

Creating a Well-Tuned Model

Assess and Analyze



Creating a Well-Tuned Model



Pitfalls and Benefits

- Pitfalls
  - Modeling tool ease of use, learning curve
  - Data entry errors
    - Check results and use engineering judgment, “does this make sense?”
    - Calculation time if too many templates, rooms, system and/or plants entered. “Keep it short and simple” principal
- Benefits
  - Powerful tools if used properly
  - Relative ease in comparing results

Energy Modeling Tips

- List of inputs (high level)
  - Project Info
  - Location (weather driven)
  - Templates
  - Rooms
  - Systems
  - Plants
  - Building Activity

- Input areas with the most impact
  - Assign rooms to systems
  - Assign systems to plants
  - Ventilation and exhaust
  - Infiltration
  - Economics
  - Schedules

Possible Strategies to Model

- Ventilation reset
- Optimum start
- Dedicated outdoor air systems
- Demand control ventilation
- Chiller sequencing
- Decoupled, variable primary, parallel chiller arrangement

- Chiller tower optimization
- Chilled water reset
- Waterside free cooling
- Double-bundle heat recovery
- Air-to-air energy recovery
- Variable frequency drives

Analyze Alternatives

Chiller Plant Options		
Plant Alternatives	Energy Performance Compared to Existing System (% Better)	Useful Life (Years)
Existing System	-	< 5
Chiller Replacement (Centrifugal)	29%	25
Chiller Replacement (Centrifugal + series plate and frame HX)	39%	25
Chiller Replacement (Centrifugal + thermal storage)	24%	20
Chiller Replacement EarthWise	26%	25
Chiller Replacement (Air-Cooled)	8%	15

The power of modeling

Top Control Strategy Improvements

Assess and Analyze

- Air Handling Systems (HVAC)
  - Temperature setup/setback
  - Calibrate sensors, especially OA sensors
  - Synchronize mechanical equipment with building occupancy
  - Improve economizer operation/maintenance
  - Reset discharge air
  - Reset static pressure
  - Adjust demand control ventilation
  - Clean/replace condenser and evaporator coils and filters

- Chilled Water Systems
  - Reset chilled and condenser water
  - Optimize start/stop of major equipment
  - Optimize cooling tower
  - Adjust fan and pump speed drives
- Heating Systems
  - Reset boiler hot water

Modeling Tools Enable ROI Analysis

- Modeling tools that have the capabilities to determine economic feasibility are best to use
- Many tools have built in economic calculations
- Modeling tools can help assess feasibility of complicated strategies
- Model scenarios can troubleshoot problems

Measure Results, Determine Effectiveness

Select improvement actions	Typical savings
Lighting—implement solutions for maximum energy savings	10–15 %
Building automation/controls	5–15%
HVAC upgrade—replace aging equipment with state-of-the-art models	5–15%
Plant upgrade — replace chillers/boilers with higher efficiency models	5–15%
Pumps and motors — replace with higher efficiency models	5–15%
Comprehensive energy savings projects — improvements in all of the above areas. Lighting solutions may account for as much as half of the savings in a comprehensive project.	20–30%

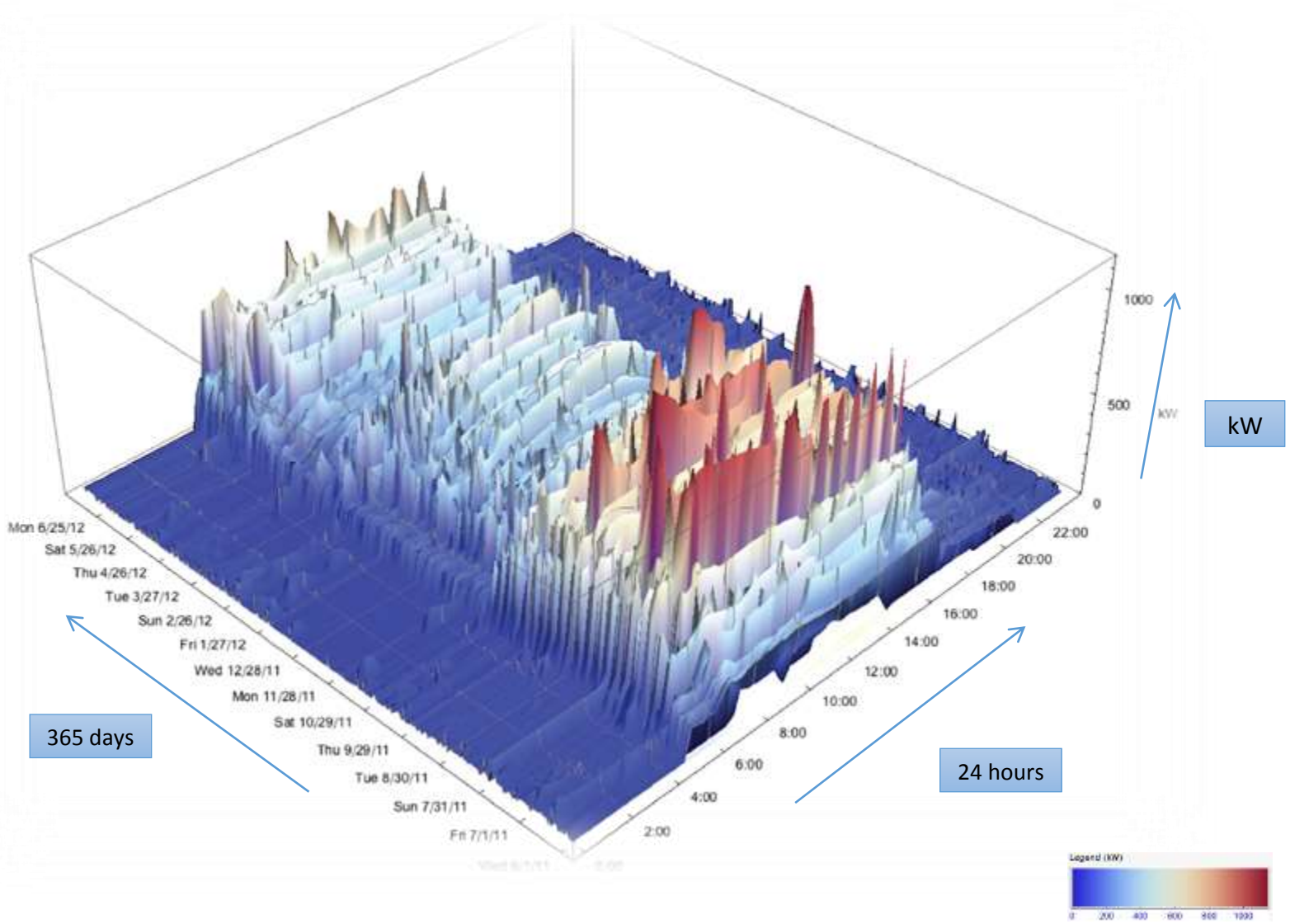
Assessment Opportunities

Measure and Validate

- Validate new construction modeling with data logging or metering data
- Compare post installation results using actual utility bills
- Remember many utility companies will accept model savings for rebates
- Fine tune building operation

Other Tools

Measure and Validate



Keys to Success

- Understand the mission, purpose and objectives of your organization and its buildings
- Use modeling to show how improving building systems' performance will help achieve the mission and objectives
- Use modeling tools for initial design and/or evaluation and to trouble shoot, fine tune and validate performance
- Invest the effort to have a well-tuned model
- Seek out experts who have modeling skills if you don't

Commercial Headquarters

Case Study

SITUATION

- Customer wanted to save energy, improve reliability, enhance returns and reduce environmental impact

APPROACH

- Analysed building systems, energy use, rate structure and procurement methods
- Recommended mission-focused energy conservation measures
- Designed and installed upgrades
  - State-of-the-art chilled water system
  - Rooftop thermal storage system
  - Re-programmed central automation control system

MEASURE/VALIDATE RESULTS

- Estimated $765,000+ annual energy/operations savings
- 25% internal rate of ROI on incremental spending
- 6.1 million pounds of carbon emission reduction
- No sacrifice of rentable space

School District

SITUATION

- School district looking to reduce energy and operating costs spent on aging infrastructure while improving the learning environment at 46 district schools

APPROACH

- Assess building systems and energy use
- Recommend mission-focused ECMs
- Design and install upgrades district-wide
  - HVAC upgrades and re-commissioning
  - Web-enabled building control system
  - Sky lighting and lighting retrofits
  - Electric-gas oven conversion
  - Water conservation measures

MEASURE/VALIDATE RESULTS

- Estimated annual energy savings of $750,000+ per year
- Maintenance cost savings of $390,000
- $10.7M program funded entirely by energy savings

Trane Manufacturing Facility, Texas

Case Study

SITUATION

- Needed to trim energy and operating costs, improve reliability, add asset value and adjust to reduced production volume

APPROACH

- Comprehensive energy analysis
- Energy conservation measures
  - Building automation system upgrade
  - Lighting system/fixtures retrofit
  - HVAC system improvements – boiler, air compressors, etc.
  - Operations, maintenance and schedule improvements

MEASURE/VALIDATE RESULTS

- $1.4 million annual energy and ops savings – two-year payback
- Reduced energy consumption by 11.5 million kilowatt hours
- Replaced aging systems – some mid-1960s era
- Improved environmental performance of building

This concludes The American Institute of Architects
Continuing Education Systems Course

Neil Maldeis

nmaldeis@trane.com