Construction Institute Presentation 3/26/09

Yale University:
Energy Conservation Experiences, Challenges and the Future

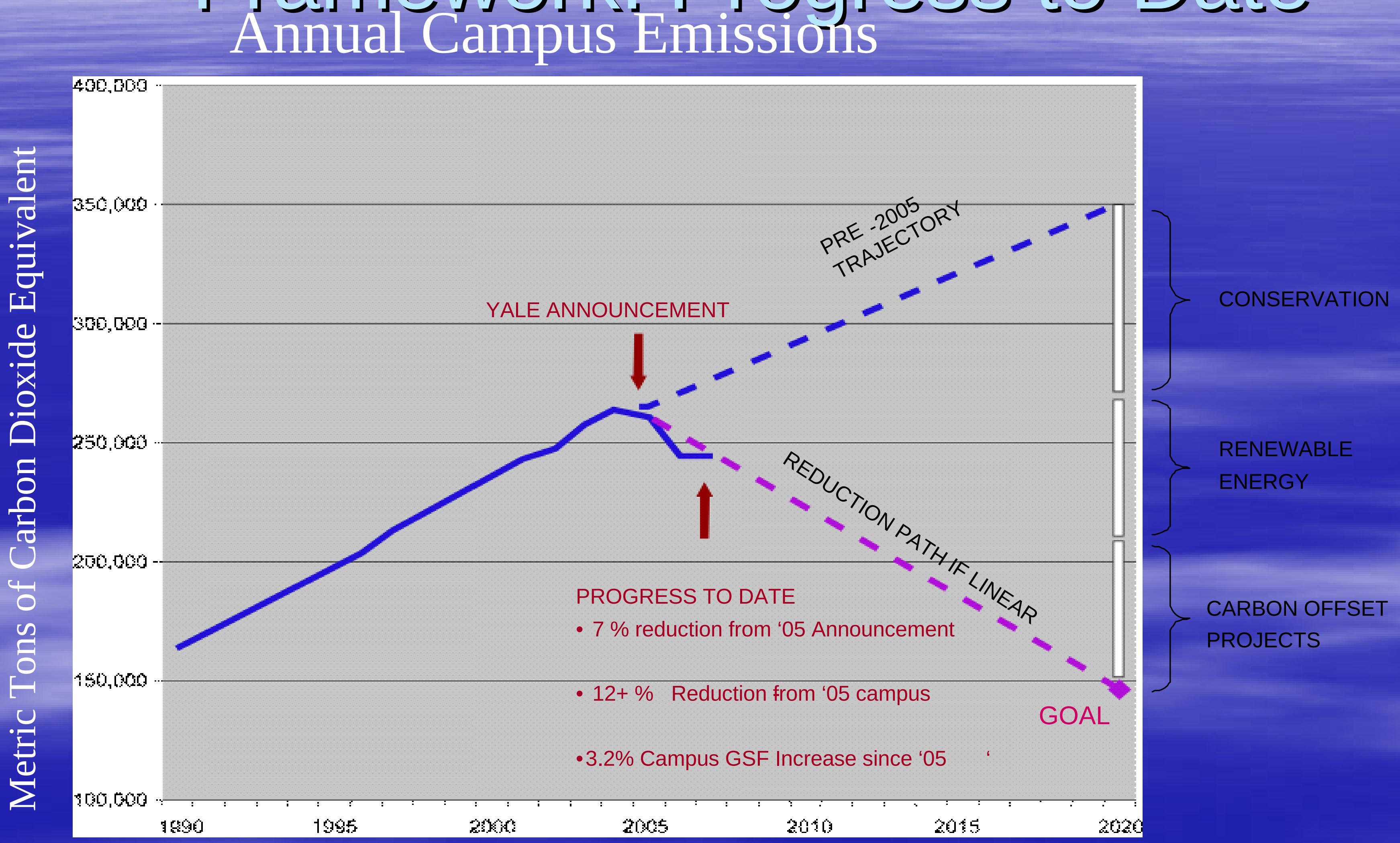
Anthony Kosior, PE, CEM
Tom Downing PE CEM, LEED AP

A Brief History: Yale's GHG Commitment

- Yale is committed to a level of investment in energy conservation and alternate energy sources that will lead, based on current projections, to a reduction in its **greenhouse gas emissions by 10% below our 1990 levels by the year 2020.** This is consistent with a similar commitment by the Connecticut State Legislature and the New England Governor's and Eastern Canadian Premiers Climate Action Plan.

- Yale President Richard Levin October, 2005

Campus GHG Reduction Framework: Progress to Date



Conservation categories

1. Systems Approach
    - To date this has been the method Yale has utilized
    - This is the “low hanging fruit” type of project: 0-3 year payback
    - Detailed list on following page regarding Completed projects & effectiveness
2. Whole Building Integrated Approach

    (Where we are heading…..)

Completed Systems-Type Conservation projects

HVAC Recommissioning of 90 Buildings (all DDC type)	19,000 MT CO_2e
Building Temperature Standardization (DDC Bldgs)	9,500 MT CO_2e
Lighting Occupancy Sensors in 85+ Bldgs	5,000 MT CO_2e
High Eff. Filters in all HVAC units	2,500 MT CO_2e
Rescheduling of Lab "Occupied" hours	1,500 MT CO_2e
Lab Rebalance & Air Change Red'n 15 to 9 (6 Bldgs)	1,000 MT CO_2e
Sensible Heat Recovery retrofits in Labs	1,500 MT CO_2e
Window Replacements Var. Bldgs	1,000 MT CO_2e
Programmable Thermostats in Smaller Bldgs	500 MT CO_2e
Demand Ventilation (CO_2 sensors& VFDs)	500 MT CO_2e
Continuous Commissioning at Key Lab Bldgs	Maintains #1 above

1 MT CO_2e = 10 MMBTU (approx)

Other Noteworthy Conservation Items

- Standardized on 28watt vs 32 watt 4' Fluorescents
- Retrofitting Old steam bldgs to Hot water as part of renovation work
- Dorm Energy Competitions – 10% reductions from 2005 baseline yr
- All New Bldgs LEED Silver or better with emphasis on energy use significantly below ASHRAE 90.1 Stds
- Using Groundwater for cooling (Standing Columns) in new bldgs & designing retrofits to existing
- Enthalpy wheels for heat recovery in new labs now standard

Cost implications

- Most GHG-reducing investments to date have had a positive economic return
- Most future investments will incur an economic cost
  - Green building premium: 2-10%
  - Renewables more costly than fossil fuels
- Estimated cost of reaching goal: less than 1% of operating budget

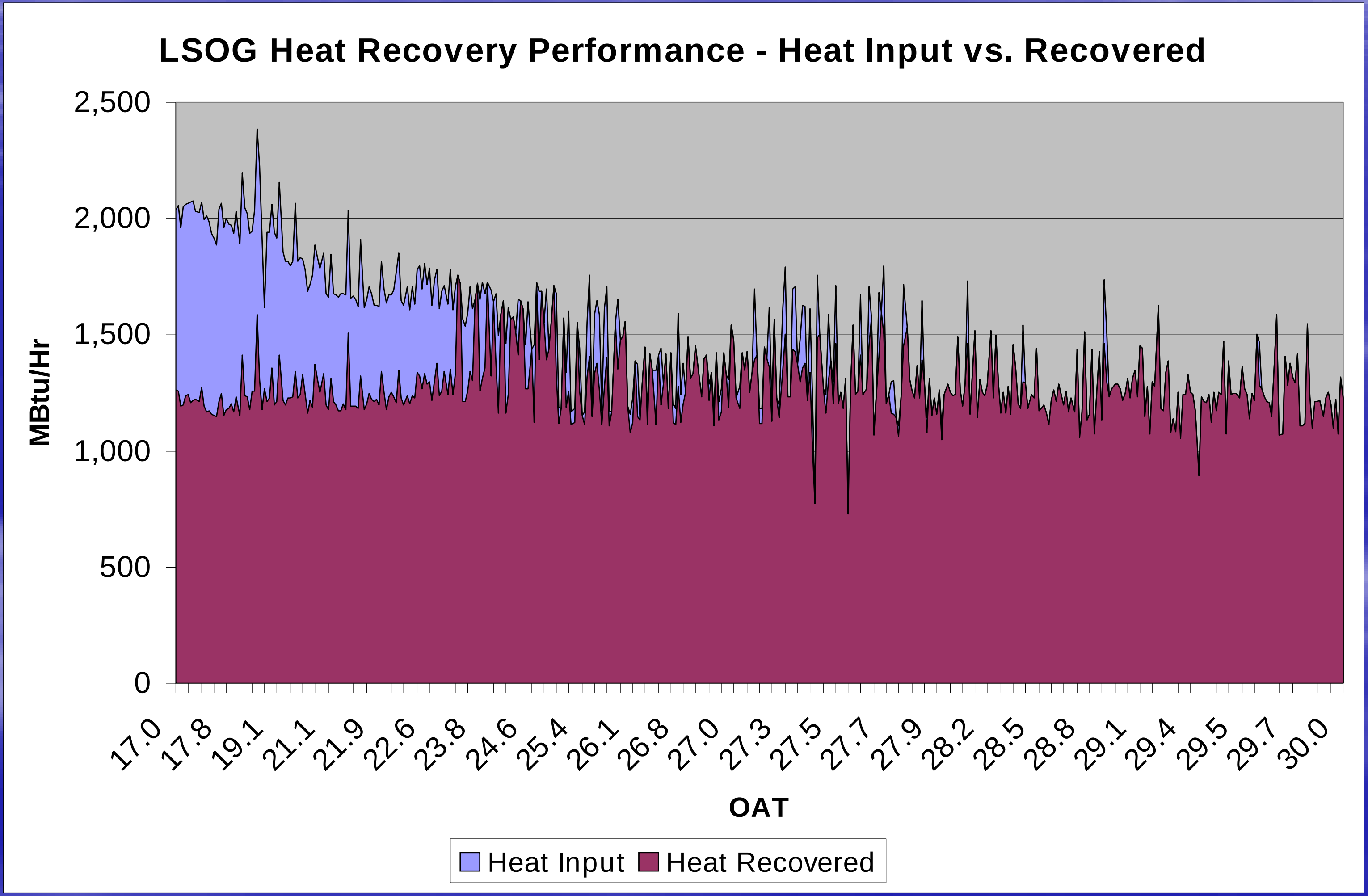
Current & Future Plans

1. Continue Systems Approach as new Technologies emerge. Some Examples…..
   - Standing Column GSHP technology
   - Evacuated Solar Tube Technology (Solar hot water Heating)
   - Active / Passive Chilled Beams
   - Thin film PV
   - Daylight Harvesting Ballasts / smart controls for lighting
   - Micro-Wind turbines
2. Installation of 2nd Cogen. Plant at the Med School (14MW)
3. Begin Comprehensive Building Approach to energy conservation

Sample Project at YSM LSOG Heat Recovery

- Sensible Heat Recovery; ~59,000CFM
- Retrofit Challenges
  - Main Supply & Exhaust for Building
  - Lab / Research Environment
  - Removal of Steam Coils / Replace with low temperature Pre-Heat Coils
- Energy Savings & Project Cost:
  - Total Savings = $120,000 ($59k for HR & $61k in ventilation reduction)
  - Total Carbon Offset ~370 MTCE
  - Total Project Cost = $1.4M, Simple Payback = 12yrs
- Measured Savings

LSOG Heat Recovery Measured Data – March 2009



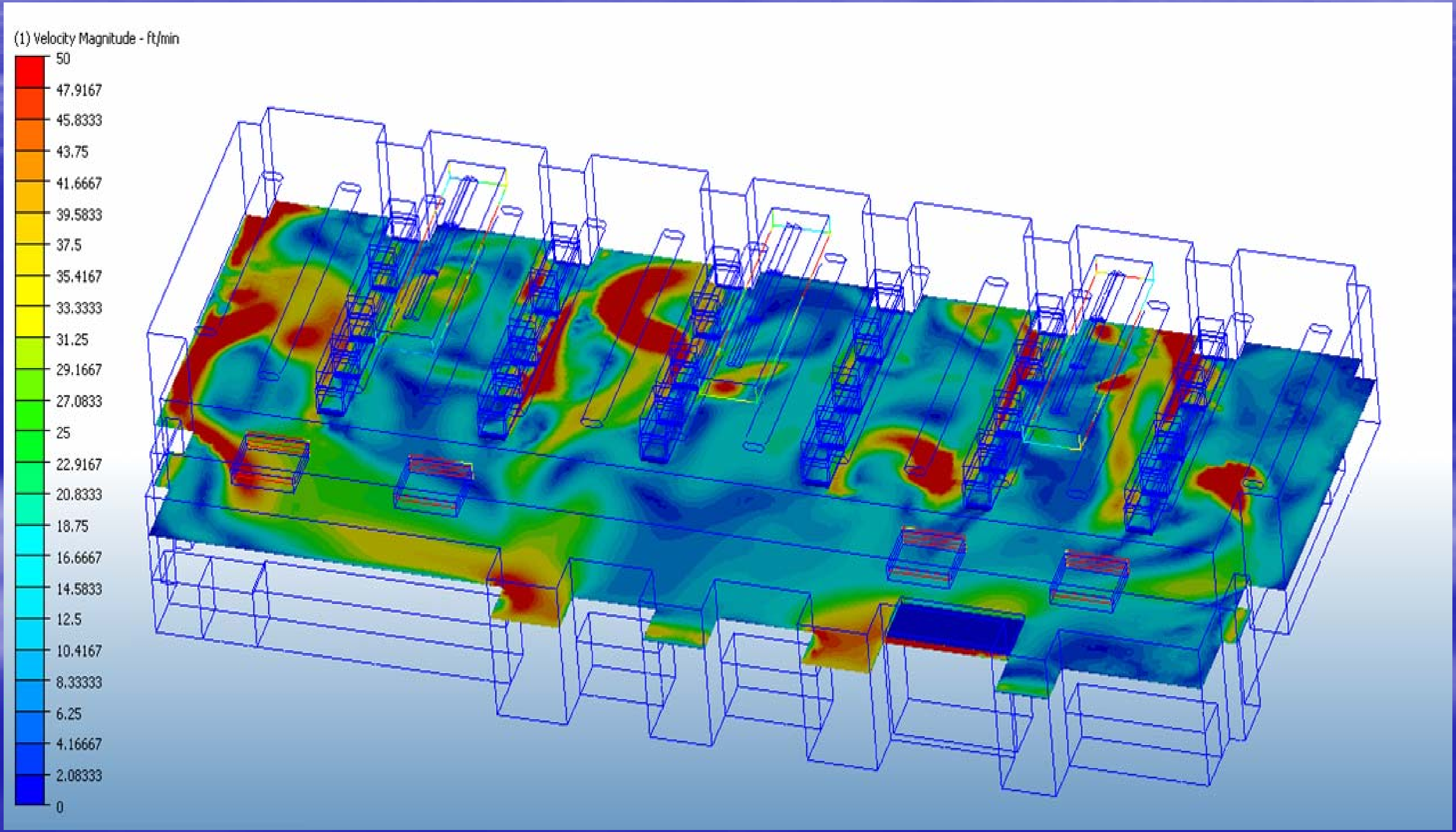
Comprehensive Building Approach

- Viewed as the next step to achieve **significant** Energy Savings after low hanging fruit is gone!
  - Requires significant Capital commitment: 5-10 year payback
  - Involves building energy modeling; this is an integrated building systems approach & takes advantage of symbiotic effects to save energy for the building as a whole
  - Similar in principal to ASHRAE “Appendix G” energy modeling practices

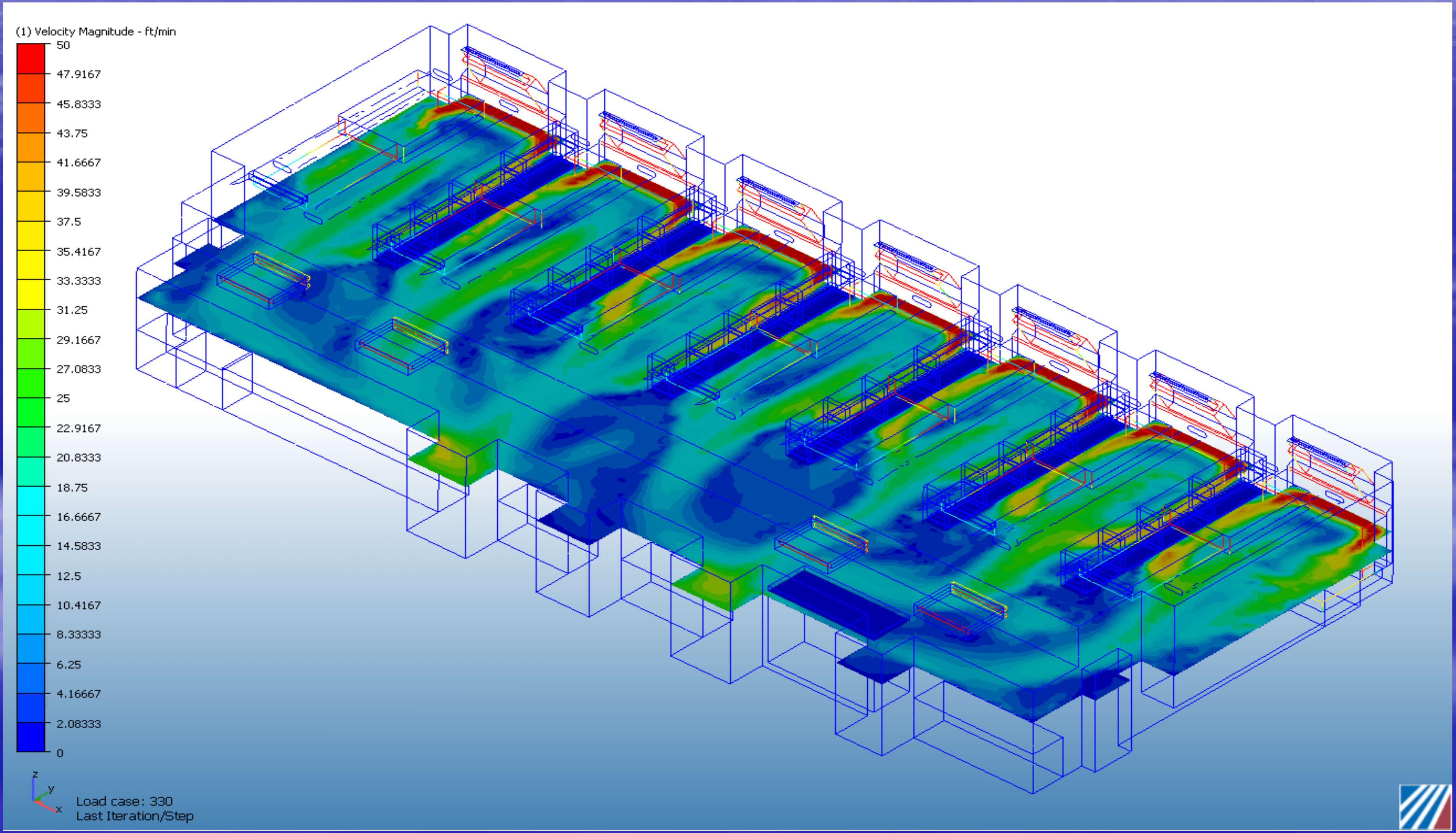
Sample Project at YSM – Comprehensive Building Approach

- TAC Building
- Energy Reduction Goal: 25% below ASHRAE 90.1
- In depth energy analysis & development of baseline energy model
- Major ECM's
  - Ventilation Reduction – labs & vivarium
  - Sensible Heat Recovery (100k CFM already implemented)
  - Lighting Retrofits (28w T8 lamps, occ sensors, etc.)
  - High Efficiency Filtration for AHU's
  - Control Modifications
- Total simple payback of all measures expected to be 5-6 years
- Utilized CFD modeling to redesign diffuser layout in labs for more efficient airflow

Comprehensive Building Approach: Sample Output Results TAC CFD Modeling – Existing Condition



Comprehensive Building Approach: Sample Output Results TAC CFD Modeling – Proposed Condition



Challenges

- Addressing occupant behavior to achieve additional energy reductions
- Creating a Cost/Benefit Model that is "Accurate"
  - Assumptions of future energy cost, Cost of Carbon, Discount rates, etc.
- Minimizing impact of New Buildings on the overall Campus GHG footprint (How green is green enough?)
- Leading edge vs. bleeding edge technologies

Expectations from our A&Es

- Push the envelope as far as energy savings possibilities, rather than being pulled along!
  - Introducing new technologies as alternatives or even as base design
- "Right Sizing" systems based upon real demand vs. the usual safety factor or past designs
  - Creates a better defined energy baseline to predict consumption and utilities required
  - Allows systems to operate most efficiently
  - Lowers first cost & decreases ongoing operational costs
- Utilize other design tools, like CFD based modeling, to provide efficient HVAC designs especially in 100% OA applications

“Right Sizing” Example
Power Study – TAC Building, YSM Campus

- Power Design Assumptions
  - Electrical System Impact
  - HVAC Load Calculations
- Research Laboratory
  - Typical Design Assumptions
    - 10-15 w/sf (lab & equipment / support areas)
  - Measured Data
    - Lab & Lab Equipment / Support Space
      - 3.6 w/sf average
      - 6.3 w/sf max
  - Factor of 2 compared with typical design assumptions
  - Equipment load can account for as much as 80% of the cooling load driving ACH rates too high (in 100% OA applications)
  - Labs 21 “Best Practices” for Laboratory Design