“Energy Conservation at Merck”

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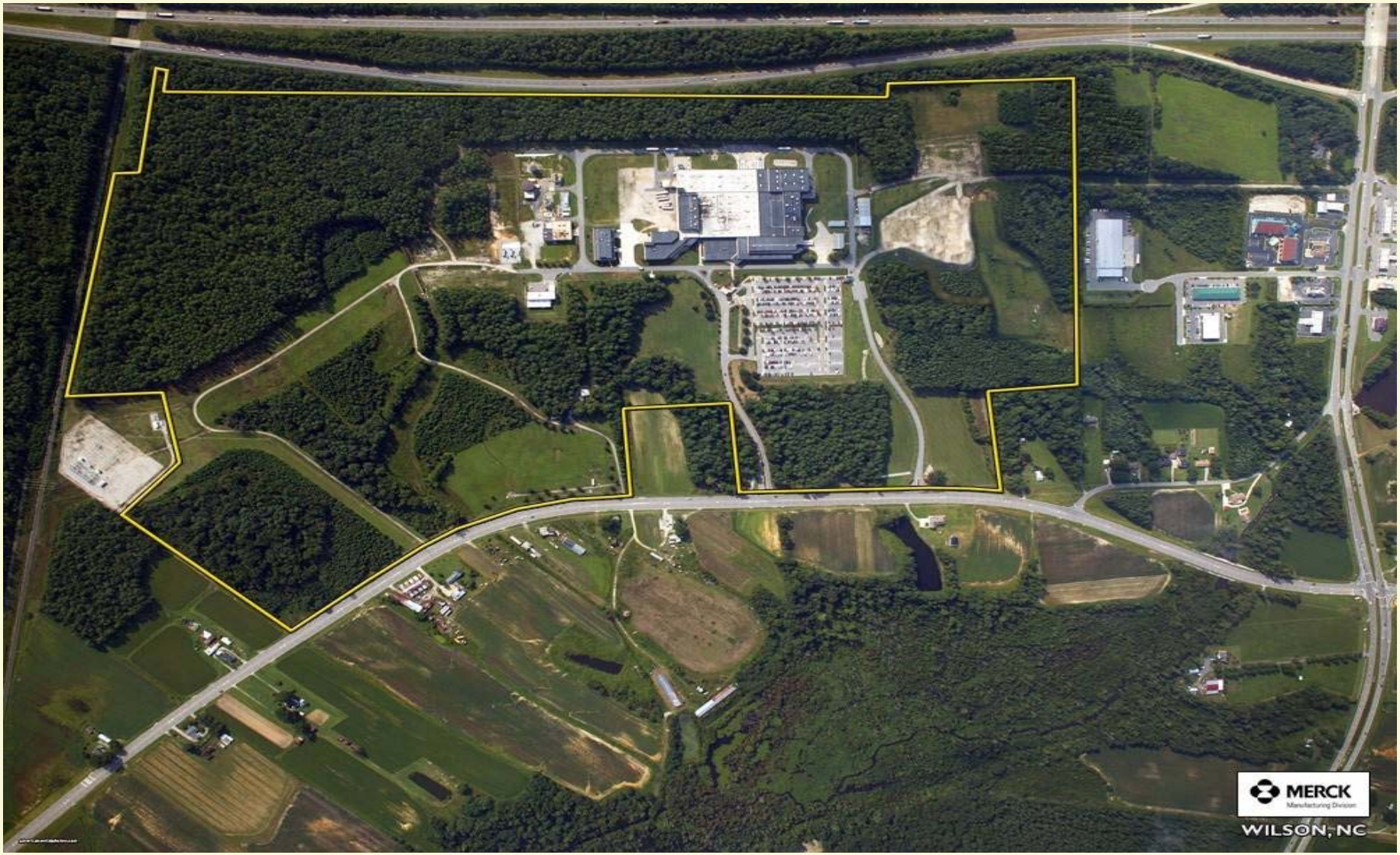
Merck – Wilson Plant Site



Site Facts

- Packaging/Manufacturing site constructed in 1983.
- The plant employs currently employs 334 people.
- Current size is 575,000 square feet on 225 acres.
- On pace to package approximately 4 billion tablets in 2008.
  - Singulair® Nexium® Fosamax® Cozaar® Hyzaar® Crixivan®
  - Vytorin® Zocor® Zetia® Proscar® Propecia® Atacand®
- Current Annual Utility Usage (2008)
  - Electricity = 27,900,000 kWh ($1,800,000)
  - Natural Gas = 1,500,000 CCF ($2,000,000)
  - #2 Fuel Oil = 45,000 GALS ($120,000)
  - Water = 27,000,000 GALS ($215,000)
  - Sewer = 850,000 GALS ($81,000)
  - Total Annual Utility Budget = $4.2 MM

Merck-Wilson Energy Saving Projects

Project	Est. Annual Savings	Installed Cost	Beginning Savings Year
Install 2 x 2,000 kW Peak Load Generators	$500,000	$1,400,000	2003
Install 3rd 2,000 kW Peak Load Generator	$150,000	$658,000	2005
Retrofit CHW System to Variable Primary	$46,000	$175,000	2005
Warehouse Lighting Retrofit	$22,000	$75,000	2005
AHU-7/AHU-46/AHU-44/AHU-45/AHU-52 Retrocommissioning	$256,000	$316,000	2007
Remaining Non-Production AHUs (9 Total) Retrocommissioning	$84,000	$155,000	2008
Chilled Water System Retrocommissioning	$152,000	$235,000	2008
Addition of Bi-Fuel Modules to Generators	$90,000	$220,000	2009

Annual Avoided Utility Costs (2008 vs 2004)

Utility	$ Savings	% Savings
Electricity	-$1,300,000	-42.3%
Natural Gas	-$475,000	-19.7%
#2 Fuel Oil	-$32,000	-18.5%
Water	-$90,000	-29.6%
Sewer	-$71,000	-47.1%
Total	-$1,968,000	-32.2%

Peak Load Generators

- Installed 3 New 2,000 kW Peak Shaving Generators
- Let the City of Wilson Run the Generators through their SCADA System
  - Run Monthly to Satisfy NC Eastern Municipal Power Agency's Peak kW Demand (approx. 180 hrs/hr)
- City of Wilson's CP-2 Electric Rate
  - On-Peak kW ($20.26/kW): MMD-Wilson's kW in the 60-minute interval during the billing month, which is used by the NC Eastern Municipal Power Agency for wholesale billing to the City of Wilson
  - Excess kW ($6.94/kW): The difference between the highest 15-minute kW registered by MMD-Wilson and the On-Peak kW for the current month.
  - Any kW that can be shifted from On-Peak to Excess will save $13.32/month (approx. 4,700 kW-Summer & 3,800 kW-Winter).

Warehouse Lighting Retrofit

- **Existing Lighting Design**
  - Approx. 150, 400-watt HPS fixtures from different manufacturers in the old warehouse, shipping & receiving & new high-bay warehouse.
  - Footcandle levels vary from 25-45 fc in the high-bay warehouse isles to 10-15 fc in the original warehouse isles to 25-40 fc in the open areas.
  - Fixture/Ballast combination = 460 watts (2000 K & 25 CRI)
- **New Lighting Design**
  - One-for-one retrofit w/ high-bay fluorescent fixtures
    - Industrial Lighting Products Himalayan fixtures containing four, 54-watt, T5HO lamps from SLI Lighting & Advanced electronic ballasts.
    - Fixture is rated as 94.1% efficient
    - All fixtures, except those on emergency circuits, are equipped with Watt-Stopper, high-bay occupancy sensors. Sensors are set to 5 min. in the isles & 30 min. in open areas.
  - Fixture/Ballast combination = 234 watts (4100 K & 85 CRI) *(49% wattage reduction) and operate when needed.*
  - Footcandle levels now constant at 12 fc in isles with no noticeable drop in "visual effective lumens"

Warehouse Lighting Retrofit (cont).

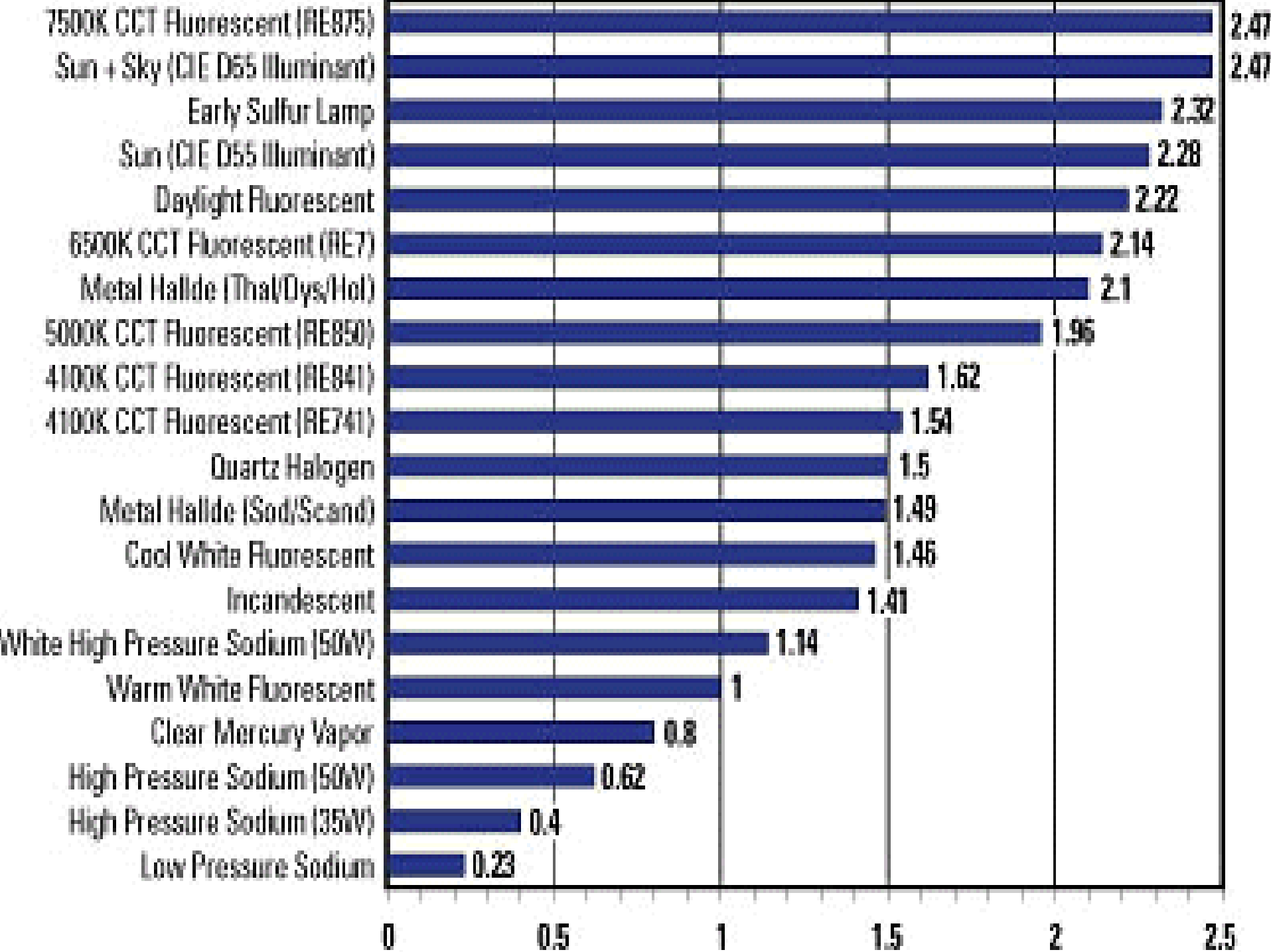
- How can you cut footcandle levels in half and maintain the same quality of light?
- The answer lies in the ratio of scotopic (color temperature) to photopic (light level) quantities (S/P value) for the light source and how your eye "perceives" brightness as well as the following equation for "visually effective lumens":

P[(S/P)^0.78 where

P = photopic amount (i.e. design lumens)

S/P = ratio of scotopic to photopic qualities of the light source (see next table)

0.78 = determined empirically in laboratory studies


7500K CCT Fluorescent (RE875)
Sun + Sky (CIE D65 Illuminant)
Early Sulfur Lamp
Sun (CIE D55 Illuminant)
Daylight Fluorescent
6500K CCT Fluorescent (RE7)
Metal Halide (Thal/Dys/Hol)
5000K CCT Fluorescent (RE850)
4100K CCT Fluorescent (RE841)
4100K CCT Fluorescent (RE741)
Quartz Halogen
Metal Halide (Sod/Scand)
Cool White Fluorescent
Incandescent
White High Pressure Sodium (50W)
Warm White Fluorescent
Clear Mercury Vapor
High Pressure Sodium (50W)
High Pressure Sodium (35W)
Low Pressure Sodium
2.47
2.47
2.32
2.28
2.22
2.14
2.1
1.96
1.62
1.54
1.5
1.49
1.46
1.41
1.14
1
0.8
0.62
0.4
0.23
0
0.5
1
1.5
2
2.5

Warehouse Lighting Retrofit (cont).

- Lets determine the "visually effective lumens" (VEL) of the light sources in MMD-Wilson's warehouse retrofit.
  - Existing 400-Watt HPS Fixture
    - Design/Mean Lumens = 40,000
    - S/P Ratio = 0.62 (from previous table)
    - VEL = 40,000[(0.62)^0.78] = **27,550**
  - New 4-lamp T5HO High-Bay Fixture
    - Design/Mean Lumens = 19,000 (4,750 per lamp
    - S/P Ratio = 1.62 (from previous table)
    - VEL = 19,000[(1.62)^0.78] = **27,681**

Let’s go to the Videotape


B5
B5

AHU & CHW Retrocommissioning

- **Employed BesTech to undertake all retrocommissioning**
  - **Company founded in 2003 in Dallas, TX by Dr. Mingsheng Lui, currently a professor of architectural engineering at the University of Nebraska at Lincoln.**
  - **Employs a unique scientific process of evaluating and optimizing the entire HVAC system – Continuous Commissioning ® developed in 1996 by engineers working in the Energy Systems Laboratory at Texas A&M**
  - **Every senior engineer has a PhD in Mechanical Engineering.**
  - **Company has implemented services in every conceivable type of building: Healthcare, Hospitality, Education, Commercial, and more.**
  - **Savings are guaranteed.**

AHU & CHW Retrocommissioning (cont.)

- Air Handling Units (AHUs)
  - Install Fan Airflow Stations (i.e. DP sensors) and VFDs on both supply & return fans
    - Ensures the lowest system resistance to save fan power energy.
    - Enables the use of true air volume tracking on fan VFD speed control to ensure positive building pressure.
  - Reset supply air temperature setpoint based on load and ambient conditions. The reset schedule will be optimized to minimize cooling energy, fan power & reheat energy.
  - Fully utilize free cooling by optimizing economizer control during mild & cold weather conditions to ensure minimum total energy usage.
  - Implement optimal outside air intake control.

AHU & CHW Retrocommissioning (cont.)

- **Terminal Units**
  - All terminal boxes will be re-commissioned to identify box performance, calibrate box airlflow & improve diffuser air distribution.
  - Disable reheat for interior zone terminal boxes.
  - Optimally reset minimum airflow of terminal boxes based on serving zones & occupancy schedule to achieve the best thermal comfort with minimal reheat.
- **Hot Water Reheat System**
  - Install VFDs on all HW reheat pumps
  - Implement optimal differential water pressure reset schedule as determined by actual building load.
  - Optimize the hot water enable/disable schedule and implement a corresponding optimal hot water temperature reset schedule

AHU & CHW Retrocommissioning (cont.)

- **Chilled Water System**
  - **Install Pump Flow Stations (i.e. DP sensors) on each CHW pump**
  - **Install VFDs on all chilled water pumps, condenser water pumps & cooling tower fans.**
  - **Chiller Operation Optimization**
    - **Both CHW & CW loop setpoints can be optimized using temperature reset schedules based on outside conditions & building load to maximize chiller efficiency.**
    - **Implement an 80% rule to ensure safe chiller system operation, minimal total cooling system (compressor, pumps, and cooling tower) energy costs, and eliminate/minimize by-pass to ensure the highest return water temperature for cooling system. This 80% rule suggests:**
      - **Each chiller load is maintained at 40% to 80% when running; and**
      - **Each pump is maintained at 40% to 80% speed, which significantly increases the chiller efficiency and reduces pump power.**
    - **Implement N+1 rule to start up another chiller/pump if the 80% rule is satisfied.**

AHU & CHW Retrocommissioning (cont.)

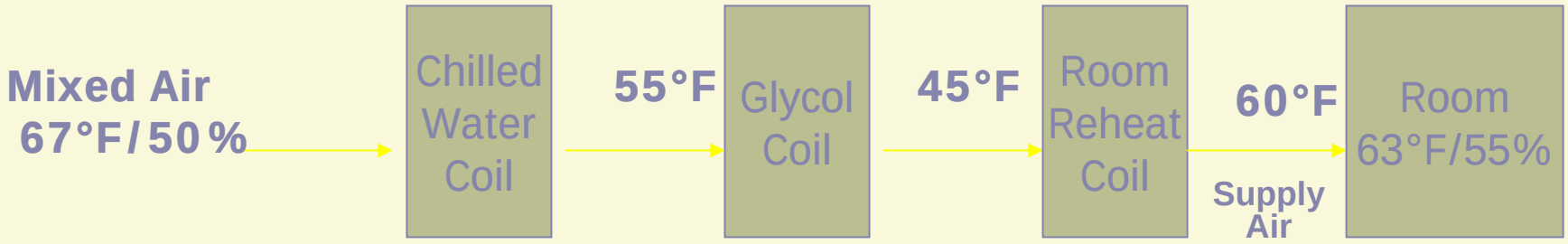
- **Chilled Water System (cont.)**
  - **Chilled Water (CHW) Loop Optimization**
    - **Utilize Pump Flow Stations to minimize system resistance.**
    - **Control CHW pump speed based on chiller load to achieve pump power savings as well as improve chiller efficiency by using higher ΔT of supply/return chilled water.**
    - **Fully open all balance valves in the CHW loop.**
    - **Control bypass together with CHW pumps to maintain minimum flow requirements of the evaporators.**
  - **Condenser Water (CW) Loop Optimization**
    - **Fully open common header valves on condenser water loop. This allows the cooling towers and condenser pumps to be used with any combination of chillers.**
    - **Use N+1 rule to operate pumps (i.e. 2 CW pumps with 1 chiller). Control CW pump speed to reduce pump power and improve chiller efficiency by maintaining optimal ΔT of supply/return condenser water.**
    - **Control cooling tower fan speed to maintain optimal condenser loop temperature. Temperature setpoint is reset based on ambient wet bulb temperature (i.e. Twb + 5F).**

Energy Conservation at Merck's New Bulk Vaccine Manufacturing Facility in Durham

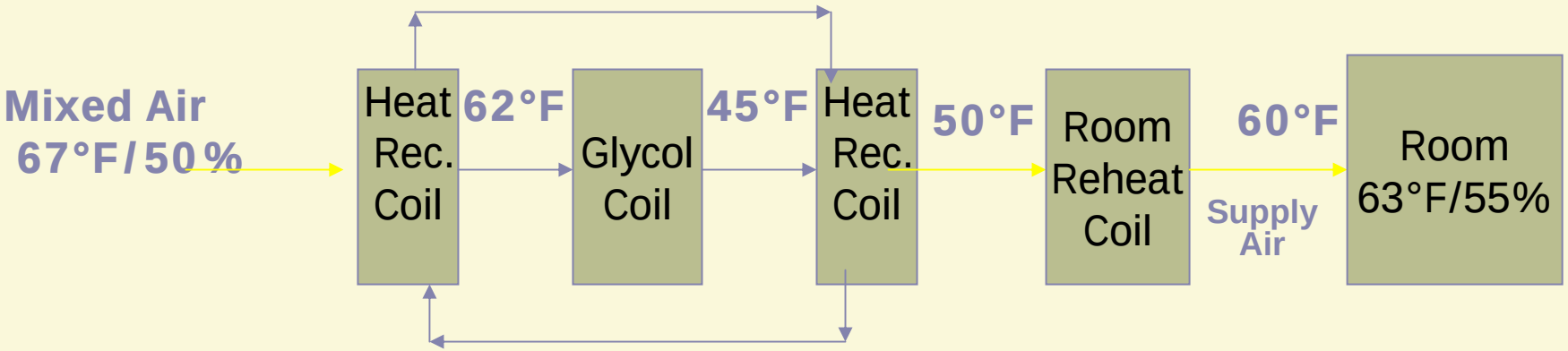
Heat Recovery Wraparound Coils

- **Least Cost Scope:** Chilled water coil and glycol coil in series in AHUs for Grade A/B areas for cooling
  - To achieve lower temperatures (63 F) in Grade A/B areas, both chilled water and glycol are required to cool the air. Air is then reheated to maintain room temperature.
- **Recommended Life Cycle Add:** Wraparound, refrigerant heat recovery coils and glycol cooling coil for area whose supply air is air change driven
  - Wraparound heat recovery coils are provided to precool the supply air before the cooling coil and reheat the supply air before being supplied to the rooms. Reduces annual heating hot water costs and peak cooling load. Only a single glycol cooling coil is required (albeit a larger one).
- **Advantages:**
  - Reduced reheat energy costs (reduced annual steam usage)
  - Reduced peak cooling load
- **Disadvantages:**
  - Shifts cooling load to less efficient glycol system from chilled water system. Decreases size of new chilled water chillers & increases size of glycol chillers.
- **Return on Investment (ROI) = 51.5% - Simple Payback = 2.2 years**

Least Cost Option



Wraparound Heat Recovery Option



Questions?