Better Buildings Summit

HVAC Part 2: Large HVAC Systems

Michael Deru, NREL
John Lambert, BoA
Ed Hegwood, RMEC

May 28, 2015
3:30-5:00 pm EDT

Agenda

- Welcome and Introductions
- Project updates/announcements
  - DOE technology demonstrations
  - HIT – Fan savings opportunities
- Opportunities for Savings with Large HVAC Systems: John Lambert, Bank of America
- Maintaining a trained work force – Facilities Engineering Technician Training Program: Ed Hegwood, Rocky Mountain Education Center
- Open discussion

DOE Technology Demonstrations

- **enVerid:** Air cleaning technology that scrubs CO_2 and VOCs to reduce outside air requirements leading to energy savings
- **A.O. Smith:** micro-combined heat and power for electricity and hot water generation (> 3,000 gals/day)
- **BuildingIQ:** Energy optimization control to reduce HVAC energy and demand
- **QM Power:** High-efficiency synchornous motor retrofits for refrigerated display cases.

High-Impact Technology – Fans

- Fans are everywhere and consume ~ 140 billion kWh per year
- Opportunities for savings
  - Proper system design and sizing
  - Optimal control – off, VSDs
  - High-efficiency fans and motors
- What resources would be useful to help save energy?
  - Design and application guidance
  - Fan selection guidance
  - Specifications

HIT Special Session on Friday

High-Impact Technology Forum:
Harnessing American Ingenuity and Innovation

Amy Jiron will moderate three sessions from 9-2

Opportunities for Savings with Large HVAC Systems

John Lambert
Bank of America

U.S. DEPARTMENT OF ENERGY

Opportunities for Savings with Large HVAC Systems

John Lambert, PE - Energy Manager

Background

- Total portfolio of more than 6500 sites with an utility spend, covering over 68 million square feet
- “Top 50” sites represent < 1% of total sites, 18% of total SF, 30% of utility spend
- Most sites had a recent ASHRAE Level I energy audit
- Data (Energy Star, PUE) indicated significant room for improvement
- Started to use consultant led ASHRAE Level II audits. Piloted Retro-Commissioning and Continuous Commissioning to identify the next level of savings

Background

Our Experience:

- Most audit reports provided a good high level overview of facility
- Audits captured much of the low hanging fruit. Some ECMs were starting to become too "cookie cutter".
- Energy Team knowledge gain generally limited to only what appears in the audit report - Detailed knowledge stays with consultant
- Site teams viewed these programs as another outsider coming in…some recommendations undone shortly after completion
- Deep dive audits focused on specific areas due to cost limitations
- Commissioning was beneficial but mixed results

The Transition…. to SEEO

SEEO - Standards for Energy Efficient Operation

How was SEEO developed ??

1. Bank and Facility Management Provider Energy Team identified exhaustive list of potential operating standards based on the following question:

   "As an energy expert If you walked into your building, what would you expect in terms of operating efficiency?"

2. Full list debated and consolidated into a list of 100+ standards:
   - BAS – System operation, operator capabilities, service contractor
   - HVAC - Scheduling, set points & sequences of operation of cooling, heating and air handling systems
   - Lighting – Control and lamps/fixtures
   - Utilities/LOB Interaction – rate structure, utility metering, water conservation, LOB occupancy.
   - Critical (White) Space – temperature, humidity and static pressure setpoints and control, operating redundancy

3. A gap assessment process was developed to assess sites

The Transition…. to SEEO

SEEO - Standards for Energy Efficient Operation

Why DIY SEEO ??

1. Bank Energy Team
   - Owner's advocate: Experienced engineers, background in performance contracting, energy management, systems design, controls, construction and operation.

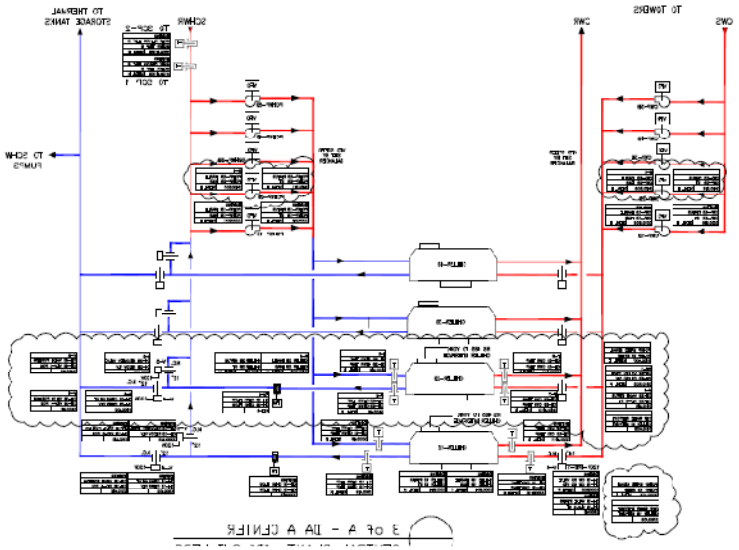
2. Facility Management Providers (FP) Energy Team
   - Multiple FP Energy Managers: Portfolio energy management, property management, facility management, lighting

…The SEEO Process

- **Pre- Visit**: Data collection, analysis & scheduling
- **On Site**: Gap assessment Q&A, listen, observe, screen shots, trends
- **Review**: Finalize gap assessment, review with site team
- **Gap Closure**: NC/LC and CapEx projects and savings
- **Project Database:** Description, savings, cost, date
- **Progress Review:** Prioritization, review issues & new projects

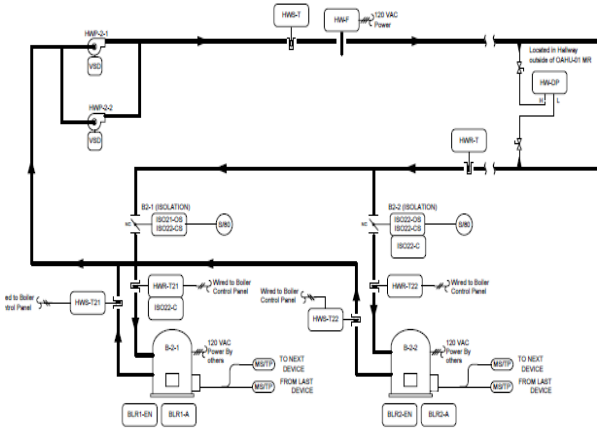
SEEO Overview for Central HVAC Systems

- **Central Cooling Plant**
  - Mechanical comfort cooling off when outside conditions allow
  - Most efficient chiller(s) operate in lead
  - CHW supply temperature reset
  - CHW delta T (Return T – Supply T) operating near design
  - VFDs on CHW system pumps
  - Optimize variable volume pumping differential pressure control setpoint
  - Condenser water reset based on OA WBT
  - Maximize cooling tower capacity and optimize fan speed control
  - Maximize water side economizer operation

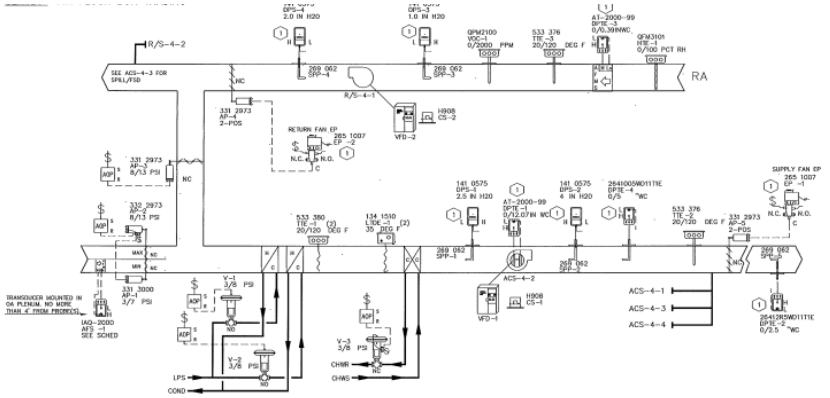


SEEO Overview for Central HVAC Systems

- **Central Heating Plant**
  - Heating disabled above 65˚F OAT
  - Hot water supply temperature reset



- **Air Handling Systems**
  - Schedule based on actual occupancy, including holidays
  - Terminal unit sub-zoning and setpoints
  - No minimum OA during unoccupied
  - Optimize airside economizer
  - DCV setpoints
  - VFDs on VAV air handling units
  - Optimize static pressure setpoint
  - Optimize DOAS heat wheel



Chilled Water Plant Gap Assessment Sample

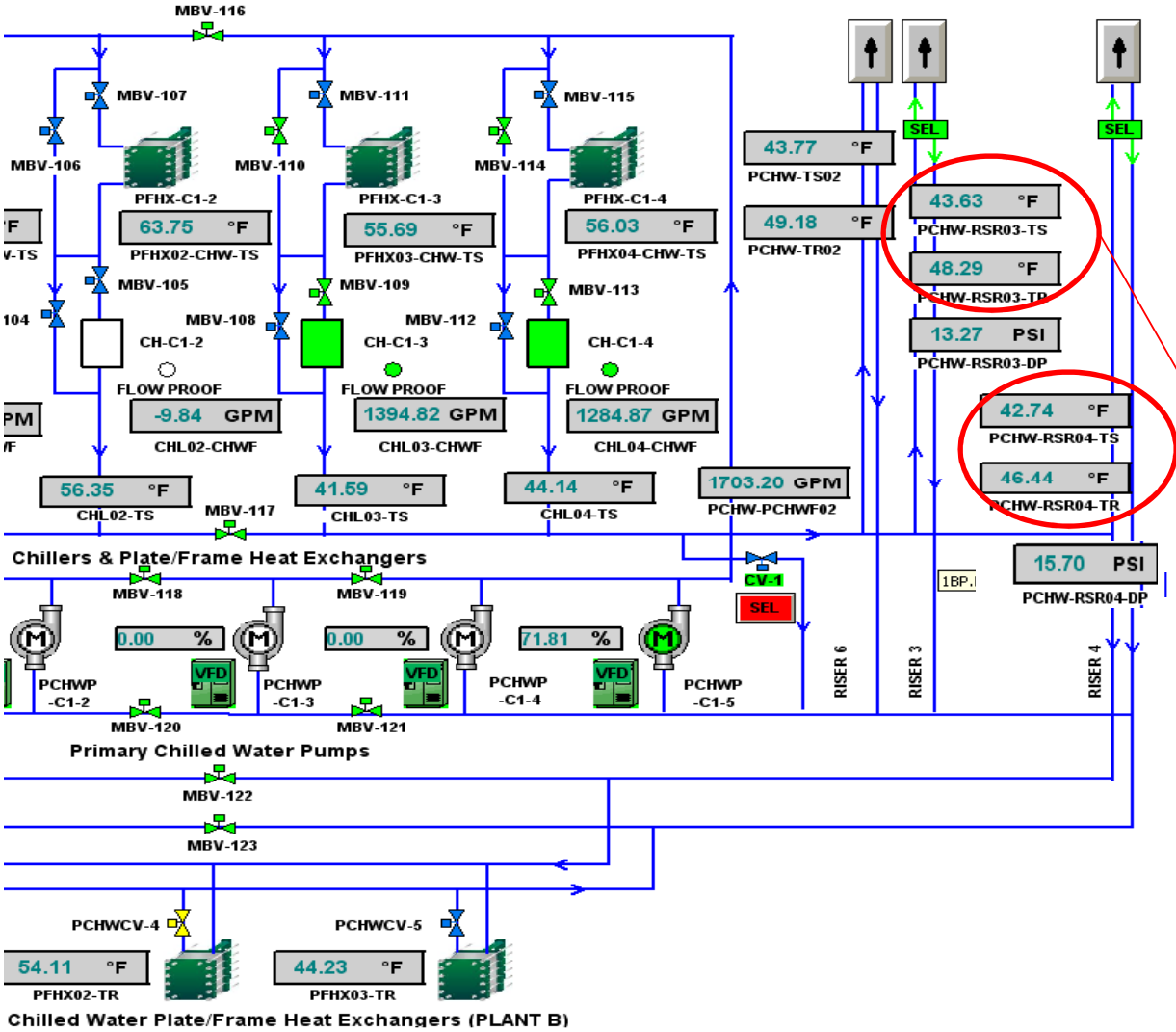
ID	STANDARD	QUESTION		RESPONSE	COMMENTS
Clg 3.1	Chilled Water supply temperature (CHWST) reset based on Outside Air Dry Bulb Temperature (or other criteria). See CHWST Reset Schedule	Is the Chilled Water (CHW) supply temperature setpoint fixed, adjusted manually or automatic reset by the BAS?		PCHWST is manually adjusted. SCHWST and TCHWST is fixed	
		Fixed?	What is the CHW supply temperature setpoint, °F?	Secondary CHWST setpoint = 48F (50F design) Tertiary CHWST setpoint = 53F (XXF design)	Why is SCHWST setpoint below design? What is the design TCHWST set point?
		Adjusted Manually?	What criteria is used to make the adjustment? *(Examples: space temp issues, outside air temperature, time of year, etc.)*	PCHWST - Time of day (lower during day, higher at night) and time of year (higher during winter day & night)	
			What are the highest and lowest CHW supply temperature setpoints that are used?	PCHWST • Highest CHW supply temperature = 45°F during night and winter?, when not set to 42F (42F design) • Lowest CHW supply temperature = 42°F during summer between 5AM and 7PM	
		Automatic Reset?	What criteria is used to reset the CHW supply temperature setpoint? *(Examples: Outside Air Drybulb Temperature, OA Enthalpy, CHW valve position, **primary/secondary flow changes, etc.**)*		
			What are the maximum and minimum CHW supply temperature setpoints and associated criteria values? *(Example: Lowest CHW supply temp =42°F when OAT ≥ 80°F, Highest CHW supply temp = 45°F when OAT ≤ 55 °F)*		
Clg 3.2	Chilled Water System operating Delta T (CHWRT - CHWST) is at least 85% of design Delta T	What is the typical difference (Delta T) between the CHW supply temperature and the CHW return temperature? Provide a range if the Delta T changes significantly, depending on the chilled water load.		PCHW designed for 16F dT (42F to 58F). Actual PCHW dT at chillers = 7F (45F to 52F). Very poor dT on PCHW Risers #3 (4.7F) and #4 (3.7F) appears to be major cause of low dT at chillers SCHW designed for 10 dT (50F to 60F). Actual SCHW dt at PFHEX = 9F (48F to 57F avg) TCHW designed for XXF dT (XXF to XXF). Actual 6th floor TCWH dt at PFHEX = 14F (49F to 63F)	Need to confirm temperature readings on PLC and identify reason(s) for low dT. Will need to review chiller minimum evaporator flow requirements to take advantage of dT improvements

Standards Reference Table Sample (hyperlink)

OA Dry Bulb Temp (°F) Design Day OA Dry Bulb Temp	**CHWST (°F)** Low CHWST = Design CHWST (or higher)
50°F	High CHWST = Design CHWST + 5°F *

* or lower if dictated by IT equipment or humidity control requirements

Theoretical Chilled Water Plant Example– Low CHW dT

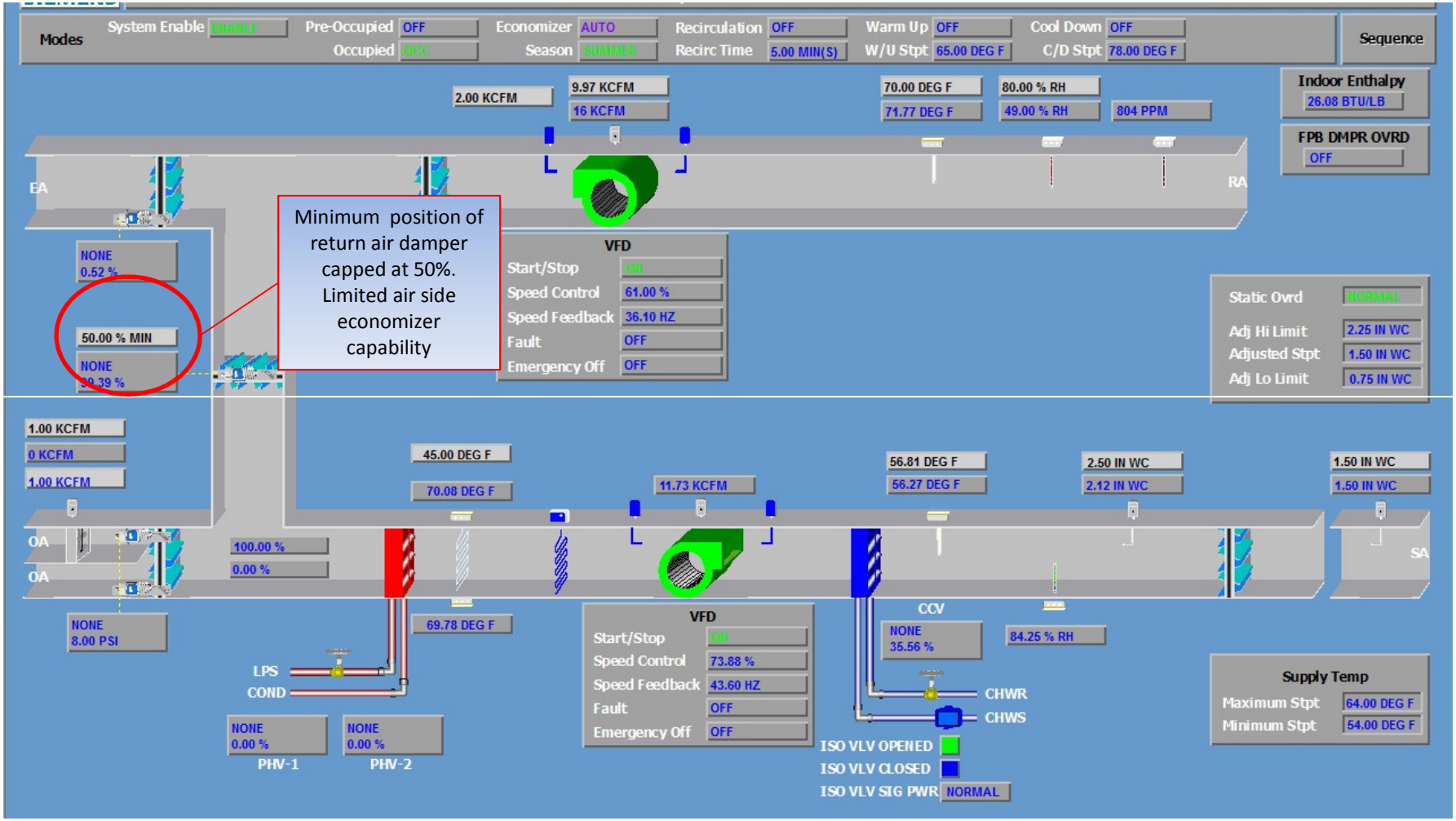


From Design Drawings

	CHILLER				
	GPM	INLET WATER TEMP. (°F)	OUTLET WATER TEMP. (°F)	MAX. PRESS. DROP (FT. H20)	WORKING PRESS. (PSIG)
	1275	58	42	10.2	300

4 ℉ to 5 ℉ dT actual versus 16 ℉ design dT

Theoretical Air Handling Unit Example – Air Side Economizer Issue



Project Database Example

ECM Description	Utility expense savings, $	CapEx Cost, $	OpEx Cost, $	Forecast Completion Date	Actual Completion Date	Savings Type	Activity Type
Operate additional cooling towers	$11,497		$0		07/15/13	Annual Savings	HVAC Control Modification - Non iC3
VFDs on Hot Water Pumps	$55,524				02/28/13	Annual Savings	HVAC System Modification
Adjust temperature set points in hallways and mechanical spaces	$5,264		$0		07/15/13	Annual Savings	HVAC Control Modification - Non iC3
Discontinue use of tape library CRAH Units 37 & 38	$7,753		$0		08/15/13	Annual Savings	HVAC Control Modification - Non iC3
Correct HX heat transfer issues to minimize secondary loop heat gain (Building A)	$3,363		TBD		04/15/15	Annual Savings	HVAC Control Modification - Non iC3
Change OA unit to reverse DA reset (Building B)	$2,000		TBD	08/01/15		Annual Savings	HVAC Control Modification - Non iC3
Reset condenser water supply temperature (Bldg B)	$5,000		$5,000	09/15/15		Annual Savings	HVAC Control Modification - Non iC3
Recommissionf Air Side Economizer for West ACS Units	$31,829		$15,600		02/11/15	Annual Savings	HVAC Control Modification - Non iC3
Broadcast Studio Lighting, HVAC & Controls	$7,683			06/01/15		Annual Savings	HVAC System Modification
Air column units VFD speed reduction/UFAD system	$5,003				03/01/15	Annual Savings	HVAC System Modification
Retrofit AHU-2 with VFD fan system and controls	$1,000		TBD	06/15/15		Annual Savings	HVAC System Modification
Increase HEX Capacity to increase economizer hours	$5,000	TBD		09/15/15		Annual Savings	HVAC System Modification
Shut down CRAC #287	$5,000		$0		06/17/14	Annual Savings	HVAC System Modification
Optimize chiller rotation	$68,552		$0		08/15/13	Annual Savings	HVAC Control Modification - Non iC3
Optimize free-cooling using the air-side economizer	$2,000		TBD	06/15/15		Annual Savings	HVAC Control Modification - Non iC3
Optimize differential pressure set points on chilled water (CHW) pumps	$2,000		TBD	06/15/15		Annual Savings	HVAC Control Modification - Non iC3
Activate local heating source for generator batteries and lower unit heater set point	$11,713		TBD	06/15/15		Annual Savings	HVAC System Modification
Run Chillers 5 & 6 as primary (additional savings)	$85,000		$0		05/15/14	Annual Savings	HVAC System Modification
Install VFDs on Cooling Tower Fans	$15,149	$190,000		07/31/15		Annual Savings	HVAC System Modification

Results

$2.8MM annual HVAC savings executed to date

- Savings reflected in Energy Star and Data Center PUE improvement
- "Bottoms Up" calculated savings ="Top Down" actual savings

Why It Works

✓Experienced Leadership

- Focusing on moving the needle & drive consistency throughout facilities

✓Facility Management Providers involvement

- Energy manager and site teams contribute to develop the best solution

✓Project review, savings tracking and reporting

- Ongoing meetings to discuss progress and issues
- Energy team involved in design & execution
- Document all projects. Monthly savings report

✓Knowledge gained during SEEO process stays with Energy team

- Maximize efficiency in Non-Utility Driven (NUD) projects
- Identify and act on opportunities that arise as site occupancy/operation changes

Challenges & Observations

- Design documents can be very difficult to pull together – don't give up!
- Site teams not understanding gap assessment questionnaire terminology…pencil whipping
- Facility Management Provider's energy manager acting as a "messenger"
- Throwing projects over the wall for site team to implement
- Overwhelming site teams with too many active gap closure projects at one time
- Going it alone – didn't get necessary focus from site team due to competing needs
- Some will see this as an opportunity and others will resist change
  - "That's how we've always done it"…."The engineer designed it that way"….
- Overly optimistic savings calculations - Peer review, "Under Promise, Over Deliver"
- High efficiency design/certification doesn't guarantee an efficient operation

Maintaining a trained work force – Facilities Engineering Technician Training Program:

Ed Hegwood
Rocky Mountain Education Center

U.S. DEPARTMENT OF ENERGY

Red Rocks Community College

Rocky Mountain Education Center
Red Rocks Community College

Facilities Engineering Technician Training Program

Facilities Engineering Technician

Powered by

HVACRedu.net
Workforce Development Online for the HVACR Industry

Development Guided by DOE Guidelines:

- For the past 2 ½ years RMEC has been working with HVACRedu.net to design and implement an FET (Facilities Engineering Technician) program that meets the needs specified by the DOE Building Operations Professional.

- This program has been packaged to be used world-wide by community colleges and employers for the entry level and existing workforce.

https://www4.eere.energy.gov/workforce/sites/default/files/DOE_BB_Fact_Sheet_NIBS_Workforce_v9.pdf

Facilities Engineering Technicians:

- Are Problem-solver Professionals
- Are Experts who contribute to making a building-as-a-system work efficiently
- Improve customer satisfaction
- Assure more up-time / less down-time
- Increase profits for building owners

Employers Need

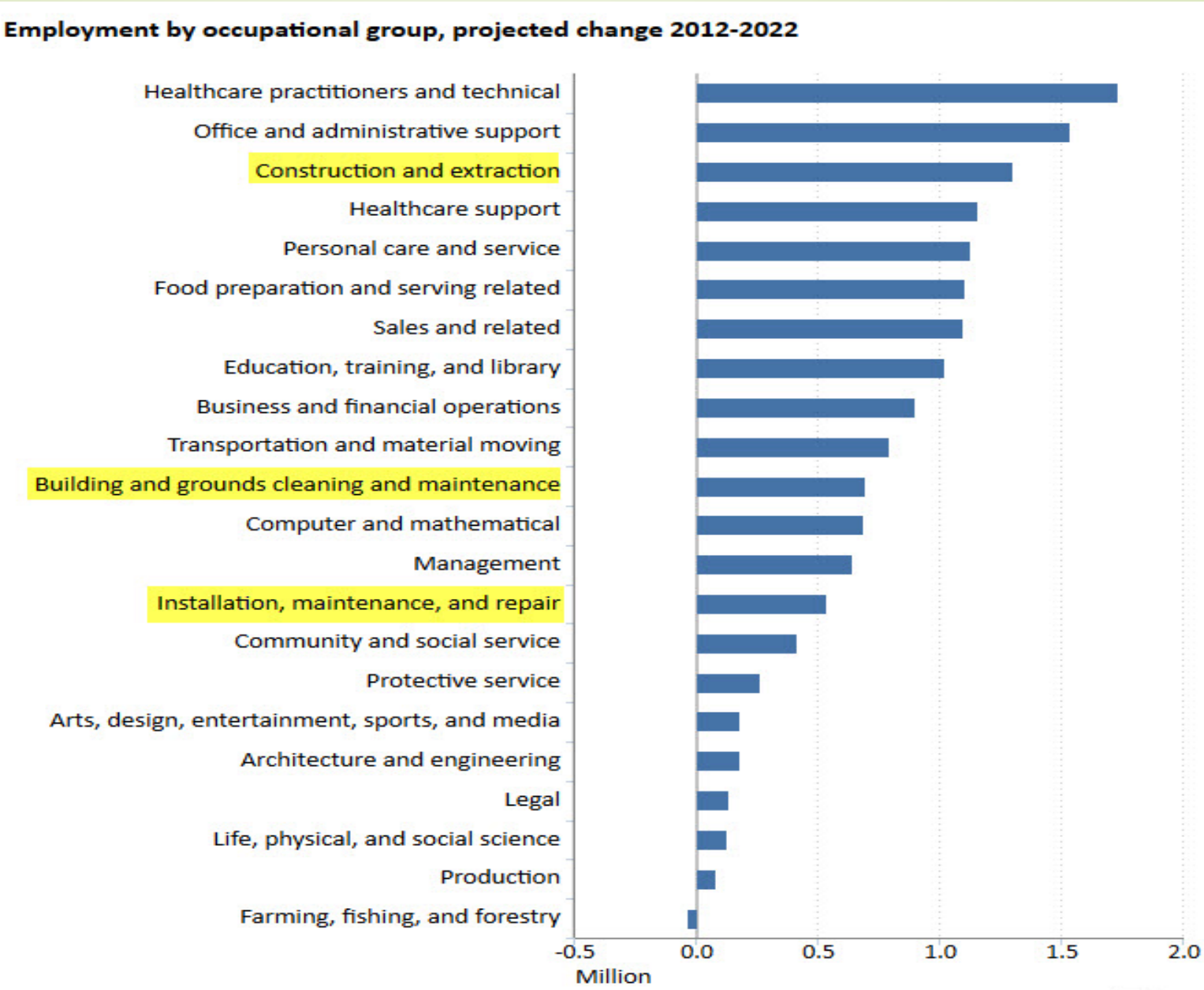
- The best way to recruit high quality new employees
- The most effective way to get new employees trained and profitable
- The most efficient way to upskill existing employees with industry credentials

Why is this important now?

BABY BOOMER RETIREES WILL HELP CREATE *55 MILLION JOBS BY 2020* -*GEORGETOWN UNIVERSITY*

http://www.georgetown.edu/news/study-finds-retirees-will-create-more-jobs-2020.html

Through 2017, *Houston* will need more than 74,000 middle skills workers a year, according to GHP's "Addressing Houston's Middle Skills Jobs Challenge" report. "This shortage of workers will likely hamper the region's ability to operate a safe work environment and even to expand," the report states. "The lack of workers could also slow projects and even lead to their cancellation."
http://www.sanjac.edu/article/shortage-middle-skills-workers-growing-concern



FETs are not a line item break out for DOL or BLS

http://www.bls.gov/opub/ted/2014/ted_20140107.htm

Why is this important now?

Other technical fields and careers are competing for the same talent pool:

- **General Maintenance and Repair Workers**
- **Heating, Air Conditioning, and Refrigeration Mechanics and Installers**
- **Electricians**

All share a similar aptitude for math, science, mechanics, and technology and all earn a living wage.

Quick Facts: General Maintenance and Repair Workers	
2012 Median Pay	$35,210 per year $16.93 per hour
Entry-Level Education	High school diploma or equivalent
Work Experience in a Related Occupation	None
On-the-job Training	Long-term on-the-job training
Number of Jobs, 2012	1,325,100
Job Outlook, 2012-22	9% (As fast as average)
Employment Change, 2012-22	125,200

Quick Facts: Heating, Air Conditioning, and Refrigeration Mechanics and Installers	
2012 Median Pay	$43,640 per year $20.98 per hour
Entry-Level Education	Postsecondary non-degree award
Work Experience in a Related Occupation	None
On-the-job Training	Long-term on-the-job training
Number of Jobs, 2012	267,600
Job Outlook, 2012-22	21% (Faster than average)
Employment Change, 2012-22	55,900

Quick Facts: Electricians	
2012 Median Pay	$49,840 per year $23.96 per hour
Entry-Level Education	High school diploma or equivalent
Work Experience in a Related Occupation	None
On-the-job Training	Apprenticeship
Number of Jobs, 2012	583,500
Job Outlook, 2012-22	20% (Faster than average)
Employment Change, 2012-22	114,700

Needs of New Employees
(with little or no work experience)

- New potential employees need a Facilities Engineering Technician (FET) career path

- An Educational Program that leads to FET jobs

Needs of New Employees (with other work experience)

- An educational program that assesses what they already know and generates an individualized program to fill in their knowledge gaps.
- An Educational Program that gives credit for what they already know.
- Flexible and Professional Learning Experiences Online

Needs of Current Employees

- An educational program that gives credit for what they already know.
- Flexible and Professional Learning Experiences Online

- A Program that prepares them to upskill with industry certifications.

OUR Solution

- **Online Educational Program**

powered by HVACRedu.net

Blended with

- **Hands on Living Labs**

Arranged by RMEC

PROGRAM

ANSI ACCREDITED PROGRAM
CERTIFICATE ISSUER

Blended Learning Program

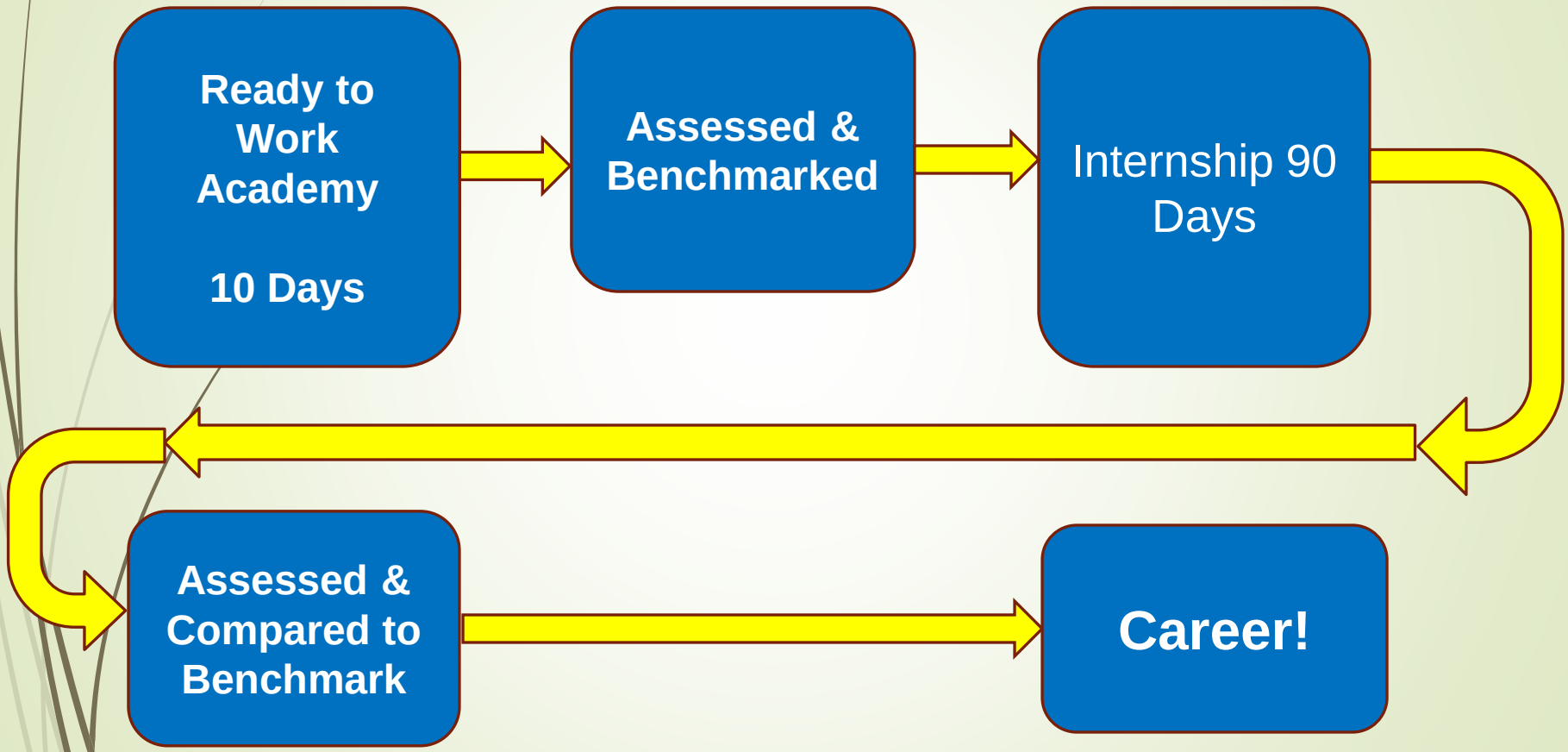
Blended Learning combines online courses with face-to-face labs – the best of both worlds for today's students

- **Theory courses are delivered via an online campus in partnership with HVACRedu.net (an ANSI CAP Accredited Certificate Issuer)**
- **Hands on Living Learning Labs can be either work experience in the field or at the employer's facility, increasing program outreach**
- **Lab testing is observed by an approved proctor to prove student competency**

Program design

- Employers identify skill-based competencies derived from specific entry-level job descriptions for FET's and the target industry certifications desired of senior FET's
- Online educational learning experiences designed by online teaching and learning experts to support those competencies
- Lab experiences designed to give students an opportunity to apply the theories learned and demonstrate competency

Entry Level Track:



Existing Workforce Track:

Questions?

Ed Hegwood, LEED AP O+M
Program Coordinator Ready to Work Academy and Energy Efficiency
Red Rocks Community College/Rocky Mountain Education Center
Lakewood, Colorado 80228
Cell-303-656-0374/ Office 303-914-6202
http://www.rmecosha.com/energy.aspx

Energy Efficiency is ALWAYS the First Step

ROCKY MOUNTAIN
EDUCATION CENTER
RED ROCKS COMMUNITY COLLEGE

What's next?

- What is your most exciting new project?
- What is your biggest challenge?
- Possible future activities
  - Optimal control sequences for air systems – ASHRAE GPC 36
  - Fan application guidance and specs
  - System level metrics for performance tracking
  - Other?