



**United
Technologies**

Building & Industrial Systems

Potential Opportunities for use of the
Smart Grid for Commercial HVAC Equipment

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My Background

To understand where I am coming from it would help to understand my background and industry activity

- **Employment** – United Technologies Building and Industrial Systems (Carrier, Otis, Fire and Security)
- **Position** – Fellow in the Advanced Systems and Technology Group with 43 years in the design and application of commercial equipment and controls
- **Industry Activity**
 - ASHRAE 90.1 – Vice Chair and member of the Mechanical Systems Committee
 - ASHRAE AES – Vice Chair of Advanced Energy Standards Committee
 - ASHRAE 189.1 – Energy and Energy Budget Working Groups
 - ASHRAE 205 – Equipment Data Format
 - ASHRAE 207P – Diagnostics for Unitary Products
 - CSA C873 BEEM Committee – Whole Building Analysis Standard
 - AHRI – Chiller Section, Unitary Large Section, Energy Recover Section
 - AHRI Systems Steering Committee – Chair
 - Other Industry Organizations – Western Cooling Center Alliance, Western Performance Alliance, LEED EA Tag

Smart Grid and Connected Equipment Opportunities

1. Smart Overall Building System Energy Efficiency
2. Peak Load Management
3. Energy Cost Management
4. Use of Renewable Energy
5. Diagnostics
6. Continuous Commissioning
7. Service and Maintenance Management

Energy Efficiency Background

- Since the 1970's efficiency requirements for HVAC systems have increased using a method of **prescriptive minimum requirements** defined thru standards like ASHRAE 90.1, IECC, Title 24 and federal requirements (DOE).
- Some are controlled and enforced at a national level, and others are implemented at state and city level.
- The approach has been to define minimum efficiencies that are based on industry standard **full load rating metrics** like EER, COP, kw/ton, etc. defined in industry rating standards like the AHRI standards
- Recently, for a few of the products, new metrics focused on average **annualized performance** have been added which include metrics like SEER, HSPF, IPLV, and IEER
- All these have been based on **one requirement for the USA** and with the assumption of equipment sized for the exact building load (no over sizing) and using the same ambient design conditions, but this is beginning to change with regional residential requirements
- The also assume that the equipment is properly installed, commissioned and maintained

Background – Net Zero Energy Goal

The Future Challenges are Significant and can not be obtained with conventional approaches

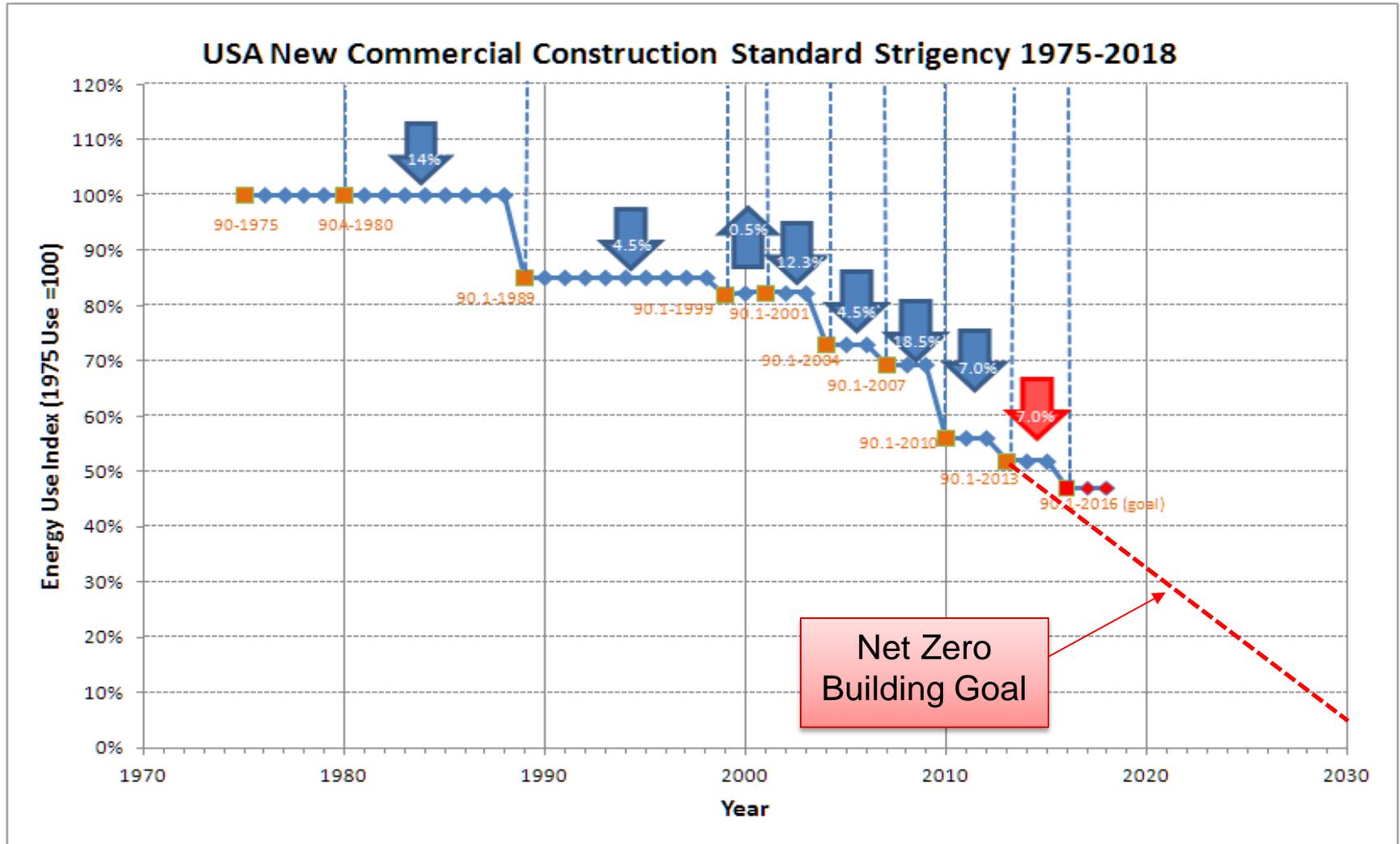


Chart based on ASHRAE 90.1-2013 determination study conducted by PNNL

Future Technology Limits

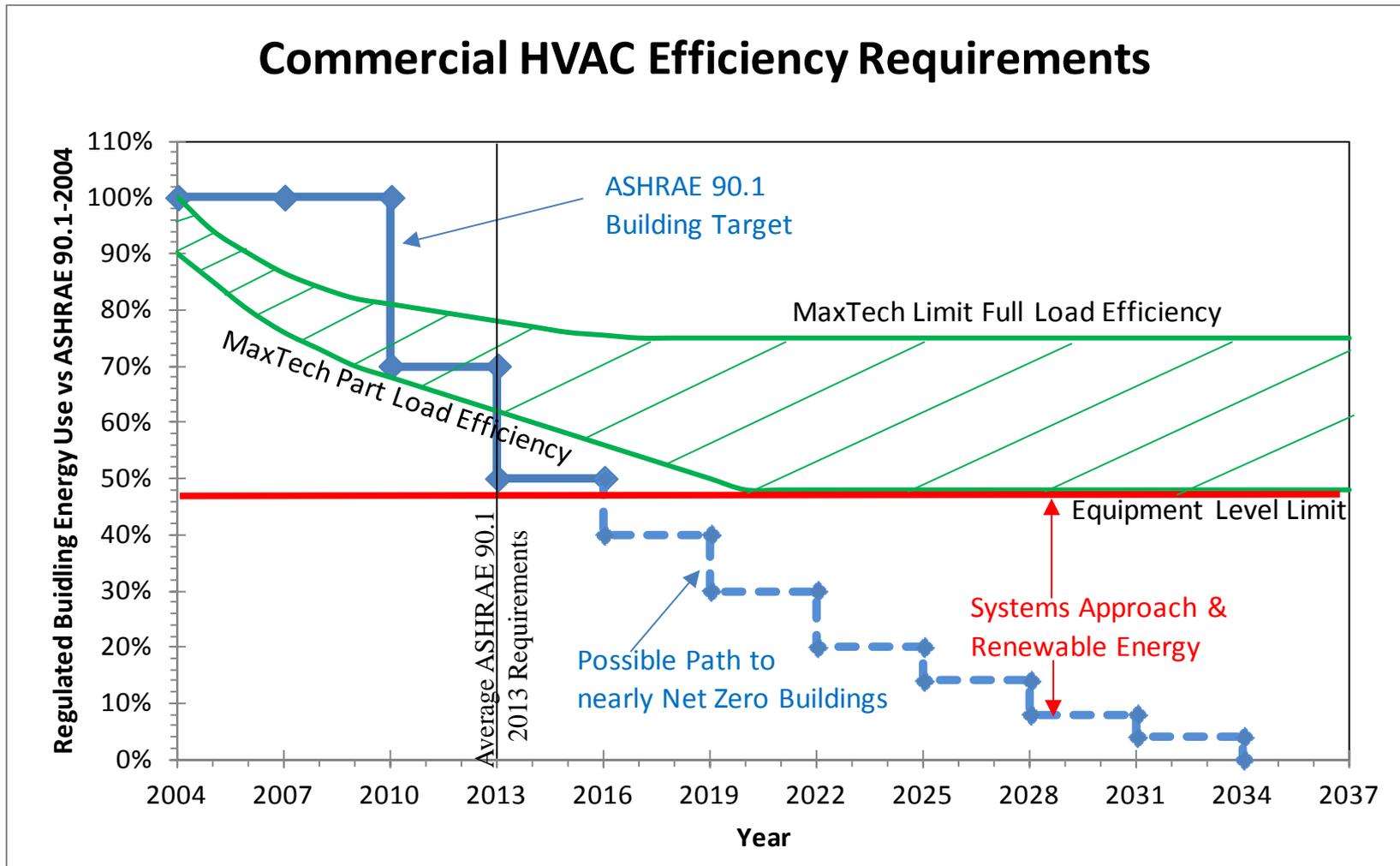
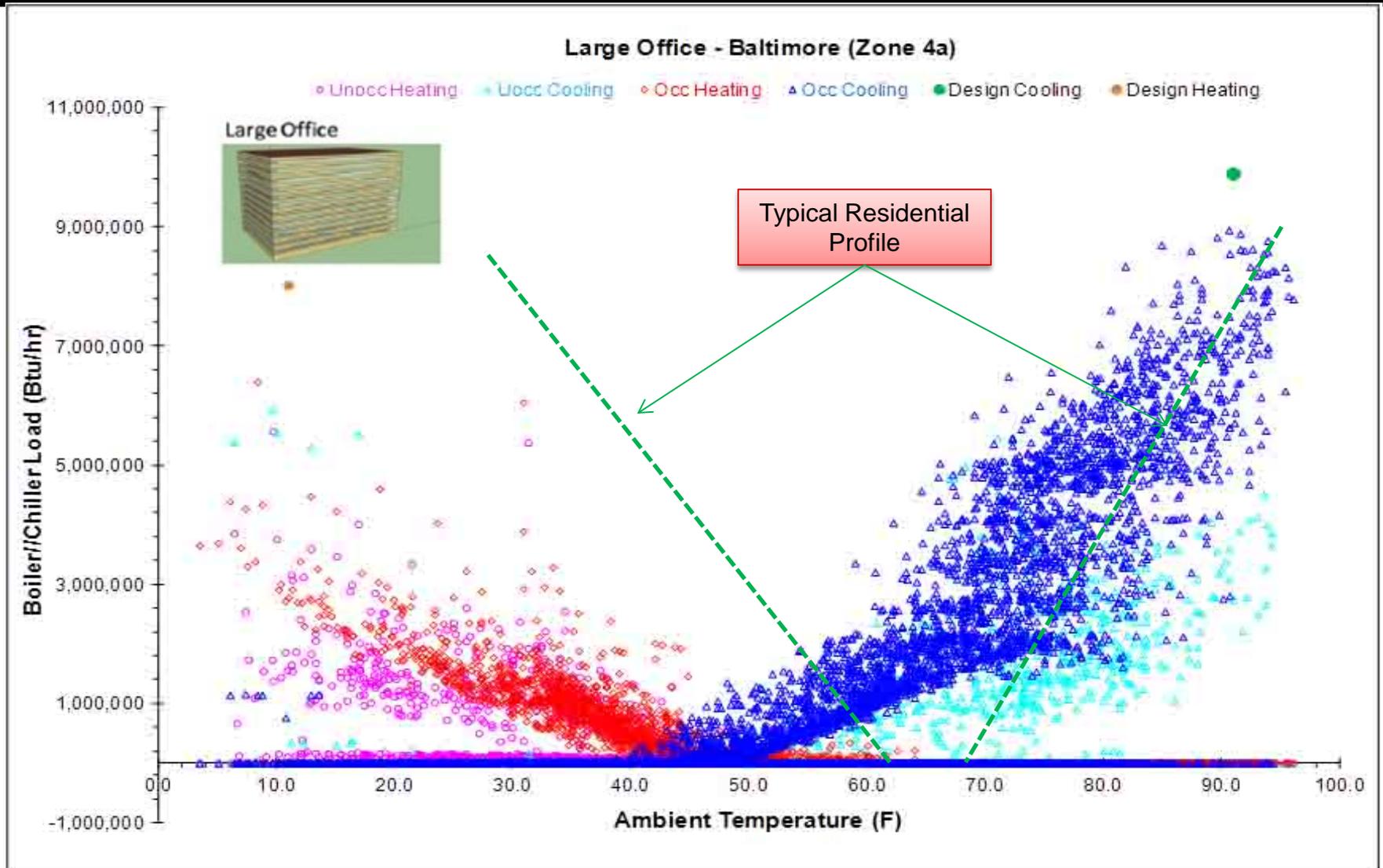


Chart is an estimate of possible future regulations to achieve Near Net Zero by 2034 based on studies done by Carrier on technical limits of HVAC equipment

Typical Commercial Office Building



Commercial Building Load Profiles are different than residential

Future Efficiency Improvement Options

Historical Approach (*Business as usual*) - Full Load Improvements

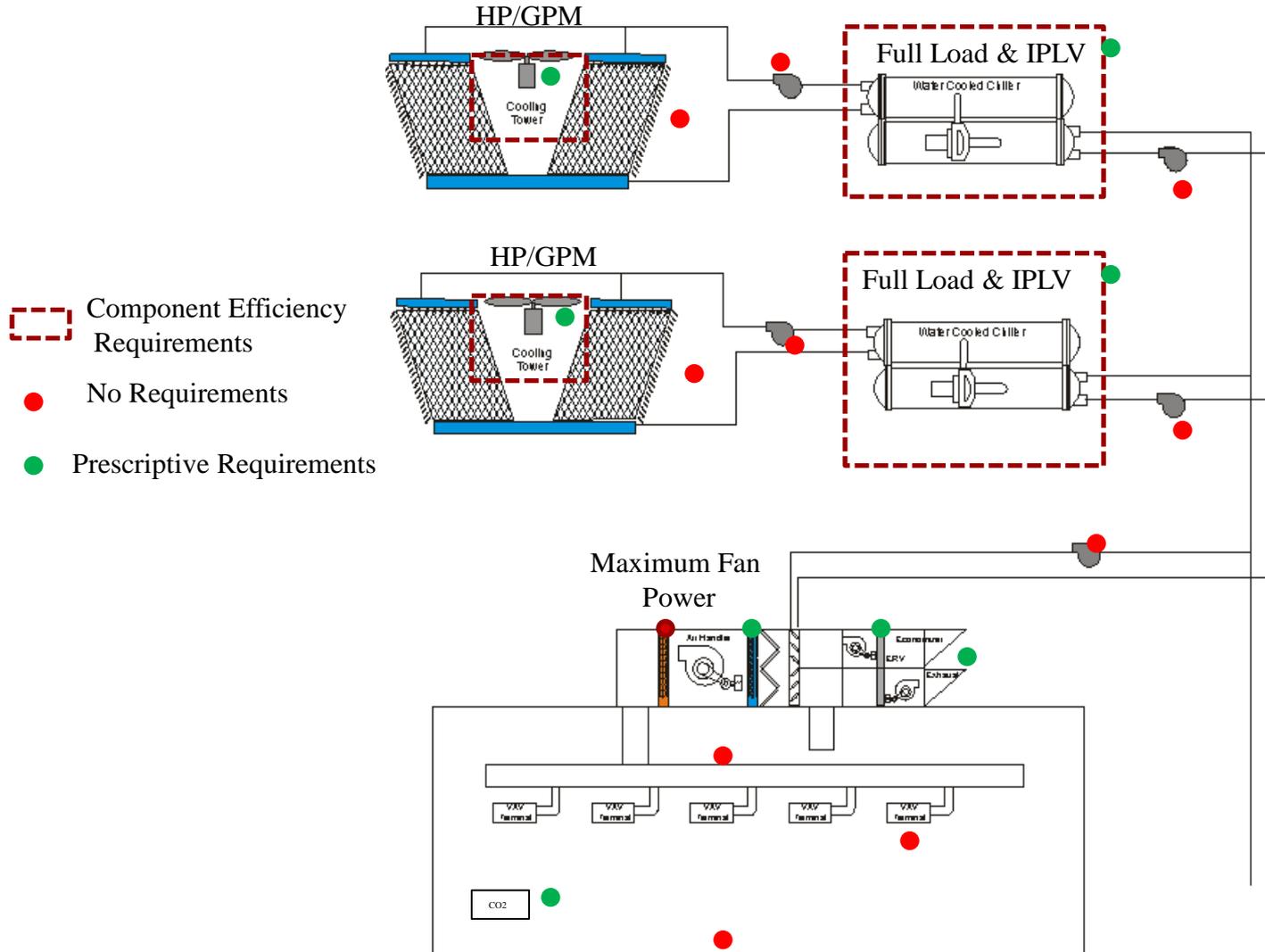
- As noted we are approaching *“Max-Tech”* on many products and significant improvements in base product full load efficiencies will be limited and often not cost effective
- We also face issues with the phase down of the HFC refrigerants that are used today, and will have to evolve to new lower GWP refrigerants that may not be as efficient, could be semi-flammable and could be more expensive to apply

Alternate Approaches to Consider

1. Switch to *new part load* or annualized metrics like IPLV for chillers and IEER for rooftops, splits, and VRF
2. *Hybrid system* with rating approaches like AHRI guideline V
3. *Subsystems approaches* (Look at the complete HVAC System)
4. *Whole Building System* approaches (ASHRAE Building Energy Quotient)
5. Defined *commissioning* requirements to make sure equipment runs correctly
6. Integrated *Fault Detection* (FDD)

Chilled Water System Example (Current)

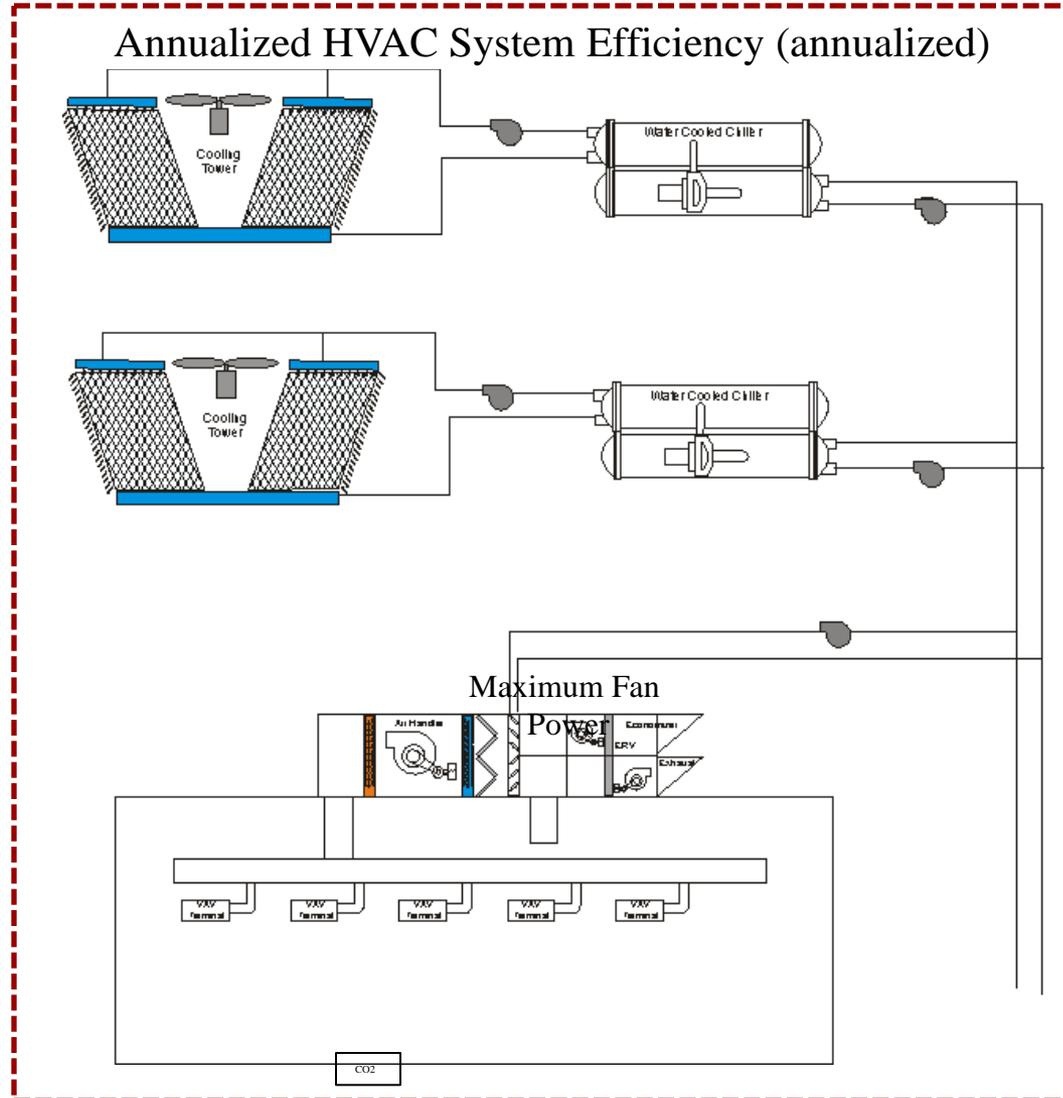
Current ASHRAE 90.1 Regulations (Prescriptive Approach)



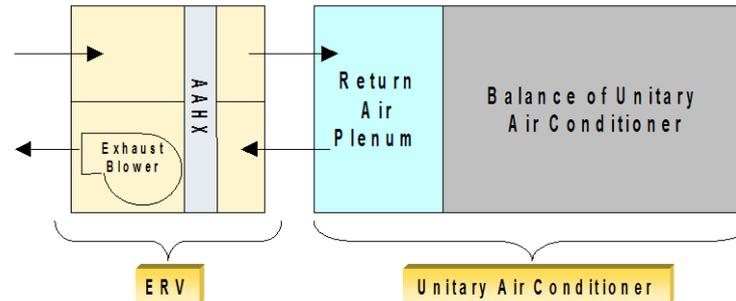
Chilled Water System Example (Alternate)

Alternate Systems Approach

Overall Efficiency Minimum Set by climate zone and building type and then component efficiencies can be traded off to meet the overall targets



Example Combined Efficiency



ERV Recovered Energy Efficiency Ratio

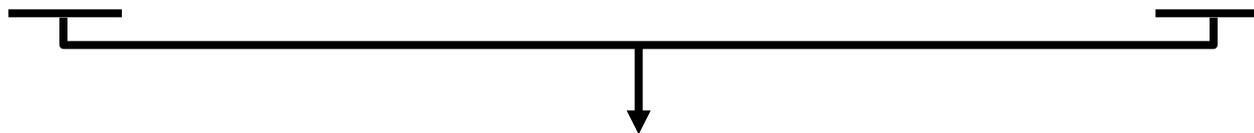
$$\text{RER} = \frac{\text{Net conditioning recovered by ERV}}{\text{Total electrical power consumed by ERV}}$$

RER

RTU Energy Efficiency Ratio

$$\text{EER} = \frac{\text{Net conditioning capacity of RTU}}{\text{Total electric power by RTU}}$$

EER



CEF = Combined Efficiency Factor

Example:

Rooftop + ERV = System CEF (30 ton system)

EER & RER = CEF

12.0 & 124.69 = 17.19

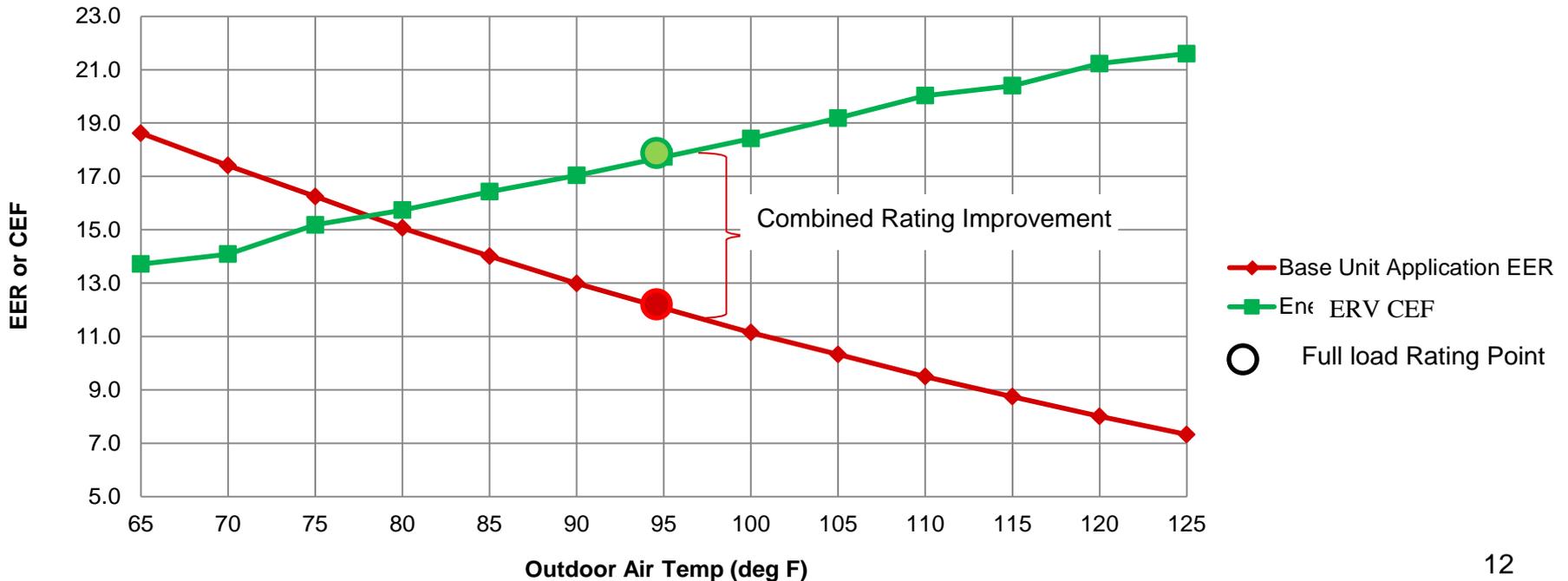
17.19 System EER for a 30 ton total system

Efficiency Comparison (ERV Example)

Example shows how over the operating range a hybrid unit like an ERV/Rooftop can have further improvements at non standard rating conditions

	Base Rooftop Unit	Combined
Model:	Rooftop	ERV
Location:	Tampa, FL	Tampa, FL
Altitude (ft)	0.0 ft	0.0 ft
CFM	3500	3500
Ext static press:	0.75"	0.75"
Ventilation Air:	50% or less (economizer)	50% OA (1750 cfm)

CEF vs Application EER



Smart Grid Opportunities for Efficiency

- Coordination of HVAC with Building Load and Anticipated Weather Conditions (i.e.. Optimal Start)
- Optimal use of Hybrid Systems (i.e. Economizers, Energy Recovery, Evaporative cooling)
- Optimal Control of systems setpoints based on anticipated weather conditions to minimize Energy Use (i.e. supply air temperature, chilled water setpoint)
- Coordination of renewable energy with thermal storage (ice storage and new storage fluids)
- Sharing energy between buildings on large sites and building complexes

Peak Load Power Management

- Commercial equipment has been capable peak power control for many years
- Often people say that a fully variable speed unit is required for demand control, but commercial equipment has multiple stages that can be easily interfaced with demand control signals
- Equipment current includes logic like the following;
 - Load Limit – When a signal is received the equipment capacity control is frozen at a given level
 - Redline – Equipment capacity is decreased
- There are also smart ways to reduce peak load
 - Use of thermal storage like ice storage
 - Use of the building as a thermal storage device thru optimal start and pre-cooling
 - Use of hybrid systems including economizers, evaporative cooling, and energy recovery

Diagnostics

- Proper configuration, operation and maintenance of HVAC equipment is critical to the realization of energy savings as well as controlling peak power
- More HVAC equipment is now be designed with advanced microprocessor based controls and sensors
- These controls can include new diagnostic routines that are able determine things like;
 - Improper operation of economizers
 - Low or improper airflow
 - Low refrigerant charge
 - Dirty and fouled heat exchangers
 - Failed components
 - Improper configuration and setpoints
 - Tracking energy use and looking for changes in use
- The key to the use of these new features is how to get them to the appropriate people and service companies
- The Smart Grid could be used, but there are also other options that are being considered

Smart Grid Challenges and Opportunities

Issues

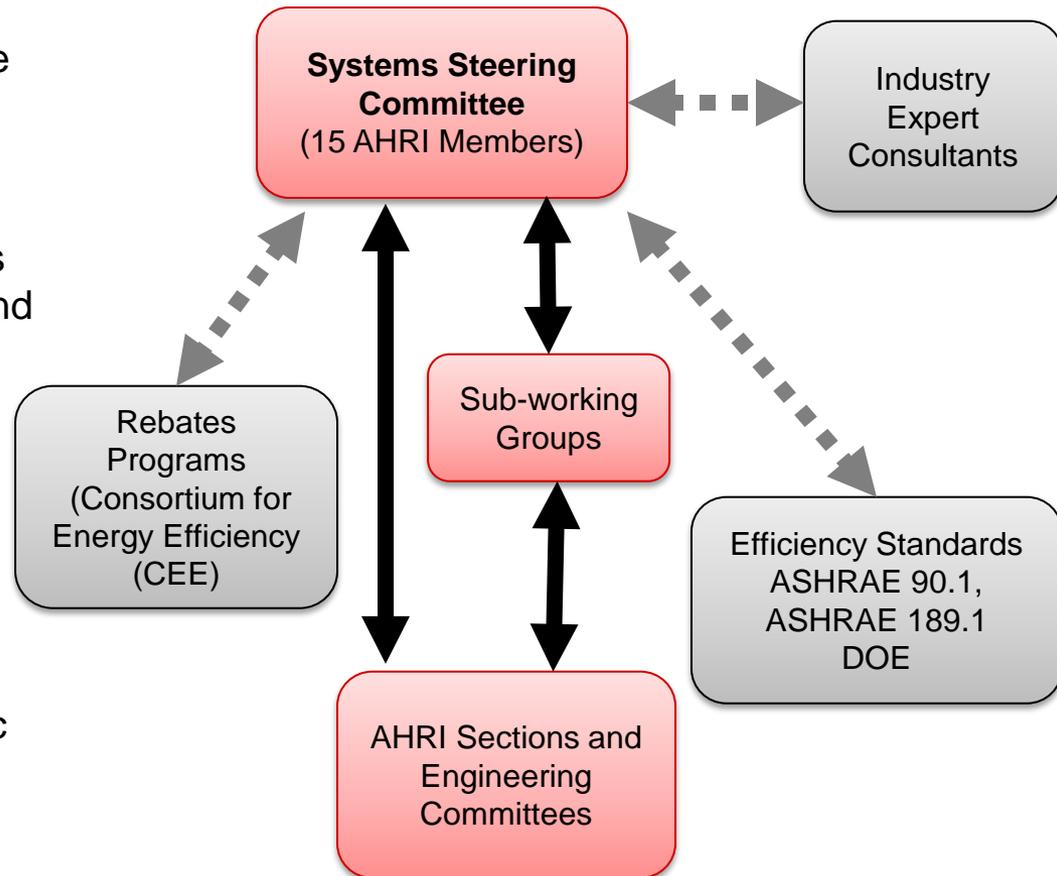
- Overall the HVAC industry still does not understand how to interface with the Smart Grid
- The features and opportunities beyond peak load are not fully understood and appreciated
- The business case is not clear as to how much the interface will cost and what the payback period will be.
- Most of the effort in the industry and regulations is focused on efficiency and this dominates R&D activity
- One of the concerns the industry as well as owners have is security and confidentiality

Opportunities

- Often in the past, incentive programs have helped transition the industry to new technology. How can we get incentive programs based on Smart Grid connected equipment
- Need to continue to expand the development of specifications as well as white papers on how to use the Smart Grid and connected equipment

AHRI Systems Steering Committee

- In order to continue to advance efficiency improvements AHRI has formed a Systems Steering Committee
- The mission of this committee is to coordinate and lead initiatives to improve efficiency at a system level as well as develop specifications, tools and guidelines to improved design and operating efficiency
- The group is in the process of developing long range strategic plans with the AHRI sections and members
- They have also indentified 16 strategic initiatives one of which includes the Smart Grid
- This group can work with DOE and the Smart Grid advocates to expand the use in commercial buildings



Questions