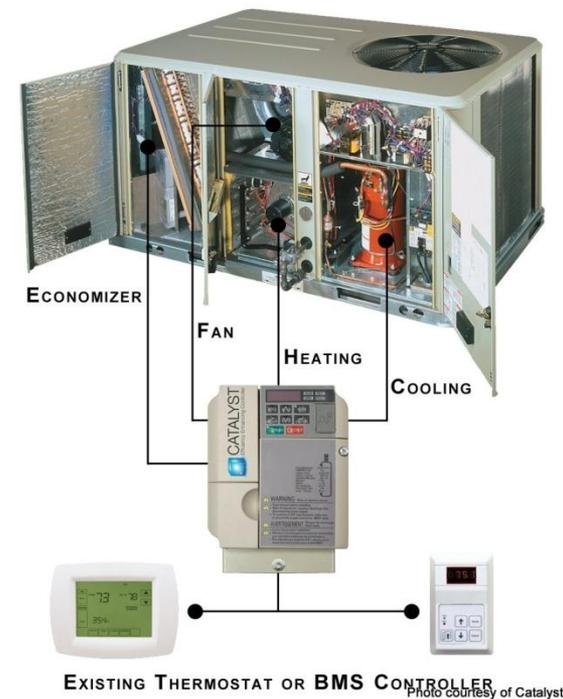


Advanced Rooftop Controller

Preliminary Seventh Power Plan Energy Efficiency Estimates

Conservation Resources Advisory Committee Meeting

December 17, 2014



Presentation Outline

- Advanced Rooftop Controller (ARC) measure background and definition
- High Level Summary of HVAC-related data in the Commercial Building Stock Assessment (CBSA)
- Measure data and preliminary potential estimates for the Seventh Plan

What is the Measure?

- Advanced Rooftop Controller (ARC) – a controller applied to single zone rooftop systems with constant speed fans
- Most commercial buildings are over-ventilated
 - Constant speed fans are set to run when the building is occupied
- The controller modulates the supply fan to reduce energy consumption

Overlap in 6P Measures

- The ARC measure may have some overlap with the following 6P Measures, and will be accounted for:
 - Rooftop Optimization and Repair
 - Demand Control Ventilation

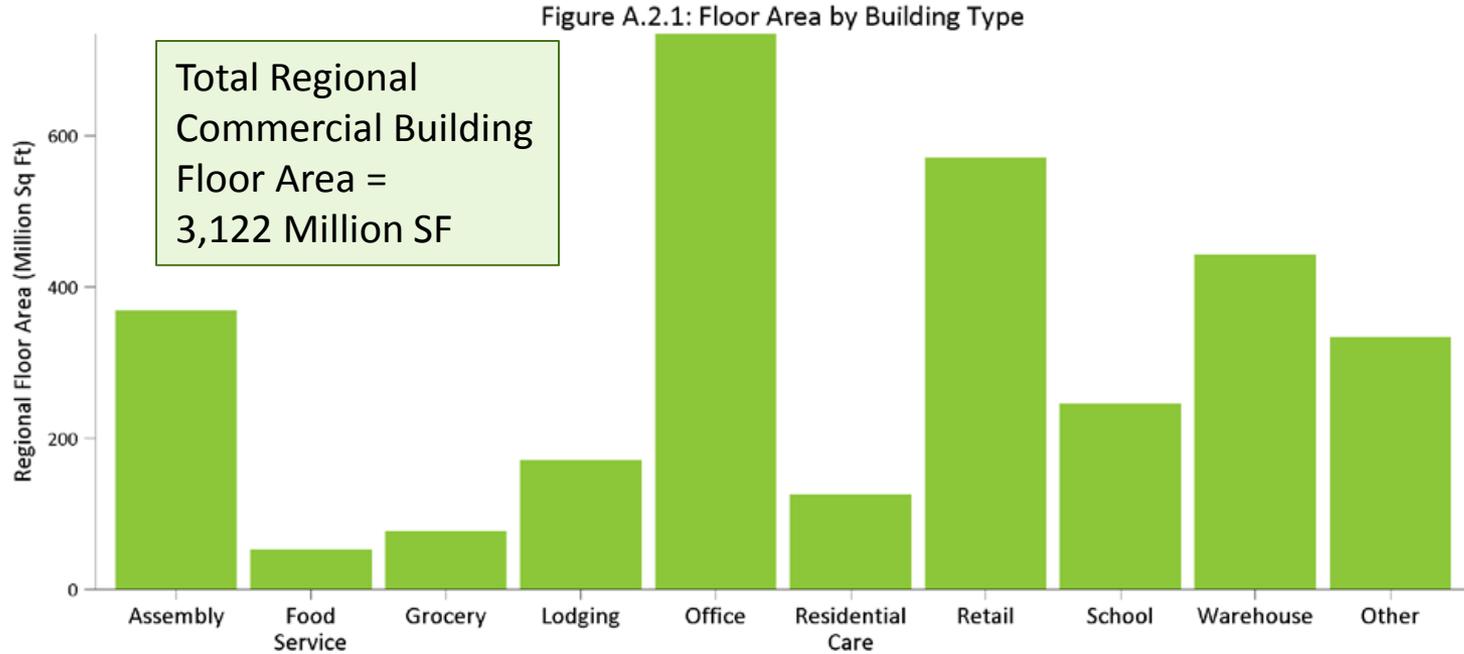
Sixth Plan Measure	aMW
Demand Control Ventilation-New	3
Demand Control Ventilation-NR	3
Demand Control Ventilation-Retro	19
Package Roof Top Optimization and Repair-New	4
Package Roof Top Optimization and Repair-NR	8
Package Roof Top Optimization and Repair-Retro	14

7P Commercial Building Types

Primary Activity	7P Building Type	Gross Floor Area in Square Feet	6P Building Type	Gross Floor Area in Square Feet
Office	Large Office	>50,000	Large Office	> 100,000
Office	Medium Office	5,000 to 50,000	Medium Office	20,000 to 100,000
Office	Small Office	<5,000	Small Office	< 20,000
Retail	Ex Large Retail	>100,000	Big Box	> 50,000
Retail	Large Retail	50,000 - 100,000	Small Box	<50,000
Retail	Medium Retail	5000 - 50,000	High End	< 20,000
Retail	Small Retail	<5000	Anchor	> 50,000
School	School K-12	Any	K-12	Any
School	University	Any	University	Any
Warehouse	Warehouse	Any	Warehouse	Any
Retail Food Sales	Supermarket	> 5000	Supermarket	> 5000
Retail Food Sales	MiniMart	< 5000	MiniMart	< 5000
Restaurant	Restaurant	Any	Restaurant	Any
Lodging	Lodging	Any	Lodging	Any
Health Care	Hospital	Any	Hospital	Any
Health Care	Residential Care	Any	OtherHealth	Any
Assembly	Assembly	Any	Assembly	Any
Other	Other	Any	Other	Any

Floor Space by Building Type

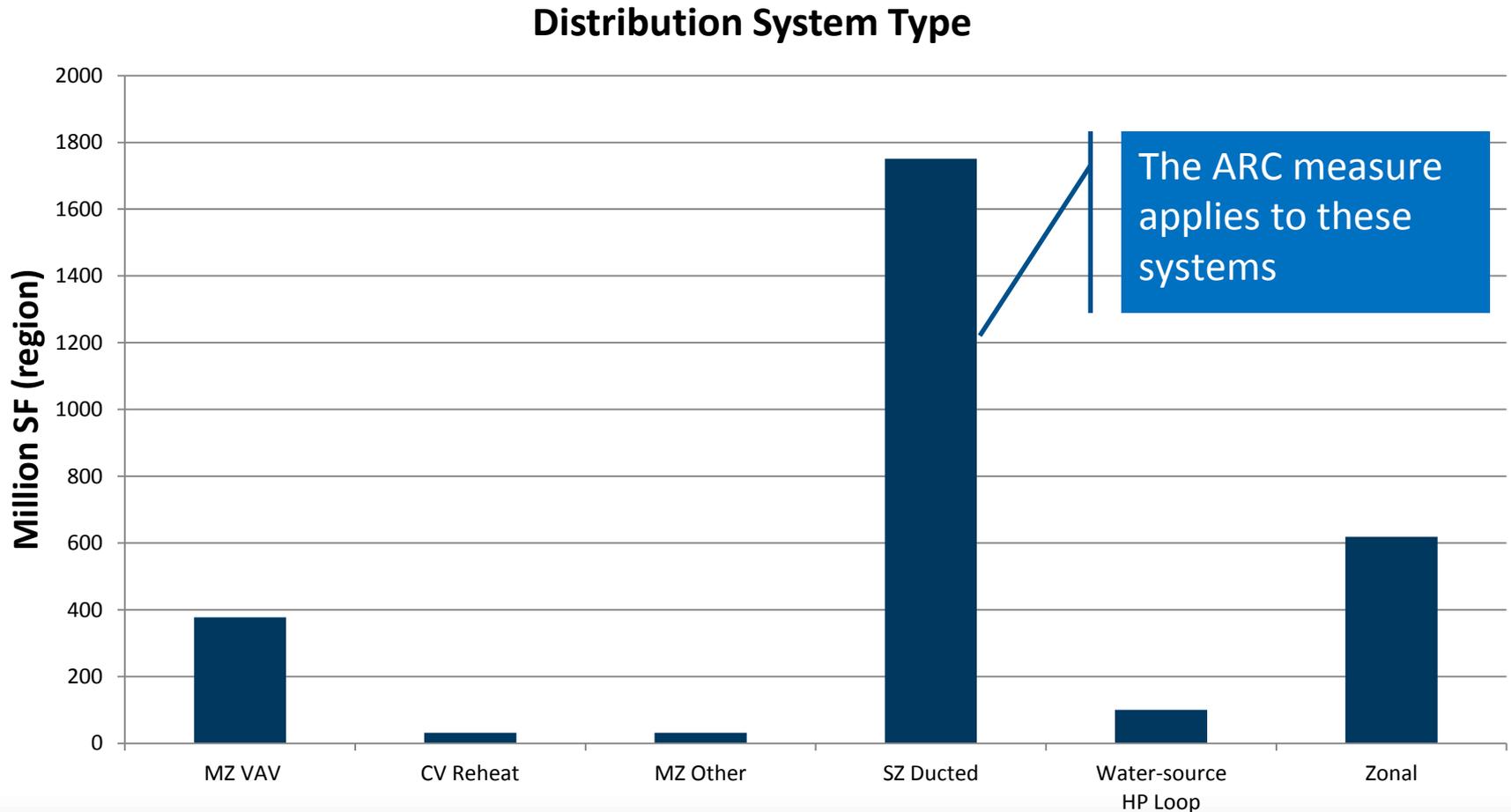
(Source: CBSA, excluding University and Hospitals)



Assembly	Food Service	Grocery	Lodging	Office	Residential Care	Retail	School	Warehouse	Other
369	53	77	171	734	125	571	245	442	333
12%	2%	2%	5%	24%	4%	18%	8%	14%	11%

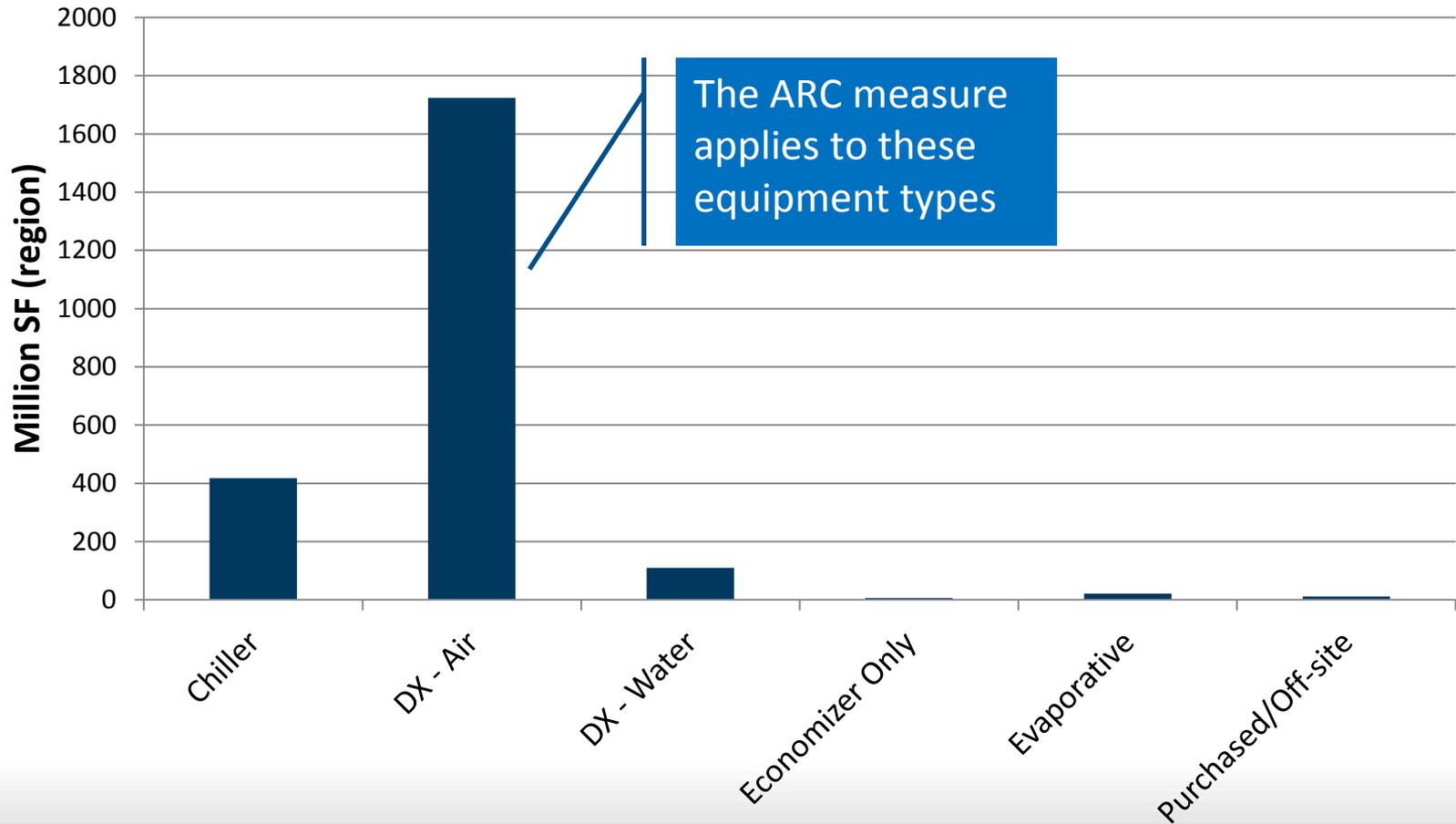
Units: Regional Floor Area (Million Sq Ft), % of row total

Distribution System by Floor Area



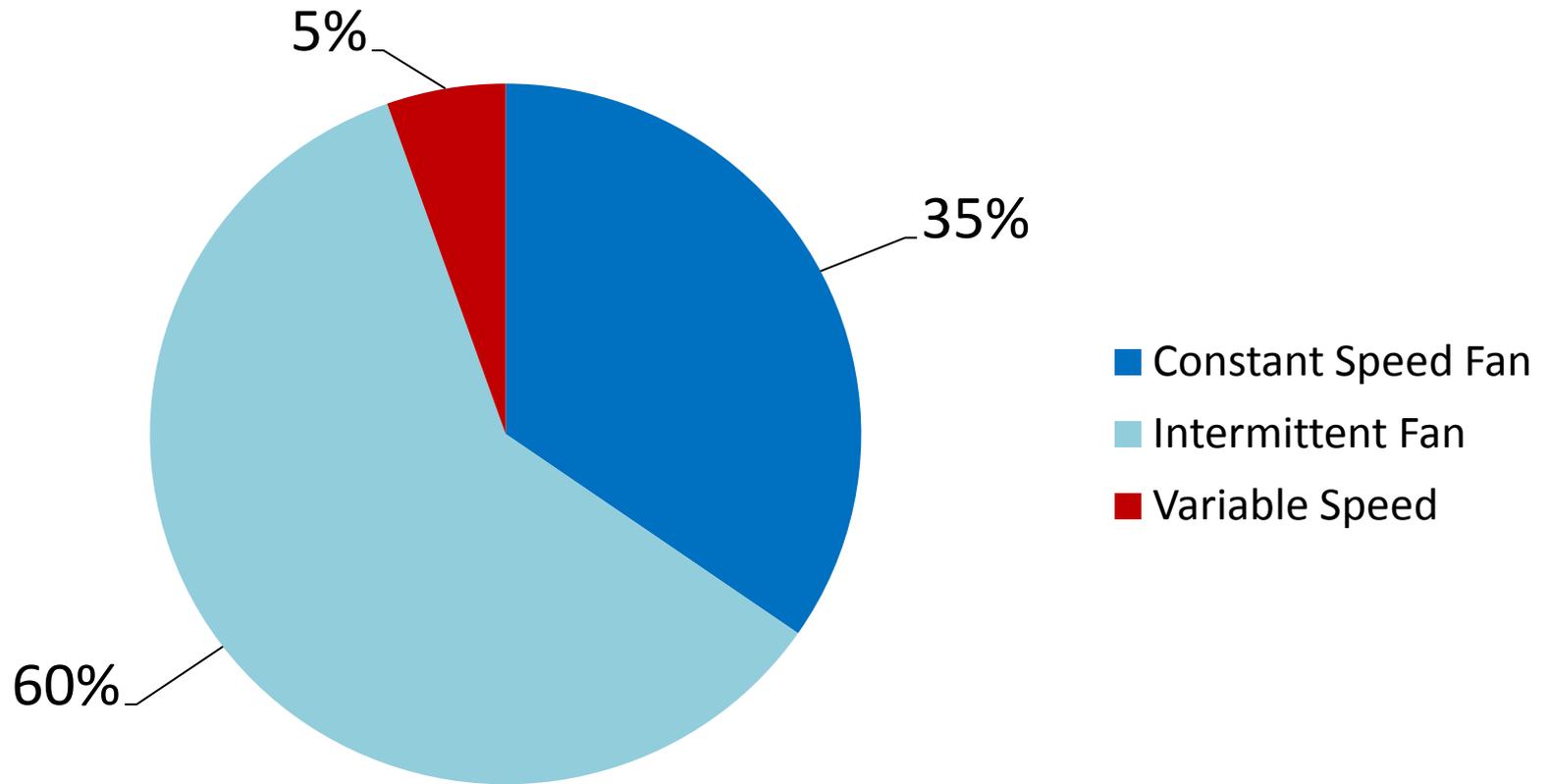
Cooling Equipment by SF

Cooled Floorspace by System Type



Fan Control Type

Fan Control in SZ Ducted Systems

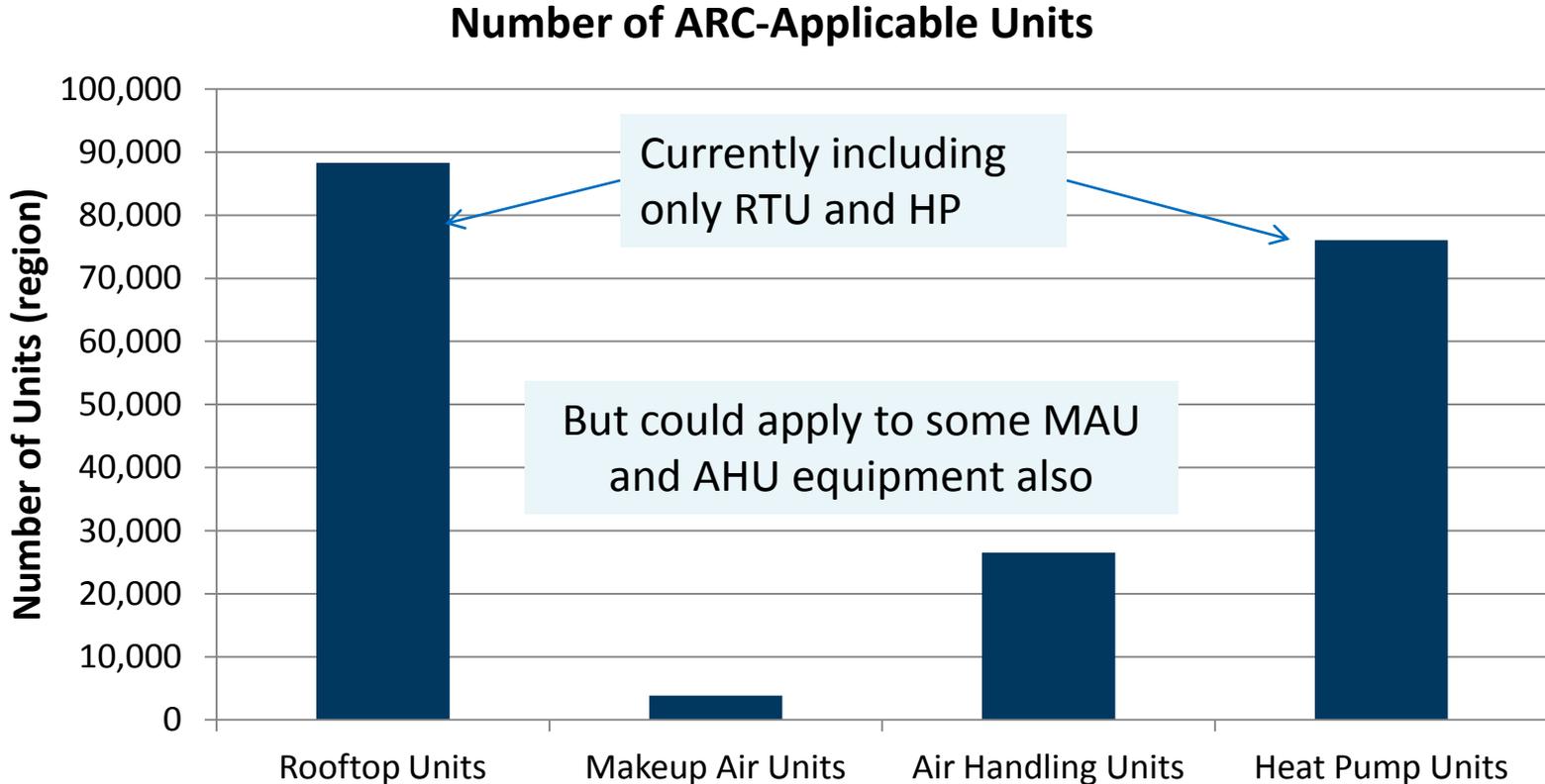


RTU Systems by Size

RTU Systems and Run Hours

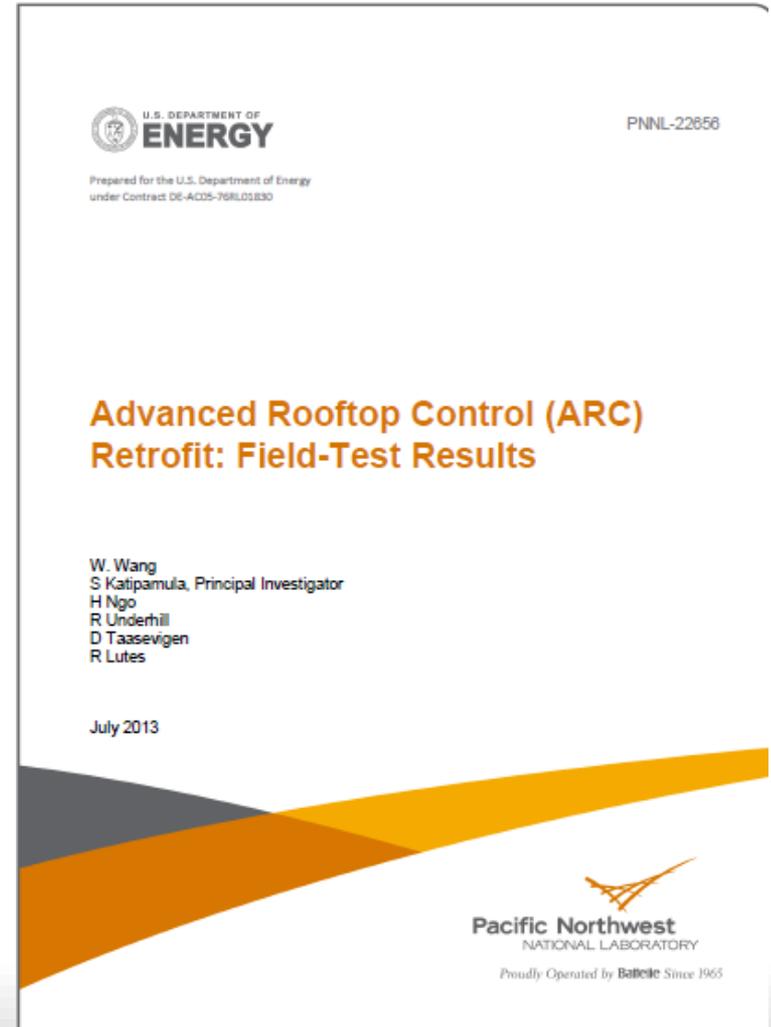
Size Category (tons)	Regional Units	Regional Hours
<10	74,216	303,009,658
10-15	25,335	113,375,445
>15	25,150	135,134,437
Grand Total	124,702	551,519,540

ARC-Applicable Units



Advanced Rooftop Controller (ARC) Retrofit: Field-Test Results

- The ARC measure is based primarily on the ARC Retrofit study conducted by Pacific Northwest National Laboratory.
- Study completed in 2013



Overview of the Study

- Pre and post measurements of 66 units in 8 different building types
- One-minute interval data over a 12-month period
- Four different US climate zones
- Controls alternated between standard (pre-retrofit mode) and advanced control modes on daily basis
- Methods per the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Guideline 14
- 91% of the savings from this measure comes from fan energy savings

ARC Equipment

- At least one new variable frequency drive (VFD)
- One new digital controller
- One new damper actuator (or modified damper actuator that interfaces to the new controller)
- Multiple sensors (discharge-air temperature, return-air temperature, outdoor-air temperature, mixed-air temperature, space temperature, return air or space CO₂, power, etc.)
- The ability to access the RTU (or network of RTUs) via a web interface
- A variety of other components, depending on the vendor

Savings Components

- There are four primary components to the ARC savings:
 - Supply Fan Speed Controls (approximately 91% of total savings)
 - Integrated Air-side Economizer Controls
 - Cooling Capacity Controls
 - Simple on/off, and staged cooling
 - Demand-Controlled Ventilation Controls
 - Return-air CO₂

ARC Measure Savings

Measure Savings Data from PNNL Report				
	Average Savings across all sites	515	Wh/h/hp	
Size Category				
<10	RTU Capacity <10 tons	1.0	kWh/h	Savings
10-15	RTU Capacity 10-15 tons	1.8	kWh/h	Savings
>15	RTU Capacity >15 tons	4.2	kWh/h	Savings
Equipment Type				
	AC Units (gas heat)	2.6	kWh/h	Savings
	HP Units	1.75	kWh/h	Savings

ARC Measure Costs

RTU Capacity (tons)	Supply Fan Size (hp)	Controller (\$)	Controller Labor (\$)	Total (\$)	\$/hp	\$/ton
≤5	1	2,200	750	2,950	2,950	1,180
> 5 and ≤ 10	2	2,600	750	3,350	1,675	447
> 10 and ≤ 15	3	3,500	750	4,250	1,417	340
> 15 and ≤ 20	5	4,000	750	4,750	950	271
> 20 and ≤ 25	7.5	4,142	750	4,892	652	217

Initial, High Level Technical Potential Estimate

Size Category	Regional Units	Regional Hours (millions)	Savings (kWh/hr)	Regional Tech Savings (aMW)	Cost Per Unit (\$)	Total Cost (million \$)	Levelized Cost (\$/MWh)
<10	74,200	303	1.00	35	3,150	234	69
10-15	25,300	113	1.80	23	4,250	108	47
>15	25,200	135	4.20	65	4,821	121	19
Grand Total	124,700	552		123		463	39

Gray cells are data from CBSA, red text are data from PNNL report
 Levelized cost of PNNL test sites is \$24.32/MWh

Saturation and Applicability

- Single-zone, ducted systems, RTU and HP, constant speed fans
- 85% achievability
- Possibly use only the fan energy portion (91%)
 - The other 9% is climate dependent
 - However, PNW has high share of electric heat, so recommend keeping it
- Achievable potential: 104 aMW
 - Final number will change slightly as applicability and saturations are applied in more detail (e.g., building type)

Questions

- Use 100% or 91%?
 - The PNNL study found that 91% of the savings is from fan energy
 - The remainder is from economizer, heating, and cooling savings
 - These are more climate-dependent savings and we don't have enough data to disaggregate these
- Measure life – 15 years?

Next Steps

- Finalize workbooks
- New construction? Covered by codes
- Consider “Catalyst lite”?
 - Half the cost
 - Only fan controls
 - Primarily applies to smaller systems
- Incorporate comments and reviewer feedback

Supplemental Slides