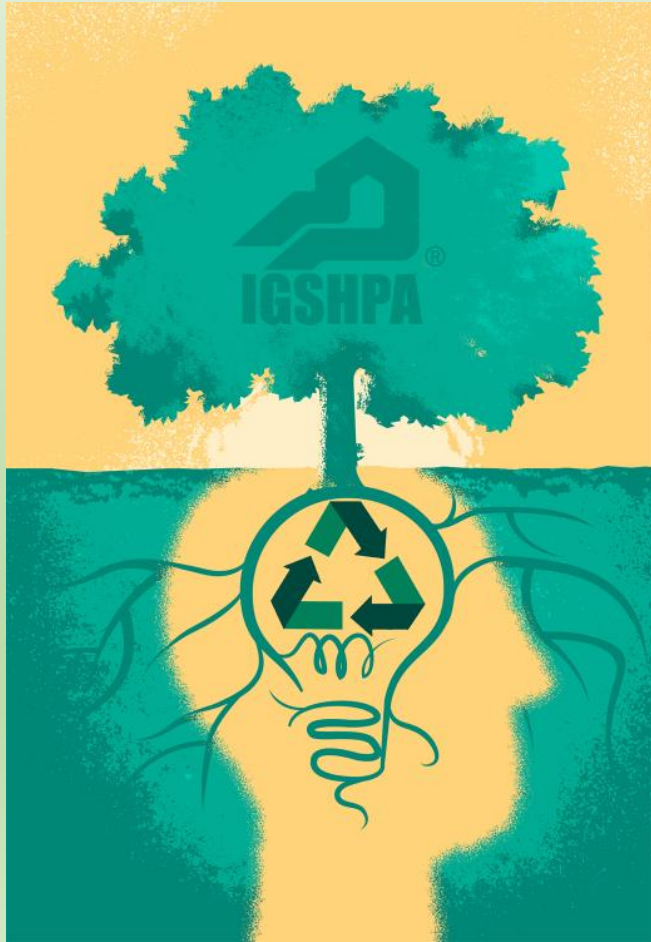


AHRI 600 - WSHP Performance



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Las Vegas, NV

December 5-7, 2023





AHRI 600

WSHP Performance

Bob Brown

VP of Engineering

WaterFurnace[®]
Smarter from the Ground Up[™]

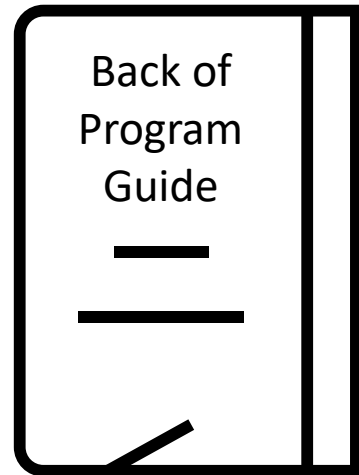


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 **2023 Conference & Expo**
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ISO/AHRI 13256 – Today's Standard

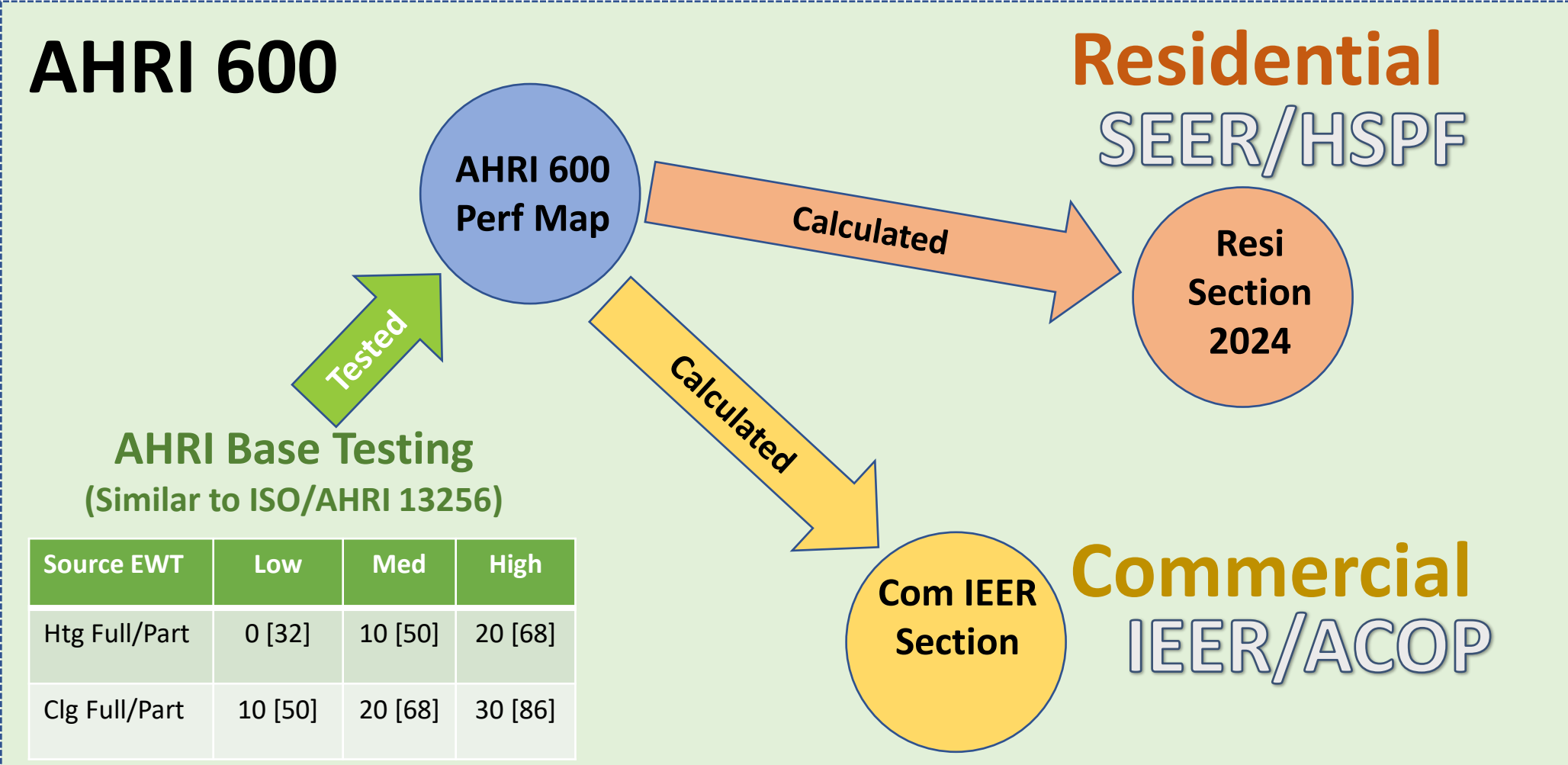
- ISO/AHRI 13256-1 – Water to Air
- ISO/AHRI 13256-2 – Water to Water
- Three Applications of WSHP's [degF]
 - WLHP 55-90 Range
 - GWHP 50 North, 70 South
 - GLHP 32-86 Range
- Fan power corrected to zero ext static
- Pump power added for internal HX PD
- Hard conversion to SI units (i.e. 80.6/66.2 and 68 degF ent air)
- Referenced by EPA/EnergyStar and Inflation Reduction Act (IRA)

ISO/AHRI 13256 Source EWT's			
Source EWT	GLHP	GWHP	WLHP
Htg Full Load	0 [32]	10 [50]	20 [68]
Htg Part Load	5 [41]	10 [50]	20 [68]
Clg Full Load	25 [77]	15 [59]	30 [86]
Clg Part Load	20 [68]	15 [59]	30 [86]

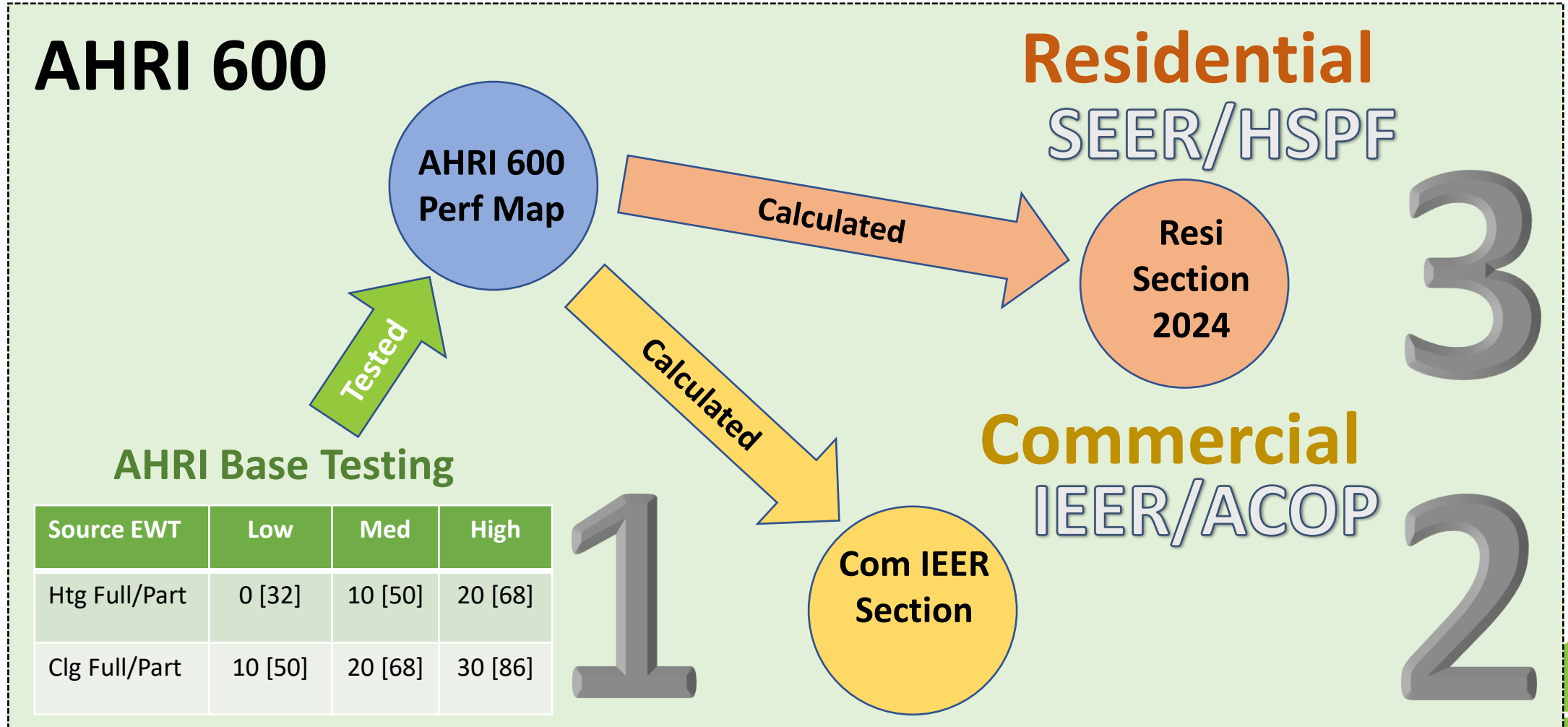
Why a New Standard?

- DOE WLHP NOPR issued Aug 2022 & notified intent to regulate commercial WSHP using **IEER** (not existing EER/COP). Also possible future DOE regulation for resi thru seasonal metric (like SEER/HSPF)
- Resi Fan External Static Pressure like AHRI 210/240 M1 table and Commercial like AHRI 340/360 table
- Remove hard conversion ent air temps to 80/67 and 70 EA Temps
- DOE desired to add system pump/tower power for both resi and commercial
- ISO Method of Test's were inadequate and other program issues
- **These issues resulted in the AHRI Geo STC transitioning from ISO 13256-1 and -2 and developing an all new AHRI 600**

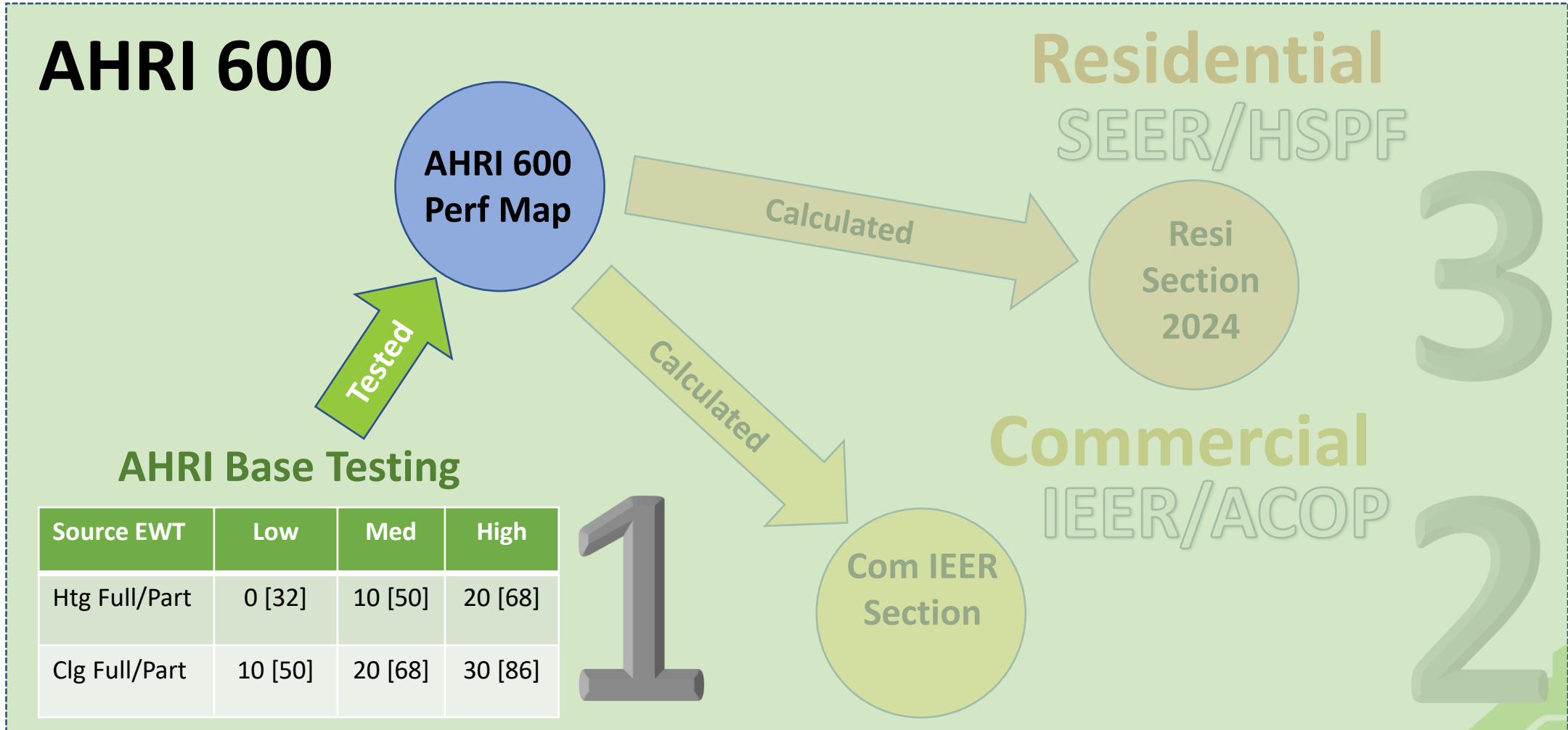
New AHRI 600 Standard Concept



New Standard AHRI 600 Main Sections



1 – Base Performance Map



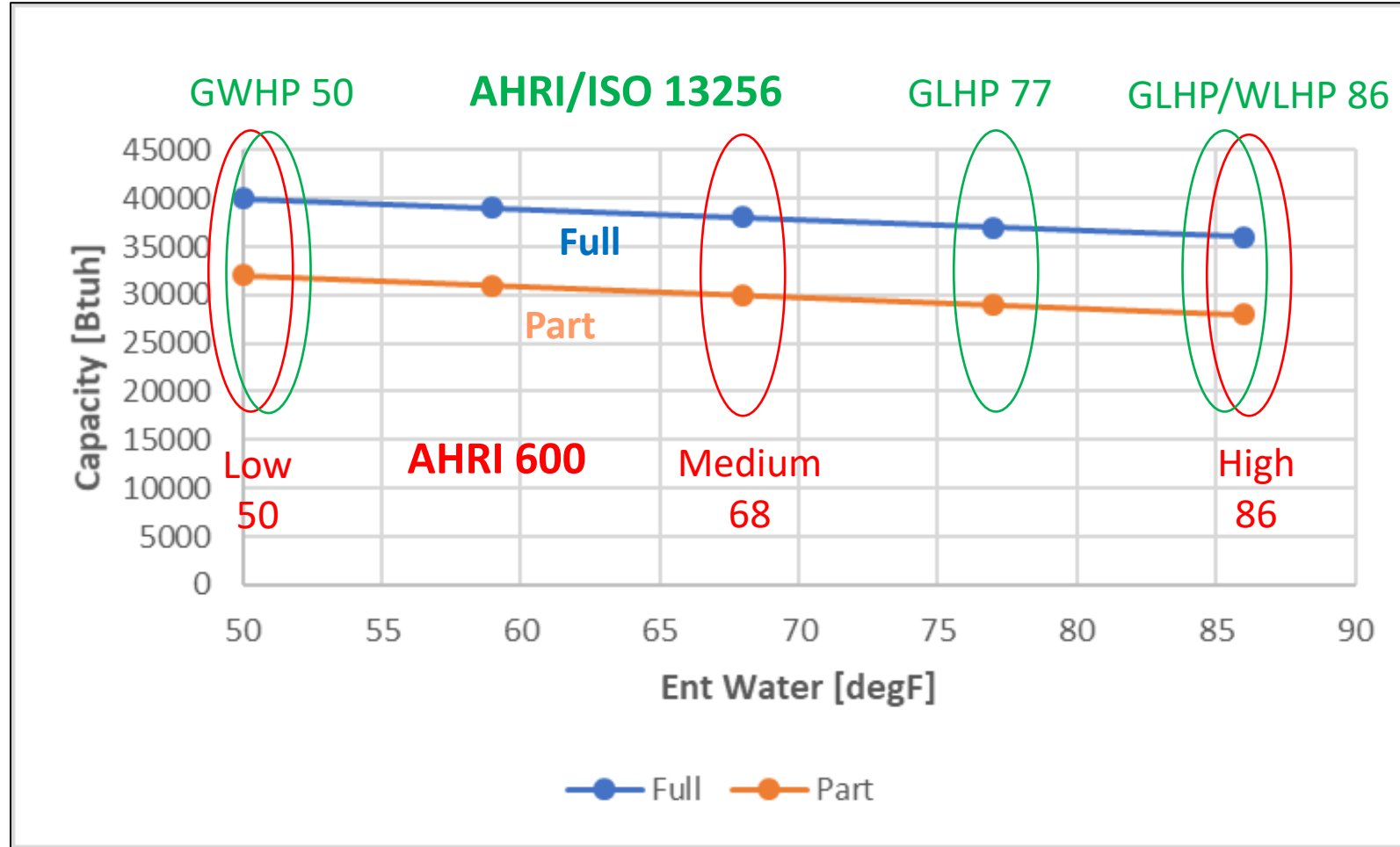
Basic Application are Still Covered

- Maintain The Three Applications of WSHP's [degF]
 - **WLHP** 55-90 Range
 - **GWHP** 50 North, 70 South
 - **GLHP** 32-86 Range
 - Heating – 32 through 70 degF range in both full and part load
 - Cooling - 50 through 86 degF range in both full and part load
 - Performance is markedly linear and creates a map usable for EWT interpolation
- Six points are used to create the map
 - Heating – 32, 50, 68 degF both Full and Part Load
 - Cooling - 50, 68, 86 degF both Full and Part Load
 - Different from AHRI/ISO 13256 but similar

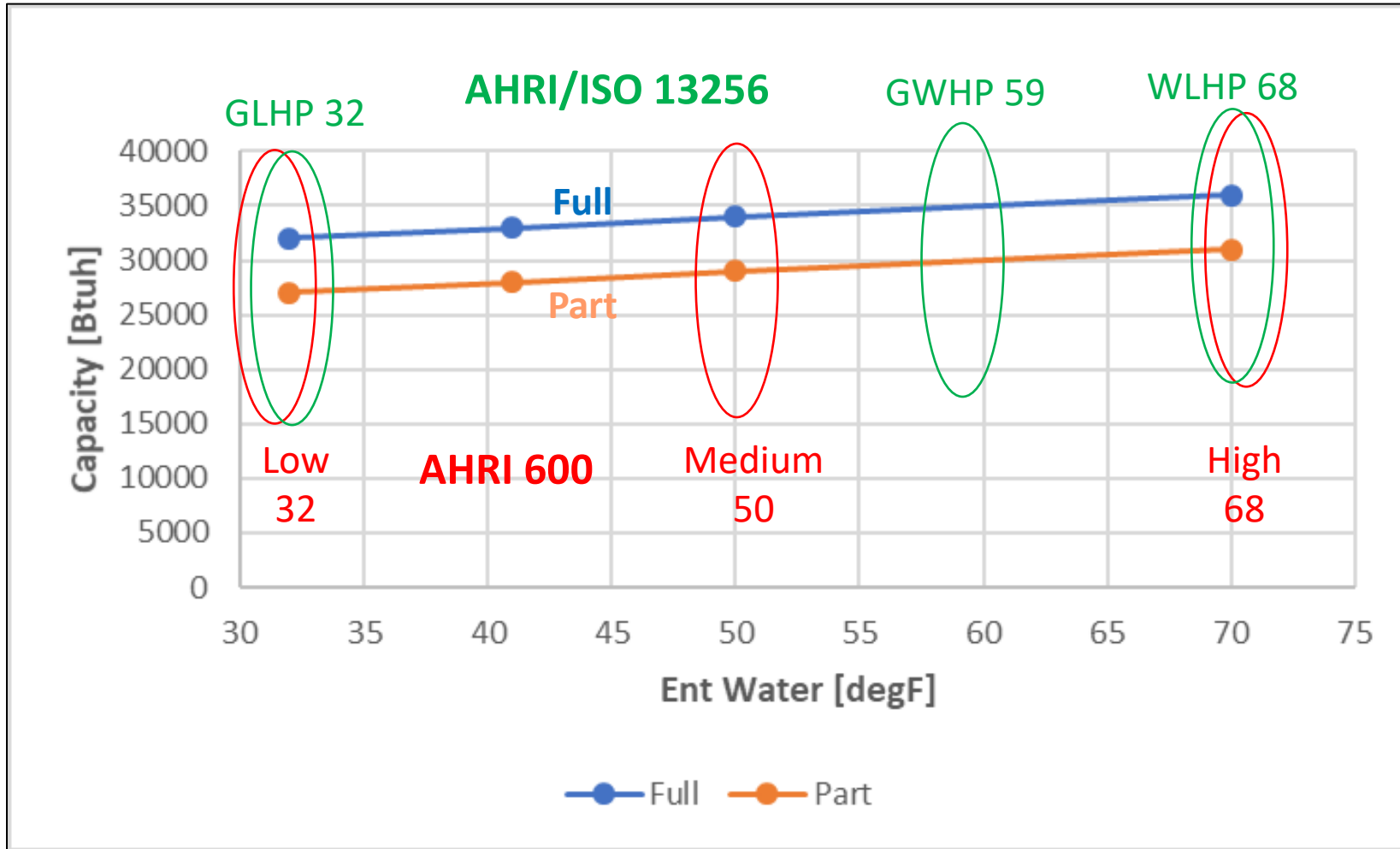
AHRI 600 Source EWT's

Source EWT	Low	Med	High
Htg Full/Part	0 [32]	10 [50]	20 [68]
Clg Full/Part	10 [50]	20 [68]	30 [86]

AHRI 600 Cooling Map – Example 3 ton



AHRI 600 Heating Map – Example 3 ton



Fan External Statics

- **Commercial** Fan external static pressure
 - Commercial similar to AHRI 340-360 table
 - Part load uses adjusted esp.
- **Future Residential** Fan external static pressure
 - Future Residential similar to AHRI 210-240 M1 - 0.50 in wg for most product.
 - Part load uses adjusted esp.

Table 5 External Static Pressure

Rated Cooling Capacity, Btu/h·1000 ¹	External Static Pressure, in H ₂ O
From 0 to 28.8	0.10
From 29 to 42.9	0.15
From 43 to 74.9	0.20
From 75 to 134	0.75
From 135 to 280	1.00
281 and greater	1.50

Note:
1. Full-load *cooling capacity* measured for *standard rating condition C3*.

Other Conditions -

- Entering Air Conditions
 - Cooling – 80 DB / 67 WB degF
 - Heating – 70 DB degF
 - No longer hard converted to SI units (80.6/66.2 and 68)

- Flow is still specified by manufacturer

- Power correction for source

heat exchanger press drop

$$\varphi_{pa} = \frac{q \cdot \Delta p_{int} \cdot 0.4349}{\eta}$$



9

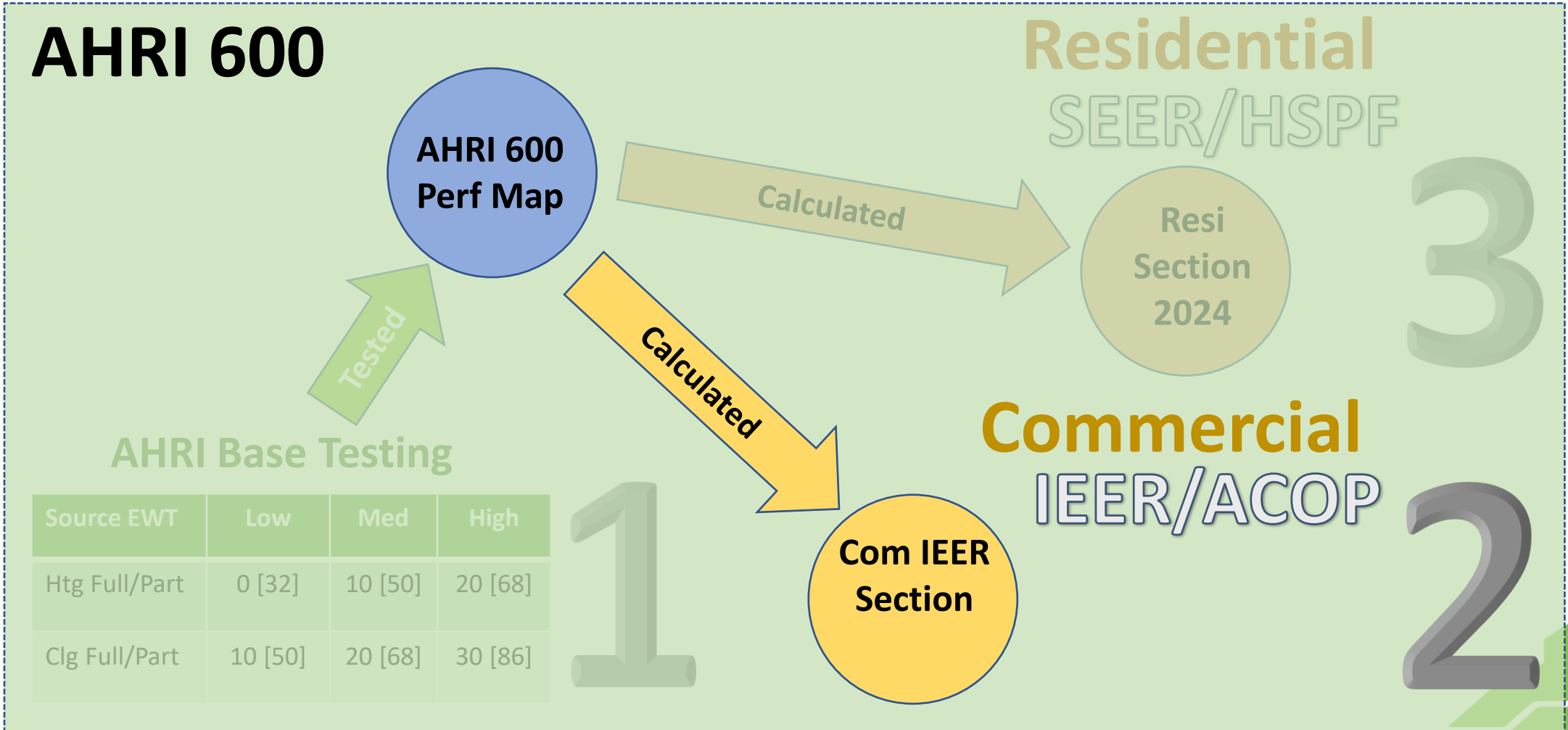
Where:

φ_{pa}	=	Pump power adjustment, W
q	=	Mean measured fluid flow rate for the test, gpm
Δp_{int}	=	Internal static pressure difference measured for the test, psi
0.4349	=	Conversion factor, W·GPM·psi
η	=	Pump efficiency, 0.75 by convention for commercial

Other New Additions

- Brine Properties –
 - Missing from AHRI/ISO 13256. Thermodynamic properties of the aqueous methanol solution calculated using the polynomial equations shown in Melinder (2010). Melinder also is authoritative source for all industry recognized brine properties.
 - Properties now based upon average source temp within HX.
- Defines standard basic model vs optional features that are not required for testing (similar to AHRI 340-360)
 - Air economizers, air dampers, reclaim coils, dessicant components, reheat coils, etc.
- Split charging procedures
- ECM fan motor testing procedure
- Several other unusual test procedure guidelines are included.

2 – Commercial IEER/COP



Original IEER Source Conditions Compared

Condition	Cap Level	Run Time %	AHRI 340/360 2019 Air	AHRI 210/240 2023 Water	AHRI 340/360 2020# Water	AHRI 1230/1231 2020& Water	AHRI 600 Water
100%	Full	2.0 %	85 95	85	85	86	85
75%	Part	61.7 %	81.5	73.5	73.5	73.5 81	73.5
50%	Part	23.8 %	68	62	62	62 74	62
25%	Part	12.5 %	65	55	55	55 67	55

AHRI 210/240 removed water cooled equipment to 340/360 in draft version 2020

-Ref Table 9 and section 6.2.2 AHRI 340/360 Draft version 2020

& -Ref Table 10 and section 11.2.1 AHRI 1230/1231 Draft version 2020

Proposed AHRI 600 – IEER Source Conditions

Same!

Condition	Cap Level	Run Time %	AHRI 340/360 2019 Air	AHRI 340/360 2020# Water	AHRI 600 Water
100%	Full	2.0 %	95	85	85
75%	Part	61.7 %	81.5	73.5	73.5
50%	Part	23.8 %	68	62	62
25%	Part	12.5 %	65	55	55

AHRI 210/240-2020 removed water-cooled equipment to 340/360

-Ref Table 9 and section 6.2.2 AHRI 340/360 Draft version 2020

System Power Allocation

Section	Internal HX PD Power	Com WLHP External Power	Resi Geo External Power	Resi Well External Power
Commercial IEER Section	AHRI 600 In Basic Testing 75% pump	Commercial IEER/ACOP	-	-
Residential Seasonal Section (future)	AHRI 600 In Basic Testing 30% pump?	-	Residential Future	Residential Future



Commercial IEER includes Full System Power

- Based upon today's variable speed pumps and modern towers
- Only standard with complete system power included!
- Tower and system pump power is modulated at part load
- First IEER to include Full System Power
 - *Unit HX PD Power* - built into base map data of AHRI 600 (Full and Part load)
 - *Tower Fan Power* – Based upon 5 to 41 Watts per ton (25-100%)
 - *Tower Pump Power* – Based upon 2.5 Watts per ton (25-100%)
 - *System Pump Power* – Based upon 3 to 34 Watts per ton (25-100%)

W/kBtuh	Full/100%	75%	50%	25%
Tower/Pump	7.2	4.4	2.7	1.8

Other Rating Points

- AEER = Application EER at 85 degF EWT with system power
- ACOP = Application COP at 50 degF EWT with system power

Results

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WSHP Console SS/PSC – 12.2 EER @ 86

Stage	EWT	Raw EER	Run %	PTPR _x	Load %	Act %	q _{int,x}	P _{int,x}	LF	CD	q _x	P _{T,x}	P _x	EER _x
A	85	11.4	0.02	0.0072	100%	100.0%	11025	911.0	-	-	11025	911.0	990.4	11.13
B	73.5	13.5	0.617	0.0044	75%	107.8%	11888	853.5	0.70	1.04	8269	617.2	669.5	12.35
C	62	16.0	0.238	0.0027	50%	114.9%	12667	788.7	0.44	1.07	5513	368.4	402.6	13.69
D	55	17.8	0.125	0.0018	25%	118.8%	13094	745.1	0.21	1.10	2756	172.9	196.5	14.03
													IEER	12.9

AEER at 85 degF EWT

- AEER = 11.1

ACOP at 50 degF EWT

- ACOP = 3.40

WSHP Base SS/PSC – 13.0 EER @ 86

Stage	EWT	Raw EER	Run %	PTPR _x	Load %	Act %	q _{int,x}	P _{int,x}	LF	CD	q _x	P _{T,x}	P _x	EER _x
A	85	14.2	0.02	0.0072	100%	100.0%	49722	3598.2	-	-	49722	3598.2	3956.2	12.57
B	73.5	17.1	0.617	0.0044	75%	107.5%	53428	3297.9	0.70	1.04	37292	2392.3	2627.3	14.19
C	62	20.3	0.238	0.0027	50%	114.8%	57100	2984.3	0.44	1.07	24861	1394.7	1548.9	16.05
D	55	22.5	0.125	0.0018	25%	119.3%	59317	2786.0	0.21	1.10	12431	643.8	750.6	16.56
													IEER	14.9

AEER at 85 degF EWT

- AEER = 12.6

ACOP at 50 degF EWT

- ACOP = 3.98

WSHP Base DC/ECM – 17.2/19.1 EER @ 86

Stage	EWT	Raw EER	Run %	PTPRx	Load %	Act %	q _{int,x}	P _{int,x}	LF	CD	q _x	P _{T,x}	P _x	EER _x
A	85	17.2	0.02	0.0072	100%	100.0%	51522	3028.6	-	-	51522	3028.6	3399.5	15.16
B	73.5	23.9	0.617	0.0044	75%	81.6%	42036	1811.3	0.92	1.01	38642	1682.5	1867.5	20.69
C	62	27.4	0.238	0.0027	50%	83.1%	42800	1609.5	0.60	1.05	25761	1018.9	1134.5	22.71
D	55	29.5	0.125	0.0018	25%	83.1%	42800	1492.9	0.30	1.09	12881	490.1	567.1	22.71
													IEER	21.3

AEER at 85 degF EWT

- Full AEER = 15.2

ACOP at 50 degF EWT

- Full ACOP = 4.06

WSHP Base VS/ECM – 17.2/19.1 EER @ 86

Stage	EWT	Raw EER	Run %	PTPRx	Load %	Act %	q _{int,x}	P _{int,x}	LF	CD	q _x	P _{T,x}	P _x	EER _x
A	85	17.4	0.02	0.0072	100%	100.0%	47967	2762.2	-	-	47967	2762.2	3107.5	15.44
B	73.5	22.4	0.617	0.0044	75%	75.0%	35975	1517.5	-	-	35975	1517.5	1675.8	21.47
C	62	37.0	0.238	0.0027	50%	50.0%	23983	699.0	-	-	23983	699.0	763.8	31.40
D	55	49.8	0.125	0.0018	25%	30.2%	14480	292.6	0.83	1.02	11992	247.7	273.8	43.80
													IEER	26.5

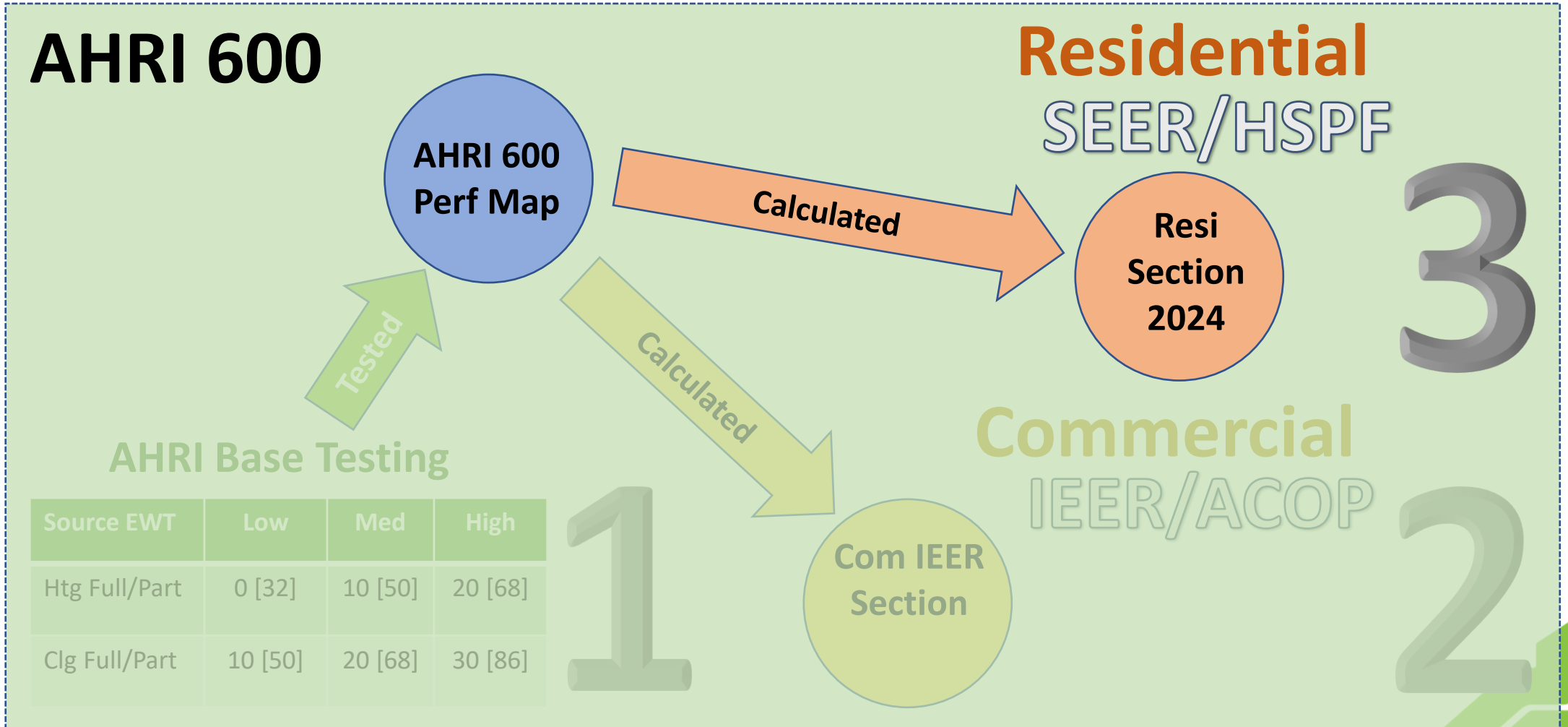
AEER at 85 degF EWT

- Full AEER = 15.4

ACOP at 50 degF EWT

- Full ACOP = 4.83

3 – Residential Seasonal Metrics



Existing AHRI 210-240 - Resid Air Source Std

- **A lot of recent changes in AHRI 210-240 for 1/1/2023**

- Appendix M1 effective Jan 1, 2023
- Uses 0.50 in wg ext fan static for ducted product
- Introduces 5 degF low temperature test point
- New metrics of SEER2, HSPF2, and EER2 replace old SEER, HSPF and EER

- **New Changes for AHRI 210-240:2024**

- Introduces Control Verification Procedure (CVP) to verify VS operation
 - Uses new load-based testing procedure to verify full range VS operation
 - Poor performance could cause a two-speed rating
- Defines Cold Climate HP (CCHP) to consolidate industry metrics using 5 degF OAT and optional testing to confirm compressor operation at low temperature
- For continuous fan operation (A2L mitigation) default cycle degradation cannot be used.

New AHRI 1600 Residential Air Source Std

- More dramatic changes to 210-240 method so new number of 1600
- New for AHRI 1600:2027
 - New population weighted Bin Hours including off cycle shoulder hours
 - Demand Defrost Credit and Debit changes
 - Airflow limits for dehumidification improvements
 - SCORE and SHORE metrics now will include off cycle energy replacing SEER2 and HSPF2
- Replaces AHRI 210-240 effective in 2029
- Reference standard for developing AHRI 600 residential seasonal method.

AHRI 600 Residential Key Assessment Points

- Assess New AHRI 1600 bins – appear more moderate with a lot of hours above 32 degF
- Will correlate bin outdoor temperature with a loop temperature
- AHRI 1600 sizes HP's based upon cooling capacity, AHRI 600 will need to size based upon heating for proper GSHP application
- Proper assessment of AHRI 600-GSHP comparison to AHRI 1600 –CCHP.
- Use fan static of 0.50 in wg for residential.
- Add typical residential system watts of circulating pumps etc.
- Currently under development for addition to AHRI 600

Questions?



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