

Total System Performance Ratio Washington State Energy Code

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Pacific Northwest

Total System Performance Ratio



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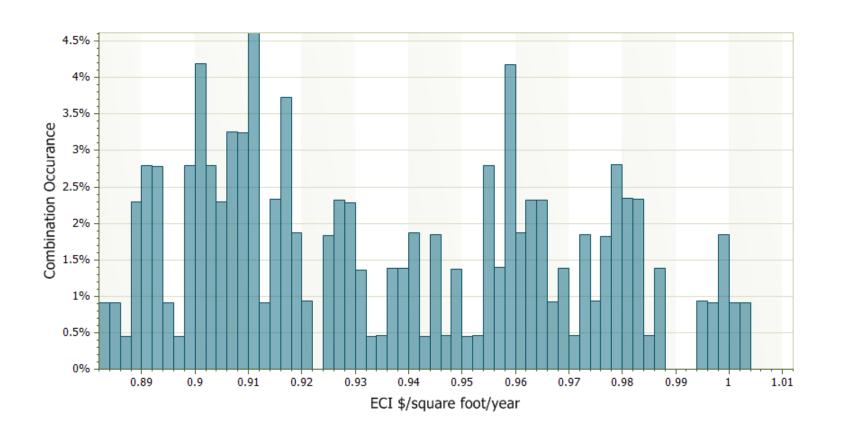
All Systems are Not Created Equal!





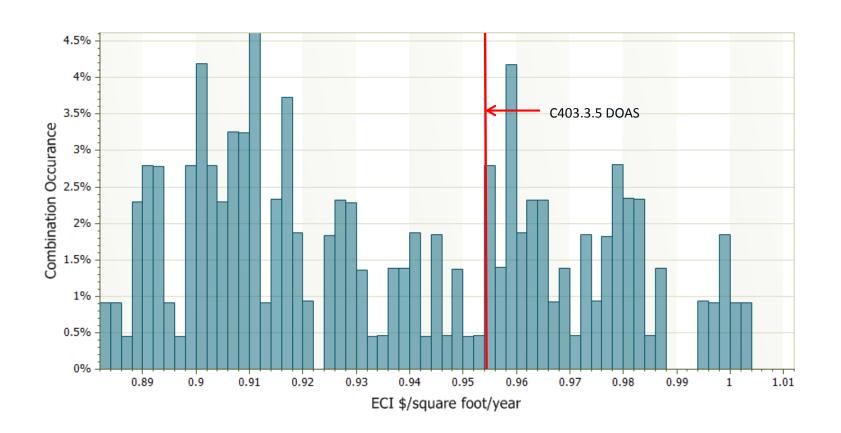


Prescriptive path allows a wide range of HVAC System Performance



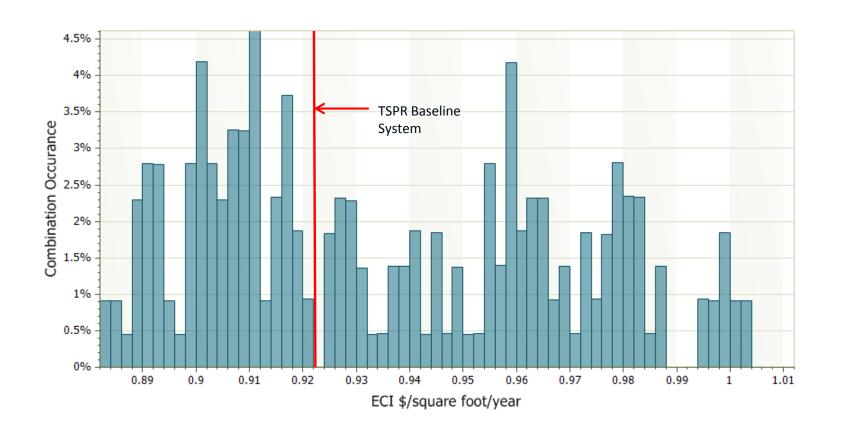


C403.3.5 DOAS eliminates some of the poorest performing options for some occupancies





TSPR – Encourages even higher performing systems but with increased flexibility





$$TSPR = \frac{Annual\ Heating, Cooling, and\ Ventilation\ Loads}{Annual\ Carbon\ Emmissions\ from\ HVAC}$$

- Systems comply if:
 - 1. Proposed TSPR > Baseline System TSPR
 - 2. All other prescriptive and mandatory requirements of Section C403 are met



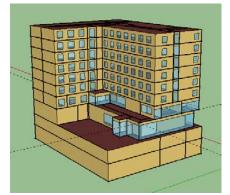
- HVAC System Performance
 - Meant to encourage the use of high efficiency HVAC systems
 - Office
 - Retail
 - Education
 - Library
 - Hope to expand to all building types in the future



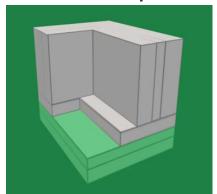
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- Uses energy modeling
- Different from C407 Whole Building Performance:
 - Tradeoffs within HVAC systems only
 - Simplified modeling approach
 - Simplified geometry
 - Default assumptions (loads, schedules, etc.)
 - Compliance tool provided
 - Estimate 50,000 ft² project requires 4-5 hours vs. 75-100 hours for C407
 - Added module to DOE's Asset Score Tool

Typical C407 Energy Model



Asset Score Simplified Model



Standard Reference Design (Baseline) **HVAC**



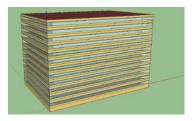
- Establish Standard Reference Design for four occupancy types
 - Based on stakeholder input

Small Office & Library



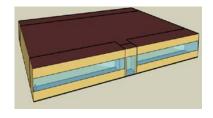
Cycling heat pump with DOAS/FRV

Large Office



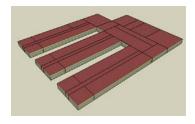
Cycling WLHP w/DOAS/ERV

Retail

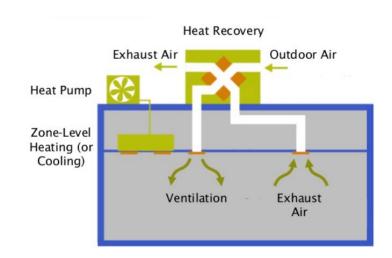


Cycling heat pump with DOAS/ERV & economizer

School



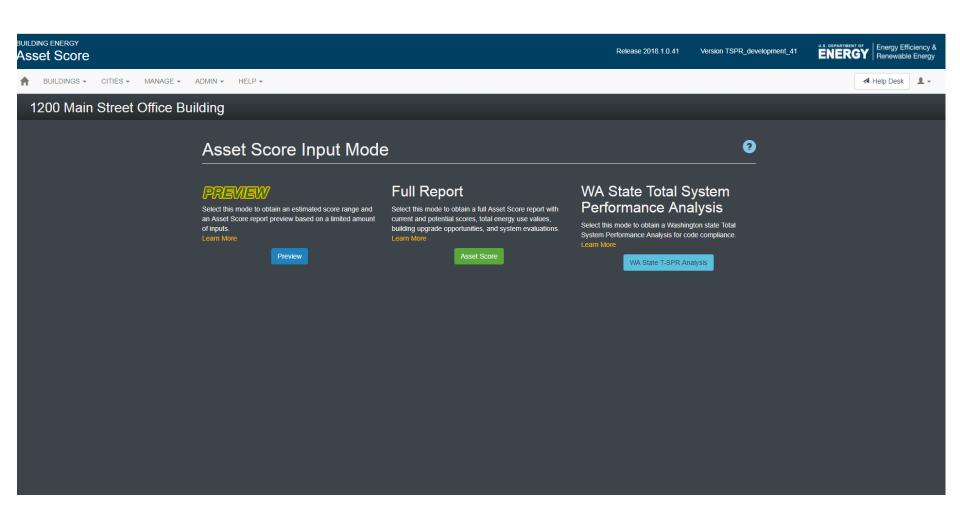
Cycling heat pump with DOAS/ERV & economizer



Dedicated Outdoor Air System

TSPR Compliance Tool - Landing Page





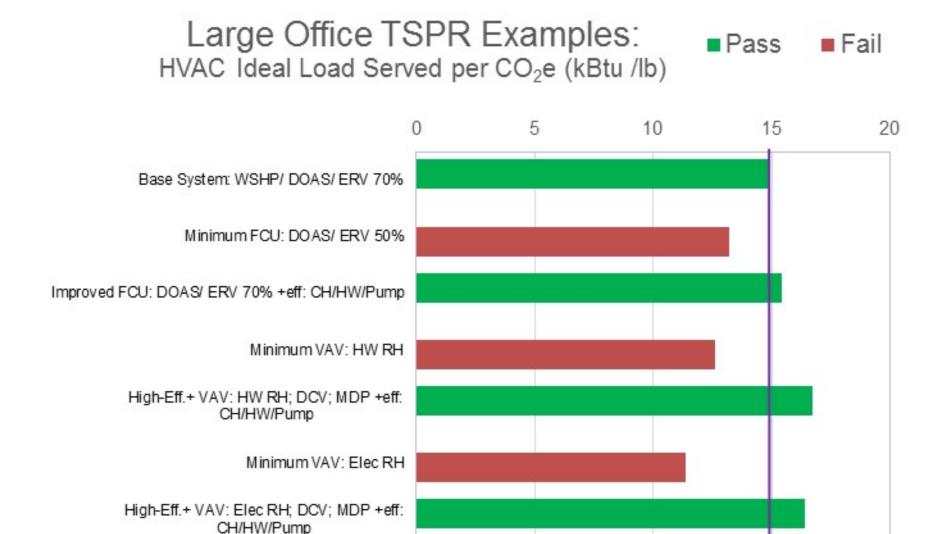
TSPR Compliance Tool - Report



BUILDING INFORMATK)N	
Example Building 2000 A St., Chicago, IL 60601	Building Type: Mtxed-Use Gross Floor Area: 100,000 ft	Analysis Date: 02/21/2013 Building ID #: XXXXXX Software Version XXXXXX
Proposed Building TSPR	:1.1	
Baseline Building TSPR	: 0.9	
Submitted By		
Name Organization Email Phone Number	John Dos XYZ Energy Services johndos@company.com 111-111-1111	
Total Gross Well Area Total Window Area	36750 ft ² 9200 ft ² 40%	
Building Window to Well Ratio Areas by Orientation North		
Gross Wall Area Gross Window Area South Gross Wall Area	9196 6° 2300 6° 9196 6°	
Gross Window Area East Gross Wall Area	2300 ft ²	
Gross Window Area West Gross Wall Area	2300 m ²	
	ALMO IC.	

TSPR Sample Results











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<u>C403.1.1 Total System Performance Ratio.</u> For systems serving office, retail, library and education occupancies subject to the requirements of Section C403.3.5, the Total System Performance Ratio (TSPR) of the <u>proposed design HVAC</u> system shall be more than or equal to the TSPR of the <u>standard reference</u> <u>design</u> as calculated according to Normative Appendix A, Calculation of Total System Performance Ratio.

Exceptions:

- 1. HVAC systems using district heating water, chilled water, or steam.
- 2. Chilled beam systems
- 3. Systems with chilled water supplied by absorption chillers
- **4.** Heating only systems.
- 5. Buildings complying with Section C407, Total Building Performance Path
- **6.** Alterations to existing buildings that do not substantially replace the entire HVAC system.

Normative Appendix A Calculation of Total System Performance Ratio

A.1 Scope. This appendix establishes criteria for demonstring compliance using the *total system* performance ratio (TSPR) for office, retail, and education occupancies. For those occupancies, HVAC systems shall comply with Section C403 and this appendix as required by Section C403.1.1.

Normative Appendix A includes a detailed ruleset serving as specifications for simplified tool

TSPR Option Example Details



System Type	Baseline: DOAS + WLHP	DOAS	+ FCU	VAV with I	HW Reheat	VAV with Electric Reheat				
TSPR Results (Load/CO2e)	14.9	8.8	15.4	12.6	16.7	11.3	16.4			
Efficiency Level	Base	Minimum	Improved	Minimum	Minimum High Efficiency		High Efficiency			
Heating Source, Efficiency	4.61 COP; Et: 80%	Boiler, 80% Boiler, 93% 16 W/GPM 12.8 W/GP AC 2.84 COP AC 3.08 CO 4.0 / 12.0 3.2 / 10.8 NA NA		Boiler, 80% Et	Boiler, 92%, Et	Elec. Resistance	Elec. Resistance			
Boiler Pump Power	NA	16 W/GPM	12.8 W/GPM	16 W/GPM	16 W/GPM	NA	NA			
Cooling Source, Efficiency	DX, 4.46 COP	AC 2.84 COP	AC 3.08 COP	WC 4.69 COP	WC 4.69 COP	WC 4.69 COP	WC 5.17 COP			
Chiller Pump: Pri/2dy (W/GPM)	NA	4.0 / 12.0	3.2 / 10.8	4.0 / 12.0	3.2 / 10.8	4.0 / 12.0	3.2 / 10.8			
Cooling Tower Efficiency; GPM/HP	40.2	NA	NA	38.2	40.2	40.2	40.2			
Fan Control, Fan Power (W/CFM)	On-Off, 0.528	On-Off, 0.16	On-Off, 0.16	VAV, 1.135	VAV, 1.021	VAV, 1.099	VAV, 0.9825			
Reheat Source	NA	NA	NA	HW Reheat	HW Reheat	Electric Reheat	Electric Reheat			
Minimum Airflow Fraction	NA	NA	NA	0.3	0.2	0.3	0.2			
Economizer Control	No	No	No	Yes	Yes	Yes	Yes			
ERV Sensible Effectiveness	0.7	0.5	0.7	NA	0.70	NA	0.70			
DCV Control	No	No	No	No	Yes (50% Area)	No	Yes (50% Area)			

Table A3 Standard Reference Design HVAC Systems

Parameter		Buildi	ng Type			
	Large Office ¹	Small Office and Libraries ¹	Retail	School		
System Type	Water-source Heat Pump	Packaged air- source Heat Pump	Packaged air- source Heat Pump	Packaged air- source Heat Pum		
Fan control ²	Cycle on load	Cycle on load	Cycle on load Cycle on lo			
Space condition fan power (W/cfm)	0.528	0.528	0.522	0.528		
Heating/Cooling sizing factor ³	1.25/1.15	1.25/1.15	1.25/1.15	1.25/1.15		
Supplemental heating availability	NA	<40°F	<40°F	<40°F		
Modeled cooling COP (Net of fan) 4	4.46	3.83	4.25	3.83		
Modeled heating COP (Net of fan) 4	4.61	3.81	3.57	3.81		
Cooling Source	DX (heat pump)	DX (heat pump)	DX (heat pump)	DX (heat pump)		
Heat source	Heat Pump	Heat Pump	Heat Pump	Heat Pump		
OSA Economizer ⁵	No	No	Yes	Yes		
Occupied ventilation source ⁶	DOAS	DOAS	DOAS	DOAS		
DOAS Fan Power (W/cfm of outside air)	0.819	0.819	0.730	0.742		
DOAS temperature control 7,8	Bypass	Wild	Bypass	Bypass		
ERV efficiency (sensible only)	70%	70%	70%	70%		
WSHP Loop Heat Rejection	Cooling Tower 9	NA	NA	NA		
WSHP Loop Heat Source	Gas Boiler 10	NA	NA	NA		
WSHP Loop Temperature Control ¹¹	50°F to 70°F	NA	NA	NA		
WSHP circulation Pump W/gpm ¹²	16	NA	NA	NA		
WSHP Loop Pumping Control ¹³	HP Valves & pump VSD	NA	NA	NA		



Standard Reference Design (Baseline) Other Components



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- Default loads and schedules standardized at ASHRAE Appendix C values
- Lighting power same as proposed design
- Envelope components same as proposed design

Building	Envelope	Trade-Off	Schedules and	Loads

Building Area Type	Schedule Index	Misc. Loads	Ventilation rate	Occupant Density	Occupant Heat Gair (Btu/h-person)			
		(W/ft2)	(cfm/ft2)	(ft2/Person)	Sensible	Latent		
Automotive facility	J	1	0.25	143	375	625		
Convention center	н	0.25	0.31	20	250	200		
Courthouse	A	0.25	0.41	14	250	200		
Dining: bar		0.23	0.41		230	200		
lounge/leisure	В	6	0.93	10	275	275		
Dining:								
cafeteria/fast food	В	6	0.93	10	275	275		
Dining: family	В	6	0.71	14	275	275		
Dormitory	D	0.6	0.11	100	250	200		
Exercise center	H	0.5	0.26	100	710	1090		
Fire station	E	1.5	0.21	33	250	200		
Gymnasium	1	0.5	0.3	33	710	1090		
Health-care clinic	E	2	0.47	200	250	200		
Hospital	E	2	0.47	200	250	200		
Hotel	F	1.11	0.08	250	250	200		
Library	С	1.5	0.11	100	250	200		
Manufacturing								
facility	ر ا	1	0.25	143	580	870		
Motel	F	1.11	0.08	250	250	200		
Motion picture								
theater	н	0.54	1.19	7	225	105		
Multifamily	D	0.62	0.06	380	250	200		
Museum	С	1.5	0.36	25	250	200		
Office	A	0.75	0.09	200	250	200		
Parking garage	K	0.73	0.05	0	250	200		
Penitentiary	F	0.5	0.25	40	250	200		
Performing arts	-	0.5	0.23	40	230	200		
theater	н	0.5	0.76	14	225	105		
Police station	E	1.5	0.76	33	250	200		
Police station Post office	A	1.5	0.21	33	250	200		
		0.96	0.21					
Religious building	H C			8	245	155		
Retail		0.3	0.23	67	250	200		
School/university	G	1.39	0.47	40	250	200		
Sports arena	Н	1	0.3	0	245	105		
Town hall	Α	1	0.09	200	250	200		
Transportation	E	0.5	0.81	10	225	105		
Warehouse	L	0.24	0.06	0	275	475		
Workshop	J	1	0.25	143	635	965		

http://sspc901.ashraepcs.org/documents/Addendum_an_Sched_and_Load.pdf

	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12am	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	T
Occupant																								Ť
Mon – Fri	0	0	0	0	0	0	0.1	0.2	0.95	0.95	0.95	0.95	0.5	0.95	0.95	0.95	0.95	0.3	0.1	0.1	0.1	0.1	0.05	T
Sat	0	0	0	0	0	0	0.1	0.1	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0	0	0	0	T
Sun	0	0	0	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0	0	T
Lighting																								
Mon – Fri	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.3	0.3	0.2	0.2	0.1	I
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.3	0.3	0.3	0.3	0.15	0.15	0.15	0.15	0.15	0.05	0.05	0.05	0.05	0.05	0.05	Ī
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	T
Plug Load	s																							
Mon – Fri	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.9	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.5	0.4	0.4	0.4	0.4	0.4	Ι
Sat	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.35	0.35	0.35	0.35	0.35	0.3	0.3	0.3	0.3	0.3	0.3	Ι
Sun	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	Τ
Infiltratio	n																							
Mon - Fri	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	Ι
Sat	1	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1	1	1	1	Ι
Sun	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	I
Cooling Se	et Poi	nt																						
Mon – Fri	80	80	80	80	80	78	77	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80	I
Sat	80	80	80	80	80	78	77	75	75	75	75	75	75	75	75	75	75	80	80	80	80	80	80	I
Sun	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	I
Heating S	et Poi	int																						
Mon – Fri	60	60	60	60	60	64	67	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	I
Sat	60	60	60	60	60	64	67	70	70	70	70	70	70	70	70	70	70	60	60	60	60	60	60	I
Sun	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	Т