ASHRAE Standard 140-2023

Results Comparison
for
Section 11, Airside HVAC Equipment Performance Tests AE301 through AE445

Results for TRNSYS18.06.0002
(TRNSYS18)
vs.
Informative Annex B16, Section B16.7.2 Example Results

Prepared By
Thermal Energy System Specialists, LLC
(TESS)

Results Developed
19-Aug-2024

ASHRAE Standard 140-2023
Computer Programs, Program Authors, and Producers of Example Results for Section 11, Airside HVAC Equipment Performance Tests AE301 through AE445

The quasi-analytical solution and programs used to generate the example results are described in Table B17-13. The first column of the table ("Model") indicates the program name and version number, or indicates a quasi-analytical solution.

The second column ("Authoring Organization") indicates the national research facility, university, or industry organization with expertise in building science that wrote the simulation software.

The third column ("Implemented By") indicates the national research facility, university, or industry organization with expertise in building science that performed the simulations or did the quasi-analytical solutions. The organizations that performed simulations either ran software written by their organization or otherwise maintained contact with the program authors during the project.

The fourth column ("Abbreviation") indicates the identifying abbreviation used in the results tables and figures.
See Standard 140, Informative Annex B17 for further details.

Table B17-13 Airside HVAC Cases
Participating Organizations and Models

Model	Authoring Organization	Implemented by	Abbreviation
Quasi-Analytical Solution (QAS)	PSU[a]/UNO[b]/TAMU[c]/NREL[d]/JNA[e]/ MDK[f], United States	NREL[d]/JNA[e]/MDK[f], United States	QAS/PSU-TAMU-NREL
DEEAP[g] 1.1.2	AAON, Inc., United States	AAON, Inc., United States	DEEAP/AAON
DeST[h] 2	Tsinghua University, China	Tsinghua University, China / LBNL[i], United States	DeST/TsinghuaU-LBNL
DOE-2.2 V48L	JJH[j]/LBNL[i]/UC[k], United States	NREL[d]/JNA[e]/MDK[f], United States	DOE-2.2/NREL
EnergyPlus 8.2.0	DOE-BT[l], United States	GARD Analytics, Inc., United States	EnergyPlus/GARD
IES-VE[m] 2014.2	IES[n], United Kingdom	IES[n], United Kingdom	IES-VE/IES
LCEM[o] 3.10	MLIT[p], Japan	TTE[q], Japan	LCEM/MLIT-TTE
TRNSYS 17.01.0028	TESS[r]/UWM[s], United States	TESS[r], United States	TRNSYS/TESS

[a] PSU: The Pennsylvania State University, United States
[b] UNO: University of Nebraska - Omaha, United States
[c] TAMU: Texas A&M University, United States
[d] NREL: National Renewable Energy Laboratory, United States
[e] JNA: J. Neymark & Associates, United States
[f] MDK: Mike D. Kennedy, Inc., United States
[g] DEEAP: Detailed Energy and Economic Analysis Program
[h] DeST: Designer's Simulation Toolkit
[i] LBNL: Lawrence Berkeley National Laboratory, United States
[J] JJH: James J. Hirsch & Associates, United States
[k] UC: University of California, United States
[l] DOE-BT: U.S. Department of Energy, Office of Building Technologies, Energy Efficiency and Renewable Energy, United States
[m] IES-VE: Integrated Environmental Solutions - Virtual Environment
[n] IES: Integrated Environmental Solutions, United Kingdom
[o] LCEM: Life Cycle Energy Management tool. *LCEM results were only generated for the FC and SZ system cases (see Informative Annex B16, Section B16.7.1); there are no LCEM results for the CV and VAV system cases (see Informative Annex B16, Section B16.7.2).*
[p] MLIT: Ministry of Land, Infrastructure, Transportation and Tourism, Japan
[q] TTE: Takasago Thermal Engineering, Japan
[r] TESS: Thermal Energy System Specialists, United States
[s] UWM: University of Wisconsin - Madison, United States

ASHRAE Standard 140-2023, Section 11 - Airside HVAC Analytical Verification Tests
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results
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Table B16.7.2-1. CV/VAV Total Coil Load, Heating + Cooling, Sensible & Latent (kWh/h)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	19.05	19.06	19.13	19.87	19.21	19.36	19.04	19.04
AE303	11.45	11.41	10.90	10.89	11.02	11.04	11.44	11.44
AE304	19.09	19.05	19.28	18.17	19.18	19.00	19.09	19.22
AE305	14.10	14.06	13.62	13.22	13.77	13.75	14.09	14.09
AE306	19.09	19.03	19.24	18.41	19.11	18.96	19.08	19.20
AE326	25.49	25.41	25.43	24.36	25.39	25.21	25.51	25.77
AE345	14.42	14.39	13.91	13.62	14.06	14.08	14.43	14.43
AE401	19.64	19.62	19.70	20.42	19.75	19.90	19.62	19.62
AE403	1.46	1.47	1.44	1.40	1.40	1.40	1.45	1.44
AE404	13.32	13.35	14.03	13.38	13.69	13.65	13.31	13.44
AE405	4.10	4.10	4.14	4.11	4.10	4.11	4.09	4.09
AE406	8.22	8.22	8.60	8.17	8.42	8.44	8.22	8.31
AE426	8.83	8.82	9.21	8.83	8.93	8.97	8.80	8.92
AE445	4.16	4.16	4.19	4.17	4.15	4.16	4.14	4.15

Table B16.7.2-2. CV/VAV Total Sensible Coil Load, Heating + Cooling (kWh/h)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	19.05	19.06	19.13	19.87	19.21	19.36	19.04	19.04
AE303	11.45	11.41	10.90	10.89	11.02	11.04	11.44	11.44
AE304	12.83	12.76	12.27	11.96	12.55	12.37	12.83	12.93
AE305	14.10	14.06	13.62	13.22	13.77	13.75	14.09	14.09
AE306	13.65	13.58	13.14	12.98	13.36	13.21	13.64	13.73
AE326	13.19	13.07	12.55	12.65	12.86	12.65	13.21	13.35
AE345	14.42	14.39	13.91	13.62	14.06	14.08	14.43	14.43
AE401	19.64	19.62	19.70	20.42	19.75	19.90	19.62	19.62
AE403	1.46	1.47	1.44	1.40	1.40	1.40	1.45	1.44
AE404	7.40	7.37	7.45	7.46	7.37	7.33	7.39	7.48
AE405	4.10	4.10	4.14	4.11	4.10	4.11	4.09	4.09
AE406	3.64	3.61	3.63	3.68	3.58	3.57	3.63	3.69
AE426	3.59	3.56	3.57	3.64	3.54	3.52	3.58	3.65
AE445	4.16	4.16	4.19	4.17	4.15	4.16	4.14	4.15

Table B16.7.2-3. CV/VAV Pre-Heating Coil Load [QHpreheat] (kWh/h)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	2.95	2.97	3.58	3.79	3.57	3.65	2.95	2.95
AE303	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE304	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE305	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE306	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE326	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE345	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE401	10.26	10.25	10.31	10.82	10.34	10.45	10.26	10.26
AE403	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE404	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE405	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE406	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE426	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE445	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Table B16.7.2-4. CV/VAV Total Cooling Coil Load [QCtotal] (kWh/h)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE303	6.74	6.71	6.46	6.42	6.48	6.48	6.73	6.73
AE304	16.58	16.55	17.07	16.10	16.78	16.66	16.58	16.71
AE305	9.38	9.35	9.18	8.93	9.20	9.20	9.37	9.37
AE306	14.36	14.31	14.80	14.03	14.49	14.40	14.36	14.47
AE326	20.76	20.69	20.99	19.94	20.78	20.65	20.78	21.03
AE345	9.70	9.68	9.47	9.29	9.51	9.53	9.71	9.71
AE401	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE403	1.46	1.47	1.44	1.40	1.40	1.40	1.45	1.44
AE404	13.32	13.35	14.03	13.38	13.69	13.65	13.31	13.44
AE405	4.10	4.10	4.14	4.11	4.10	4.11	4.09	4.09
AE406	8.22	8.22	8.60	8.17	8.42	8.44	8.22	8.31
AE426	8.83	8.82	9.21	8.83	8.93	8.97	8.80	8.92
AE445	4.16	4.16	4.19	4.17	4.15	4.16	4.14	4.15

Table B16.7.2-5. CV/VAV Sensible Cooling Coil Load [QCsensible] (kWh/h)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE303	6.74	6.71	6.46	6.42	6.48	6.48	6.73	6.73
AE304	10.32	10.26	10.06	9.89	10.16	10.03	10.31	10.41
AE305	9.38	9.35	9.18	8.93	9.20	9.20	9.37	9.37
AE306	8.92	8.87	8.70	8.60	8.74	8.65	8.91	9.00
AE326	8.46	8.35	8.11	8.23	8.25	8.10	8.47	8.62
AE345	9.70	9.68	9.47	9.29	9.51	9.53	9.71	9.71
AE401	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE403	1.46	1.47	1.44	1.40	1.40	1.40	1.45	1.44
AE404	7.40	7.37	7.45	7.46	7.37	7.33	7.39	7.48
AE405	4.10	4.10	4.14	4.11	4.10	4.11	4.09	4.09
AE406	3.64	3.61	3.63	3.68	3.58	3.57	3.63	3.69
AE426	3.59	3.56	3.57	3.64	3.54	3.52	3.58	3.65
AE445	4.16	4.16	4.19	4.17	4.15	4.16	4.14	4.15

Table B16.7.2-6. CV/VAV Latent Cooling Coil Load [QClatent] (kWh/h)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE303	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE304	6.26	6.29	7.01	6.21	6.62	6.63	6.26	6.29
AE305	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE306	5.44	5.44	6.10	5.43	5.75	5.75	5.44	5.47
AE326	12.30	12.34	12.88	11.71	12.53	12.56	12.31	12.42
AE345	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE401	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE403	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE404	5.92	5.97	6.58	5.92	6.32	6.31	5.92	5.96
AE405	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE406	4.59	4.61	4.97	4.49	4.84	4.87	4.59	4.62
AE426	5.24	5.27	5.63	5.19	5.39	5.46	5.22	5.26
AE445	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Table B16.7.2-7. CV/VAV Zone 1 Reheat Coil Load [QH1reheat] (kWh/h)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	7.71	7.71	7.47	7.71	7.51	7.54	7.71	7.71
AE303	2.26	2.25	2.14	2.15	2.18	2.19	2.26	2.26
AE304	0.99	0.99	0.86	0.80	0.94	0.92	0.99	0.99
AE305	2.26	2.26	2.14	2.07	2.19	2.19	2.26	2.26
AE306	2.26	2.26	2.14	2.11	2.21	2.19	2.26	2.26
AE326	2.26	2.26	2.14	2.13	2.21	2.19	2.27	2.27
AE345	2.26	2.25	2.14	2.09	2.18	2.19	2.26	2.26
AE401	4.50	4.50	4.50	4.58	4.50	4.52	4.49	4.49
AE403	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE404	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE405	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE406	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE426	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE445	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table B16.7.2-8. CV/VAV Zone 2 Reheat Coil Load [QH2reheat] (kWh/h)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	8.39	8.38	8.08	8.38	8.13	8.17	8.38	8.38
AE303	2.46	2.45	2.30	2.32	2.36	2.37	2.45	2.45
AE304	1.52	1.51	1.35	1.27	1.46	1.42	1.52	1.52
AE305	2.46	2.45	2.30	2.22	2.37	2.37	2.46	2.46
AE306	2.46	2.46	2.30	2.27	2.40	2.37	2.46	2.46
AE326	2.46	2.46	2.30	2.29	2.40	2.37	2.47	2.47
AE345	2.46	2.45	2.30	2.24	2.36	2.37	2.46	2.46
AE401	4.88	4.87	4.89	5.01	4.90	4.93	4.87	4.87
AE403	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE404	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE405	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE406	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE426	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE445	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table B16.7.2-9. CV/VAV Outdoor Air Temperature (°F)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	-29.00	-29.00	-29.00	-29.00	-29.00	-29.00	-29.00	-29.00
AE303	15.50	15.50	15.50	15.50	15.50	15.50	15.50	15.50
AE304	26.90	26.89	26.90	26.89	26.90	26.90	26.90	26.90
AE305	24.90	24.89	24.90	24.89	24.90	24.90	24.90	24.90
AE306	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
AE326	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
AE345	24.90	24.89	24.90	24.89	24.90	24.90	24.90	24.90
AE401	-29.00	-29.00	-29.00	-29.00	-29.00	-29.00	-29.00	-29.00
AE403	15.50	15.50	15.50	15.50	15.50	15.50	15.50	15.50
AE404	26.90	26.89	26.90	26.89	26.90	26.90	26.90	26.90
AE405	24.90	24.89	24.90	24.89	24.90	24.90	24.90	24.90
AE406	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
AE426	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
AE445	24.90	24.89	24.90	24.89	24.90	24.90	24.90	24.90

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Table B16.7.2-10. CV/VAV Outdoor Air Humidity Ratio (g/gda)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.000259	0.000259	0.000260	0.000300	0.000259	0.000262	0.000259	0.000259
AE303	0.002936	0.002895	0.002948	0.002900	0.002933	0.002947	0.002936	0.002936
AE304	0.016774	0.016783	0.016850	0.016800	0.016772	0.016839	0.016774	0.016774
AE305	0.004491	0.004457	0.004510	0.004500	0.004481	0.004508	0.004491	0.004491
AE306	0.015556	0.015523	0.015630	0.015600	0.015565	0.015616	0.015556	0.015556
AE326	0.015556	0.015523	0.015630	0.015600	0.015565	0.015616	0.015556	0.015556
AE345	0.004491	0.004457	0.004510	0.004500	0.004481	0.004508	0.004491	0.004491
AE401	0.000259	0.000259	0.000260	0.000300	0.000259	0.000262	0.000259	0.000259
AE403	0.002936	0.002895	0.002948	0.002900	0.002933	0.002947	0.002936	0.002936
AE404	0.016774	0.016783	0.016850	0.016800	0.016772	0.016839	0.016774	0.016774
AE405	0.004491	0.004457	0.004510	0.004500	0.004481	0.004508	0.004491	0.004491
AE406	0.015556	0.015523	0.015630	0.015600	0.015565	0.015616	0.015556	0.015556
AE426	0.015556	0.015523	0.015630	0.015600	0.015565	0.015616	0.015556	0.015556
AE445	0.004491	0.004457	0.004510	0.004500	0.004481	0.004508	0.004491	0.004491

Table B16.7.2-11. CV/VAV Outdoor Air Mass Flow Rate (kgda/s)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.2814	0.2814	0.2832	0.2965	0.2842	0.2832	0.2814	0.2814
AE303	0.2781	0.2781	0.2832	0.2815	0.2842	0.2832	0.2781	0.2781
AE304	0.2755	0.2756	0.2832	0.2735	0.2842	0.2832	0.2755	0.2755
AE305	0.2774	0.2774	0.2832	0.2774	0.2842	0.2832	0.2774	0.2774
AE306	0.2761	0.2761	0.2832	0.2754	0.2842	0.2832	0.2760	0.2760
AE326	0.7483	0.7484	0.7362	0.7137	0.7389	0.7362	0.7483	0.7483
AE345	0.7535	0.7537	0.7362	0.7217	0.7389	0.7362	0.7535	0.7535
AE401	0.2814	0.2814	0.2832	0.2971	0.2842	0.2832	0.2814	0.2814
AE403	0.2781	0.2781	0.2832	0.2860	0.2842	0.2832	0.2781	0.2781
AE404	0.2753	0.2754	0.2832	0.2729	0.2842	0.2832	0.2753	0.2753
AE405	0.2774	0.2775	0.2832	0.2776	0.2842	0.2832	0.2774	0.2774
AE406	0.2755	0.2756	0.2832	0.2747	0.2842	0.2832	0.2755	0.2755
AE426	0.3321	0.3325	0.3384	0.3294	0.3314	0.3335	0.3313	0.3313
AE445	0.3350	0.3354	0.3383	0.3359	0.3343	0.3335	0.3341	0.3341

Table B16.7.2-12. CV/VAV Cooling Coil Outlet Air Temperature (°C)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22
AE303	12.21	12.21	12.20	12.17	12.20	12.20	12.21	12.21
AE304	12.21	12.21	12.20	12.22	12.20	12.20	12.21	12.21
AE305	12.21	12.21	12.20	12.28	12.20	12.20	12.21	12.21
AE306	12.21	12.21	12.18	12.22	12.20	12.20	12.21	12.21
AE326	12.21	12.21	12.20	12.22	12.20	12.20	12.20	12.20
AE345	12.21	12.21	12.20	12.22	12.20	12.20	12.20	12.20
AE401	7.22	7.22	7.22	7.22	7.20	7.22	7.22	7.22
AE403	12.66	12.65	12.67	12.67	12.66	12.66	12.67	12.68
AE404	12.48	12.46	12.46	12.44	12.47	12.47	12.49	12.49
AE405	12.66	12.65	12.67	12.67	12.66	12.66	12.67	12.67
AE406	12.66	12.65	12.67	12.67	12.66	12.66	12.66	12.66
AE426	12.66	12.65	12.66	12.67	12.66	12.66	12.67	12.67
AE445	12.66	12.65	12.67	12.67	12.66	12.66	12.67	12.67

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301-AE445
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Table B16.7.2-13. CV/VAV Cooling Coil Outlet Relative Humidity [RHcco] (%)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	24.73	24.73		23.96	23.89	24.65	24.64	24.64
AE303	48.15	47.69	48.22	47.92	47.46	48.02	48.18	48.18
AE304	100.00	100.00	95.49	100.00	99.13	100.00	100.00	100.00
AE305	65.72	65.34	65.84	65.53	64.91	65.57	65.75	65.75
AE306	100.00	100.00	96.21	100.00	99.25	100.00	100.00	100.00
AE326	100.00	100.00	98.89	100.00	99.93	100.00	100.00	100.00
AE345	51.09	50.71	51.33	51.14	50.99	51.10	51.11	51.11
AE401	4.14	4.15		4.80	4.15	4.17	4.15	4.15
AE403	36.39	36.01	36.39	34.29	35.85	35.98	36.37	36.35
AE404	100.00	100.00	97.24	100.00	98.71	100.00	100.00	100.00
AE405	53.46	53.17	53.52	51.85	52.78	53.05	53.43	53.44
AE406	100.00	100.00	99.38	100.00	99.76	100.00	100.00	100.00
AE426	100.00	100.00	99.58	100.00	99.95	100.00	100.00	100.00
AE445	49.58	49.24	49.78	49.66	49.46	49.58	49.56	49.56

Table B16.7.2-14. CV/VAV Supply Fan Air Temperature Rise (°C)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.56	0.56	0.59	0.56	0.59	0.58	0.56	0.56
AE303	0.57	0.57	0.59	0.61	0.58	0.58	0.57	0.57
AE304	0.57	0.57	0.59	0.61	0.58	0.58	0.57	0.57
AE305	0.57	0.57	0.59	0.61	0.58	0.58	0.57	0.57
AE306	0.57	0.57	0.59	0.56	0.58	0.58	0.57	0.57
AE326	0.57	0.57	0.59	0.56	0.58	0.58	0.57	0.57
AE345	0.57	0.57	0.59	0.56	0.58	0.58	0.57	0.57
AE401	0.07	0.09	0.09	0.06	0.09	0.09	0.07	0.07
AE403	0.11	0.13	0.13	0.11	0.12	0.12	0.11	0.11
AE404	0.30	0.32	0.33	0.33	0.31	0.31	0.29	0.30
AE405	0.11	0.13	0.12	0.11	0.12	0.12	0.11	0.11
AE406	0.11	0.13	0.12	0.11	0.12	0.12	0.11	0.11
AE426	0.11	0.13	0.12	0.11	0.12	0.12	0.11	0.11
AE445	0.11	0.13	0.12	0.11	0.12	0.12	0.11	0.11

Table B16.7.2-15. CV/VAV Supply Air Temperature (°C)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	7.78	7.78	7.81	7.78	7.81	7.80	7.78	7.78
AE303	12.78	12.78	12.79	12.78	12.78	12.78	12.79	12.79
AE304	12.78	12.78	12.79	12.83	12.78	12.78	12.78	12.79
AE305	12.78	12.78	12.79	12.89	12.78	12.78	12.78	12.78
AE306	12.78	12.78	12.77	12.78	12.78	12.78	12.78	12.78
AE326	12.78	12.78	12.79	12.78	12.78	12.78	12.77	12.77
AE345	12.78	12.78	12.79	12.78	12.78	12.78	12.77	12.77
AE401	7.30	7.31	7.31	7.28	7.29	7.31	7.29	7.29
AE403	12.78	12.78	12.79	12.78	12.78	12.78	12.78	12.79
AE404	12.78	12.78	12.79	12.78	12.78	12.78	12.78	12.78
AE405	12.78	12.78	12.79	12.78	12.78	12.78	12.78	12.78
AE406	12.78	12.78	12.79	12.78	12.78	12.78	12.77	12.77
AE426	12.78	12.78	12.78	12.78	12.78	12.78	12.78	12.78
AE445	12.78	12.78	12.79	12.78	12.78	12.78	12.78	12.78

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301-AE445
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Table B16.7.2-16. CV/VAV Supply Air Humidity Ratio (g/gda)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.001548	0.001548	0.001534	0.001500	0.001496	0.001549	0.001542	0.001542
AE303	0.004231	0.004190	0.004235	0.004200	0.004168	0.004234	0.004236	0.004236
AE304	0.008852	0.008852	0.008443	0.008900	0.008773	0.008891	0.008854	0.008856
AE305	0.005789	0.005755	0.005797	0.005800	0.005716	0.005795	0.005794	0.005794
AE306	0.008852	0.008852	0.008492	0.008900	0.008784	0.008888	0.008856	0.008856
AE326	0.008852	0.008852	0.008747	0.008900	0.008845	0.008909	0.008848	0.008848
AE345	0.004491	0.004457	0.004510	0.004500	0.004481	0.004508	0.004491	0.004491
AE401	0.000259	0.000259	0.000260	0.000300	0.000259	0.000262	0.000259	0.000259
AE403	0.003291	0.003252	0.003288	0.003100	0.003241	0.003265	0.003289	0.003289
AE404	0.009015	0.009004	0.008749	0.009000	0.008894	0.009056	0.009017	0.009018
AE405	0.004846	0.004814	0.004851	0.004700	0.004784	0.004826	0.004835	0.004845
AE406	0.009126	0.009116	0.009068	0.009200	0.009106	0.009175	0.009122	0.009122
AE426	0.009126	0.009116	0.009080	0.009200	0.009124	0.009184	0.009129	0.009129
AE445	0.004491	0.004457	0.004510	0.004500	0.004481	0.004508	0.004491	0.004491

Table B16.7.2-17. CV/VAV Supply Air Specific Volume (L/kgda)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	797.83	797.73	833.33		830.35		793.92	793.92
AE303	815.50	815.34	833.33		830.35		811.55	811.55
AE304	821.52	821.42	833.33		830.35		817.53	817.54
AE305	817.53	817.38	833.33		830.35		813.57	813.57
AE306	821.52	821.42	833.33		830.35		817.53	817.53
AE326	821.52	821.42	833.33		830.35		817.48	817.48
AE345	815.84	815.69	833.33		830.35		811.84	811.84
AE401	794.80	794.73	833.33		830.35		794.28	794.29
AE403	814.28	814.12	833.33		830.35		813.51	813.53
AE404	821.73	821.61	833.33		830.35		819.66	819.67
AE405	816.31	816.16	833.33		830.35		815.52	815.53
AE406	821.88	821.76	833.33		830.35		821.07	821.06
AE426	821.88	821.76	833.33		830.35		821.11	821.11
AE445	815.84	815.69	833.33		830.35		815.07	815.07

Table B16.7.2-18. CV/VAV Supply Air Enthalpy (J/gda)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	11.73		11.71		11.61		11.71	11.71
AE303	23.54		23.55		23.37		23.56	23.56
AE304	35.20		34.16		34.99		35.21	35.22
AE305	27.47		27.49		27.27		27.49	27.49
AE306	35.20		34.26		35.02		35.22	35.22
AE326	35.20		34.93		35.17		35.19	35.19
AE345	24.19		24.24		24.16		24.19	24.19
AE401	7.99		8.00		7.98		7.99	7.99
AE403	21.16		21.16		21.02		21.16	21.17
AE404	35.62		34.93		35.30		35.62	35.63
AE405	25.09		25.10		24.92		25.07	25.09
AE406	35.90		35.74		35.83		35.88	35.88
AE426	35.90		35.76		35.88		35.91	35.91
AE445	24.19		24.24		24.16		24.20	24.20

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301-AE445
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Table B16.7.2-19. CV/VAV Supply Air Mass Flow Rate (kgda/s)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.7705	0.7706	0.7362	0.7709	0.7389	0.7362	0.7705	0.7705
AE303	0.7538	0.7540	0.7362	0.7319	0.7389	0.7362	0.7538	0.7538
AE304	0.7483	0.7484	0.7362	0.7111	0.7389	0.7362	0.7483	0.7483
AE305	0.7520	0.7521	0.7362	0.7213	0.7389	0.7362	0.7519	0.7519
AE306	0.7483	0.7484	0.7362	0.7160	0.7389	0.7362	0.7483	0.7483
AE326	0.7483	0.7484	0.7362	0.7137	0.7389	0.7362	0.7483	0.7483
AE345	0.7535	0.7537	0.7362	0.7217	0.7389	0.7362	0.7535	0.7535
AE401	0.2814	0.2814	0.2832	0.2971	0.2842	0.2832	0.2814	0.2752
AE403	0.3357	0.3361	0.3385	0.3369	0.3351	0.3335	0.3350	0.3348
AE404	0.5392	0.5399	0.5492	0.5354	0.5384	0.5414	0.5388	0.5385
AE405	0.3347	0.3352	0.3383	0.3359	0.3342	0.3335	0.3339	0.3340
AE406	0.3321	0.3325	0.3384	0.3297	0.3315	0.3335	0.3314	0.3312
AE426	0.3321	0.3325	0.3384	0.3294	0.3314	0.3335	0.3313	0.3313
AE445	0.3350	0.3354	0.3383	0.3359	0.3343	0.3335	0.3341	0.3341

Table B16.7.2-20. CV/VAV Outdoor Air Mass Flow to Supply Air Mass Flow Ratio (fraction)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.365	0.365	0.385	0.385	0.385	0.385	0.365	0.365
AE303	0.369	0.369	0.385	0.385	0.385	0.385	0.369	0.369
AE304	0.368	0.368	0.385	0.385	0.385	0.385	0.368	0.368
AE305	0.369	0.369	0.385	0.385	0.385	0.385	0.369	0.369
AE306	0.369	0.369	0.385	0.385	0.385	0.385	0.369	0.369
AE326	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
AE345	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
AE401	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.022
AE403	0.828	0.828	0.837	0.849	0.848	0.849	0.830	0.831
AE404	0.511	0.510	0.516	0.510	0.528	0.523	0.511	0.511
AE405	0.829	0.828	0.837	0.826	0.850	0.849	0.831	0.831
AE406	0.830	0.829	0.837	0.833	0.857	0.849	0.831	0.832
AE426	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
AE445	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table B16.7.2-21. CV/VAV Zone 1 Supply Air Temperature (°C)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	29.28	29.29	29.67		29.65	29.58	29.27	29.27
AE303	19.18	19.18	19.05		19.10	19.10	19.18	19.18
AE304	15.59	15.58	15.31		15.48	15.42	15.59	15.60
AE305	19.18	19.18	19.05		19.11	19.10	19.18	19.18
AE306	19.18	19.18	19.02		19.14	19.10	19.19	19.19
AE326	19.18	19.18	19.05		19.14	19.10	19.19	19.19
AE345	19.18	19.18	19.05		19.10	19.10	19.18	19.18
AE401	46.92	46.95	46.85		46.70	46.50	46.83	46.81
AE403	12.78	12.78	12.79		12.78	12.78	12.78	12.79
AE404	12.78	12.78	12.79		12.78	12.78	12.79	12.78
AE405	12.78	12.78	12.79		12.78	12.78	12.78	12.78
AE406	12.78	12.78	12.79		12.79	12.78	12.77	12.77
AE426	12.78	12.78	12.78		12.79	12.78	12.78	12.78
AE445	12.78	12.78	12.79		12.78	12.78	12.78	12.78

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301-AE445
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results
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Table B16.7.2-22. CV/VAV Zone 1 Air Temperature (°C)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	21.11	21.11	21.11	21.11	21.13	21.11	21.11	21.11
AE303	23.33	23.33	23.33	23.33	23.34	23.33	23.33	23.33
AE304	23.89	23.89	23.89	23.89	23.89	23.89	23.88	23.89
AE305	23.33	23.33	23.33	23.33	23.34	23.33	23.33	23.33
AE306	23.33	23.33	23.33	23.33	23.34	23.33	23.33	23.33
AE326	23.33	23.33	23.33	23.33	23.34	23.33	23.33	23.33
AE345	23.33	23.33	23.33	23.33	23.34	23.33	23.33	23.33
AE401	21.11	21.11	21.11	21.11	21.15	21.11	21.12	21.10
AE403	23.33	23.33	23.33	23.33	23.34	23.33	23.33	23.34
AE404	23.89	23.89	23.89	23.89	23.90	23.89	23.88	23.88
AE405	23.33	23.33	23.33	23.33	23.34	23.33	23.33	23.33
AE406	23.33	23.33	23.33	23.33	23.34	23.33	23.32	23.32
AE426	23.33	23.33	23.33	23.33	23.34	23.33	23.33	23.33
AE445	23.33	23.33	23.33	23.33	23.34	23.33	23.33	23.33

Table B16.7.2-23. CV/VAV Zone 1 Humidity Ratio (g/gda)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.002197	0.002197	0.002225		0.002172	0.002253	0.002187	0.002187
AE303	0.004893	0.004852	0.004930		0.004844	0.004938	0.004900	0.004900
AE304	0.009518	0.009519	0.009140		0.009448	0.009595	0.009525	0.009527
AE305	0.006453	0.006419	0.006492		0.006391	0.006499	0.006460	0.006460
AE306	0.009519	0.009519	0.009190		0.009459	0.009592	0.009525	0.009525
AE326	0.009519	0.009519	0.009442		0.009520	0.009613	0.009517	0.009517
AE345	0.005153	0.005119	0.005204		0.005156	0.005212	0.005155	0.005155
AE401	0.002304	0.002303	0.002332		0.002289	0.002374	0.002269	0.002295
AE403	0.004970	0.004930	0.004996		0.004925	0.005021	0.004988	0.004986
AE404	0.009908	0.009895	0.009651		0.009788	0.009980	0.009921	0.009919
AE405	0.006530	0.006497	0.006557		0.006473	0.006582	0.006537	0.006549
AE406	0.010823	0.010812	0.010775		0.010803	0.010931	0.010838	0.010837
AE426	0.010823	0.010812	0.010787		0.010825	0.010940	0.010844	0.010844
AE445	0.006174	0.006139	0.006216		0.006169	0.006264	0.006192	0.006192

Table B16.7.2-24. CV/VAV Zone 2 Supply Air Temperature (°C)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	27.82	27.83	28.08		28.09	28.03	27.81	27.81
AE303	18.75	18.74	18.57		18.64	18.64	18.75	18.75
AE304	16.46	16.46	16.19		16.36	16.29	16.48	16.48
AE305	18.75	18.74	18.57		18.66	18.64	18.75	18.75
AE306	18.75	18.75	18.54		18.69	18.64	18.76	18.76
AE326	18.75	18.75	18.57		18.69	18.64	18.76	18.76
AE345	18.75	18.74	18.57		18.64	18.64	18.75	18.75
AE401	36.04	36.05	35.95		35.89	35.77	35.99	36.00
AE403	12.78	12.78	12.79		12.78	12.78	12.78	12.79
AE404	12.78	12.78	12.79		12.78	12.78	12.79	12.78
AE405	12.78	12.78	12.79		12.78	12.78	12.78	12.78
AE406	12.78	12.78	12.79		12.79	12.78	12.77	12.77
AE426	12.78	12.78	12.78		12.79	12.78	12.78	12.78
AE445	12.78	12.78	12.79		12.78	12.78	12.78	12.78

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TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Table B16.7.2-25. CV/VAV Zone 2 Air Temperature (°C)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	22.22	22.22	22.22	22.22	22.25	22.22	22.22	22.22
AE303	24.44	24.44	24.44	24.44	24.45	24.44	24.44	24.44
AE304	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
AE305	24.44	24.44	24.44	24.44	24.45	24.44	24.44	24.44
AE306	24.44	24.44	24.44	24.44	24.45	24.44	24.44	24.44
AE326	24.44	24.44	24.44	24.44	24.45	24.44	24.44	24.44
AE345	24.44	24.44	24.44	24.44	24.45	24.44	24.44	24.44
AE401	22.22	22.22	22.22	22.22	22.26	22.22	22.22	22.20
AE403	24.44	24.44	24.44	24.44	24.46	24.44	24.44	24.45
AE404	25.00	25.00	25.00	25.00	25.02	25.00	25.00	25.00
AE405	24.44	24.44	24.44	24.44	24.46	24.44	24.44	24.44
AE406	24.44	24.44	24.44	24.44	24.46	24.44	24.43	24.44
AE426	24.44	24.44	24.44	24.44	24.46	24.44	24.44	24.44
AE445	24.44	24.44	24.44	24.44	24.46	24.44	24.44	24.44

Table B16.7.2-26. CV/VAV Zone 2 Humidity Ratio (g/gda)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.002382	0.002382	0.002421		0.002365	0.002454	0.002372	0.002372
AE303	0.005081	0.005040	0.005135		0.005036	0.005139	0.005090	0.005090
AE304	0.009708	0.009708	0.009340		0.009640	0.009796	0.009716	0.009718
AE305	0.006642	0.006608	0.006697		0.006584	0.006700	0.006650	0.006650
AE306	0.009709	0.009709	0.009390		0.009652	0.009793	0.009716	0.009716
AE326	0.009709	0.009709	0.009650		0.009713	0.009814	0.009708	0.009708
AE345	0.005342	0.005308	0.005409		0.005349	0.005413	0.005345	0.005345
AE401	0.002310	0.002310	0.002330		0.002287	0.002374	0.002289	0.002292
AE403	0.005029	0.004989	0.005071		0.004985	0.005084	0.005049	0.005048
AE404	0.010241	0.010229	0.009998		0.010124	0.010327	0.010261	0.010258
AE405	0.006590	0.006556	0.006633		0.006533	0.006645	0.006598	0.006609
AE406	0.010883	0.010871	0.010849		0.010863	0.010994	0.010900	0.010900
AE426	0.010883	0.010871	0.010861		0.010885	0.011003	0.010906	0.010906
AE445	0.006234	0.006197	0.006292		0.006229	0.006327	0.006253	0.006253

Table B16.7.2-27. CV/VAV Moisture Added to Zone 1 by Latent Gains (g/s)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.231	0.231	0.235		0.231	0.239	0.229	0.229
AE303	0.230	0.230	0.236		0.230	0.239	0.231	0.231
AE304	0.230	0.230	0.237		0.230	0.239	0.232	0.232
AE305	0.230	0.230	0.236		0.230	0.239	0.231	0.231
AE306	0.230	0.230	0.237		0.230	0.239	0.231	0.231
AE326	0.230	0.230	0.236		0.230	0.239	0.231	0.231
AE345	0.230	0.230	0.236		0.230	0.239	0.231	0.231
AE401	0.231	0.231	0.235		0.231	0.239	0.226	0.226
AE403	0.230	0.230	0.236		0.230	0.239	0.232	0.232
AE404	0.230	0.230	0.237		0.230	0.239	0.232	0.232
AE405	0.230	0.230	0.236		0.230	0.239	0.232	0.232
AE406	0.230	0.230	0.236		0.230	0.239	0.232	0.232
AE426	0.230	0.230	0.236		0.230	0.239	0.232	0.232
AE445	0.230	0.230	0.236		0.230	0.239	0.232	0.232

[(Zone Supply Air Mass Flow) × {(Zone Humidity Ratio) – (Zone Supply Air Humidity Ratio)} × 1000 g/kg]

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Table B16.7.2-28. CV/VAV Moisture Added to Zone 2 by Latent Gains (g/s)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.346	0.346	0.352		0.346	0.359	0.344	0.344
AE303	0.345	0.345	0.356		0.345	0.359	0.347	0.347
AE304	0.345	0.345	0.356		0.345	0.359	0.347	0.347
AE305	0.345	0.345	0.356		0.345	0.359	0.347	0.347
AE306	0.345	0.345	0.356		0.345	0.359	0.347	0.347
AE326	0.345	0.345	0.358		0.345	0.359	0.347	0.347
AE345	0.345	0.345	0.356		0.345	0.359	0.347	0.347
AE401	0.346	0.346	0.352		0.346	0.359	0.342	0.343
AE403	0.345	0.345	0.357		0.345	0.359	0.349	0.348
AE404	0.345	0.345	0.358		0.345	0.359	0.348	0.348
AE405	0.345	0.345	0.356		0.345	0.359	0.348	0.349
AE406	0.345	0.345	0.356		0.345	0.359	0.349	0.348
AE426	0.345	0.345	0.356		0.345	0.359	0.348	0.348
AE445	0.345	0.345	0.357		0.345	0.359	0.348	0.348

[(Zone Supply Air Mass Flow) × {(Zone Humidity Ratio) – (Zone Supply Air Humidity Ratio)} × 1000 g/kg]

Table B16.7.2-29. CV/VAV Return Fan Air Temperature Rise (°C)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301	0.35	0.30	0.29		0.29	0.29	0.35	0.35
AE303	0.34	0.30	0.29		0.29	0.29	0.34	0.34
AE304	0.34	0.30	0.29		0.29	0.29	0.34	0.34
AE305	0.34	0.30	0.29		0.29	0.29	0.34	0.34
AE306	0.34	0.30	0.29		0.29	0.29	0.34	0.34
AE326	0.34	0.30	0.29		0.29	0.29	0.34	0.34
AE345	0.34	0.30	0.29		0.29	0.29	0.34	0.34
AE401								0.00
AE403	0.00	0.03	0.00		0.00	0.01	0.00	0.00
AE404	0.11	0.11	0.10		0.09	0.10	0.11	0.11
AE405	0.00	0.01	0.00		0.00	0.01	0.00	0.00
AE406	0.00	0.01	0.00		0.00	0.01	0.00	0.00
AE426	0.00	0.01	0.00		0.00	0.01	0.00	0.00
AE445	0.00	0.01	0.00		0.00	0.01	0.00	0.00

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Table B16.7.2-30. CV/VAV Delta Preheat Coil Load, CV - VAV (kWh/h)

Test case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301 - AE401	-7.31	-7.28	-6.73	-7.03	-6.77	-6.80	-7.31	-7.31
AE303 - AE403	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE304 - AE404	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE305 - AE405	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE306 - AE406	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE326 - AE426	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE345 - AE445	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table B16.7.2-31. CV/VAV Delta Sensible Cooling Coil Load, CV - VAV (kWh/h)

Test case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301 - AE401	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE303 - AE403	5.28	5.24	5.02	5.02	5.08	5.08	5.28	5.28
AE304 - AE404	2.92	2.88	2.61	2.43	2.79	2.70	2.93	2.94
AE305 - AE405	5.28	5.24	5.04	4.81	5.10	5.08	5.28	5.28
AE306 - AE406	5.29	5.26	5.07	4.92	5.16	5.09	5.29	5.31
AE326 - AE426	4.87	4.79	4.54	4.59	4.71	4.58	4.89	4.96
AE345 - AE445	5.55	5.52	5.28	5.11	5.36	5.37	5.56	5.56

Table B16.7.2-32. CV/VAV Delta Latent Cooling Coil Load, CV - VAV (kWh/h)

Test case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301 - AE401	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE303 - AE403	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE304 - AE404	0.33	0.32	0.43	0.30	0.30	0.32	0.34	0.33
AE305 - AE405	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE306 - AE406	0.86	0.84	1.13	0.94	0.91	0.88	0.85	0.85
AE326 - AE426	7.07	7.08	7.25	6.52	7.14	7.10	7.09	7.15
AE345 - AE445	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table B16.7.2-33. CV/VAV Delta Total Cooling Coil Load, CV - VAV (kWh/h)

Test case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE301 - AE401	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE303 - AE403	5.28	5.24	5.02	5.02	5.08	5.08	5.28	5.28
AE304 - AE404	3.26	3.20	3.04	2.73	3.09	3.02	3.27	3.26
AE305 - AE405	5.28	5.24	5.04	4.81	5.10	5.08	5.28	5.28
AE306 - AE406	6.14	6.10	6.21	5.86	6.07	5.97	6.14	6.16
AE326 - AE426	11.93	11.87	11.79	11.11	11.85	11.68	11.97	12.12
AE345 - AE445	5.55	5.52	5.28	5.11	5.36	5.37	5.56	5.56

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301-AE445
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results
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Table B16.7.2-34. CV Delta Cooling Coil Load, Economizer Operation (kWh/h)

Test case	Load	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE345-AE305	Total Cooling	0.32	0.33	0.29	0.36	0.31	0.33	0.33	0.33
	Sensible Cooling	0.32	0.33	0.29	0.36	0.31	0.33	0.33	0.33
	Latent Cooling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE326 - AE306	Total Cooling	6.40	6.38	6.19	5.91	6.29	6.25	6.42	6.56
	Sensible Cooling	-0.46	-0.52	-0.58	-0.37	-0.50	-0.56	-0.44	-0.39
	Latent Cooling	6.86	6.90	6.78	6.28	6.78	6.81	6.86	6.95

Table B16.7.2-35. VAV Delta Cooling Coil Load, Economizer Operation (kWh/h)

Test case	Load	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	TRNSYS TESS	TRNSYS18 TESS
AE445-AE405	Total Cooling	0.06	0.05	0.05	0.06	0.05	0.05	0.05	0.05
	Sensible Cooling	0.06	0.05	0.05	0.06	0.05	0.05	0.05	0.05
	Latent Cooling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AE426 - AE406	Total Cooling	0.61	0.61	0.61	0.66	0.51	0.54	0.59	0.60
	Sensible Cooling	-0.04	-0.05	-0.05	-0.04	-0.04	-0.05	-0.04	-0.04
	Latent Cooling	0.65	0.66	0.66	0.69	0.55	0.59	0.63	0.64

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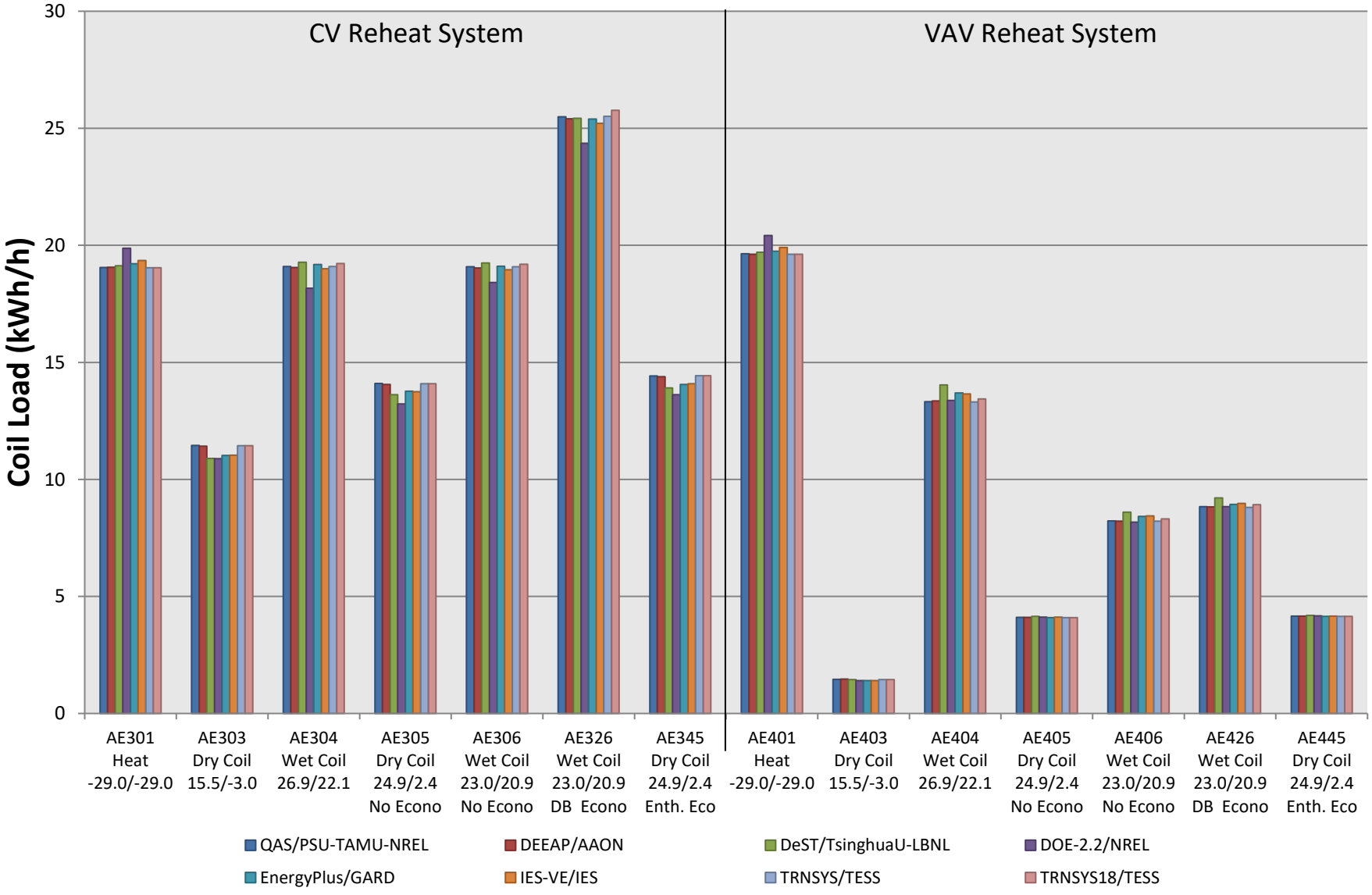
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-1. CV/VAV Total Coil Load, Heating + Cooling, Sensible & Latent



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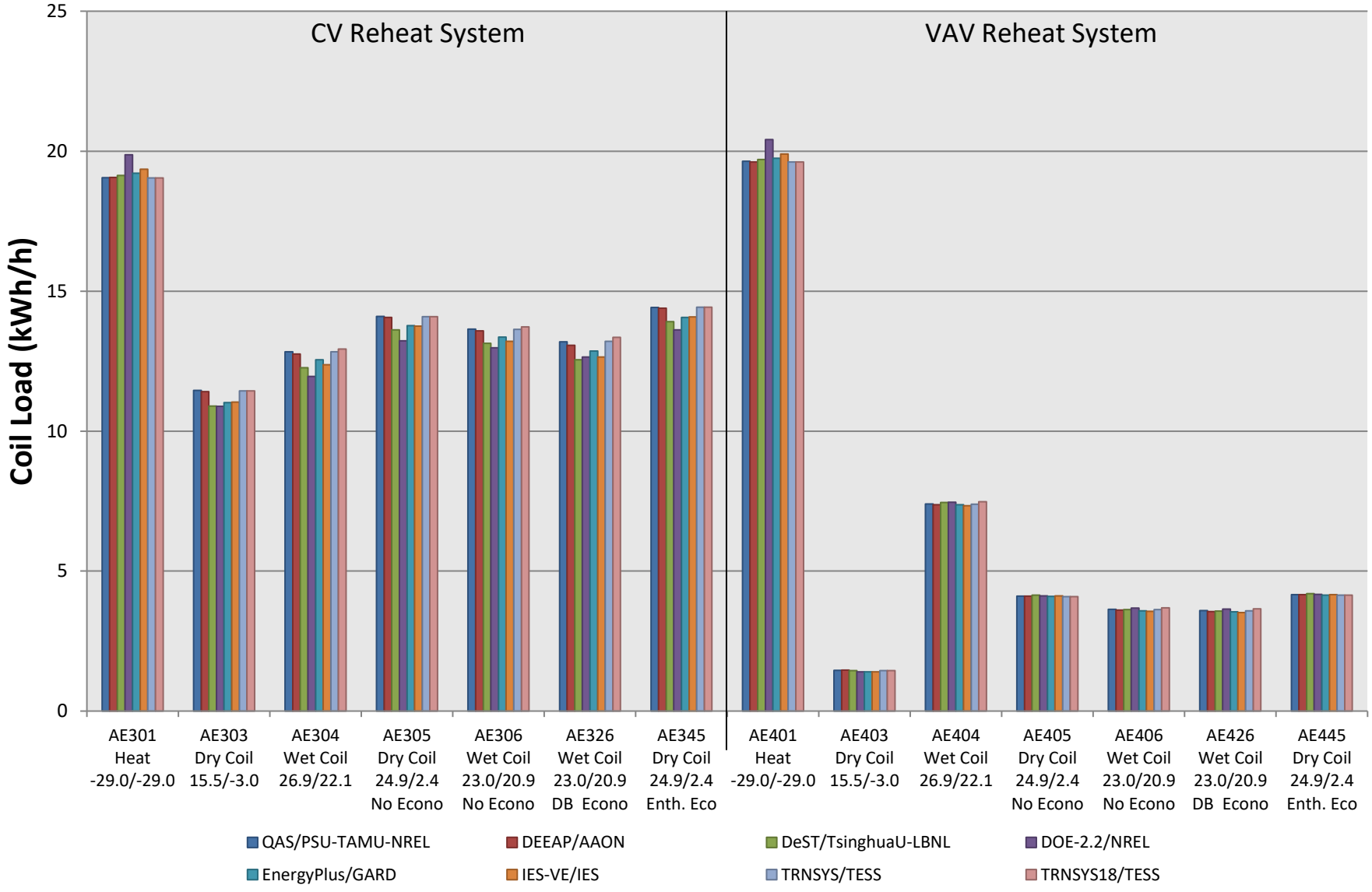
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-2. CV/VAV Total Sensible Coil Load, Heating + Cooling



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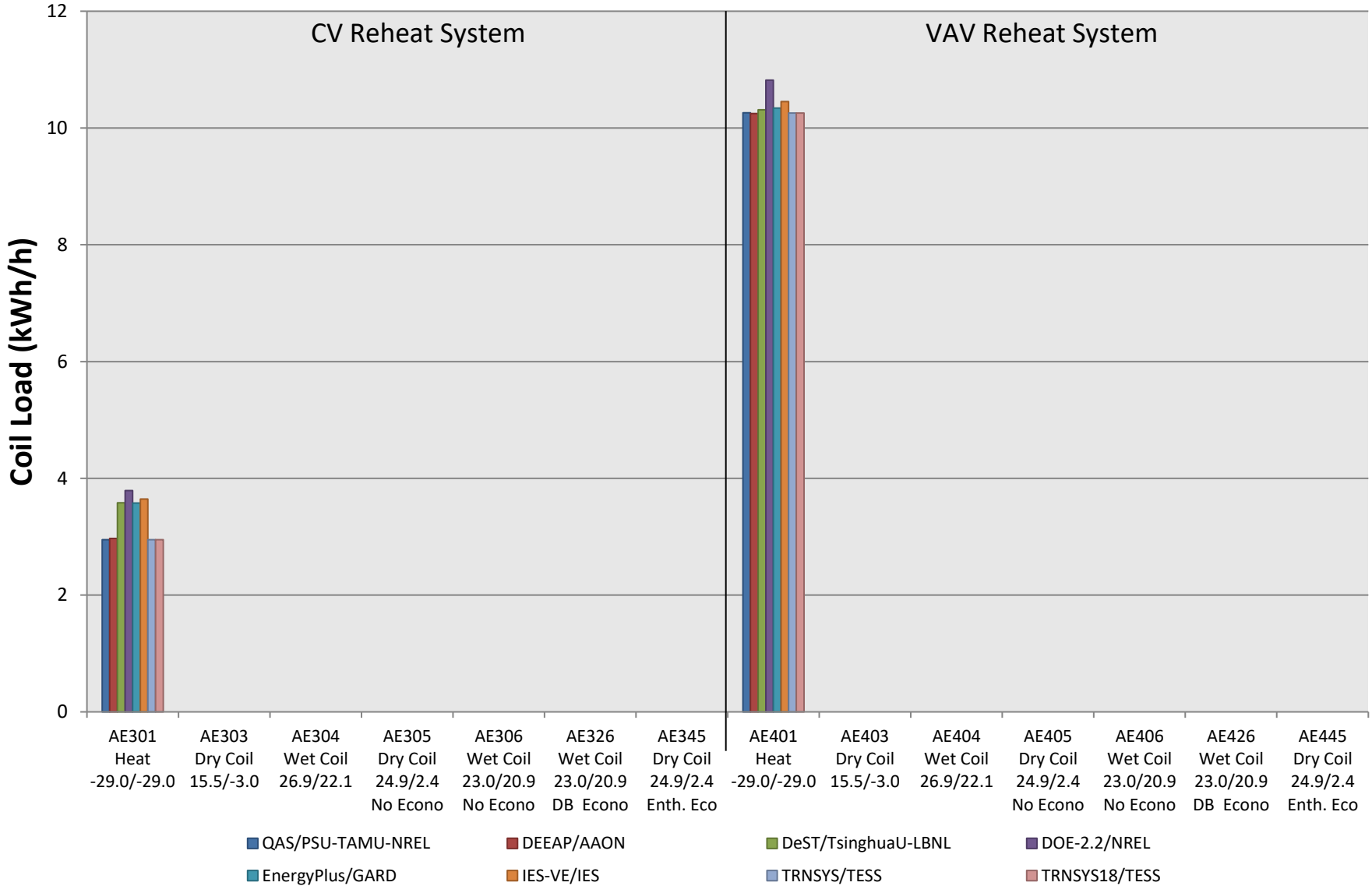
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-3. CV/VAV Pre-Heating Coil Load [QHpreheat]



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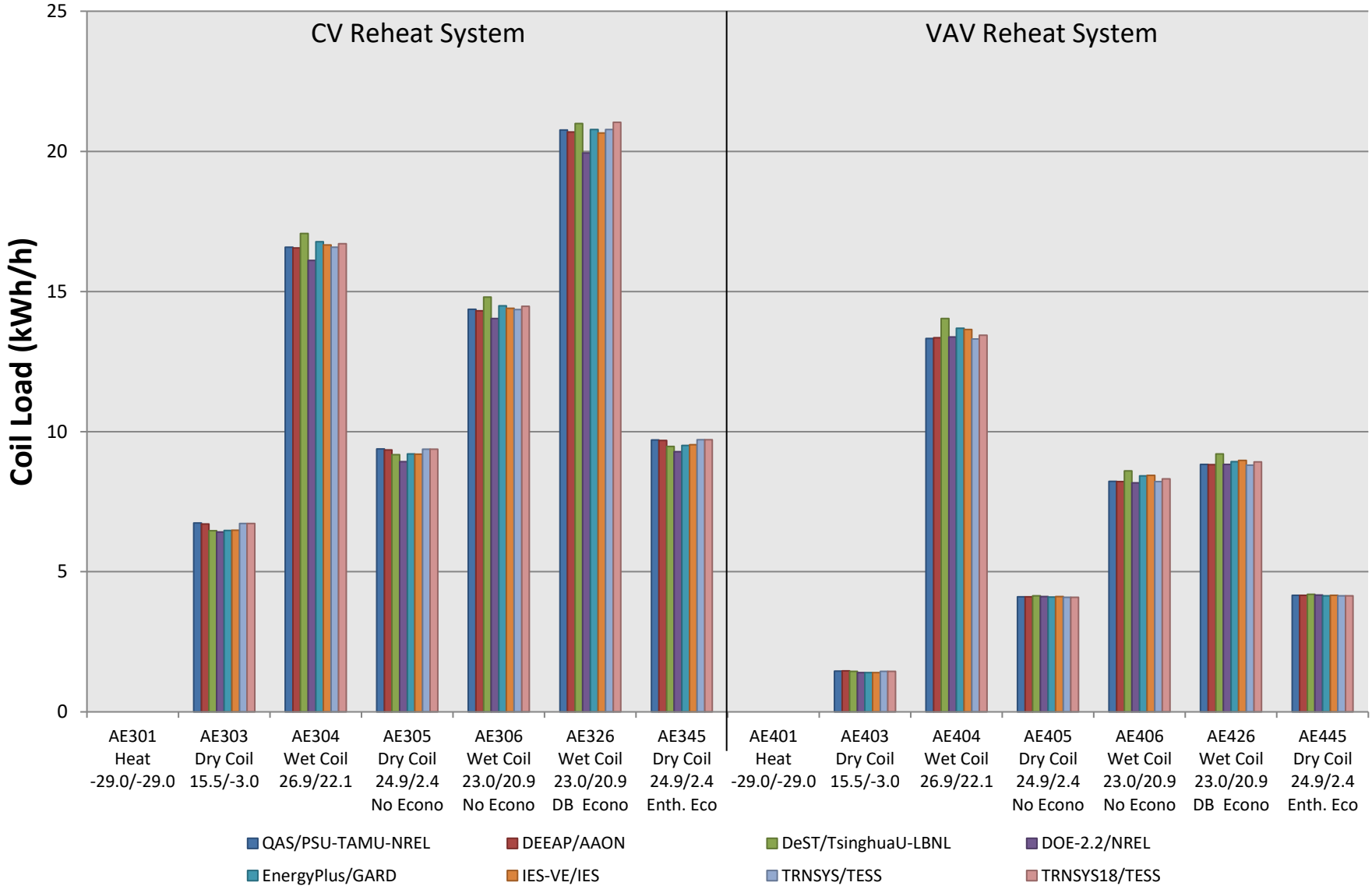
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-4. CV/VAV Cooling Coil Load, Total [QCtotal]



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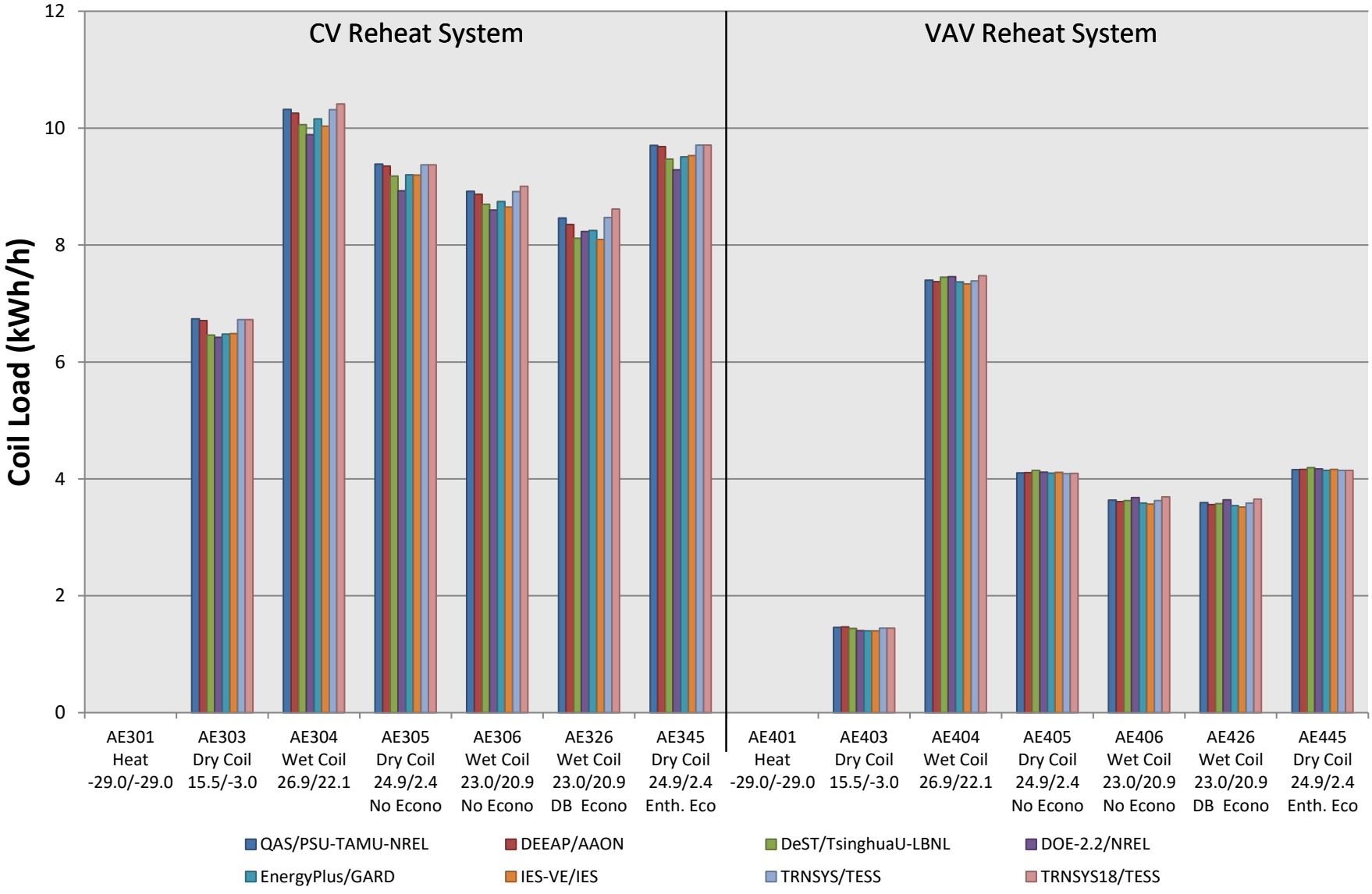
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-5. CV/VAV Cooling Coil Load, Sensible [QCsensible]



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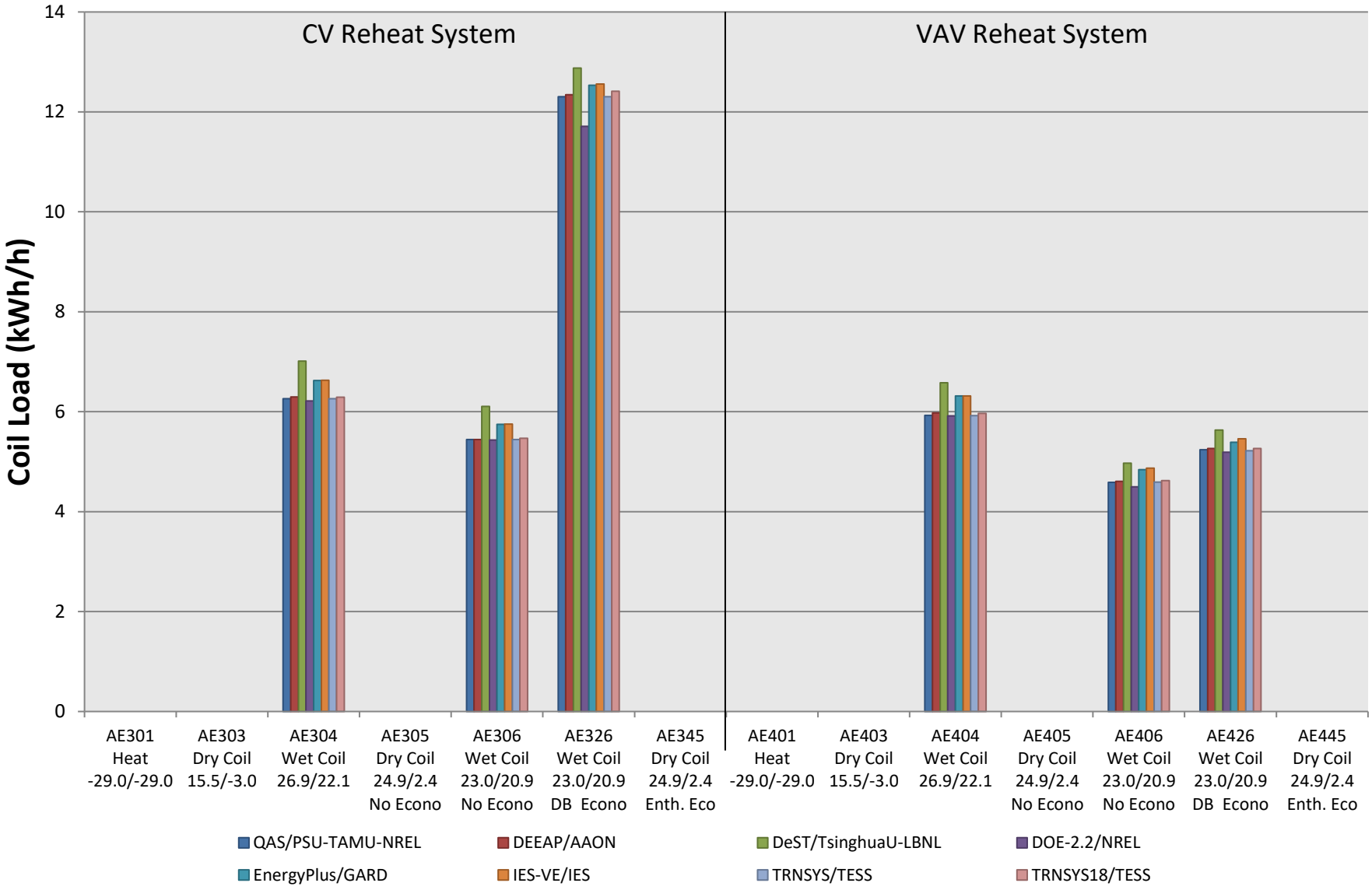
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

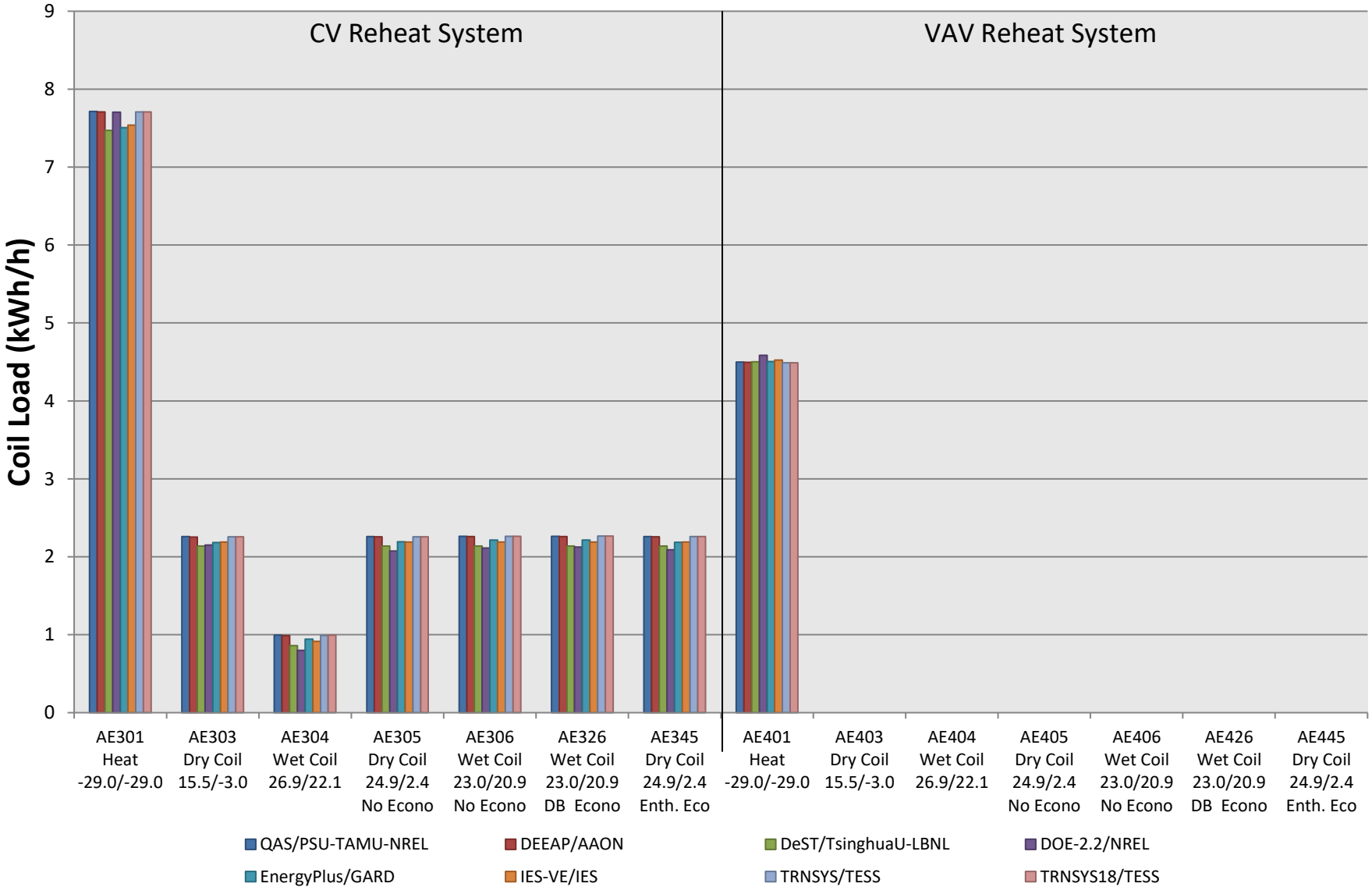
Figure B16.7.2-6. CV/VAV Cooling Coil Load, Latent [QClatent]



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-7. CV/VAV Zone 1 Reheat Load [QH1reheat]



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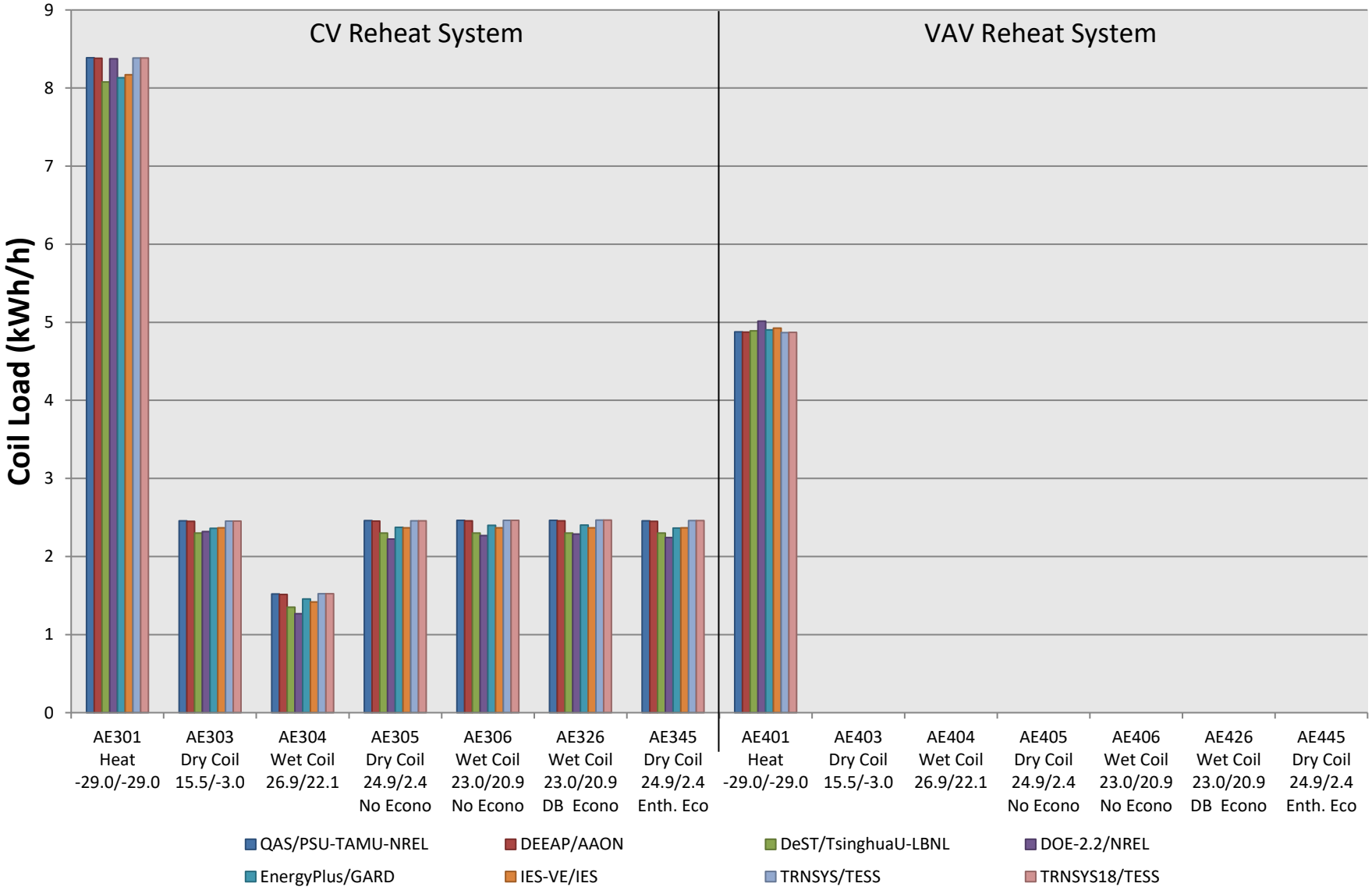
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-8. CV/VAV Zone 2 Reheat Load [QH2reheat]



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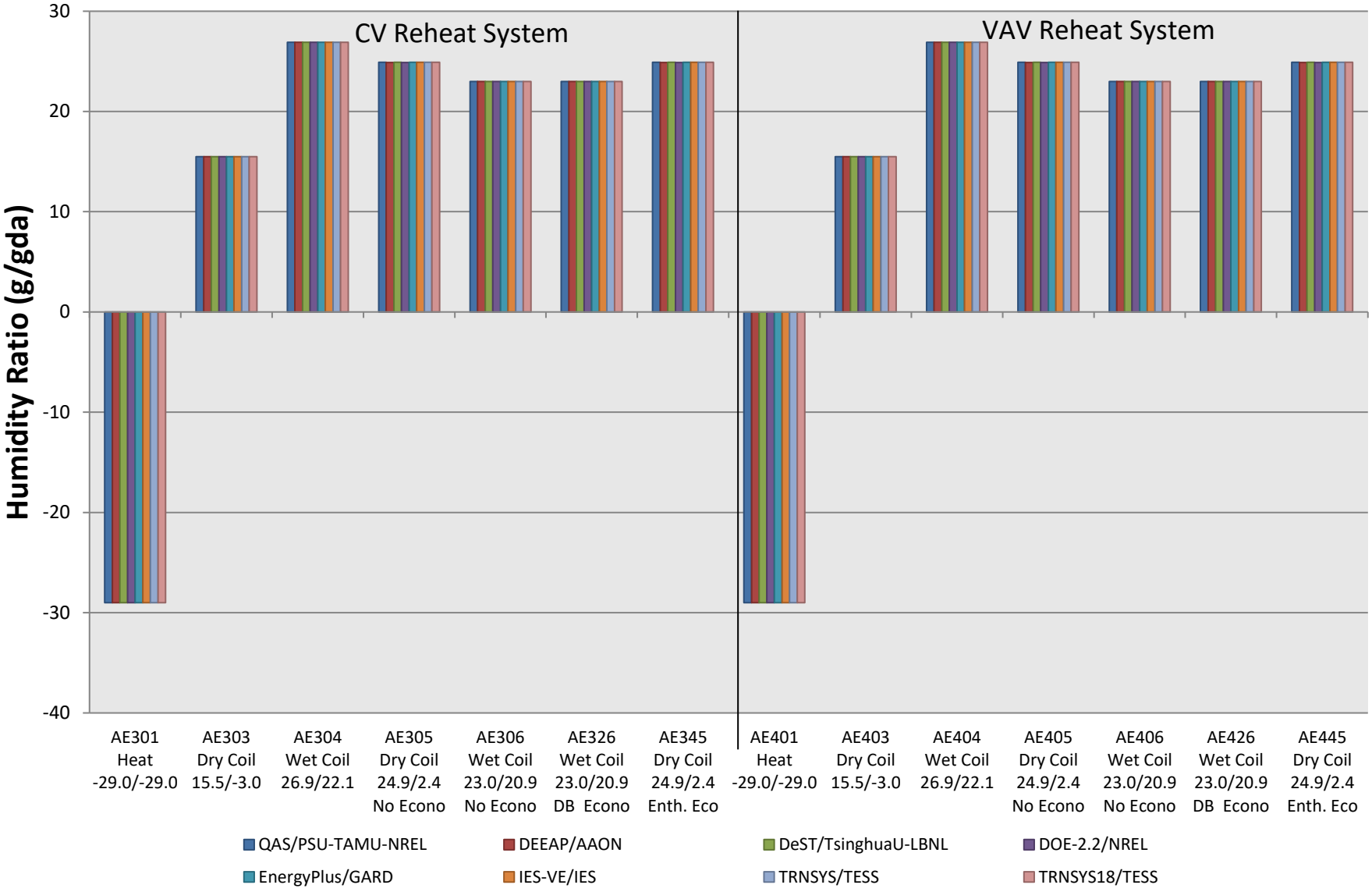
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

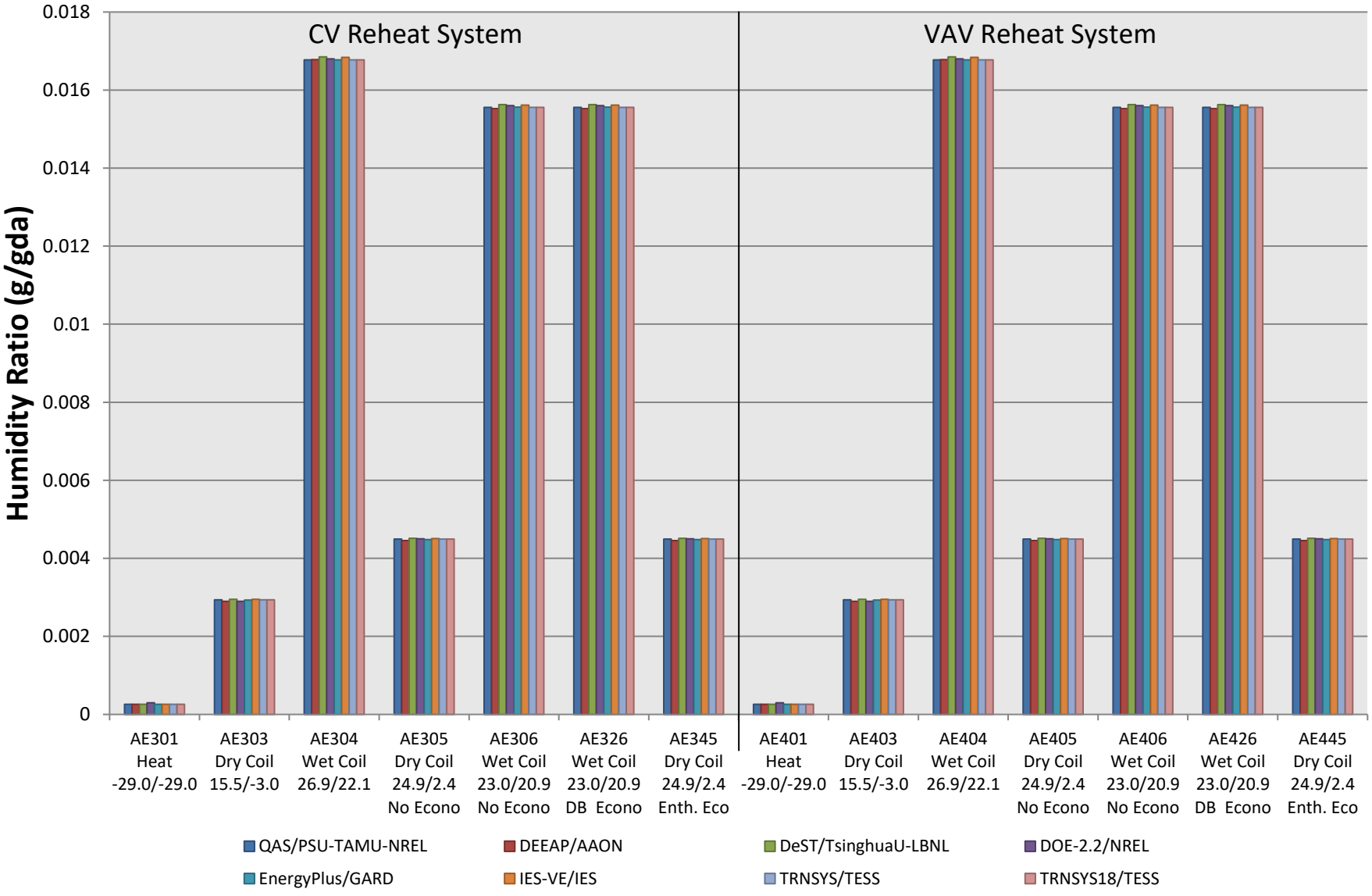
Figure B16.7.2-9. CV/VAV Outdoor Air Temperature



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

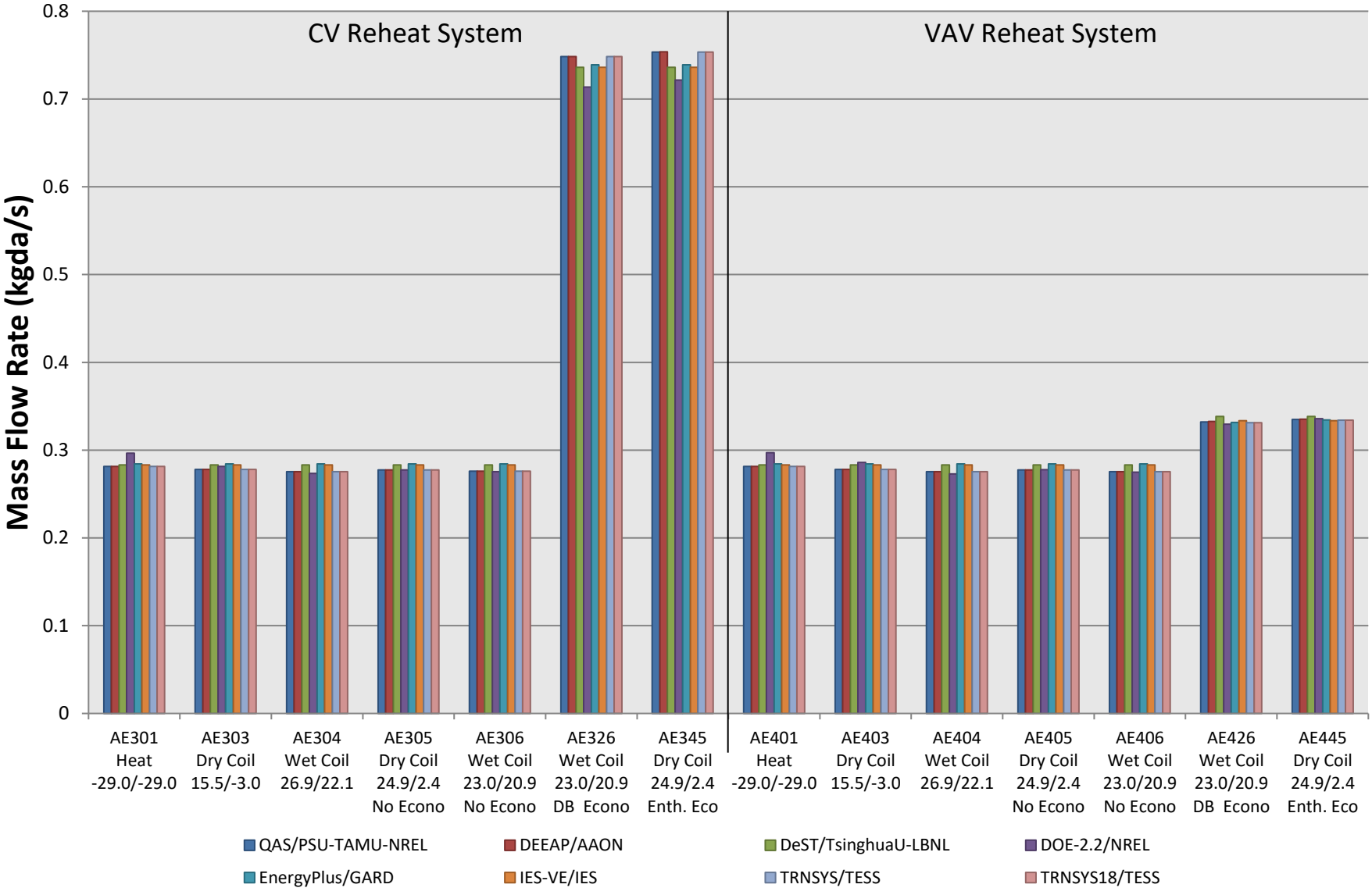
Figure B16.7.2-10. CV/VAV Outdoor Air Humidity Ratio



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

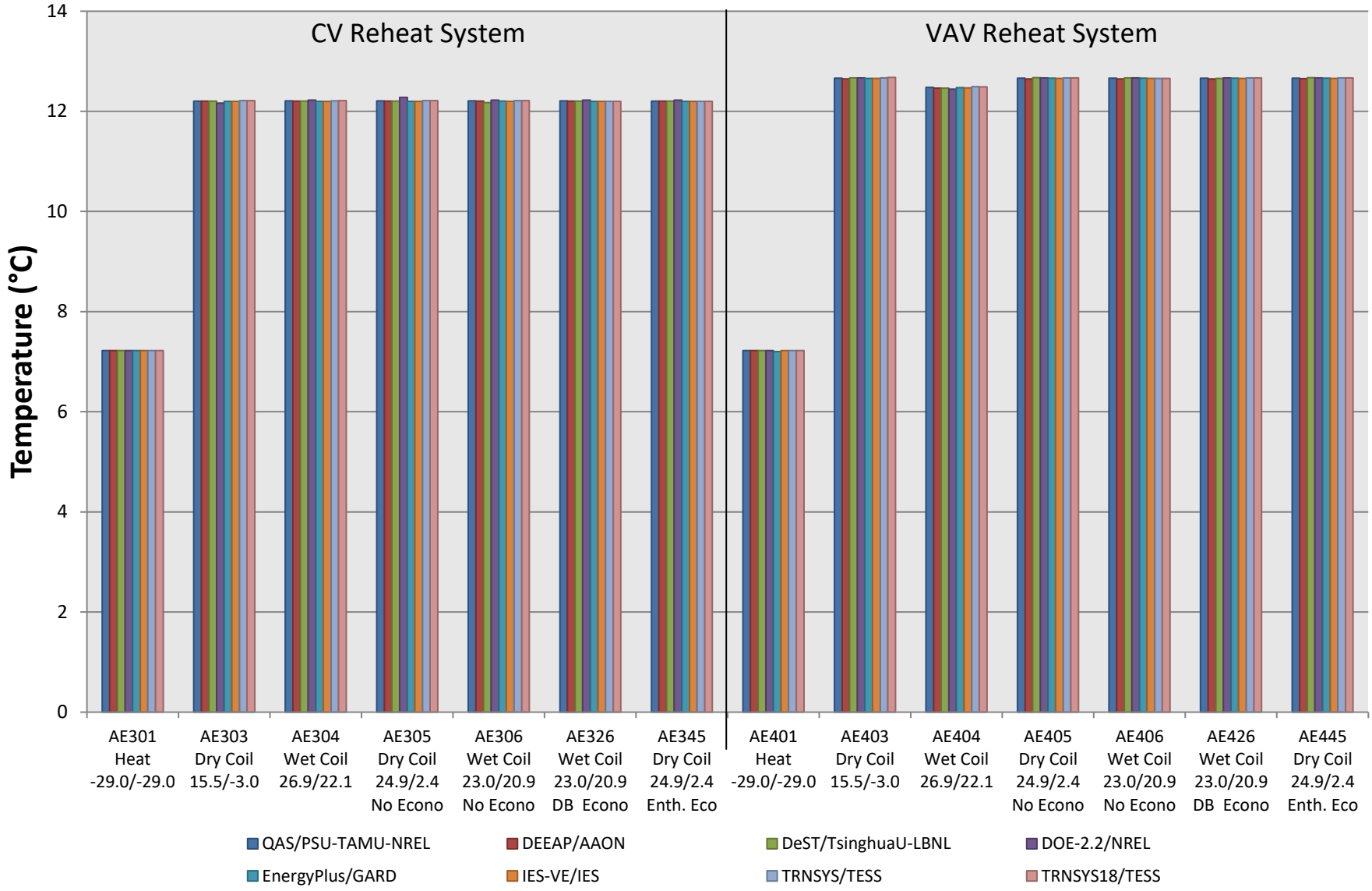
Figure B16.7.2-11. CV/VAV Outdoor Air Mass Flow Rate



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

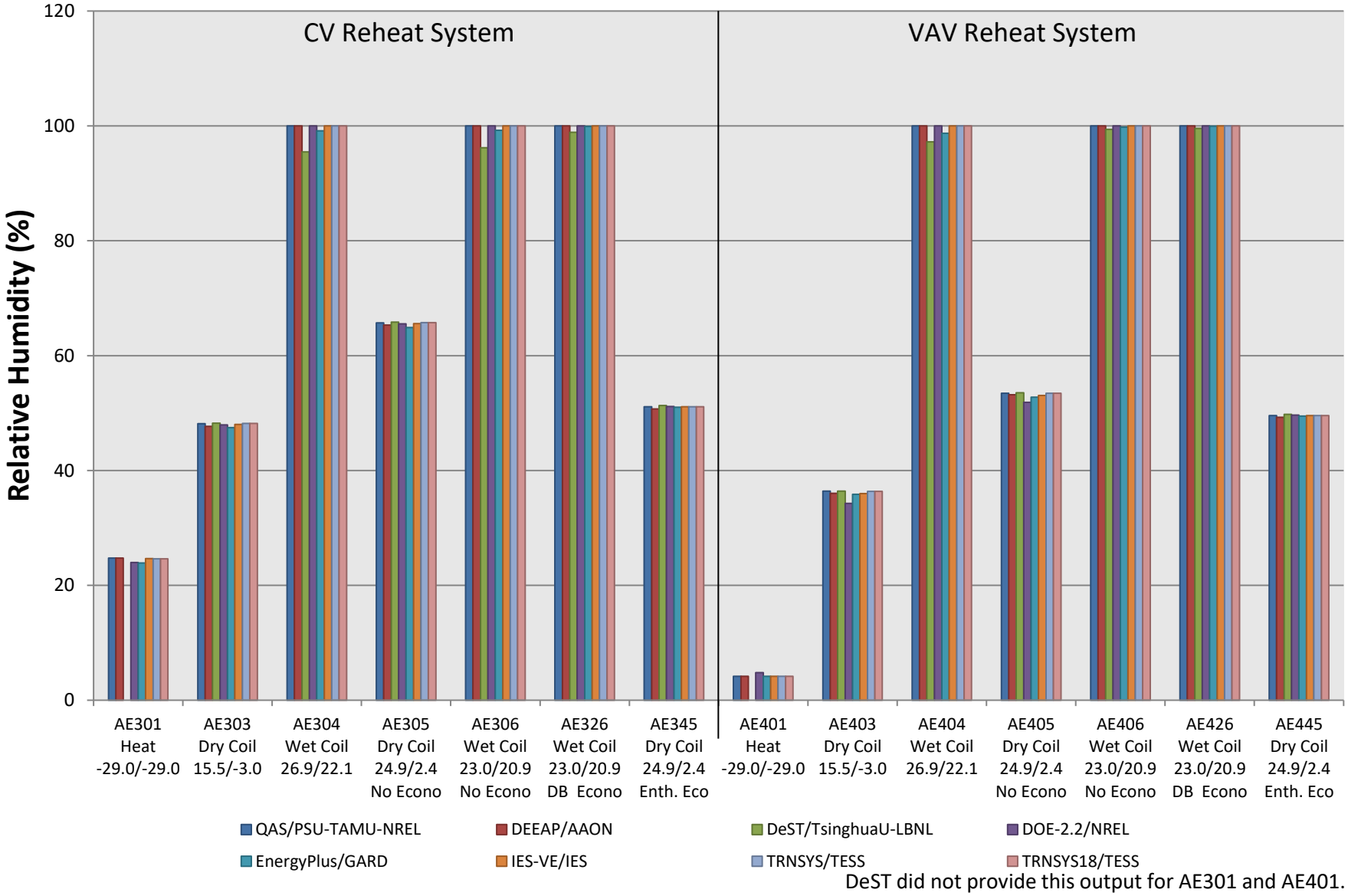
Figure B16.7.2-12. CV/VAV Cooling Coil Outlet Air Temperature



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-13. CV/VAV Cooling Coil Outlet Relative Humidity [RHcco]

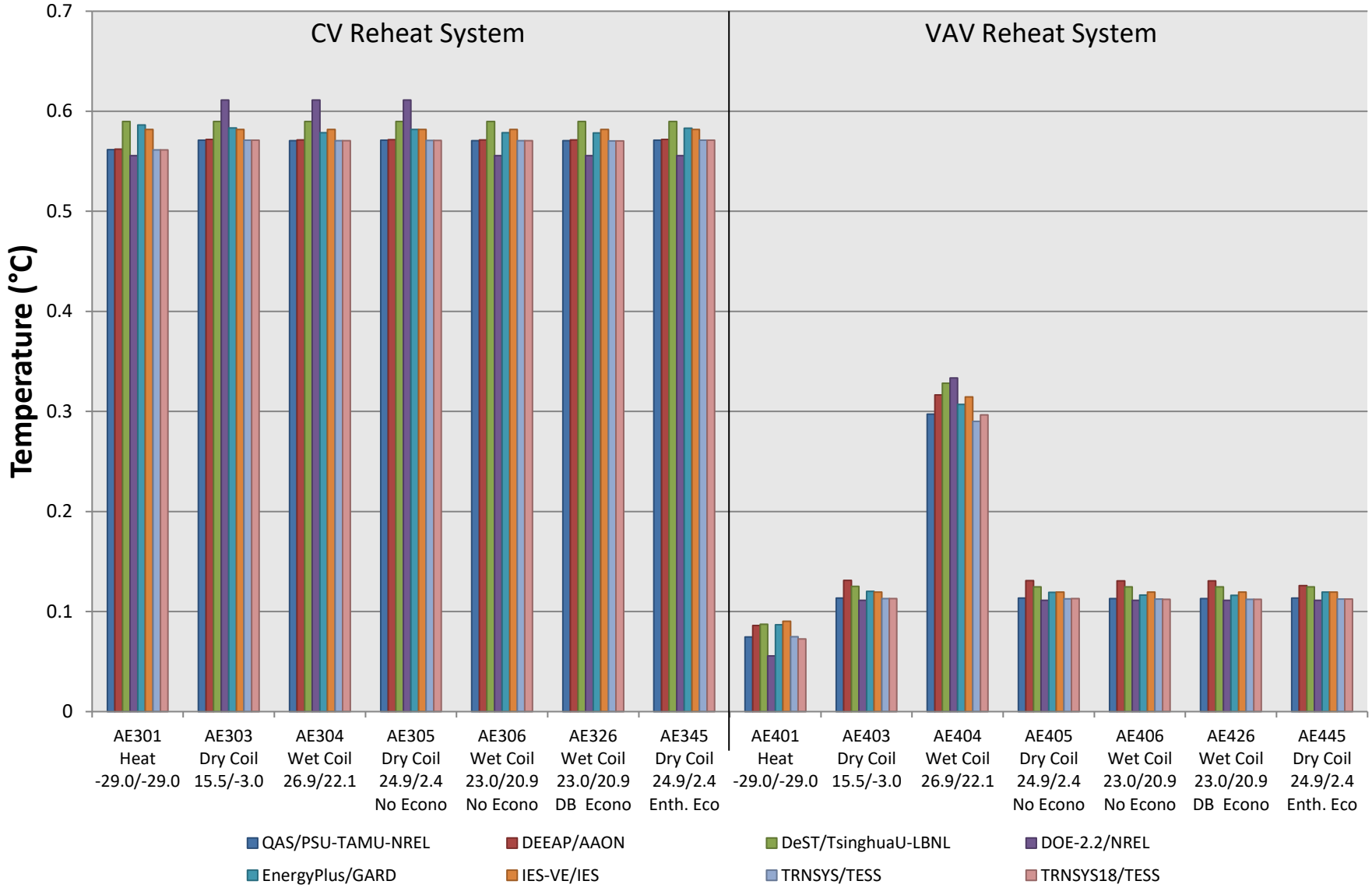


DeST did not provide this output for AE301 and AE401.

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-14. CV/VAV Supply Fan Air Temperature Rise

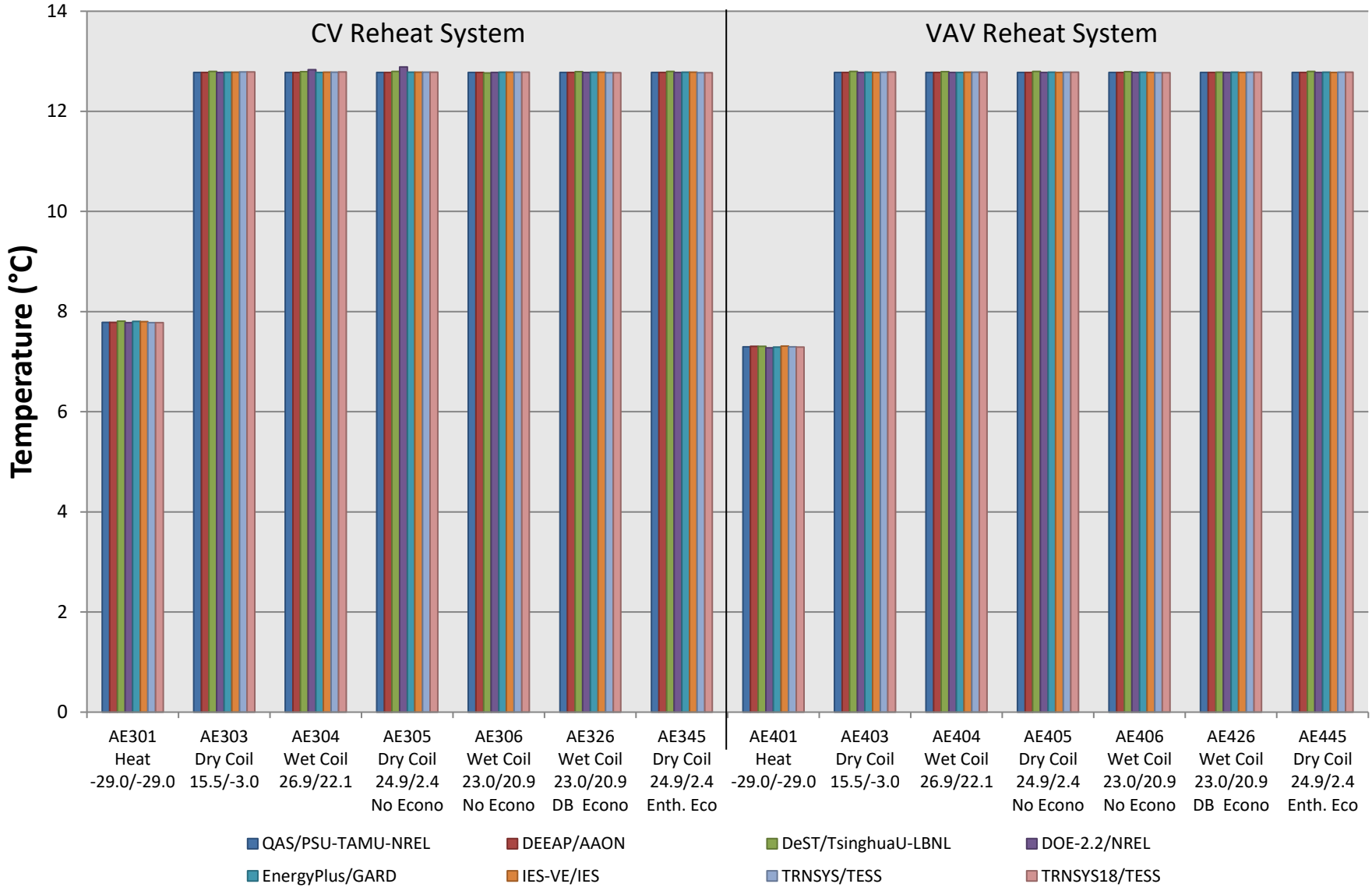


DOE-2.2 has limited temperature output precision.

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-15. CV/VAV Supply Air Temperature



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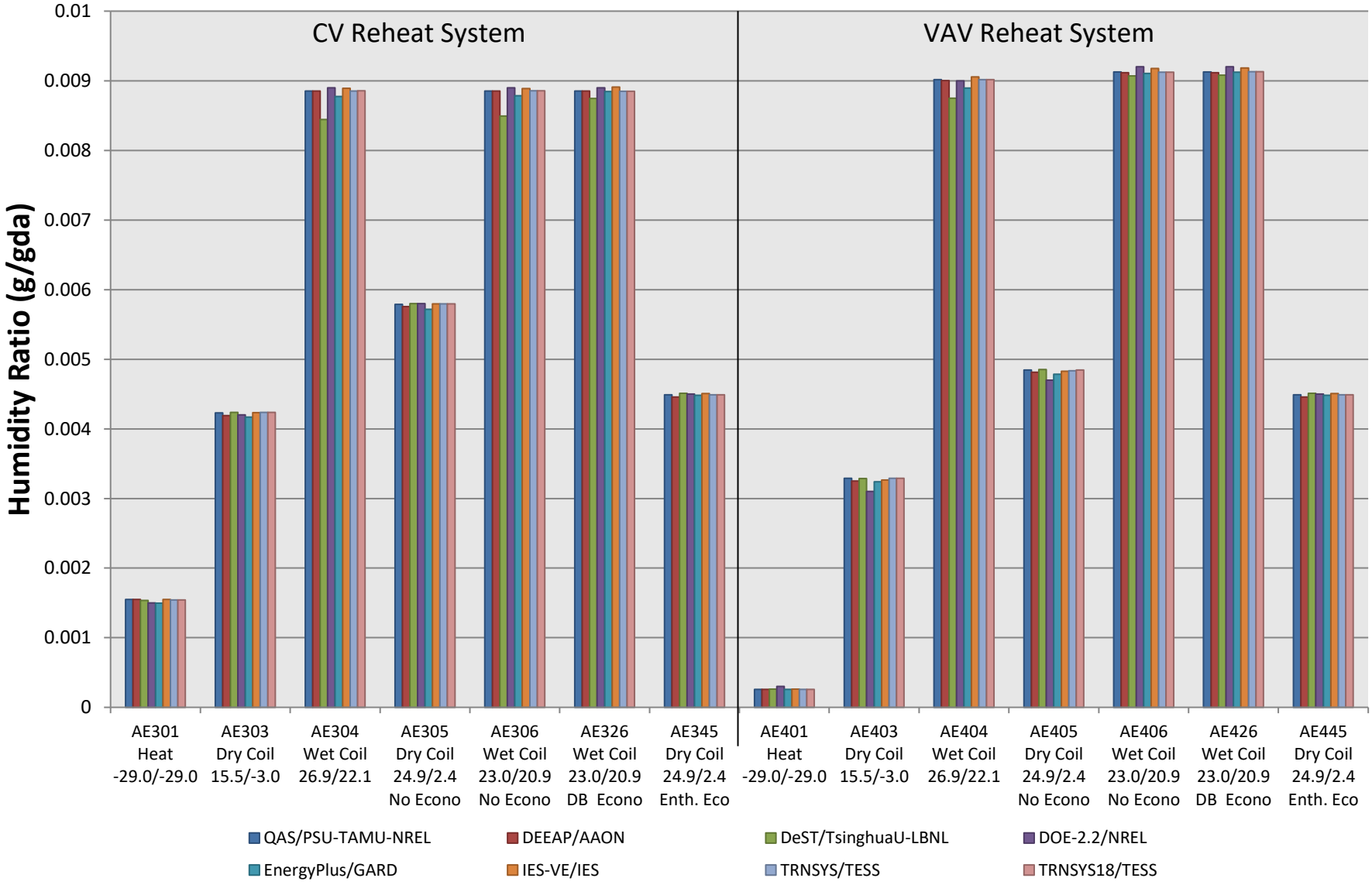
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

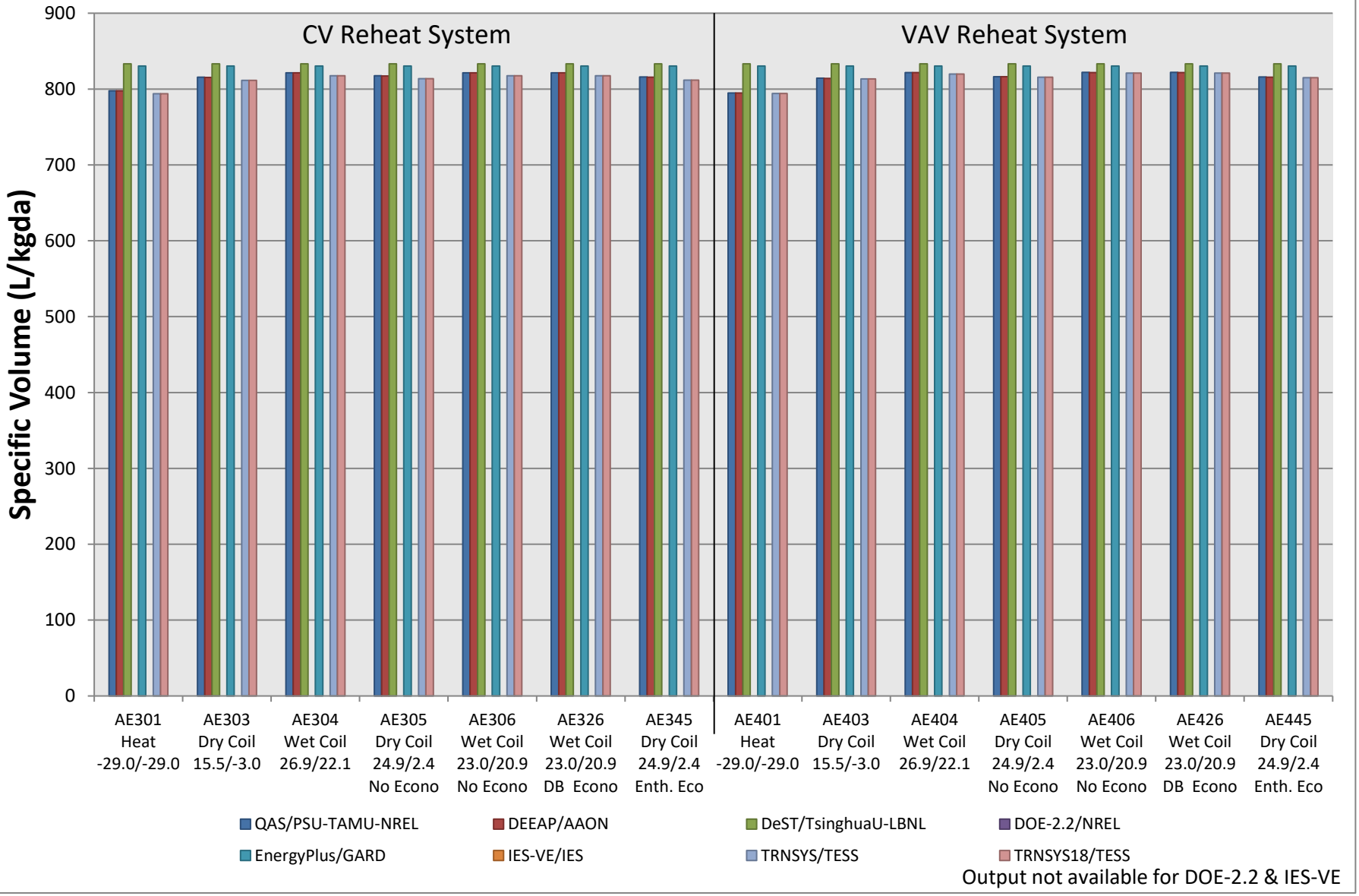
Figure B16.7.2-16. CV/VAV Supply Air Humidity Ratio



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-17. CV/VAV Supply Air Specific Volume

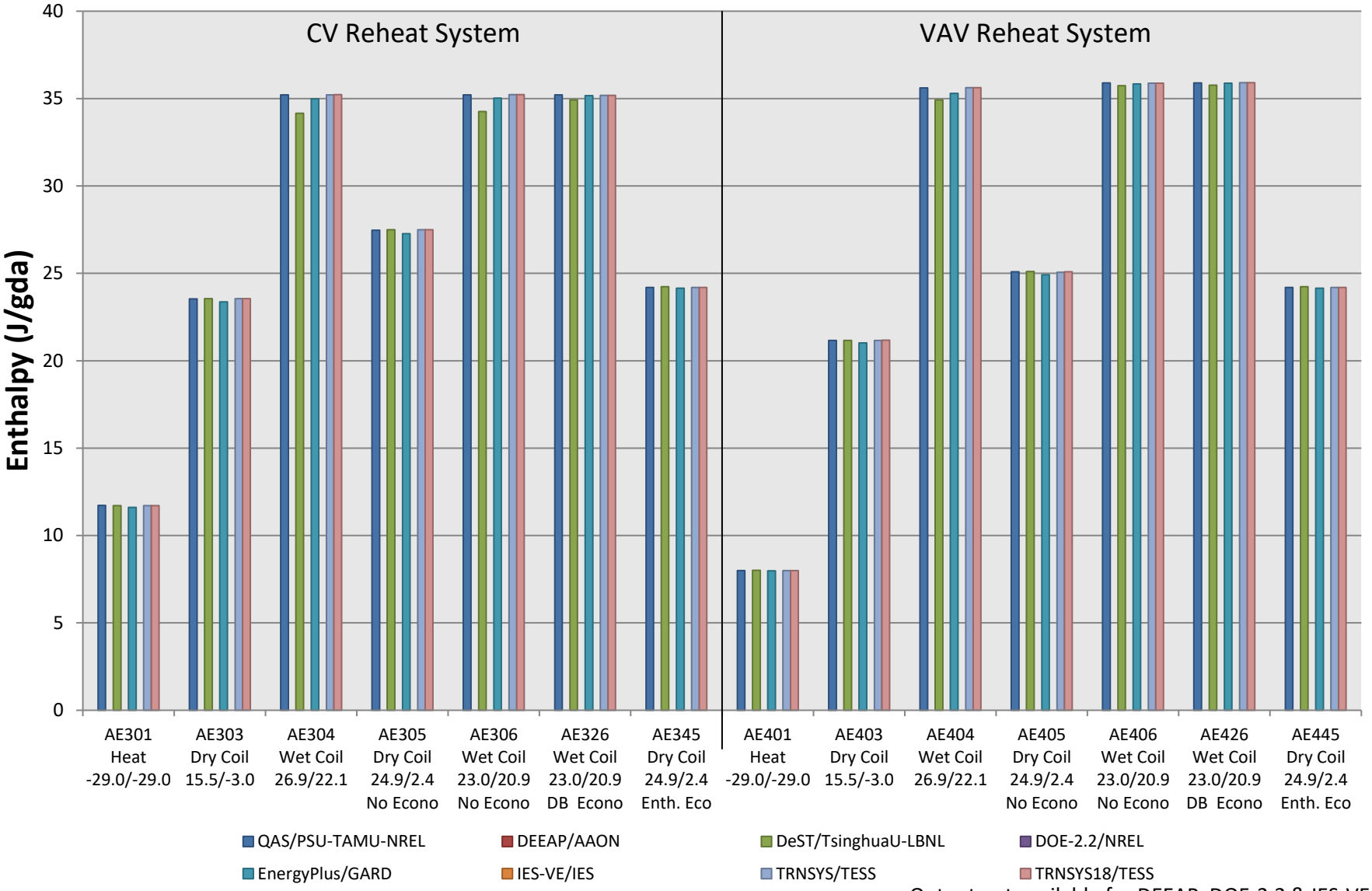


Output not available for DOE-2.2 & IES-VE

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-18. CV/VAV Supply Air Enthalpy

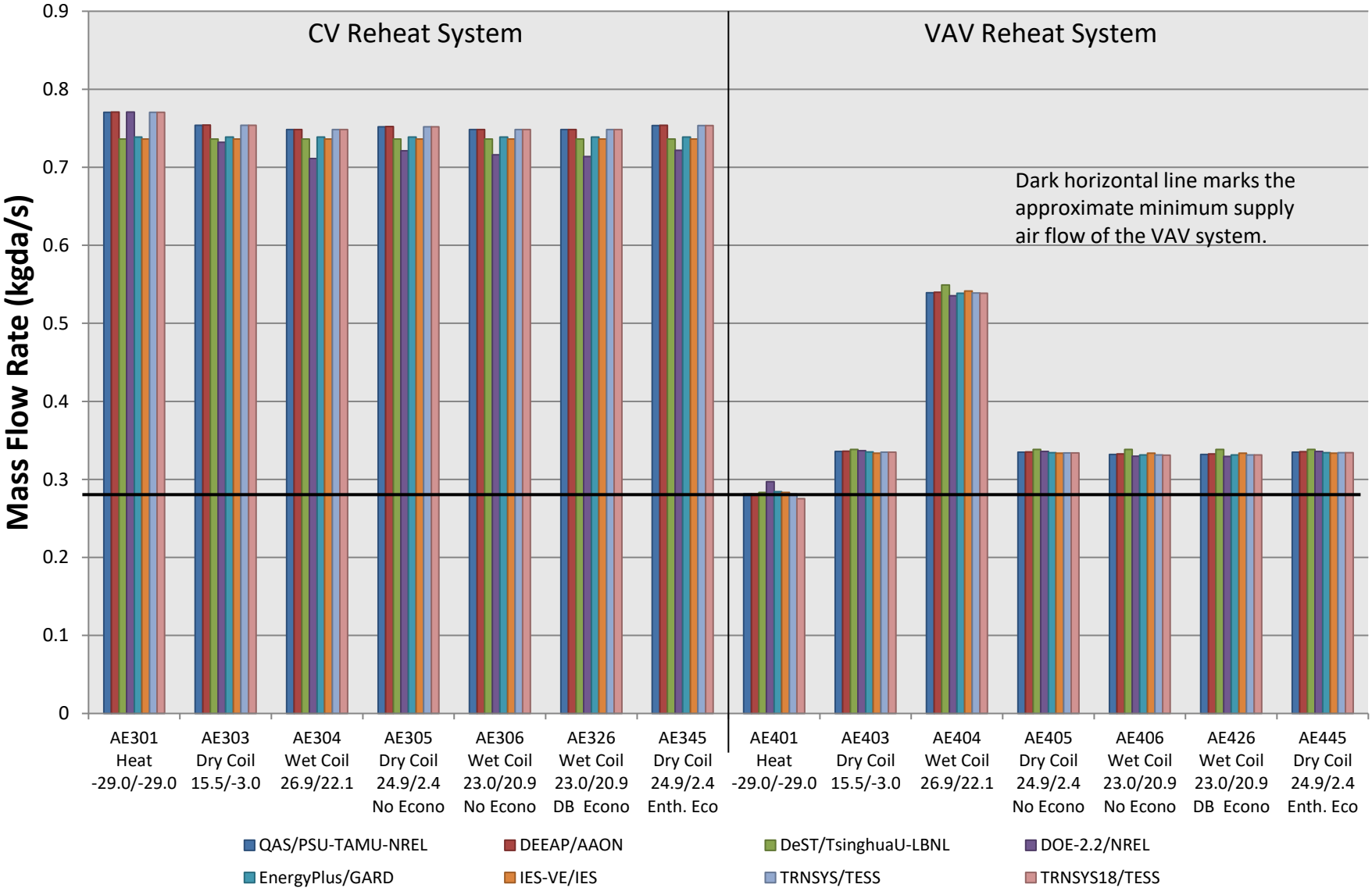


Output not available for DEEAP, DOE-2.2 & IES-VE

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

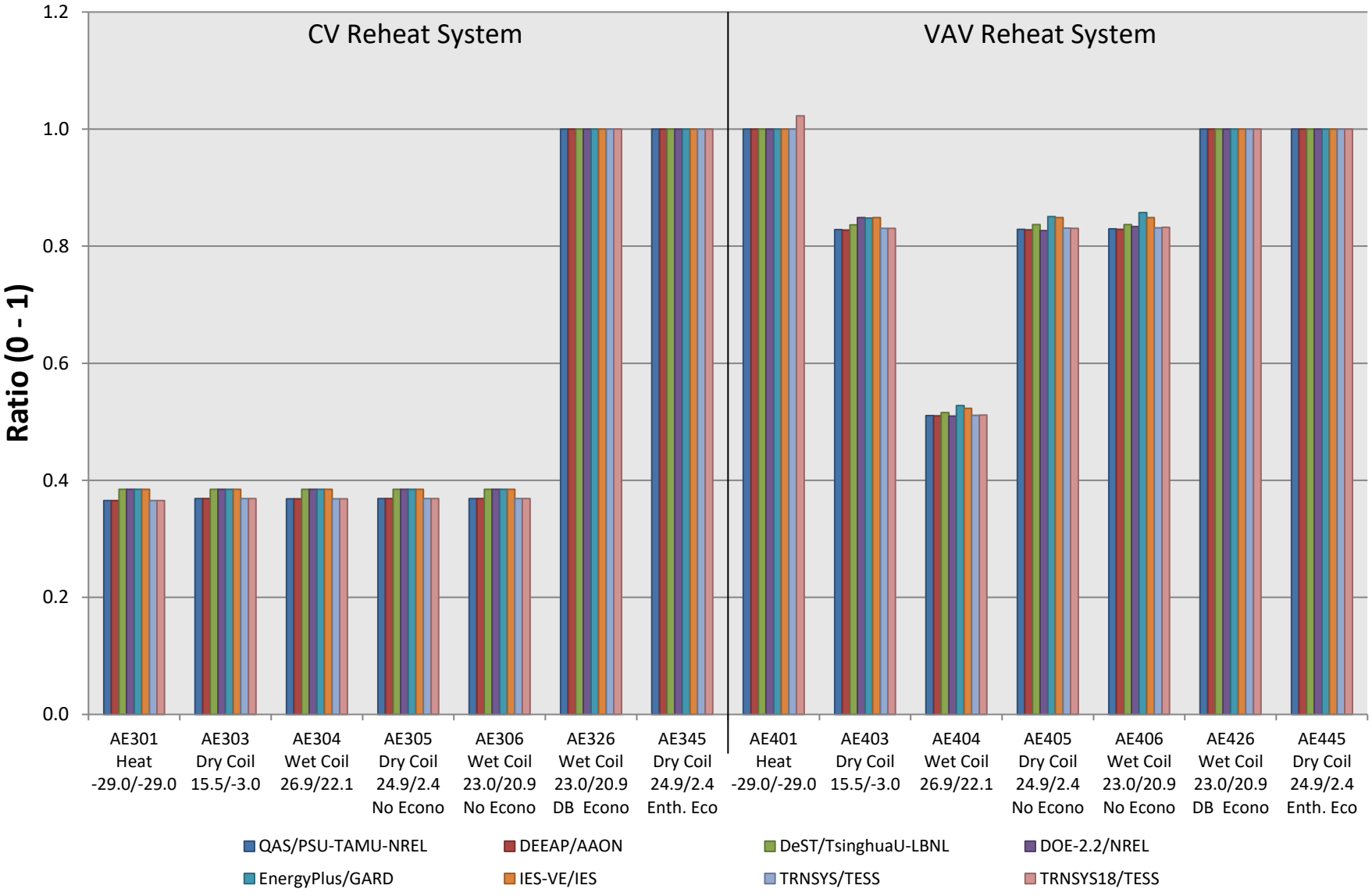
Figure B16.7.2-19. CV/VAV Supply Air Mass Flow Rate



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

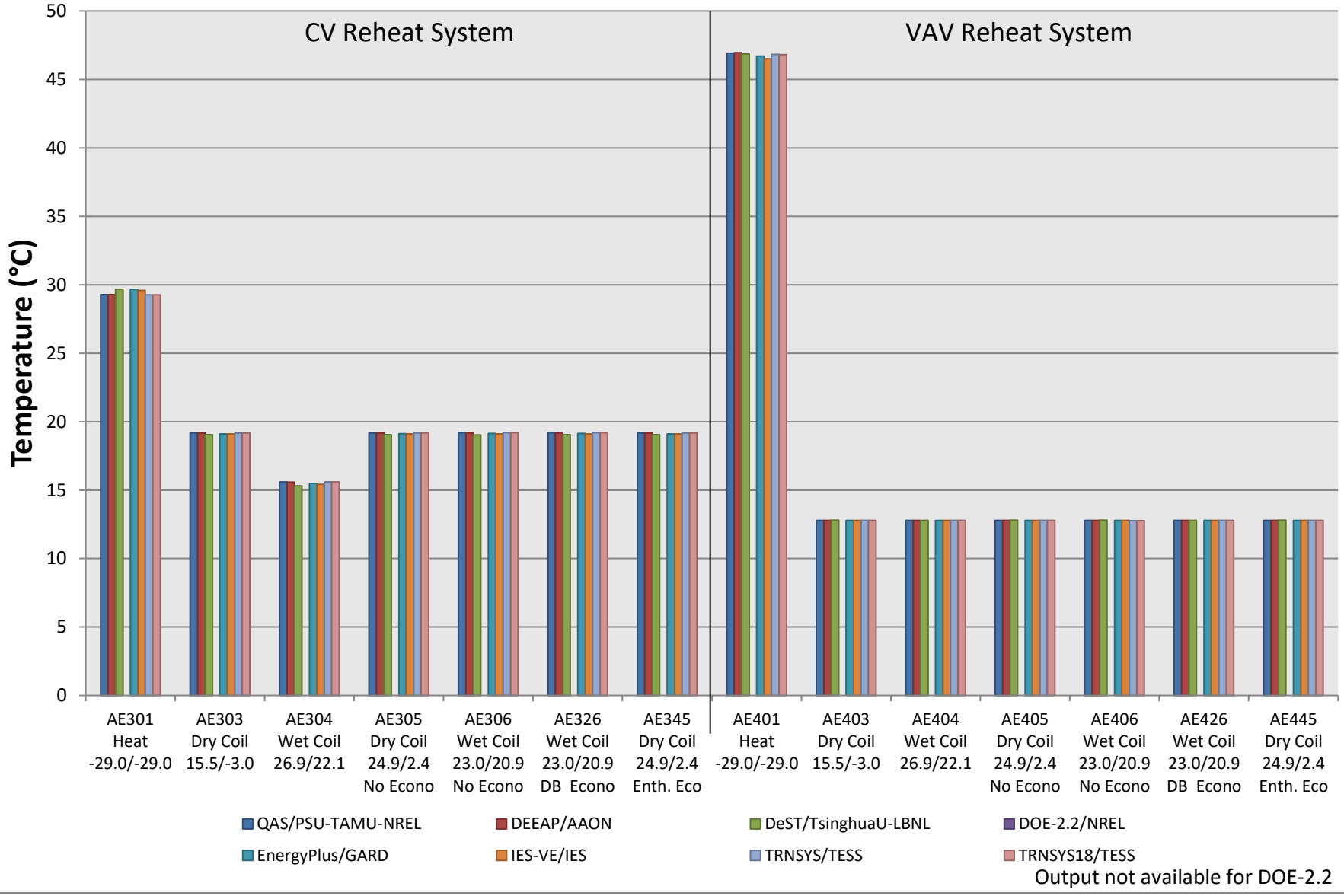
Figure B16.7.2-20. CV/VAV Outdoor Air to Supply Air Mass Flow Ratio



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

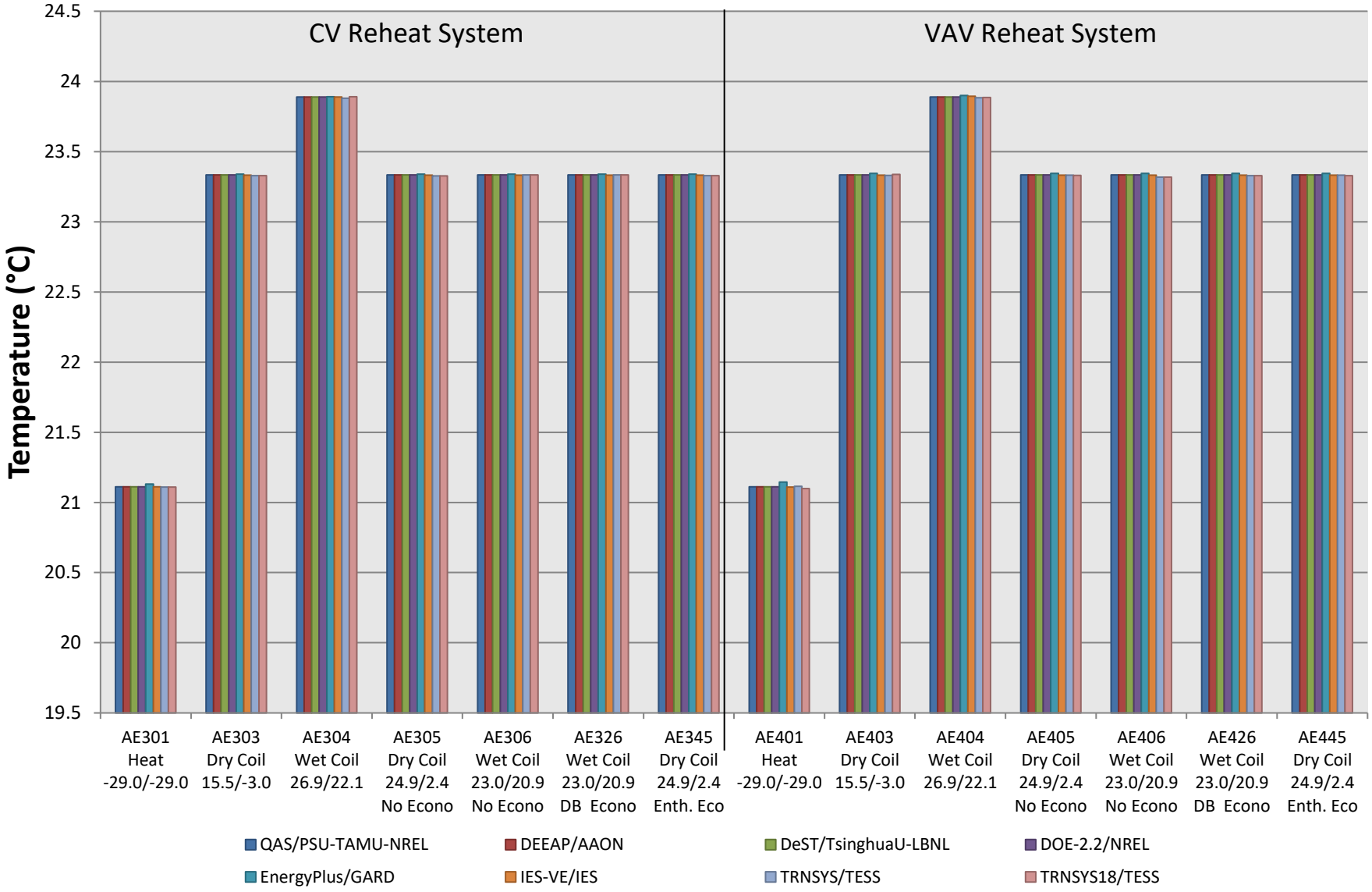
Figure B16.7.2-21. CV/VAV Zone 1 Supply Air Temperature



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

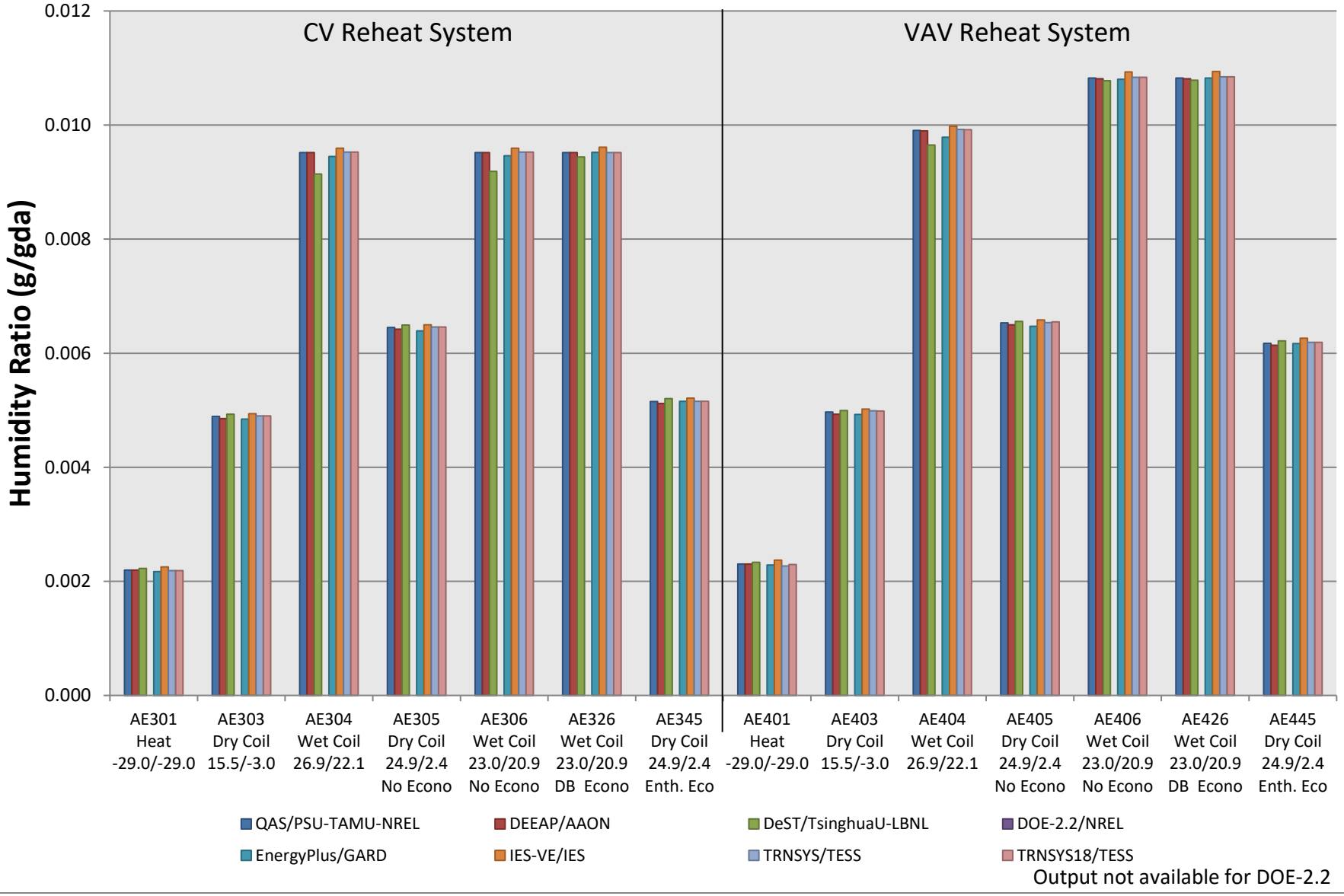
Figure B16.7.2-22. CV/VAV Zone 1 Air Temperature



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

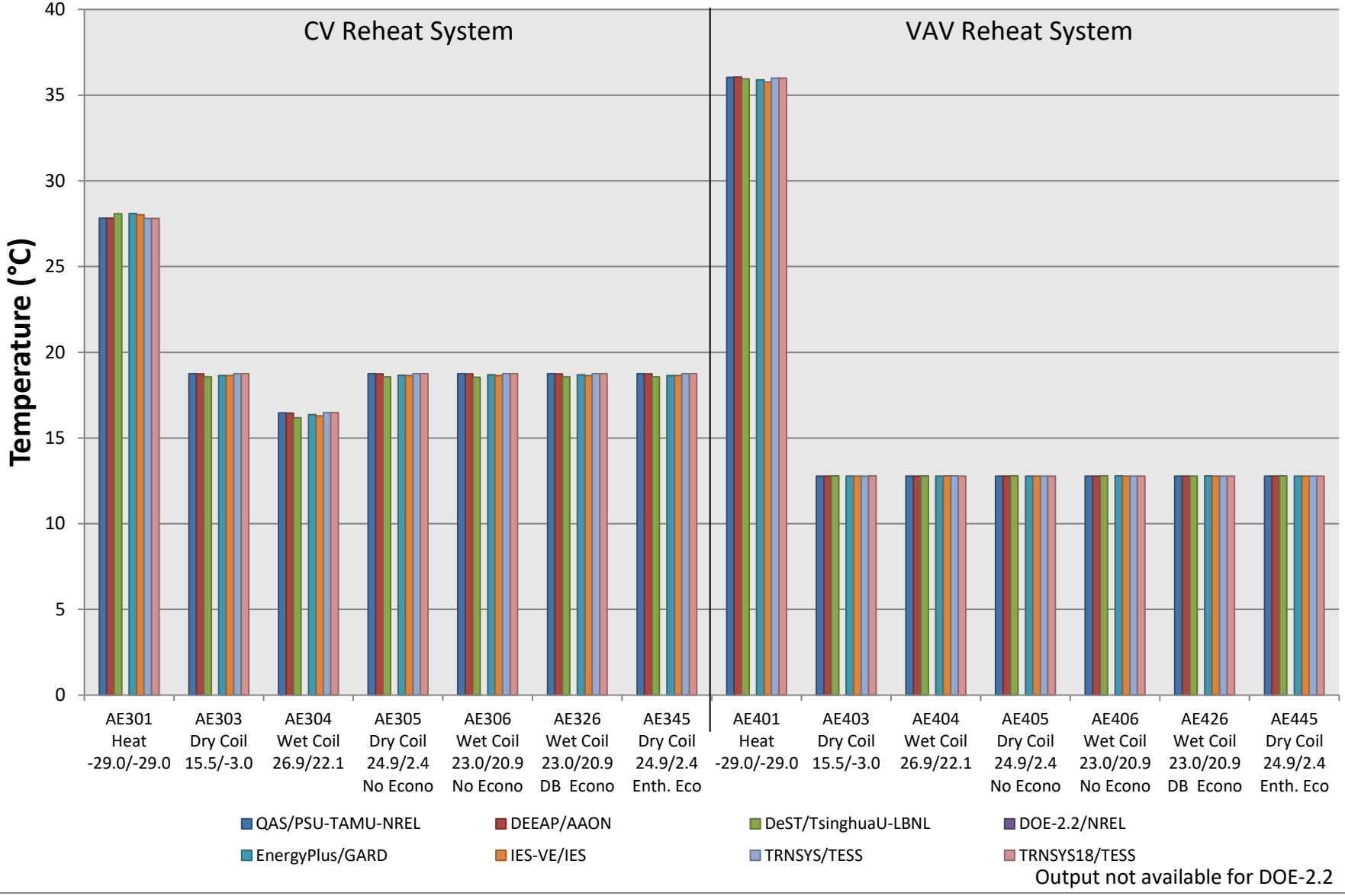
Figure B16.7.2-23. CV/VAV Zone 1 Humidity Ratio



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

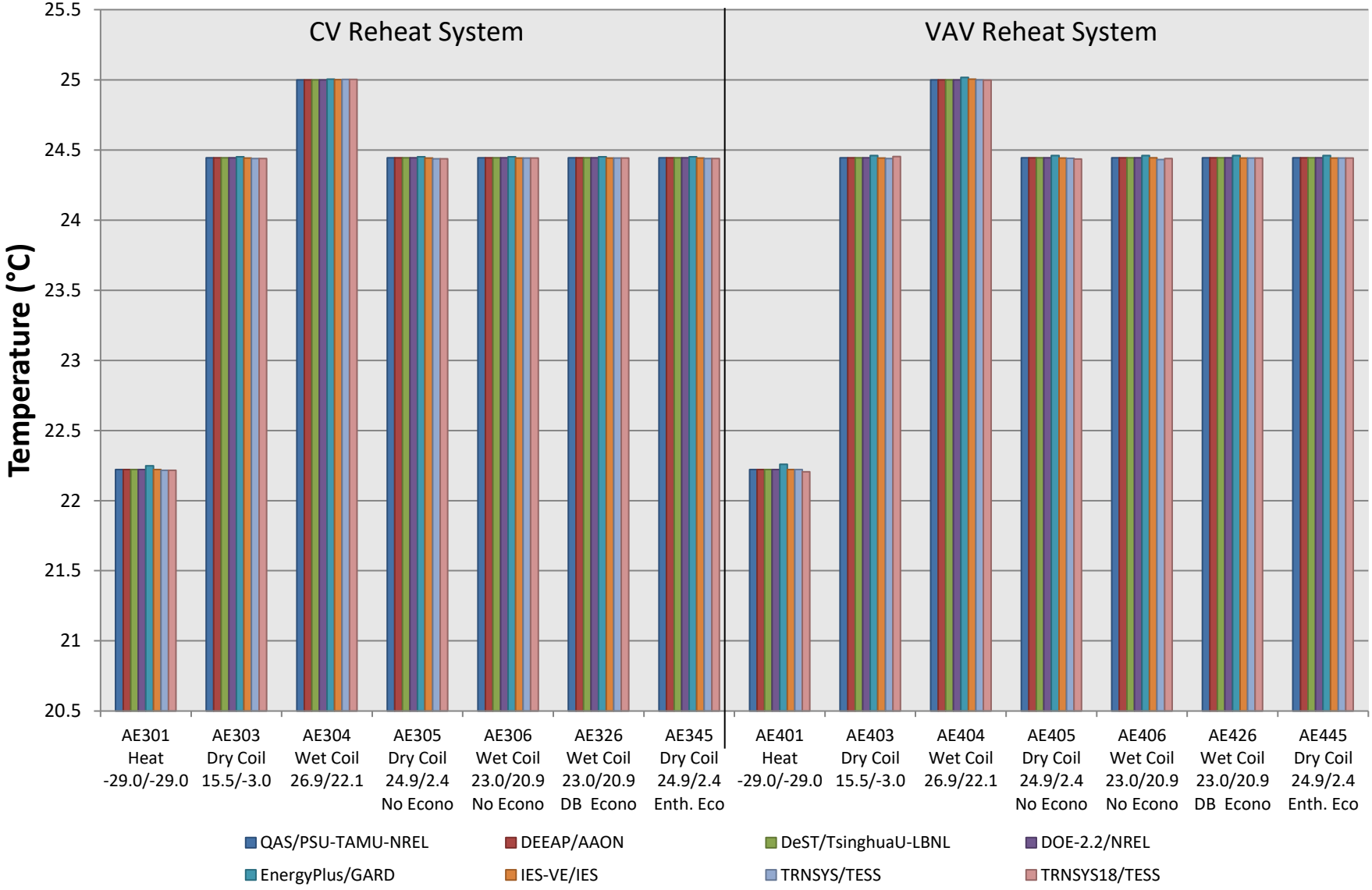
Figure B16.7.2-24. CV/VAV Zone 2 Supply Air Temperature



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-25. CV/VAV Zone 2 Air Temperature



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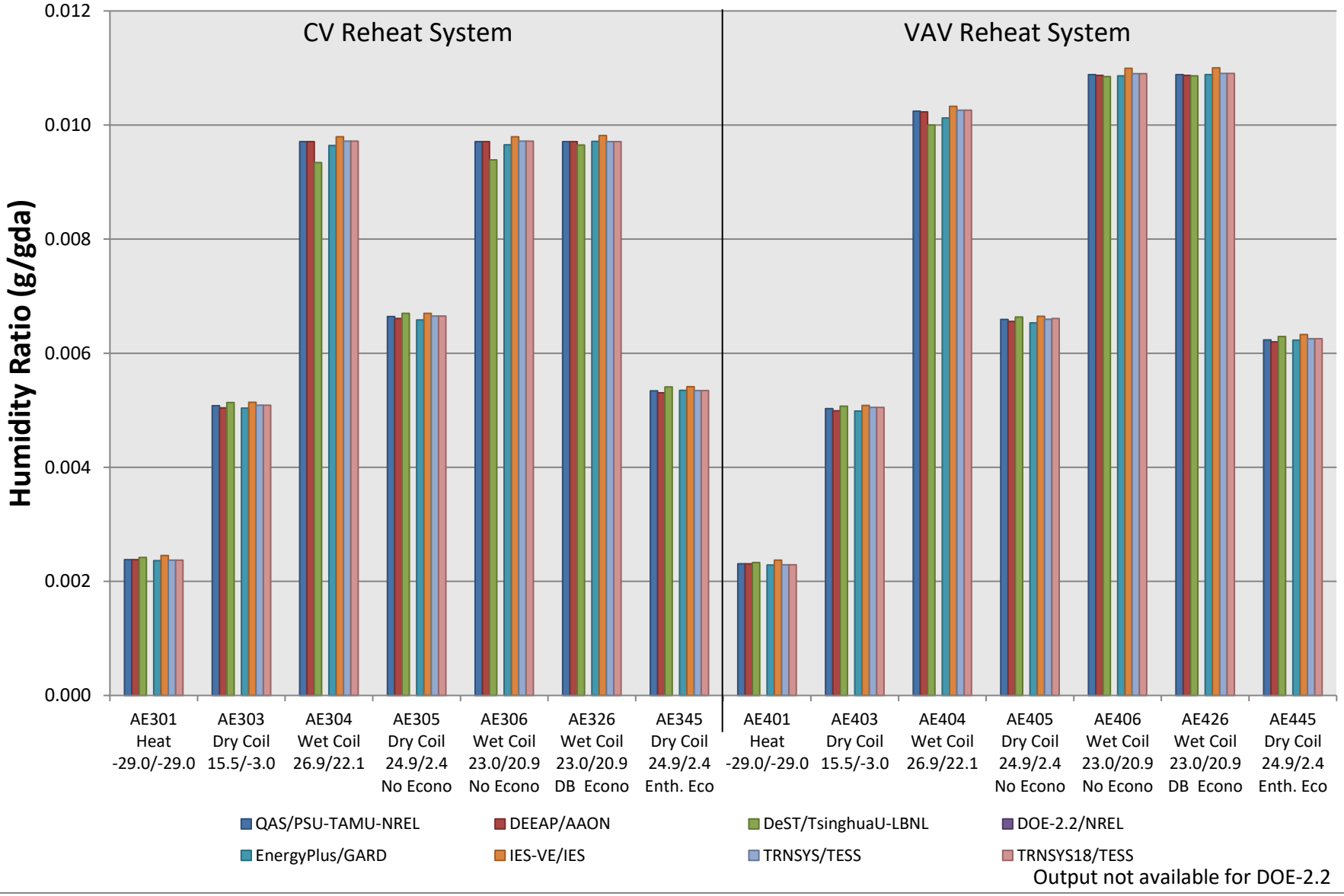
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-26. CV/VAV Zone 2 Humidity Ratio



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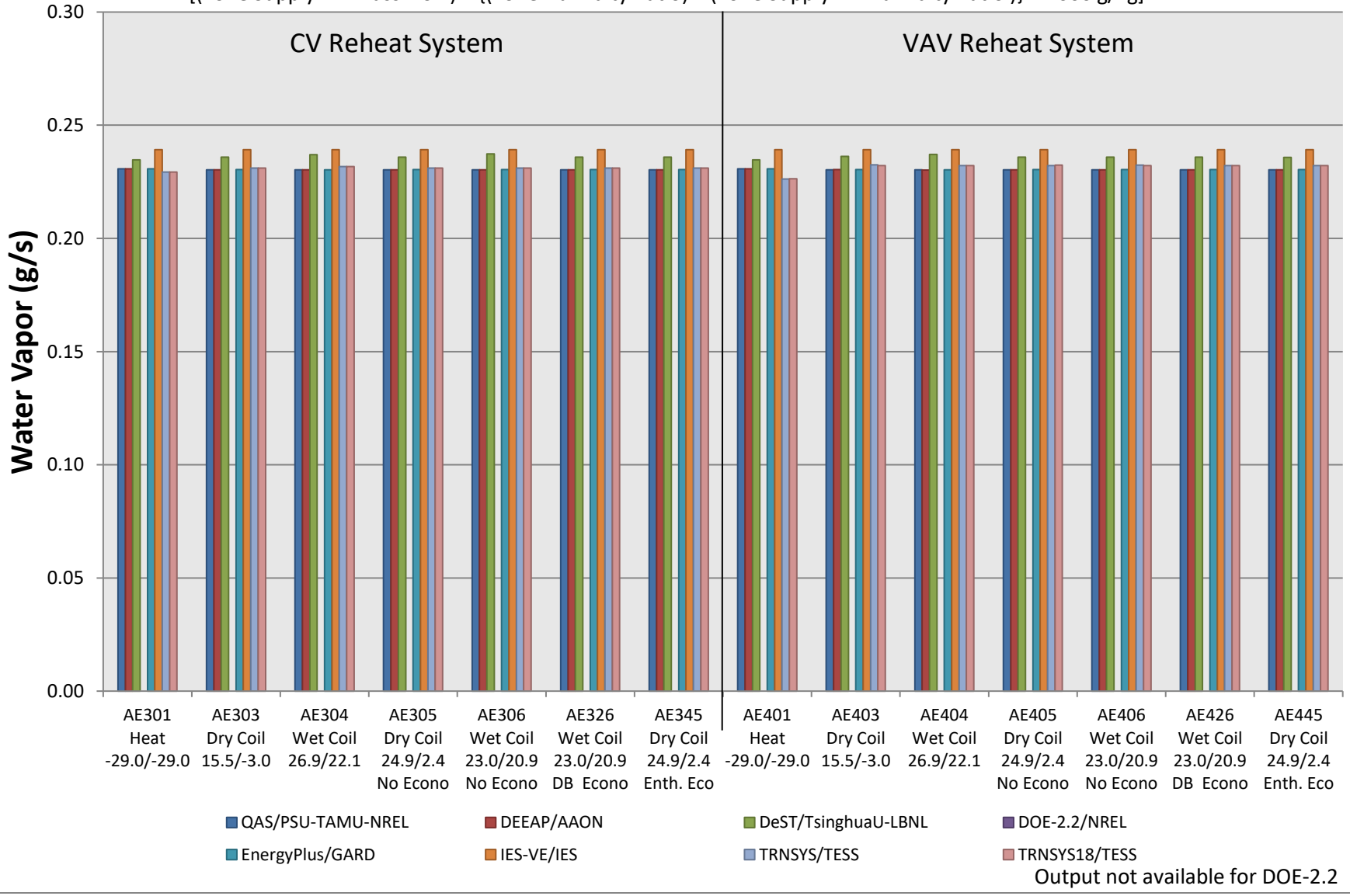
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-27. CV/VAV Moisture Added to Zone 1 by Latent Gains

[(Zone Supply Air Mass Flow) × {(Zone Humidity Ratio) – (Zone Supply Air Humidity Ratio)} × 1000 g/kg]



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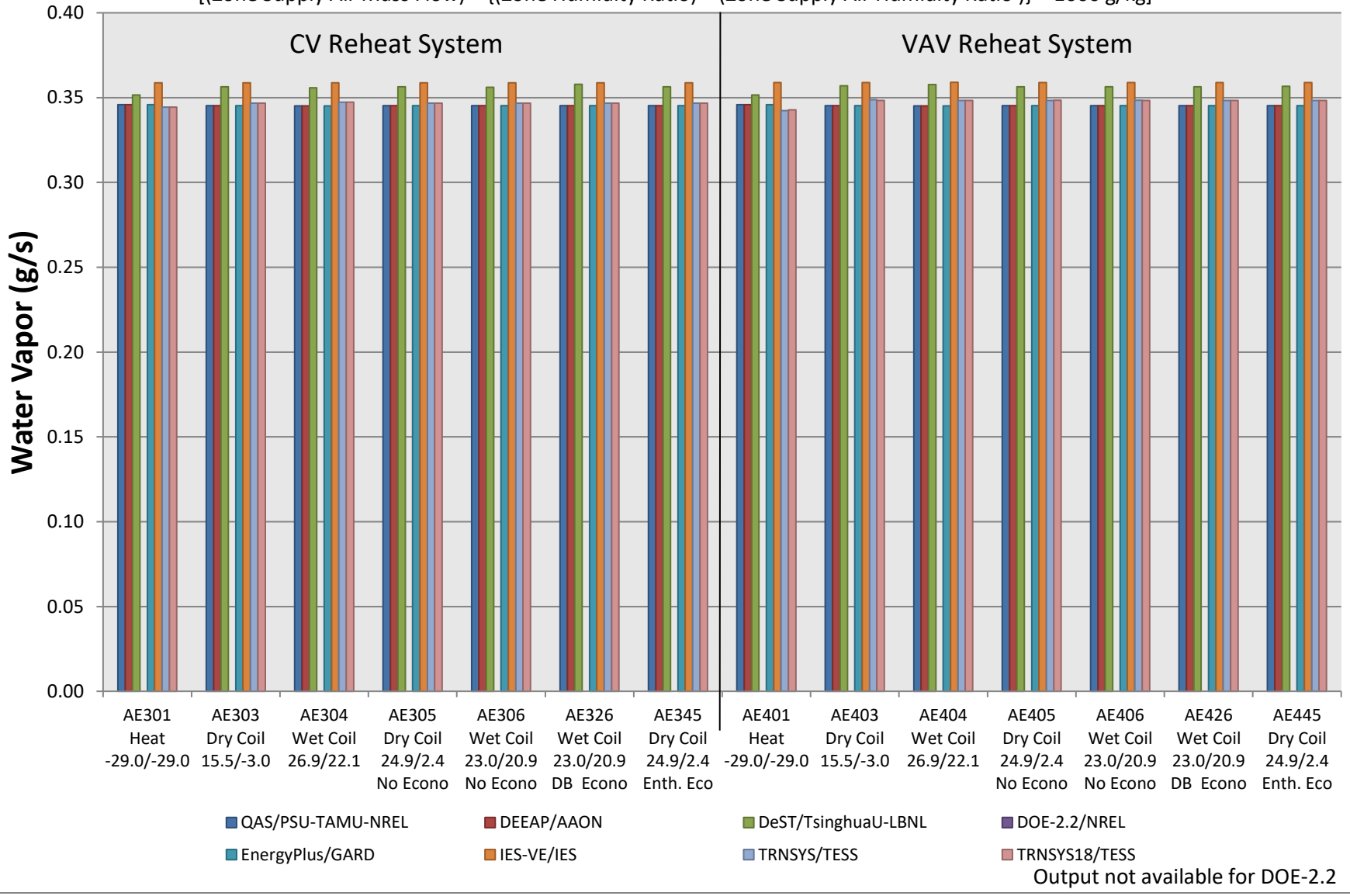
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-28. CV/VAV Moisture Added to Zone 2 by Latent Gains

[(Zone Supply Air Mass Flow) × {(Zone Humidity Ratio) – (Zone Supply Air Humidity Ratio)} × 1000 g/kg]



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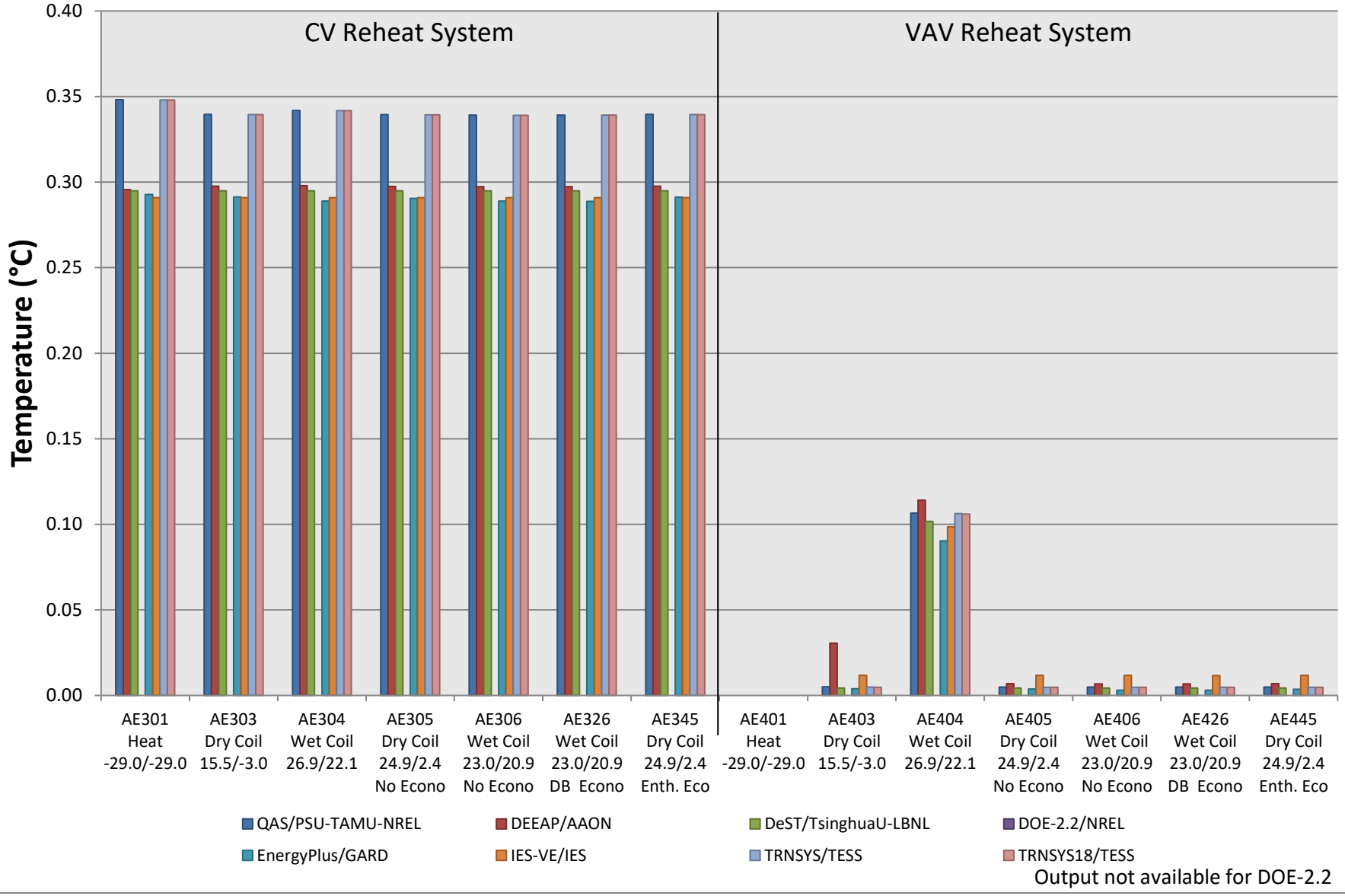
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-29. CV/VAV Return Fan Air Temperature Rise



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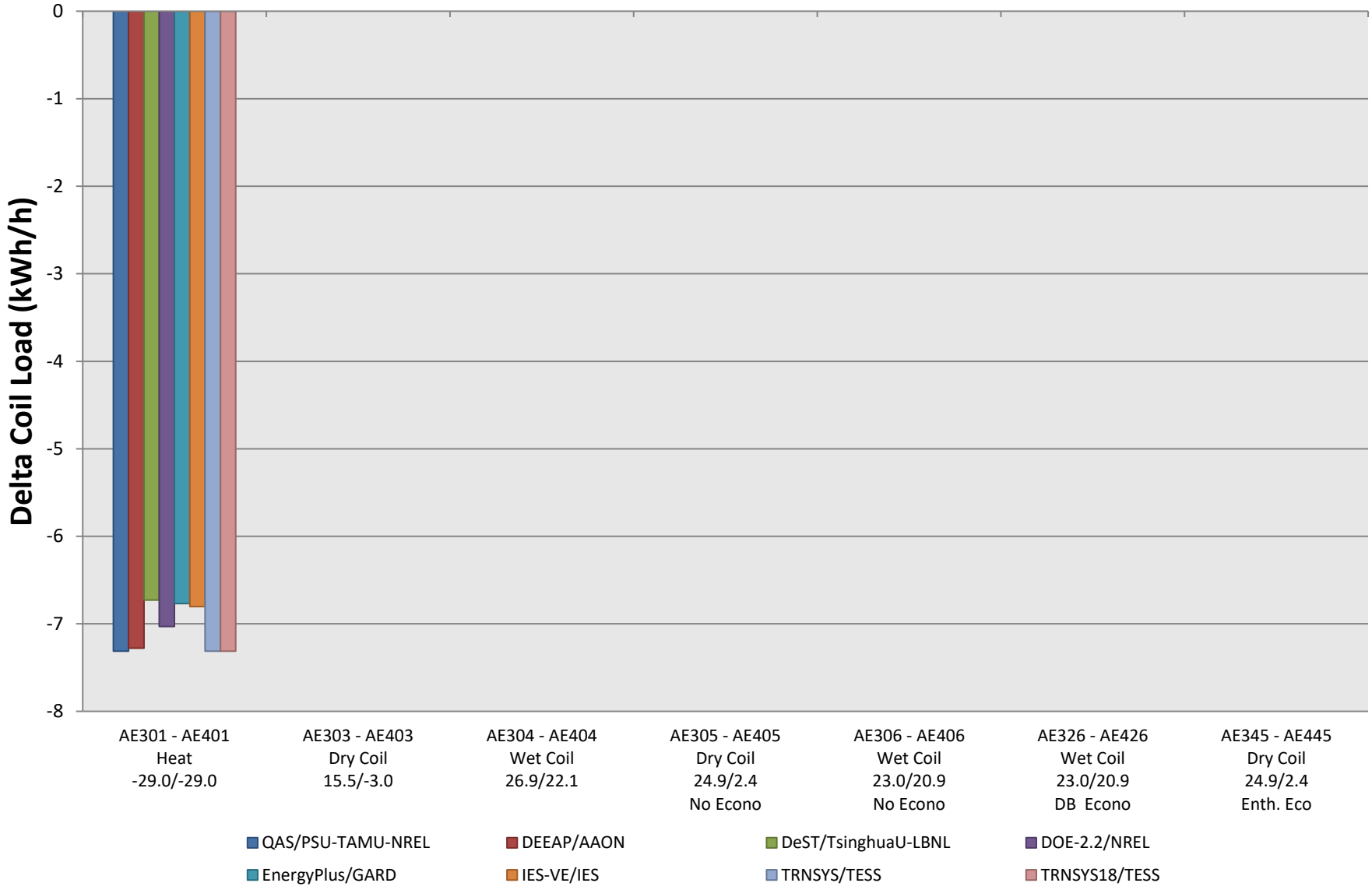
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-30. CV/VAV Delta Pre-Heating Coil Load, CV-VAV



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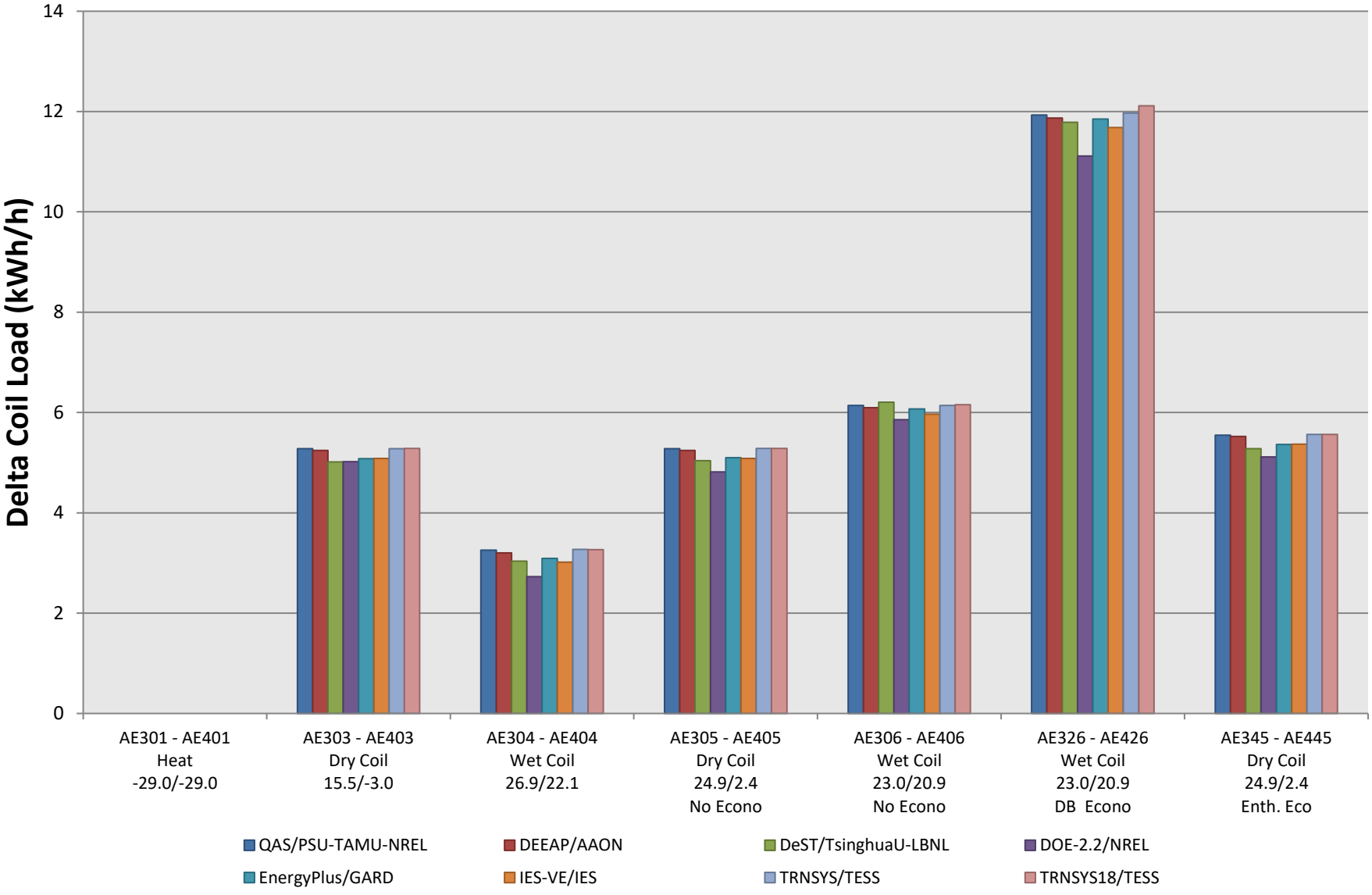
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-31. CV/VAV Delta Total Cooling Coil Load, CV-VAV



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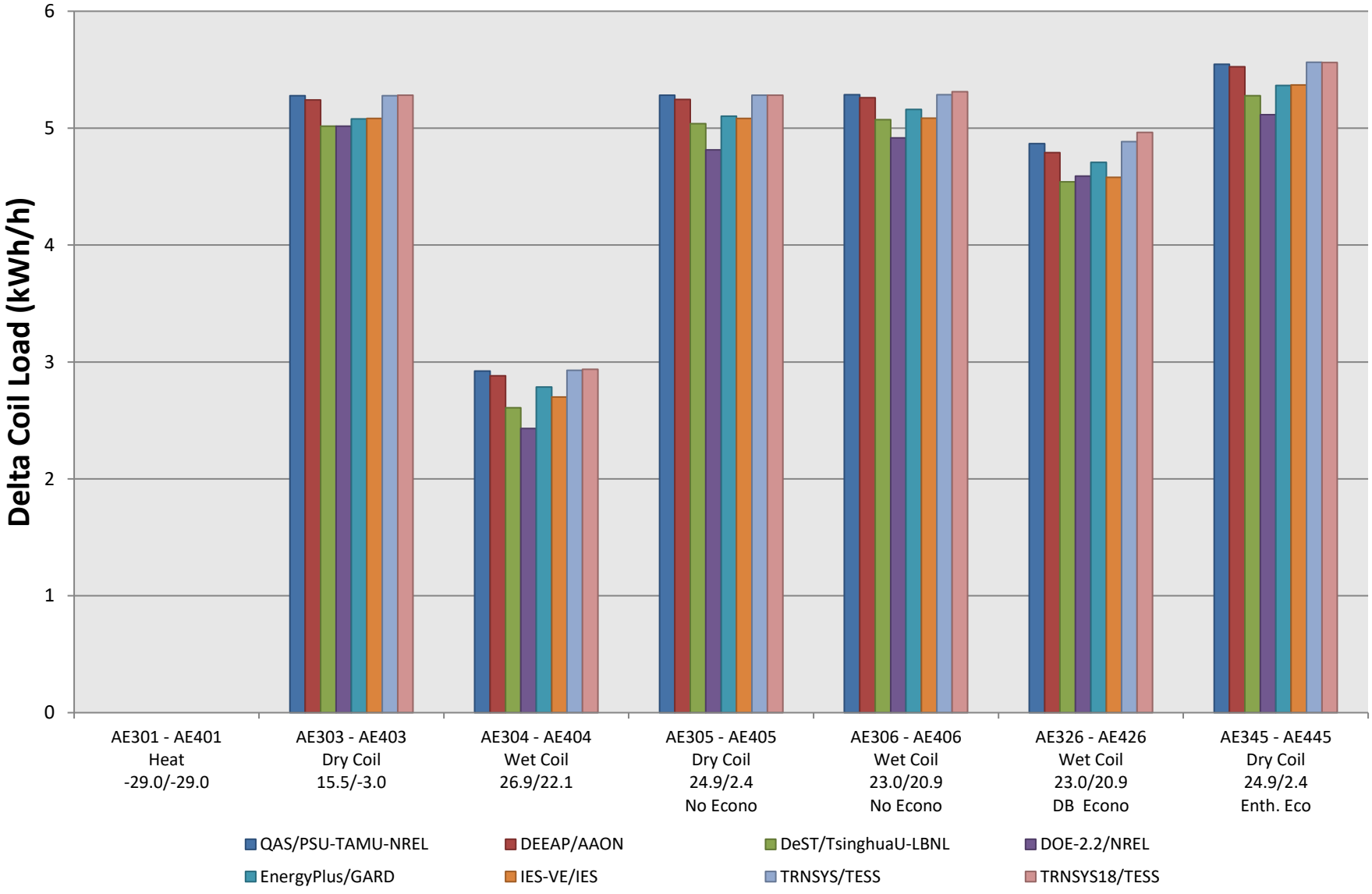
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

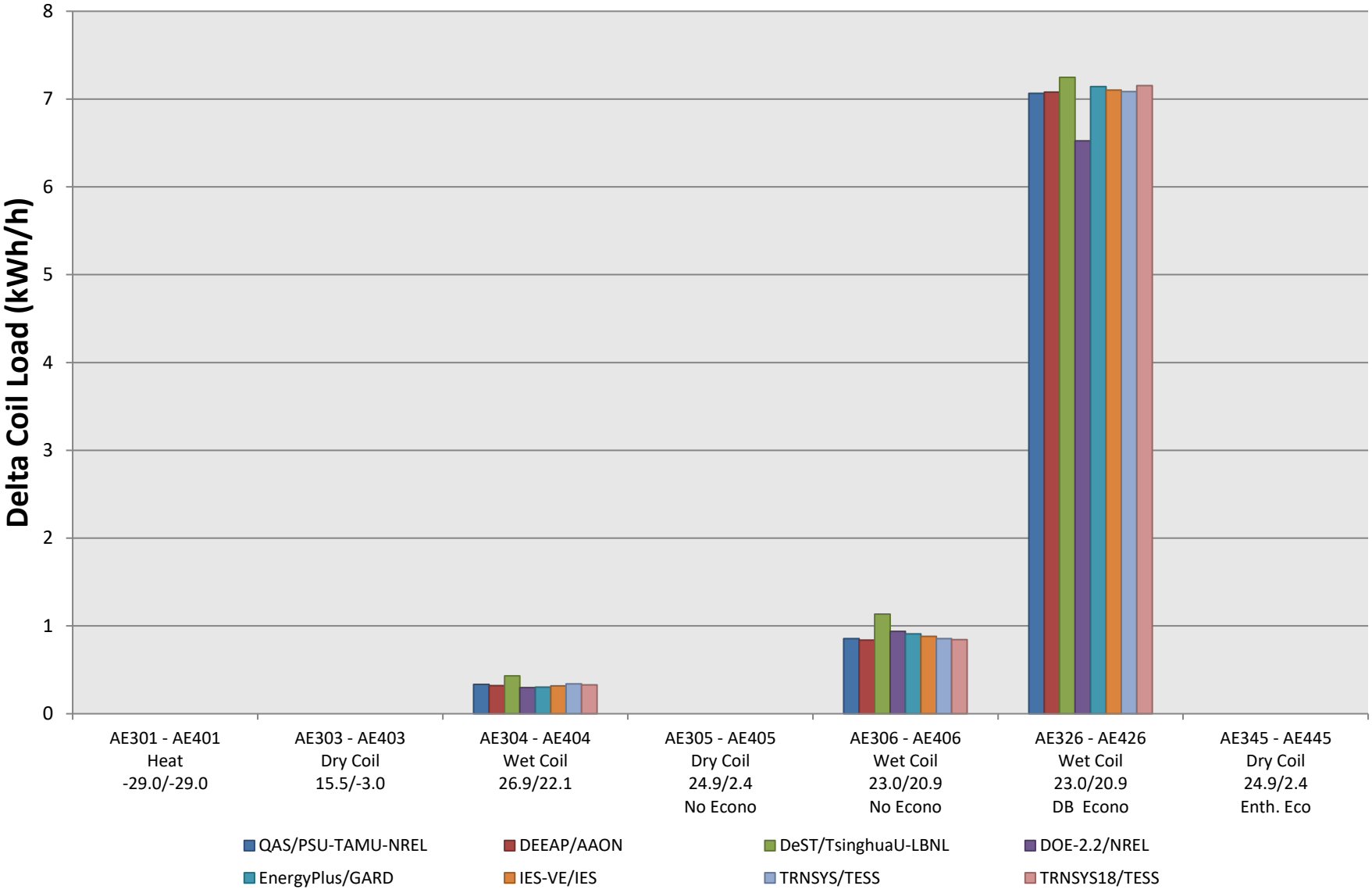
Figure B16.7.2-32. CV/VAV Delta Sensible Cooling Coil Load, CV-VAV



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

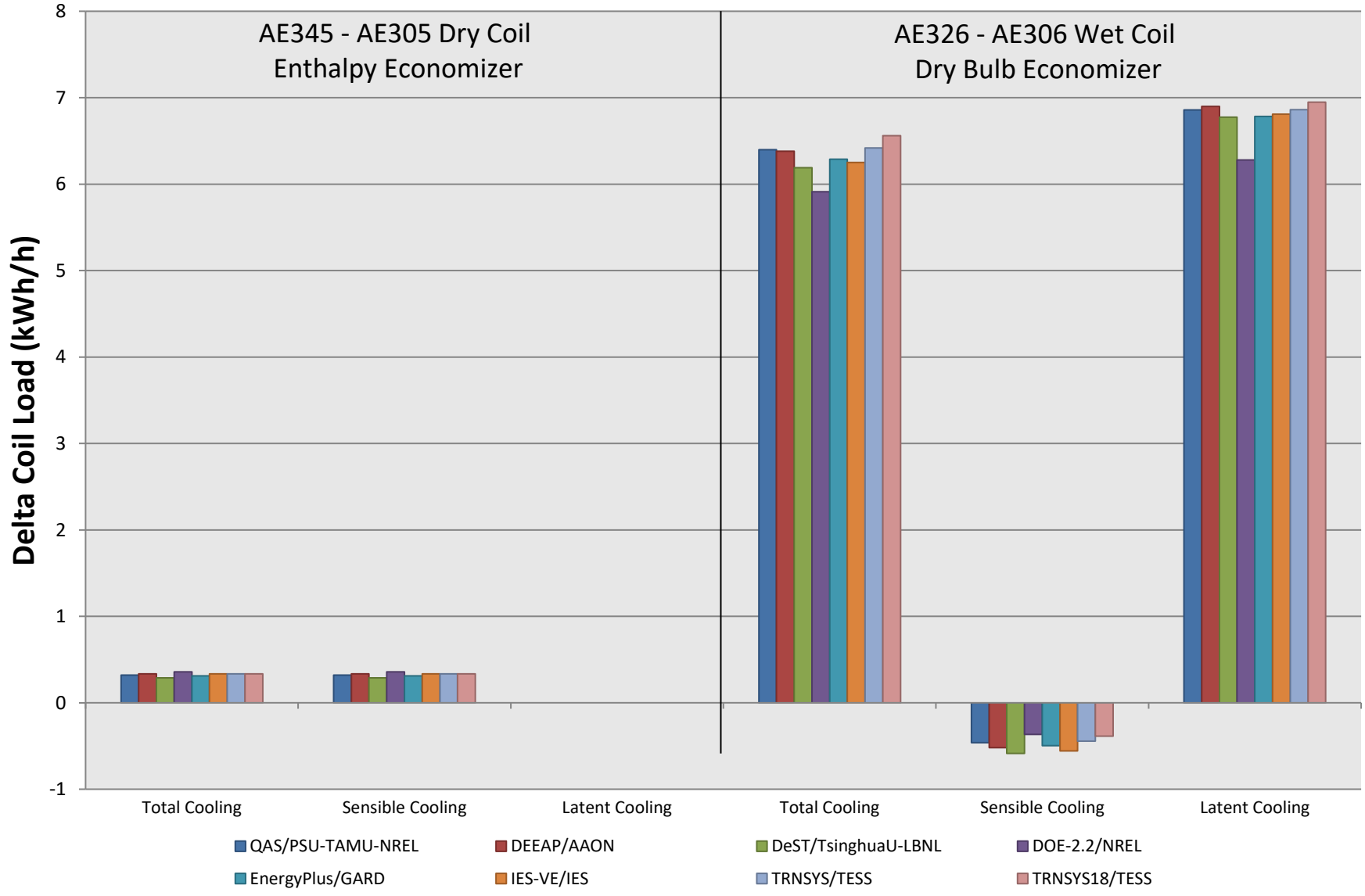
Figure B16.7.2-33. CV/VAV Delta Latent Cooling Coil Load, CV-VAV



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE301 - AE445

TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-34. CV Delta Cooling Coil Load, Economizer Operation



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TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.2 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.2-35. VAV Delta Cooling Coil Load, Economizer Operation