

ASHRAE Standard 140-2023

Results Comparison for Section 11, Airside HVAC Equipment Performance Tests AE101 through AE245

Results for TRNSYS18.06.0002
(TRNSYS18)
vs.
Informative Annex B16, Section B16.7.1 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 AE101 through AE245

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 B16.7.1 Example Results
 By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024**

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**ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101-AE245
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024**

Table B16.7.1-1. FC/SZ Heating Coil Load [QH] (kWh/h)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	8.420	8.413	8.452	8.768	8.453	8.513	8.372	8.416	8.414
AE103	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE104	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE201	8.360	8.349	8.385	8.709	8.387	8.446	8.302	8.356	8.356
AE203	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE204	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE205	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE206	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE226	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE245	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table B16.7.1-2. FC/SZ Total Cooling Coil Load [QCtotal] (kWh)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE103	0.783	0.784	0.778	0.777	0.766	0.762	0.763	0.780	0.783
AE104	5.551	5.553	5.836	5.533	5.673	5.607	5.646	5.548	5.619
AE201	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE203	0.856	0.853	0.845	0.840	0.833	0.830	0.830	0.852	0.856
AE204	5.628	5.623	5.897	5.711	5.739	5.675	5.713	5.625	5.677
AE205	1.916	1.910	1.929	1.908	1.913	1.915	1.911	1.913	1.913
AE206	2.677	2.664	2.818	2.731	2.738	2.696	2.699	2.671	2.702
AE226	3.362	3.335	3.643	3.405	3.418	3.377	3.391	3.355	3.412
AE245	2.208	2.202	2.216	2.188	2.207	2.210	2.202	2.209	2.209

Table B16.7.1-3. FC/SZ Sensible Cooling Coil Load [QC_sensible] (kWh/h)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE103	0.783	0.784	0.778	0.777	0.766	0.762	0.752	0.780	0.783
AE104	3.497	3.488	3.543	3.521	3.499	3.480	3.389	3.493	3.539
AE201	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE203	0.856	0.853	0.845	0.840	0.833	0.830	0.819	0.852	0.856
AE204	3.574	3.559	3.608	3.590	3.566	3.547	3.456	3.571	3.616
AE205	1.916	1.910	1.929	1.908	1.913	1.915	1.880	1.913	1.913
AE206	1.706	1.701	1.731	1.723	1.697	1.695	1.646	1.703	1.733
AE226	1.562	1.557	1.593	1.597	1.555	1.552	1.503	1.560	1.613
AE245	2.208	2.202	2.216	2.188	2.207	2.210	2.171	2.209	2.209

**ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101-AE245
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results
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Table B16.7.1-4. FC/SZ 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	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE103	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000
AE104	2.054	2.065	2.293	2.012	2.174	2.127	2.256	2.054	2.080
AE201	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AE203	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000
AE204	2.054	2.065	2.289	2.121	2.173	2.128	2.257	2.054	2.061
AE205	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.000	0.000
AE206	0.970	0.963	1.087	1.008	1.042	1.000	1.053	0.968	0.969
AE226	1.800	1.778	2.050	1.808	1.863	1.825	1.888	1.795	1.799
AE245	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.000	0.000

Table B16.7.1-5. FC/SZ Outdoor Air Temp (°C)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	-29.000	-29.000	-29.000	-29.000	-29.000	-29.000	-29.000	-29.000	-29.000
AE103	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500
AE104	26.900	26.889	26.900	26.889	26.900	26.900	26.900	26.900	26.900
AE201	-29.000	-29.000	-29.000	-29.000	-29.000	-29.000	-29.000	-29.000	-29.000
AE203	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500	15.500
AE204	26.900	26.889	26.900	26.889	26.900	26.900	26.900	26.900	26.900
AE205	24.900	24.889	24.900	24.889	24.900	24.900	24.900	24.900	24.900
AE206	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
AE226	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
AE245	24.900	24.889	24.900	24.889	24.900	24.900	24.900	24.900	24.900

Table B16.7.1-6. FC/SZ Outdoor Air Humidity Ratio (%)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	0.000259	0.000259	0.000260	0.000300	0.000259	0.000262	0.000344	0.000259	0.000259
AE103	0.002936	0.002895	0.002948	0.002900	0.002933	0.002947	0.002934	0.002936	0.002948
AE104	0.016774	0.016783	0.016850	0.016800	0.016772	0.016839	0.016761	0.016774	0.016850
AE201	0.000259	0.000259	0.000260	0.000300	0.000259	0.000262	0.000344	0.000259	0.000259
AE203	0.002936	0.002895	0.002948	0.002900	0.002933	0.002947	0.002934	0.002936	0.002936
AE204	0.016774	0.016783	0.016850	0.016800	0.016772	0.016839	0.016761	0.016774	0.016774
AE205	0.004491	0.004457	0.004510	0.004500	0.004481	0.004508	0.004487	0.004491	0.004491
AE206	0.015556	0.015523	0.015630	0.015600	0.015565	0.015616	0.015546	0.015556	0.015556
AE226	0.015556	0.015523	0.015630	0.015600	0.015565	0.015616	0.015546	0.015556	0.015556
AE245	0.004491	0.004457	0.004510	0.004500	0.004481	0.004508	0.004487	0.004491	0.004491

**ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101-AE245
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024**

Table B16.7.1-7. FC/SZ 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	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	0.113	0.113	0.113	0.120	0.114	0.113	0.113	0.113	0.113
AE103	0.111	0.112	0.113	0.112	0.114	0.113	0.113	0.111	0.111
AE104	0.110	0.110	0.113	0.109	0.114	0.113	0.113	0.110	0.110
AE201	0.113	0.113	0.113	0.120	0.114	0.113	0.113	0.113	0.113
AE203	0.111	0.112	0.113	0.113	0.114	0.113	0.113	0.111	0.111
AE204	0.110	0.110	0.113	0.109	0.114	0.113	0.113	0.110	0.110
AE205	0.111	0.111	0.113	0.111	0.114	0.113	0.113	0.111	0.111
AE206	0.110	0.110	0.113	0.110	0.114	0.113	0.113	0.110	0.110
AE226	0.336	0.336	0.340	0.329	0.341	0.340	0.340	0.335	0.335
AE245	0.340	0.340	0.340	0.333	0.341	0.340	0.340	0.340	0.340

Table B16.7.1-8. FC/SZ 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	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	29.32	29.33	29.09	29.22	29.05	28.99	29.04	29.31	29.31
AE103	18.50	18.50	18.46	19.00	18.51	18.52	18.51	18.51	18.50
AE104	14.94	14.93	14.70	15.22	14.93	14.84	14.92	14.95	14.95
AE201	29.32	29.33	29.09	28.67	29.05	28.99	29.04	29.31	29.31
AE203	18.50	18.50	18.46	18.44	18.51	18.52	18.51	18.51	18.50
AE204	14.94	14.93	14.72	14.61	14.93	14.84	14.92	14.95	14.95
AE205	18.51	18.50	18.46	18.44	18.52	18.52	18.52	18.51	18.51
AE206	18.51	18.51	18.46	18.44	18.59	18.52	18.58	18.52	18.52
AE226	18.51	18.51	18.44	18.44	18.59	18.52	18.58	18.52	18.52
AE245	18.50	18.50	18.46	18.44	18.51	18.52	18.51	18.50	18.50

Table B16.7.1-9. FC/SZ Relative Humidity at Cooling Coil Outlet [RHcco] (%)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	6.39	6.38		6.40	6.52	6.75	6.87	6.35	6.35
AE103	32.84	32.54	33.03	31.65	32.51	32.91	32.55	32.87	32.97
AE104	100.00	100.00	98.66	99.96	99.62	100.00	100.00	100.00	100.00
AE201	6.39	6.38		6.61	6.51	6.75	6.87	6.35	6.35
AE203	32.84	32.54	33.03	32.77	32.51	32.91	32.55	32.86	32.88
AE204	100.00	100.00	98.62	100.00	99.64	100.00	100.00	100.00	100.00
AE205	44.56	44.31	44.81	44.85	44.11	44.59	44.20	44.59	44.57
AE206	100.00	100.00	99.36	99.93	99.03	100.00	100.00	100.00	100.00
AE226	100.00	100.00	99.65	99.93	99.81	100.00	100.00	100.00	100.00
AE245	34.09	33.84	34.33	34.29	33.99	34.06	34.07	34.10	34.10

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By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024**

Table B16.7.1-10. FC/SZ 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	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	0.6058	0.6066	0.5899	0.0000	0.5861	0.5818	0.5890	0.6057	0.6059
AE103	0.5838	0.5845	0.5899	0.0000	0.5833	0.5818	0.5890	0.5837	0.5838
AE104	0.5758	0.5765	0.5899	0.0000	0.5766	0.5818	0.5890	0.5757	0.5759
AE201	0.6058	0.6066	0.5899		0.5861	0.5818	0.5890	0.6057	0.6057
AE203	0.5838	0.5845	0.5899		0.5833	0.5818	0.5890	0.5837	0.5895
AE204	0.5758	0.5765	0.5899		0.5766	0.5818	0.5890	0.5757	0.5757
AE205	0.5836	0.5843	0.5899		0.5816	0.5818	0.5890	0.5835	0.5735
AE206	0.5826	0.5833	0.5899		0.5738	0.5818	0.5890	0.5825	0.5825
AE226	0.5826	0.5833	0.5899		0.5737	0.5818	0.5890	0.5825	0.5825
AE245	0.5838	0.5863	0.5899		0.5831	0.5818	0.5890	0.5837	0.5837

Table B16.7.1-11. FC/SZ Supply Air Temperature (°C)

Test Case	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	29.92	29.93	29.68	29.22	29.64	29.58	29.62	29.91	29.92
AE103	19.09	19.08	19.05	19.00	19.09	19.10	19.10	19.09	19.08
AE104	15.51	15.51	15.29	15.22	15.50	15.43	15.51	15.52	15.52
AE201	29.92	29.93	29.68		29.64	29.58	29.62	29.91	29.92
AE203	19.09	19.08	19.05		19.09	19.10	19.10	19.10	19.09
AE204	15.51	15.51	15.31		15.50	15.42	15.51	15.52	15.52
AE205	19.09	19.09	19.05		19.11	19.10	19.11	19.09	19.09
AE206	19.10	19.10	19.05		19.16	19.10	19.16	19.11	19.10
AE226	19.10	19.10	19.03		19.16	19.10	19.16	19.10	19.10
AE245	19.09	19.09	19.05		19.09	19.10	19.10	19.08	19.08

Table B16.7.1-12. FC/SZ 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	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	0.001604	0.001604	0.001642	0.001600	0.001612	0.001670	0.001696	0.001595	0.001596
AE103	0.004325	0.004284	0.004337	0.004300	0.004284	0.004355	0.004285	0.004330	0.004342
AE104	0.010605	0.010599	0.010296	0.010800	0.010558	0.010581	0.010585	0.010612	0.010614
AE201	0.001604	0.001604	0.001642	0.001600	0.001612	0.001670	0.001698	0.001595	0.001595
AE203	0.004325	0.004285	0.004337	0.004300	0.004284	0.004355	0.004285	0.004330	0.004330
AE204	0.010605	0.010600	0.010306	0.010400	0.010561	0.010580	0.010585	0.010612	0.010612
AE205	0.005884	0.005850	0.005900	0.005900	0.005832	0.005916	0.005838	0.005888	0.005888
AE206	0.013368	0.013367	0.013227	0.013300	0.013302	0.013424	0.013413	0.013376	0.013371
AE226	0.013368	0.013367	0.013257	0.013300	0.013410	0.013424	0.013413	0.013373	0.013373
AE245	0.004491	0.004457	0.004510	0.004500	0.004481	0.004508	0.004487	0.004491	0.004491

**ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101-AE245
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024**

Table B16.7.1-13. FC/SZ 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	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	860.78	860.69	833.33		830.35		833.00	856.54	856.75
AE103	833.63	833.45	833.33		830.35		833.00	829.58	829.77
AE104	831.69	831.55	833.33		830.35		833.00	827.67	827.87
AE201	860.78	860.69	833.33		830.35		833.00	856.54	856.54
AE203	833.63	833.45	833.33		830.35		833.00	829.59	829.58
AE204	831.69	831.55	833.33		830.35		833.00	827.67	827.67
AE205	835.71	835.55	833.33		830.35		833.00	831.64	831.63
AE206	845.69	845.57	833.33		830.35		833.00	841.60	841.57
AE226	845.69	845.57	833.33		830.35		833.00	841.58	841.58
AE245	833.85	833.70	833.33		830.35		833.00	829.76	829.76

Table B16.7.1-14. FC/SZ 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	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	34.20		34.02		33.90		34.14	34.17	34.17
AE103	30.17		30.14		30.05		30.08	30.19	30.21
AE104	42.44		41.40		42.29		42.37	42.46	42.47
AE201	34.21		34.02		33.90		34.14	34.17	34.17
AE203	30.18		30.14		30.05		30.08	30.19	30.19
AE204	42.44		41.44		42.29		42.37	42.46	42.46
AE205	34.13		34.10		33.99		34.03	34.14	34.14
AE206	53.12		52.67		53.00		53.29	53.15	53.13
AE226	53.12		52.74		53.27		53.29	53.14	53.14
AE245	30.60		30.58		30.55		30.59	30.59	30.59

Table B16.7.1-15. FC/SZ 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	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	0.3296	0.3297	0.3398	0.3586	0.3410	0.3398	0.3398	0.3296	0.3296
AE103	0.3404	0.3404	0.3398	0.3372	0.3410	0.3398	0.3398	0.3404	0.3403
AE104	0.3412	0.3412	0.3398	0.3279	0.3410	0.3398	0.3398	0.3411	0.3411
AE201	0.3296	0.3297	0.3398	0.3591	0.3410	0.3398	0.3398	0.3296	0.3296
AE203	0.3404	0.3404	0.3398	0.3377	0.3410	0.3398	0.3398	0.3403	0.3404
AE204	0.3412	0.3412	0.3398	0.3284	0.3410	0.3398	0.3398	0.3411	0.3411
AE205	0.3395	0.3396	0.3398	0.3333	0.3410	0.3398	0.3398	0.3395	0.3395
AE206	0.3355	0.3356	0.3398	0.3295	0.3410	0.3398	0.3398	0.3355	0.3355
AE226	0.3355	0.3356	0.3398	0.3294	0.3410	0.3398	0.3398	0.3355	0.3355
AE245	0.3403	0.3403	0.3398	0.3331	0.3410	0.3398	0.3398	0.3403	0.3403

**ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101-AE245
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024**

Table B16.7.1-16. FC/SZ Outdoor Air Mass Flow to Supply Air Mass Flow Ratio (fraction)

Test Case	QAS	DEEAP	DeST	DOE-2.2	EnergyPlus	IES-VE	LCEM	TRNSYS	TRNSYS18
	PSU-TAMU-NREL	AAON	TsinghuaU-LBNL	NREL	GARD	IES	MLIT-TTE	TESS	TESS
AE101	0.342	0.342	0.333	0.333	0.333	0.333	0.334	0.342	0.342
AE103	0.328	0.328	0.333	0.333	0.333	0.333	0.333	0.328	0.328
AE104	0.323	0.323	0.333	0.333	0.333	0.333	0.334	0.323	0.323
AE201	0.342	0.342	0.333	0.333	0.333	0.333	0.333	0.342	0.342
AE203	0.328	0.328	0.333	0.333	0.333	0.333	0.333	0.328	0.328
AE204	0.323	0.323	0.333	0.333	0.333	0.333	0.333	0.323	0.323
AE205	0.328	0.328	0.333	0.333	0.333	0.333	0.333	0.328	0.328
AE206	0.328	0.328	0.333	0.333	0.333	0.333	0.333	0.328	0.328
AE226	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
AE245	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table B16.7.1-17. FC/SZ Zone Air Temperature (°C)

Test Case	QAS	DEEAP	DeST	DOE-2.2	EnergyPlus	IES-VE	LCEM	TRNSYS	TRNSYS18
	PSU-TAMU-NREL	AAON	TsinghuaU-LBNL	NREL	GARD	IES	MLIT-TTE	TESS	TESS
AE101	21.11	21.11	21.10	21.11	21.12	21.11	21.11	21.11	21.11
AE103	23.33	23.33	23.35	23.33	23.33	23.33	23.33	23.33	23.32
AE104	23.89	23.89	23.88	23.89	23.88	23.89	23.89	23.89	23.89
AE201	21.11	21.11	21.10	21.11	21.12	21.11	21.11	21.11	21.11
AE203	23.33	23.33	23.35	23.33	23.33	23.33	23.33	23.34	23.33
AE204	23.89	23.89	23.90	23.89	23.88	23.89	23.89	23.89	23.89
AE205	23.33	23.33	23.35	23.33	23.33	23.33	23.33	23.33	23.33
AE206	23.33	23.33	23.34	23.33	23.33	23.33	23.33	23.34	23.33
AE226	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33	23.33
AE245	23.33	23.33	23.35	23.33	23.33	23.33	23.33	23.32	23.32

Table B16.7.1-18. FC/SZ Zone Humidity Ratio (g/gda)

Test Case	QAS	DEEAP	DeST	DOE-2.2	EnergyPlus	IES-VE	LCEM	TRNSYS	TRNSYS18
	PSU-TAMU-NREL	AAON	TsinghuaU-LBNL	NREL	GARD	IES	MLIT-TTE	TESS	TESS
AE101	0.002304	0.002304	0.002332	0.002200	0.002289	0.002370	0.002373	0.002291	0.002291
AE103	0.005002	0.004961	0.005031	0.005000	0.004960	0.005059	0.004960	0.005009	0.005021
AE104	0.011280	0.011274	0.010986	0.011500	0.011233	0.011285	0.011261	0.011291	0.011293
AE201	0.002304	0.002304	0.002332	0.002200	0.002289	0.002374	0.002374	0.002291	0.002291
AE203	0.005002	0.004961	0.005031	0.005000	0.004960	0.005059	0.004960	0.005009	0.005009
AE204	0.011280	0.011274	0.010995	0.011100	0.011236	0.011284	0.011261	0.011291	0.011291
AE205	0.006562	0.006528	0.006593	0.006600	0.006507	0.006620	0.006513	0.006569	0.006569
AE206	0.014054	0.014053	0.013921	0.014000	0.013978	0.014128	0.014089	0.014065	0.014059
AE226	0.014054	0.014053	0.013951	0.014100	0.014086	0.014128	0.014089	0.014062	0.014062
AE245	0.005168	0.005134	0.005204	0.005200	0.005156	0.005212	0.005162	0.005170	0.005170

**ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101-AE245
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024**

Table B16.7.1-19. FC/SZ Moisture Added to Zone 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	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE101	0.231	0.231	0.235	0.215	0.231	0.238	0.230	0.229	0.229
AE103	0.230	0.230	0.236	0.236	0.230	0.239	0.230	0.231	0.231
AE104	0.230	0.230	0.234	0.229	0.230	0.239	0.229	0.232	0.232
AE201	0.231	0.231	0.235	0.215	0.231	0.239	0.230	0.229	0.229
AE203	0.230	0.230	0.236	0.236	0.230	0.239	0.230	0.231	0.231
AE204	0.230	0.230	0.234	0.230	0.230	0.239	0.229	0.232	0.232
AE205	0.230	0.230	0.236	0.233	0.230	0.239	0.230	0.231	0.231
AE206	0.230	0.230	0.236	0.231	0.230	0.239	0.230	0.231	0.231
AE226	0.230	0.230	0.236	0.264	0.230	0.239	0.230	0.231	0.231
AE245	0.230	0.230	0.236	0.233	0.230	0.239	0.230	0.231	0.231

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

Table B16.7.1-20. FC/SZ 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	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE201	0.2721	0.2950	0.2950	0.2778	0.2897	0.2909	0.2950	0.2720	0.2720
AE203	0.3126	0.2970	0.2950	0.2778	0.2913	0.2909	0.2950	0.3125	0.3125
AE204	0.3261	0.2972	0.2950	0.2778	0.2880	0.2909	0.2950	0.3260	0.3260
AE205	0.3125	0.2969	0.2950	0.3333	0.2904	0.2909	0.2950	0.3123	0.3124
AE206	0.3119	0.2964	0.2950	0.2778	0.2865	0.2909	0.2950	0.3118	0.3118
AE226	0.3119	0.2964	0.2950	0.3333	0.2865	0.2909	0.2950	0.3118	0.3118
AE245	0.3126	0.2970	0.2950	0.3333	0.2912	0.2909	0.2950	0.3125	0.3125

**ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101-AE245
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024**

Table B16.7.1-21. FC/SZ Delta Coil Load: SZ - FC (kWh/h)

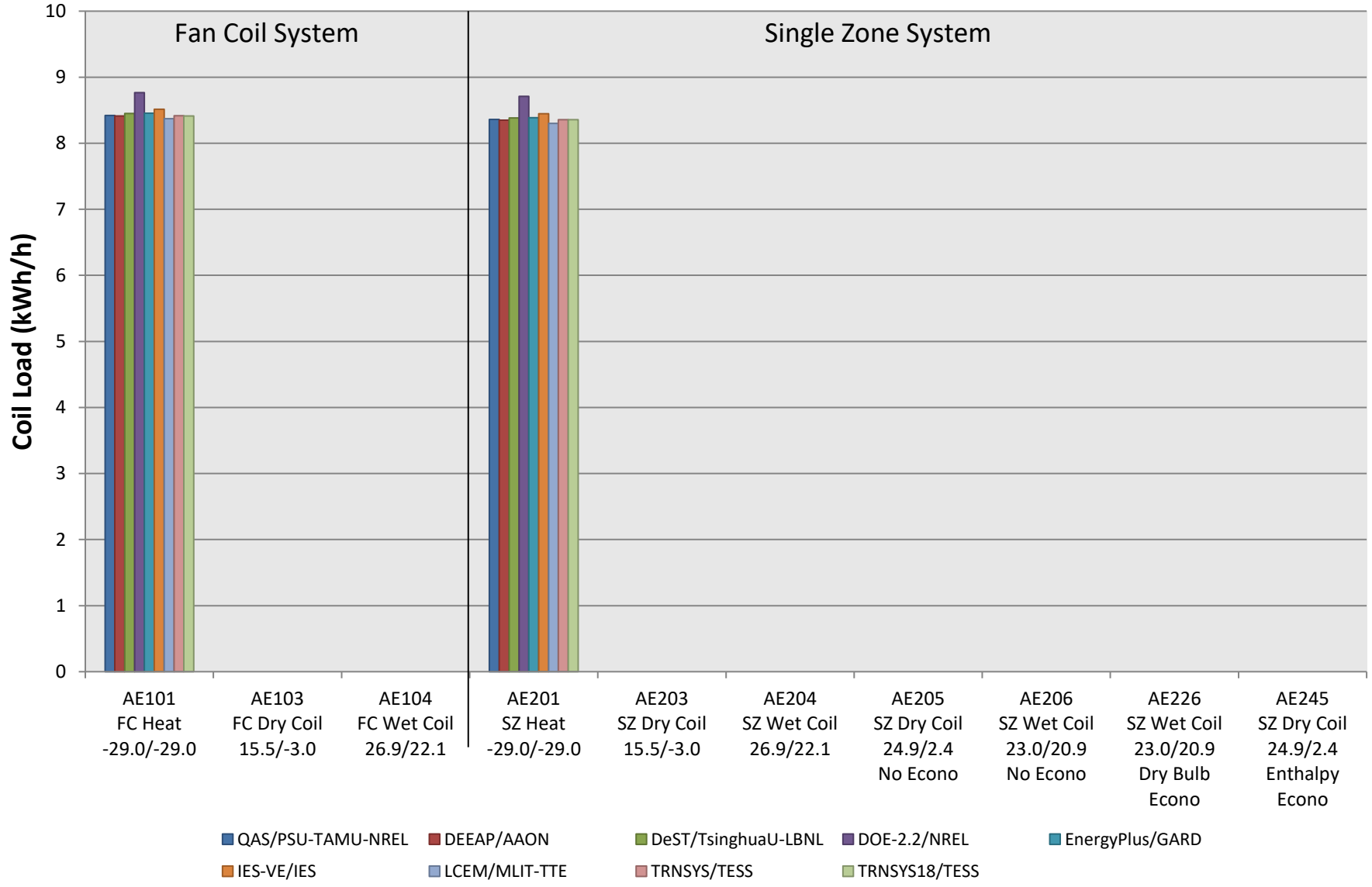
Test Case	Load	QAS PSU-TAMU-NREL	DEEAP AAON	DeST TsinghuaU-LBNL	DOE-2.2 NREL	EnergyPlus GARD	IES-VE IES	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE201-AE101	Heating	-0.060	-0.065	-0.067	-0.058	-0.066	-0.067	-0.070	-0.060	-0.058
AE203-AE103	Sensible Cooling	0.073	0.069	0.068	0.063	0.067	0.068	0.068	0.072	0.073
AE204-AE104	Total Cooling	0.077	0.070	0.061	0.178	0.066	0.068	0.068	0.077	0.059
	Sensible Cooling	0.077	0.070	0.065	0.069	0.067	0.067	0.067	0.077	0.077
	Latent Cooling	0.000	-0.000	-0.004	0.109	-0.001	0.001	0.001	-0.000	-0.019

Table B16.7.1-22. SZ Delta 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	LCEM MLIT-TTE	TRNSYS TESS	TRNSYS18 TESS
AE245-AE205	Total Cooling	0.291	0.292	0.287	0.279	0.295	0.295	0.291	0.296	0.296
	Sensible Cooling	0.291	0.292	0.287	0.279	0.295	0.295	0.292	0.296	0.296
	Latent Cooling	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	0.000	0.000
AE226-AE206	Total Cooling	0.685	0.671	0.825	0.673	0.680	0.681	0.692	0.684	0.711
	Sensible Cooling	-0.145	-0.144	-0.138	-0.126	-0.142	-0.143	-0.142	-0.143	-0.120
	Latent Cooling	0.830	0.815	0.963	0.799	0.822	0.825	0.835	0.827	0.830

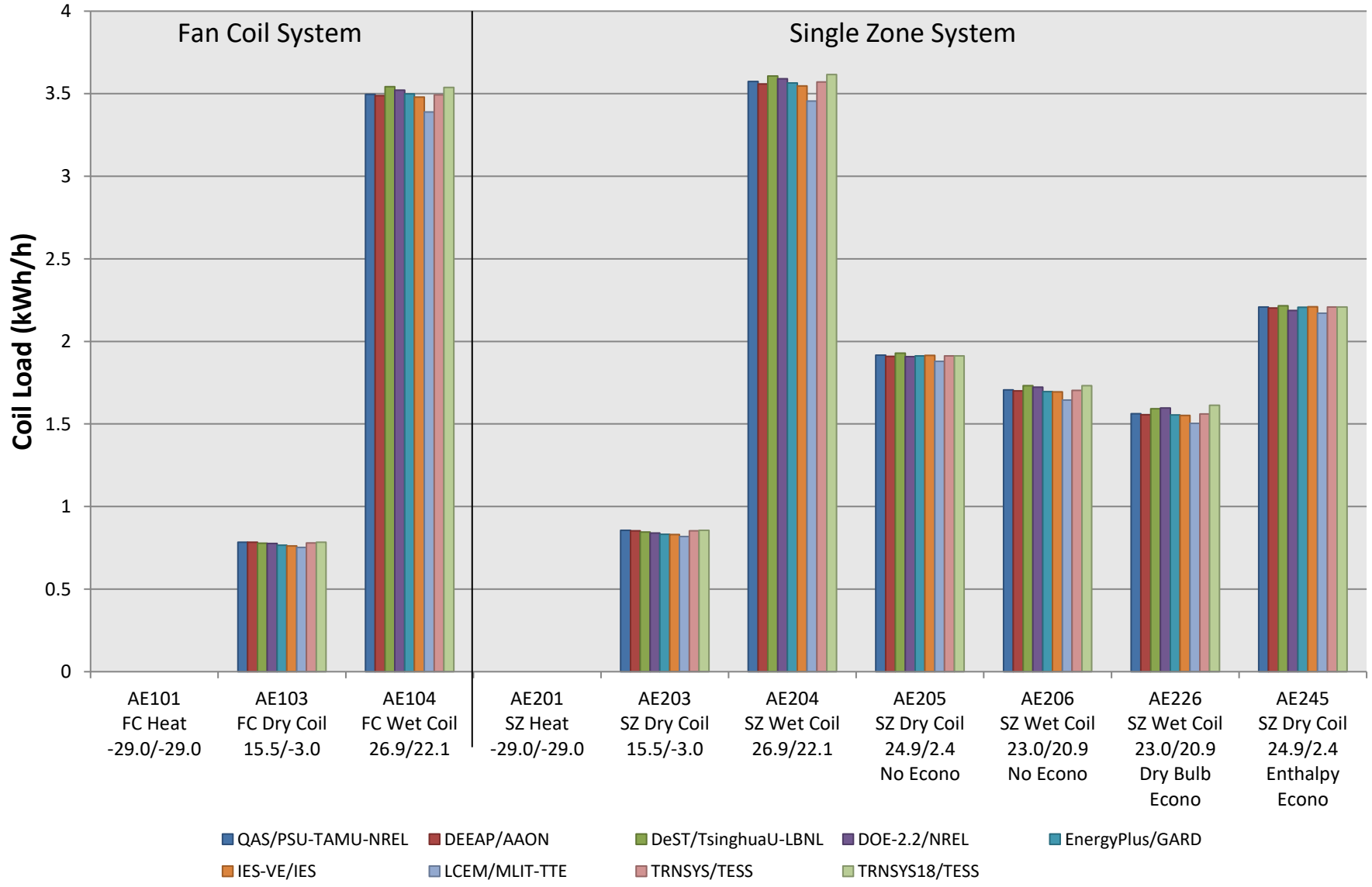
ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101 - AE245
 TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-

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Figure B16.7.1-1. FC/SZ Heating Coil Load [QH]



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101 - AE245
 TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.1-3. FC/SZ Cooling Coil Load, Sensible [QC_sensible]



2024
Figure B16.7.1-5. FC/SZ Outdoor Air Temperature

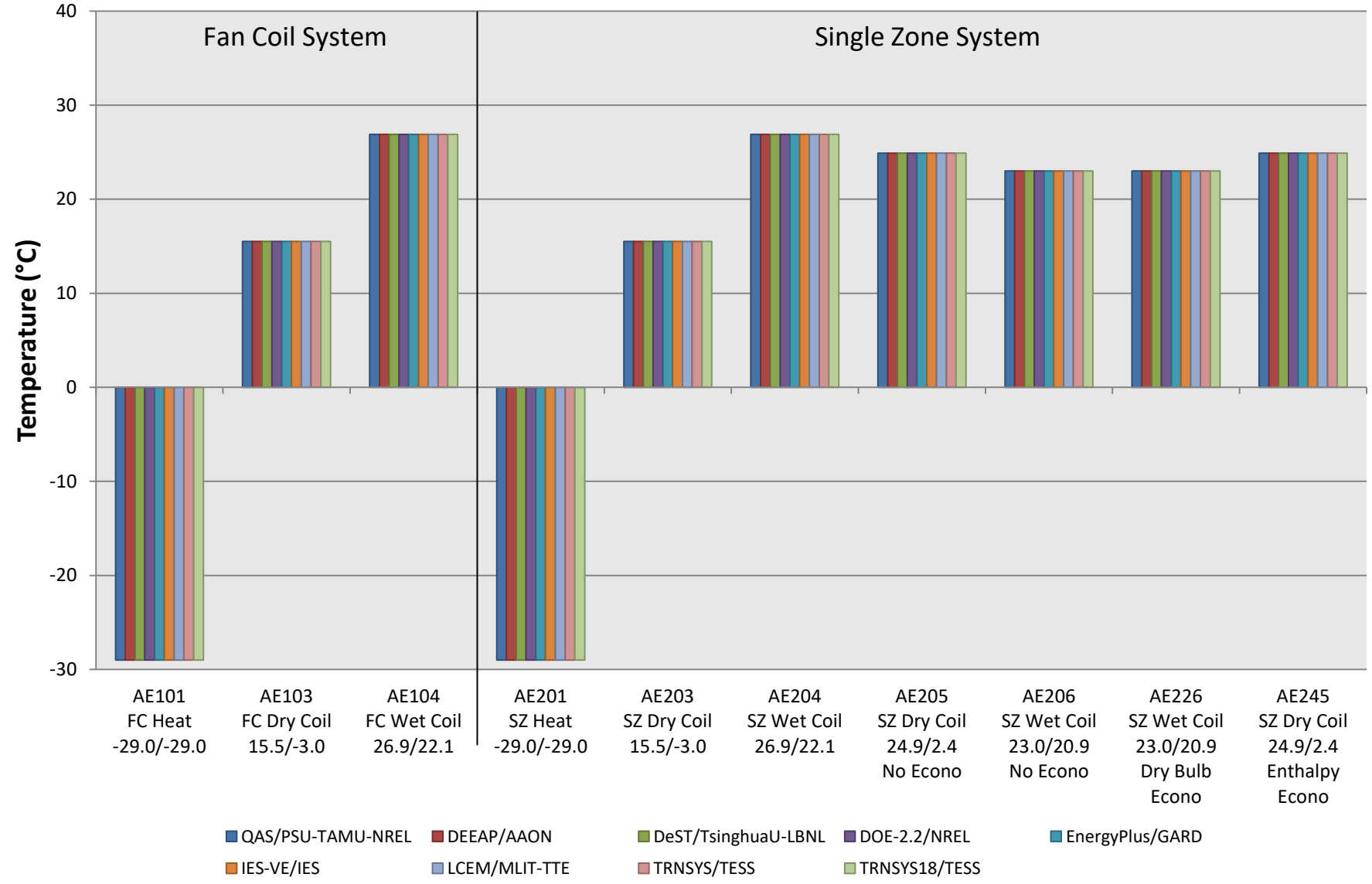
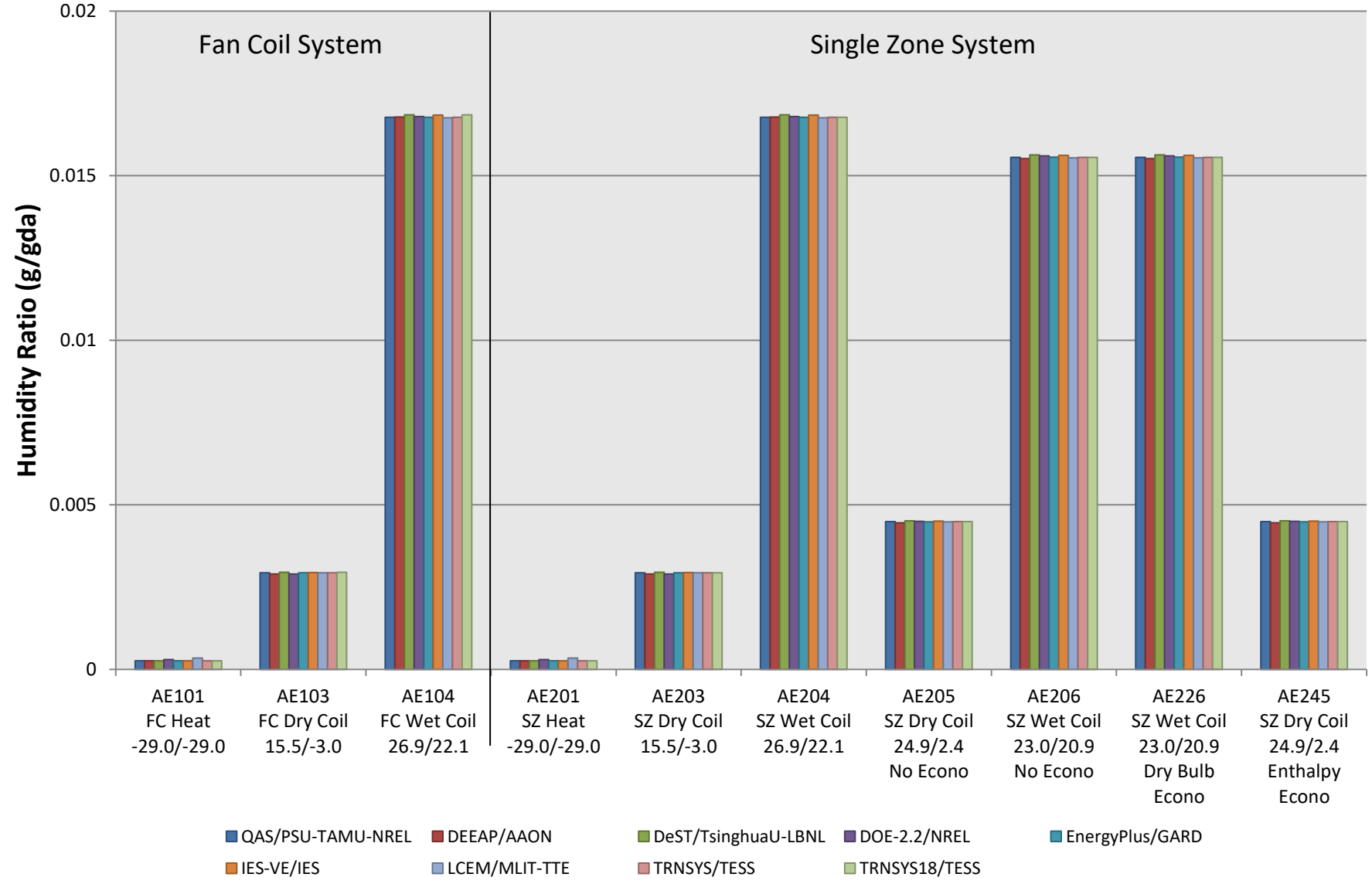
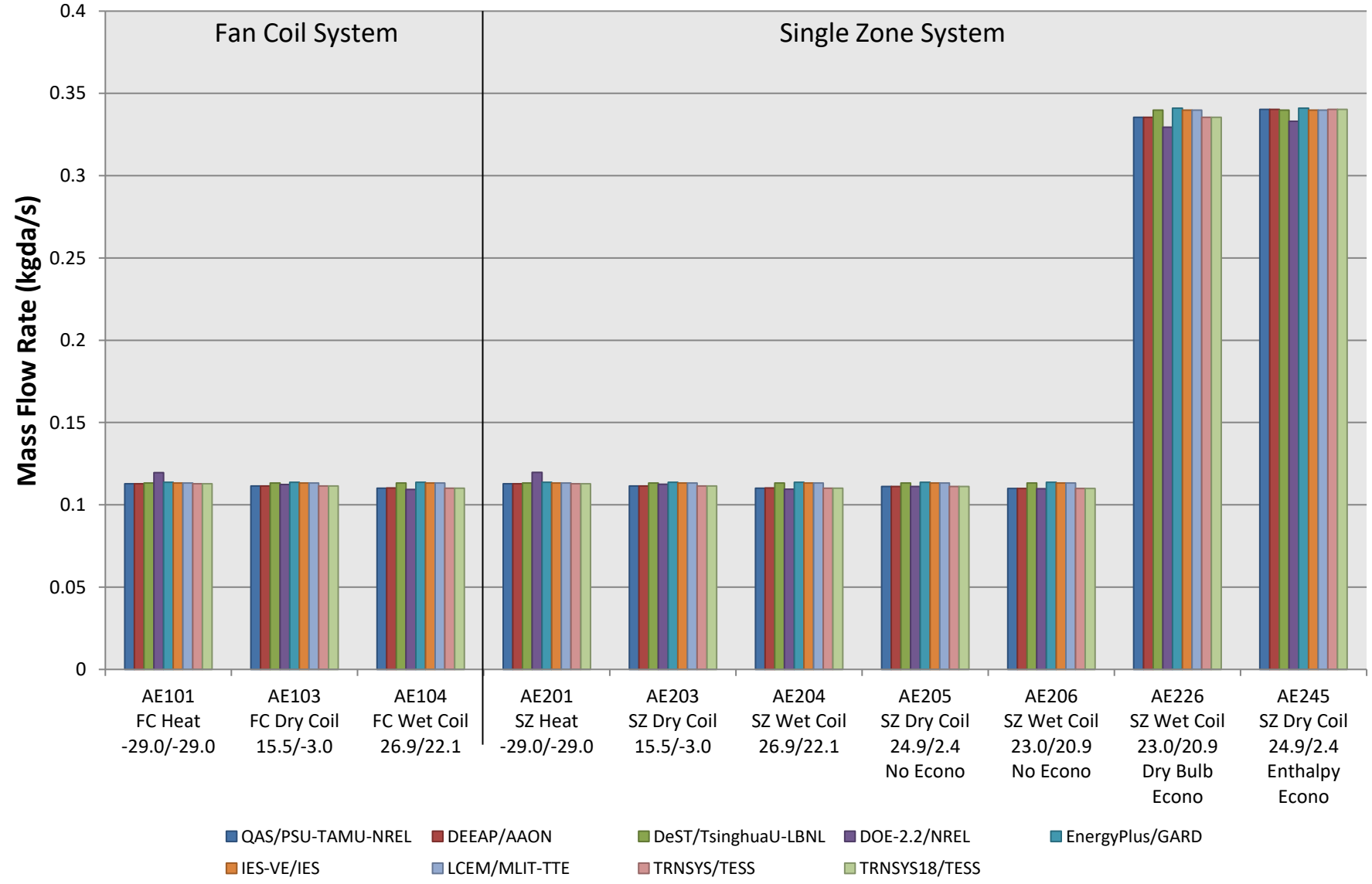


Figure B16.7.1-6. FC/SZ Outdoor Air Humidity Ratio



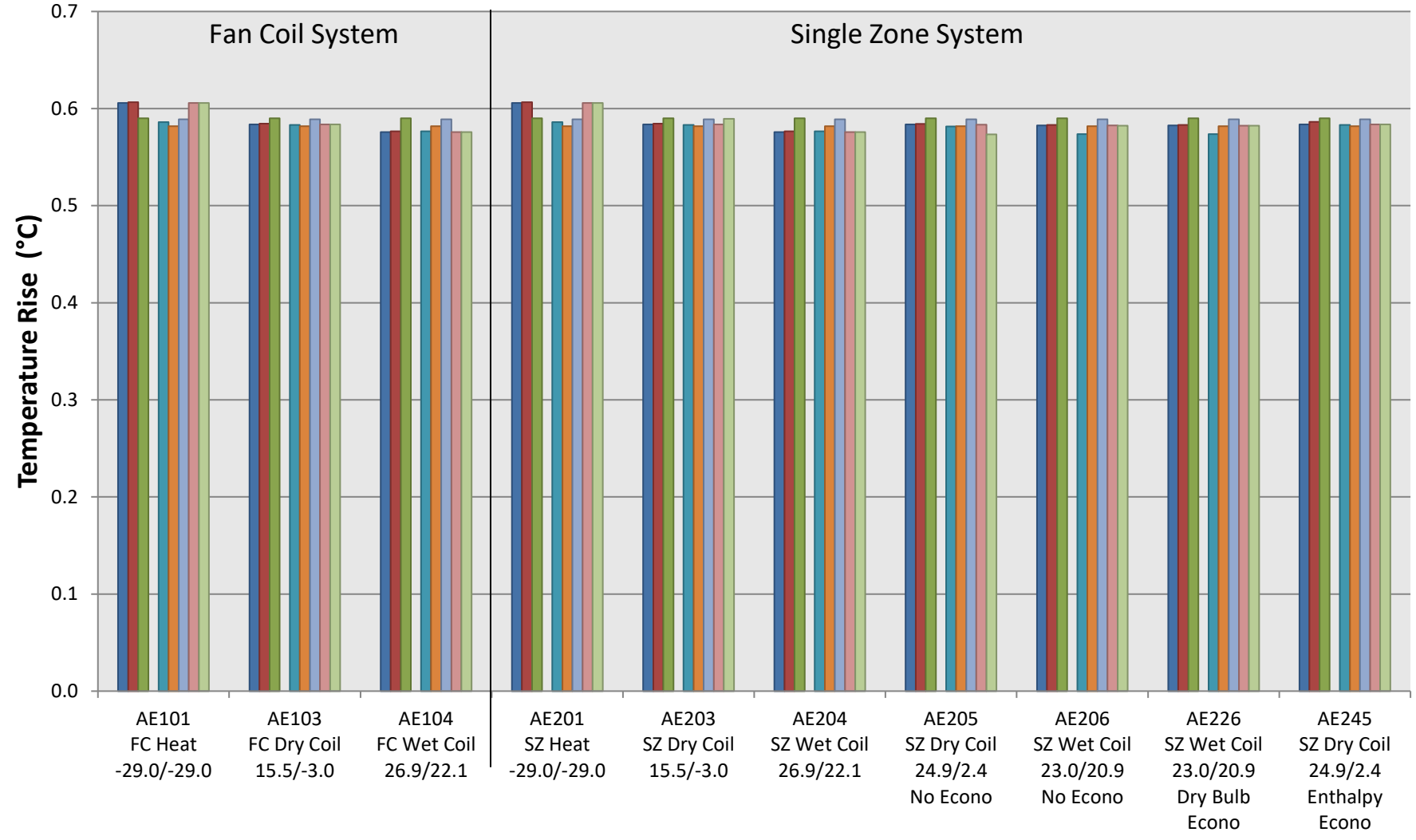
ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101 - AE245
 TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.1-7. FC/SZ Outdoor Air Mass Flow Rate



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101 - AE245
 TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.1-10. FC/SZ Supply Fan Air Temperature Rise

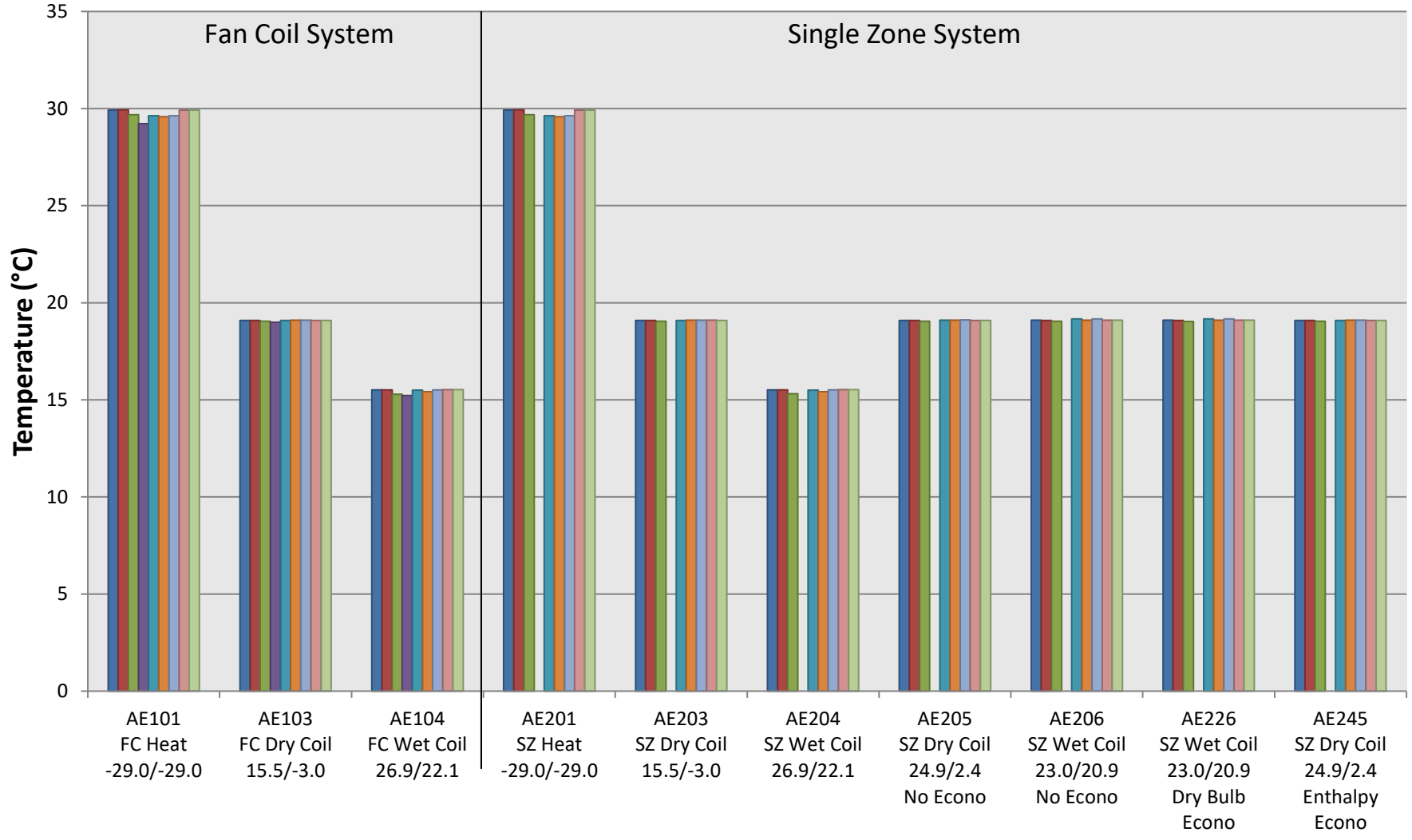


- QAS/PSU-TAMU-NREL
- DEEAP/AAON
- DeST/TsinghuaU-LBNL
- DOE-2.2/NREL
- EnergyPlus/GARD
- IES-VE/IES
- LCEM/MLIT-TTE
- TRNSYS/TESS
- TRNSYS18/TESS

Output not available for DOE-2.2

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101 - AE245
 TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-

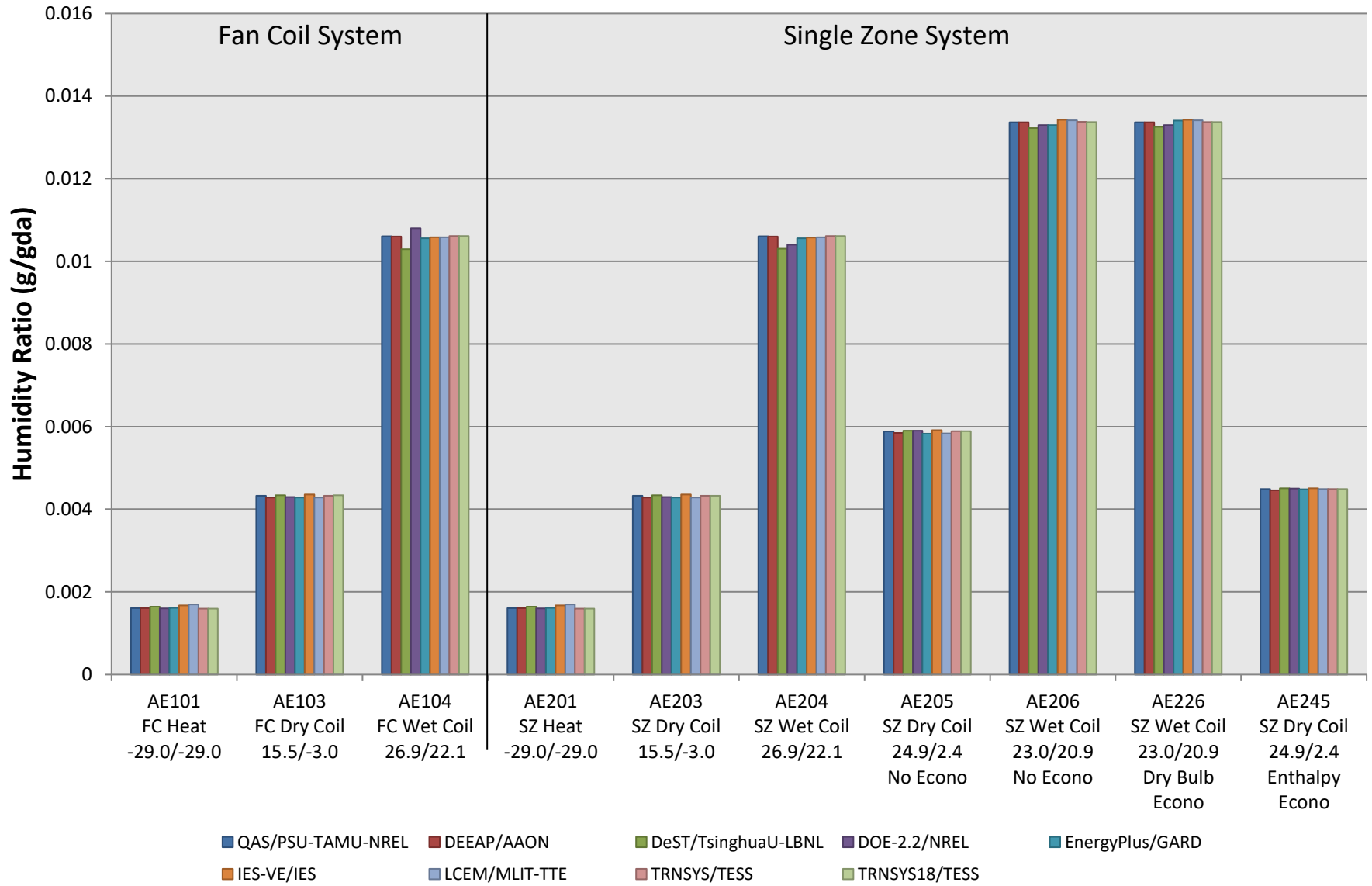
Figure B16.7.1-11. FC/SZ Supply Air Temperature



■ QAS/PSU-TAMU-NREL
 ■ DEEAP/AAON
 ■ DeST/TsinghuaU-LBNL
 ■ DOE-2.2/NREL
 ■ EnergyPlus/GARD
■ IES-VE/IES
 ■ LCEM/MLIT-TTE
 ■ TRNSYS/TESS
 ■ TRNSYS18/TESS

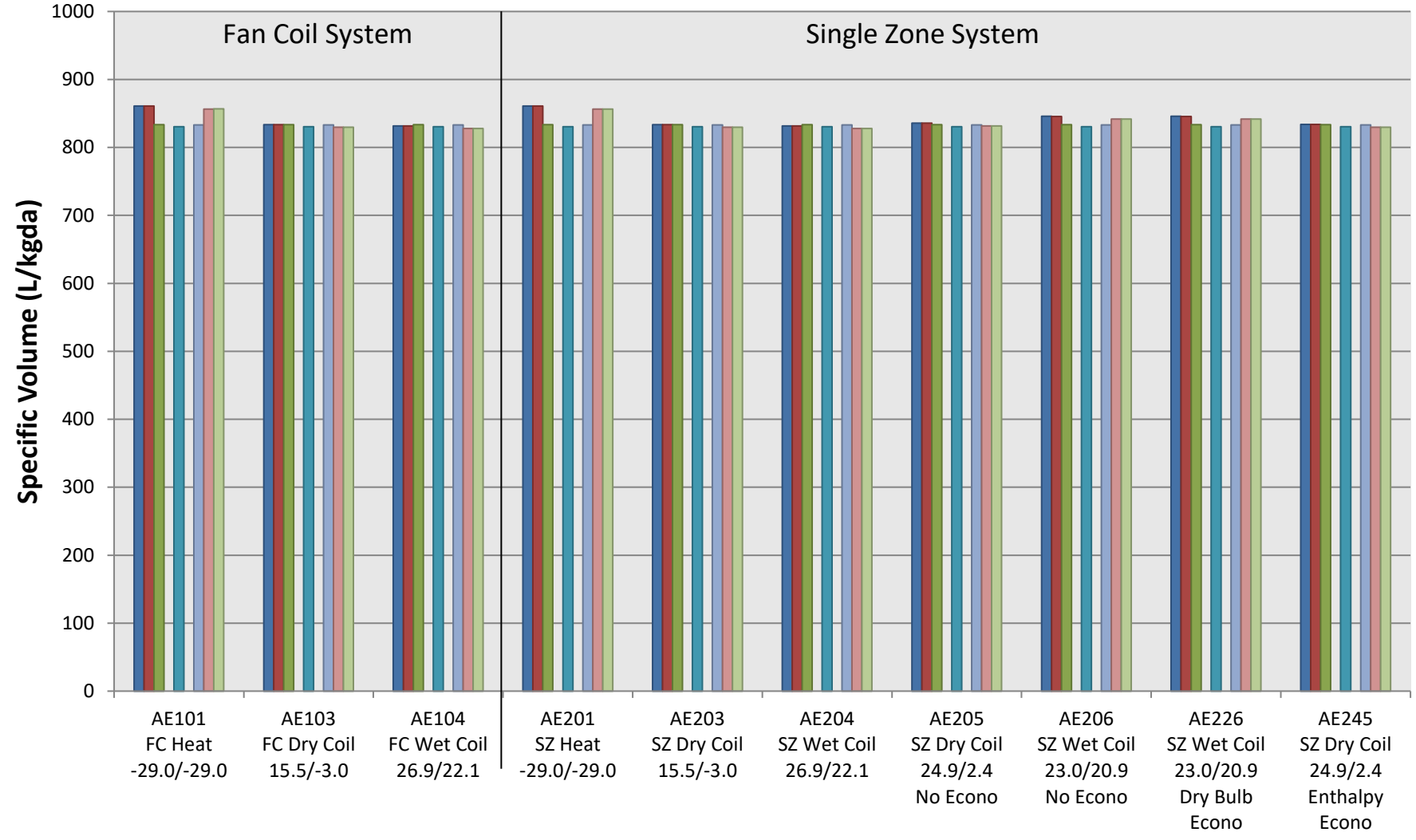
Output not available for DOE-2.2 for SZ Cases

Figure B16.7.1-12. FC/SZ Supply Air Humidity Ratio



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101 - AE245
 TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-
 2024

Figure B16.7.1-13. FC/SZ Supply Air Specific Volume

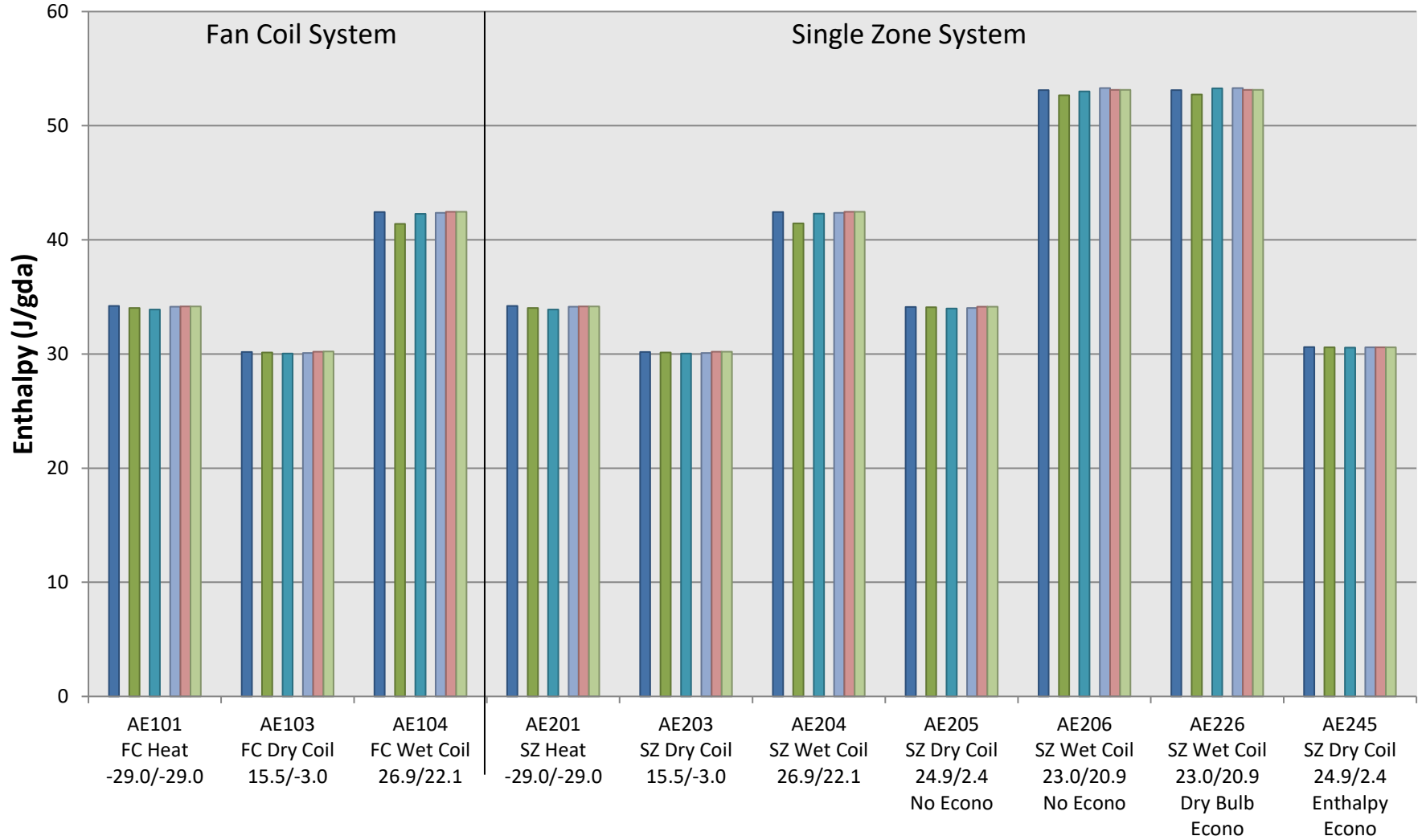


■ QAS/PSU-TAMU-NREL
 ■ DEEAP/AAON
 ■ DeST/TsinghuaU-LBNL
 ■ DOE-2.2/NREL
 ■ EnergyPlus/GARD
■ IES-VE/IES
 ■ LCEM/MLIT-TTE
 ■ TRNSYS/TESS
 ■ TRNSYS18/TESS

Output not available for DOE-2.2 & IES-VE

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101 - AE245
 TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-

²⁰²⁴
Figure B16.7.1-14. FC/SZ Supply Air Enthalpy



■ QAS/PSU-TAMU-NREL
 ■ DEEAP/AAON
 ■ DeST/TsinghuaU-LBNL
 ■ DOE-2.2/NREL
 ■ EnergyPlus/GARD
■ IES-VE/IES
 ■ LCEM/MLIT-TTE
 ■ TRNSYS/TESS
 ■ TRNSYS18/TESS

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

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101 - AE245
 TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-
 2024

Figure B16.7.1-15. FC/SZ Supply Air Mass Flow Rate

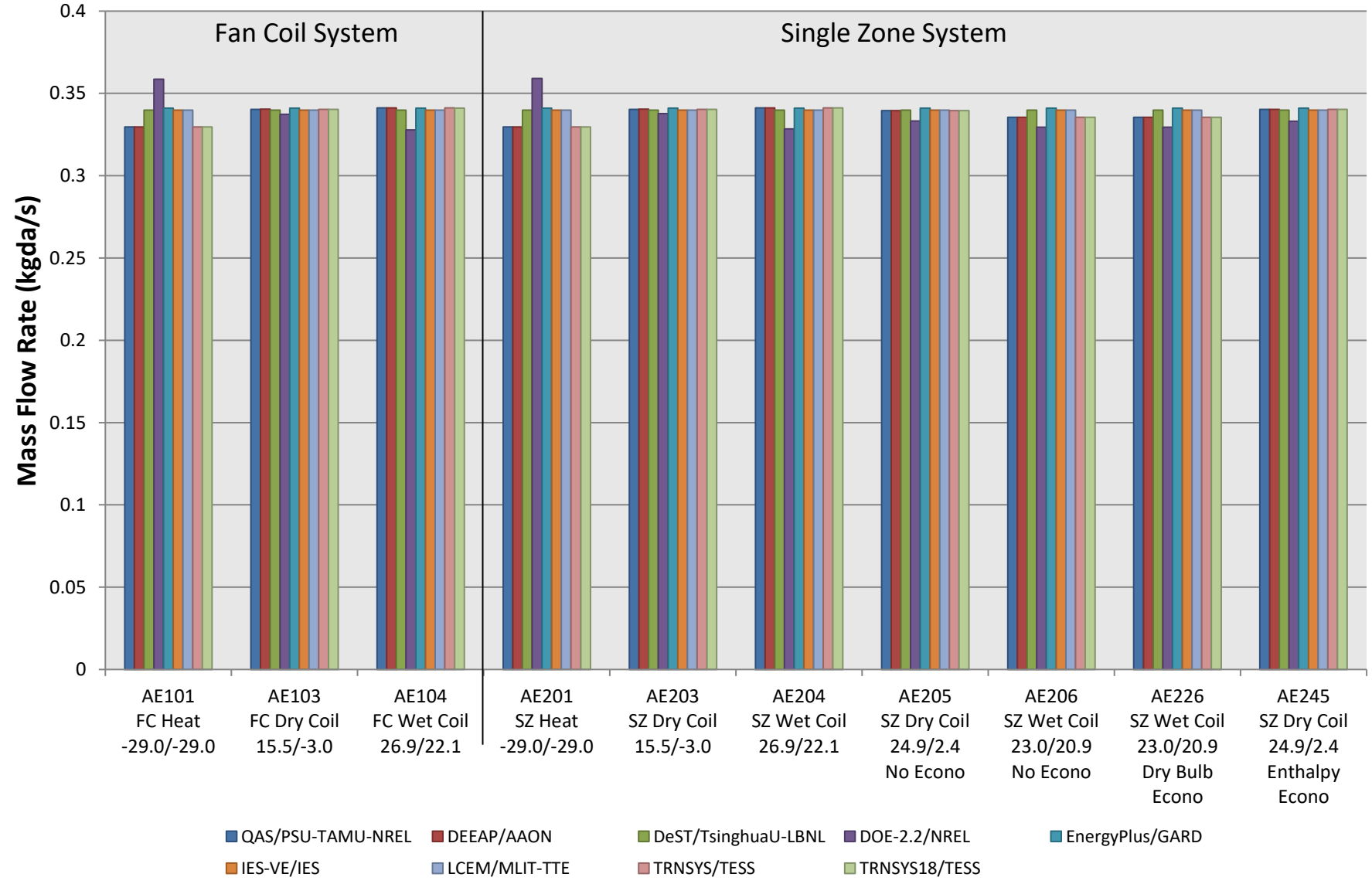
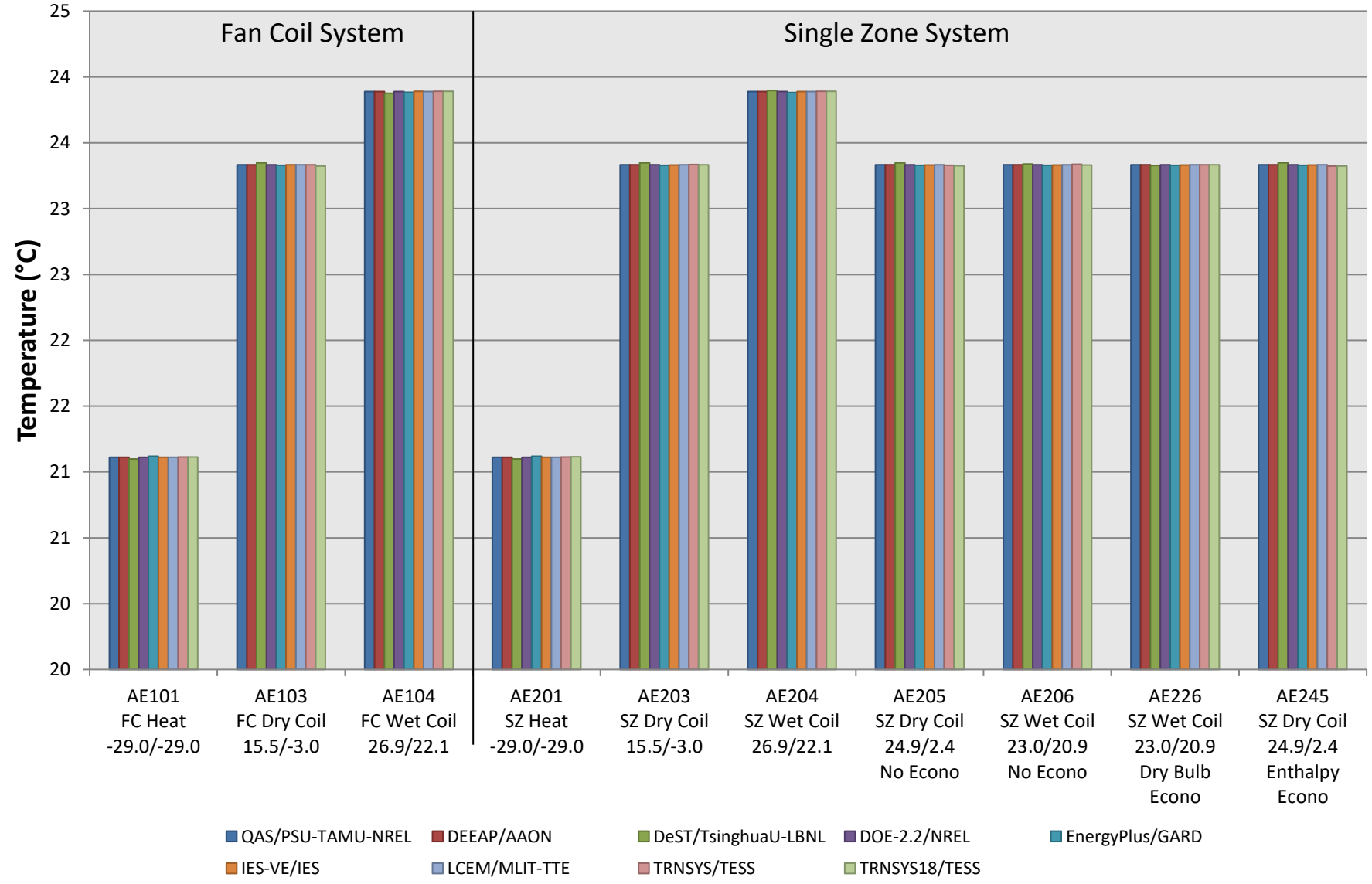


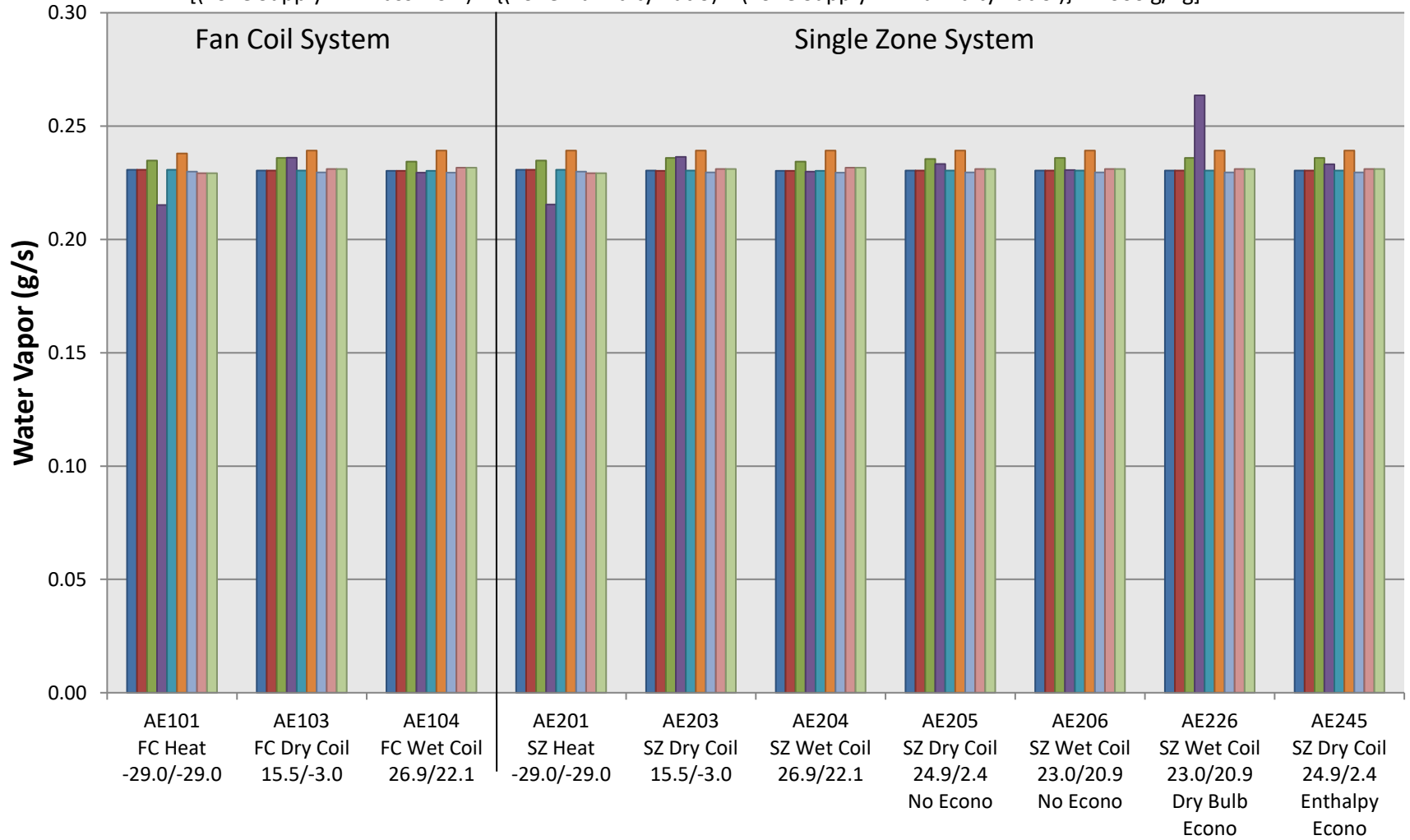
Figure B16.7.1-17. FC/SZ Zone Air Temperature



ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101 - AE245
 TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.7.1-19. FC/SZ Moisture Added to Zone by Latent Gains

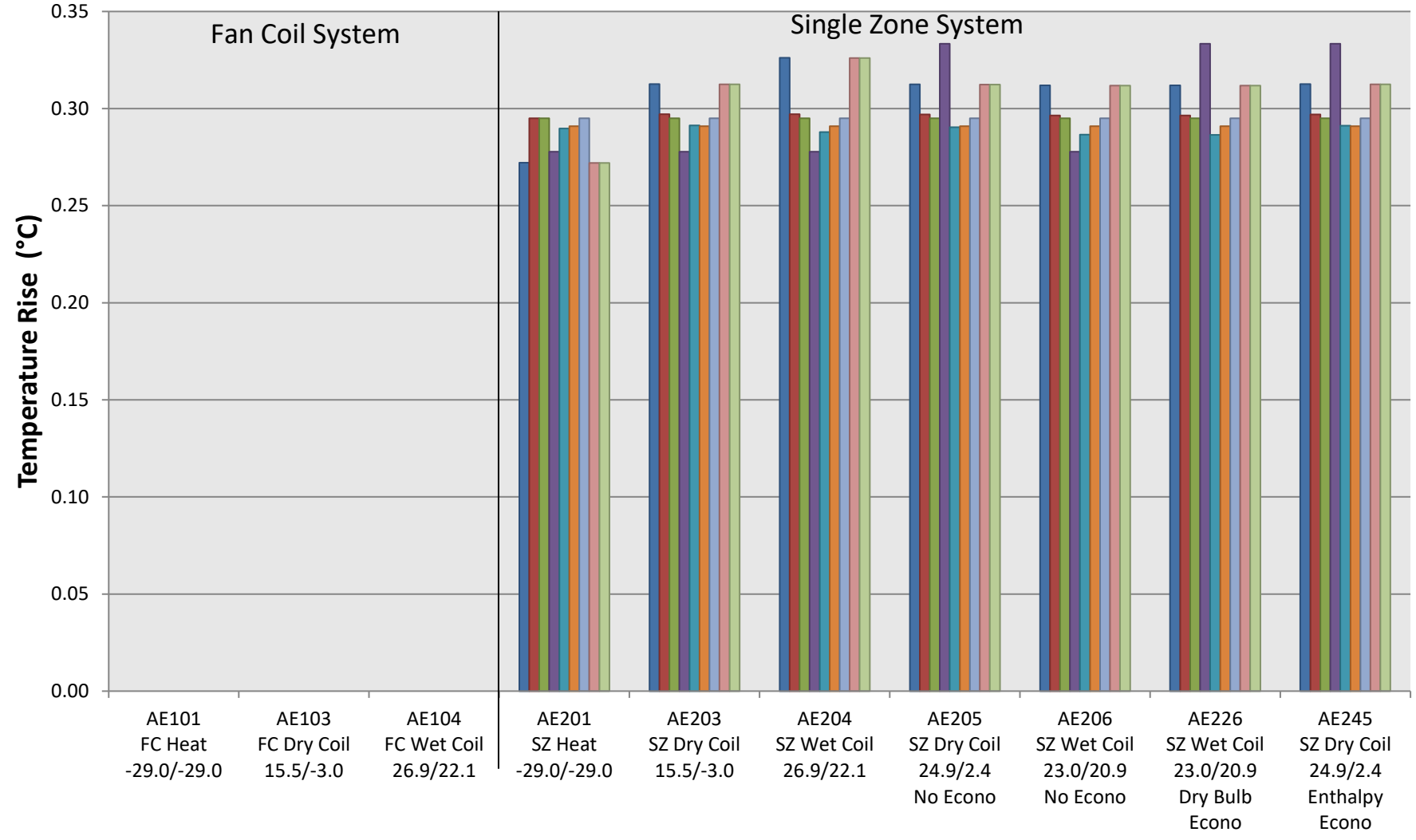
$$[(\text{Zone Supply Air Mass Flow}) \times \{(\text{Zone Humidity Ratio}) - (\text{Zone Supply Air Humidity Ratio})\} \times 1000 \text{ g/kg}]$$



■ QAS/PSU-TAMU-NREL ■ DEEAP/AAON ■ DeST/TsinghuaU-LBNL ■ DOE-2.2/NREL ■ EnergyPlus/GARD
■ IES-VE/IES ■ LCEM/MLIT-TTE ■ TRNSYS/TESS ■ TRNSYS18/TESS

DOE-2.2 has limited humidity ratio output precision

Figure B16.7.1-20. FC/SZ Return Fan Air Temperature Rise



■ QAS/PSU-TAMU-NREL
 ■ DEEAP/AAON
 ■ DeST/TsinghuaU-LBNL
 ■ DOE-2.2/NREL
 ■ EnergyPlus/GARD
■ IES-VE/IES
 ■ LCEM/MLIT-TTE
 ■ TRNSYS/TESS
 ■ TRNSYS18/TESS

DOE-2.2 has limited temperature output precision

ASHRAE Standard 140-2023, Results Comparison for Airside HVAC BESTEST Cases AE101 - AE245
 TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.7.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-

²⁰²⁴
Figure B16.7.1-21. FC/SZ Delta Coil Load, SZ - FC

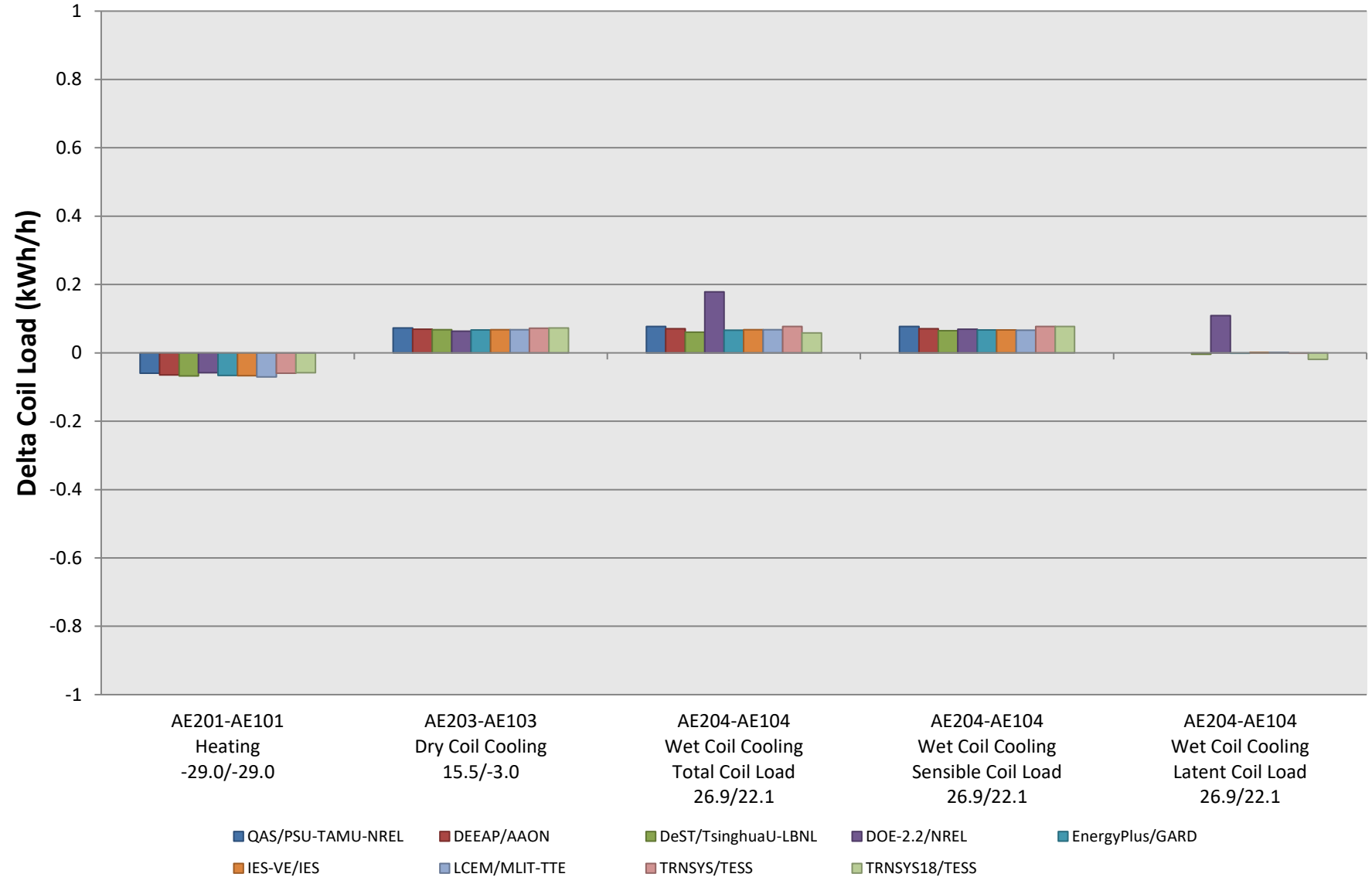


Figure B16.7.1-22. FC/SZ Delta Coil Load, Economizer Operation

