ASHRAE Standard 140-2023

Test Results Comparison
for
Section 9 - HVAC Equipment Performance Tests CE100 through CE200

Results for TRNSYS18.06.0002
(TRNSYS18)
vs.
Informative Annex B16, Section B16.5.1 Example Results

Prepared By
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Results Developed
19-Aug-2024

ASHRAE Standard 140-2023
Participating Organizations and Computer Programs for
Quasi-analytical Solutions and Example Simulation Results
Section 9 - HVAC Equipment Performance Tests CE100 through CE200

The quasi-analytical solutions and programs used to generate the example simulation results are described in Table B17-1. The first column of Table B17-1 ("Model"), indicates the proper 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 or did the quasi-analytical solutions.

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 entries in the fourth column are the abbreviations for the simulations and quasi-analytical solutions generally used in the tables and charts which follow.

See Standard 140, Annex B17 for further details.

TABLE B17-1
Participating Organizations and Computer Programs

Model	Authoring Organization	Implemented By	Abbreviation
Quasi-Analytical solution with ideal controller model	Hochschule Technik & Architektur Luzern, Switzerland (HTAL)	Hochschule Technik & Architektur Luzern, Switzerland	HTAL1
Quasi-Analytical solution with realistic controller model	Hochschule Technik & Architektur Luzern, Switzerland	Hochschule Technik & Architektur Luzern, Switzerland	HTAL2
Quasi-Analytical Solution with ideal controller model	Technische Universität Dresden, Germany (TUD)	Technische Universität Dresden, Germany	TUD
CA-SIS V1	Electricité de France, France (EDF)	Electricité de France, France	CA-SIS
CLIM2000 2.1.6	Electricité de France, France	Electricité de France, France	CLM2000
DOE-2.1E-088	LANL/LBNL/ESTSC,[a,b,c] USA	CIEMAT,[d] Spain	DOE21E/CIEMAT DOE2.1-E/CIEMAT
DOE-2.1E-133	LANL/LBNL/JJH,[a,b,e] USA	NREL/JNA,[f] USA	DOE21E/NREL DOE2.1-E/NREL
ENERGYPLUS 1.0.0.023	LBNL/UIUC/CERL/OSU/GARD Analytics/FSEC/DOE-OBT,[a,g,h,i,j,k]	GARD Analytics, USA	E+ EnergyPlus
TRNSYS 14.2-TUD with ideal controller model	University of Wisconsin, USA; Technische Universität Dresden, Ger.	Technische Universität Dresden, Germany	TRN-id TRNSYS-ideal
TRNSYS 14.2-TUD with real controller model	University of Wisconsin, USA; Technische Universität Dresden, Ger.	Technische Universität Dresden, Germany	TRN-re TRNSYS-real

[a]LANL: Los Alamos National Laboratory, United States
[b]LBNL: Lawrence Berkeley National Laboratory, United States
[c]ESTSC: Energy Science and Technology Software Center (at Oak Ridge National Laboratory), United States
[d]CIEMAT: Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas, Spain
[e]JJH: James J. Hirsch & Associates, United States
[f]NREL/JNA: National Renewable Energy Laboratory/J. Neymark & Associates, United States
[g]UIUC: University of Illinois Urbana/Champaign, United States
[h]CERL: U.S. Army Corps of Engineers, Construction Engineering Research Laboratories, United States
[i]OSU: Oklahoma State University, United States
[j]FSEC: University of Central Florida, Florida Solar Energy Center, United States
[k]DOE-OBT: U.S. Department of Energy, Office of Building Technology, State and Community Programs, Energy Efficiency and Renewable Energy, United States

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TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

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

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TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B16.5.1-1. Space Cooling Electricity Consumption

Energy Consumption, Total (kWh,e)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	1531	1530	1521	1519	1520	1522	1512	1512	1531	1.2%	1531	1531	1531	1541
CE110	1077	1089	1061	1065	1069	1067	1062	1061	1089	2.6%	1076	1077	1077	1085
CE120	1012	1012	1011	1003	1006	1007	1002	1002	1012	1.0%	1013	1011	1011	1022
CE130	110	109	105	106	109	109	110	105	110	4.3%	111	110	110	111
CE140	68	69	65	66	68	68	69	65	69	5.8%	69	69	68	69
CE150	1208	1207	1202	1183	1197	1199	1192	1183	1208	2.1%	1206	1207	1207	1215
CE160	1140	1139	1138	1107	1132	1137	1133	1107	1140	2.9%	1140	1139	1139	1148
CE165	1502	1501	1499	1470	1491	1500	1490	1470	1502	2.1%	1498	1500	1500	1511
CE170	638	638	629	620	635	636	636	620	638	2.8%	641	638	638	646
CE180	1083	1082	1077	1080	1082	1081	1080	1077	1083	0.5%	1083	1082	1082	1085
CE185	1544	1543	1541	1547	1540	1542	1538	1538	1547	0.6%	1545	1543	1543	1561
CE190	164	164	160	160	164	164	165	160	165	3.1%	165	164	164	167
CE195	250	250	245	246	250	250	252	245	252	2.7%	252	250	250	255
CE200	1477	1464	1468	1440	1465	1480	1480	1440	1480	2.7%	1476	1477	1477	1482
Energy Consumption, Compressor (kWh,e)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	1319	1318	1307	1311		1311	1303	1303	1319	1.2%	1319	1319	1319	1329
CE110	889	899	866	883		879	876	866	899	3.7%	888	889	889	896
CE120	840	840	850	838		836	832	832	850	2.2%	841	839	839	849
CE130	95	94	93	93		94	95	93	95	2.1%	95	94	94	96
CE140	57	57	55	56		56	57	55	57	3.9%	57	57	56	57
CE150	1000	999	1007	982		992	987	982	1007	2.5%	999	999	999	1007
CE160	950	949	963	926		947	944	926	963	3.9%	950	949	949	958
CE165	1283	1281	1291	1256		1280	1272	1256	1291	2.8%	1279	1280	1280	1291
CE170	531	530	539	523		528	529	523	539	3.0%	533	530	530	537
CE180	909	908	914	912		907	906	906	914	0.9%	908	908	908	911
CE185	1340	1339	1343	1344		1337	1334	1334	1344	0.7%	1340	1339	1338	1354
CE190	138	138	139	138		138	138	138	139	1.4%	138	138	138	140
CE195	217	217	219	217		216	218	216	219	1.1%	219	217	217	221
CE200	1250	1239	1249	1218		1253	1253	1218	1253	2.8%	1249	1250	1250	1255
Energy Consumption, Supply Fan (kWh,e)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	144	144	145	141	144	144	142	141	145	2.9%	144	144	144	145
CE110	128	129	133	122	128	128	127	122	133	8.5%	128	128	128	128
CE120	117	117	110	110	116	117	115	110	117	6.3%	117	117	117	118
CE130	10	10	8	8	10	10	10	8	10	23.1%	10	10	10	10
CE140	8	8	7	6	8	8	8	6	8	27.2%	8	8	8	8
CE150	141	141	133	136	140	141	139	133	141	5.7%	141	141	141	142
CE160	129	129	119	121	128	129	128	119	129	7.8%	129	129	129	130
CE165	149	150	142	145	149	149	148	142	150	5.6%	149	149	149	150
CE170	73	73	61	63	73	73	73	61	73	16.1%	74	73	73	74
CE180	118	119	111	112	118	118	118	111	119	6.9%	119	119	119	119
CE185	139	139	135	137	139	139	139	135	139	3.0%	139	139	139	141
CE190	18	18	14	14	18	18	18	14	18	22.9%	18	18	18	18
CE195	23	23	18	18	23	23	23	18	23	23.3%	23	23	23	23
CE200	154	153	149	151	153	155	155	149	155	3.5%	154	155	155	155
Energy Consumption, Condenser Fan (kWh,e)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	68	68	68	67		67	67	67	68	2.0%	68	68	68	68
CE110	60	61	62	60		60	59	59	62	4.9%	60	60	60	60
CE120	55	55	51	55		55	54	51	55	6.5%	55	55	55	55
CE130	5	5	4	5		5	5	4	5	22.7%	5	5	5	5
CE140	4	4	3	4		4	4	3	4	19.3%	4	4	4	4
CE150	66	66	62	65		66	65	62	66	5.6%	66	66	66	67
CE160	61	61	56	60		61	60	56	61	8.4%	61	61	61	61
CE165	70	70	67	69		70	69	67	70	5.1%	70	70	70	70
CE170	34	34	29	34		34	34	29	34	16.1%	35	34	34	35
CE180	56	56	52	56		56	55	52	56	7.1%	56	56	56	56
CE185	65	65	63	66		65	65	63	66	3.9%	65	65	65	66
CE190	8	9	7	8		8	9	7	9	27.7%	9	9	9	9
CE195	11	11	8	11		11	11	8	11	25.2%	11	11	11	11
CE200	73	72	70	71		73	73	70	73	4.1%	73	73	73	73

* ABS[(Max-Min) / (Mean of Analytical Solutions)]

ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B16.5.1-2. COP: Mean, and (Max-Min)/Mean

Mean COP								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	2.39	2.39	2.43	2.41	2.40	2.40	2.42	2.39	2.43	1.7%	2.39	2.39	2.39	2.37
CE110	3.38	3.34	3.46	3.41	3.40	3.41	3.43	3.34	3.46	3.5%	3.38	3.38	3.38	3.35
CE120	3.59	3.59	3.61	3.62	3.61	3.61	3.63	3.59	3.63	1.1%	3.59	3.59	3.59	3.55
CE130	1.91	1.91	1.98	1.95	1.90	1.92	1.92	1.90	1.98	3.8%	1.89	1.91	1.91	1.87
CE140	2.77	2.73	2.92	2.85	2.77	2.80	2.80	2.73	2.92	6.6%	2.75	2.77	2.77	2.73
CE150	3.62	3.63	3.67	3.70	3.65	3.65	3.67	3.62	3.70	2.2%	3.63	3.63	3.63	3.60
CE160	3.84	3.84	3.87	3.95	3.86	3.85	3.86	3.84	3.95	2.9%	3.83	3.84	3.84	3.81
CE165	2.92	2.92	2.95	2.99	2.94	2.93	2.94	2.92	2.99	2.2%	2.93	2.93	2.93	2.90
CE170	3.38	3.39	3.44	3.48	3.40	3.39	3.40	3.38	3.48	2.9%	3.37	3.39	3.39	3.34
CE180	4.04	4.04	4.08	4.03	4.04	4.05	4.06	4.03	4.08	1.4%	4.04	4.04	4.04	3.99
CE185	2.85	2.85	2.87	2.82	2.85	2.85	2.86	2.82	2.87	1.8%	2.85	2.85	2.85	2.81
CE190	3.41	3.41	3.49	3.46	3.39	3.41	3.40	3.39	3.49	2.7%	3.39	3.41	3.41	3.35
CE195	2.31	2.31	2.36	2.34	2.30	2.32	2.31	2.30	2.36	2.5%	2.29	2.31	2.31	2.26
CE200	3.62	3.61	3.67	3.71	3.65	3.61	3.61	3.61	3.71	2.7%	3.62	3.62	3.62	3.61

(Max - Min)/Mean COP								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	0.000	0.001	0.002	0.001	0.003	0.000	0.000	0.000	0.003	----	0.000		0.000	0.000
CE110	0.000	0.010	0.002	0.001	0.003	0.000	0.011	0.000	0.011	----	0.000		0.000	0.000
CE120	0.000	0.004	0.001	0.001	0.003	0.000	0.012	0.000	0.012	----	0.000		0.000	0.000
CE130	0.000	0.038	0.013	0.009	0.004	0.000	0.172	0.000	0.172	----	0.000		0.000	0.000
CE140	0.000	0.056	0.011	0.019	0.004	0.000	0.204	0.000	0.204	----	0.000		0.000	0.000
CE150	0.003	0.003	0.001	0.005	0.011	0.000	0.009	0.000	0.011	----	0.000		0.001	0.000
CE160	0.003	0.005	0.001	0.003	0.011	0.000	0.010	0.000	0.011	----	0.000		0.000	0.000
CE165	0.010	0.003	0.001	0.003	0.012	0.000	0.008	0.000	0.012	----	0.000		0.000	0.000
CE170	0.000	0.006	0.002	0.004	0.015	0.000	0.043	0.000	0.043	----	0.000		0.000	0.000
CE180	0.005	0.002	0.002	0.010	0.029	0.000	0.012	0.000	0.029	----	0.000		0.000	0.000
CE185	0.007	0.004	0.002	0.010	0.034	0.000	0.009	0.000	0.034	----	0.000		0.000	0.000
CE190	0.000	0.023	0.007	0.019	0.040	0.000	0.101	0.000	0.101	----	0.000		0.000	0.001
CE195	0.000	0.017	0.008	0.017	0.043	0.000	0.086	0.000	0.086	----	0.000		0.000	0.001
CE200	0.006	0.000	0.000	0.005	0.012	0.000	0.000	0.000	0.012	----	0.000		0.000	0.000

* ABS[(Max-Min) / (Mean of Analytical Solutions)]

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TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B16.5.1-3. Coil Loads: Total, Sensible, and Latent

Coil Load, Total (kWh,thermal)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	3800	3800	3841	3794	3798	3800	3798	3794	3841	1.3%	3800	3800	3800	3800
CE110	3765	3766	3804	3756	3763	3765	3763	3756	3804	1.3%	3765	3765	3765	3765
CE120	3749	3749	3763	3739	3747	3748	3747	3739	3763	0.6%	3749	3749	3749	3749
CE130	219	219	216	215	217	219	220	215	220	2.1%	219	219	219	218
CE140	198	198	196	195	196	198	199	195	199	2.0%	198	198	197	197
CE150	4517	4517	4543	4528	4509	4517	4515	4509	4543	0.8%	4518	4517	4518	4517
CE160	4501	4500	4516	4508	4491	4500	4499	4491	4516	0.6%	4501	4500	4500	4500
CE165	4538	4538	4567	4549	4529	4537	4535	4529	4567	0.9%	4537	4537	4538	4537
CE170	2233	2232	2226	2237	2225	2232	2232	2225	2237	0.5%	2232	2232	2233	2232
CE180	4495	4495	4510	4535	4481	4495	4494	4481	4535	1.2%	4495	4495	4494	4449
CE185	4507	4535	4565	4583	4523	4535	4534	4507	4583	1.7%	4535	4535	4534	4535
CE190	578	577	573	579	574	577	578	573	579	1.0%	578	577	578	577
CE195	602	601	595	602	598	601	601	595	602	1.1%	601	601	601	601
CE200	5498	5436	5534	5522	5484	5498	5498	5436	5534	1.8%	5498	5498	5498	5497
Coil Load, Sensible (kWh,thermal)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	3800	3800	3841	3794	3798	3800	3798	3794	3841	1.3%	3800	3800	3800	3800
CE110	3765	3766	3804	3756	3763	3765	3763	3756	3804	1.3%	3765	3765	3765	3765
CE120	3749	3749	3763	3739	3747	3748	3747	3739	3763	0.6%	3749	3749	3749	3749
CE130	219	219	216	215	217	219	220	215	220	2.1%	219	219	219	218
CE140	198	198	196	195	196	198	199	195	199	2.0%	198	198	197	197
CE150	3778	3778	3804	3786	3776	3778	3776	3776	3804	0.7%	3778	3778	3779	3778
CE160	3761	3761	3777	3769	3759	3761	3760	3759	3777	0.5%	3761	3761	3761	3761
CE165	3798	3798	3828	3809	3795	3798	3796	3795	3828	0.9%	3798	3798	3799	3798
CE170	1493	1493	1487	1498	1491	1492	1492	1487	1498	0.7%	1493	1493	1493	1493
CE180	1537	1538	1553	1607	1537	1538	1537	1537	1607	4.5%	1538	1538	1538	1538
CE185	1548	1578	1608	1653	1577	1578	1577	1548	1653	6.6%	1578	1578	1578	1579
CE190	208	208	203	212	206	208	208	203	212	4.4%	208	208	208	207
CE195	232	232	226	235	230	231	232	226	235	4.1%	232	232	232	231
CE200	4276	4215	4313	4303	4274	4277	4277	4215	4313	2.3%	4277	4277	4277	4276
Coil Load, Latent (kWh,thermal)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE110	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE120	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE130	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE140	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE150	739	739	739	742	733	739	739	733	742	1.2%	739	739	739	739
CE160	740	739	739	739	732	739	739	732	740	1.1%	739	739	739	739
CE165	740	739	739	740	733	739	739	733	740	1.0%	739	739	739	739
CE170	740	739	739	739	734	739	739	734	740	0.9%	739	739	739	739
CE180	2958	2957	2957	2928	2944	2957	2957	2928	2958	1.0%	2957	2957	2956	2912
CE185	2959	2957	2957	2930	2946	2957	2957	2930	2959	1.0%	2958	2957	2956	2957
CE190	370	370	370	366	368	370	370	366	370	1.0%	370	370	370	370
CE195	370	370	370	367	368	370	370	367	370	0.9%	370	370	370	370
CE200	1222	1221	1221	1219	1210	1221	1221	1210	1222	1.0%	1221	1221	1221	1221

* ABS[(Max-Min) / (Mean of Analytical Solutions)]

Table B16.5.1-4. Sensible Coil Load minus Zone Load (Fan Heat)

Sensible Coil - Zone Load, (Fan Heat) (kWh,thermal)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	144	144	187	139	144	144	142	139	187	33.6%	144	144	144	145
CE110	128	129	168	119	128	128	127	119	168	38.2%	128	128	128	128
CE120	117	117	133	108	116	117	115	108	133	21.8%	117	117	117	118
CE130	10	10	8	8	10	10	10	8	10	27.0%	10	10	10	10
CE140	8	8	7	6	8	8	8	6	8	25.6%	8	8	8	8
CE150	141	141	168	149	140	141	139	139	168	20.2%	141	141	142	142
CE160	129	129	147	137	129	129	128	128	147	14.3%	129	129	129	130
CE165	149	149	181	161	149	149	148	148	181	22.4%	149	149	150	150
CE170	73	73	69	79	73	73	73	69	79	14.2%	74	73	74	74
CE180	117	118	135	188	119	118	118	117	188	60.1%	118	119	118	119
CE185	109	139	171	215	140	139	139	109	215	76.5%	139	139	139	141
CE190	18	18	15	24	18	18	18	15	24	51.0%	18	18	18	18
CE195	23	23	18	28	23	23	23	18	28	40.8%	23	23	23	23
CE200	154	153	193	181	154	155	155	153	193	25.7%	154	155	155	155

* ABS[(Max-Min) / (Mean of Analytical Solutions)]

ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B16.5.1-5. Zone Loads: Total, Sensible, and Latent

Zone Load, Total (kWh,thermal)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	3656	3656	3654	3655	3654	3656	3656	3654	3656	0.1%	3656	3656	3656	3655
CE110	3637	3637	3636	3637	3636	3637	3637	3636	3637	0.0%	3637	3637	3637	3636
CE120	3632	3632	3630	3632	3631	3632	3631	3630	3632	0.0%	3632	3632	3632	3631
CE130	209	209	207	208	207	209	209	207	209	1.3%	209	209	209	208
CE140	190	190	189	188	188	190	190	188	190	1.1%	190	190	190	189
CE150	4376	4376	4375	4376	4375	4376	4376	4375	4376	0.0%	4376	4376	4376	4376
CE160	4371	4371	4370	4371	4370	4371	4371	4370	4371	0.0%	4371	4371	4371	4370
CE165	4388	4388	4386	4387	4386	4388	4387	4386	4388	0.0%	4388	4388	4388	4387
CE170	2159	2159	2157	2158	2157	2159	2159	2157	2159	0.1%	2159	2159	2159	2158
CE180	4376	4376	4375	4376	4375	4376	4376	4375	4376	0.0%	4376	4376	4376	4330
CE185	4396	4396	4394	4395	4393	4395	4395	4393	4396	0.1%	4396	4396	4396	4394
CE190	557	559	558	558	558	559	559	557	559	0.4%	559	559	559	559
CE195	576	579	577	577	576	578	579	576	579	0.5%	579	579	579	578
CE200	5343	5283	5342	5343	5342	5343	5343	5283	5343	1.1%	5343	5343	5343	5342
Zone Load, Sensible (kWh,thermal)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	3656	3656	3654	3655	3654	3656	3656	3654	3656	0.1%	3656	3656	3656	3655
CE110	3637	3637	3636	3637	3636	3637	3637	3636	3637	0.0%	3637	3637	3637	3636
CE120	3632	3632	3630	3632	3631	3632	3631	3630	3632	0.0%	3632	3632	3632	3631
CE130	209	209	207	208	207	209	209	207	209	1.3%	209	209	209	208
CE140	190	190	189	188	188	190	190	188	190	1.1%	190	190	190	189
CE150	3637	3637	3636	3637	3636	3637	3636	3636	3637	0.0%	3637	3637	3637	3636
CE160	3632	3632	3630	3632	3631	3632	3631	3630	3632	0.0%	3632	3632	3632	3631
CE165	3649	3649	3647	3648	3647	3649	3648	3647	3649	0.1%	3649	3649	3649	3648
CE170	1420	1420	1418	1419	1418	1419	1419	1418	1420	0.1%	1420	1420	1420	1419
CE180	1420	1420	1418	1419	1418	1419	1419	1418	1420	0.1%	1420	1420	1420	1419
CE185	1439	1439	1437	1437	1437	1438	1438	1437	1439	0.2%	1439	1439	1439	1438
CE190	190	190	188	188	188	190	190	188	190	1.0%	190	190	190	189
CE195	209	209	207	208	207	209	209	207	209	1.1%	209	209	209	208
CE200	4122	4062	4121	4122	4121	4122	4122	4062	4122	1.5%	4122	4122	4122	4121
Zone Load, Latent (kWh,thermal)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE110	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE120	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE130	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE140	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE150	739	739	739	739	739	739	739	739	739	0.1%	739	739	739	739
CE160	739	739	739	739	739	739	739	739	739	0.1%	739	739	739	739
CE165	739	739	739	739	739	739	739	739	739	0.1%	739	739	739	739
CE170	739	739	739	739	739	739	739	739	739	0.1%	739	739	739	739
CE180	2957	2957	2957	2958	2957	2957	2957	2957	2958	0.0%	2957	2957	2957	2912
CE185	2957	2957	2957	2958	2957	2957	2957	2957	2958	0.0%	2957	2957	2957	2957
CE190	367	370	370	370	370	370	370	367	370	0.8%	370	370	370	370
CE195	367	370	370	370	370	370	370	367	370	0.8%	370	370	370	370
CE200	1221	1221	1221	1221	1221	1221	1221	1221	1221	0.0%	1221	1221	1221	1221

* ABS[(Max-Min) / (Mean of Analytical Solutions)]

Table B16.5.1-6. Latent Coil Load minus Zone Load (Should be 0)

Latent Coil - Zone Load, (Should be 0) (kWh,thermal)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE110	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE120	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE130	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE140	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE150	0	0	0	2	-7	0	0	-7	2	----	0	0	0	0
CE160	1	0	0	0	-7	0	0	-7	1	----	0	0	0	0
CE165	1	0	0	1	-6	0	0	-6	1	----	0	0	0	0
CE170	1	0	0	-1	-6	0	0	-6	1	----	0	0	0	0
CE180	1	0	0	-30	-13	0	0	-30	1	----	1	0	-1	0
CE185	2	0	0	-28	-11	0	0	-28	2	----	1	0	-1	0
CE190	3	0	0	-3	-2	0	0	-3	3	----	0	0	0	0
CE195	3	0	0	-3	-1	0	0	-3	3	----	0	0	0	0
CE200	1	0	0	-2	-11	0	0	-11	1	----	0	0	0	0

* ABS[(Max-Min) / (Mean of Analytical Solutions)]

ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B16.5.1-7. Sensitivities for Space Cooling Electricity Consumption

Delta Qtot (kWh,e)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE110-CE100	-454	-441	-460	-454	-451	-455	-450	-460	-441	4.1%	-454	-454	-453	-456
CE120-CE110	-65	-77	-50	-62	-63	-60	-60	-77	-50	41.2%	-64	-66	-66	-63
CE120-CE100	-519	-518	-510	-516	-514	-515	-510	-519	-510	1.8%	-518	-520	-520	-519
CE130-CE100	-1421	-1421	-1415	-1413	-1411	-1414	-1402	-1421	-1402	1.3%	-1420	-1421	-1421	-1430
CE140-CE130	-42	-40	-40	-40	-41	-41	-41	-42	-40	4.8%	-42	-41	-41	-42
CE140-CE110	-1009	-1020	-996	-999	-1001	-999	-993	-1020	-993	2.6%	-1007	-1009	-1009	-1015
CE150-CE110	131	118	141	118	128	132	130	118	141	17.9%	130	129	129	131
CE160-CE150	-68	-68	-65	-76	-65	-62	-59	-76	-59	25.8%	-66	-67	-68	-67
CE165-CE160	362	362	362	363	359	363	357	357	363	1.7%	357	360	361	363
CE170-CE150	-570	-569	-573	-563	-562	-563	-556	-573	-556	3.1%	-565	-569	-569	-570
CE180-CE150	-125	-125	-125	-103	-115	-118	-112	-125	-103	18.0%	-124	-124	-125	-130
CE180-CE170	445	444	448	460	447	445	444	444	460	3.6%	442	445	444	439
CE185-CE180	461	461	464	467	458	460	458	458	467	1.9%	462	461	461	476
CE190-CE180	-919	-918	-917	-920	-918	-917	-915	-920	-915	0.6%	-917	-918	-918	-918
CE190-CE140	96	95	95	94	96	96	96	94	96	2.6%	96	96	96	98
CE195-CE190	86	86	85	86	86	86	86	85	86	2.0%	87	86	86	88
CE195-CE185	-1294	-1293	-1296	-1301	-1290	-1292	-1287	-1301	-1287	1.1%	-1292	-1293	-1293	-1306
CE195-CE130	140	141	140	140	142	141	141	140	142	1.5%	142	141	141	144
CE200-CE100	-54	-66	-53	-79	-55	-42	-32	-79	-32	87.3%	-55	-53	-54	-60

Del Qcomp (kWh,e)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE110-CE100	-430	-419	-442	-428		-432	-427	-442	-419	5.3%	-431	-430	-430	-432
CE120-CE110	-49	-59	-16	-45		-43	-44	-59	-16	87.9%	-47	-50	-50	-47
CE120-CE100	-479	-478	-457	-473		-475	-471	-479	-457	4.5%	-478	-480	-480	-480
CE130-CE100	-1224	-1224	-1214	-1218		-1218	-1208	-1224	-1208	1.3%	-1224	-1225	-1225	-1233
CE140-CE130	-38	-37	-38	-37		-38	-38	-38	-37	3.7%	-38	-38	-38	-38
CE140-CE110	-832	-842	-811	-827		-823	-819	-842	-811	3.7%	-831	-833	-833	-839
CE150-CE110	111	100	141	99		113	111	99	141	38.3%	111	110	110	111
CE160-CE150	-50	-50	-44	-56		-45	-42	-56	-42	27.5%	-49	-50	-50	-50
CE165-CE160	333	332	329	330		333	328	328	333	1.6%	328	331	331	333
CE170-CE150	-469	-469	-468	-459		-464	-458	-469	-458	2.3%	-466	-469	-469	-470
CE180-CE150	-91	-91	-93	-70		-85	-80	-93	-70	25.0%	-91	-91	-92	-97
CE180-CE170	378	378	375	389		379	378	375	389	3.6%	375	378	378	373
CE185-CE180	431	431	428	432		430	428	428	432	0.9%	432	431	431	444
CE190-CE180	-771	-770	-775	-774		-770	-768	-775	-768	0.9%	-770	-770	-770	-771
CE190-CE140	81	81	85	82		82	82	81	85	4.5%	82	81	81	83
CE195-CE190	79	79	79	79		79	80	79	80	0.8%	80	79	79	81
CE195-CE185	-1123	-1122	-1124	-1127		-1120	-1116	-1127	-1116	1.0%	-1121	-1122	-1121	-1133
CE195-CE130	122	123	126	124		123	123	122	126	3.0%	123	122	123	125
CE200-CE100	-69	-79	-58	-93		-58	-50	-93	-50	62.3%	-70	-69	-69	-74

Del Q IDfan (kWh,e)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE110-CE100	-16	-15	-12	-19	-16	-16	-16	-19	-12	41.9%	-16	-16	-16	-16
CE120-CE110	-11	-12	-23	-12	-11	-11	-11	-23	-11	111.4%	-11	-11	-11	-11
CE120-CE100	-27	-27	-36	-31	-27	-27	-27	-36	-27	32.2%	-27	-27	-27	-27
CE130-CE100	-134	-134	-137	-133	-133	-133	-132	-137	-132	3.7%	-134	-134	-134	-134
CE140-CE130	-2	-2	-1	-2	-2	-2	-2	-2	-1	36.7%	-2	-2	-2	-2
CE140-CE110	-120	-121	-126	-116	-119	-120	-118	-126	-116	8.3%	-120	-120	-120	-120
CE150-CE110	13	12	0	14	13	13	13	0	14	106.4%	13	13	13	13
CE160-CE150	-12	-12	-14	-15	-12	-12	-11	-15	-11	32.6%	-12	-12	-12	-12
CE165-CE160	20	21	23	24	20	20	20	20	24	21.6%	20	20	20	20
CE170-CE150	-68	-68	-72	-73	-67	-68	-66	-73	-66	9.7%	-68	-68	-68	-68
CE180-CE150	-23	-22	-22	-24	-22	-22	-21	-24	-21	12.1%	-22	-23	-23	-23
CE180-CE170	45	46	49	49	45	45	45	45	49	9.9%	45	45	45	45
CE185-CE180	21	20	24	25	21	21	21	20	25	24.1%	21	21	21	22
CE190-CE180	-100	-101	-97	-98	-100	-100	-100	-101	-97	4.3%	-101	-101	-101	-101
CE190-CE140	10	10	7	8	10	10	10	7	10	28.2%	10	10	10	10
CE195-CE190	5	5	4	4	5	5	5	4	5	30.8%	5	5	5	5
CE195-CE185	-116	-116	-117	-119	-116	-117	-116	-119	-116	2.6%	-117	-117	-117	-118
CE195-CE130	13	13	9	10	12	12	12	9	13	29.1%	12	12	12	13
CE200-CE100	10	9	4	10	10	11	12	4	12	78.4%	10	11	11	10

Del Q ODfan (kWh,e)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE110-CE100	-8	-7	-6	-7		-7	-7	-8	-6	29.9%	-7	-7	-7	-8
CE120-CE110	-5	-6	-11	-5		-5	-5	-11	-5	114.1%	-5	-5	-5	-5
CE120-CE100	-13	-13	-17	-12		-13	-13	-17	-12	37.1%	-13	-13	-13	-13
CE130-CE100	-63	-63	-64	-62		-63	-62	-64	-62	3.7%	-63	-63	-63	-63
CE140-CE130	-1	-1	-1	-1		-1	-1	-1	-1	37.5%	-1	-1	-1	-1
CE140-CE110	-56	-57	-59	-56		-56	-56	-59	-56	6.3%	-56	-56	-56	-56
CE150-CE110	6	5	0	5		6	6	0	6	100.7%	6	6	6	6
CE160-CE150	-5	-5	-7	-5		-6	-5	-7	-5	27.1%	-6	-6	-6	-6
CE165-CE160	9	9	11	9		10	9	9	11	17.3%	9	9	9	9
CE170-CE150	-32	-32	-34	-31		-32	-31	-34	-31	8.2%	-32	-32	-32	-32
CE180-CE150	-10	-10	-10	-9		-11	-10	-11	-9	14.3%	-11	-11	-11	-11
CE180-CE170	22	22	23	22		21	21	21	23	9.6%	21	21	21	21
CE185-CE180	9	9	11	10		10	10	9	11	24.6%	10	10	10	10
CE190-CE180	-48	-47	-45	-48		-47	-47	-48	-45	5.5%	-47	-47	-47	-47
CE190-CE140	4	5	3	4		5	5	3	5	34.5%	5	5	5	5
CE195-CE190	3	2	2	3		2	2	2	3	62.1%	2	2	2	2
CE195-CE185	-54	-54	-55	-55		-55	-54	-55	-54	2.0%	-55	-55	-55	-55
CE195-CE130	6	6	4	6		6	6	4	6	27.2%	6	6	6	6
CE200-CE100	5	4	2	4		5	6	2	6	77.9%	5	5	5	5

* ABS[(Max-Min) / (Mean of Analytical Solutions)]

ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B16.5.1-8. Sensitivities for COP and Coil Loads

Delta COP (kWh,t)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE110-CE100	0.99	0.95	1.03	1.01	1.00	1.01	1.01	0.95	1.03	7.6%	0.99	0.99	0.99	0.98
CE120-CE110	0.21	0.25	0.16	0.21	0.21	0.20	0.20	0.16	0.25	44.5%	0.21	0.21	0.21	0.20
CE120-CE100	1.20	1.20	1.18	1.22	1.20	1.20	1.21	1.18	1.22	2.8%	1.20	1.20	1.20	1.18
CE130-CE100	-0.48	-0.48	-0.46	-0.45	-0.50	-0.48	-0.50	-0.50	-0.45	10.0%	-0.50	-0.48	-0.48	-0.50
CE140-CE130	0.86	0.83	0.94	0.90	0.87	0.88	0.88	0.83	0.94	13.4%	0.86	0.86	0.86	0.85
CE140-CE110	-0.61	-0.61	-0.54	-0.56	-0.63	-0.61	-0.63	-0.63	-0.54	13.9%	-0.63	-0.61	-0.61	-0.63
CE150-CE110	0.24	0.29	0.21	0.29	0.25	0.24	0.25	0.21	0.29	31.9%	0.25	0.25	0.25	0.25
CE160-CE150	0.22	0.21	0.20	0.25	0.21	0.20	0.19	0.19	0.25	30.4%	0.21	0.21	0.21	0.21
CE165-CE160	-0.92	-0.92	-0.91	-0.96	-0.92	-0.92	-0.92	-0.96	-0.91	5.5%	-0.90	-0.91	-0.91	-0.90
CE170-CE150	-0.24	-0.24	-0.23	-0.22	-0.26	-0.26	-0.27	-0.27	-0.22	19.1%	-0.26	-0.24	-0.24	-0.26
CE180-CE150	0.42	0.41	0.42	0.33	0.39	0.40	0.38	0.33	0.42	22.8%	0.42	0.41	0.41	0.39
CE180-CE170	0.66	0.65	0.64	0.55	0.65	0.65	0.65	0.55	0.66	16.9%	0.68	0.65	0.65	0.65
CE185-CE180	-1.19	-1.19	-1.21	-1.20	-1.19	-1.20	-1.20	-1.21	-1.19	1.7%	-1.20	-1.19	-1.19	-1.18
CE190-CE180	-0.63	-0.63	-0.60	-0.57	-0.65	-0.64	-0.65	-0.65	-0.57	12.7%	-0.66	-0.63	-0.63	-0.64
CE190-CE140	0.64	0.68	0.57	0.60	0.62	0.61	0.61	0.57	0.68	16.4%	0.64	0.64	0.64	0.62
CE195-CE190	-1.10	-1.10	-1.13	-1.12	-1.09	-1.09	-1.10	-1.13	-1.09	3.3%	-1.09	-1.10	-1.10	-1.08
CE195-CE185	-0.54	-0.54	-0.51	-0.49	-0.55	-0.54	-0.55	-0.55	-0.49	12.1%	-0.55	-0.54	-0.54	-0.55
CE195-CE130	0.40	0.40	0.38	0.38	0.40	0.40	0.39	0.38	0.40	4.2%	0.40	0.40	0.40	0.39
CE200-CE100	1.23	1.22	1.24	1.30	1.24	1.21	1.19	1.19	1.30	8.9%	1.23	1.23	1.23	1.23

Del Q coil,t (kWh,t)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE110-CE100	-35	-34	-38	-38	-35	-35	-35	-38	-34	12.5%	-35	-35	-35	-35
CE120-CE110	-16	-17	-40	-16	-16	-16	-16	-40	-16	146.5%	-16	-16	-17	-16
CE120-CE100	-51	-51	-78	-55	-51	-51	-51	-78	-51	52.7%	-51	-52	-52	-51
CE130-CE100	-3581	-3581	-3626	-3579	-3581	-3581	-3578	-3626	-3578	1.3%	-3581	-3581	-3581	-3582
CE140-CE130	-21	-21	-20	-21	-21	-21	-21	-21	-20	4.9%	-21	-21	-22	-21
CE140-CE110	-3567	-3568	-3608	-3561	-3567	-3567	-3565	-3608	-3561	1.3%	-3567	-3567	-3568	-3567
CE150-CE110	752	751	739	772	746	752	752	739	772	4.4%	752	752	753	753
CE160-CE150	-16	-17	-26	-19	-18	-17	-16	-26	-16	59.5%	-17	-17	-18	-17
CE165-CE160	37	38	51	40	38	37	36	36	51	40.0%	36	37	38	37
CE170-CE150	-2284	-2285	-2317	-2291	-2284	-2285	-2283	-2317	-2283	1.5%	-2285	-2286	-2286	-2285
CE180-CE150	-22	-22	-33	7	-28	-22	-21	-33	7	172.5%	-22	-23	-25	-68
CE180-CE170	2262	2263	2284	2298	2256	2263	2262	2256	2298	1.8%	2263	2263	2261	2217
CE185-CE180	12	40	55	48	41	40	40	12	55	107.3%	40	40	40	86
CE190-CE180	-3917	-3918	-3937	-3956	-3907	-3917	-3916	-3956	-3907	1.3%	-3918	-3918	-3916	-3872
CE190-CE140	380	379	377	384	378	380	379	377	384	1.8%	380	379	380	380
CE195-CE190	24	24	23	23	23	24	24	23	24	5.8%	24	24	24	24
CE195-CE185	-3905	-3934	-3970	-3981	-3925	-3934	-3933	-3981	-3905	1.9%	-3934	-3934	-3933	-3935
CE195-CE130	383	382	379	387	381	382	382	379	387	1.9%	382	382	382	382
CE200-CE100	1698	1636	1693	1728	1687	1698	1700	1636	1728	5.4%	1697	1697	1697	1697

Del Q coil,s (kWh,t)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE110-CE100	-35	-34	-38	-38	-35	-35	-35	-38	-34	12.5%	-35	-35	-35	-35
CE120-CE110	-16	-17	-40	-16	-16	-16	-16	-40	-16	146.5%	-16	-16	-17	-16
CE120-CE100	-51	-51	-78	-55	-51	-51	-51	-78	-51	52.8%	-51	-52	-52	-51
CE130-CE100	-3581	-3581	-3626	-3579	-3581	-3581	-3578	-3626	-3578	1.3%	-3581	-3581	-3581	-3582
CE140-CE130	-21	-21	-20	-21	-21	-21	-21	-21	-20	4.9%	-21	-21	-22	-21
CE140-CE110	-3567	-3568	-3608	-3561	-3567	-3567	-3565	-3608	-3561	1.3%	-3567	-3567	-3568	-3567
CE150-CE110	13	12	0	30	13	13	13	0	30	228.7%	13	13	14	13
CE160-CE150	-17	-17	-26	-17	-17	-17	-16	-26	-16	58.9%	-17	-17	-18	-17
CE165-CE160	37	37	51	40	36	37	36	36	51	40.1%	36	37	38	37
CE170-CE150	-2285	-2285	-2317	-2288	-2285	-2285	-2283	-2317	-2283	1.5%	-2285	-2286	-2286	-2285
CE180-CE150	-2241	-2240	-2250	-2179	-2239	-2240	-2239	-2250	-2179	3.2%	-2241	-2240	-2241	-2240
CE180-CE170	44	45	66	109	46	45	45	44	109	144.8%	45	45	45	45
CE185-CE180	11	40	55	46	39	40	40	11	55	110.0%	40	40	40	41
CE190-CE180	-1329	-1330	-1350	-1394	-1331	-1330	-1329	-1394	-1329	4.9%	-1330	-1330	-1330	-1330
CE190-CE140	10	10	7	18	10	10	9	7	18	100.3%	10	10	11	10
CE195-CE190	24	24	23	23	23	24	24	23	24	5.7%	24	24	24	24
CE195-CE185	-1316	-1346	-1382	-1418	-1347	-1346	-1345	-1418	-1316	7.6%	-1346	-1347	-1346	-1348
CE195-CE130	13	13	10	20	13	12	12	10	20	81.6%	12	12	12	13
CE200-CE100	476	415	472	509	477	477	479	415	509	19.7%	476	476	476	476

Del Qcoil,lat (kWh,t)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE110-CE100	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE120-CE110	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE120-CE100	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE130-CE100	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE140-CE130	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE140-CE110	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE150-CE110	739	739	739	742	733	739	739	733	742	1.2%	739	739	739	739
CE160-CE150	1	0	0	-2	-1	0	0	-2	1	----	0	0	0	0
CE165-CE160	0	0	0	1	1	0	0	0	1	----	0	0	0	0
CE170-CE150	1	0	0	-3	1	0	0	-3	1	----	0	0	0	0
CE180-CE150	2219	2218	2218	2186	2211	2218	2218	2186	2219	1.5%	2218	2218	2217	2172
CE180-CE170	2218	2218	2218	2189	2210	2218	2218	2189	2218	1.3%	2218	2218	2217	2172
CE185-CE180	1	0	0	2	2	0	0	0	2	----	0	0	0	45
CE190-CE180	-2588	-2587	-2587	-2562	-2576	-2587	-2587	-2588	-2562	----	-2588	-2587	-2586	-2542
CE190-CE140	370	370	370	366	368	370	370	366	370	1.0%	370	370	370	370
CE195-CE190	0	0	0	0	0	0	0	0	0	----	0	0	0	0
CE195-CE185	-2589	-2587	-2587	-2563	-2578	-2587	-2587	-2589	-2563	----	-2588	-2587	-2587	-2587
CE195-CE130	370	370	370	367	368	370	370	367	370	0.9%	370	370	370	370
CE200-CE100	1222	1221	1221	1219	1210	1221	1221	1210	1222	1.0%	1221	1221	1221	1221

* ABS[(Max-Min) / (Mean of Analytical Solutions)]

ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results
By Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B16.5.1-9. Indoor Drybulb Temperature: Mean and (Max-Min)/Mean

Mean IDB (°C)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	22.2	22.2	22.3	22.3	22.2	22.2	22.6	22.2	22.6	2.0%	22.2	22.2	22.2	22.2
CE110	22.2	22.2	22.3	22.3	22.2	22.2	22.5	22.2	22.5	1.5%	22.2	22.2	22.2	22.2
CE120	26.7	26.7	26.8	26.7	26.7	26.7	27.1	26.7	27.1	1.4%	26.7	26.7	26.7	26.7
CE130	22.2	22.2	22.1	22.1	22.2	22.2	21.6	21.6	22.2	2.5%	22.2	22.2	22.2	22.2
CE140	22.2	22.2	22.1	22.1	22.2	22.2	21.5	21.5	22.2	3.1%	22.2	22.2	22.2	22.2
CE150	22.2	22.2	22.3	22.3	22.2	22.2	22.7	22.2	22.7	2.1%	22.2	22.2	22.2	22.2
CE160	26.7	26.7	26.8	26.7	26.7	26.7	27.0	26.7	27.0	1.1%	26.7	26.7	26.7	26.7
CE165	23.3	23.3	23.4	23.4	23.3	23.3	23.8	23.3	23.8	2.1%	23.3	23.3	23.3	23.3
CE170	22.2	22.2	22.2	22.2	22.2	22.2	22.1	22.1	22.2	0.5%	22.2	22.2	22.2	22.2
CE180	22.2	22.2	22.3	22.3	22.2	22.2	22.3	22.2	22.3	0.6%	22.2	22.2	22.2	22.2
CE185	22.2	22.2	22.3	22.3	22.2	22.2	22.4	22.2	22.4	0.8%	22.2	22.2	22.2	22.2
CE190	22.2	22.2	22.1	22.1	22.2	22.2	21.9	21.9	22.2	1.1%	22.2	22.2	22.2	22.2
CE195	22.2	22.2	22.1	22.1	22.2	22.2	22.0	22.0	22.2	0.9%	22.2	22.2	22.2	22.2
CE200	26.7	26.7	26.8	26.8	26.7	26.7	26.7	26.7	26.8	0.4%	26.7	26.7	26.7	26.7
(Max - Min)/Mean IDB (°C)								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.000	0.049	----	0.000		0.002	0.000
CE110	0.000	0.000	0.000	0.000	0.000	0.000	0.048	0.000	0.048	----	0.000		0.002	0.000
CE120	0.000	0.000	0.000	0.000	0.000	0.000	0.077	0.000	0.077	----	0.000		0.002	0.000
CE130	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.000	0.056	----	0.000		0.001	0.000
CE140	0.000	0.000	0.000	0.000	0.000	0.000	0.069	0.000	0.069	----	0.000		0.002	0.000
CE150	0.000	0.000	0.000	0.000	0.000	0.000	0.054	0.000	0.054	----	0.000		0.002	0.000
CE160	0.000	0.000	0.000	0.000	0.000	0.000	0.045	0.000	0.045	----	0.000		0.002	0.000
CE165	0.000	0.000	0.000	0.000	0.000	0.000	0.051	0.000	0.051	----	0.000		0.002	0.000
CE170	0.000	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.050	----	0.000		0.001	0.000
CE180	0.000	0.000	0.000	0.000	0.000	0.000	0.035	0.000	0.035	----	0.000		0.001	0.000
CE185	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.021	----	0.000		0.001	0.000
CE190	0.000	0.000	0.000	0.000	0.000	0.000	0.028	0.000	0.028	----	0.000		0.001	0.000
CE195	0.000	0.000	0.000	0.000	0.000	0.000	0.023	0.000	0.023	----	0.000		0.001	0.000
CE200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	----	0.000		0.000	0.000

* ABS[(Max-Min) / (Mean of Analytical Solutions)]

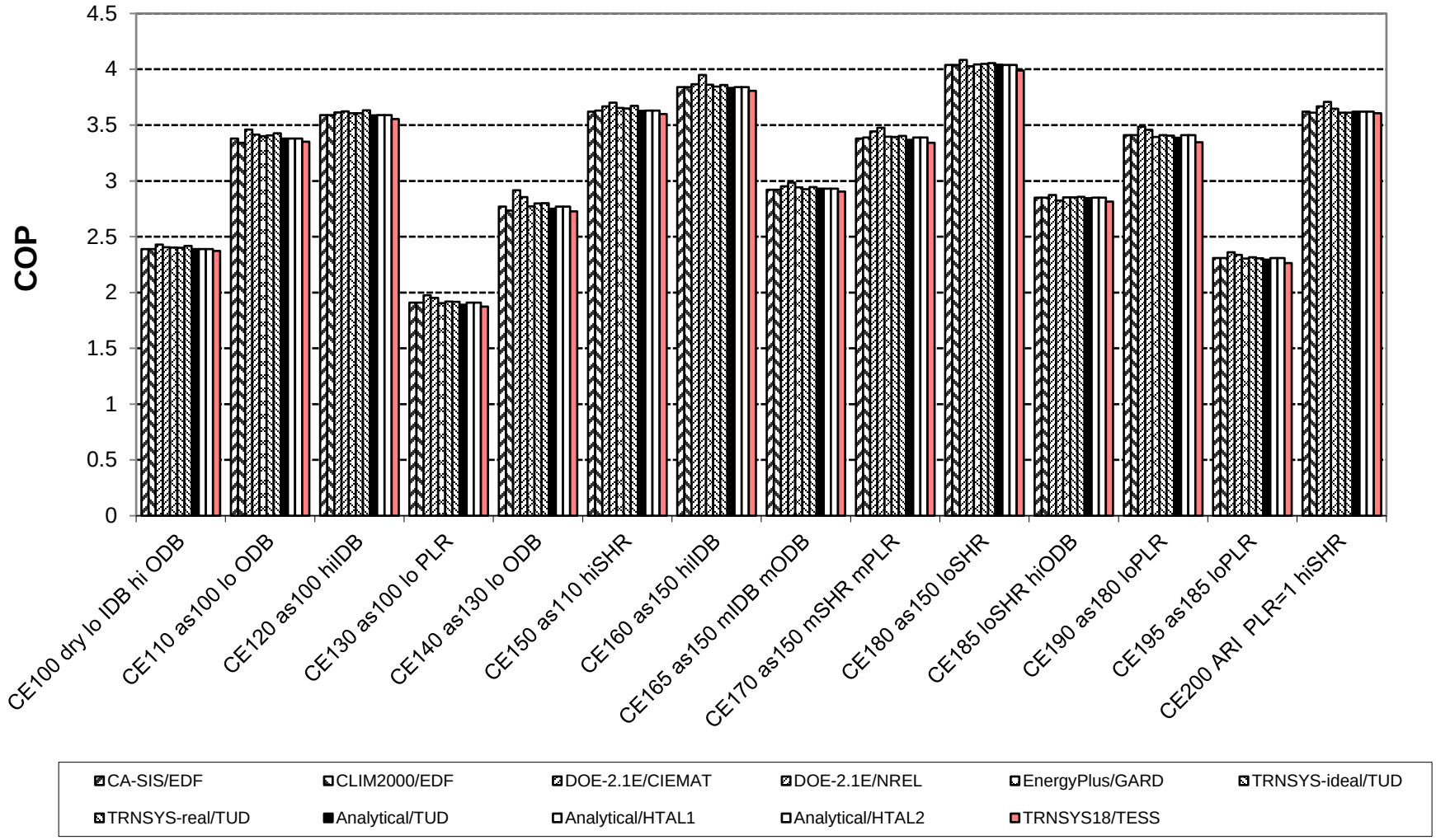
Table B16.5.1-10. Humidity Ratio: Mean and (Max-Min)/Mean

Mean Humidity Ratio								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	0.0075	0.0069	0.0076	0.0074	0.0075	0.0075	0.0075	0.0069	0.0076	9.4%	0.0074	0.0073	0.0073	0.0077
CE110	0.0066	0.0069	0.0070	0.0064	0.0066	0.0066	0.0066	0.0064	0.0070	9.8%	0.0065	0.0064	0.0064	0.0067
CE120	0.0080	0.0070	0.0078	0.0078	0.0080	0.0080	0.0080	0.0070	0.0080	13.2%	0.0079	0.0079	0.0079	0.0080
CE130	0.0075	0.0069	0.0076	0.0073	0.0075	0.0075	0.0075	0.0069	0.0076	9.4%	0.0074	0.0073	0.0073	0.0077
CE140	0.0065	0.0069	0.0071	0.0064	0.0066	0.0066	0.0066	0.0064	0.0071	10.2%	0.0065	0.0064	0.0064	0.0067
CE150	0.0083	0.0085	0.0082	0.0083	0.0084	0.0083	0.0085	0.0082	0.0085	4.0%	0.0082	0.0082	0.0082	0.0085
CE160	0.0102	0.0101	0.0097	0.0099	0.0103	0.0101	0.0102	0.0097	0.0103	5.8%	0.0100	0.0099	0.0099	0.0102
CE165	0.0093	0.0099	0.0090	0.0092	0.0094	0.0093	0.0095	0.0090	0.0099	9.2%	0.0093	0.0092	0.0092	0.0095
CE170	0.0106	0.0107	0.0105	0.0105	0.0106	0.0105	0.0105	0.0105	0.0107	2.2%	0.0104	0.0105	0.0105	0.0106
CE180	0.0164	0.0164	0.0166	0.0164	0.0162	0.0163	0.0164	0.0162	0.0166	2.6%	0.0162	0.0162	0.0162	0.0169
CE185	0.0162	0.0171	0.0164	0.0162	0.0161	0.0162	0.0163	0.0161	0.0171	6.4%	0.0161	0.0161	0.0161	0.0161
CE190	0.0160	0.0161	0.0163	0.0159	0.0159	0.0159	0.0157	0.0157	0.0163	3.5%	0.0158	0.0159	0.0159	0.0158
CE195	0.0156	0.0164	0.0158	0.0155	0.0154	0.0155	0.0153	0.0153	0.0164	7.0%	0.0154	0.0154	0.0154	0.0154
CE200	0.0114	0.0115	0.0109	0.0111	0.0115	0.0113	0.0113	0.0109	0.0115	5.1%	0.0111	0.0111	0.0111	0.0114
(Max - Min)/Mean Humidity Ratio								Statistics, All Results						19-Aug-24
	CA-SIS	CLM2000	DOE21E	DOE21E	E+	TRN-id	TRN-re			(Max-Min)		Analytical		TRNSYS18
Case	EDF	EDF	CIEMAT	NREL	GARD	TUD	TUD	Min	Max	/Analytical*	TUD	HTAL1	HTAL2	TESS
CE100	0.000	0.022	0.000	0.000	0.001	0.000	0.000	0.0000	0.0217	----	0.000		0.000	0.000
CE110	0.000	0.022	0.014	0.000	0.000	0.000	0.000	0.0000	0.0217	----	0.000		0.000	0.000
CE120	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.0000	0.0005	----	0.000		0.000	0.000
CE130	0.000	0.010	0.000	0.000	0.001	0.000	0.000	0.0000	0.0101	----	0.000		0.000	0.000
CE140	0.000	0.012	0.014	0.000	0.001	0.000	0.000	0.0000	0.0142	----	0.000		0.000	0.000
CE150	0.012	0.000	0.000	0.000	0.013	0.000	0.013	0.0000	0.0132	----	0.000		0.000	0.000
CE160	0.020	0.000	0.010	0.010	0.013	0.000	0.011	0.0000	0.0196	----	0.000		0.000	0.000
CE165	0.011	0.001	0.011	0.000	0.013	0.000	0.013	0.0000	0.0131	----	0.000		0.000	0.001
CE170	0.000	0.000	0.010	0.000	0.011	0.000	0.024	0.0000	0.0238	----	0.000		0.001	0.000
CE180	0.018	0.000	0.012	0.012	0.010	0.000	0.040	0.0000	0.0402	----	0.000		0.001	0.000
CE185	0.012	0.006	0.018	0.012	0.011	0.000	0.025	0.0000	0.0246	----	0.000		0.001	0.000
CE190	0.000	0.000	0.018	0.019	0.014	0.000	0.031	0.0000	0.0312	----	0.000		0.001	0.003
CE195	0.000	0.006	0.019	0.019	0.014	0.000	0.024	0.0000	0.0241	----	0.000		0.001	0.003
CE200	0.018	0.000	0.009	0.009	0.013	0.000	0.000	0.0000	0.0175	----	0.000		0.000	0.000

* ABS[(Max-Min) / (Mean of Analytical Solutions)]

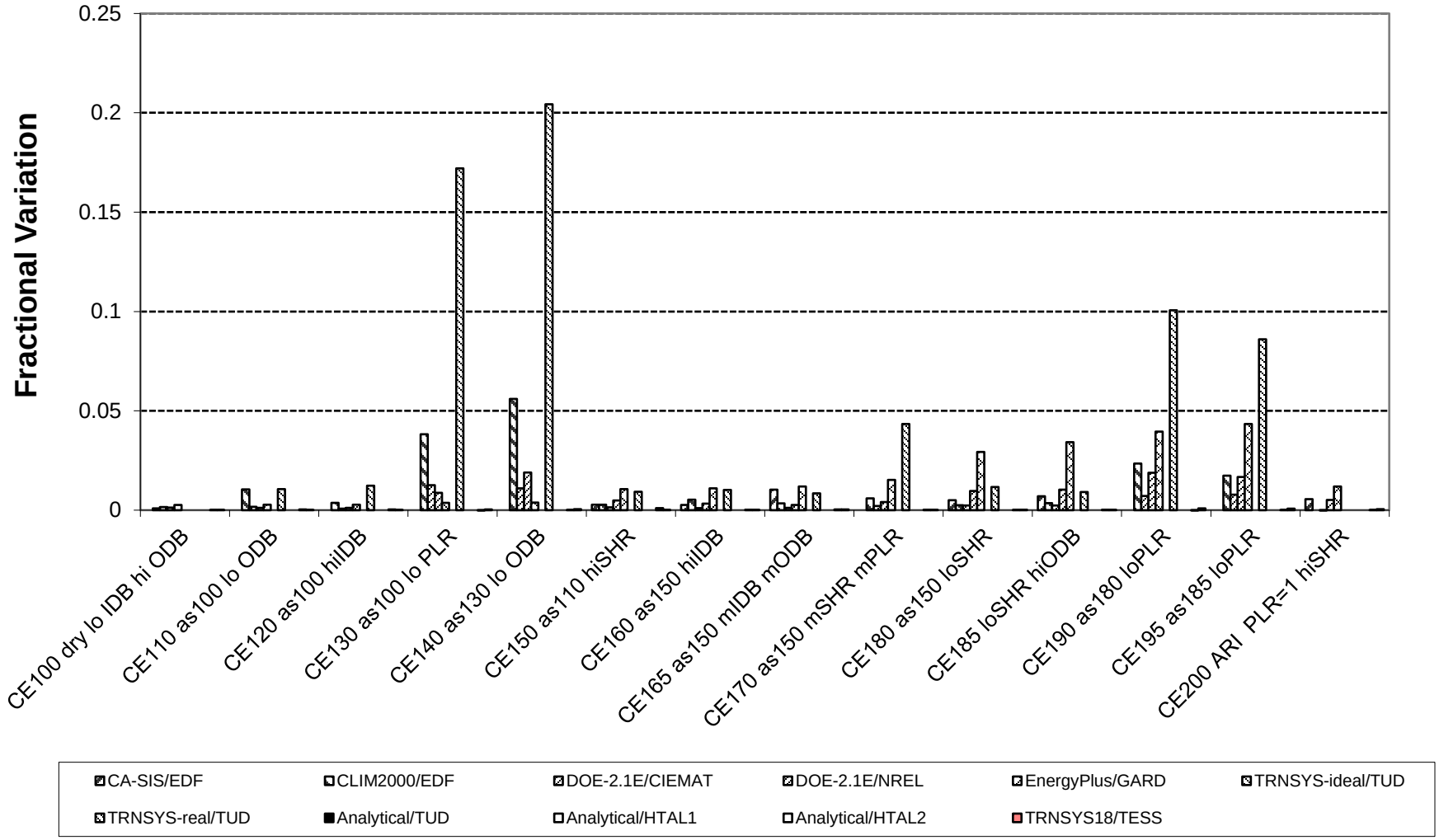
ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-1.
HVAC BESTEST: Mean COP



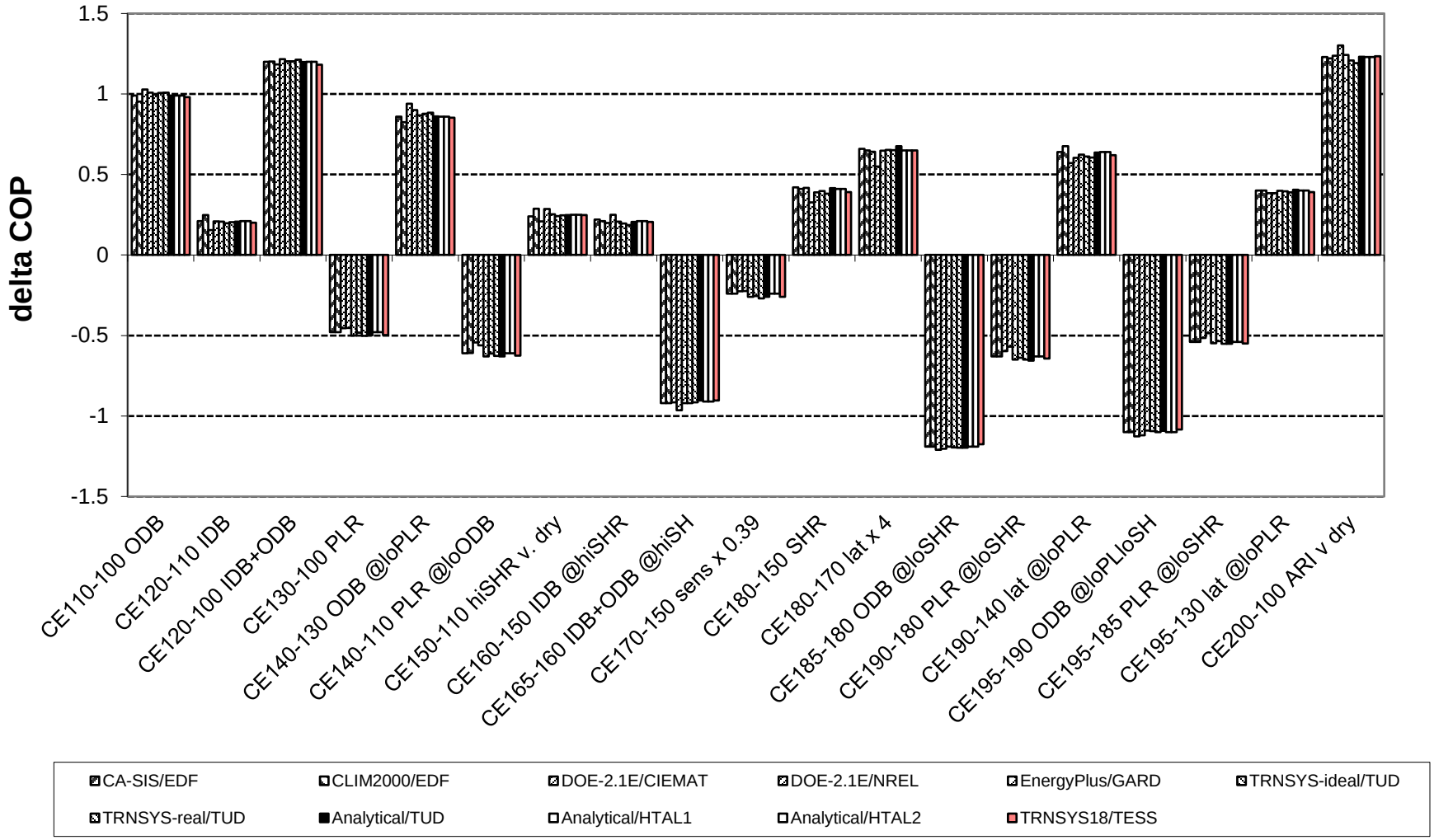
ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-2.
HVAC BESTEST: (Maximum - Minimum)/Mean COP



ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-3.
HVAC BESTEST: Mean COP Sensitivities



ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-4.
HVAC BESTEST: Total Space Cooling Electricity Consumption

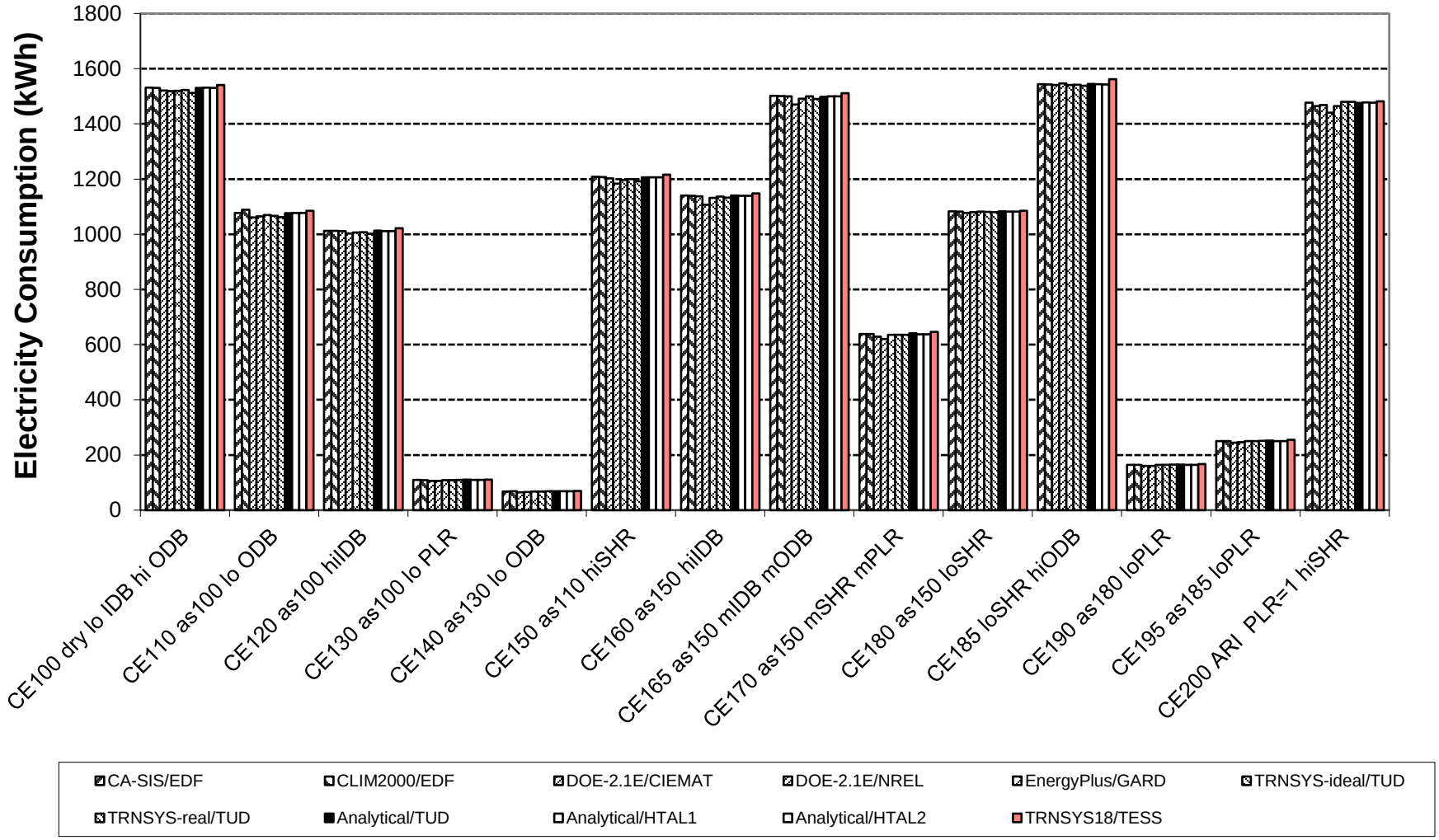


Figure B16.5.1-5.
HVAC BESTEST: Total Space Cooling Electricity Sensitivities

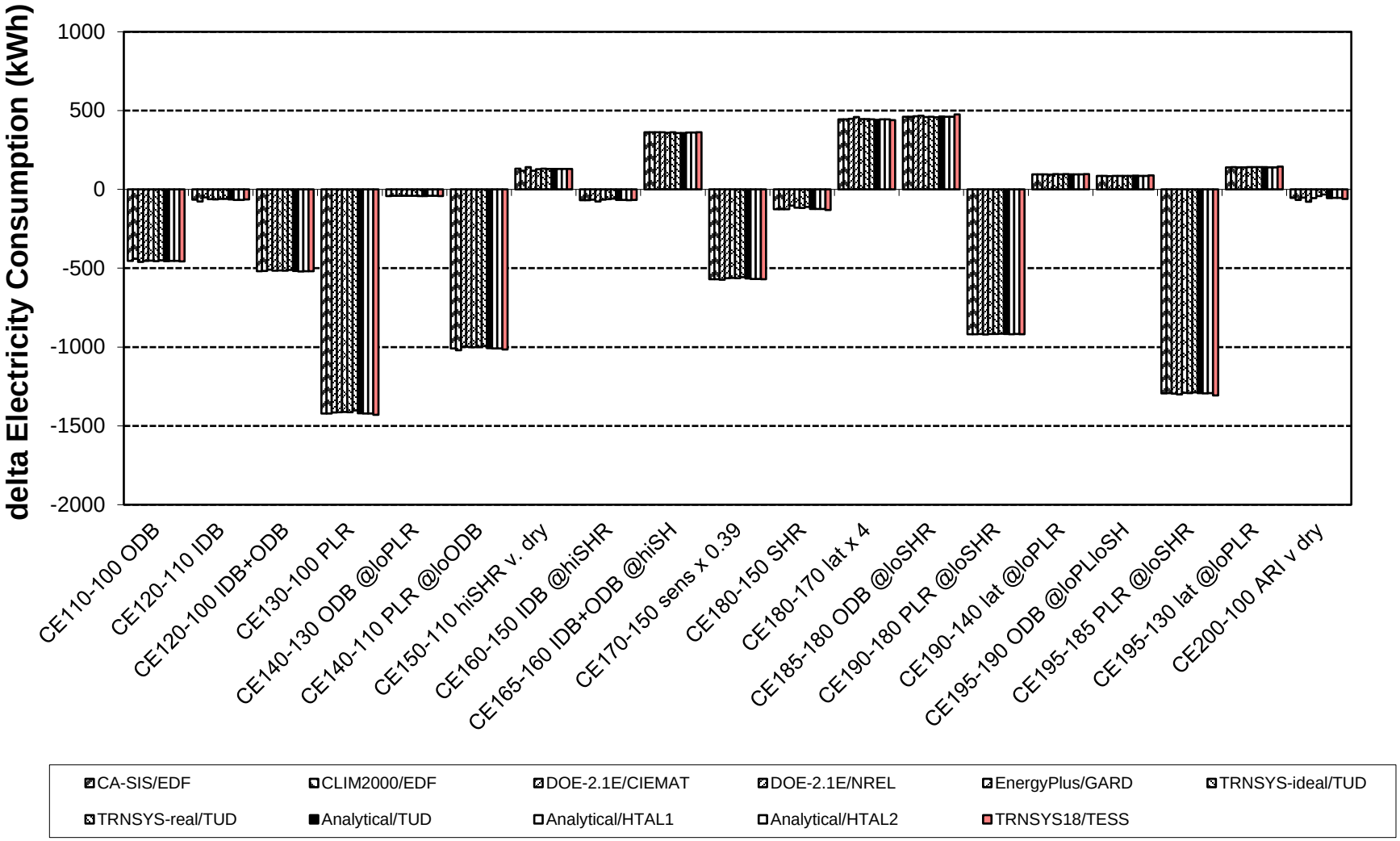
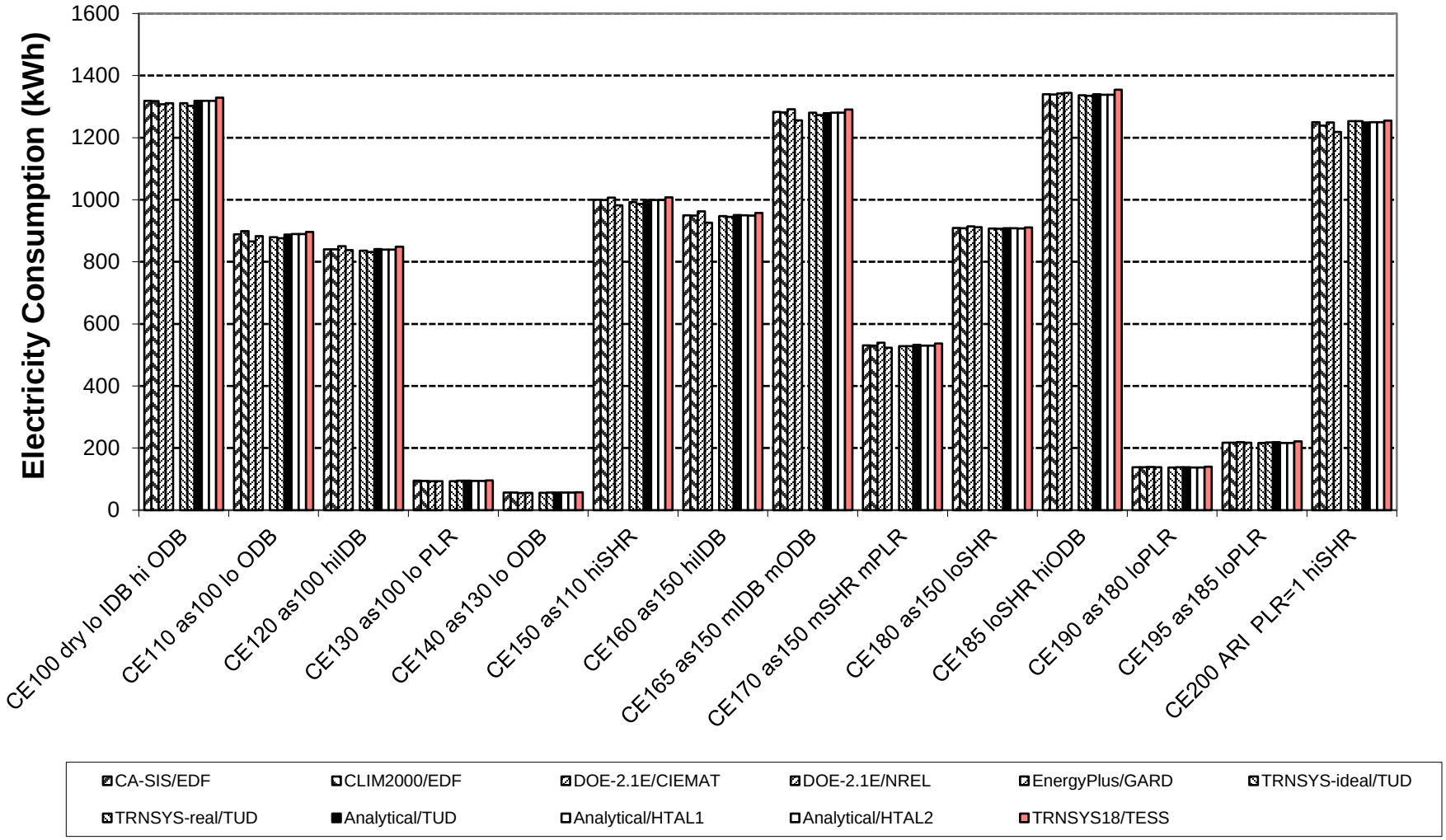


Figure B16.5.1-6.
HVAC BESTEST: Compressor Electricity Consumption



ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-7.
HVAC BESTEST: Total Compressor Electricity Sensitivities

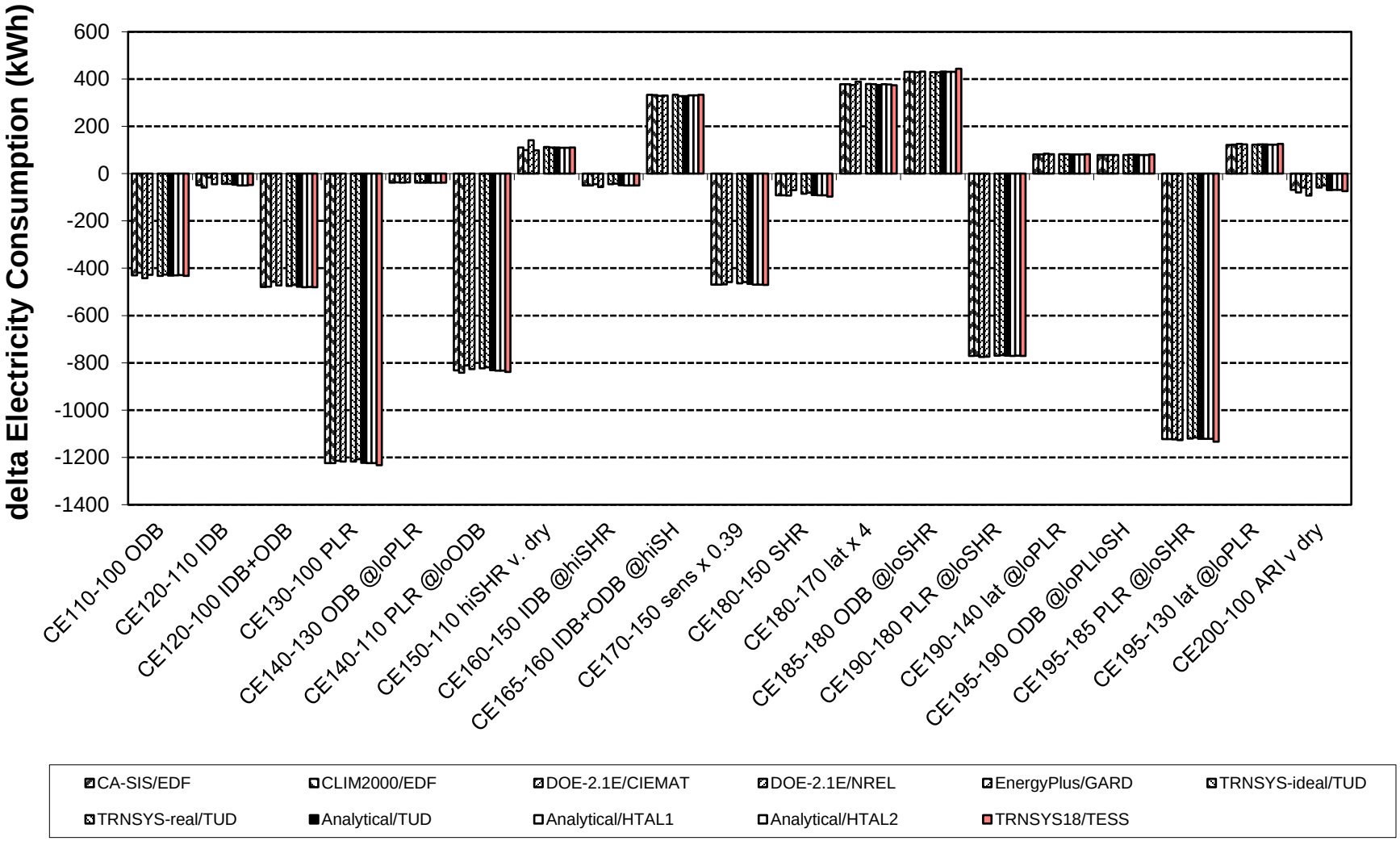


Figure B16.5.1-8.
HVAC BESTEST: Total Indoor (Supply) Fan Electricity Consumption

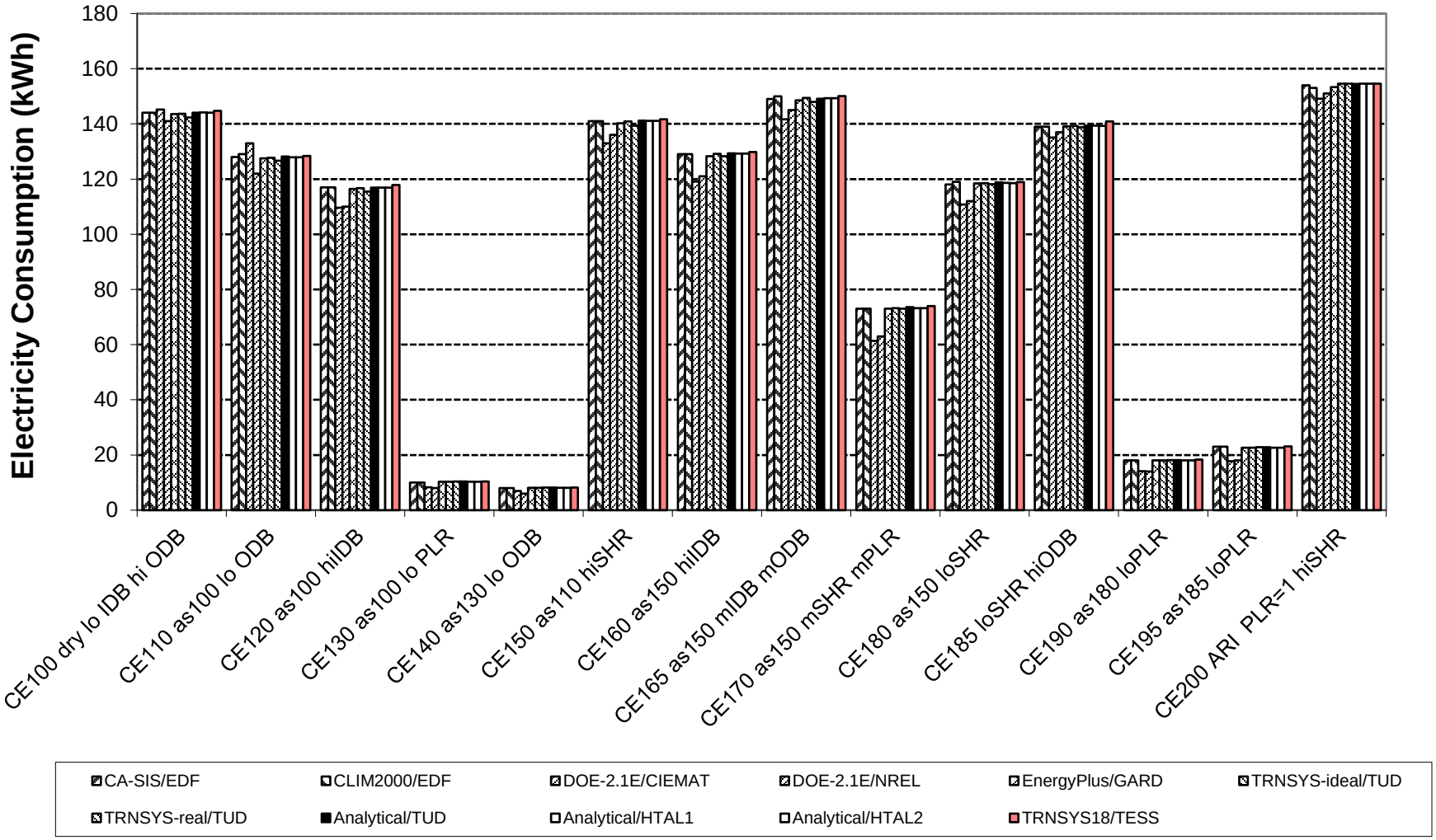
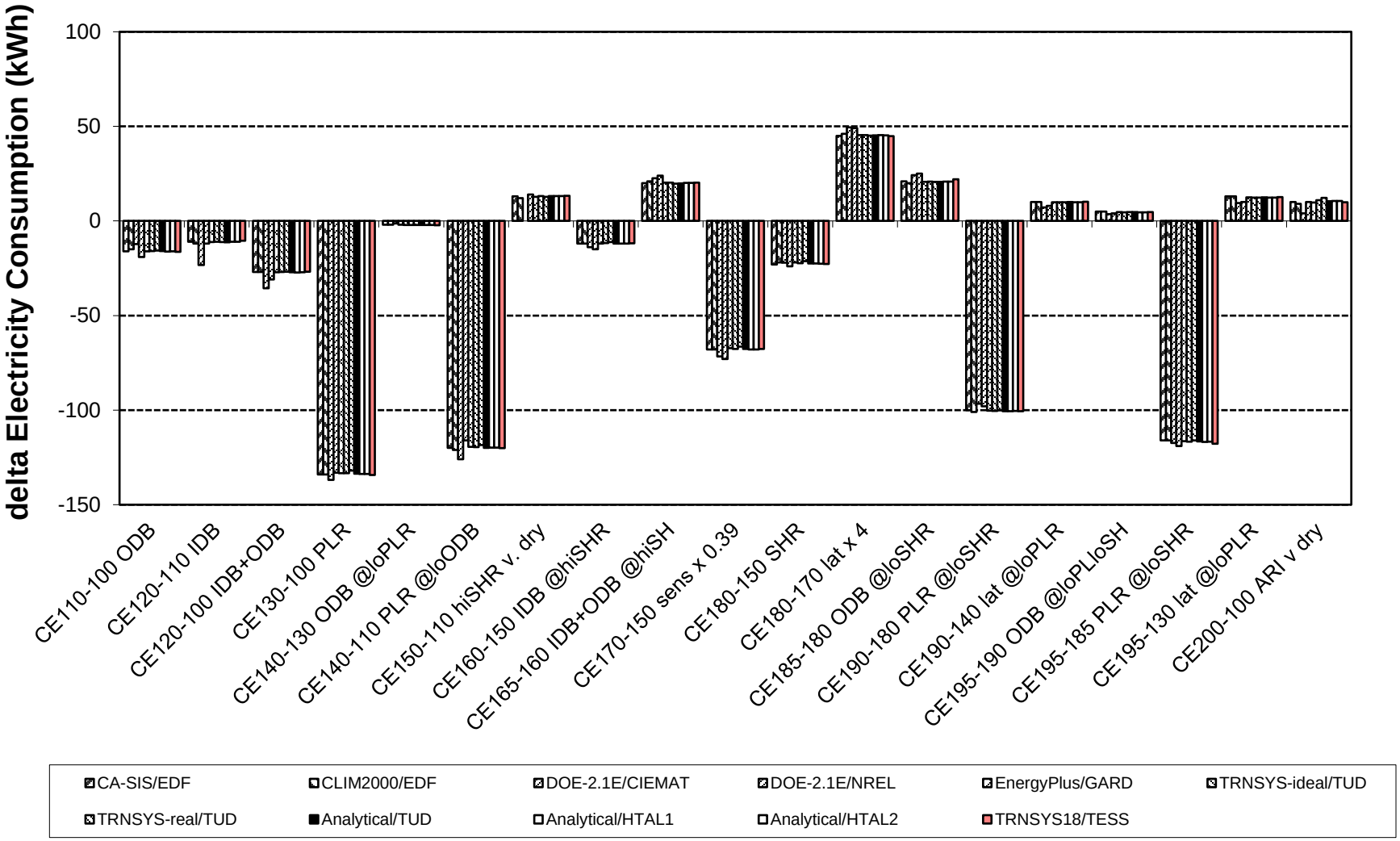
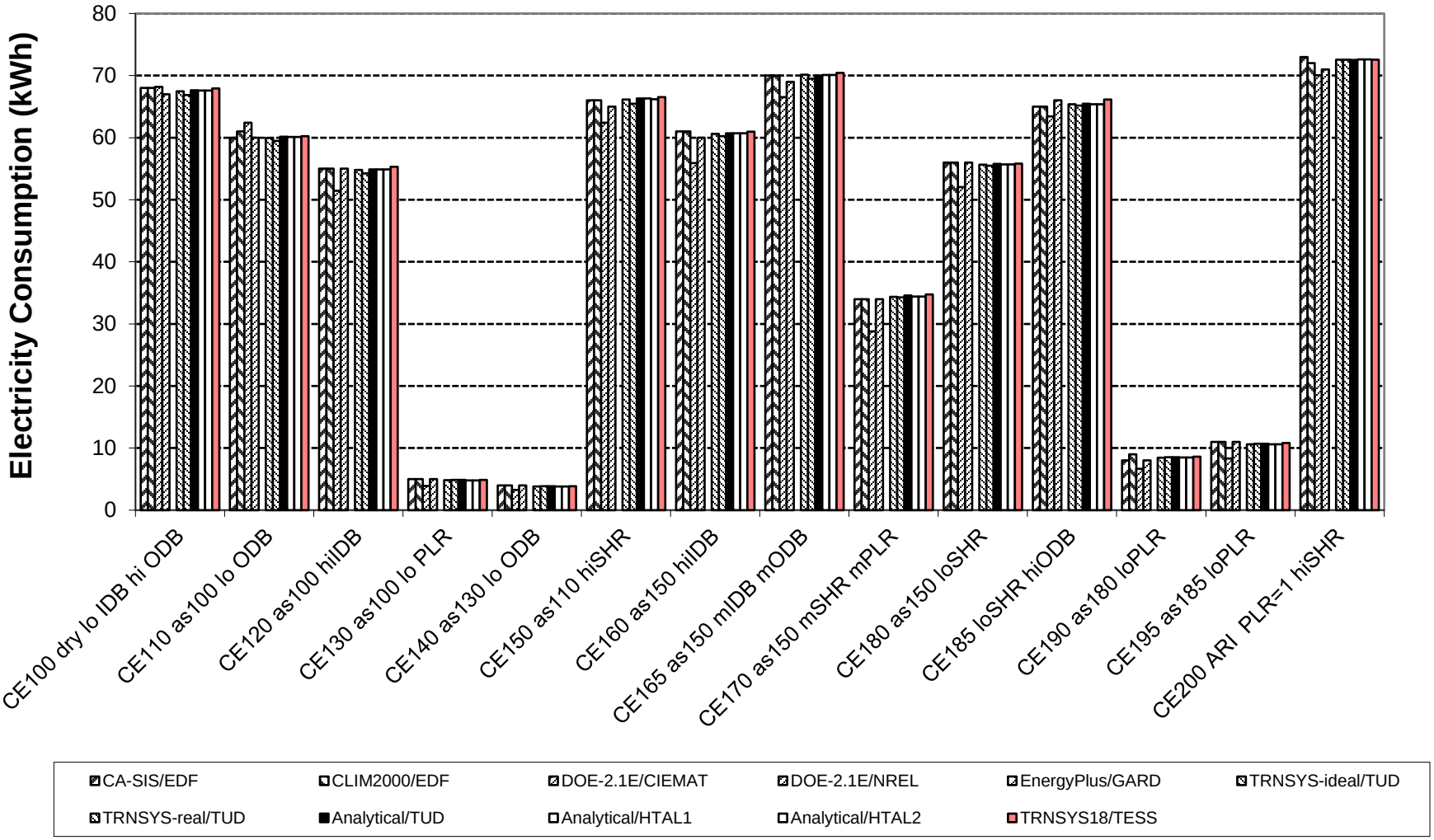


Figure B16.5.1-9.
HVAC BESTEST: Indoor (Supply) Fan Electricity Sensitivities



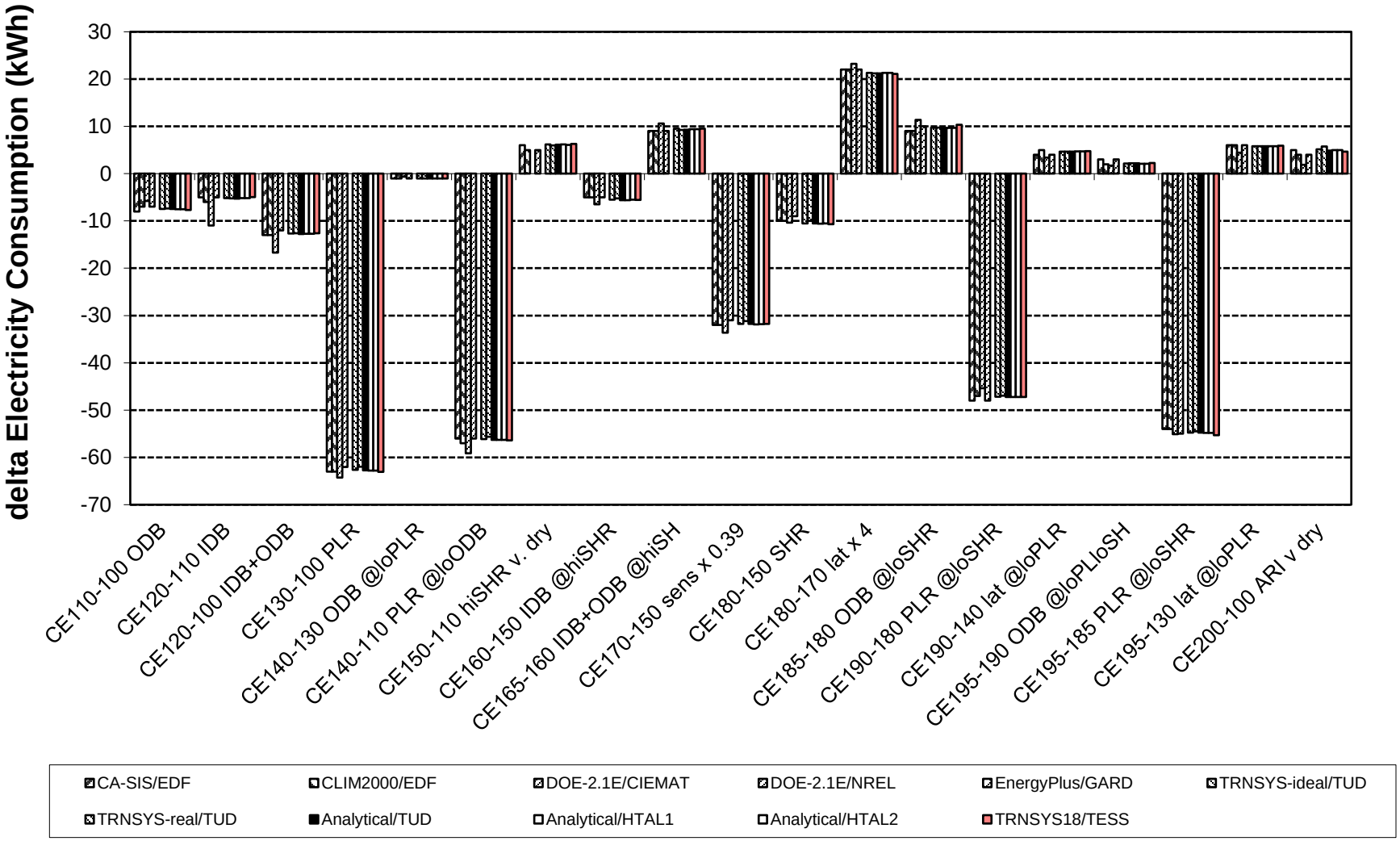
ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-10.
HVAC BESTEST: Outdoor (Condenser) Fan Electricity Consumption



ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-11.
HVAC BESTEST: Outdoor (Condenser) Fan Electricity Sensitivities



ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-12.
HVAC BESTEST: Total Coil Load

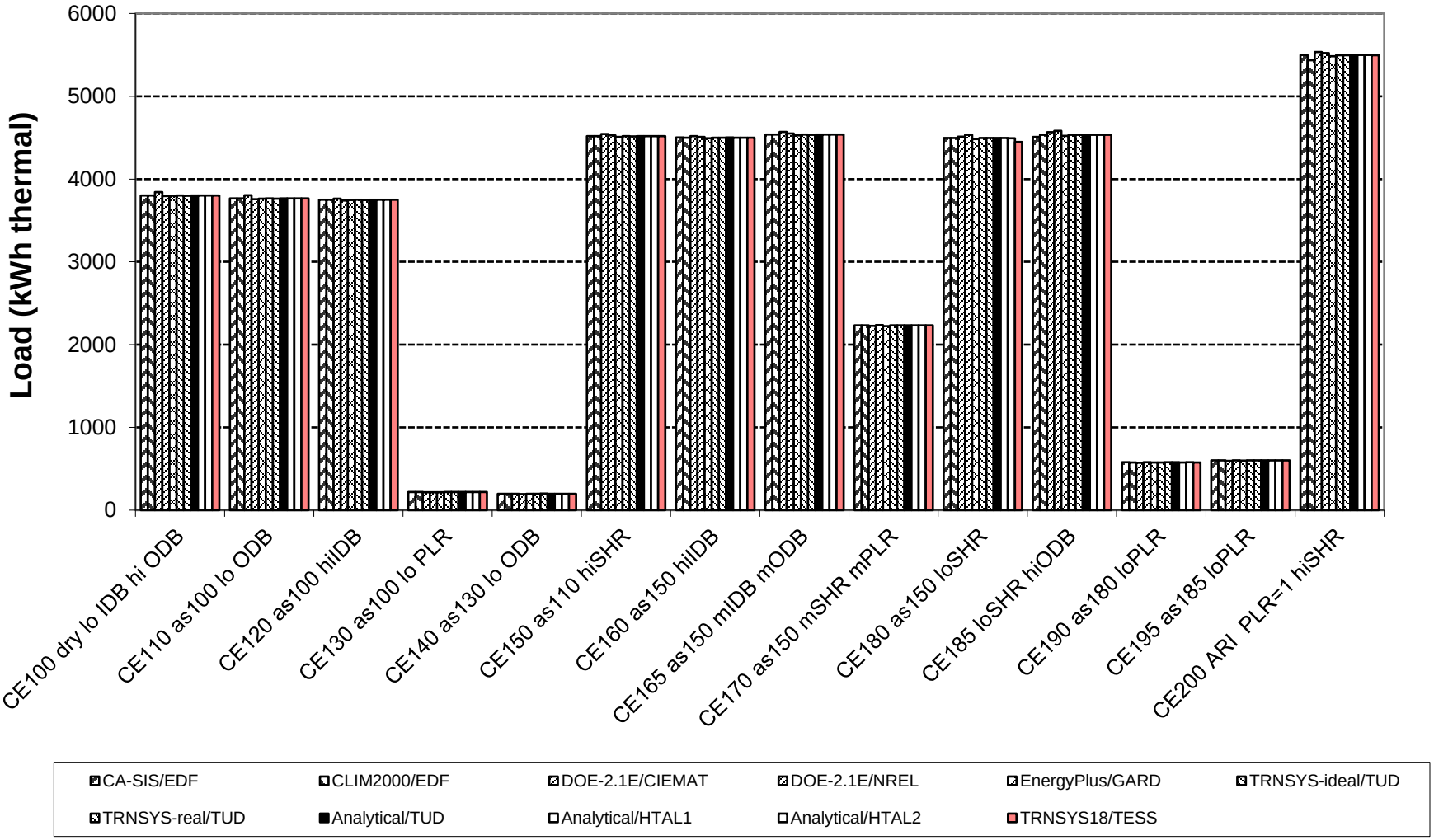


Figure B16.5.1-13.
HVAC BESTEST: Total Coil Load Sensitivities

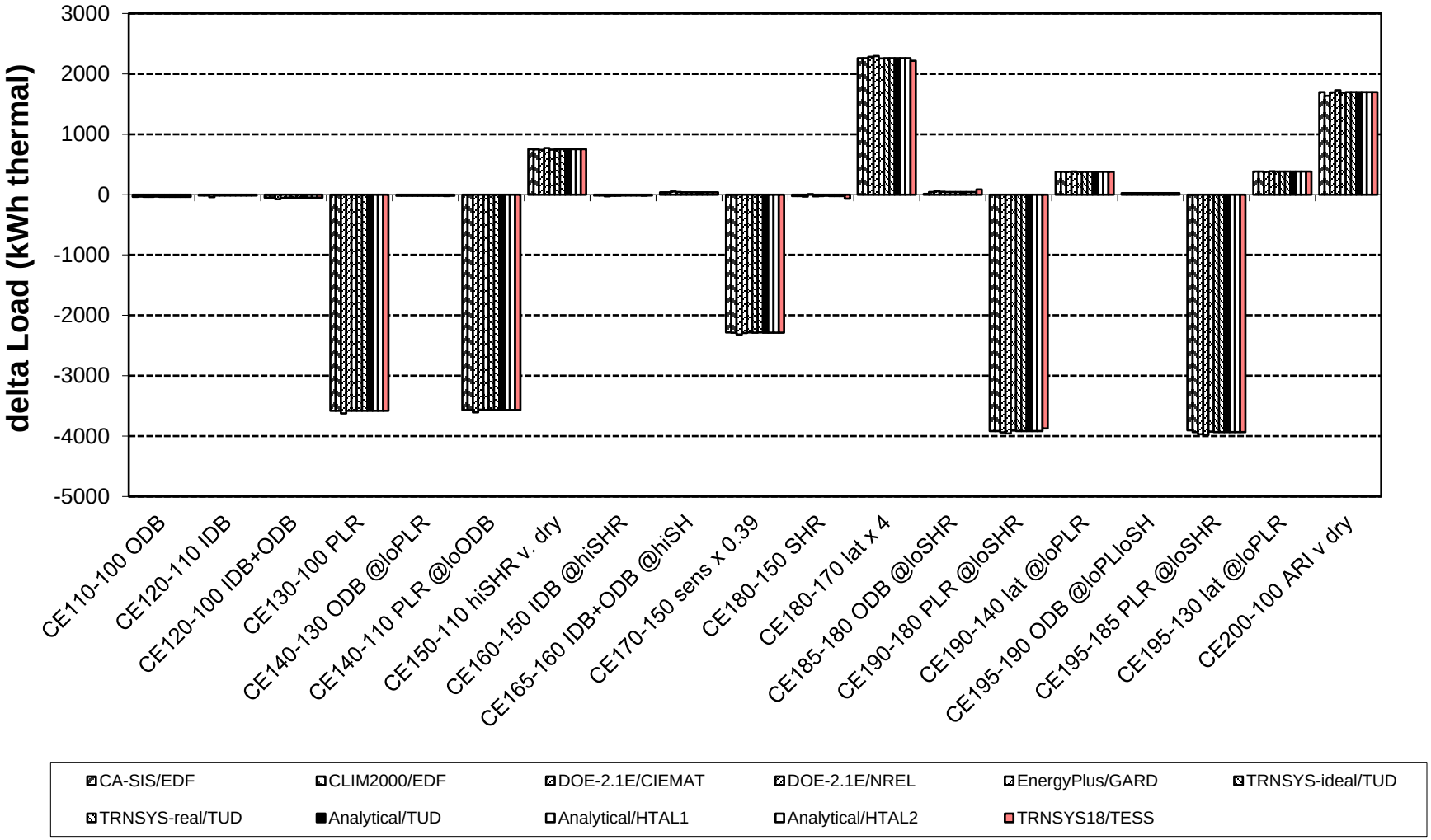


Figure B16.5.1-14.
HVAC BESTEST: Sensible Coil Load

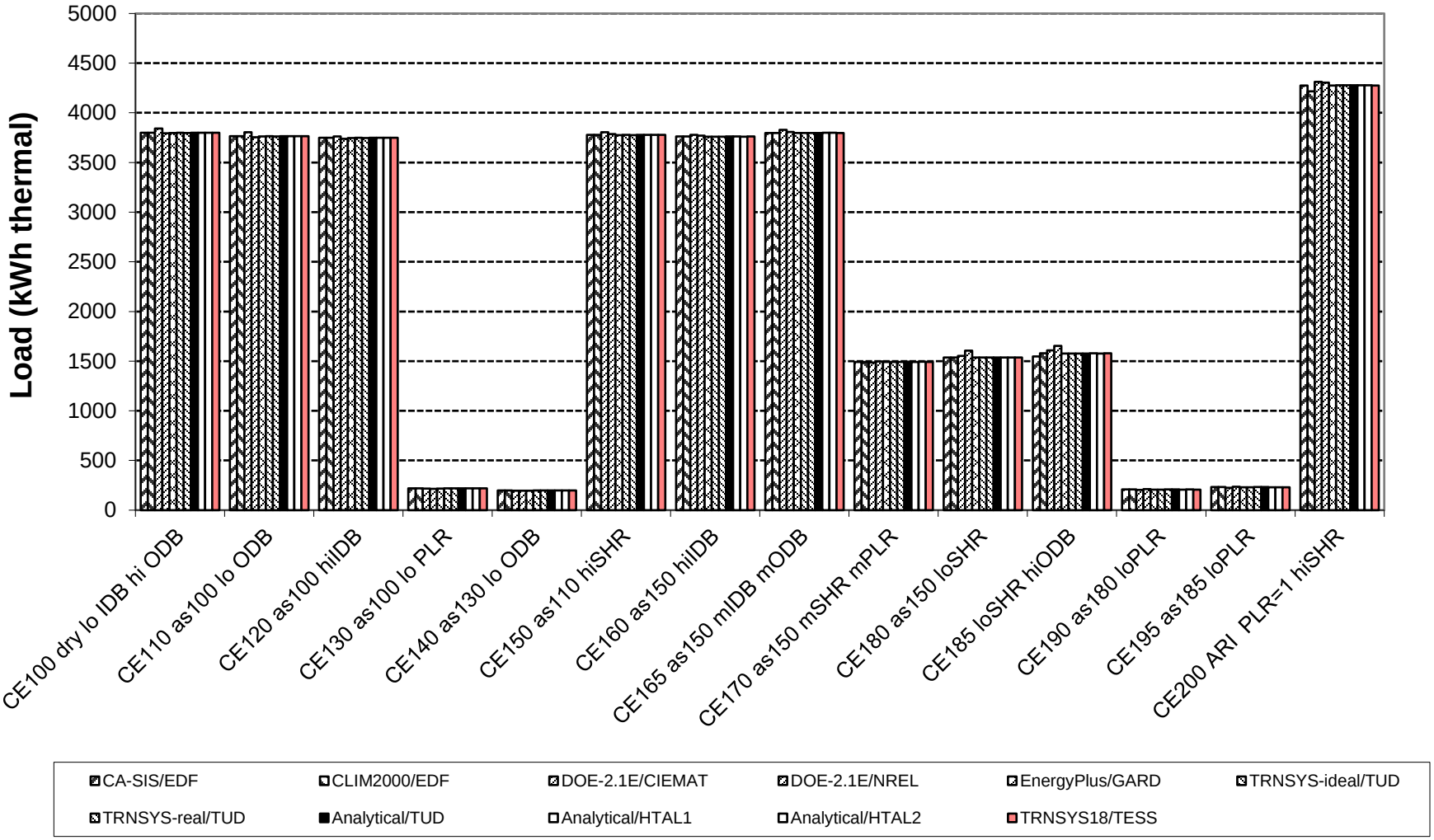


Figure B16.5.1-15.
HVAC BESTEST: Sensible Coil Load Sensitivities

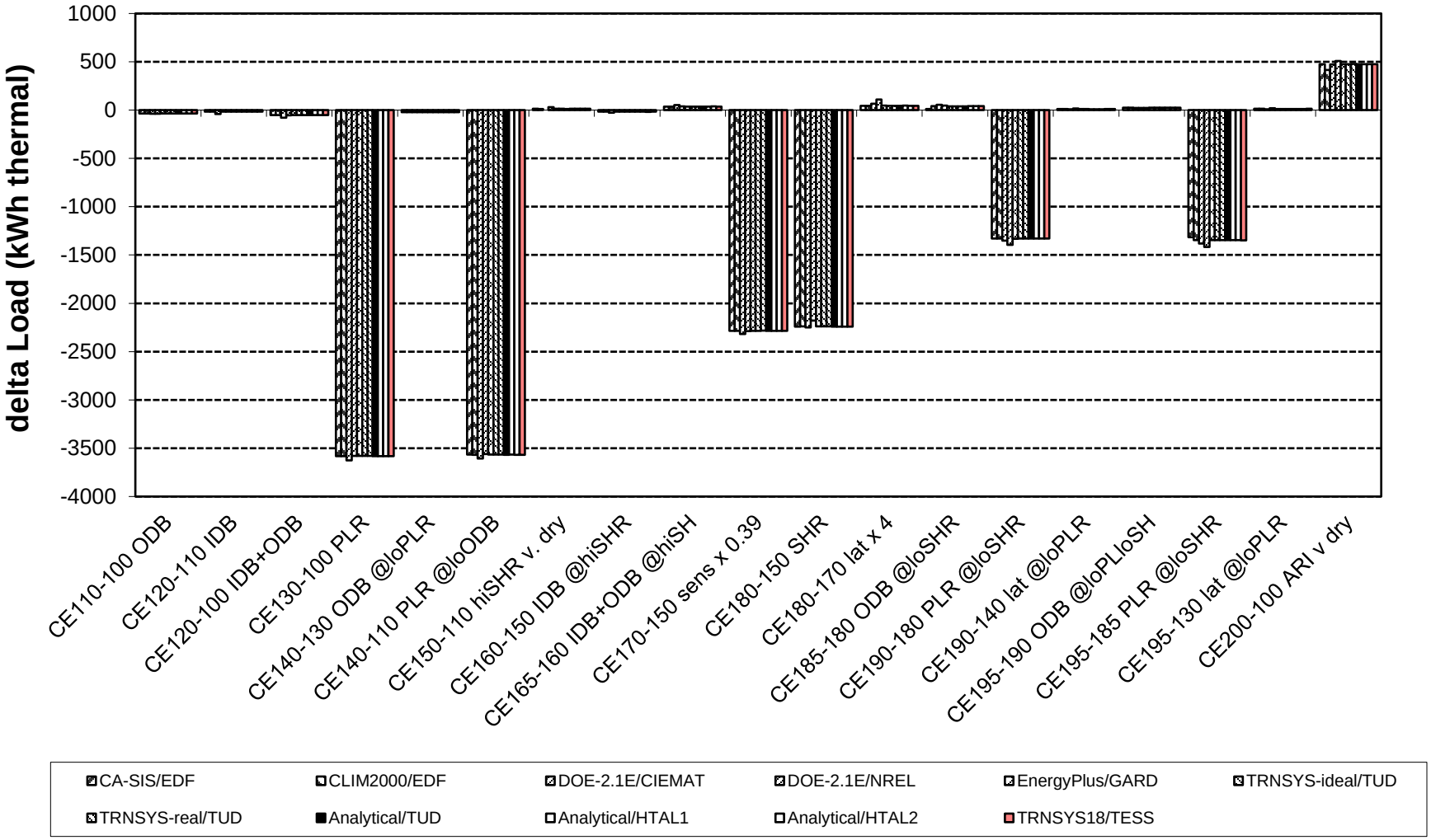


Figure B16.5.1-16.
HVAC BESTEST: Latent Coil Load

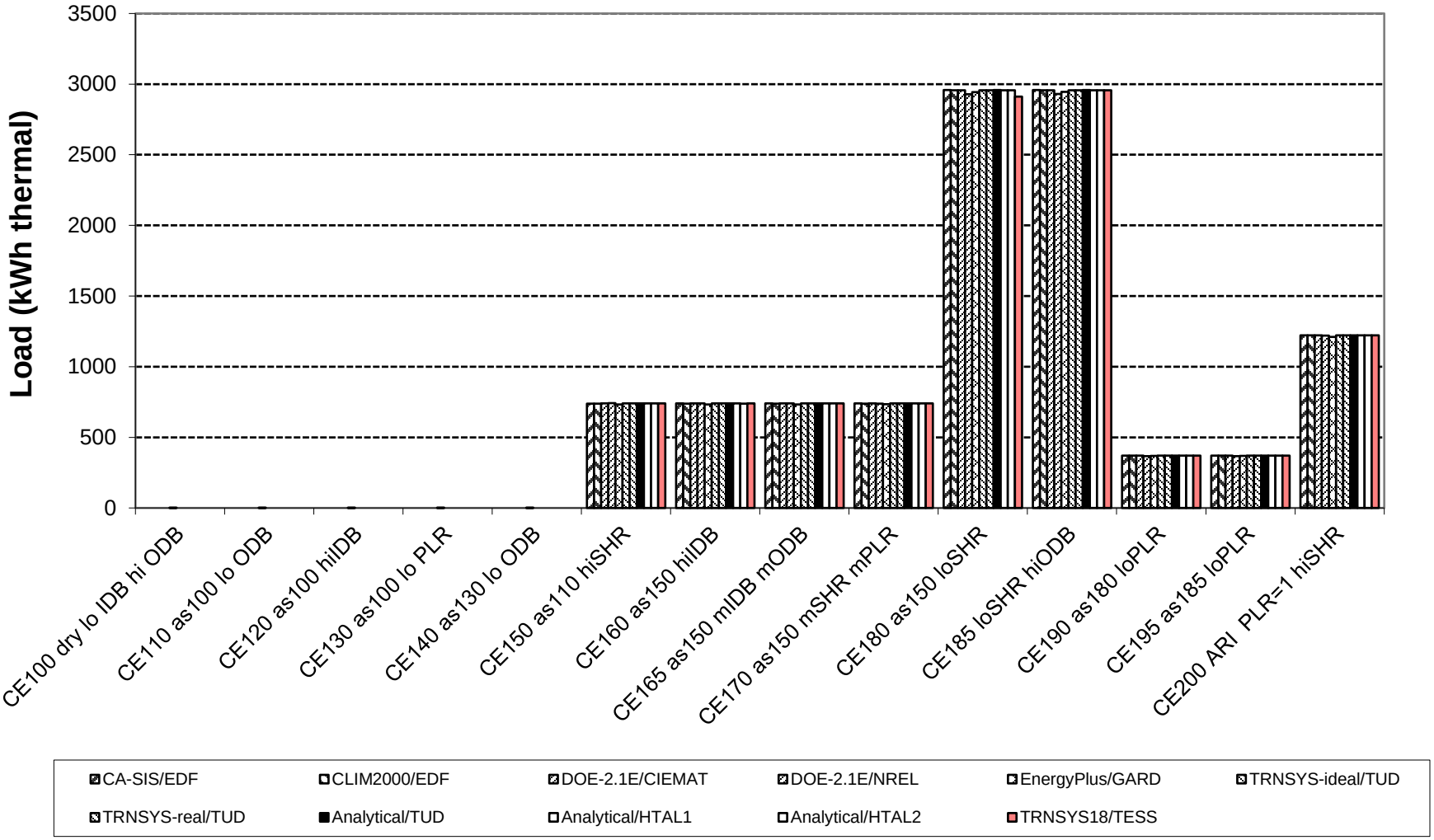
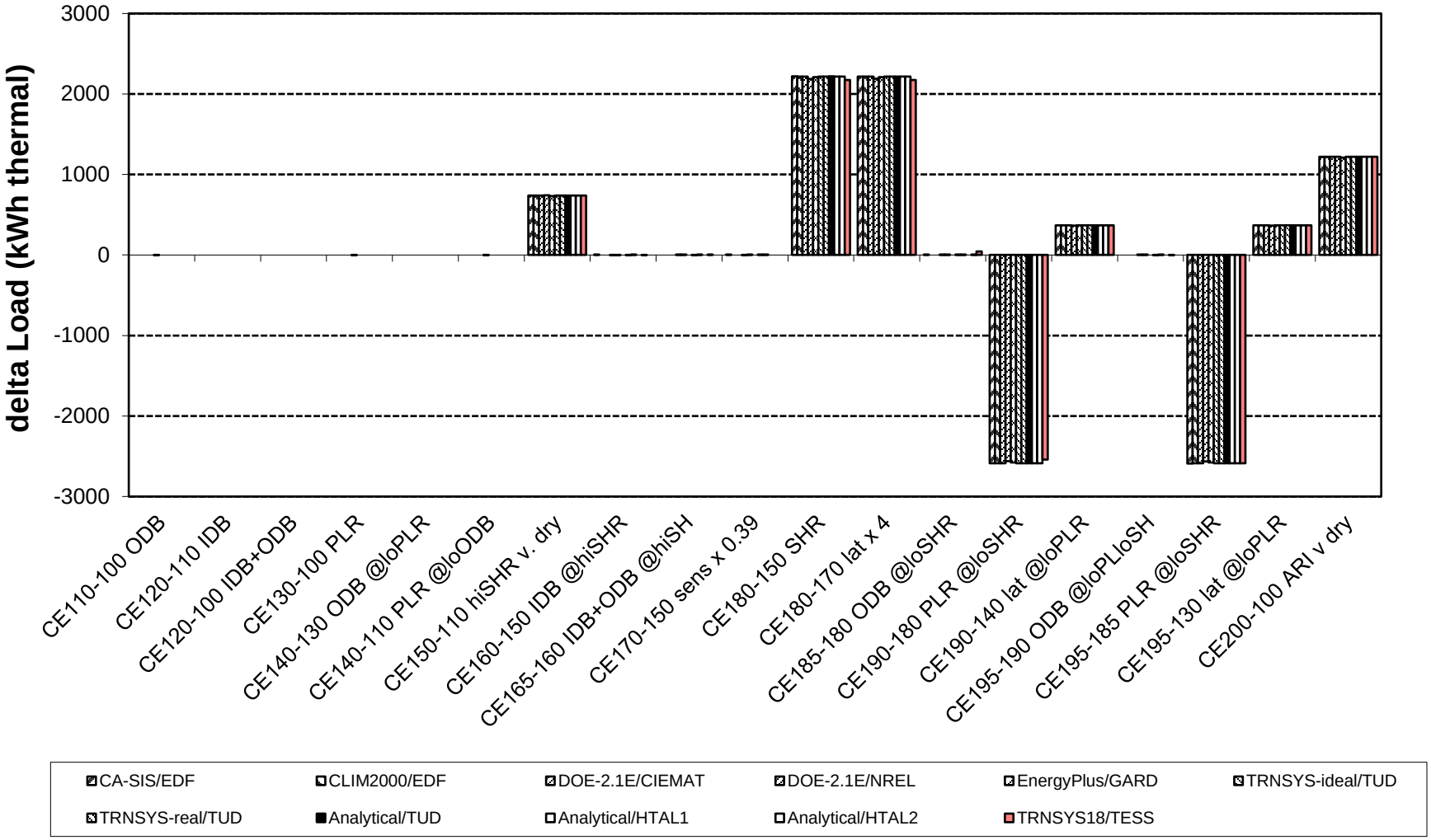


Figure B16.5.1-17.
HVAC BESTEST: Latent Coil Load Sensitivities



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TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-18.
HVAC BESTEST: Mean Indoor Drybulb Temperature

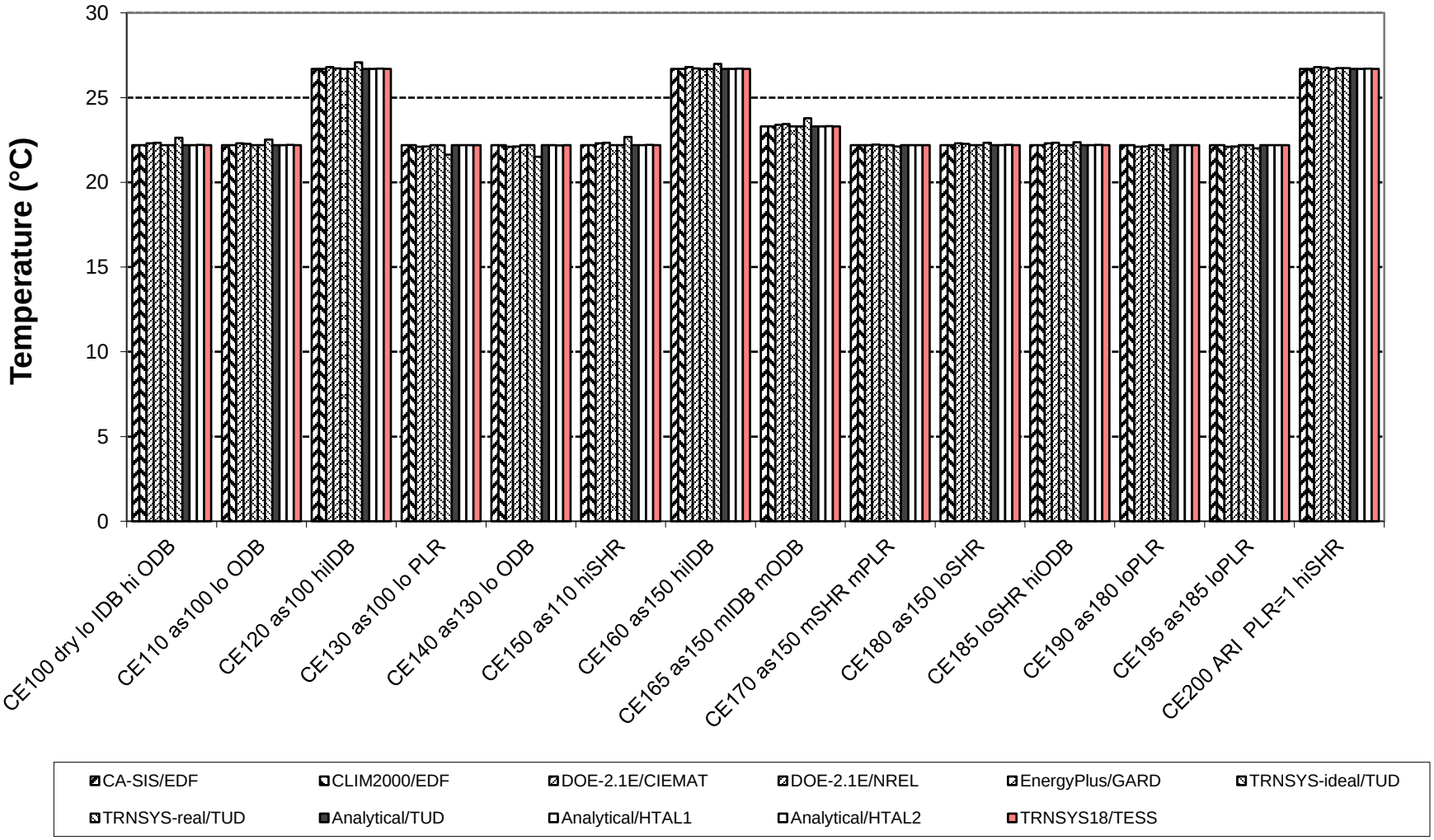


Figure B16.5.1-19.
HVAC BESTEST: (Maximum - Minimum)/Mean Indoor Drybulb Temperature

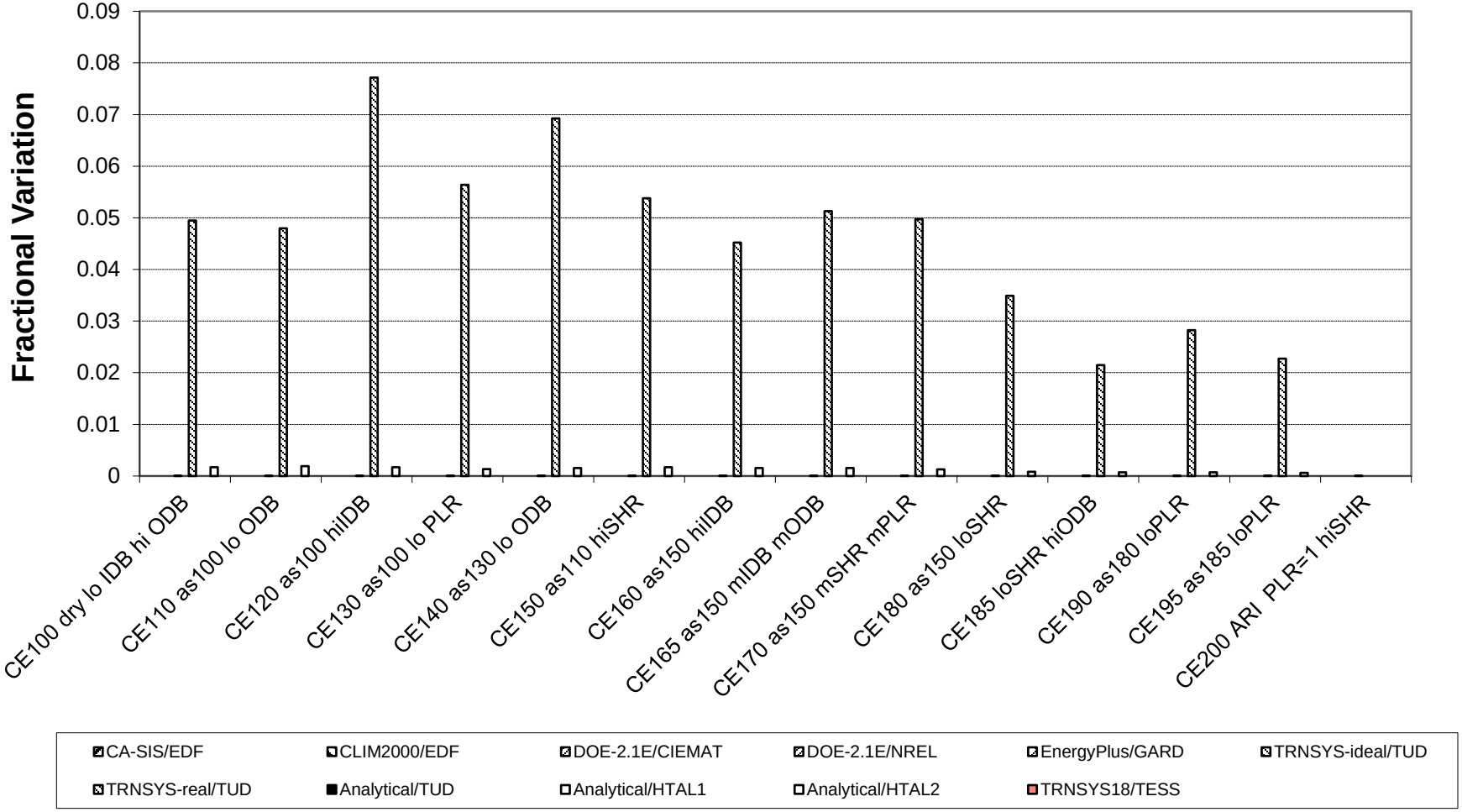
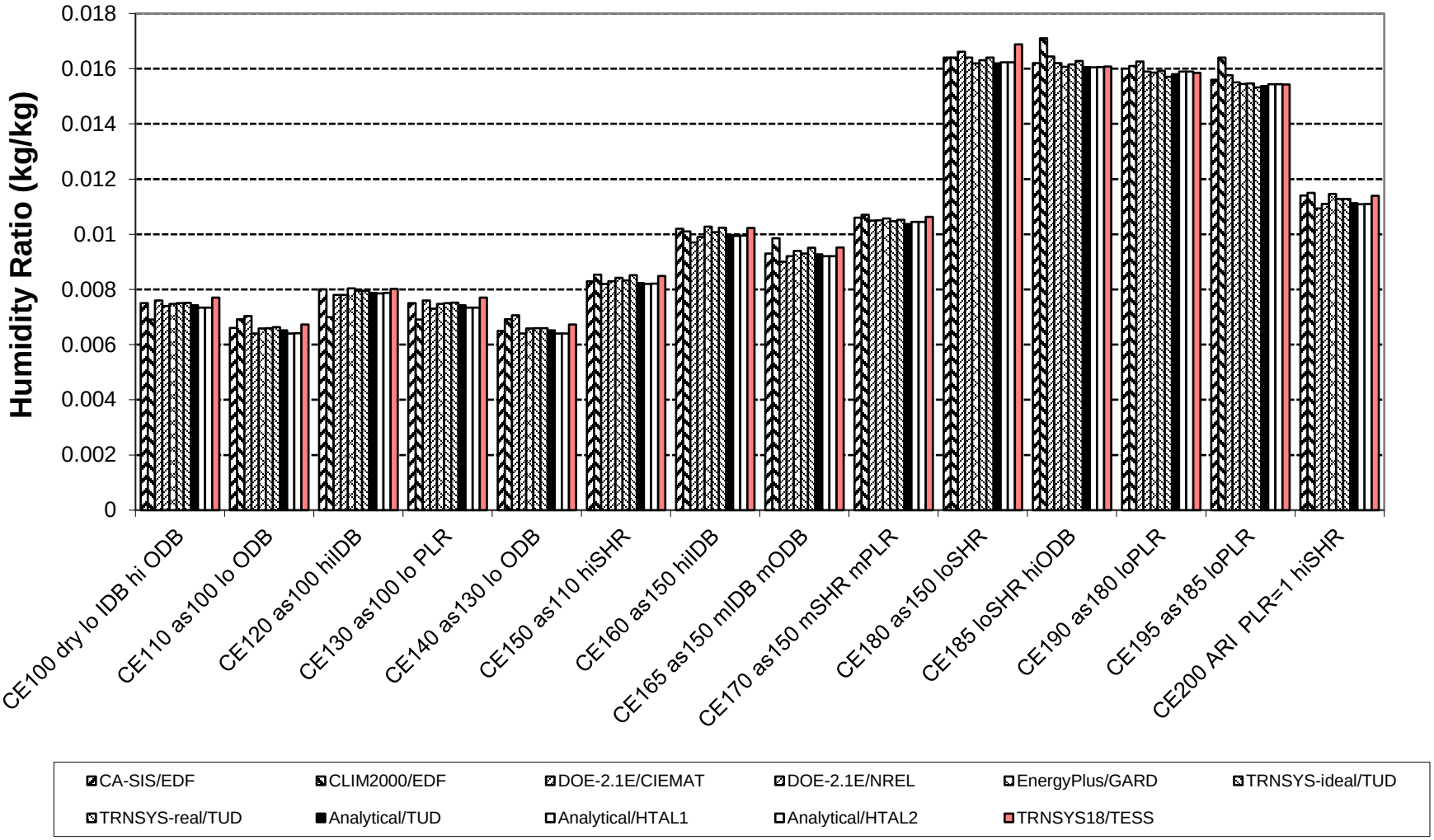
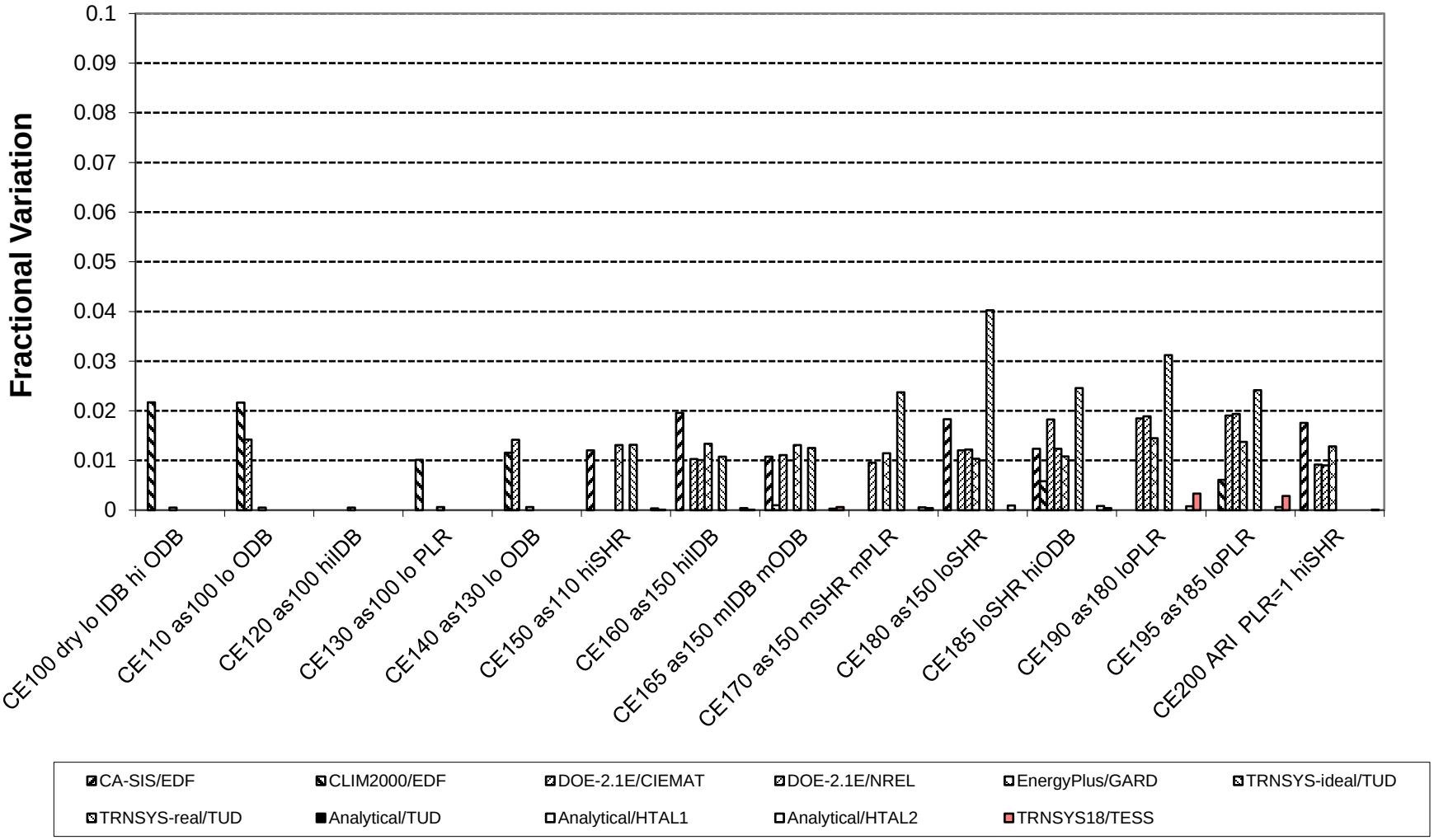


Figure B16.5.1-20.
HVAC BESTEST: Mean Indoor Humidity Ratio



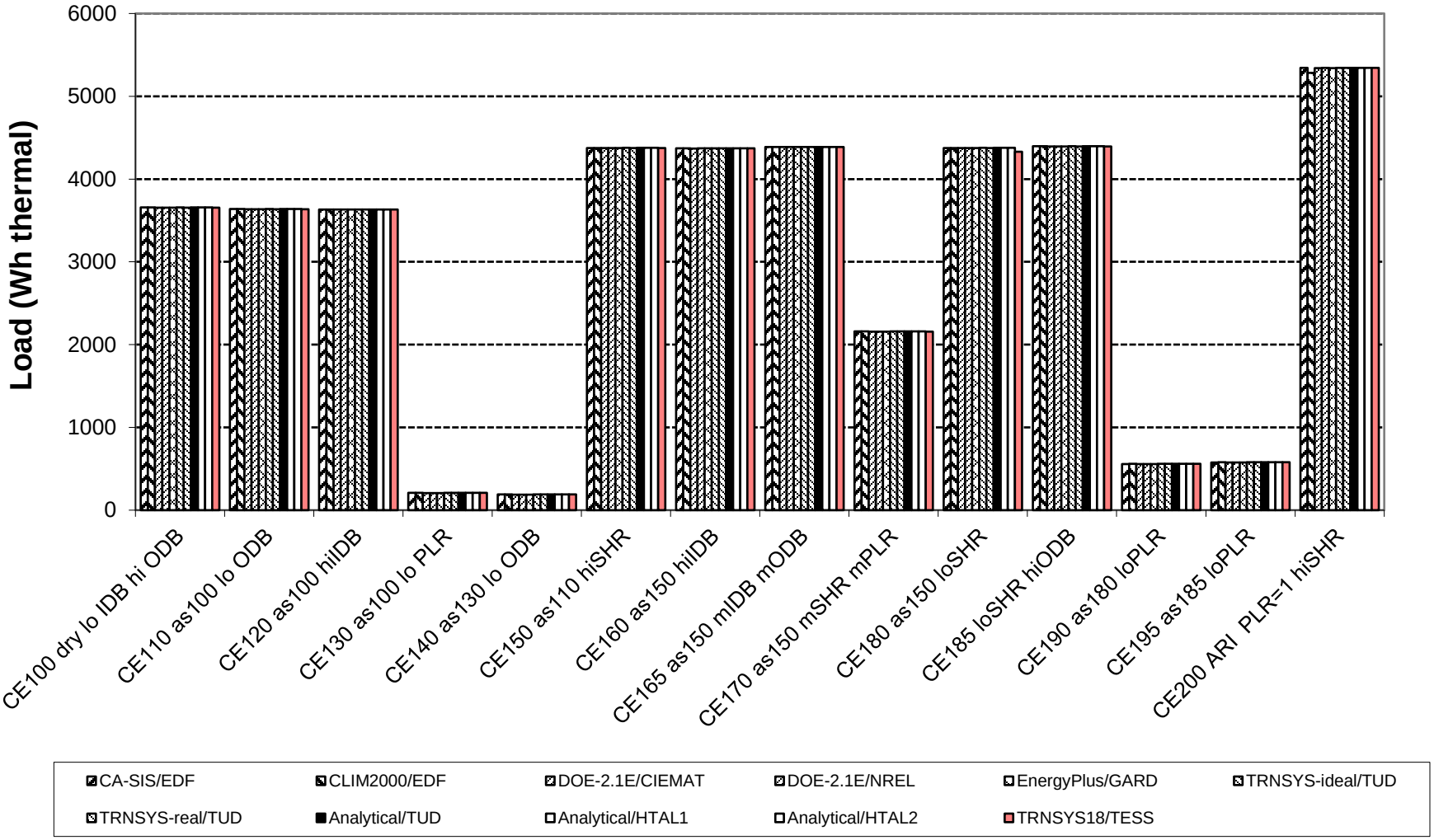
ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-21.
HVAC BESTEST: (Maximum - Minimum)/Mean Indoor Humidity Ratio



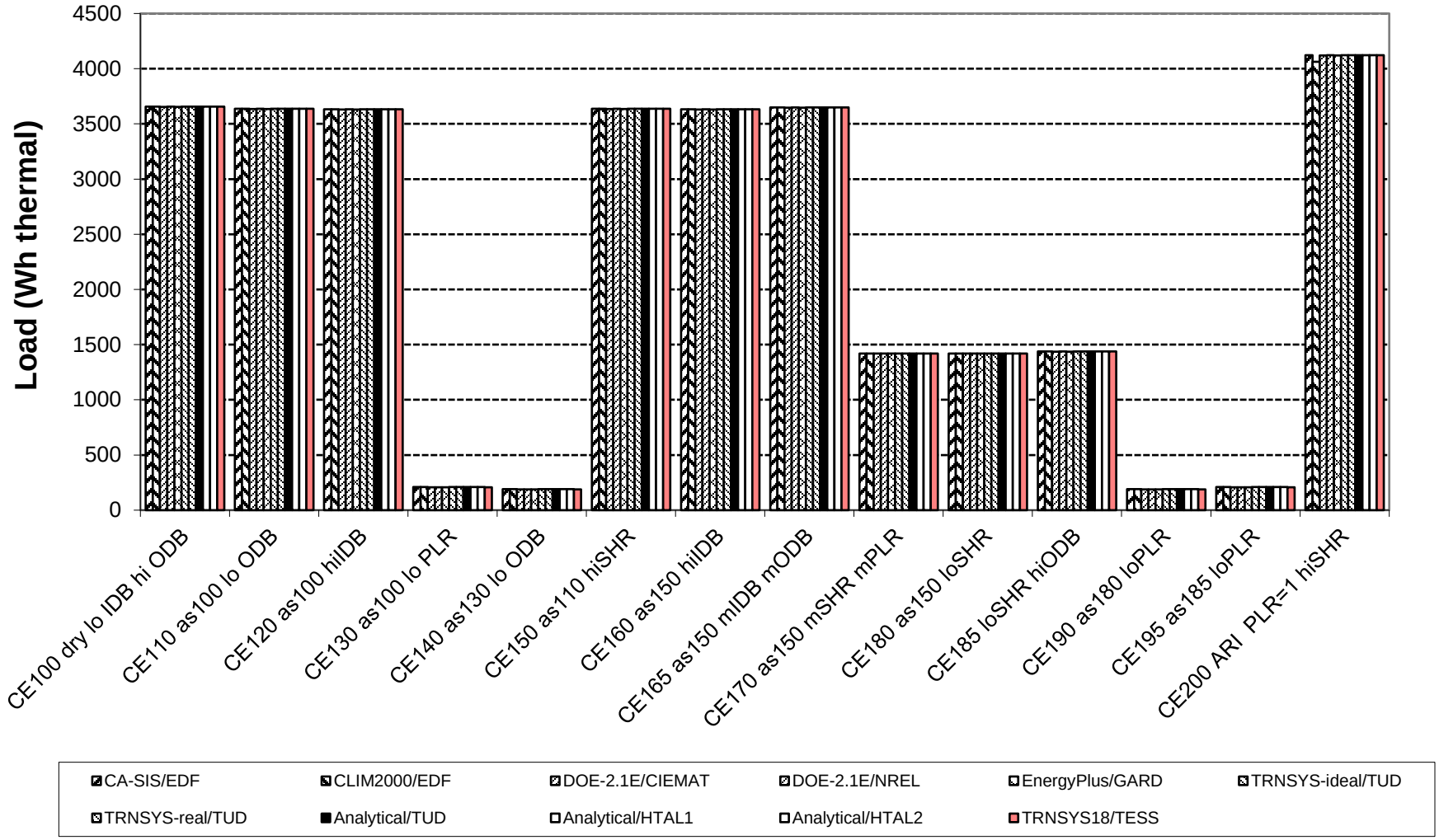
ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-22.
HVAC BESTEST: Total Zone Load



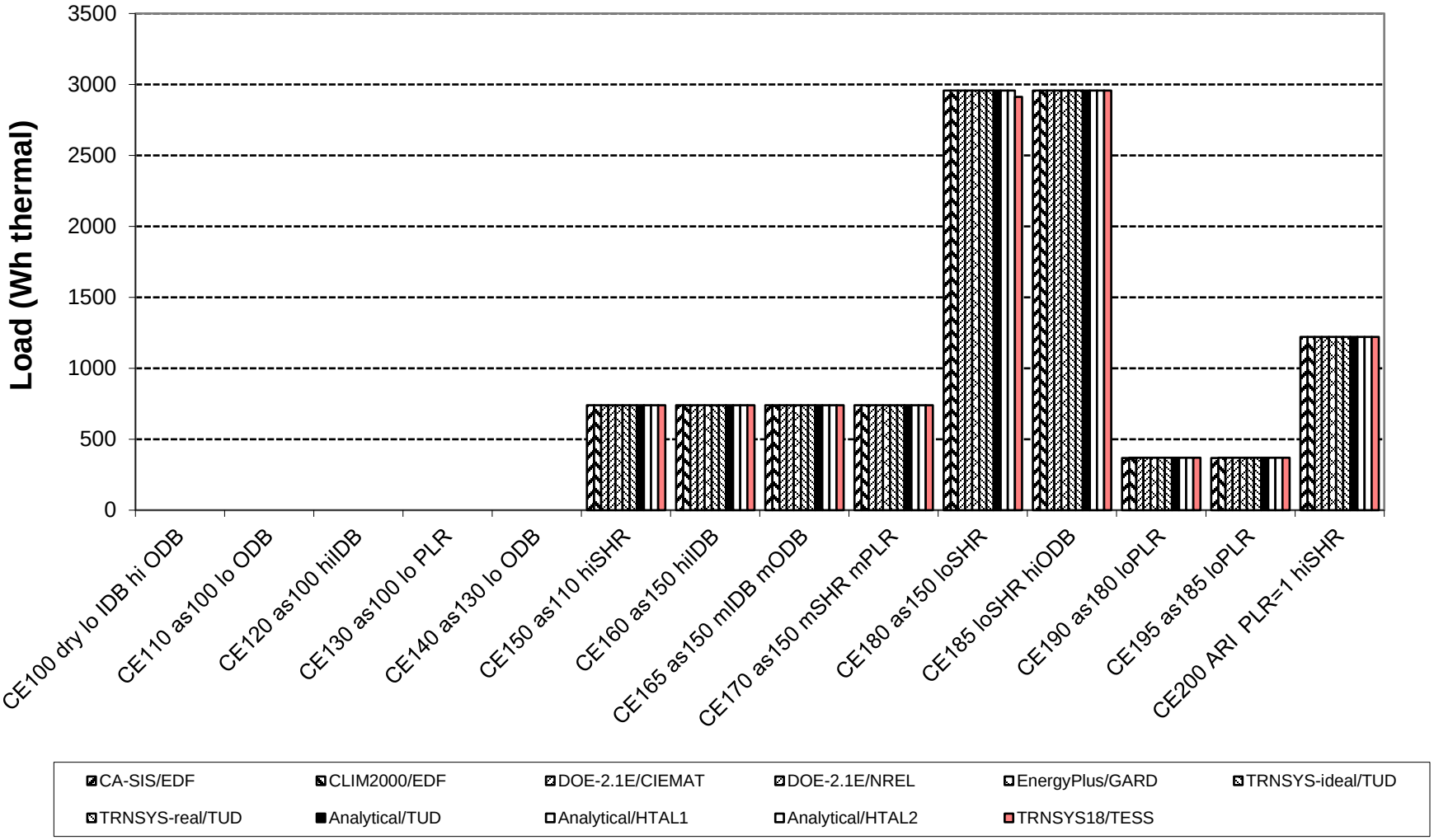
ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-23.
HVAC BESTEST: Sensible Zone Load



ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-24.
HVAC BESTEST: Latent Zone Load



ASHRAE Standard 140-2023 Test Results Comparison for Section 9 - HVAC Equipment Performance Tests CE100 through CE200
TRNSYS18.06.0002 (TRNSYS18) vs. Annex B16, Section B16.5.1 Example Results, by Thermal Energy System Specialists, LLC (TESS), 19-Aug-2024

Figure B16.5.1-25.
HVAC BESTEST: Sensible Coil Load - Zone Load (Fan Heat)

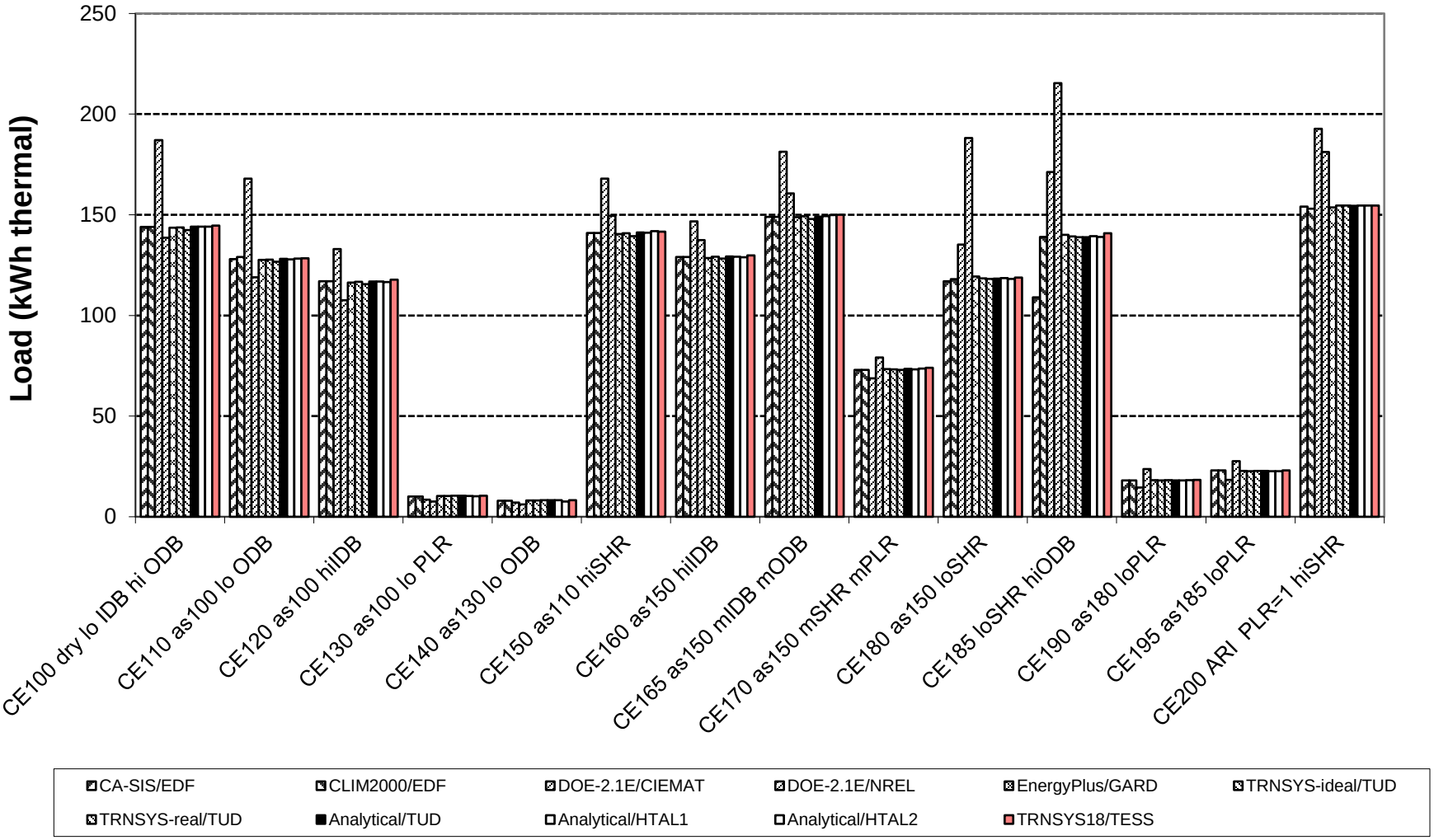
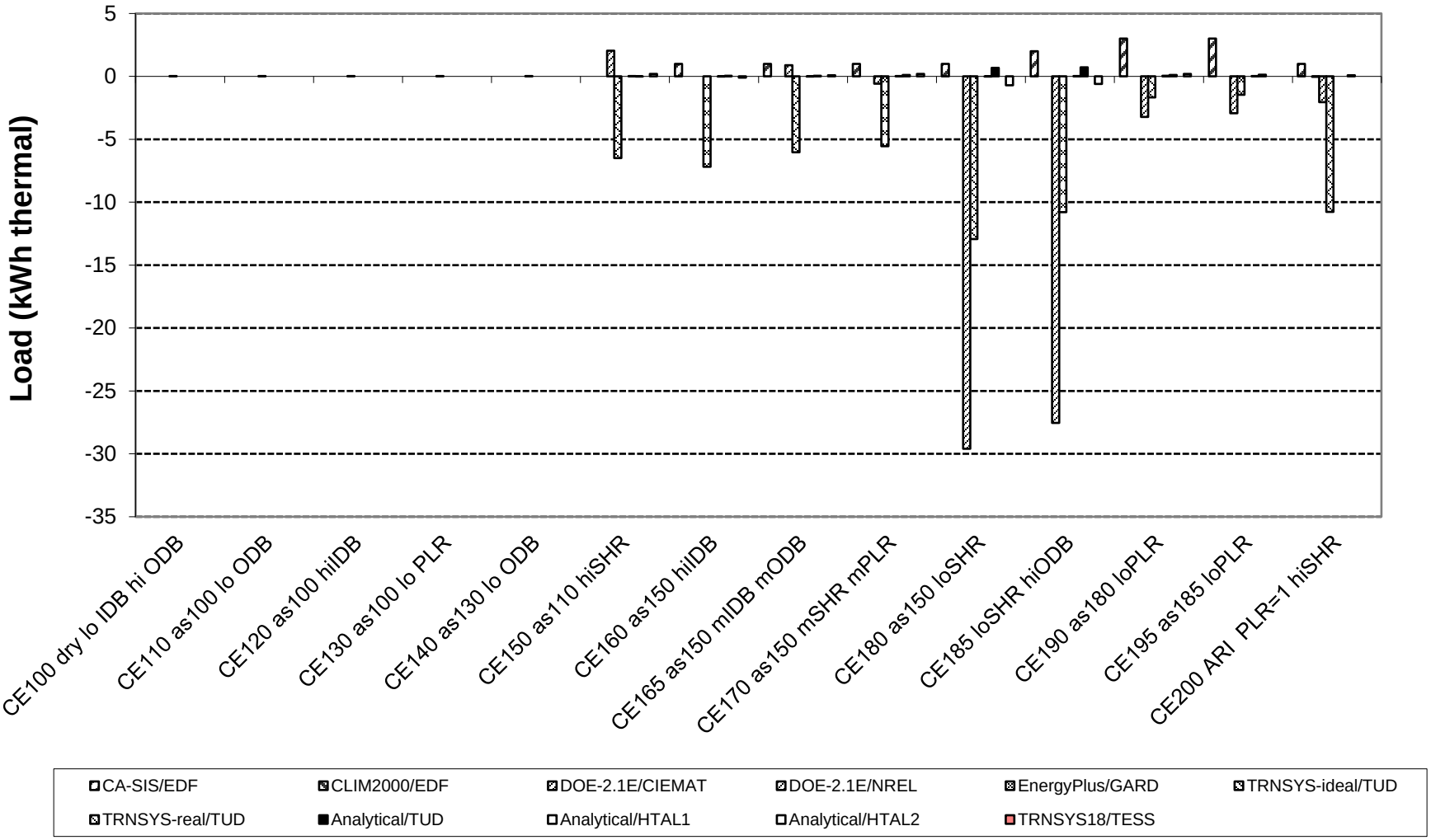



Figure B16.5.1-26.
HVAC BESTEST: Latent Coil Load - Latent Zone Load (Should = 0)