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Fuel Substitution Impacts

An Exploratory Study

Michael R. Jaske, Ph.D.
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California Energy Commission

Study Objectives

- Conduct a preliminary assessment of the relative importance of alternative assumptions for substitution of electricity for natural gas in residential and commercial buildings
- Develop a tool that can assess both annual energy and hourly electric load impacts
- Provide a starting point for assessments of the amount and type of generation resource additions needed

Study Status

- Part 1 – Complete
  - Define scenarios
  - Create annual energy impacts
  - Explore alternative hourly profiles
  - Deliver preliminary hourly results for EG impacts
- Part 2 – In process, due December 2019
  - Refine scenarios and energy impacts
  - Refine hourly profiles
  - Report results

Approach

- Start analysis from 2017 IEPR natural gas demand forecast
- Devise electrification scenarios at the sector and end-use level
- Quantify annual natural gas displaced and electric energy added at the utility, sector and end-use level
- Produce hourly electric load impacts from annual electric energy increases

Scale of Fuel Substitution

- Policy initiatives encouraging building decarbonization:
  - 2019 Title 24 building standards eliminated a barrier
  - SB1477 – explicit financing of fuel substitution
  - AB3232 – study directing C/E assessment
  - CPUC relaxation of the 3-prong test
  - Local jurisdictions banning new NG hookups
- Major unknowns:
  - electrification of just natural gas or other fuels also?
  - Replacing natural gas via market forces or programs?

GHG Emissions

- GHG emission sources:
  - Direct combustion – burning fuels in appliances and equipment
  - Hydrofluorcarbons (HFC) – refrigerants in various appliances with compressors
  - Fugitive emissions (FE) - Methane leakage upstream in the upstream distribution system
  - Incomplete combustion (IC) – methane leaks onsite

SCENARIO DESIGN

PG&E NG Forecast

		2017 IEPR Gas Forecast (MM Therms)					
Sector	**End-Use**	**1990**	**2017**	**2020**	**2025**	**2030**	**2030%**
Res	central AC	20.94	0	0	0	0	0%
Res	central space heating	1288.14	1330.16	1351.26	1399.25	1452.55	40%
Res	clothes drying	28.90	60.71	62.57	67.43	74.03	2%
Res	cooking	78.23	136.31	138.20	145.02	153.09	4%
Res	hot tub fuel	16.22	31.70	32.67	34.36	35.91	1%
Res	hot water clothes washing	206.49	278.54	285.48	299.07	312.56	9%
Res	hot water dishwashing	123.14	193.22	201.19	217.46	232.71	6%
Res	pool heating	14.06	42.74	43.66	45.42	47.15	1%
Res	water heating	478.48	565.78	579.74	610.20	637.81	17%
Comm	Heating	373.39	381.18	375.57	359.20	337.83	9%
Comm	Cooling	17.50	17.28	17.05	16.34	15.30	0%
Comm	Water Heating	52.02	75.06	78.90	85.38	91.48	3%
Comm	Cooking	40.36	48.45	49.65	50.92	51.49	1%
Comm	Refrigeration	0.89	1.42	1.49	1.59	1.67	0%
Comm	Miscellaneous	126.93	178.79	186.36	196.84	205.77	6%
R-C total		2865.69	3341.342	3403.796	3528.478	3649.352	100%

SCE NG Forecast

		2017 IEPR Gas Forecast (MM Therms)					
Sector	**End-Use**	**1990**	**2017**	**2020**	**2025**	**2030**	**2030%**
Res	central A/C	21.76	0.00	0.00	0.00	0.00	0%
Res	central space heating	967.72	959.68	964.74	979.34	993.63	28%
Res	clothes drying	78.78	121.58	125.41	130.88	135.69	4%
Res	cooking	164.43	194.28	194.41	200.46	205.71	6%
Res	hot tub fuel	51.45	58.33	59.23	60.94	62.39	2%
Res	hot water clothes washing	190.32	281.18	282.98	297.19	307.07	9%
Res	hot water dishwashing	120.70	175.80	182.32	198.46	211.27	6%
Res	pool heating	66.95	60.42	59.87	59.34	58.63	2%
Res	water heating	461.87	601.97	607.32	632.86	652.92	18%
Comm	Heating	171.10	229.79	232.64	234.14	231.96	6%
Comm	Cooling	41.09	55.17	57.13	60.18	62.93	2%
Comm	Water Heating	53.16	87.13	92.26	101.10	109.80	3%
Comm	Cooking	49.15	82.36	86.62	92.99	98.61	3%
Comm	Refrigeration	2.32	4.32	4.54	4.89	5.19	0%
Comm	Miscellaneous	238.77	388.20	407.06	437.00	465.23	13%
Res-Comm Total		2679.57	3300.20	3356.53	3489.78	3601.02	100%

SDG&E NG Forecast

		2017 IEPR Gas Forecast (MM Therms)					
Sector	**End-Use**	**1990**	**2017**	**2020**	**2025**	**2030**	**2030%**
Res	central A/C	3.24	0.00	0.00	0.00	0.00	0.0%
Res	central space heating	159.78	169.44	170.48	174.15	179.89	22.2%
Res	clothes drying	13.93	21.98	22.45	23.70	24.82	3.1%
Res	cooking	27.34	36.02	35.59	36.16	36.59	4.5%
Res	hot tub fuel	10.53	14.52	14.73	15.12	15.44	1.9%
Res	hot water clothes washing	51.37	70.10	71.50	73.87	78.92	9.7%
Res	hot water dishwashing	31.22	46.15	48.02	51.21	54.18	6.7%
Res	pool heating	4.62	5.30	5.17	5.08	5.19	0.6%
Res	water heating	113.60	153.24	155.68	160.42	167.80	20.7%
Comm	Heating	58.80	90.75	92.42	93.87	93.96	11.6%
Comm	Cooling	12.56	17.75	18.47	19.63	20.72	2.6%
Comm	Water Heating	15.49	24.76	26.13	28.53	30.93	3.8%
Comm	Cooking	14.03	18.50	19.10	19.94	20.67	2.6%
Comm	Refrigeration	0.13	0.21	0.22	0.23	0.24	0.0%
Comm	Miscellaneous	39.76	66.23	69.57	75.06	80.41	9.9%
Res-Comm Total		556.38	734.94	749.53	776.98	809.77	100%

Forecast Summary

- Residential space and water heating are by far the largest natural gas uses
- Utility service areas have much different space heating requirements
- Commercial miscellaneous end-use is a hodgepodge of specialized applications
- Space and water heating in both sectors are the clear focus, especially given weather sensitivity

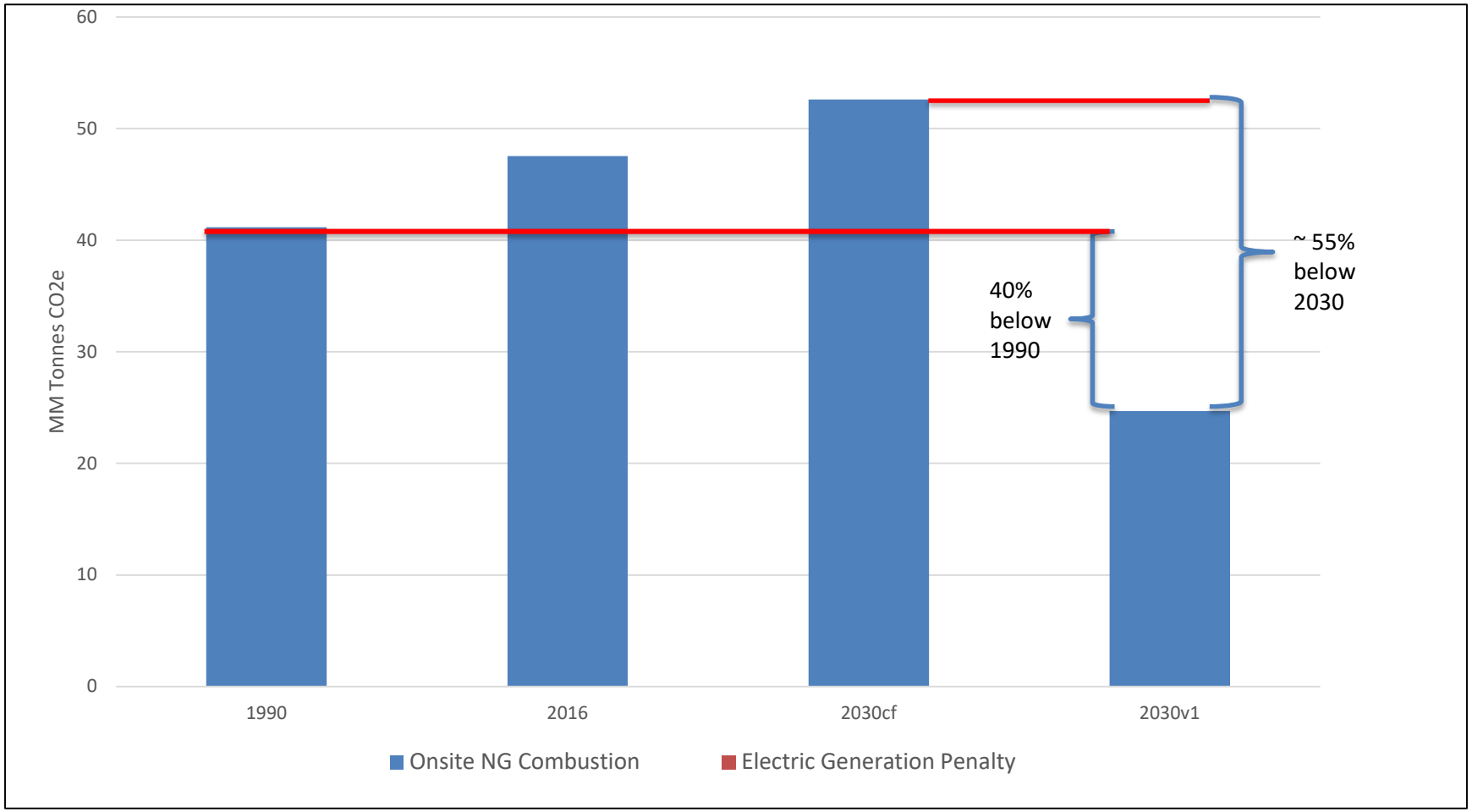
New Construction Issues

- Residential New Construction
  - Share of new SF houses 100% electric
  - Share of new MF dwellings 100% electric
- Commercial New Construction
  - Which building types can be 100% electric
  - Electric fuel share for end-uses for building types that require natural gas

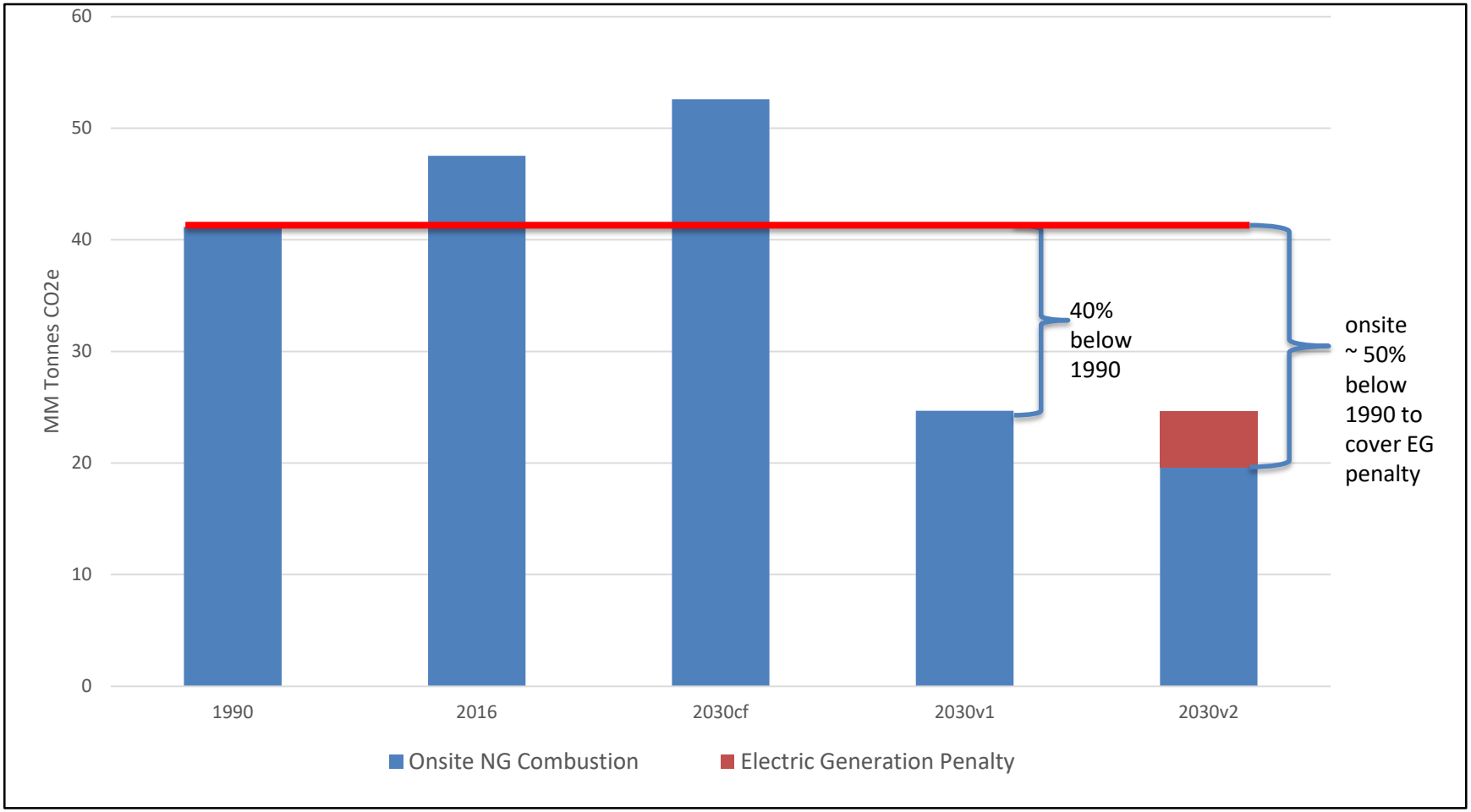
Building Retrofit Issues

- When heat pumps are installed for space heat and water heat, what happens with other NG end-uses?
- When heat pumps are installed in non-AC dwellings how much A/C load is added?
- What proportion of older houses and commercial buildings require expensive electric service upgrades?
- If large scale FS is to occur, should natural gas energy efficiency programs change?

AB3232 – Load Growth



AB3232 – Net or Gross?



Fuel Substitution Scenarios

- An assessment of 2019 T24 Building Standards inducing electric space/water heating in new construction
  - starting in 2020 and rising to 15% by 2030
  - starting in 2020 and rising to 25% by 2030
- Displacement of baseline residential space and water heat by 2030
  - 10% of baseline SH and WH end-use projections
  - 25% of baseline SH and WH end-use projections
- Simplified AB 3232 - 40% reduction from 1990 natural gas fuel use in buildings by 2030

Consumption or Sales?

- NG displacement clearly results in added electric load
- Incremental electric load can be supplied by behind the meter (BTM) PV and/or battery storage systems in some hours of the day
- This study focuses on the “gross” incremental load and defers the question of BTM supply versus grid supply to another phase

2030 Energy Shift from Natural Gas to Electricity

#	Scenario	Natural Gas Displaced (MM Therms)	Electricity Added (GWh)
1	Res New Construction - 10% by 2030	77	600
2	Res New Construction - 25% by 2030	130	1000
3	Res 10% Total Displacement by 2030	486	3802
4	Res 25% Total Displacement by 2030	1216	9506
5	Res/Comm 40% below 1990 by 2030	3802	32852

FURTHER ISSUES

Non-Combustion Emissions

- HFC emissions are from electric appliances with refrigerants and can only be reduced by changing refrigerants
- Incomplete combustion may be reduced by better burner design and maintenance practices, but is eliminated with electrification
- Fugitive emissions occur at many stages of production to distribution

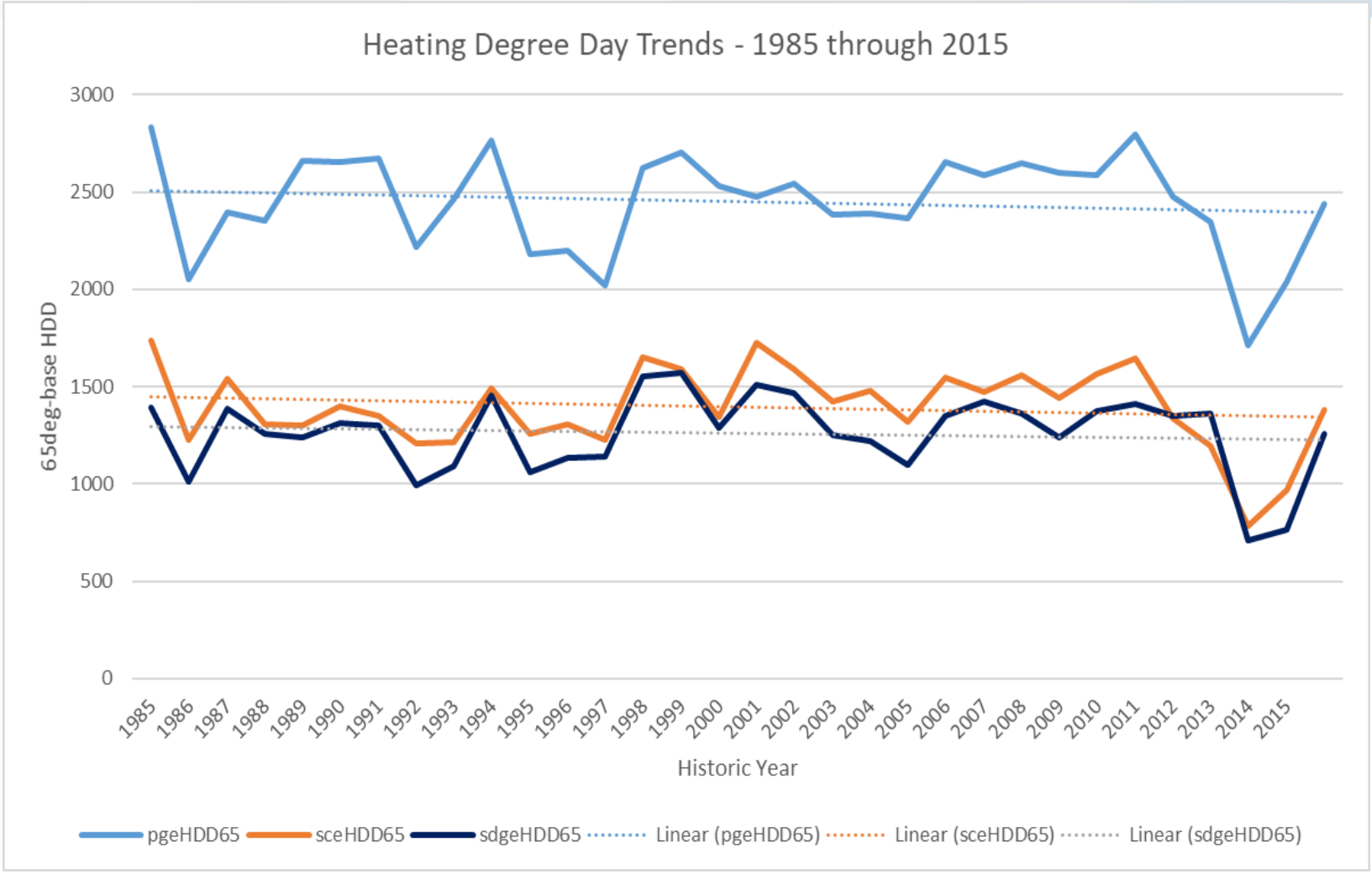
Hourly Load Profiles

- Translating annual incremental electric energy into load impacts requires a tool with sector/end-use hourly load profiles
- Three existing sources of load profiles:
  - SoCalGas study (derived from E3 IRP profiles)
  - OpenEI residential profiles
  - ADM load profiles for Res/Com end-uses
- Potential Sources:
  - New analyses using building simulation models
  - EE EM&V studies and/or customer AMI data

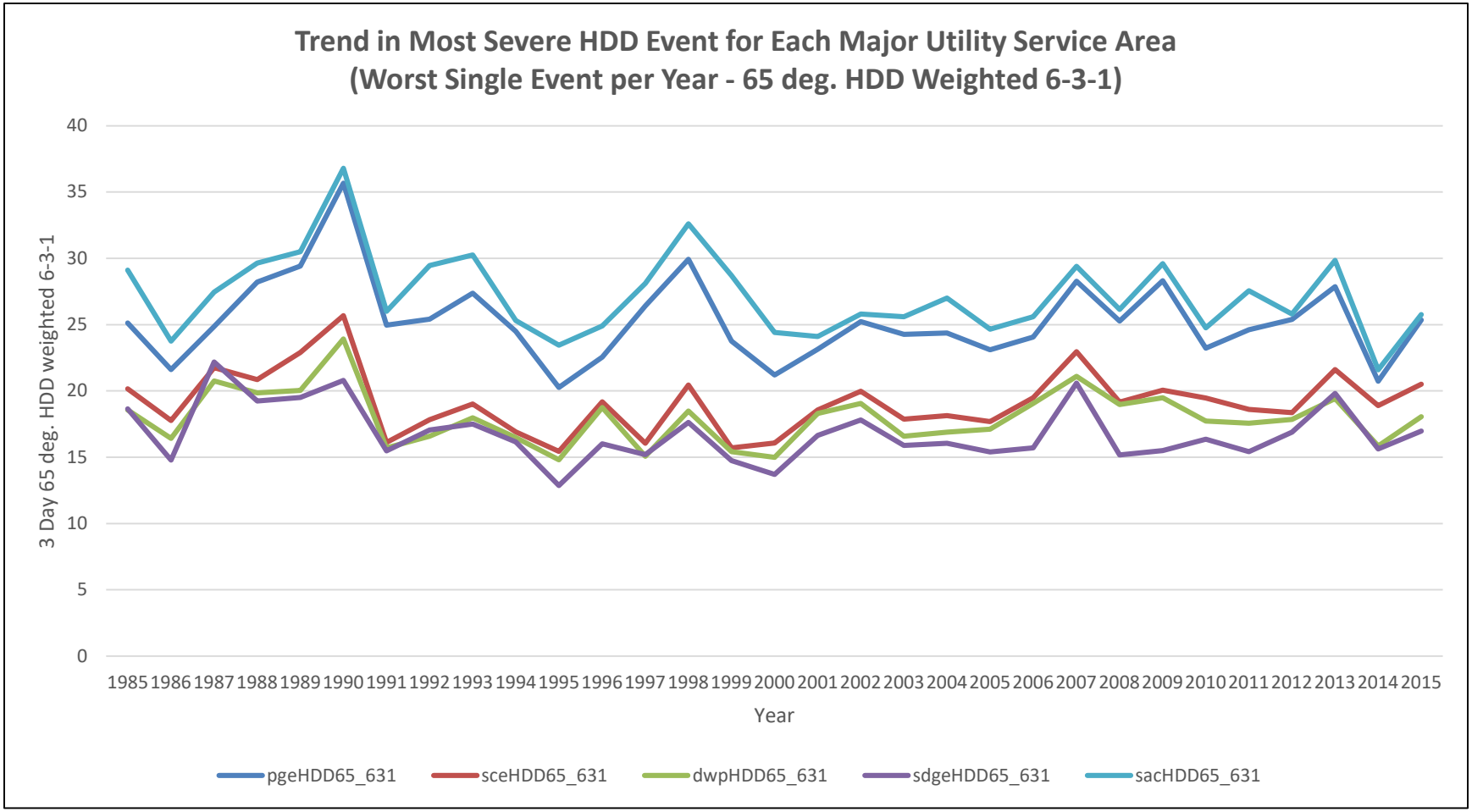
Weather Influence

- Intuitively, residential space heat is more sensitive to weather than commercial space heat
- Duration and patterns of weather-induced space heat load profiles have not yet been studied to the extent of summer air conditioning load
- Are there significant climate trends affecting electric space heat energy and/or short term weather events affecting “peak” incremental electric load?

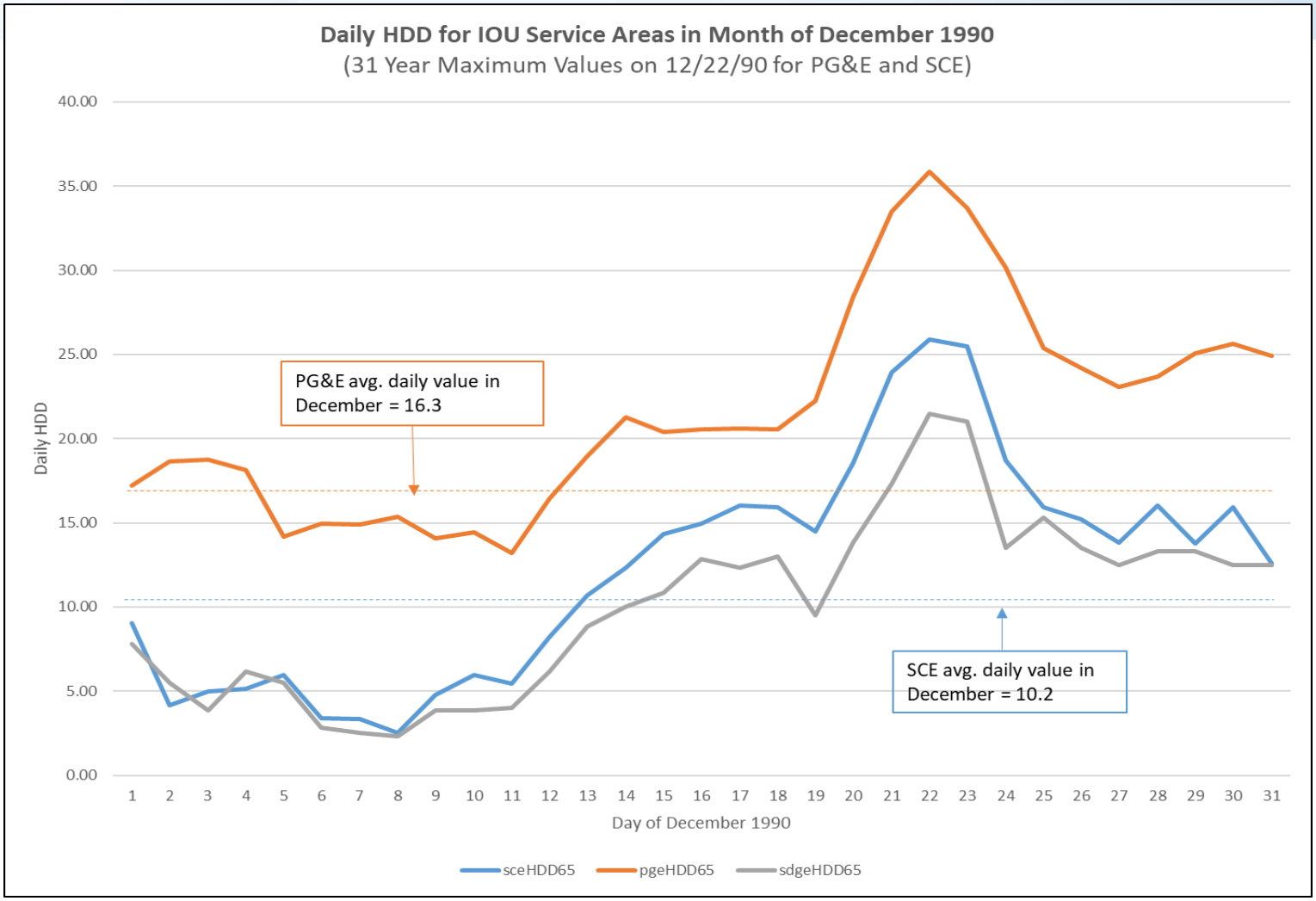
Climate Trends



Cold Weather Severity Trend



Severity of "Peak Day" Weather



Overview of Initial Results

- Initial hourly load assessment:
  - Winter incremental hourly load results highly sensitive to residential space heat hourly profiles
  - Each profile source used a weather selection method appropriate to its original purpose
  - Electricity projections require analysis of multiple alternative weather years to guide system planning and operations
  - Summer incremental load increases are not trivial and commercial building profiles are more important in the summer period
- Further details of energy and load impacts to be provided at December 2 IEPR workshop

Study Limitations

- CO2 is not the only source of GHG emissions, others are not studied here, but those in CARB inventory seem small by comparison
- C/E analysis of specific technologies is beyond the scope of this study
- Hourly load profiles are not customized to expected heat pump performance
- The scenario projections are too uncertain to include in official CEC managed demand forecasts, but important enough to be published to enable comment and further development

Continuing Activity

- Staff (EAD/SAO) is assessing electric system impact of a preliminary version of incremental loads from the simplified AB3232 scenario
- Technical support from Navigant Consulting:
  - improve impact projection capabilities
  - Begin developing performance and cost estimates
  - Identify barriers
  - Integrate analysis into AB 3232 study plans
- Coordination with CPUC SB1477 and CPUC R.19-01-011 assessments

Questions?