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Fuel Substitution Impacts

An Exploratory Study

Part II

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December 2, 2019
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 (reported 9/26/19 wkshp)
  - Define scenarios
  - Create annual energy impacts
  - Explore alternative hourly profiles
  - Deliver preliminary hourly results for EG impacts
- Part 2 – Expected completion December 2019
  - Refine scenarios and energy impacts
  - Refine hourly profiles
  - Document results
  - Final report in review

Fuel Substitution Scenarios

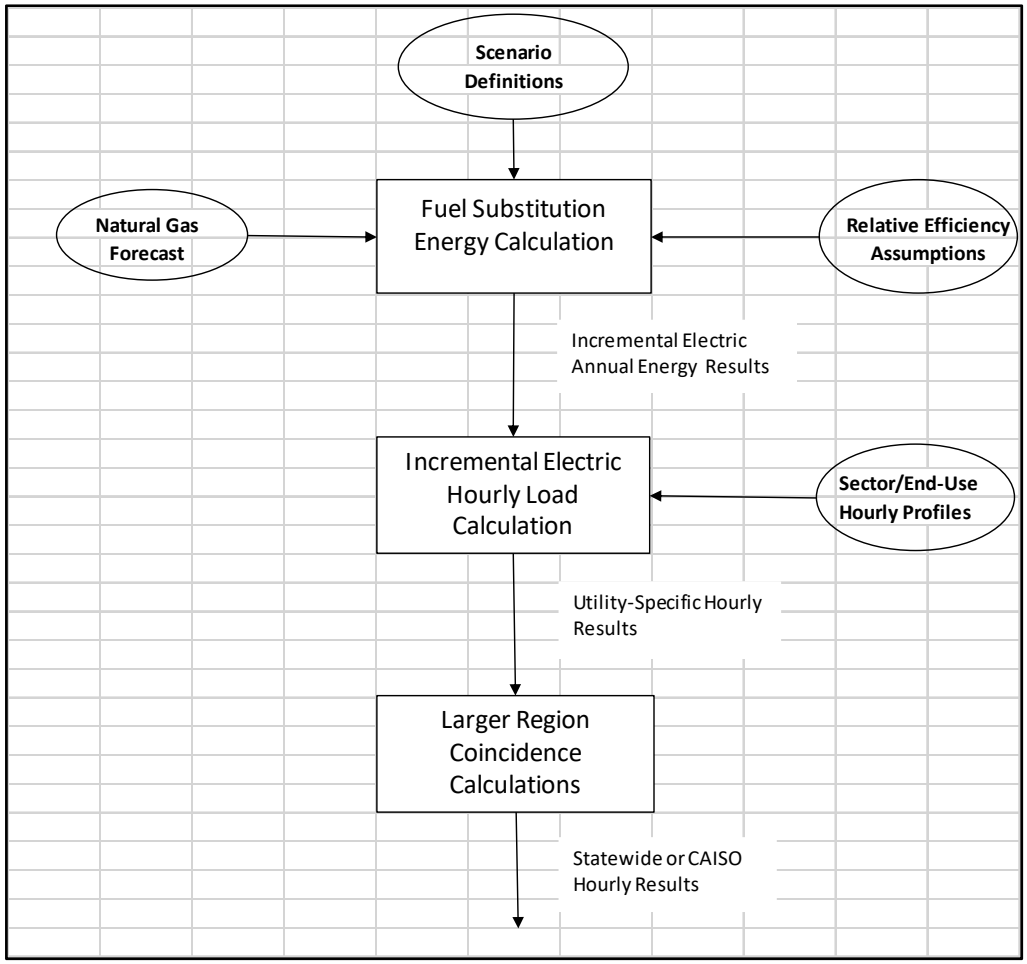
- An assessment of 2019 T24 Building Standards inducing all electric appliances in new residential and commercial construction
  - starting in 2020 and rising to 15% by 2030
  - starting in 2020 and rising to 25% by 2030
- Displacement of baseline residential space and water heat by 2030
  - 10% of baseline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

APPROACH

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 and sector/end-use hourly load profiles

Analysis Flowchart



Disaggregation

Variable	Level of Disaggregation	
Utility	PG&E, SDG&E, SCE, LADWP, SMUD	
Sectors	Residential	Commercial Building
End-Uses	Space Heat	Cool/Vent
	Water Heat	Space Heat
	Clothes Dryer	Water Heat
	Cooking	Cooking
	Pool/Spa	Comm Refrig
		Miscellaneous

Key Equation

- Key assumption – equal level of service before/after FS activity
- Incremental EE = Displaced NGE * (Average NG Eff/Average EE Eff)
- Where:
  - Incremental EE = incremental electric energy added
  - Displaced NGE = displaced natural gas energy
  - Average NG Eff = average efficiency of displaced natural gas appliances/equipment
  - Average EE Eff = average efficiency of added electric appliances/equipment

End-Use Efficiency Sensitivity

- Test of sensitivity of energy efficiency assumptions on results in the SCE service area

			Original Assumptions			Revised Assumptions		
Sector	**End-use**	**Natural Gas Displaced (MM Therms)**	**NG Eff**	**Elec Eff**	**Electric Energy (GWh)**	**NG Eff**	**Elec Eff**	**Electric Energy (GWh)**
Res	Space Heat	413.0	0.8	3	3227.0	0.74	3.631	2466.3
Res	Water Heat	375.8	0.8	3	2936.4	0.6875	3.119	2427.2
Res	Clothes Dryer	88.4	0.8	3	690.9	0.8	2.5	829.1
Res	Cooking	107.0	0.8	3	836.4	0.375	0.82	1434.5
Res	Pool/Spa	50.0	0.8	3	390.5	0.8	3	390.5
Res	Total	1034.2			8081.3			7547.5

Scenario Results (Annual Energy)

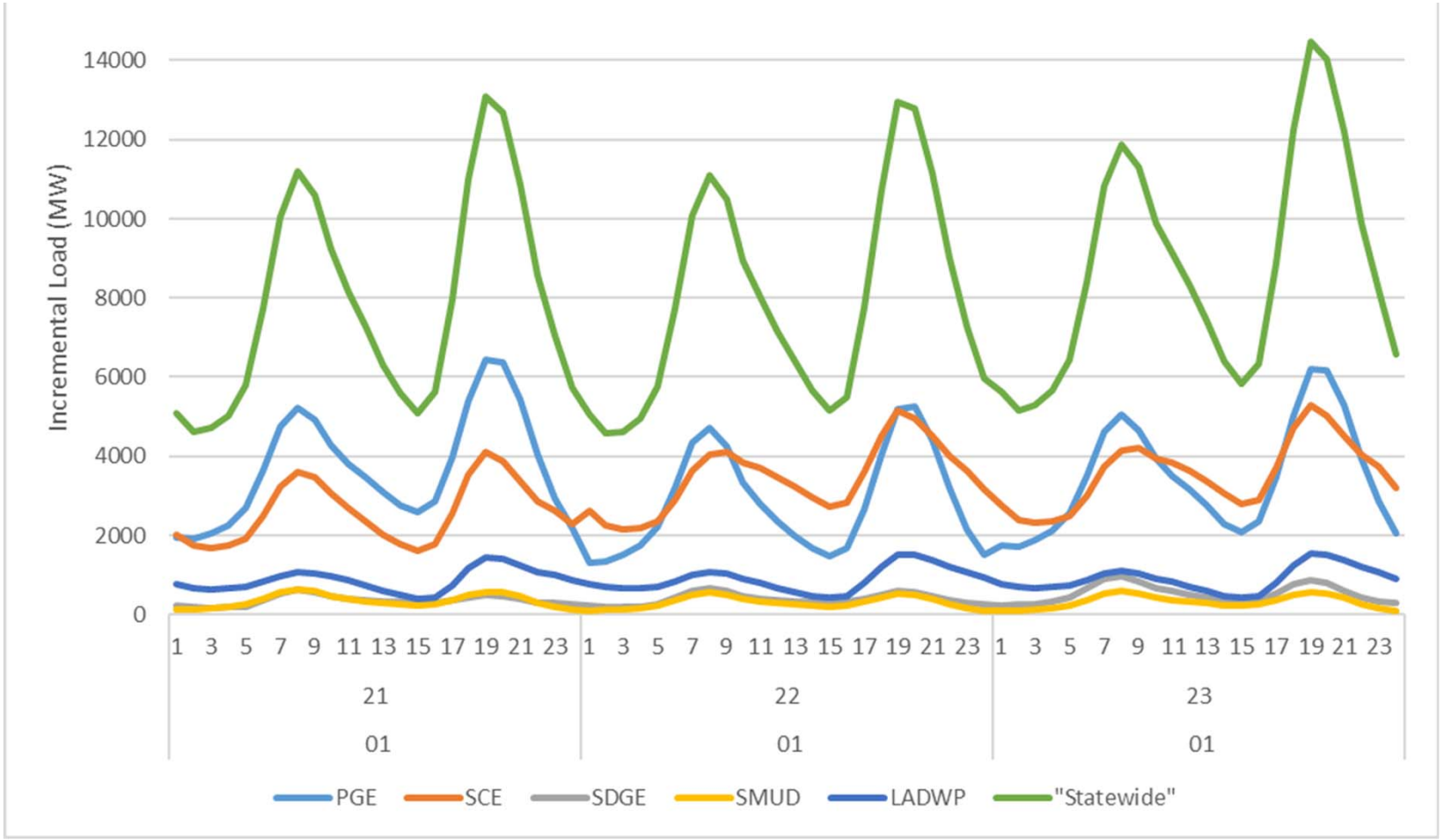
#	Scenario Name	Utility	2025 Load Increase (GWh)	2030 Load Increase (GWh)	2025 Load Reduction (MM therms)	2030 Load Reduction (MM therms)
1	SB350REF	"State"	265.90	875.77	34.03	112.08
2	SB350AGG	"State"	664.76	2189.42	85.08	280.20
3	Res Retrofit 10% by 2030	"State"	2011.98	3802.35	257.50	486.63
4	Res Retrofit 25% by 2030	"State"	5027.45	9505.87	643.42	1216.57
5	Res/Comm 40% below 1990 by 2030	"State"	17532.34	33131.08	2244.94	4243.09

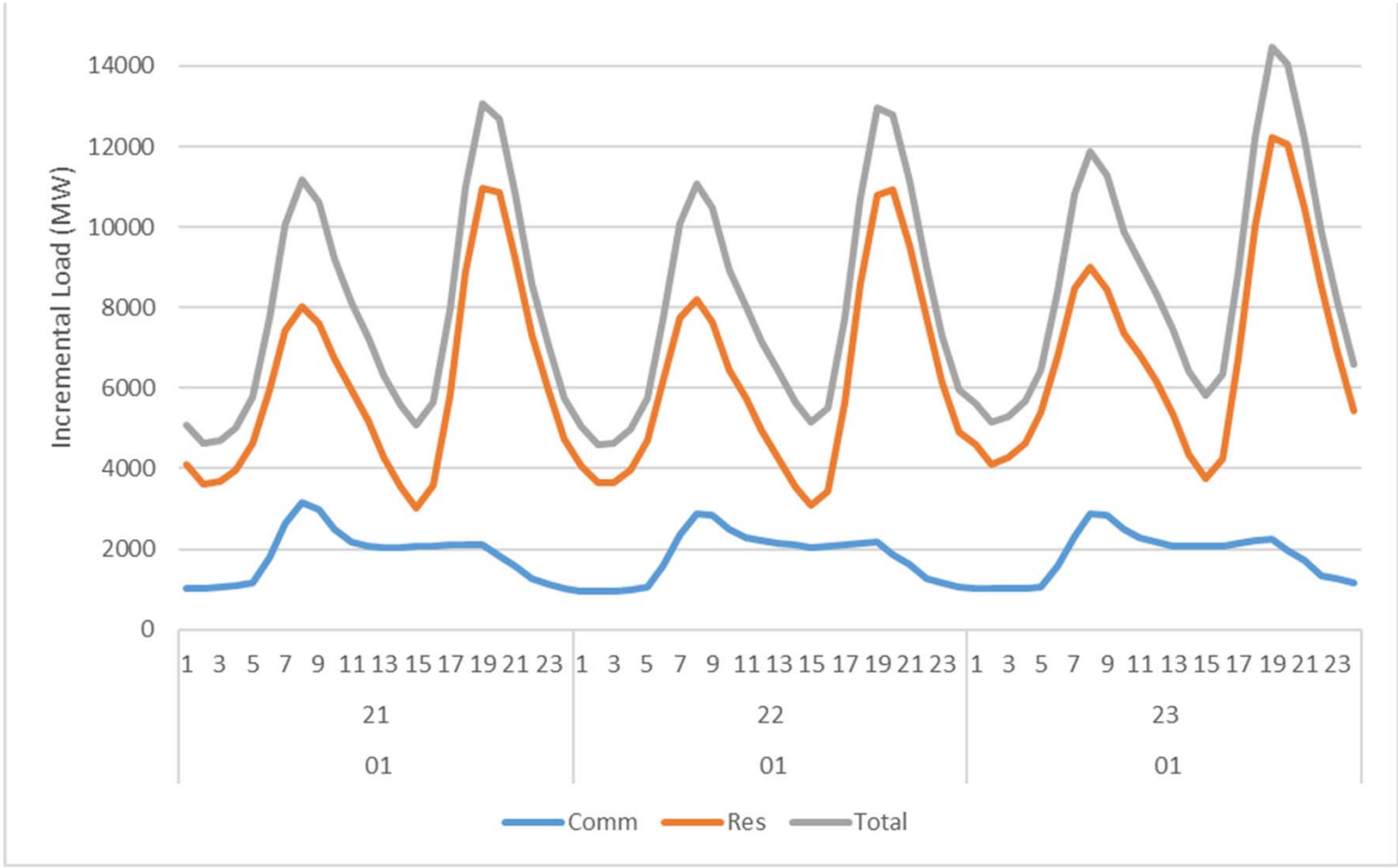
HOURLY ELECTRICITY ANALYSIS

Hourly Load Profiles

- Translating annual incremental electric energy into load impacts requires a tool with sector/end-use hourly load profiles
- Four existing sources of load profiles were acquired and used:
  - Navigant 2017 AAEE hourly projections
  - SoCalGas study (derived from E3 IRP profiles)
  - openEI residential space heating profiles
  - ADM load profiles for Res/Com end-uses

Tool Version/Profile Source	PG&E	SCE	SDG&E	CAISO
Ver9C – key End-uses from 2017 version of AAEE tool plus SoCalGas Study (E3 profiles)	11/23	11/23	11/23	11/23
Ver9D – Ver9C with residential space heat replaced by openEI profiles by zone weighted to utility service area	12/21	12/20	3/15	12/20
Ver10 – ADM profiles with zonal profiles weighted to utility service area with a few minor end-uses from 2017 AAEE package	12/1	1/28	11/26	1/23


Incremental Load (MW)
14000
12000
10000
8000
6000
4000
2000
0
1 3 5 7 9 11 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17 19 21 23
21
01
22
01
23
01
PGE
SCE
SDGE
SMUD
LADWP
"Statewide"


Incremental Load (MW)
14000
12000
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1 3 5 7 9 11 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17 19 21 23
21
01
22
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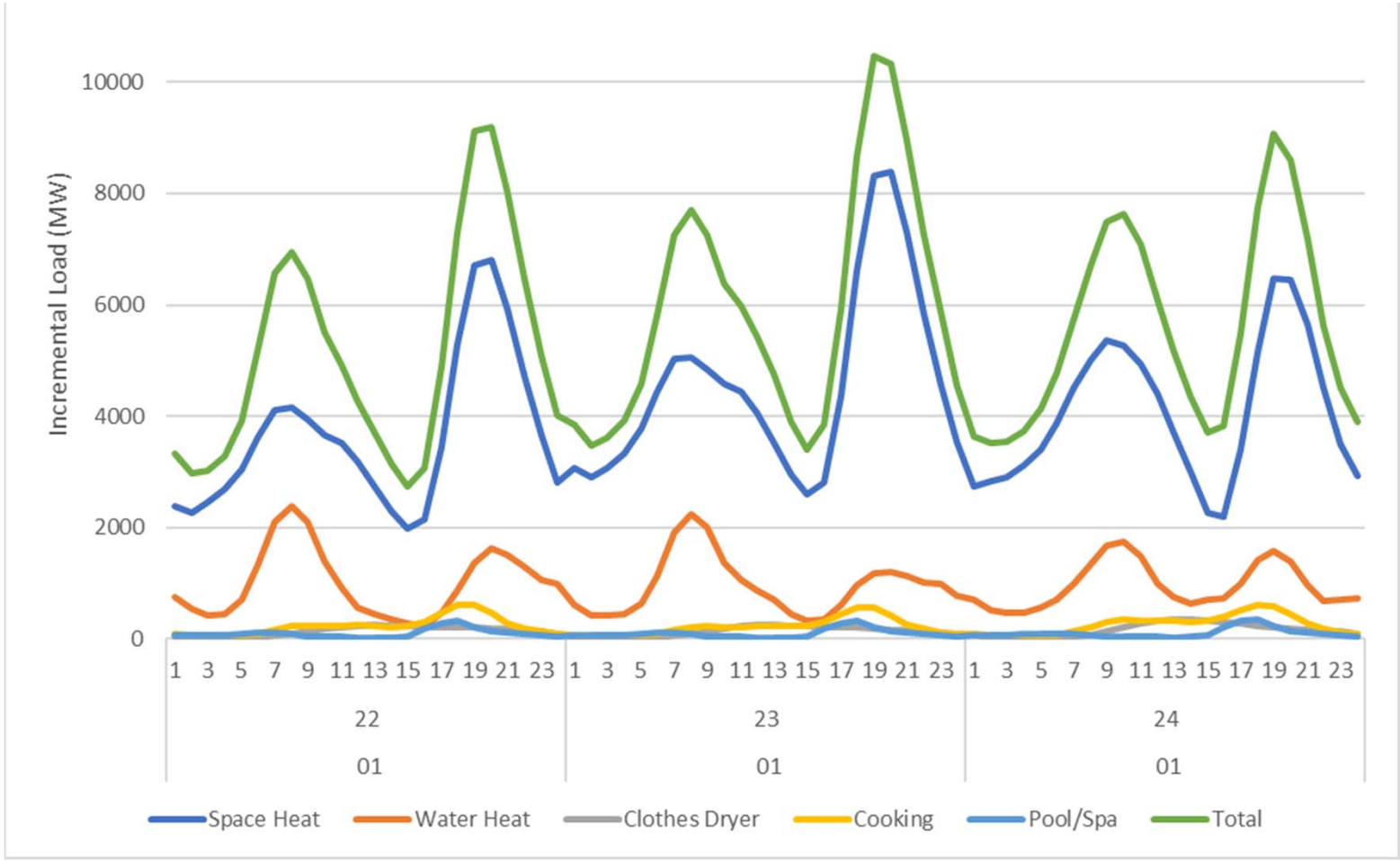
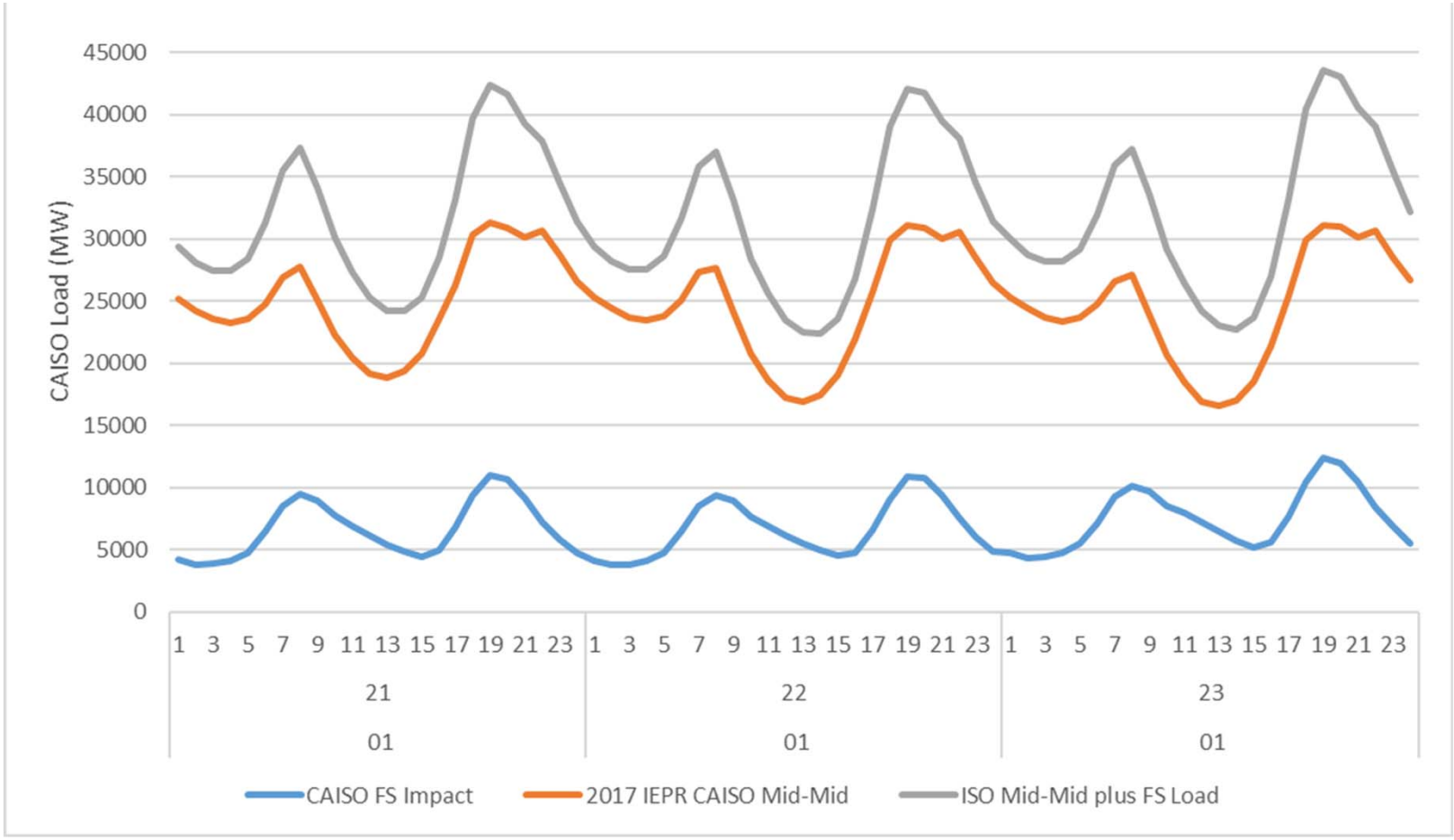
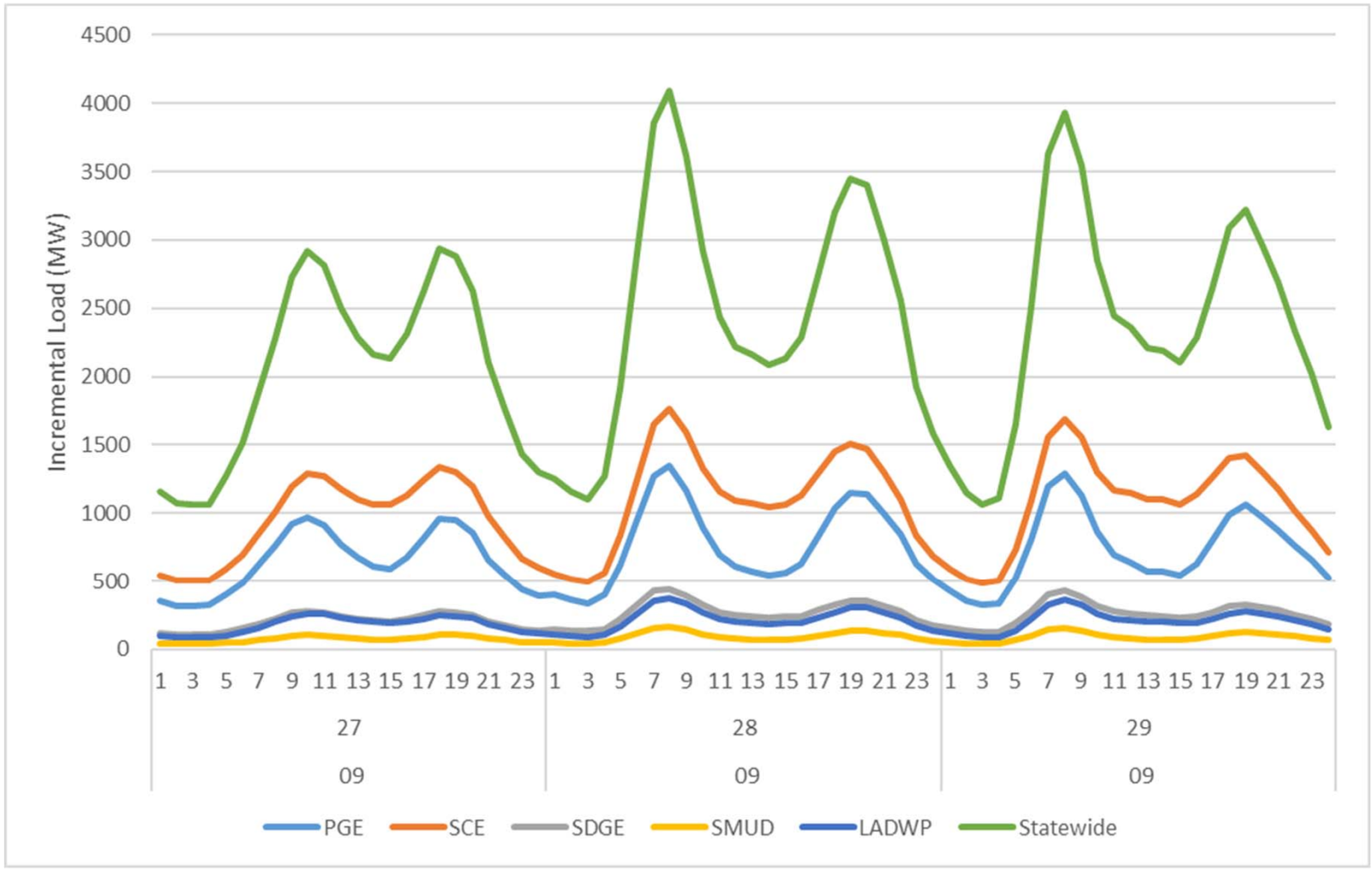
Comm
Res
Total


Incremental Load (MW)
10000
8000
6000
4000
2000
0
1 3 5 7 9 11 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17 19 21 23
22
01
23
01
24
01
Space Heat
Water Heat
Clothes Dryer
Cooking
Pool/Spa
Total


CAISO Load (MW)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1 3 5 7 9 11 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17 19 21 23
21
01
22
01
23
01
CAISO FS Impact
2017 IEPR CAISO Mid-Mid
ISO Mid-Mid plus FS Load


4500
4000
3500
3000
2500
2000
1500
1000
500
0
Incremental Load (MW)
1 3 5 7 9 11 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17 19 21 23
27
09
28
09
29
09
PGE
SCE
SDGE
SMUD
LADWP
Statewide

Lessons Learned

- Developed a sense of relative importance of sectors and end-uses on annual energy and hourly loads
- Winter incremental hourly load results highly sensitive to residential space heat hourly profiles, but each profile source used a weather selection method appropriate to its original purpose
- Summer incremental load increases are not trivial and commercial building profiles are more important in the summer period; but increased residential A/C load from new heat pump capability has not been addressed
- Details of what specific natural gas technologies are displaced and electric technologies are added are important, but highly speculative at this time

Limitations on Study Results

- GHG emission consequences, and the impacts from mitigating non-combustion GHG sources, have not been addressed
- C/E analysis of specific technologies is beyond the scope of this study
- Hourly space heat load profiles are not customized to expected heat pump performance
- This is not an AB 3232 study

Continuing Activity

- Staff (EAD/SAO) will report electric system impact of the incremental loads from the Pseudo-AB3232 scenario at the 12/4/2019 workshop
- Technical support from Navigant Consulting:
  - improve impact projection capabilities
  - Begin developing performance and cost estimates
  - Identify barriers
- Parametric space heat load profile work using CBECC-Res to generate new space heat load profiles with multiple heat pump technologies

Conclusion

- Staff believes these scenario projections are too uncertain to include in official CEC managed demand forecasts, but important enough to be published to enable comment, discussion, and induce additional analytic work among stakeholders

Questions?

Appendix

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%

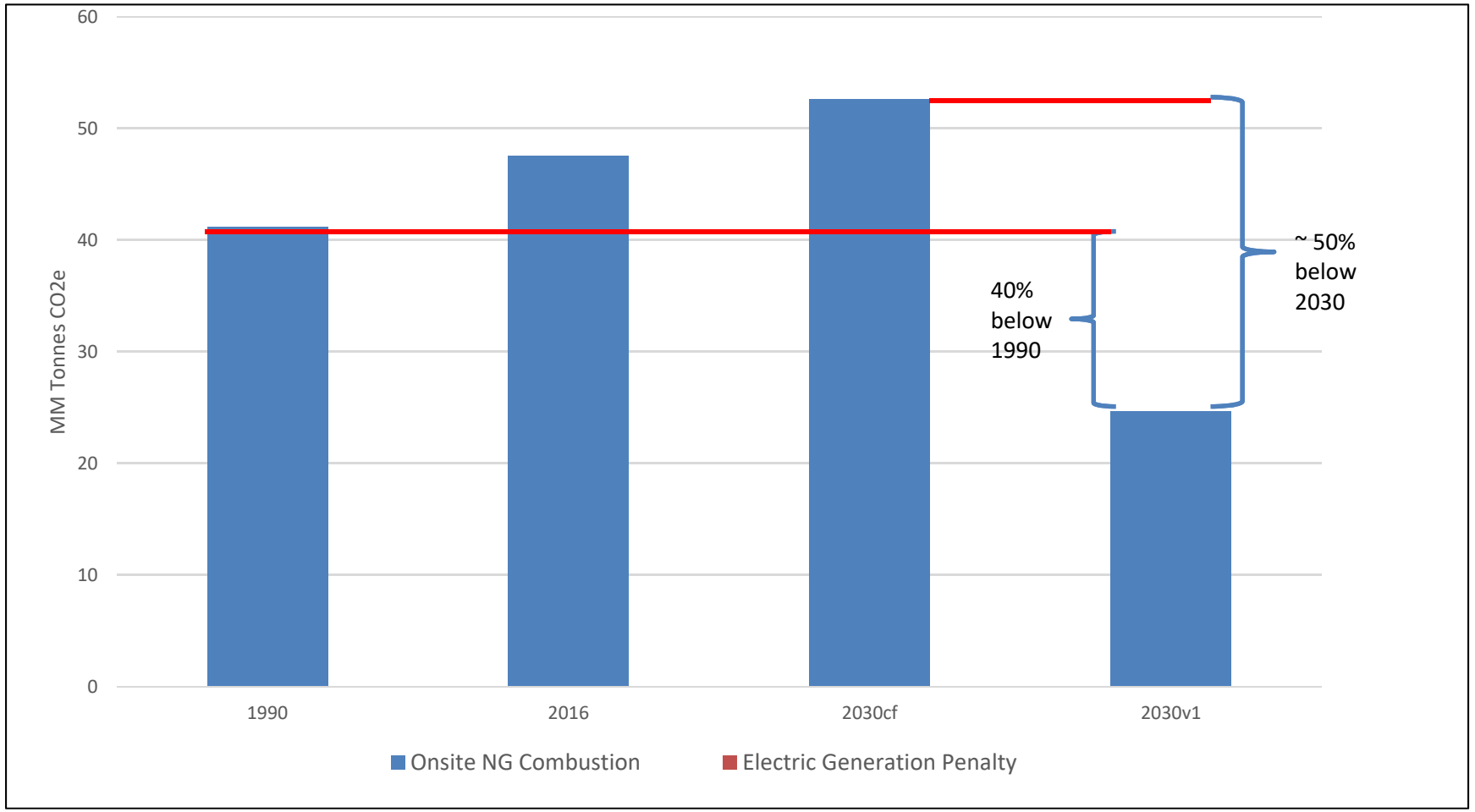
LADWP NG Forecast

		LADWP 2017 IEPR Gas Forecast (MM Therms)					
Sector	**End-Use**	**1990**	**2017**	**2020**	**2025**	**2030**	**2030%**
Res	central AC	9.60	0.00	0.00	0.00	0.00	0.0%
Res	central space heating	358.18	359.83	356.89	357.53	359.25	35.4%
Res	clothes drying	24.46	27.54	28.25	30.13	33.51	3.3%
Res	cooking	65.19	57.25	57.26	58.50	59.54	5.9%
Res	hot tub fuel	9.92	6.49	6.43	6.38	6.31	0.6%
Res	hot water clothes washing	63.07	77.04	77.94	81.57	84.91	8.4%
Res	hot water dishwashing	31.84	43.65	45.49	49.39	53.12	5.2%
Res	pool heating	26.86	12.88	12.39	12.28	12.15	1.2%
Res	water heating	169.74	181.44	182.69	188.75	197.19	19.4%
Comm	Heating	60.44	56.77	57.02	56.11	54.04	5.3%
Comm	Cooling	11.40	12.54	13.12	13.88	14.45	1.4%
Comm	Water Heating	17.28	21.48	22.86	25.08	27.16	2.7%
Comm	Cooking	14.78	16.85	17.86	19.22	20.30	2.0%
Comm	Refrigeration	0.70	0.76	0.80	0.86	0.90	0.1%
Comm	Miscellaneous	68.45	77.17	81.03	86.52	91.12	9.0%
R/C	Total	931.89	951.68	960.01	986.20	1013.95	100.0%

SMUD NG Forecast

		SMUD 2017 IEPR Gas Forecast (MM Therms)					
Sector	**End-Use**	**1990**	**2017**	**2020**	**2025**	**2030**	**2030%**
Res	central AC	3.15	0.03	0.04	0.06	0.08	0.0%
Res	central space heating	137.94	137.65	141.00	148.15	155.92	36.2%
Res	clothes drying	1.18	6.57	6.79	7.33	7.85	1.8%
Res	cooking	7.53	13.60	13.74	13.99	14.38	3.3%
Res	hot tub fuel	3.20	3.49	3.63	3.99	4.31	1.0%
Res	hot water clothes washing	20.49	29.87	30.70	32.43	34.02	7.9%
Res	hot water dishwashing	13.50	20.25	21.13	22.94	24.66	5.7%
Res	pool heating	6.80	6.38	6.50	6.77	7.04	1.6%
Res	water heating	44.29	61.02	62.66	66.14	69.33	16.1%
Comm	Heating	53.22	57.86	58.00	57.59	57.04	13.3%
Comm	Cooling	1.23	1.09	1.07	1.04	0.99	0.2%
Comm	Water Heating	10.42	13.97	14.62	15.68	16.67	3.9%
Comm	Cooking	6.82	7.14	7.37	7.75	8.08	1.9%
Comm	Refrigeration	0.54	0.71	0.75	0.80	0.85	0.2%
Comm	Miscellaneous	19.63	26.01	26.81	27.95	28.93	6.7%
R/C	Total	329.97	385.65	394.81	412.61	430.13	100.0%

AB3232 – Load Growth



AB3232 – Net or Gross?