Knowledge to Shape Your Future

Leveraging NEMS to Produce State-Level Commercial End-Use Forecasts

Frank A. Monforte, Ph.D.
Paige Schaefer

Itron
Knowledge to Shape Your Future

Background

Late 1980's early 1990's electric utilities were heavy into end-use forecasting to support Demand Side Planning.

EPRI developed REEPS, COMMEND and INFORM to support end-use forecasting.

Market research funding was available to populate the model databases with utility specific survey data.

With market restructuring end-use forecasting fell out of favor.

Onsite survey worked dried up and the knowledge base of end-use modeling dwindled at the utilities.

The California experience, however, has led to a resurgence in Demand Side Planning.

Utilities are once again looking at end-use forecasting, but with limited market research dollars.

End-use Forecasting on a tight budget

Working closely with the EIA we have developed a Statistically Adjusted End-Use Approach.

This approach leverages the end-use data supplied by the EIA to produce end-use energy forecasts at the state or utility level.

SAE Approach

Break the Average Use Into End-Use Components

- » $Use_{y,m} = Heat_{y,m} + Cool_{y,m} + Other_{y,m}$

Define Each Component in Terms of its End-Use Structure (e.g.)

- » Cool = f(Saturation, Efficiency, Utilization)

Construct Annual End-use Indexes

Multiply by Monthly Variables (HDD, CDD, BD)

Estimate Model Using Least Squares

End-Use Variable Definitions

$$XCool_{y,m} = CoolIndex_{y} \times CoolUse_{y,m}$$

Index variables provide a measure of equipment stock in place

$$CoolIndex_{y} = Cool_{base} \times \frac{\left(CoolShare_{y} / Eff_{y} \right)}{\left(CoolShare_{base} / Eff_{base} \right)}$$

End-Use Variable Definitions

$$XCool_{y,m} = CoolIndex_{y} \times CoolUse_{y,m}$$

Use variables measure equipment utilization

$$CoolUse_{y,m} = \left(\frac{CDD_{y,m}}{NormCDD} \right) \times \left(\frac{Output_{y}}{Output_{base}} \right)^{.25} \times \left(\frac{Price_{y,m}}{Price_{base}} \right)^{-.18}$$

End-Use Variable Definitions

$$XHeat_{y,m} = HeatIndex_{y} \times HeatUse_{y,m}$$

$$HeatIndex_{y} = Heat_{base} \times \frac{\left(HeatShare_{y} / Eff_{y} \right)}{\left(HeatShare_{base} / Eff_{base} \right)}$$

End-Use Variable Definitions

$$XHeat_{y,m} = HeatIndex_{y} \times HeatUse_{y,m}$$

$$HeatIndex_{y} = Heat_{base} \times \frac{\left(HeatShare_{y} / Eff_{y} \right)}{\left(HeatShare_{base} / Eff_{base} \right)}$$

$$HeatUse_{y,m} = \left(\frac{HDD_{y,m}}{NormHDD} \right) \times \left(\frac{Output_{y}}{Output_{base}} \right)^{.25} \times \left(\frac{Price_{y,m}}{Price_{base}} \right)^{-.18}$$

End-Use Variable Definitions

$$XOther_{y,m} = OtherIndex_{y} \times OtherUse_{y,m}$$

$$OtherIndex_{y} = \sum_{type} EU_{base}^{type} \times \frac{\left(EUShare_{y}^{type} \Big/ Eff_{y}^{type} \right)}{\left(EUShare_{base}^{type} \Big/ Eff_{base}^{type} \right)}$$

End-Use Variable Definitions

$$XOther_{y,m} = OtherIndex_{y} \times OtherUse_{y,m}$$

$$OtherIndex_{y} = \sum_{type} EU_{base}^{type} \times \frac{\left(EUShare_{y}^{type} \middle/ Eff_{y}^{type} \right)}{\left(EUShare_{base}^{type} \middle/ Eff_{base}^{type} \right)}$$

$$OtherUse_{y,m} = \left(\frac{BillDays_{y,m}}{30.5} \right) \times \left(\frac{Output_{y}}{Output_{base}} \right)^{.25} \times \left(\frac{Price_{y,m}}{Price_{base}} \right)^{-.18}$$

SAE Equation

$$Use_{y,m} = b_1 XHeat_{y,m} + b_2 XCool_{y,m} + b_3 XOther_{y,m}$$

$$+ b_k OtherStuff_{y,m} + e_{y,m}$$

NEMS Efficiency Data

Table 32. Commercial Sector Equipment Stock Efficiency
Stock Avg. Equip. Efficiency ..(Btu Out/Btu In, unless noted)

	Heat	Cool	Vent	DHW	Cooking	Refrig	O. Light	I.Light
1997	1.07	2.68	0.39	0.98	0.70	1.30	47.45	47.45
1998	1.08	2.71	0.39	0.98	0.70	1.30	47.99	47.99
1999	1.09	2.74	0.40	0.98	0.70	1.31	48.40	48.40
2000	1.09	2.76	0.40	0.98	0.71	1.31	48.90	48.90
2001	1.10	2.79	0.40	0.98	0.71	1.32	49.57	49.57
2002	1.10	2.82	0.41	0.99	0.72	1.32	50.05	50.05
2003	1.11	2.85	0.41	0.99	0.72	1.32	50.40	50.40
2004	1.11	2.87	0.41	0.99	0.73	1.33	50.69	50.69
2005	1.11	2.90	0.41	0.99	0.73	1.33	51.03	51.03
2006	1.12	2.92	0.42	0.99	0.73	1.33	51.40	51.40
2007	1.12	2.95	0.42	0.99	0.73	1.33	51.73	51.73
2008	1.12	2.97	0.42	0.99	0.74	1.34	52.04	52.04
2009	1.12	3.00	0.43	0.99	0.74	1.34	52.31	52.31
2010	1.12	3.02	0.43	0.99	0.74	1.34	52.57	52.57
2011	1.12	3.04	0.43	1.00	0.74	1.34	52.82	52.82
2012	1.12	3.06	0.43	1.00	0.74	1.34	53.07	53.07
2013	1.12	3.08	0.44	1.00	0.74	1.34	53.30	53.30
2014	1.12	3.10	0.44	1.00	0.74	1.34	53.54	53.54
2015	1.12	3.12	0.44	1.00	0.75	1.34	53.94	53.94
2016	1.12	3.13	0.45	1.00	0.75	1.34	54.33	54.33
2017	1.12	3.15	0.45	1.00	0.75	1.34	54.74	54.74
2018	1.12	3.16	0.45	1.00	0.75	1.34	55.18	55.18
2019	1.12	3.18	0.46	1.00	0.75	1.34	55.60	55.60
2020	1.12	3.20	0.46	1.00	0.75	1.34	55.99	55.99

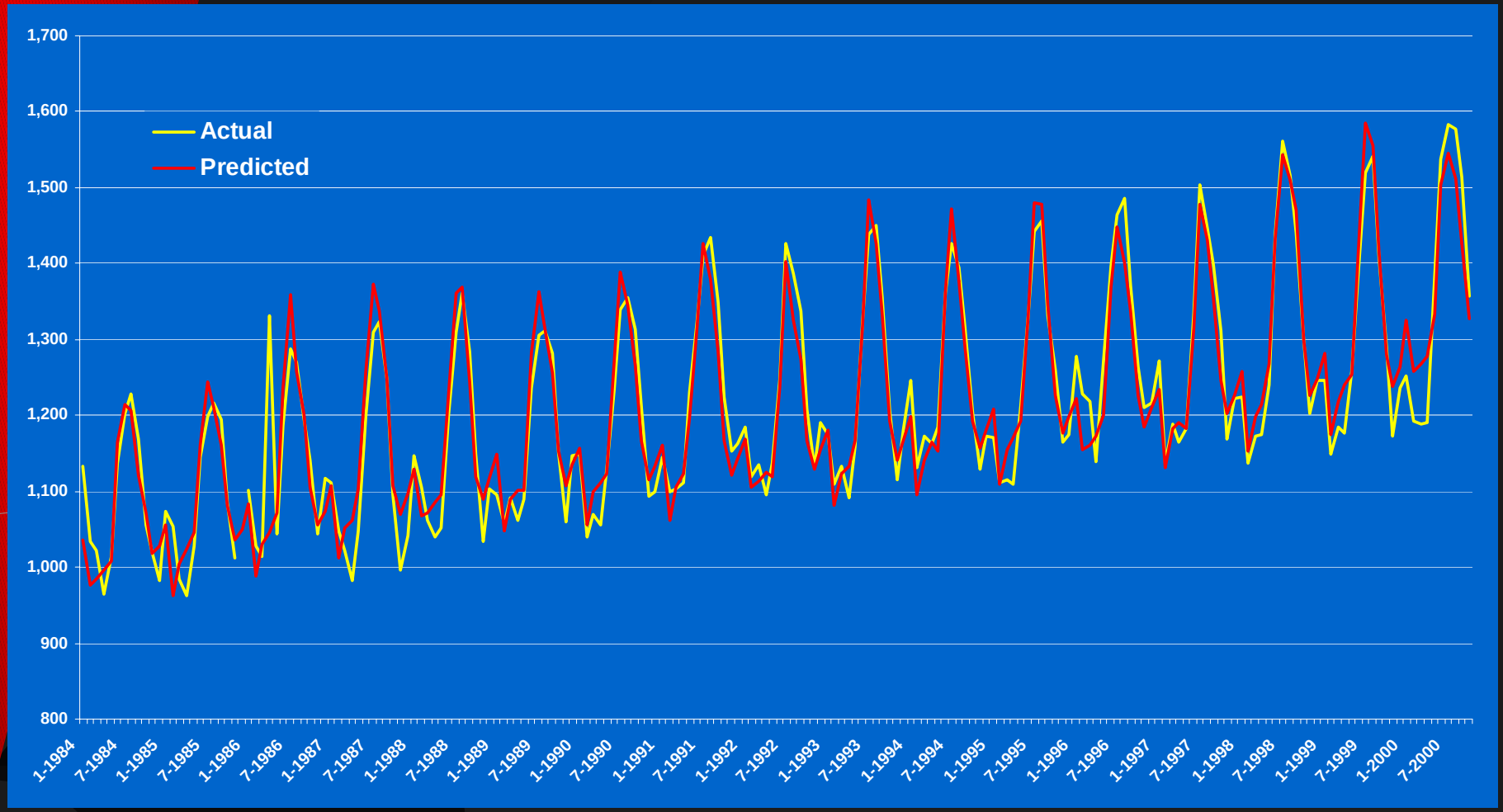
Sample Share Data (East South Central)

	Heat	Cool	Vent	DHW	Cooking	Refrig	O. Light	I.Light	Office	Misc
1980	31.5%	80.0%	100.0%	38.0%	7.1%	48.0%	76.0%	100.0%	100.0%	100.0%
1981	31.5%	80.0%	100.0%	38.1%	7.2%	48.2%	75.9%	100.0%	108.0%	101.0%
1982	31.6%	80.1%	100.0%	38.2%	7.3%	48.2%	75.8%	100.0%	116.0%	102.0%
1983	31.7%	80.2%	100.0%	38.3%	7.7%	48.2%	75.7%	100.0%	124.0%	103.0%
1984	31.8%	80.3%	100.0%	38.7%	8.3%	48.3%	75.6%	100.0%	132.0%	104.0%
1985	32.2%	80.7%	100.0%	39.3%	9.7%	48.3%	75.5%	100.0%	140.0%	105.0%
1986	32.5%	81.0%	100.0%	40.0%	11.0%	48.2%	75.5%	100.0%	148.0%	106.0%
1987	32.8%	81.3%	100.0%	40.7%	12.3%	48.2%	75.4%	100.0%	156.0%	107.0%
1988	33.2%	81.7%	100.0%	41.3%	13.7%	48.2%	75.3%	100.0%	164.0%	108.0%
1989	33.5%	82.0%	100.0%	42.0%	15.0%	48.2%	75.3%	99.9%	172.0%	109.0%
1990	33.8%	82.7%	100.0%	42.7%	15.2%	48.1%	75.2%	99.7%	180.0%	110.0%
1991	34.2%	83.3%	100.0%	43.3%	15.3%	48.1%	75.2%	99.6%	185.0%	111.0%
1992	34.5%	84.0%	100.0%	44.0%	15.5%	48.1%	75.2%	99.4%	190.0%	112.0%
1993	34.8%	84.7%	100.0%	44.7%	15.7%	48.1%	75.1%	99.2%	195.0%	113.0%
1994	35.2%	85.3%	100.0%	45.3%	15.8%	48.1%	75.1%	99.0%	200.0%	114.0%
1995	35.5%	86.0%	100.0%	46.0%	16.0%	48.1%	75.1%	98.5%	205.0%	115.0%
1996	35.8%	86.3%	100.0%	46.7%	16.2%	48.1%	75.0%	97.7%	206.5%	115.5%
1997	36.2%	86.7%	100.0%	47.3%	16.3%	48.1%	75.0%	96.8%	208.0%	116.0%
1998	36.5%	87.0%	100.0%	48.0%	16.5%	48.1%	75.0%	96.0%	209.5%	116.5%
1999	37.3%	87.7%	100.0%	48.9%	16.8%	48.1%	74.9%	95.3%	211.0%	117.0%
2000	37.9%	88.2%	100.0%	49.6%	17.0%	48.1%	74.9%	94.6%	212.5%	117.5%
2001	38.4%	88.6%	100.0%	50.1%	17.2%	48.1%	74.9%	94.0%	214.0%	118.0%
2002	38.7%	88.9%	100.0%	50.5%	17.3%	48.1%	74.8%	93.5%	215.5%	118.5%
2003	38.9%	89.1%	100.0%	50.7%	17.4%	48.1%	74.8%	93.0%	217.0%	119.0%
2004	39.1%	89.3%	100.0%	51.0%	17.5%	48.1%	74.8%	92.4%	218.5%	119.5%
2005	39.3%	89.4%	100.0%	51.1%	17.5%	48.1%	74.7%	91.9%	220.0%	120.0%
2006	39.4%	89.5%	100.0%	51.2%	17.6%	48.1%	74.7%	91.4%	221.5%	120.5%
2007	39.5%	89.6%	100.0%	51.3%	17.6%	48.1%	74.7%	91.3%	223.0%	121.0%
2008	39.5%	89.6%	100.0%	51.4%	17.6%	48.1%	74.7%	91.4%	224.5%	121.5%
2009	39.6%	89.7%	100.0%	51.4%	17.6%	48.1%	74.6%	91.6%	226.0%	122.0%
2010	39.6%	89.7%	100.0%	51.5%	17.7%	48.1%	74.6%	91.7%	227.5%	122.5%
2011	39.6%	89.7%	100.0%	51.5%	17.7%	48.1%	74.6%	91.7%	229.0%	123.0%
2012	39.6%	89.8%	100.0%	51.5%	17.7%	48.1%	74.6%	91.6%	230.6%	123.5%
2013	39.7%	89.8%	100.0%	51.6%	17.7%	48.1%	74.5%	91.6%	232.1%	124.0%
2014	39.7%	89.8%	100.0%	51.6%	17.7%	48.1%	74.5%	91.5%	233.7%	124.5%
2015	39.7%	89.8%	100.0%	51.6%	17.7%	48.1%	74.5%	91.5%	235.3%	125.1%
2016	39.7%	89.8%	100.0%	51.6%	17.7%	48.1%	74.4%	91.4%	236.8%	125.6%
2017	39.7%	89.8%	100.0%	51.6%	17.7%	48.1%	74.4%	91.4%	238.4%	126.1%
2018	39.7%	89.8%	100.0%	51.6%	17.7%	48.1%	74.4%	91.3%	240.0%	126.6%
2019	39.7%	89.8%	100.0%	51.6%	17.7%	48.1%	74.4%	91.3%	241.7%	127.1%
2020	39.7%	89.8%	100.0%	51.6%	17.7%	48.1%	74.3%	91.3%	243.3%	127.7%

1998 End-Use Sales per Employee (kWh)

	ENC	ESC	MATL	MNT	NENG	PAC	SATL	WNC	WSC
Heat	483	1,030	459	846	247	669	845	821	427
Cool	2,130	3,752	1,781	2,726	1,266	1,758	4,017	2,418	4,785
Vent	1,078	1,104	1,013	1,133	1,033	932	1,121	978	1,112
DHW	270	473	333	372	389	283	487	281	331
Cooking	470	559	378	386	405	407	530	343	481
Refrig	1,466	1,549	1,335	1,355	1,399	1,105	1,524	1,346	1,584
O. Light	444	445	411	465	402	387	458	407	458
I.Light	4,160	4,201	3,821	4,453	3,798	3,606	4,285	3,806	4,327
Office	434	415	411	464	408	398	440	386	427
Misc	698	712	666	724	641	606	726	633	722
Total	11,633	14,238	10,607	12,924	9,987	10,151	14,435	11,419	14,655

Use Per Employee – Monthly



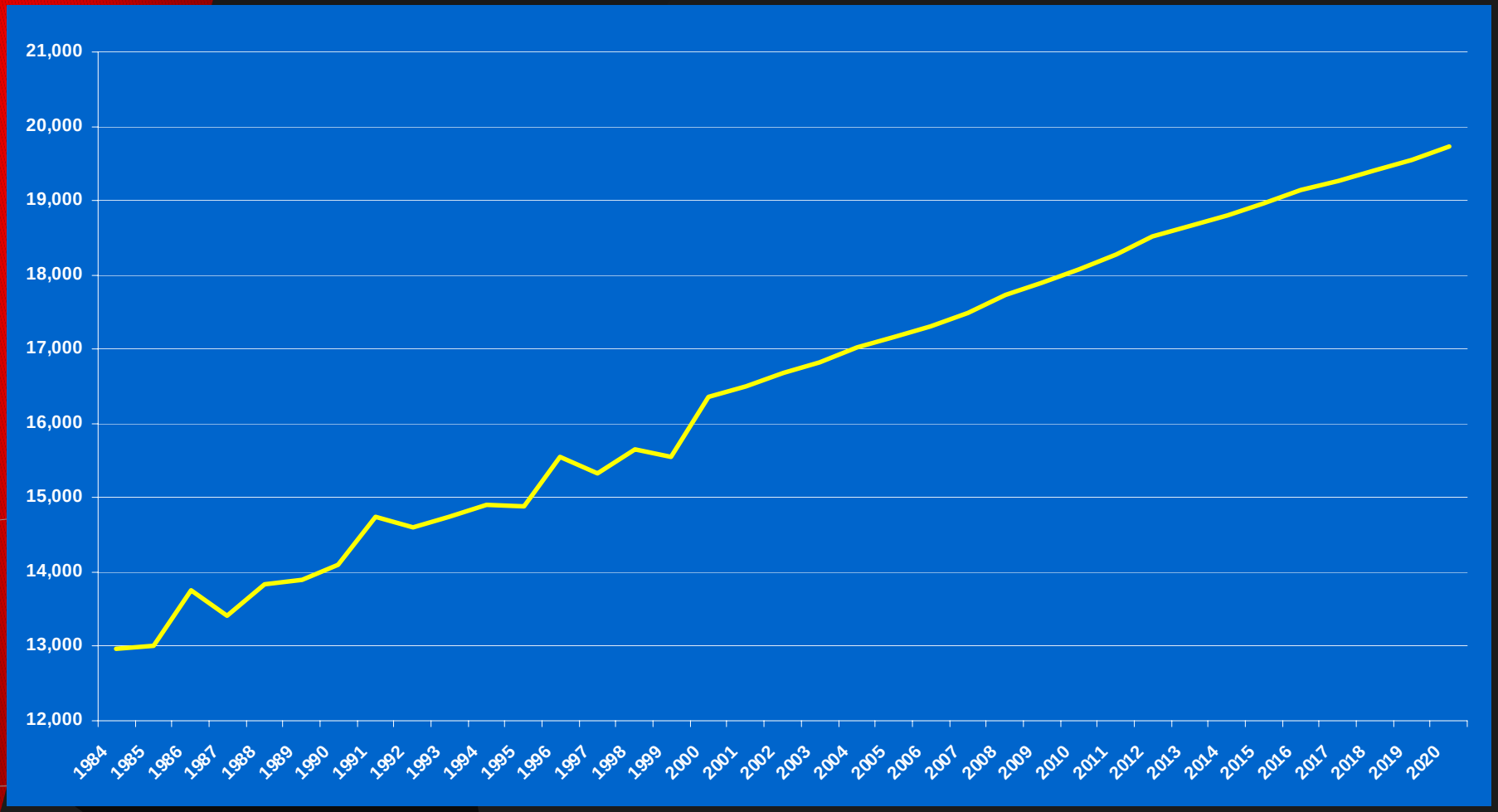
Itron

Knowledge to Shape Your Future

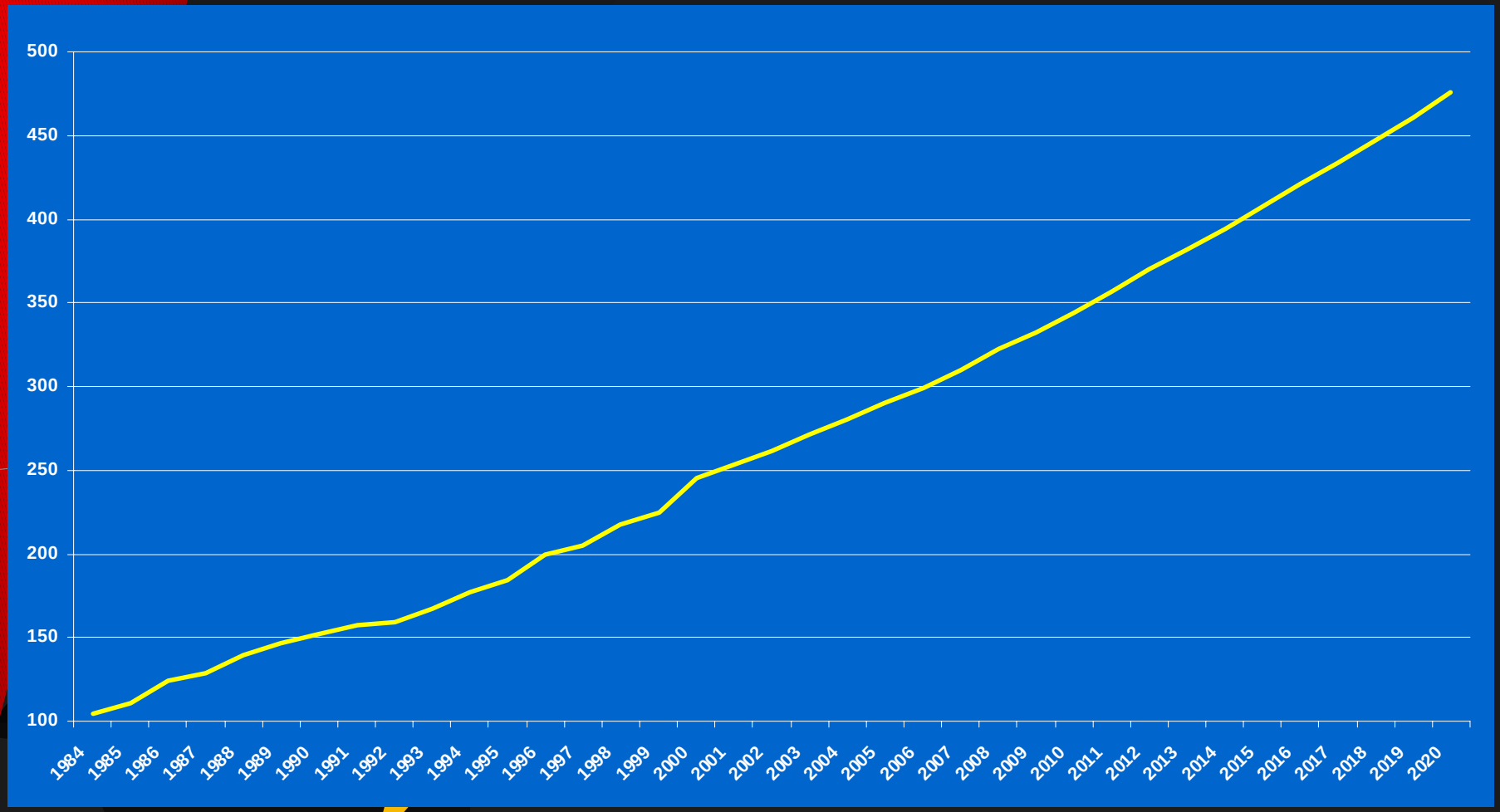
Electric / Gas / Water

Information collection, analysis and application

Use Per Employee - Annual



Commercial Sales Forecast (TWh)



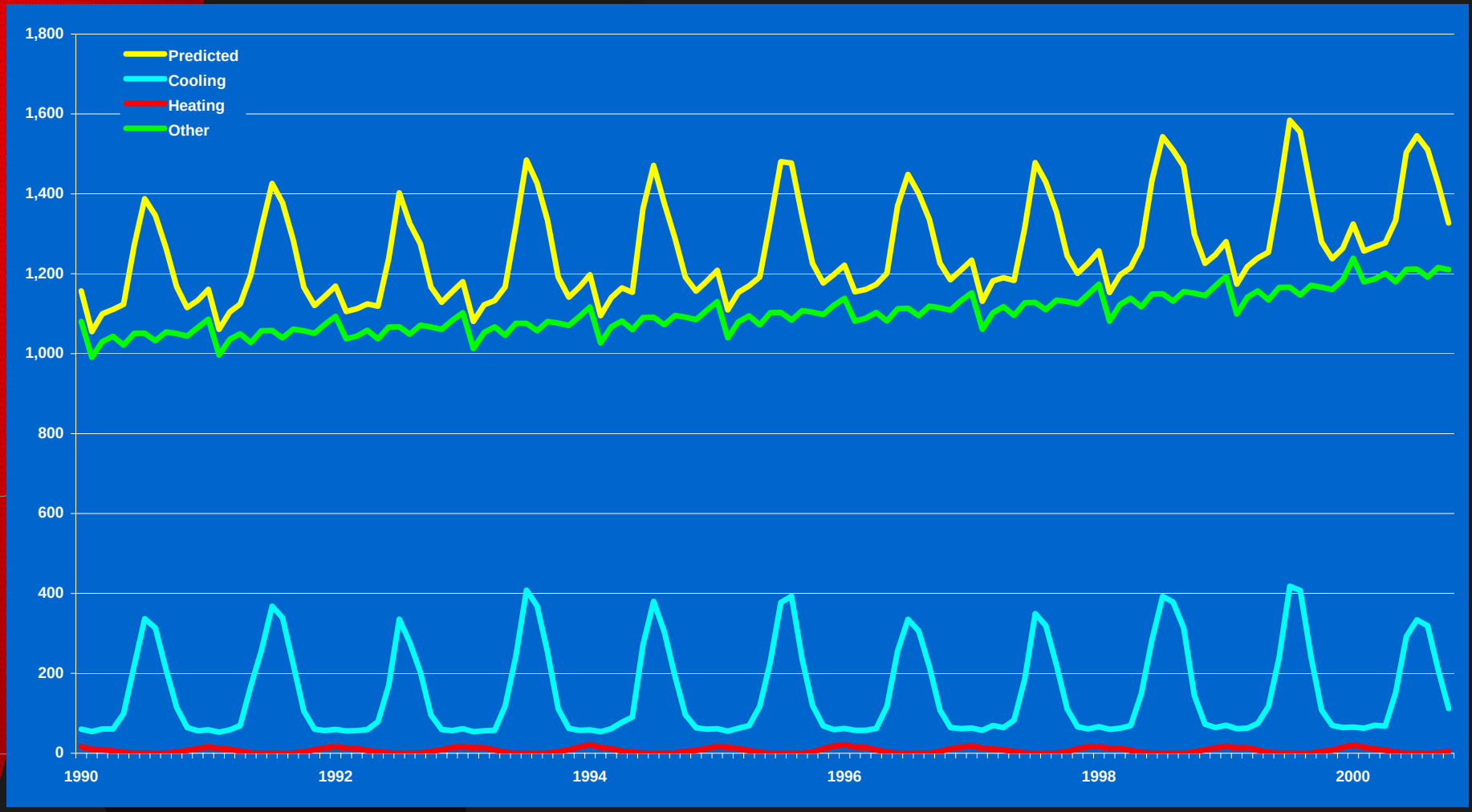
Itron

Knowledge to Shape Your Future

Electric / Gas / Water

Information collection, analysis and application

Decomposition of Predicted Value



Itron

Knowledge to Shape Your Future

Electric / Gas / Water

Information collection, analysis and application

Conclusions

The SAE modeling approach provides a reasonable balance between incorporating end-use structure for long-term forecasting and accuracy for short-term forecasting.

By leveraging the EIA produced end-use data, utilities have an inexpensive alternative to survey-based end-use forecasting.

End-use forecasts are still in the background, and they can be used to decompose the monthly and annual forecasts into end-use components.

Scenario analysis can be incorporated into this approach by running forecasts with alternative assumptions about appliance saturation levels and efficiency levels.