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Form 4. Demand Forecast Methods and Models

Demand Forecast Methodology

For most years the City of Anaheim, Public Utilities Department (City of Anaheim) has used linear regression modeling to forecast averages to forecast peak load, total system energy consumption, and total energy consumption by customer class. However, in 2011 and 2013, the unpredictability of the economy and lack of staff drove the City to utilize annual averages to conduct these forecasts. The reliability of the annual average forecasts came within 2.5% of actual load. In early 2014, the City of Anaheim expanded their Resource Planning Group, invested in advanced econometric and statistical software, and implemented a new production cost model. This enabled the City to return to econometrical modeling to forecast peak load and total system energy consumption for the 2015 IEPR. Using hourly observations, two econometric models are developed to create a 20-year monthly forecast for peak load and total system energy, adjusted manually for peak planned additions and reductions for future years. Total energy consumption by customer class is estimated using average percentages of system load for each class. The City of Anaheim uses STATA (SE 13) as its econometric software. The Appendix to this section includes statistical results to the equations detailed below.

Demand Forecast Methodology- Energy Efficiency and Demand-Side Measures

At this time, the City of Anaheim does not separately identify the impacts of energy efficiency (EE) and other demand-side measures; rather, they are embedded in the data used to determine the base load energy forecast. EE and other demand-side measures are absorbed in the actual numbers we use as constants for our forecast of peak demand, total system energy, and customer class consumption. For example, total savings for fiscal year ending June 2007 realized a total of 3.153 MW peak demand reduction as a result of energy efficiency and demand response programs. A total energy savings of 8,241 MWh (or 8.2 GWh) were realized as a result of energy efficiency and demand-side measures. Our peak for this period was 593 MW in July 2006. Our total energy as measured at Lewis substation was 2,687 GWh. If these programs were not in place, the resulting load for fiscal year 2007 would have been 2,695.2 with a peak load of 596 MW. In using the actual numbers as the constant, Anaheim creates the forecast using other variables that impact the constants (which are the monthly actual data for consumption).

The nominal amount of EE and other demand-side measures (which is currently around 1% of total energy consumption) is hard to forecast separately, as significant reductions have only occurred in the past few years. As the City of Anaheim moves forward with its energy efficiency and demand-side measures, a better method of calculating future

improvements will have to be created. At this time, more data is needed to forecast the reduction in consumption caused by EE and demand-side measures.

Anaheim uses historic energy usage by customer class in its forecast for future energy consumption. The historic energy usage reflects all energy efficiency programs that were implemented over the course of the last 10+ years (with the most significant reductions occurring in the past few years). The historic usage data includes the cumulative impacts of all Anaheim's conservation programs, energy efficiency products (LED lights, CFL light bulb installation), and energy efficiency programs. Anaheim's energy load growth is thereby impacted by the EE and demand-side programs the City provides, specifically conservation and energy efficiency programs. The past actual energy demand mega-watt hours are mitigated by a negative energy demand as a result of these programs.

I. System Forecast

a. Total Consumption

Total consumption is forecasted using four years of historical hourly data to estimate the following equation:

$$\text{Total Energy}_t = \alpha + \varsigma\ \text{Load}_t + \beta_1\ \text{Temperature}_t + D_1\ \text{Holiday}_t + V_t + \varepsilon_t$$

Where:

ς Load = the first difference of load from t-1 and t
Temperature = Temperature at hour t
Holiday = Dummy variable to identify weekend and holidays
V_t = Vector of dummy variables for hours 2-24
ε_t = Error term

Following the econometric estimation, hourly forecasted load is summed up to create monthly and annual total system load forecast. The forecast is then adjusted manually for additions and reductions for future years.

Weather Assumptions

The City of Anaheim collects hourly temperature observations from equipment owned and maintained by the City at its Linda-Vista Reservoir. This data is included within its SCADA system and is the sole set used to calculate maximum monthly temperatures, cooling degree-days and heating degree-days.

High temperature cases were not developed using an econometric analysis, but instead the City of Anaheim prefers to assume normal weather in future forecasting, using the past five-year average hourly temperatures.

Load Additions and Reductions

The econometric model in I(a) is adjusted for planned energy growth for industrial, commercial and residential projects which are expected to increase energy demand. Examples of such projects are a new apartment complex, hospital, or Disney expansion. In addition, the model is adjusted for expected reductions in system load, particularly due to residential and commercial solar and energy efficiency programs. A list of projects that contribute to system load growth and reduction is located in the Appendix.

Econometric Model Testing

Using the above econometric model, Anaheim performed test forecasts for 2013, and months 1-9 of 2014. The model produced accurate estimation results of 0.6% and 1.76%, respectfully.

System Load	CY 13 Actual Total System Load (MWh)	CY 13 Total System Load (MWh) Forecast	% Error
System Load (MWh)	2,465,603	2,451,221	0.58%
System Load	**Month 1-9 CY 14 Actual Total System Load (MWh)**	**Month 1-9 CY 14 Total System Load (MWh) Forecast**	**% Error**
System Load (MWh)	2,137,083	2,099,429	1.76%

b. Peak Demand

Monthly peak demand is forecasted using 14 years of historical monthly data to estimate the following equation:

$$\text{Peak Demand}_t = \alpha + \beta_1 \text{ System Load}_t + V_t + \varepsilon_t$$

Where:
System Load = Total System Load for month t
V_t = Vector of dummy variables to identify each month
ε_t = Error term

The Peak Demand forecasted by the above equation was compared to the Peak Demand forecasted from the System Load model. As the results were similar, the second equation provided a closer estimate when estimated to fit previous years' actuals. Following the econometric estimation, the forecast is adjusted manually for peak additions and reductions for future years.

Peak Additions and Reductions

The econometric model in I(b) is adjusted for planned peak growth for industrial, commercial and residential projects which are expected to increase energy demand. Examples of such projects are a new apartment complex, hospital, or Disney expansion. In addition, the model is adjusted for expected reductions in peak demand, particularly due to residential and commercial solar, and energy efficiency programs. A list of projects that contribute to peak growth and reduction is located in the Appendix.

Econometric Model Testing

Using the above econometric model, Anaheim performed test forecasts for 2013, and 2014. The models produced accurate predictions, however model I(b) was the superior model for peak estimation.

Model I(b)	CY 14 Actual Peak Load (MW)	CY 14 Peak Load (MW) Forecast I(b)	% Error
	578	570	1.38%
Model I(a)	**CY 14 Actual Peak Load (MWh)**	**CY 14 Peak Load (MWh) Forecast I(a)**	**% Error**
	578	561	2.94%

II. Customer Class Forecast

In June 2014, Anaheim switched to a new CIS System which will provide a larger data pool for future forecasting than ever previously available. As a full annual data set is not currently available, Anaheim has designed its Customer Class forecast using average proportions. Historically, distribution losses within Anaheim's system amount to 3.5% of total system energy consumption. In addition, Anaheim has observed a steady split between classes over the past four years of 45% Industrial, 31% Commercial, 24% Residential and 1% Street Lighting and Other. Using this methodology, the Total Consumption forecast described in I(a) above is adjusted with the corresponding percentage share.

Energy and Peak Loss Estimates

The City of Anaheim does not estimate losses by customer class. As discussed earlier, the City of Anaheim has used the difference between the system forecast and the sum of the customer class forecasts to produces an annual distribution loss estimate. This approach has worked with a varying degree of success, and is prone to changing loss percentages over the length of the forecast as the two sets of energy estimates diverge or converge. Historically, Anaheim's distribution loss percentage averages 3.5%. In this forecast, we have adjusted the monthly system energy forecast so that its annual sum is

approximately 3.5% greater than the annual sum of all customer classes. By targeting our loss percentage to our historical 3.5%, we have allowed our two sets of energy forecasts to be compatible with one another and maintained the monthly and seasonal variations of the respective forecast results.

Anaheim's transmission losses, assumed to be 3% of the energy produced by our generation resources, have been added to the peak forecast presented in this data request. All transmission losses occur outside of Anaheim's distribution system.

III. Historical Forecast

Historically, the Anaheim System and Retail demand forecasts over the last eight years have been within 2.25% accuracy (on average). The data is listed in GWh and percentage, below.

FY	Forecast System (GWh)	Actual System (GWh)	Difference	Forecast Retail (GWh)	Actual Retail (GWh)	Difference	Type of Forecast
2014	2446.30	2465.45	.66%	2374.69	2376.30	.07%	Historical Data
2013	2483.59	2525.30	1.68%	2396.53	2416.82	.85%	Historical Data
2012	2507.62	2472.54	1.4%	2421.84	2379.31	1.76%	Historical Data
2011*	2626.84	2457.88	6.43%	2536.12	2370.60	7.91%	Historical Data
2010	2626.56	2529.35	3.8%	2533.632	2452.400	3.31%	Statistical Data
2009	2665.76	2597.812	2.62%	2571.634	2533.824	1.49 %	Statistical Data
2008	2700.910	2694.465	.2%	2606.743	2596.912	.38%	Statistical Data
Average			**1.79%**			**2.25%**	

**Note: 2011 was an anomaly. In 2011, Anaheim experienced lower than expected temperatures and lower loads in the commercial and industrial sector, as a result of customers leaving Anaheim. Overall, on average the temperature was 4.5 degrees lower than the previous year. Additionally, we had forecasted new Developments in Anaheim that were delayed and eventually never built, which impacted our forecasted numbers.*

Appendix 4.1

Table 4.1: Total Energy Consumption

```
Number of obs =   32547
F( 26, 32520) = 3442.78
Prob > F      =  0.0000
R-squared     =  0.7661
Root MSE      =   30.23
```

load	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
load						
D1.	.4293169	.0227968	18.83	0.000	.3846343	.4739995
temp	2.896482	.0258659	111.98	0.000	2.845784	2.94718
hol	-41.62394	.4073381	-102.19	0.000	-42.42234	-40.82554
hourday						
2	-11.7502	.8820481	-13.32	0.000	-13.47904	-10.02135
3	-18.23056	.9035634	-20.18	0.000	-20.00158	-16.45954
4	-19.1505	.959891	-19.95	0.000	-21.03192	-17.26908
5	-12.21326	1.102376	-11.08	0.000	-14.37396	-10.05256
6	2.77518	1.246511	2.23	0.026	.331973	5.218387
7	16.97978	1.306669	12.99	0.000	14.41866	19.5409
8	25.71889	1.27768	20.13	0.000	23.21459	28.22319
9	32.11451	1.267243	25.34	0.000	29.63066	34.59835
10	38.09977	1.240025	30.73	0.000	35.66928	40.53027
11	42.37009	1.215771	34.85	0.000	39.98713	44.75304
12	44.92128	1.218139	36.88	0.000	42.53368	47.30888
13	46.78687	1.259986	37.13	0.000	44.31725	49.25649
14	49.48251	1.306262	37.88	0.000	46.92219	52.04283
15	51.96797	1.335762	38.91	0.000	49.34982	54.58611
16	53.72811	1.324251	40.57	0.000	51.13253	56.32369
17	56.81429	1.308961	43.40	0.000	54.24868	59.3799
18	61.07345	1.231302	49.60	0.000	58.66005	63.48685
19	65.04595	1.124289	57.86	0.000	62.8423	67.2496
20	68.93295	1.033206	66.72	0.000	66.90783	70.95807
21	67.79503	.9313405	72.79	0.000	65.96957	69.62049
22	56.83847	.8814034	64.49	0.000	55.11089	58.56606
23	37.83468	.8765728	43.16	0.000	36.11656	39.55279
24	16.68136	.910167	18.33	0.000	14.8974	18.46532
_cons	70.71402	1.727371	40.94	0.000	67.32831	74.09973

Table 4.2: Peak Demand

Source	SS	df	MS
Model	760917.262	12	63409.7718
Residual	113271.672	154	735.53034
Total	874188.934	166	5266.1984

Number of obs	167
F(12, 154)	86.21
Prob > F	0.0000
R-squared	0.8704
Adj R-squared	0.8603
Root MSE	27.121

peak	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
systemloadloadatlewis	.0024072	.0002182	11.03	0.000	.0019762	.0028382
jan	-55.99144	10.35352	-5.41	0.000	-76.4447	-35.53819
feb	-15.66484	10.62482	-1.47	0.142	-36.65405	5.32436
mar	-37.60283	10.34079	-3.64	0.000	-58.03093	-17.17472
may	13.72508	10.76305	1.28	0.204	-7.537199	34.98736
jun	-7.261614	11.12978	-0.65	0.515	-29.24836	14.72513
jul	-12.74186	14.65796	-0.87	0.386	-41.69848	16.21477
aug	-8.401315	15.55729	-0.54	0.590	-39.13455	22.33192
sep	53.17345	12.98254	4.10	0.000	27.52659	78.82031
oct	12.39259	11.27014	1.10	0.273	-9.871432	34.65661
nov	-3.853789	10.25214	-0.38	0.708	-24.10677	16.3992
dec	-54.89142	10.51747	-5.22	0.000	-75.66855	-34.1143
_cons	-74.95691	44.01877	-1.70	0.091	-161.9155	12.00165

Table 4.3: **Load Additions and Reductions Projects**

System Load Additions Projects
Disney Expansion (Attractions and Hotels)
Disney Third Gate
ARA Entitlements (26 acres) (Specific Plan)
Hotels (Caltrans Property at ARA)
Sprint
Industrial Corridor
Telecommunications (LaPlama near Magnolia Ave)
Dow ntow n Development
Platinum Triangle
Kaiser Hospital
Anaheim Concourse
Anaheim Westgate Center
Water Pump Station (east Anaheim)
Norcal (coke cola plant, etc.)
System Load Reduction Projects
Disney TES
Extron TES
Solar (Residential)
Solar (convention center)

Table 4.4: **Peak Additions and Reductions Projects**

Peak Additions Projects
Disney Expansion (Attractions and Hotels)
Disney Third Gate
ARA Entitlements (26 acres) (Specific Plan)
Hotels (Caltrans Property at ARA)
Sprint
Industrial Corridor
Telecommunications (LaPlama near Magnolia Ave)
Dow ntow n Development
Platinum Triangle
Kaiser Hospital
Anaheim Concourse
Anaheim Westgate Center
Water Pump Station (east Anaheim)
Norcal (coke cola plant, etc.)
Peak Reduction Projects
Disney TES (2MW)
Marriott TES
Solar (Residential)
Solar (convention center)