State Econometric Models

Model Development

- We used a similar process to last year to find models with a good fit, with an appropriate mix of explanatory variables, and that passed the tests for serial correlation and heteroskedasticity.
- Added another year of history (2013)
- Switched to the population-weighted virtual weather station
- For some states, changes were made to the explanatory variables or sample periods
  - changes (if any) are shown for each state

Dependent and Explanatory Variables

Variables	Eviews name	Units
Dependent variable:		
Electricity sales	**ELECTRICITY_SALES**	**Gwh**
Explanatory variables:		
Electricity prices	**REAL_ELECTRICITY_PRICE**	**Cents/Kwh in 2009 dollars ***
Natural gas prices	**REAL_NATURAL_GAS_PRICE**	**Dollars/Mcf in 2009 dollars ***
Real personal income	**REAL_INCOME**	**Thousands of 2009 dollars ***
Population	**POPULATION**	**Number of people**
Manufacturing employment	**MANUFACTURING_EMP**	**Number of jobs**
Non-manufacturing employment	**NON_MANUFACTURING_EMP**	**Number of jobs**
Non-farm employment	**NON_FARM_EMP**	**Number of jobs**
Gross state product	**REAL_GSP**	**Millions of chained 2009 dollars**
Cooling degree days	**CDD**	**Fahrenheit**
Heating degree days	**HDD**	**Fahrenheit**

**** Original data was in nominal dollars. SUFG converted it to real 2009 dollars using state level CPI from IHS Global Insight.***

Arkansas

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1990 2013
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	26579.63	3339.833	7.958372	0.0000	
@MOVAV(REAL_ELECTRICITY_PRICE,3)	-2057.705	178.8651	-11.50423	0.0000	-0.3197
REAL_GSP	0.222283	0.013761	16.15294	0.0000	0.5511
CDD	3.240904	0.595194	5.445123	0.0000	0.1464
HDD	1.305267	0.447506	2.916756	0.0088	0.1118

R-squared	0.992661	Mean dependent var	40279.71
Adjusted R-squared	0.991117	S.D. dependent var	6719.508
S.E. of regression	633.3275	Durbin-Watson stat	1.473360
F-statistic	642.5209		
Prob(F-statistic)	0.000000		

Changes: electricity price did not use a moving average previously; natural gas price was dropped

Illinois

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1990 2013
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	85631.92	16794.60	5.098778	0.0001	
@MOVAV(REAL_ELECTRICITY_PRICE,5)	-2398.837	659.2909	-3.638511	0.0017	-0.1363
REAL_GSP	0.081879	0.015590	5.252025	0.0000	0.3877
CDD	10.99190	1.417119	7.756509	0.0000	0.0804
HDD	2.005417	0.667445	3.004618	0.0073	0.0887

R-squared	0.989730	Mean dependent var	133177.1
Adjusted R-squared	0.987568	S.D. dependent var	10840.50
S.E. of regression	1208.690	Durbin-Watson stat	1.927055
F-statistic	457.7760		
Prob(F-statistic)	0.000000		

Change: per capita income and non-manufacturing employment have been replaced by GSP

Indiana

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1990 2013
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	33718.69	4263.215	7.909217	0.0000	
@MOVAV(REAL_ELECTRICITY_PRICE,3)	-2072.168	269.1211	-7.699760	0.0000	-0.1575
@MOVAV(REAL_NATURAL_GAS_PRICE,3)	528.2982	122.5911	4.309434	0.0004	0.0332
REAL_GSP	0.236684	0.006259	37.81729	0.0000	0.6597
CDD	5.945190	0.873182	6.808652	0.0000	0.0657
HDD	1.581184	0.459513	3.440997	0.0029	0.0900

R-squared	0.996051	Mean dependent var	95772.67
Adjusted R-squared	0.994954	S.D. dependent var	10914.61
S.E. of regression	775.3028	Durbin-Watson stat	2.111233
F-statistic	908.0568		
Prob(F-statistic)	0.000000		

No changes in drivers or starting year from 2014 model

Iowa

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1990 2013
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	18943.27	3132.870	6.046618	0.0000	
REAL_ELECTRICITY_PRICE	-1593.057	231.4430	-6.883151	0.0000	-0.2519
REAL_NATURAL_GAS_PRICE (-2)	226.2321	73.97976	3.058028	0.0071	0.0292
REAL_INCOME/POPULATION	434.4074	106.1228	4.093442	0.0008	0.3869
REAL_GSP	0.089356	0.029014	3.079787	0.0068	0.2875
CDD	2.766519	0.616787	4.485372	0.0003	0.0648
HDD	0.471215	0.206361	2.283448	0.0355	0.0794

R-squared	0.995080	Mean dependent var	39249.38
Adjusted R-squared	0.993343	S.D. dependent var	5545.565
S.E. of regression	452.4621	Durbin-Watson stat	1.865698
F-statistic	573.0092		
Prob(F-statistic)	0.000000		

Change: natural gas price was added

Kentucky

- The Paducah Gaseous Diffusion Plant (PGDP) closed in mid-2013, a large (3 GW) load on the TVA system
  - Accounted for more than 10% of the state's retail sales
- SUFG could not fit an econometric model with that drop in load
  - We propose to develop a model using a load adjustment

KY Load Adjustment

- We propose to adjust the 2013 historical load up to what it would have been with PGDP operational, develop the econometric model, then subtract the PGDP load from the forecast
- We will make the same adjustments when determining the allocation factor
- Since the load adjustments occur to the portion of the load outside of the MISO footprint, any errors introduced by the adjustment should have less impact on the LRZ forecast

Kentucky

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1994 2013
Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	-77897.63	12101.31	-6.437125	0.0000	
@MOVAV(REAL_ELECTRICITY_PRICE,3)	-1584.538	826.3808	-1.917443	0.0758	-0.1212
@MOVAV(REAL_NATURAL_GAS_PRICE,3)	896.4493	232.8831	3.849354	0.0018	0.0617
POPULATION	0.034166	0.003304	10.33949	0.0000	1.6352
CDD	4.638003	1.828520	2.536479	0.0237	0.0723
HDD	3.759639	1.174261	3.201706	0.0064	0.1968

R-squared	0.967353	Mean dependent var	84499.31
Adjusted R-squared	0.955694	S.D. dependent var	6956.077
S.E. of regression	1464.184	Durbin-Watson stat	1.809730
F-statistic	82.96713		
Prob(F-statistic)	0.000000		

Change: starting year has been changed from 1990 to 1994

Louisiana

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1990 2013
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	59374.89	8871.980	6.692406	0.0000	
@MOVAV(REAL_ELECTRICITY_PRICE,3)	-3588.096	532.2390	-6.741512	0.0000	-0.3074
REAL_GSP	0.141978	0.020493	6.928105	0.0000	0.3673
CDD	4.906066	1.772056	2.768573	0.0122	0.1871
HDD	3.945677	1.488811	2.650220	0.0158	0.0776

R-squared	0.960884	Mean dependent var	76559.79
Adjusted R-squared	0.952649	S.D. dependent var	6438.349
S.E. of regression	1401.006	Durbin-Watson stat	1.781461
F-statistic	116.6830		
Prob(F-statistic)	0.000000		

Change: per capita income and manufacturing employment have been replaced by GSP

Michigan

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1990 2013
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	43803.67	11496.61	3.810139	0.0013	
REAL_ELECTRICITY_PRICE(-2)	-2280.165	507.2398	-4.495241	0.0003	-0.2277
REAL_INCOME/POPULATION	1337.749	232.2243	5.760591	0.0000	0.4722
REAL_GSP	0.047346	0.021274	2.225522	0.0391	0.1876
CDD	5.586437	1.504317	3.713604	0.0016	0.0450
HDD	1.560792	0.638137	2.445855	0.0250	0.0966

R-squared	0.984279	Mean dependent var	99914.92
Adjusted R-squared	0.979912	S.D. dependent var	8469.197
S.E. of regression	1200.363	Durbin-Watson stat	1.789823
F-statistic	225.3902		
Prob(F-statistic)	0.000000		

Change: starting year has been changed from 1992 to 1990

Minnesota

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1992 2013
Included observations: 22

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	20576.21	3699.593	5.561749	0.0000	
@MOVAV(REAL_ELECTRICITY_PRICE,4)	-748.8661	314.4687	-2.381369	0.0300	-0.0940
@MOVAV(REAL_NATURAL_GAS_PRICE,4)	569.7097	135.0755	4.217714	0.0007	0.0501
REAL_INCOME	0.000150	8.53E-06	17.64468	0.0000	0.5243
CDD	7.083996	1.320929	5.362889	0.0001	0.0752
HDD	1.041439	0.307265	3.389388	0.0037	0.1353

R-squared	0.991567	Mean dependent var	61014.41
Adjusted R-squared	0.988932	S.D. dependent var	6794.611
S.E. of regression	714.8173	Durbin-Watson stat	1.818049
F-statistic	376.2795		
Prob(F-statistic)	0.000000		

Changes: starting year has been changed from 1990 to 1992; electricity and natural gas prices now use 4-year moving averages instead of 3-year moving averages

Mississippi

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1993 2013
Included observations: 21

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	16105.32	5072.862	3.174800	0.0063	
@MOVAV(REAL_ELECTRICITY_PRICE,2)	-1692.783	255.4988	-6.625405	0.0000	-0.2898
REAL_INCOME(-1)	0.000183	5.93E-05	3.090968	0.0075	0.3545
REAL_GSP	0.201376	0.088016	2.287936	0.0371	0.4003
CDD	3.296009	0.704433	4.678954	0.0003	0.1667
HDD	1.437900	0.644115	2.232366	0.0413	0.0800

R-squared	0.985573	Mean dependent var	44431.10
Adjusted R-squared	0.980764	S.D. dependent var	4308.771
S.E. of regression	597.6077	Durbin-Watson stat	2.064809
F-statistic	204.9383		
Prob(F-statistic)	0.000000		

Changes: starting year has been changed from 1991 to 1993; electricity price now uses 2-year moving averages instead of 3-year moving averages; per capita income has been replaced by a lagged total income

Missouri

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1998 2013
Included observations: 16

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	-99007.54	14626.41	-6.769094	0.0000	
@MOVAV(REAL_ELECTRICITY_PRICE,5)	-2484.731	542.1817	-4.582839	0.0010	-0.2474
POPULATION	0.016488	0.001841	8.954426	0.0000	1.1952
NON_MANUFACTURING_EMP	0.031252	0.006514	4.797392	0.0007	0.9279
CDD	8.479600	1.019905	8.314105	0.0000	0.1655
HDD	2.500053	0.594768	4.203408	0.0018	0.1457

R-squared	0.989047	Mean dependent var	78499.50
Adjusted R-squared	0.983570	S.D. dependent var	5920.461
S.E. of regression	758.8787	Durbin-Watson stat	1.898750
F-statistic	180.5944		
Prob(F-statistic)	0.000000		

Change: starting year has been changed from 1997 to 1998

Montana

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1996 2013
Included observations: 18

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	2739.967	3772.436	0.726313	0.4828	
REAL_ELECTRICITY_PRICE	-2014.651	232.0327	-8.682616	0.0000	-1.1398
@MOVAV(REAL_NATURAL_GAS_PRICE,5)	544.5881	84.63668	6.434422	0.0000	0.2836
REAL_INCOME/POPULATION	298.7459	58.71022	5.088483	0.0004	0.7796
MANUFACTURING_EMP	0.271165	0.071228	3.806996	0.0029	0.3527
CDD	1.976617	0.801431	2.466360	0.0313	0.0674
HDD	0.765575	0.228727	3.347118	0.0065	0.4035

R-squared	0.949994	Mean dependent var	13633.39
Adjusted R-squared	0.922717	S.D. dependent var	1031.667
S.E. of regression	286.8011	Durbin-Watson stat	1.934246
F-statistic	34.82859		
Prob(F-statistic)	0.000002		

No changes in drivers or starting year from 2014 model

North Dakota

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1995 2013
Included observations: 19

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	-6463.323	1198.565	-5.392552	0.0001	
@MOVAV(REAL_ELECTRICITY_PRICE,2)	-677.6237	124.5469	-5.440713	0.0001	-0.3024
@MOVAV(REAL_NATURAL_GAS_PRICE,3)	149.1068	34.44355	4.329019	0.0007	0.0441
NON_MANUFACTURING_EMP	0.056434	0.001209	46.68167	0.0000	1.4743
HDD	0.317828	0.069226	4.591136	0.0004	0.2508

R-squared	0.995151	Mean dependent var	10985.74
Adjusted R-squared	0.993766	S.D. dependent var	2318.660
S.E. of regression	183.0709	Durbin-Watson stat	1.845949
F-statistic	718.3514		
Prob(F-statistic)	0.000000		

No changes in drivers or starting year from 2014 model

South Dakota

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1995 2013
Included observations: 19

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	-19443.84	1233.943	-15.75749	0.0000	
REAL_ELECTRICITY_PRICE(-2)	-475.7095	76.51588	-6.217134	0.0000	-0.3146
REAL_NATURAL_GAS_PRICE(-2)	63.92909	22.23205	2.875538	0.0130	0.0304
POPULATION	0.038971	0.001050	37.10305	0.0000	2.7003
CDD	0.504849	0.162773	3.101555	0.0084	0.0384
HDD	0.200510	0.053482	3.749132	0.0024	0.1547

R-squared	0.997501	Mean dependent var	9591.947
Adjusted R-squared	0.996540	S.D. dependent var	1581.594
S.E. of regression	93.02632	Durbin-Watson stat	1.851350
F-statistic	1037.993		
Prob(F-statistic)	0.000000		

Change: electricity and natural gas prices now use 2-year lagged prices instead of 3-year moving averages

Texas

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1996 2013
Included observations: 18

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	86031.22	18049.69	4.766353	0.0005	
REAL_ELECTRICITY_PRICE(-2)	-4120.164	1670.959	-2.465748	0.0297	-0.0856
REAL_NATURAL_GAS_PRICE(-2)	2697.458	932.0740	2.894038	0.0135	0.0383
REAL_GSP	0.145399	0.007357	19.76215	0.0000	0.5313
CDD	26.16797	5.234784	4.998864	0.0003	0.2416
HDD	17.80360	5.172099	3.442239	0.0049	0.0992

R-squared	0.987684	Mean dependent var	331390.5
Adjusted R-squared	0.982553	S.D. dependent var	28690.53
S.E. of regression	3789.660	Durbin-Watson stat	1.968183
F-statistic	192.4748		
Prob(F-statistic)	0.000000		

Changes: starting year has been changed from 1990 to 1996; electricity prices now uses 2-year lagged prices instead of 5-year moving averages; per capita income has been dropped; natural gas prices have been added

Wisconsin

Dependent Variable: ELECTRICITY_SALES
Method: Least Squares
Sample: 1990 2013
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Elasticity at 2013 (weather at means)
C	20061.26	2202.430	9.108695	0.0000	
@MOVAV(REAL_ELECTRICITY_PRICE,3)	-1208.035	110.0411	-10.97804	0.0000	-0.1687
REAL_NATURAL_GAS_PRICE	249.2321	65.61098	3.798634	0.0013	0.0240
REAL_GSP	0.196129	0.003549	55.26382	0.0000	0.7494
CDD	4.206383	0.688373	6.110612	0.0000	0.0405
HDD	0.681842	0.245735	2.774705	0.0125	0.0761

R-squared	0.996456	Mean dependent var	63245.42
Adjusted R-squared	0.995472	S.D. dependent var	6980.190
S.E. of regression	469.7064	Durbin-Watson stat	1.550660
F-statistic	1012.273		
Prob(F-statistic)	0.000000		

Changes: electricity price did not use a moving average previously; per capita income was dropped

Next Steps

- Re-calculate the allocation models to convert state-level forecasts to LRZ level forecasts
- Develop improved LRZ energy to peak demand conversion models
- Incorporate econometric model drivers
- Run and validate state econometric models
- July workshop

More Next Steps

- Develop confidence intervals that capture uncertainty of macroeconomic variables
- Determine EE/DR/DG adjustments
- Determine LRZ level energy and peak demand forecasts
- Determine MISO system energy and peak demand forecasts
- September workshop
- Develop forecast report