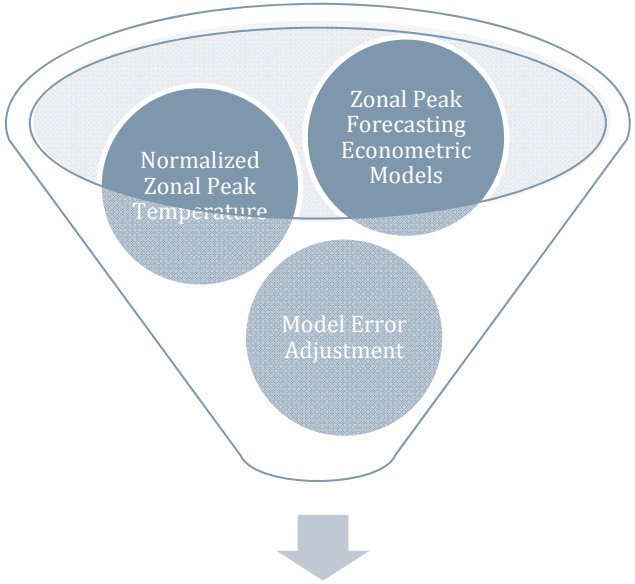
Independent Load Forecast Workshop

September 17, 2015

Weather and Peak Loads

Selected Weather Stations

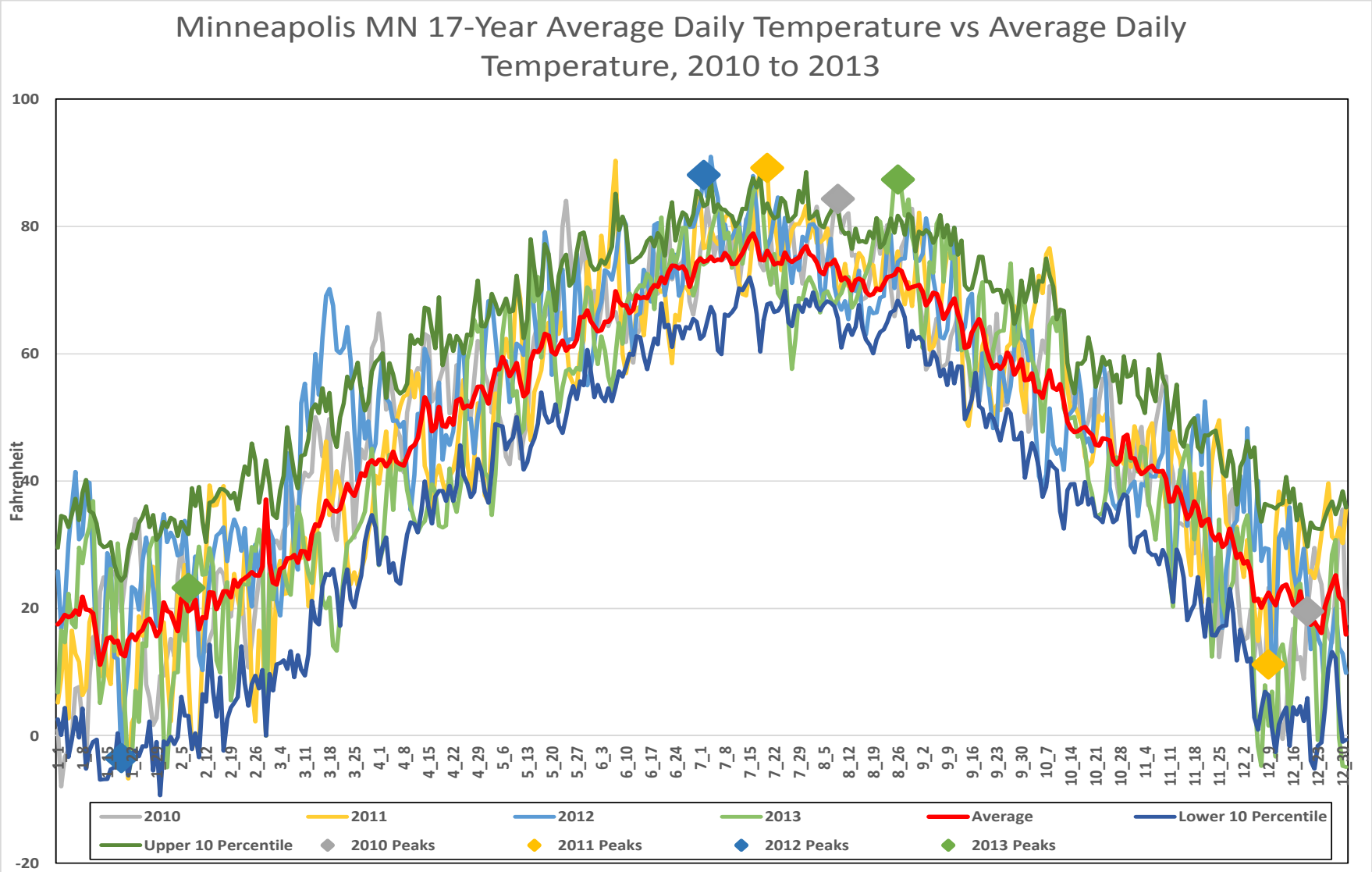


Zonal Summer and Winter Load Factors

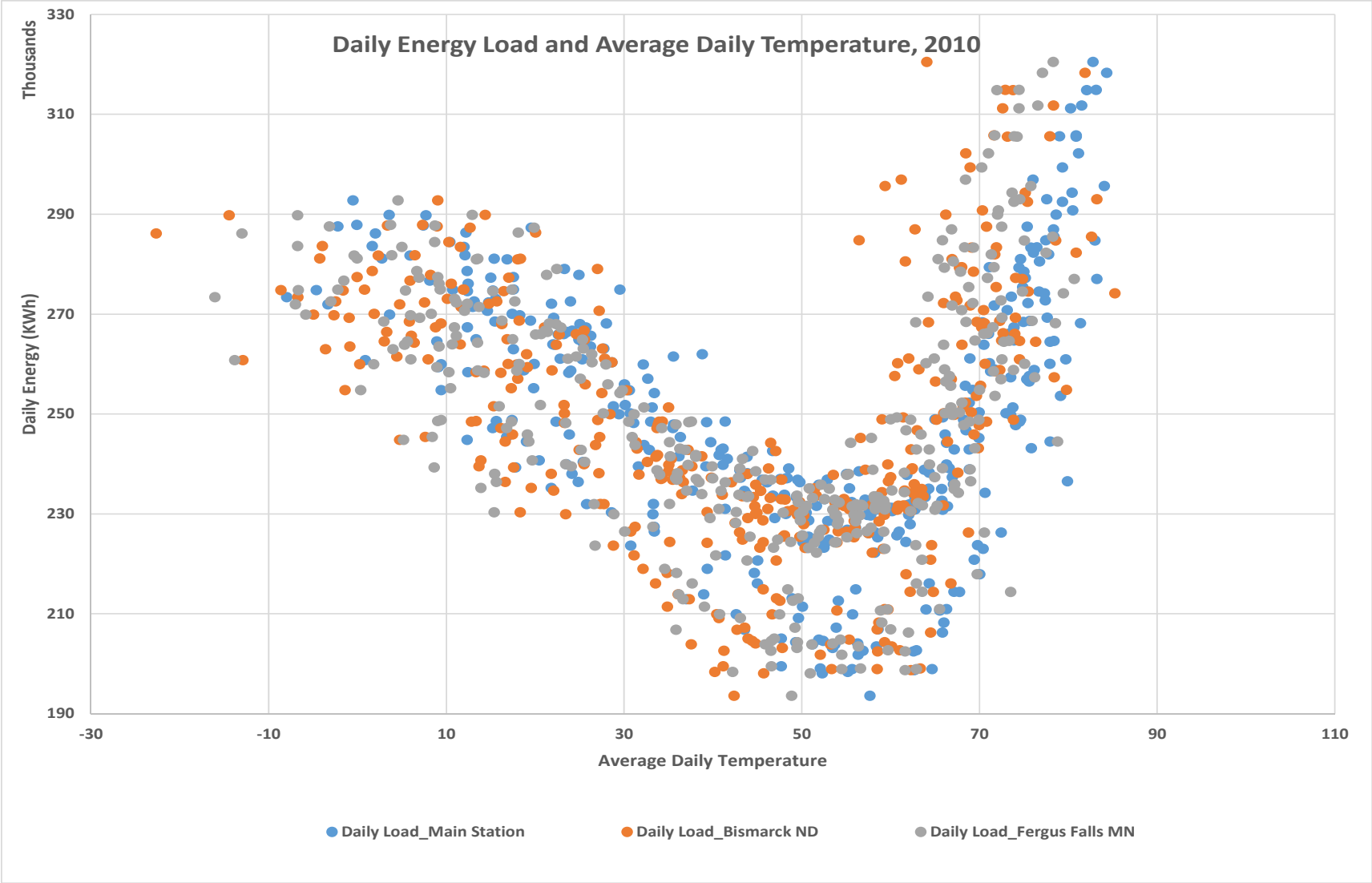
Weather STATION	Zone
Minneapolis St Paul International Airport MN	LRZ 1
Milwaukee Mitchell International Airport WI	LRZ 2
Des Moines International Airport IA	LRZ 3
Springfield Abraham Lincoln Capital Airport IL	LRZ 4
St Louis Lambert International Airport MO	LRZ 5
Indianapolis International Airport IN	LRZ 6
Lansing Capital City Airport MI	LRZ 7
Little Rock Airport Adams Field AR	LRZ 8
Lake Charles Regional Airport LA	LRZ 9
Jackson International Airport MS	LRZ 10

Hourly weather data source: Midwest Regional Climate Center

Peak Loads and Extreme Temperatures, MN



Daily Loads and Average Daily Temperatures, LRZ 1



Methodology – Sample Selection

- Total sample size: 5 years hourly load records (43824 records for each LRZ)
- Sub-samples are selected to model winter and summer peaks under extreme temperature
- Steps to pick sub-samples
  - First, pick the top 5000 hourly loads;
  - Then select:
    - Winter: January, February, November and December
    - Summer: July, August and September
    - Daily peak load only; holidays and weekends are excluded
- The sample size of sub-samples ranges from 350-450 depending on LRZs

Methodology - Model

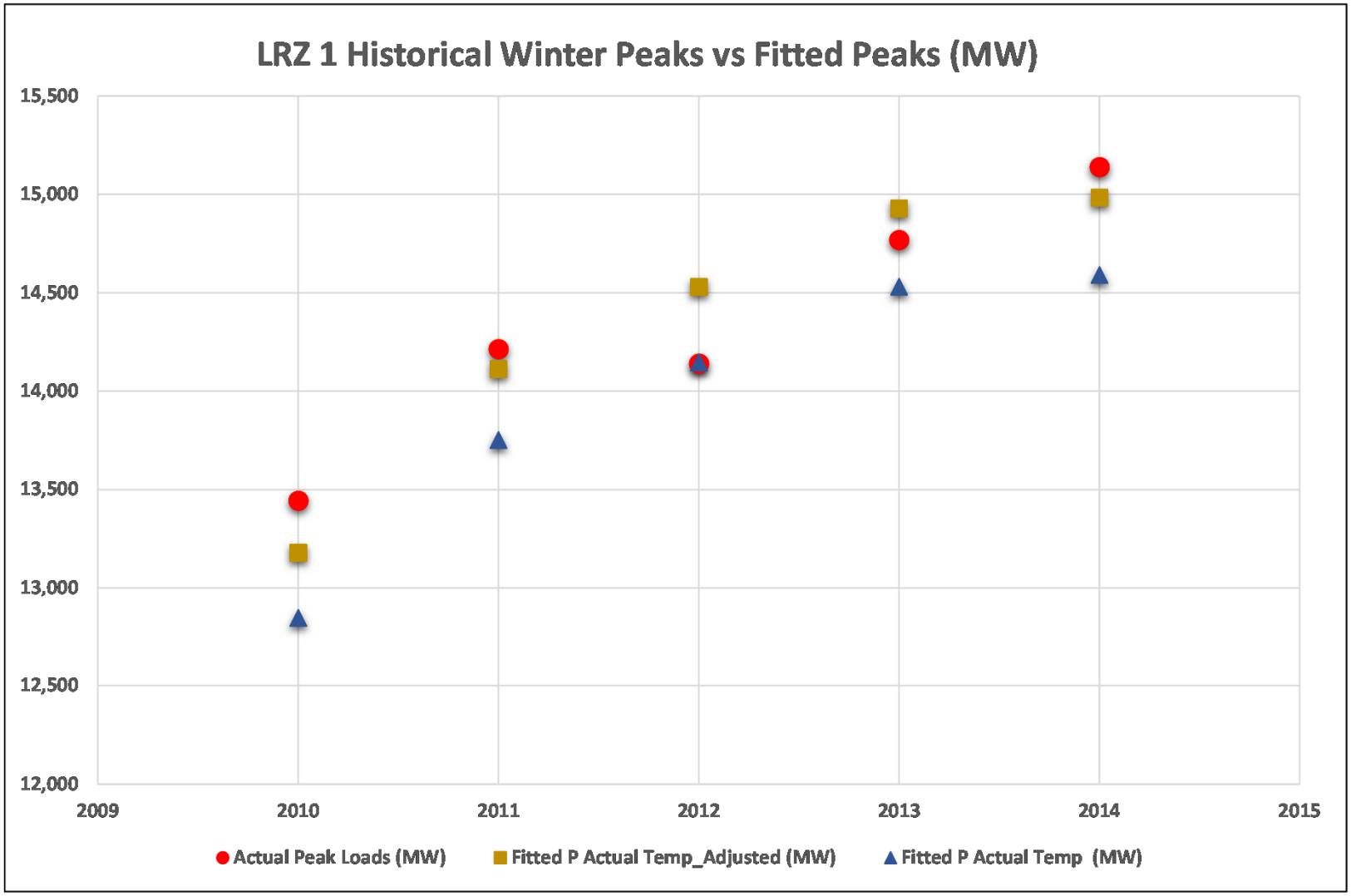
- Seasonal dummy variables are used to model the nonlinear relationship among temperatures and electricity loads;
- Interaction terms of weather dummies and temperature are used to show the variant energy consumption changing patterns during winter and summer
- Dependent variable: daily peak load factor
- The best fitting model is selected after model comparison for each LRZ
- Independent variables used:
  - Average daily temperature
  - Hourly temperature
  - Maximum daily hourly temperature
  - Weekday (1-5)
  - Month

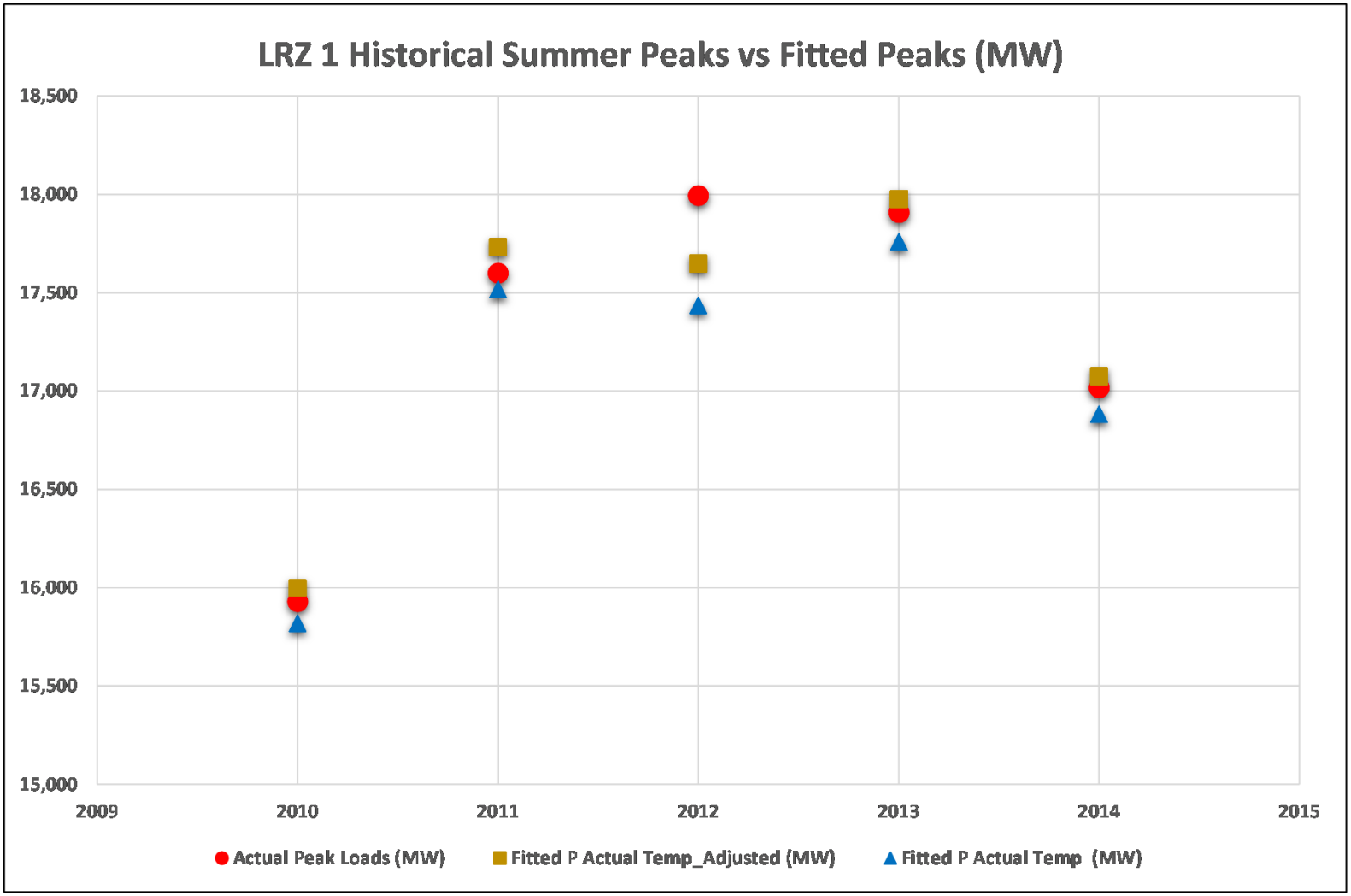
Underforecasting Issue

- In most instances, the model underforecasts the actual peaks
- This is because the model forecasts the mean value for a given temperature
- Most peak demands happen away from the mean of the distribution of load levels at a given temperature
- We have made an adjustment to try to capture how far out on the distribution the peaks occur

Methodology - Adjustments

- Adjustments are made to fitted peaks based on the number of standard deviations of fitted peaks from actual peaks
- Unusual peaks are treated as outliers and excluded
  - e.g., summer peaks in September


LRZ 1 Historical Winter Peaks vs Fitted Peaks (MW)
15,500
15,000
14,500
14,000
13,500
13,000
12,500
12,000
2009
2010
2011
2012
2013
2014
2015
Actual Peak Loads (MW)
Fitted P Actual Temp_Adjusted (MW)
Fitted P Actual Temp (MW)


LRZ 1 Historical Summer Peaks vs Fitted Peaks (MW)
18,500
18,000
17,500
17,000
16,500
16,000
15,500
15,000
2009
2010
2011
2012
2013
2014
2015
Actual Peak Loads (MW)
Fitted P Actual Temp_Adjusted (MW)
Fitted P Actual Temp (MW)

Normal Temperatures (°F) on Peak

LRZ	Winter			Summer		
	Hourly Temp	Average Daily Temp	Daily Max Temp	Hourly Temp	Average Daily Temp	Daily Max Temp
LRZ 1	-2.7	5.0	14.5	93.9	85.0	93.9
LRZ 2	-2.8	-1.1	6.4	89.3	82.7	92.0
LRZ 3	5.3	4.6	14.7	91.1	85.4	96.3
LRZ 4	4.9	10.3	19.4	94.2	84.7	94.7
LRZ 5	10.1	14.9	24.8	98.4	90.1	100.0
LRZ 6	5.2	12.7	22.6	91.3	82.8	92.0
LRZ 7	12.6	12.5	20.9	91.1	81.5	92.1
LRZ 8	18.5	24.1	32.6	99.5	88.3	101.1
LRZ 9	35.8	39.5	52.0	93.1	86.6	98.5
LRZ 10	27.1	33.0	43.0	95.6	86.7	98.9

Zonal Peak Demand Conversion Factors

LRZ	New		Old	
	Summer	Winter	Summer	Winter
1	**1.541**	**1.329**	1.568	1.282
2	**1.695**	**1.336**	1.672	1.267
3	**1.635**	**1.323**	1.638	1.275
4	**1.707**	**1.348**	1.717	1.303
5	**1.741**	**1.451**	1.749	1.405
6	**1.508**	**1.372**	1.542	1.340
7	**1.792**	**1.286**	1.826	1.245
8	**1.726**	**1.448**	1.739	1.412
9	**1.536**	**1.388**	1.634	1.363
10	**1.815**	**1.444**		

Multiply average hourly load by conversion factor to determine peak

Summer Coincidence Factors

LRZ	Average	2010	2011	2012	2013	2014
1	**0.956**	0.968	1.000	0.945	0.973	0.896
2	**0.983**	0.948	1.000	0.969	0.999	1.000
3	**0.975**	0.952	0.986	0.974	0.969	0.992
4	**0.961**	1.000	0.988	0.945	0.988	0.885
5	**0.958**	1.000	0.971	0.949	0.963	0.907
6	**0.979**	0.962	0.991	0.973	1.000	0.970
7	**0.974**	0.913	0.961	1.000	0.999	0.998
8	**0.928**	0.964	0.936	0.929	0.936	0.875
9	**0.917**	0.982	0.909	0.911	0.862	0.920
10	**0.876**	0.952	0.901	0.896	0.785	0.845

Winter Coincidence Factors

LRZ	Average	2010	2011	2012	2013	2014
1	**0.989**	0.992	0.994	0.962	1.000	0.994
2	**0.982**	0.993	0.976	0.963	0.990	0.989
3	**0.989**	0.996	0.971	1.000	0.979	1.000
4	**0.994**	1.000	1.000	1.000	0.980	0.992
5	**0.985**	0.962	1.000	1.000	0.964	1.000
6	**0.975**	0.975	0.993	0.992	0.928	0.988
7	**0.957**	0.988	0.958	0.938	0.959	0.944
8	**0.949**	0.889	0.929	0.995	0.954	0.981
9	**0.910**	0.830	0.949	0.894	0.900	0.979
10	**0.918**	0.917	0.889	0.940	0.852	0.993

State Energy Forecasts

Dependent and Explanatory Variables

Variables	Eviews Name	Data Source
Dependent variable:		
Electricity sales	ELECTRICITY_SALES	EIA
Explanatory variables:		
Electricity prices	REAL_ELECTRICITY_PRICE	EIA*
Natural gas prices	REAL_NATURAL_GAS_PRICE	EIA*
Real personal income	REAL_INCOME	IHS Global Insight
Population	POPULATION	IHS Global Insight
Manufacturing employment	MANUFACTURING_EMP	IHS Global Insight
Non-manufacturing employment	NON_MANUFACTURING_EMP	IHS Global Insight
Non-farm employment	NON_FARM_EMP	IHS Global Insight
Gross state product	REAL_GSP	IHS Global Insight
Cooling degree days	CDD	NOAA/NCDC
Heating degree days	HDD	NOAA/NCDC

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

Explanatory Variable CAGR* (%)

Variables	AR	IL	IN	IA	KY	LA	MI	MN	MS	MO	MT	ND	SD	TX	WI
REAL_ELECTRICITY_PRICE	1.05	1.29	1.29	-0.03	-0.14	1.06	1.29	-0.03	-0.14	-0.01	0.56	-0.03	-0.01	1.06	1.29
REAL_NATURAL_GAS_PRICE			2.40	2.95	2.35			2.62			3.06	2.85	3.05	3.97	2.11
REAL_INCOME								2.64	2.56						
POPULATION					0.49					0.50			0.81		
REAL_INCOME/ POPULATION				1.94			1.80				2.01				
REAL_GSP	2.36	2.02	2.05	2.36		4.75**	1.67		1.96					3.27	2.14
NON_MANUFACTURING_EMP										0.73		0.70			
MANUFACTURING_EMP											0.07				

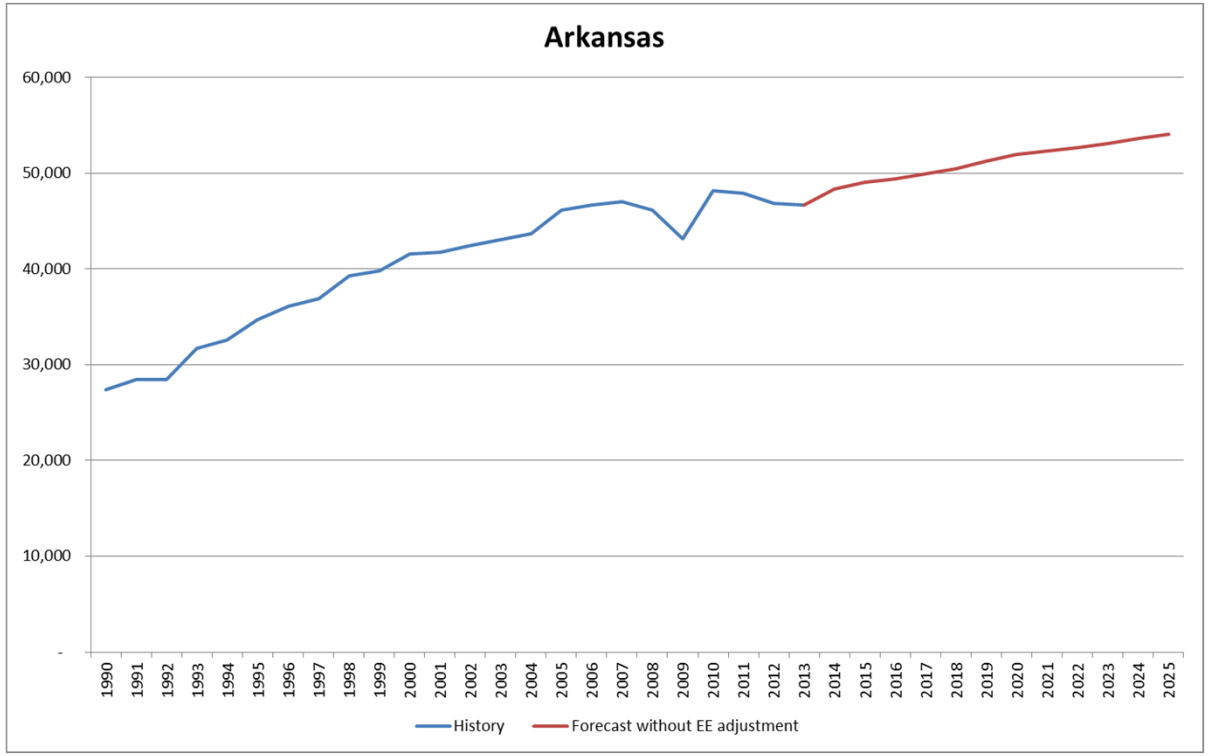
- *CAGR – Compound Annual Growth Rate*
- *For Louisiana, real GSP forecast for the manufacturing sector was used to drive the growth of real GSP for the state.*

EE Adjustments

- Last year, EE adjustments were made at the state level and were based on state mandates, supplemented with discussions with individual state experts
- This year, the adjustments will be made at the LRZ level
- Thus, the state projections are not produced at the net level

Arkansas Retail Sales (GWh)

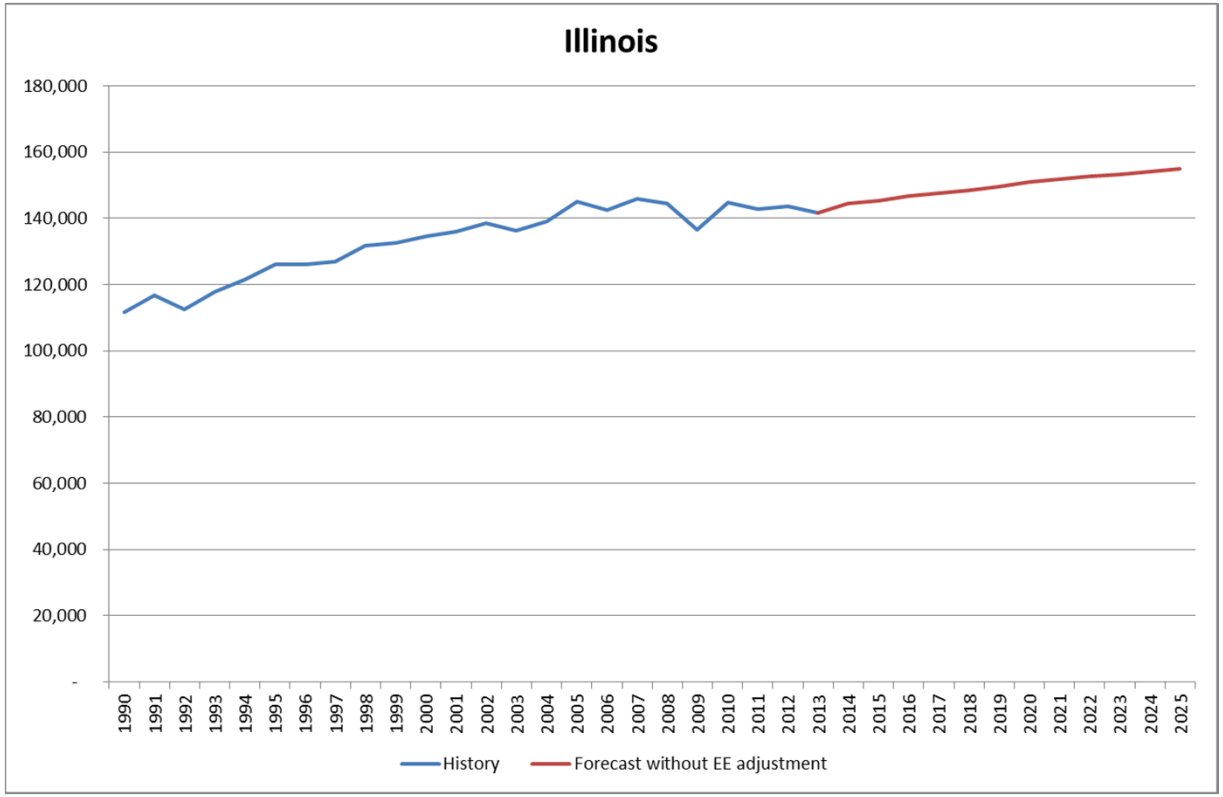
- 2016-2025 projected CAGR
  - gross 1.00%
- 1990-2013 actual CAGR
  - 2.35%



CAGR – Compound Annual Growth Rate

Illinois Retail Sales (GWh)

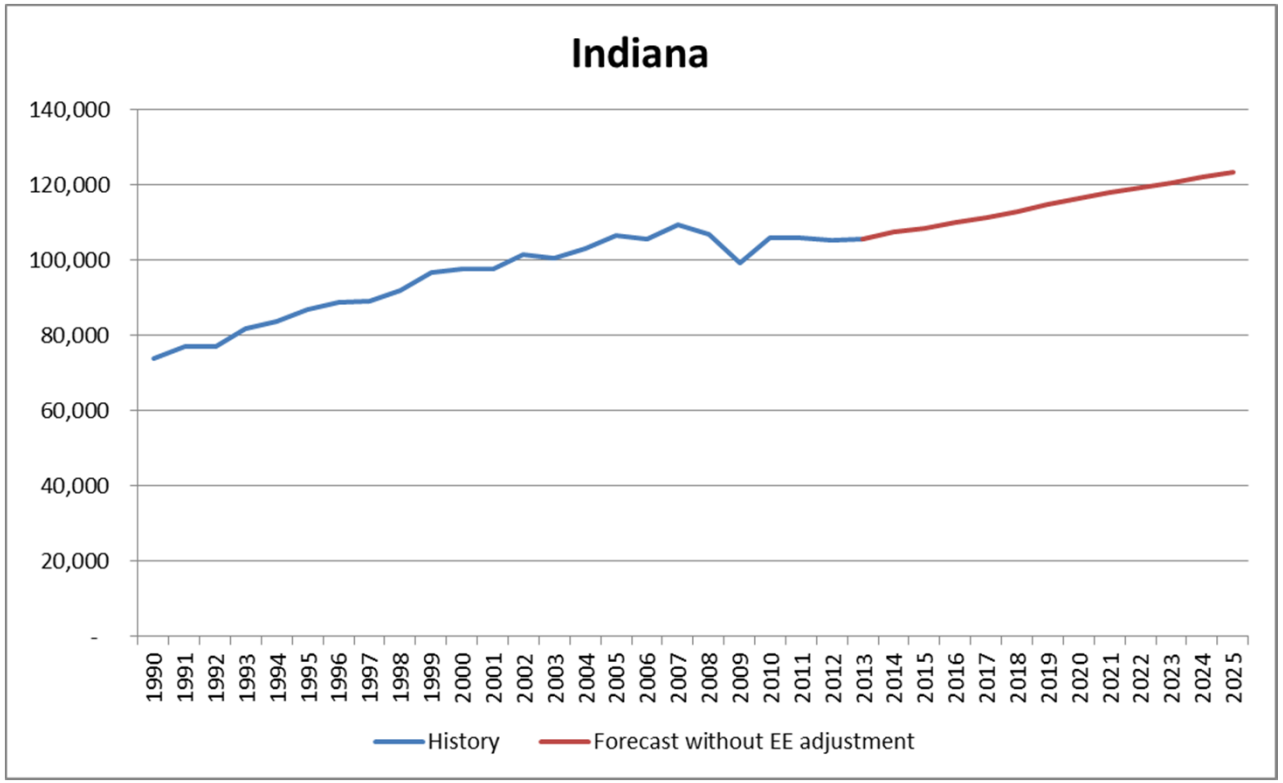
- 2016-2025 projected CAGR
  - gross 0.63%
- 1990-2013 actual CAGR
  - 1.05%



CAGR – Compound Annual Growth Rate

Indiana Retail Sales (GWh)

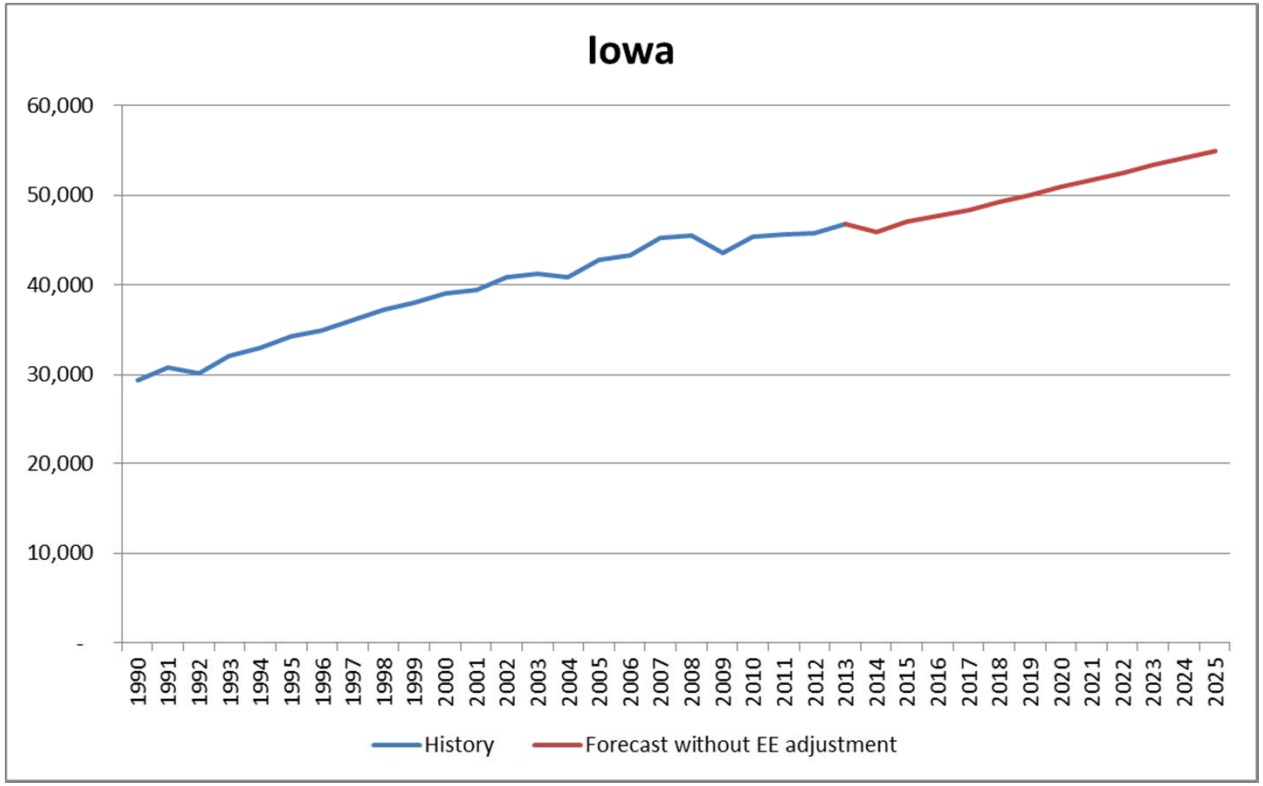
- 2016-2025 projected CAGR
  - gross 1.29%
- 1990-2013 actual CAGR
  - 1.56%



CAGR – Compound Annual Growth Rate

Iowa Retail Sales (GWh)

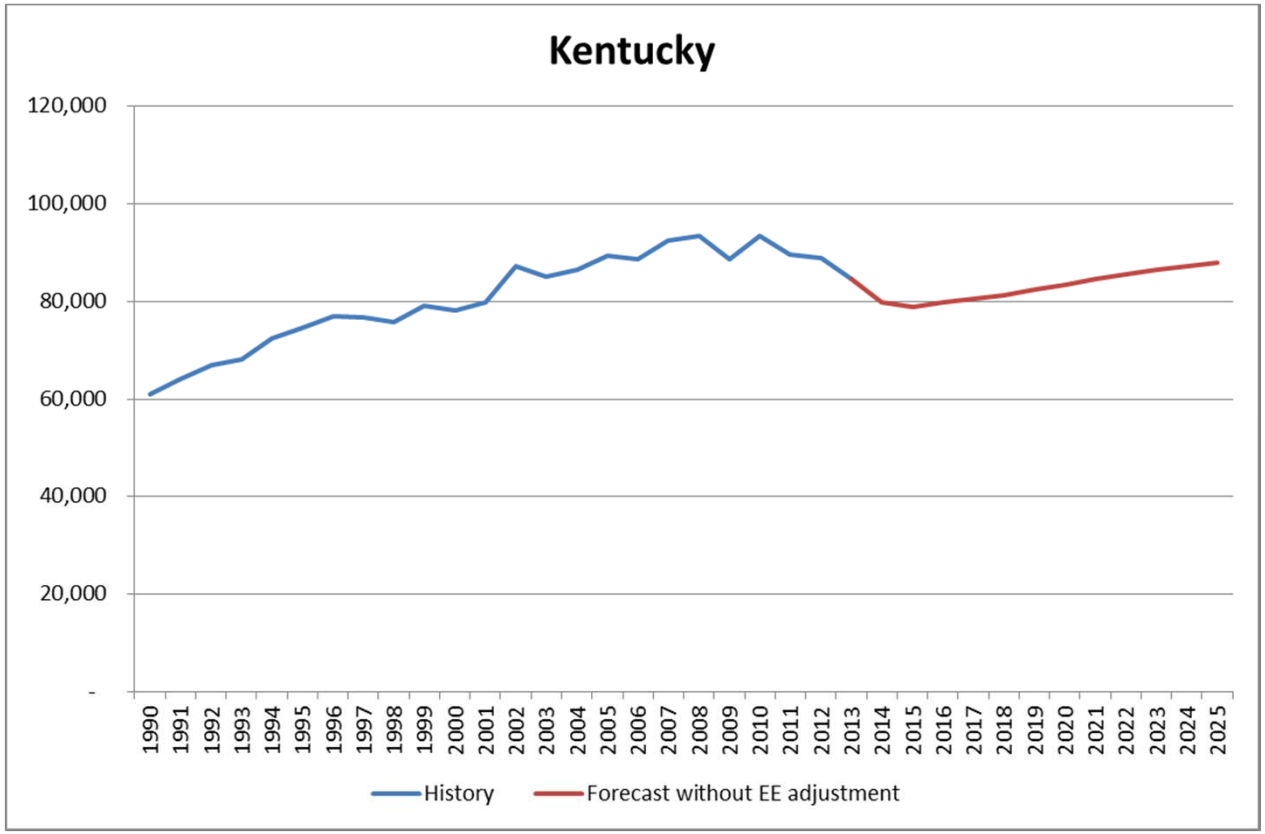
- 2016-2025 projected CAGR
  - gross 1.60%
- 1990-2013 actual CAGR
  - 2.03%



CAGR – Compound Annual Growth Rate

Kentucky Retail Sales (GWh)

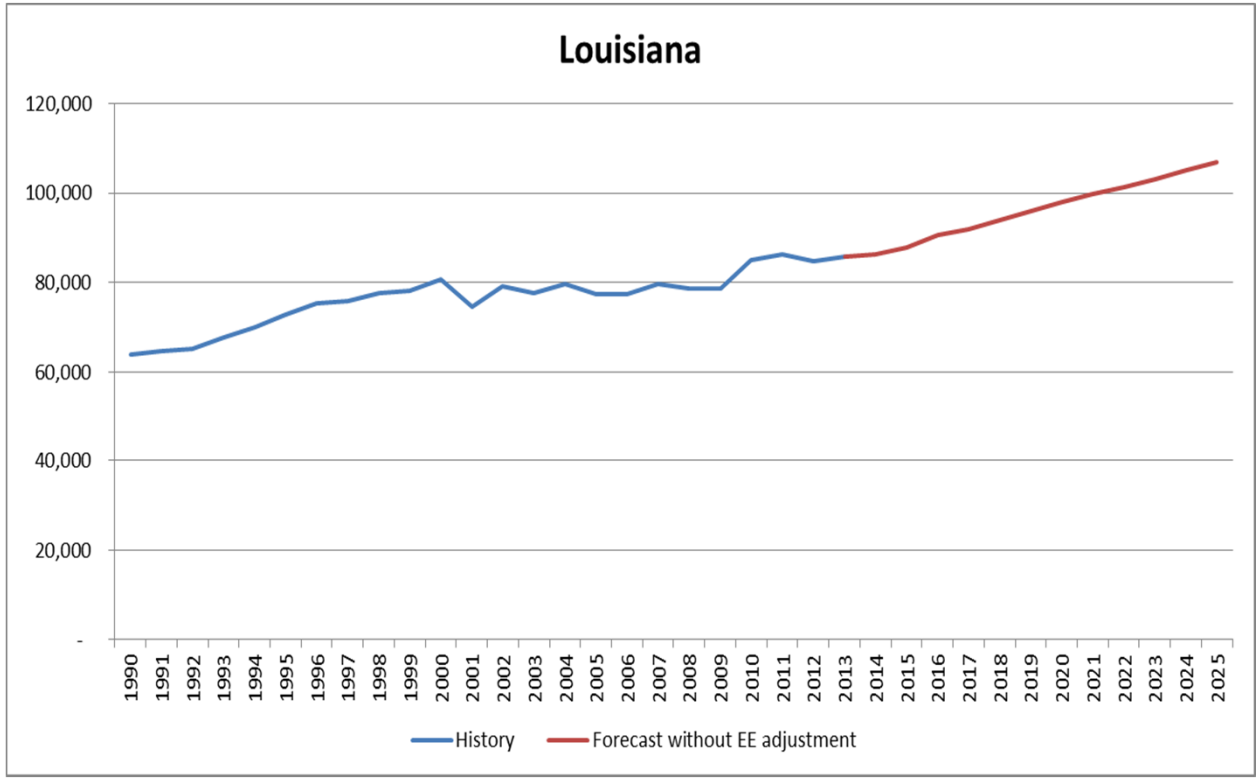
- 2016-2025 projected CAGR
  - gross 1.09%
- 1990-2013 actual CAGR
  - 1.43%



CAGR – Compound Annual Growth Rate

Louisiana Retail Sales (GWh)

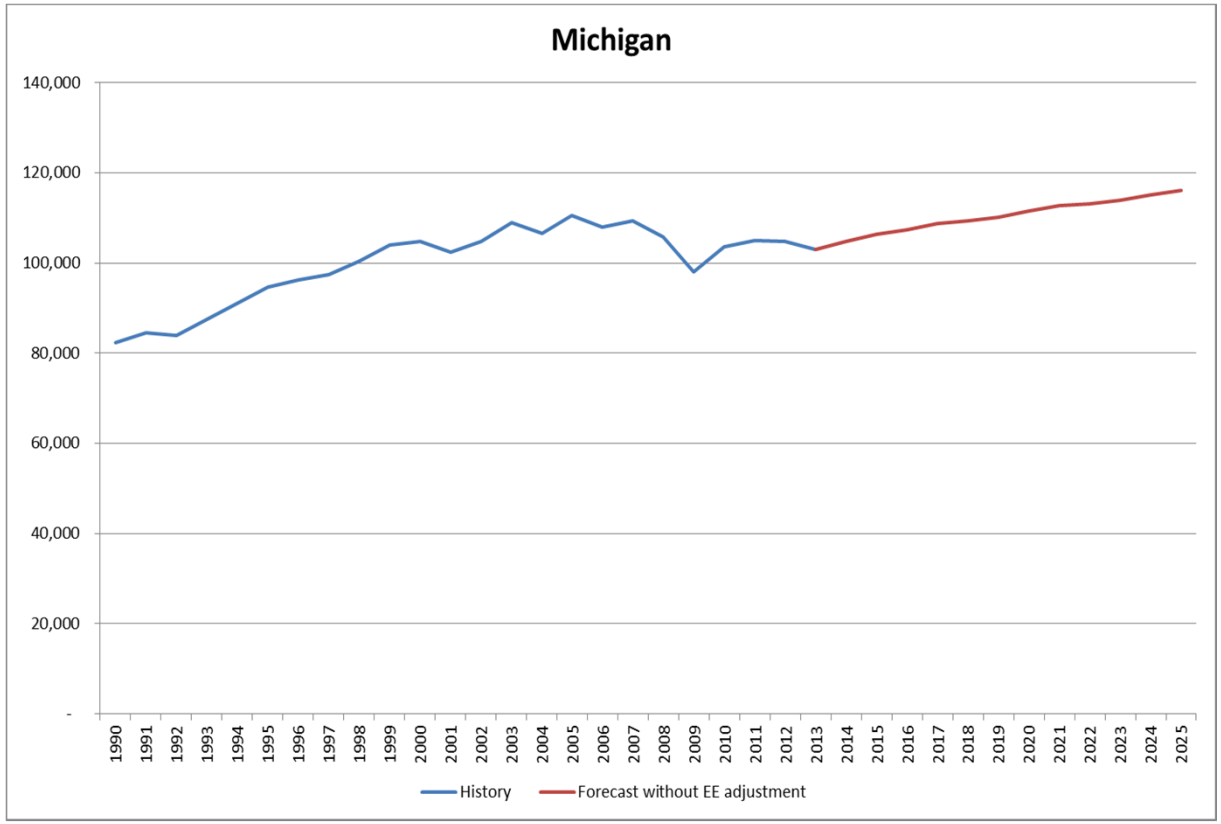
- 2016-2025 projected CAGR
  - gross 1.87%
- 1990-2013 actual CAGR
  - 1.30%



CAGR – Compound Annual Growth Rate

Michigan Retail Sales (GWh)

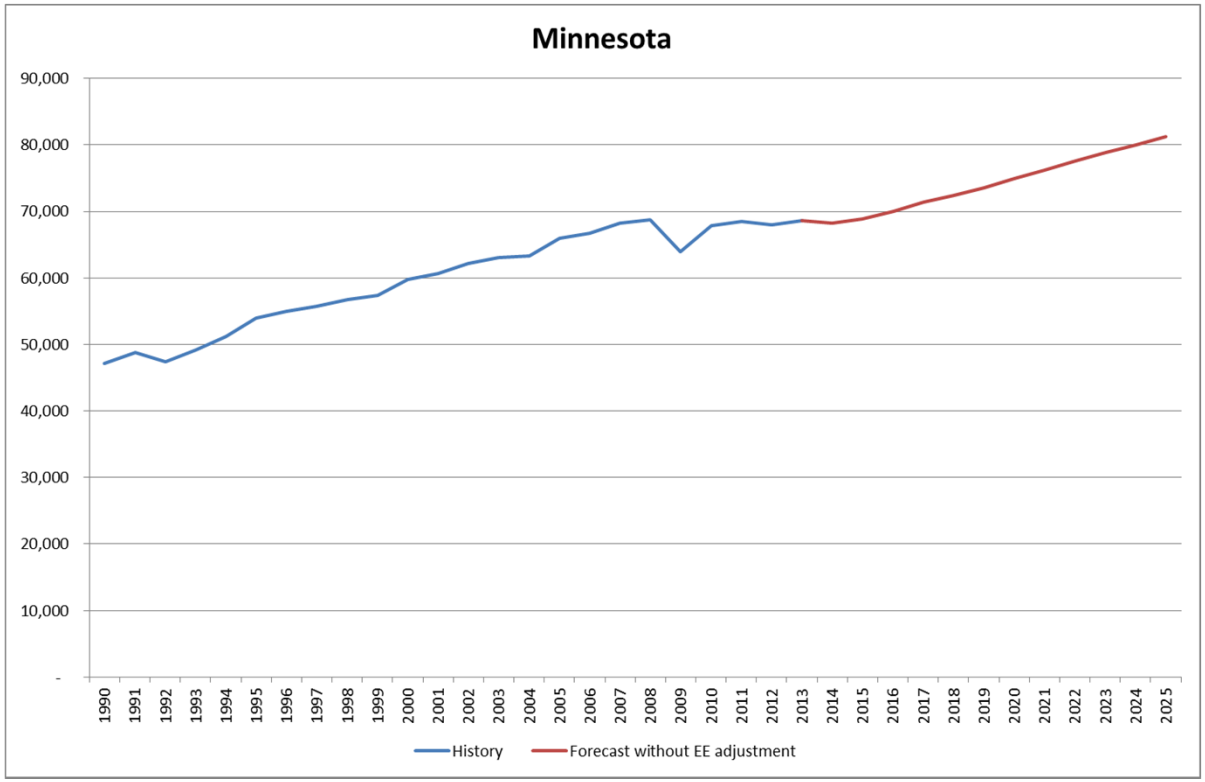
- 2016-2025 projected CAGR
  - gross 0.88%
- 1990-2013 actual CAGR
  - 0.98%



CAGR – Compound Annual Growth Rate

Minnesota Retail Sales (GWh)

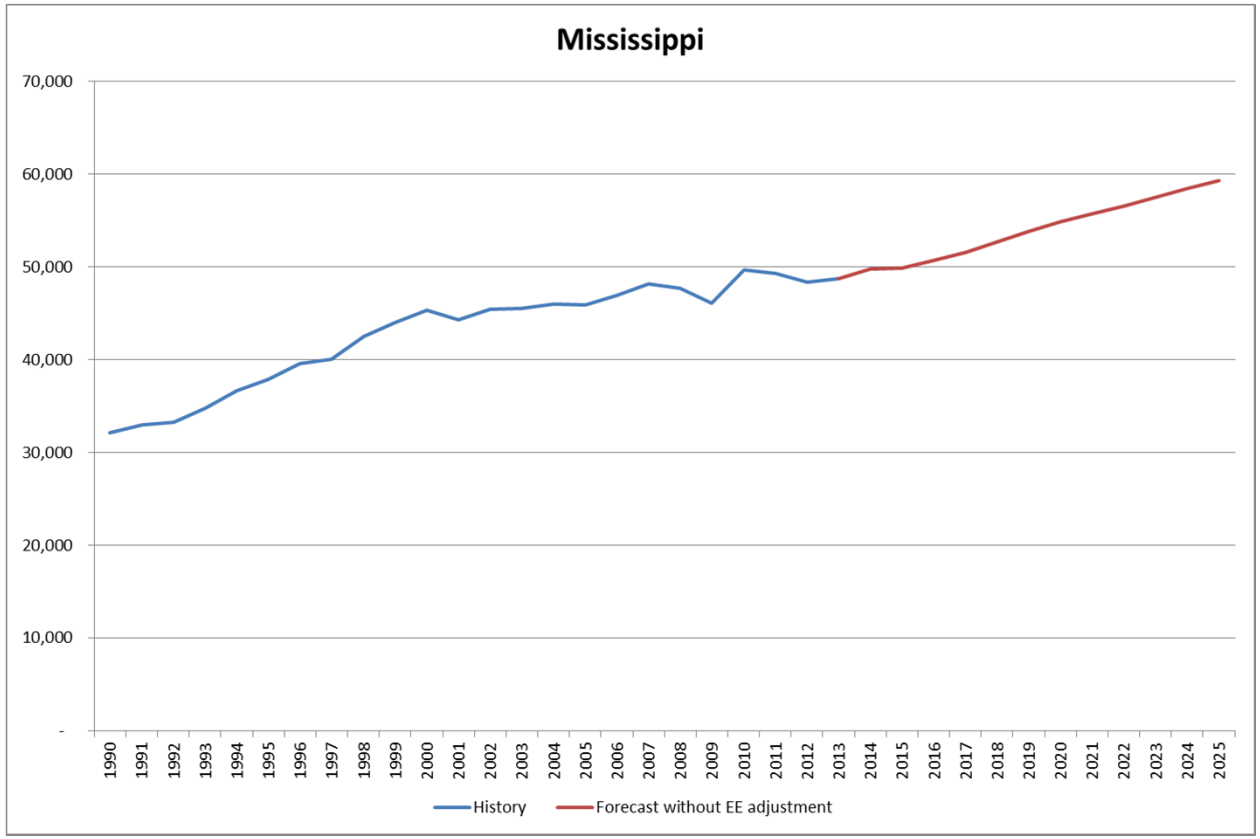
- 2016-2025 projected CAGR
  - gross 1.67%
- 1990-2013 actual CAGR
  - 1.64%



CAGR – Compound Annual Growth Rate

Mississippi Retail Sales (GWh)

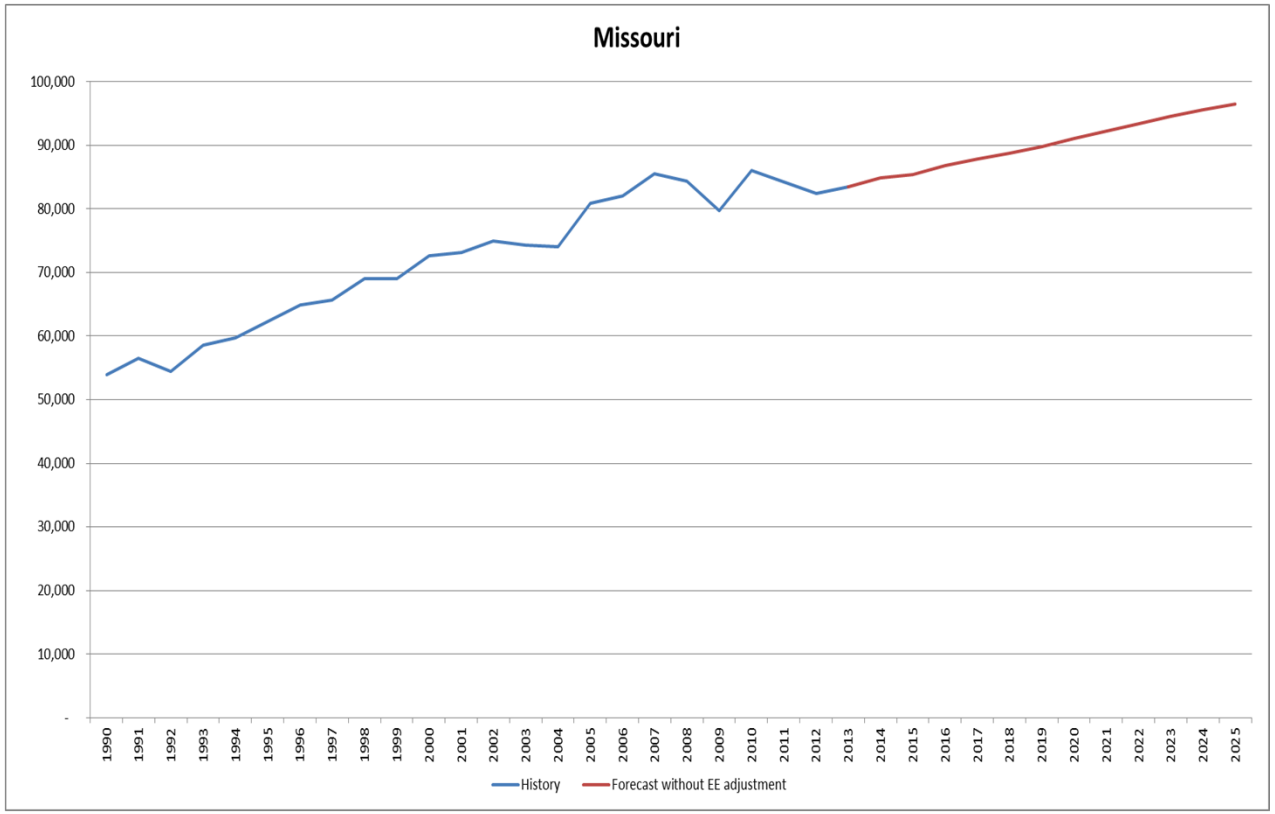
- 2016-2025 projected CAGR
  - gross 1.76%
- 1990-2013 actual CAGR
  - 1.83%



CAGR – Compound Annual Growth Rate

Missouri Retail Sales (GWh)

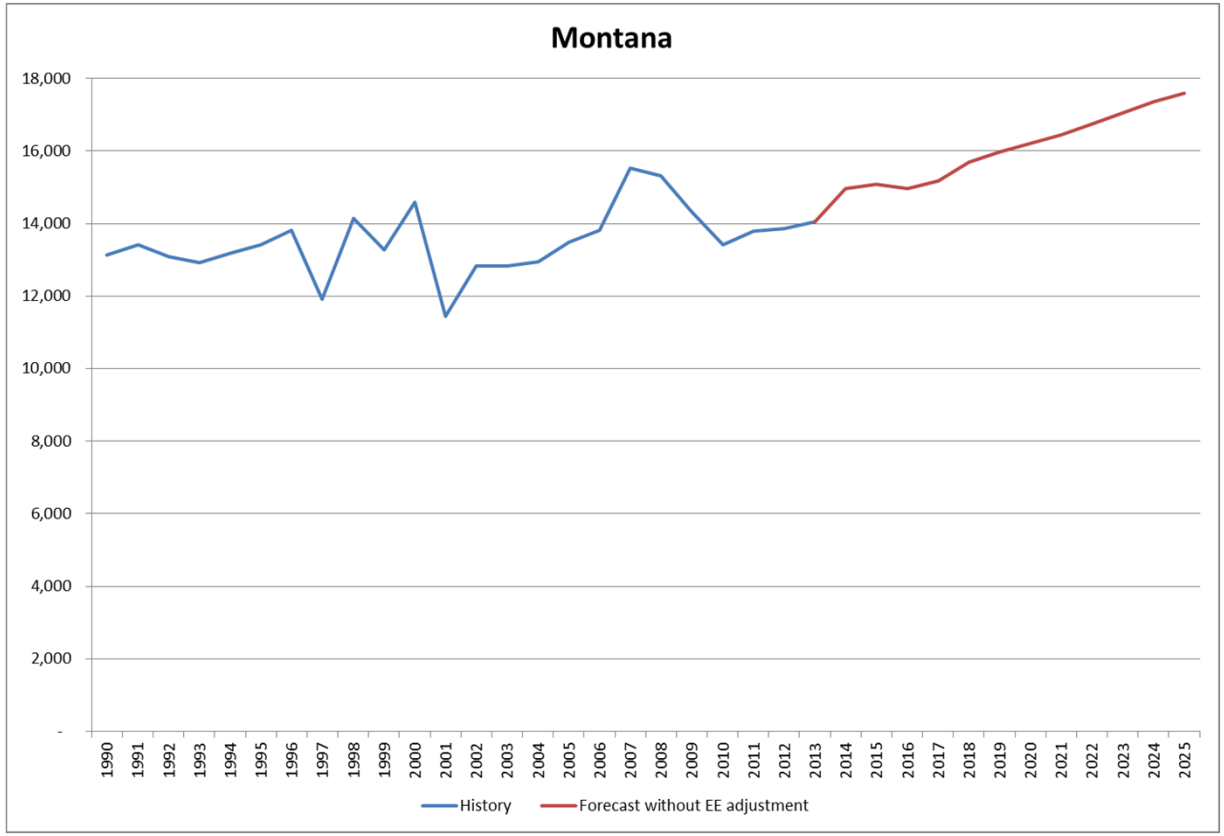
- 2016-2025 projected CAGR
  - gross 1.18%
- 1990-2013 actual CAGR
  - 1.92%



CAGR – Compound Annual Growth Rate

Montana Retail Sales (GWh)

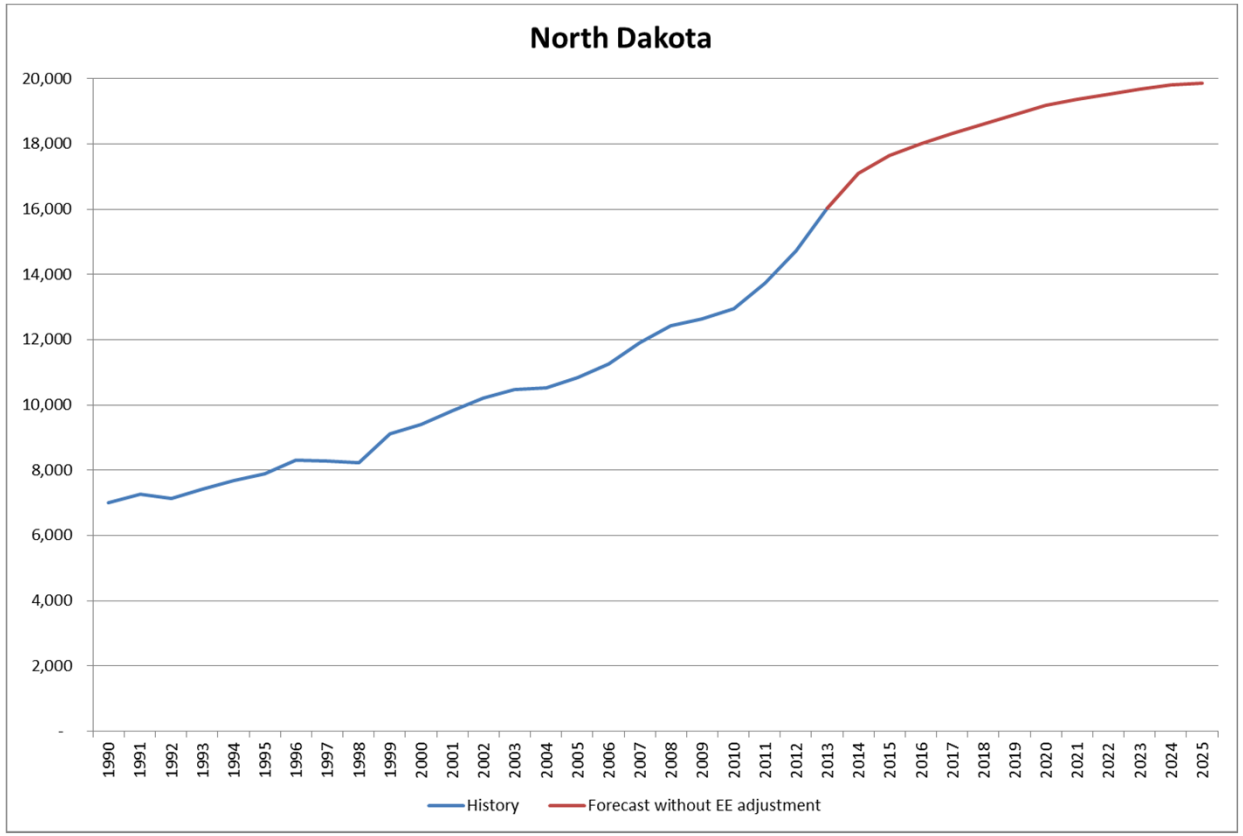
- 2016-2025 projected CAGR
  - gross 1.82%
- 1990-2013 actual CAGR
  - 0.29%



CAGR – Compound Annual Growth Rate

North Dakota Retail Sales (GWh)

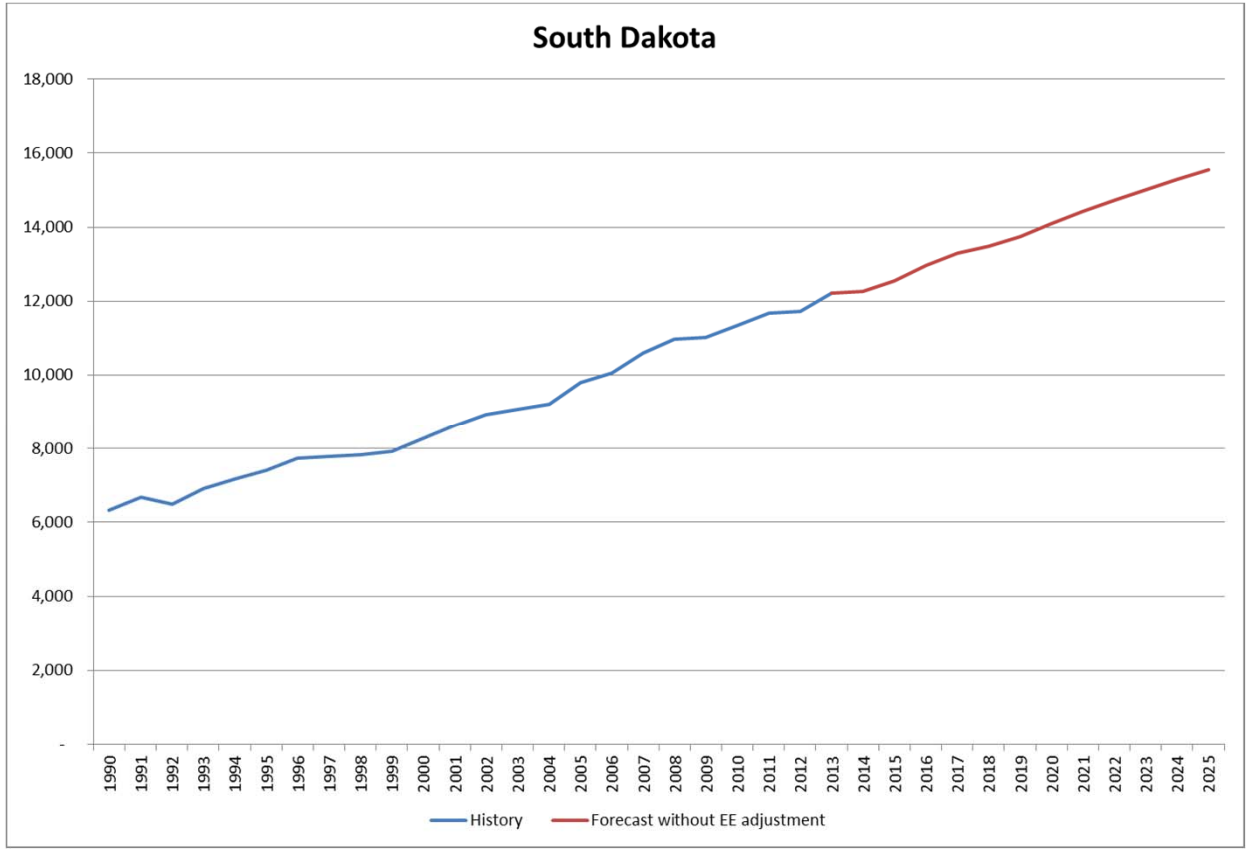
- 2016-2025 projected CAGR
  - gross 1.08%
- 1990-2013 actual CAGR
  - 3.66%



CAGR – Compound Annual Growth Rate

South Dakota Retail Sales (GWh)

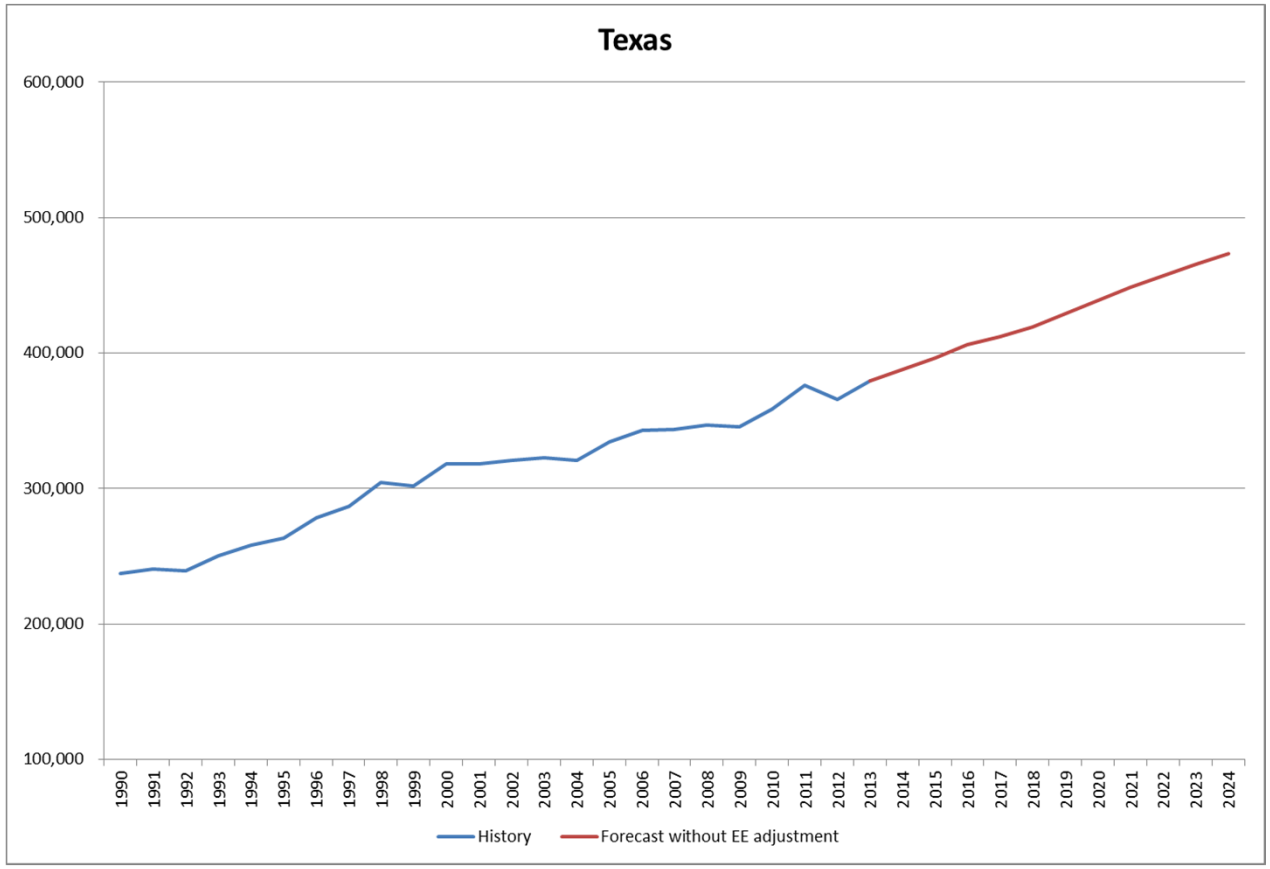
- 2016-2025 projected CAGR
  - gross 2.02%
- 1990-2013 actual CAGR
  - 2.90%



CAGR – Compound Annual Growth Rate

Texas Retail Sales (GWh)

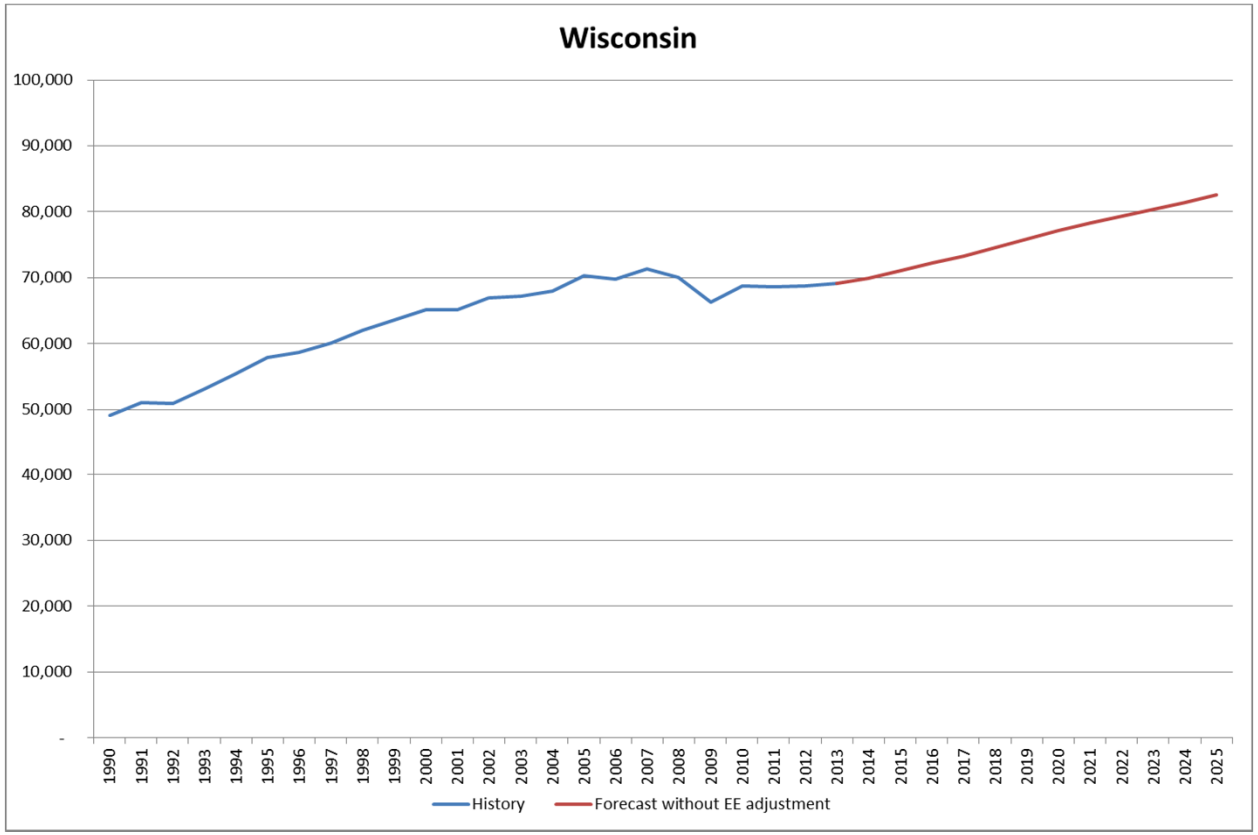
- 2016-2025 projected CAGR
  - gross 1.91%
- 1990-2013 actual CAGR
  - 2.06%



CAGR – Compound Annual Growth Rate

Wisconsin Retail Sales (GWh)

- 2016-2025 projected CAGR
  - gross 1.49%
- 1990-2013 actual CAGR
  - 1.49%



CAGR – Compound Annual Growth Rate

LRZ Energy Forecasts

Retail Sales vs. Metered Load

- The state-level forecasts are developed for retail sales (customer level) but the LRZ forecasts need to be for metered loads (substation level)
- The difference is primarily due to losses on the distribution system
- We have calculated an adjustment based on historical data

EE/DR Adjustments

- Net forecasts are determined using adjustments for energy efficiency and demand response at the LRZ level
- The economic potential from the AEG study was input to EGEAS; the amount selected by EGEAS is used here

LRZ Gross* Metered Load (GWh)

Year	LRZ1	LRZ2	LRZ3	LRZ4	LRZ5	LRZ6	LRZ7	LRZ8	LRZ9	LRZ`10
2014	98,715	65,959	46,385	50,717	43,973	104,714	101,227	37,452	106,448	22,897
2015	99,938	67,058	47,432	51,069	44,176	104,846	102,860	37,949	108,487	22,917
2016	101,565	68,040	48,086	51,501	44,815	106,134	103,717	38,275	111,573	23,329
2017	103,429	69,094	48,749	51,820	45,245	107,278	105,012	38,650	113,379	23,726
2018	105,123	70,148	49,613	52,123	45,610	108,561	105,595	39,076	115,534	24,250
2019	106,834	71,398	50,426	52,565	46,044	110,067	106,390	39,704	118,239	24,758
2020	108,716	72,600	51,258	52,989	46,604	111,623	107,890	40,209	120,758	25,224
2021	110,539	73,578	52,042	53,314	47,117	113,008	108,894	40,520	122,988	25,628
2022	112,351	74,476	52,871	53,602	47,621	114,224	109,338	40,805	125,136	26,028
2023	114,083	75,443	53,671	53,855	48,091	115,440	110,193	41,120	127,202	26,445
2024	115,769	76,436	54,473	54,157	48,533	116,667	111,200	41,501	129,633	26,867
2025	117,445	77,426	55,274	54,473	48,880	117,911	112,274	41,862	131,887	27,293
Compound Annual Growth Rates (%)										
2014-2019	1.59	1.60	1.68	0.72	0.92	1.00	1.00	1.17	2.12	1.58
2014-2025	1.59	1.47	1.61	0.65	0.97	1.08	0.95	1.02	1.97	1.61
2016-2025	1.63	1.45	1.56	0.63	0.97	1.18	0.88	1.00	1.88	1.76

* Without adjustment for EE/DR

LRZ Net* Metered Load (GWh)

Year	LRZ1	LRZ2	LRZ3	LRZ4	LRZ5	LRZ6	LRZ7	LRZ8	LRZ9	LRZ10
2014	98,715	65,959	46,385	50,717	43,973	104,714	101,227	37,452	106,448	22,897
2015	99,696	66,772	47,137	50,781	43,920	104,528	102,450	37,857	108,433	22,894
2016	101,187	67,618	47,556	51,025	44,358	105,594	103,127	38,128	111,465	23,287
2017	102,903	68,543	47,981	51,156	44,588	106,511	104,248	38,446	113,210	23,665
2018	104,435	69,470	48,602	51,270	44,755	107,559	104,660	38,813	115,292	24,170
2019	105,971	70,596	49,169	51,523	44,991	108,822	105,286	39,379	117,912	24,657
2020	107,661	71,683	49,752	51,760	45,354	110,130	106,624	39,821	120,337	25,102
2021	109,287	72,553	50,284	51,897	45,672	111,261	107,471	40,066	122,464	25,485
2022	110,890	73,350	50,856	51,998	45,983	112,218	107,763	40,283	124,498	25,863
2023	112,402	74,220	51,396	52,065	46,261	113,167	108,471	40,528	126,441	26,258
2024	113,858	75,119	51,933	52,180	46,513	114,120	109,334	40,835	128,738	26,657
2025	115,302	76,056	52,470	52,330	46,695	115,104	110,316	41,123	130,852	27,065
Compound Annual Growth Rates (%)										
2014-2019	1.43	1.37	1.17	0.32	0.46	0.77	0.79	1.01	2.07	1.49
2014-2025	1.42	1.30	1.13	0.29	0.55	0.86	0.78	0.85	1.89	1.53
2016-2025	1.46	1.32	1.10	0.28	0.57	0.96	0.75	0.84	1.80	1.68

* With adjustment for state EE programs

LRZ Peak Demand

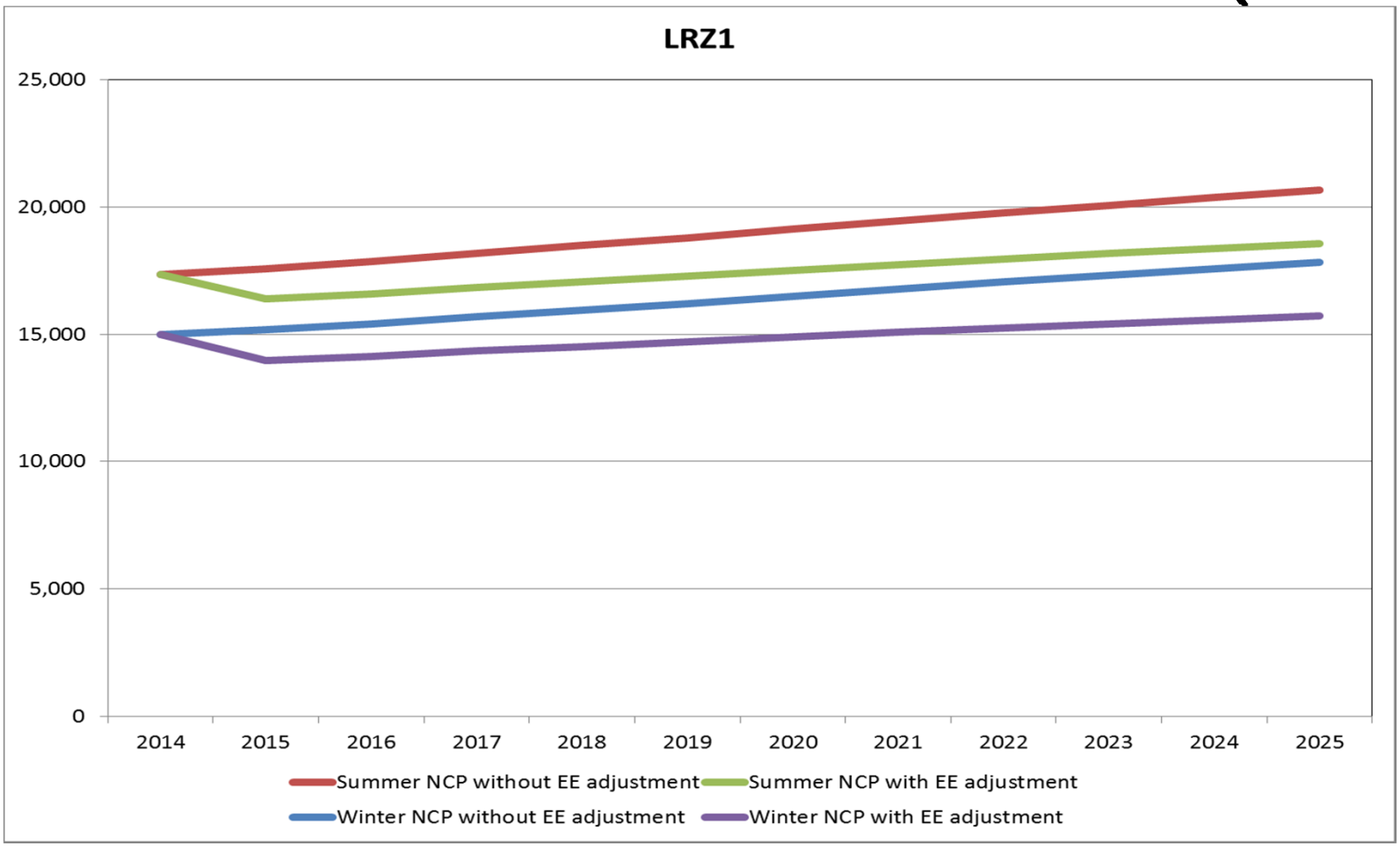
Metered Load vs. Resource Needs

- The peak demand forecasts are developed for metered loads (substation level) but resource needs are determined at the generator level
- The difference is primarily due to losses on the transmission system
- We have NOT calculated an adjustment because we do not have the necessary data
- We will work with MISO to get that data

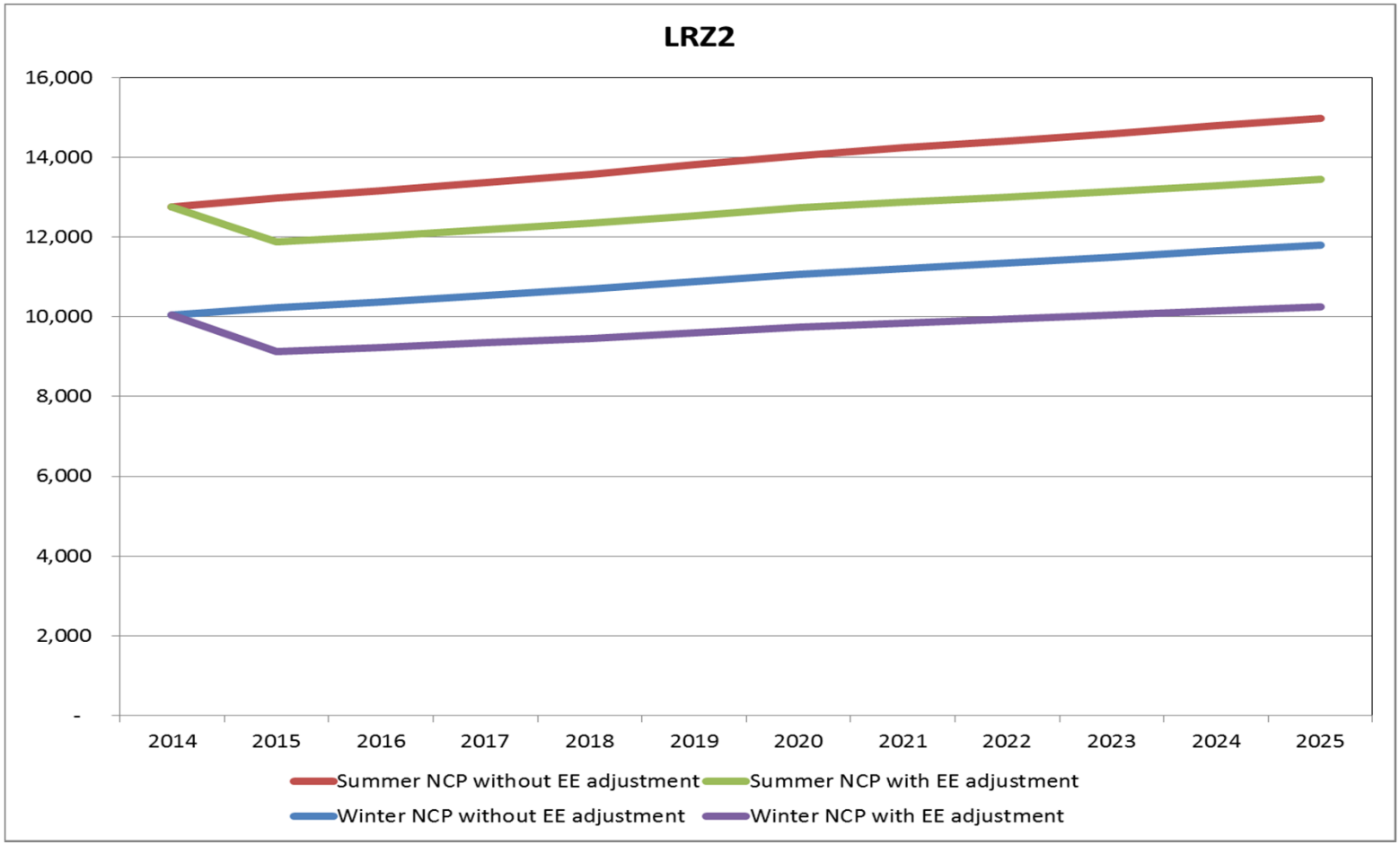
LRZ Non-coincident Peaks

- The following slides provide LRZ summer and winter peak demands that are non-coincident with the MISO peak
- Thus, the arithmetic sum of the LRZ peaks is greater than the MISO coincident peak

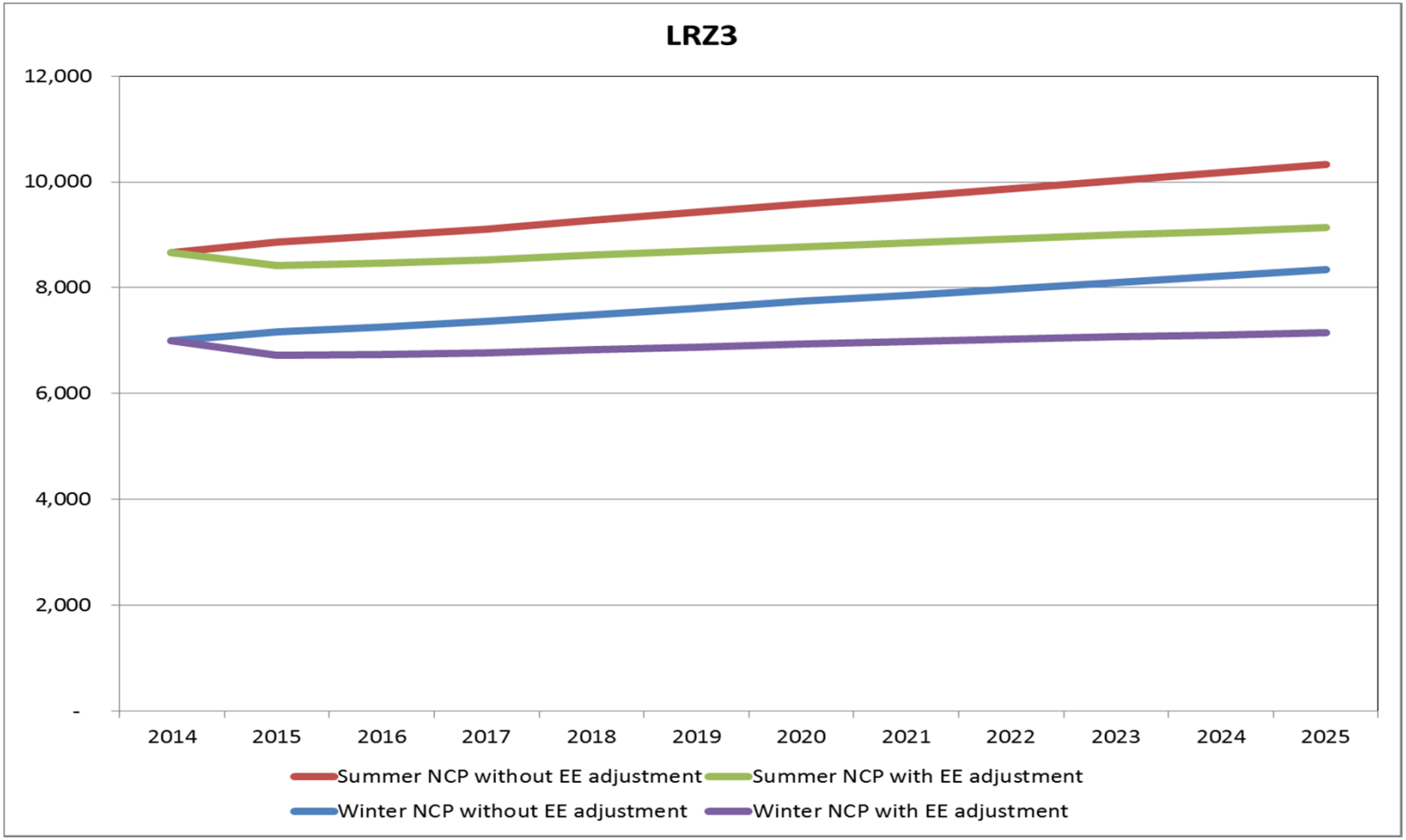
LRZ 1 Non-coincident Peak (MW)



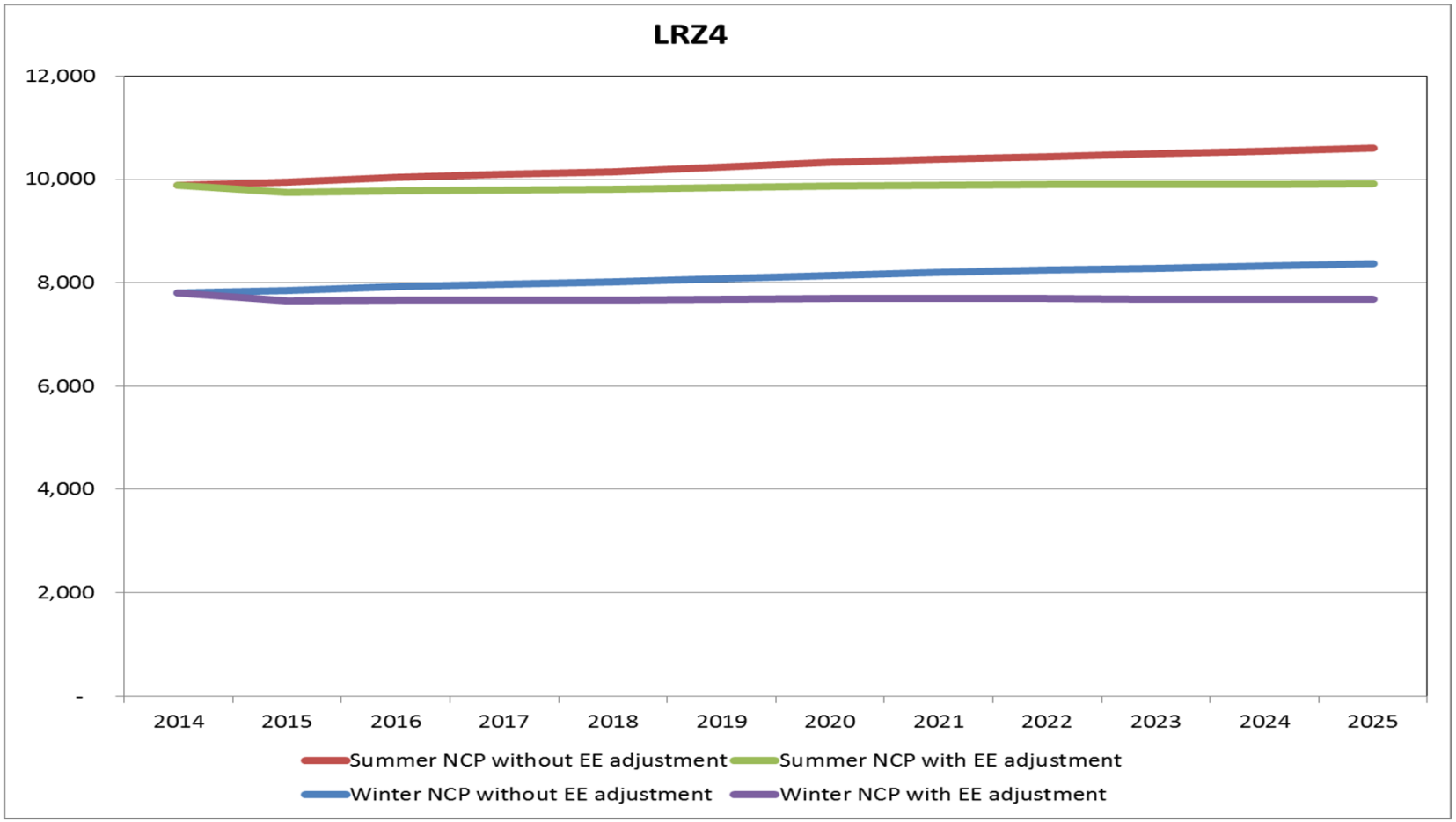
LRZ 2 Non-coincident Peak (MW)



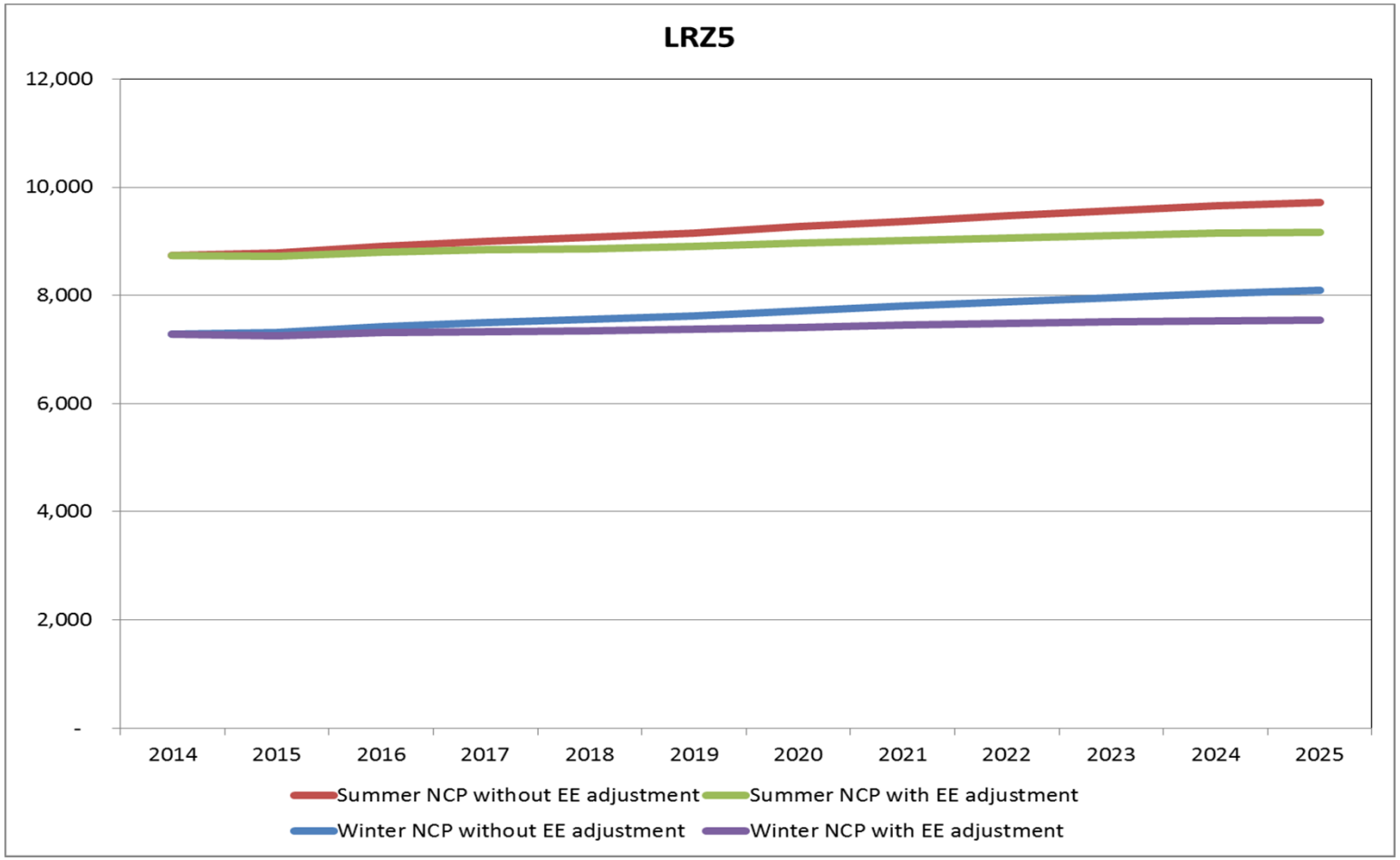
LRZ 3 Non-coincident Peak (MW)



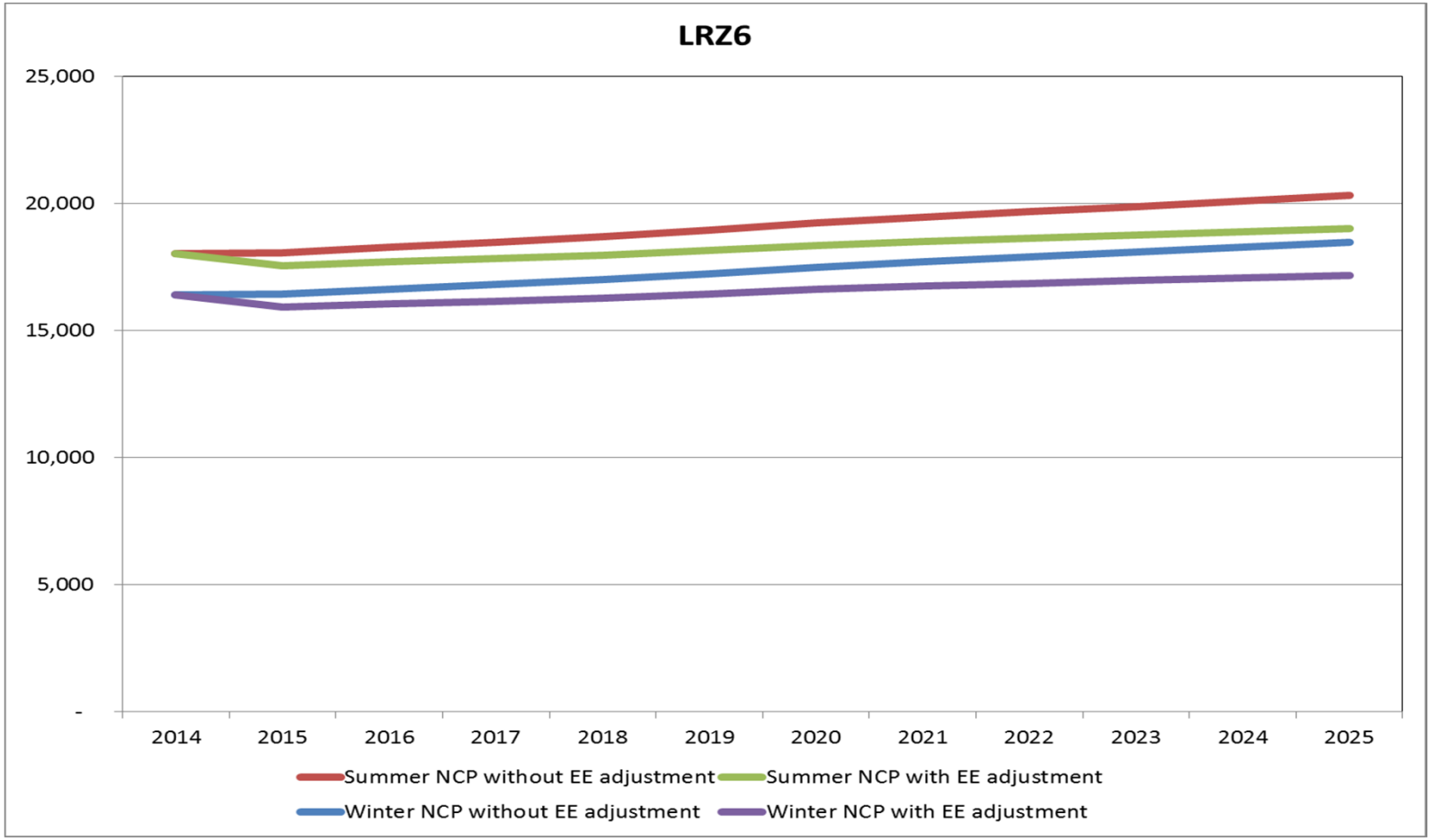
LRZ 4 Non-coincident Peak (MW)



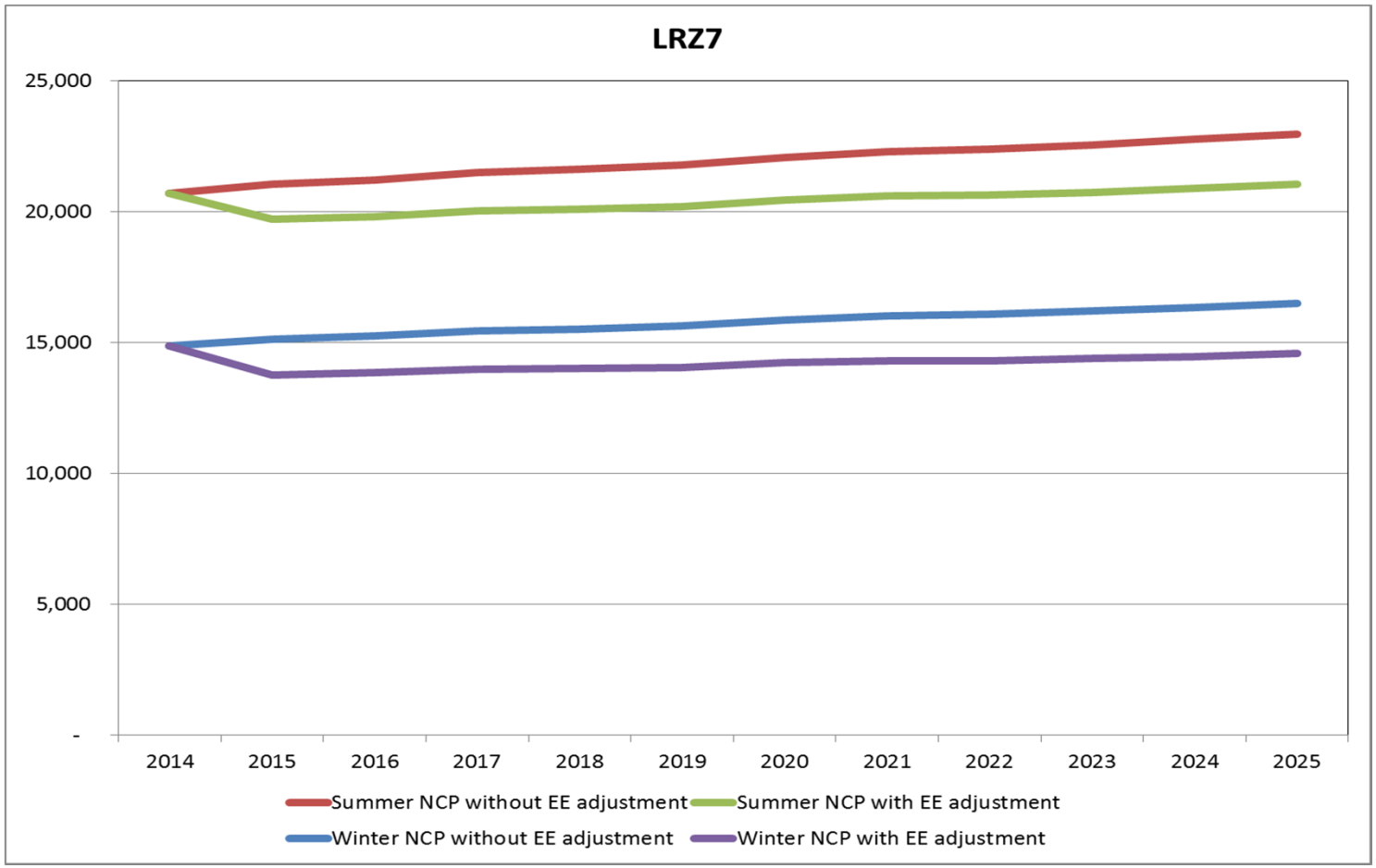
LRZ 5 Non-coincident Peak (MW)



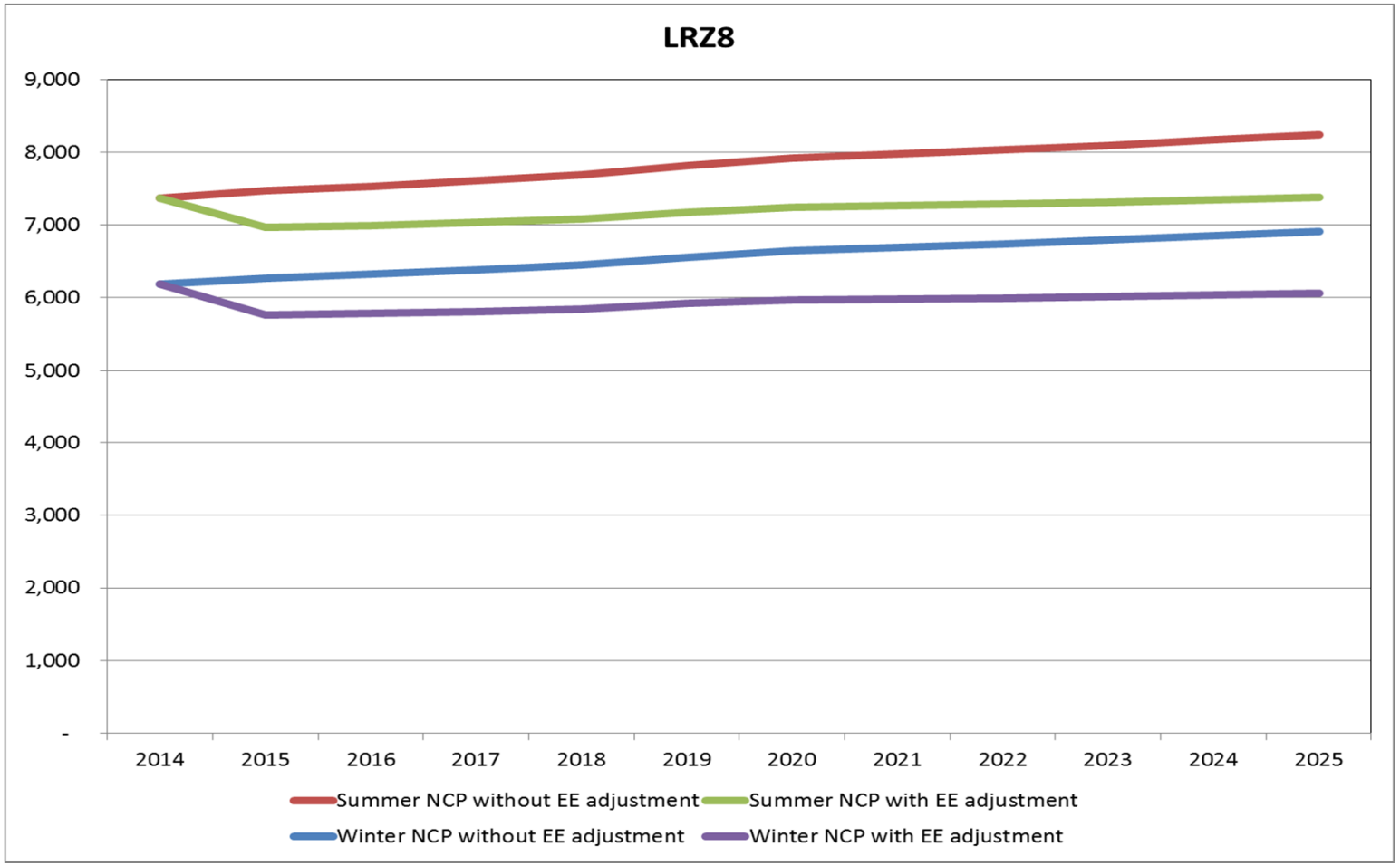
LRZ 6 Non-coincident Peak (MW)



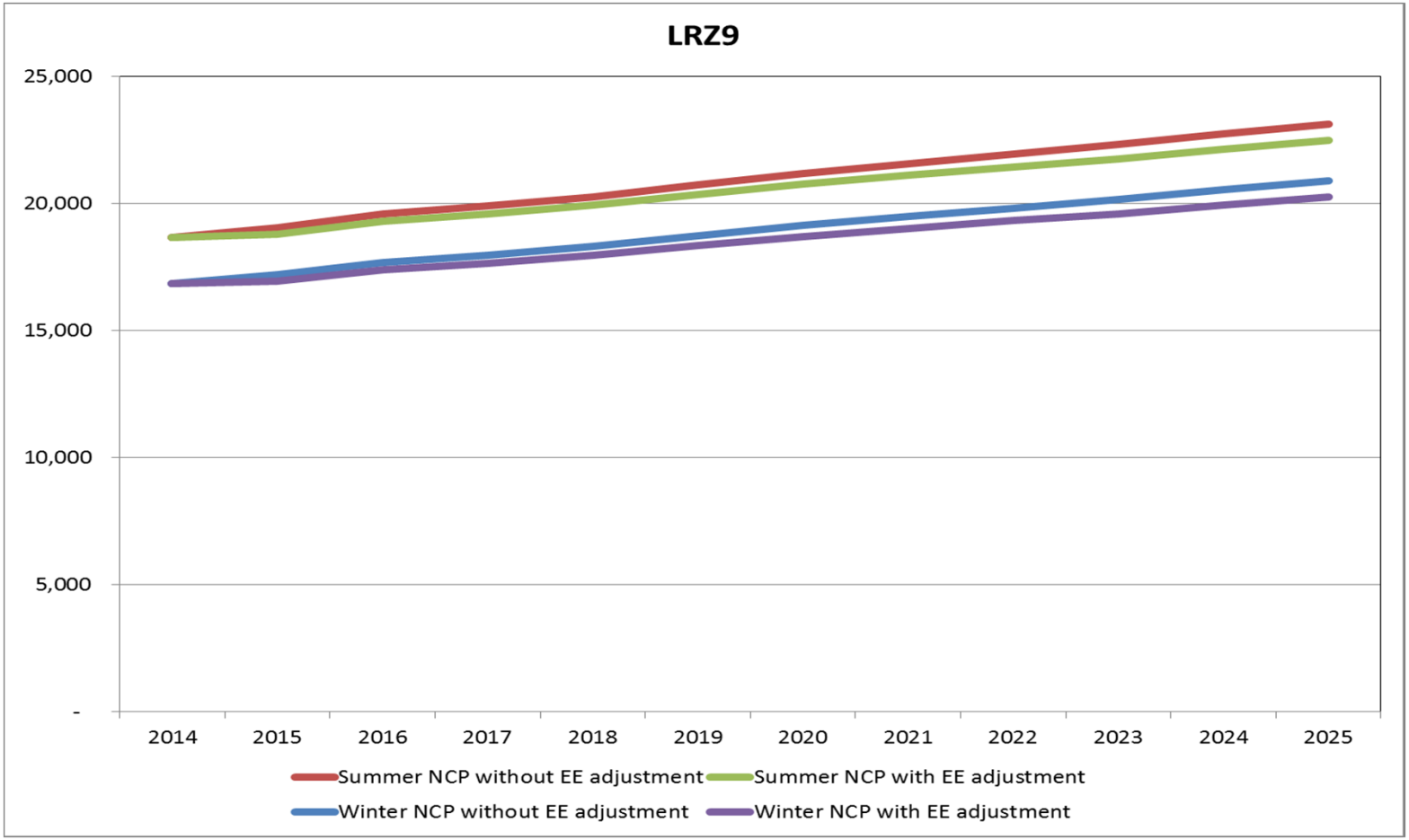
LRZ 7 Non-coincident Peak (MW)



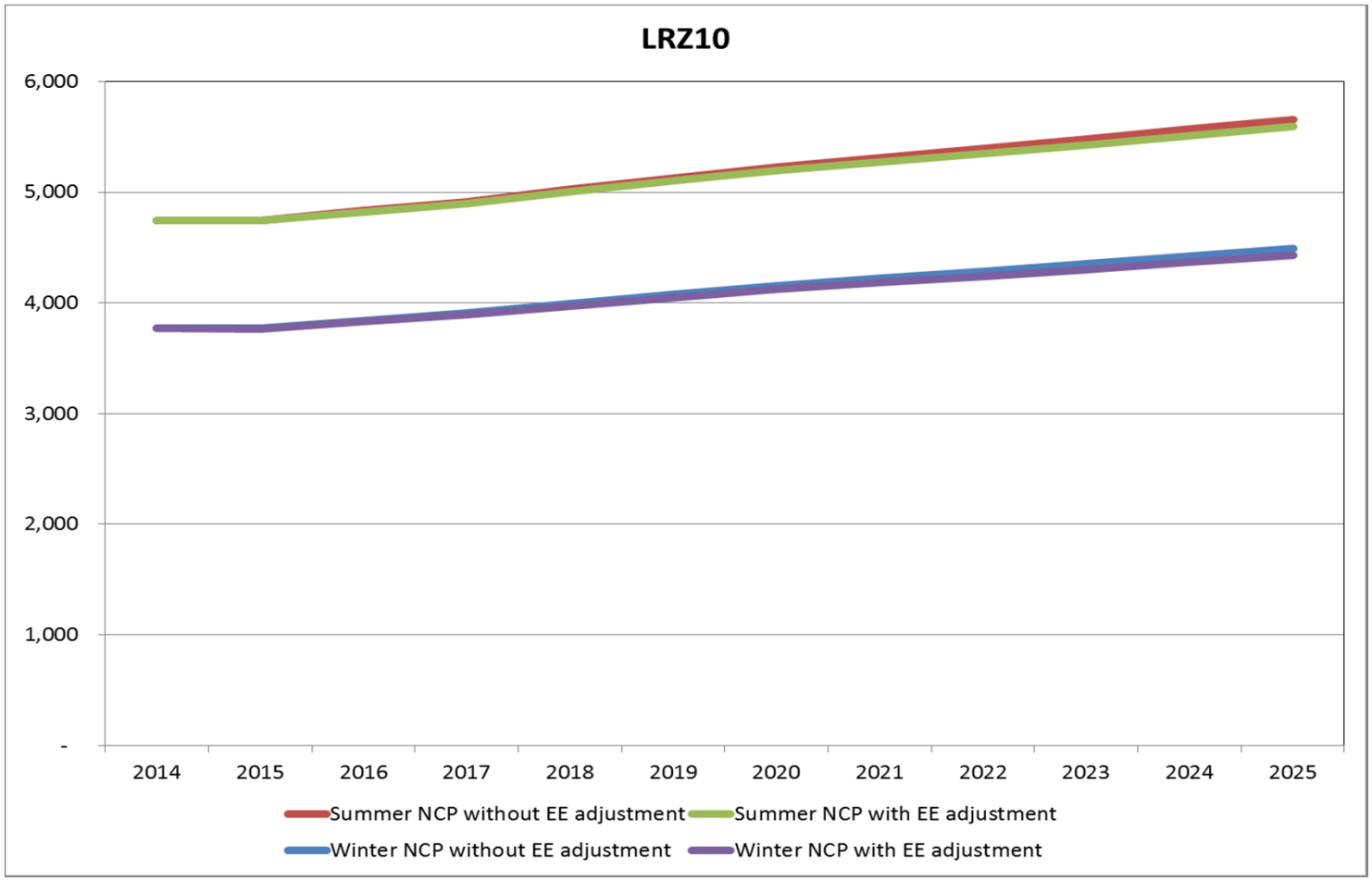
LRZ 8 Non-coincident Peak (MW)



LRZ 9 Non-coincident Peak (MW)



LRZ 10 Non-coincident Peak (MW)



MISO Level Forecasts

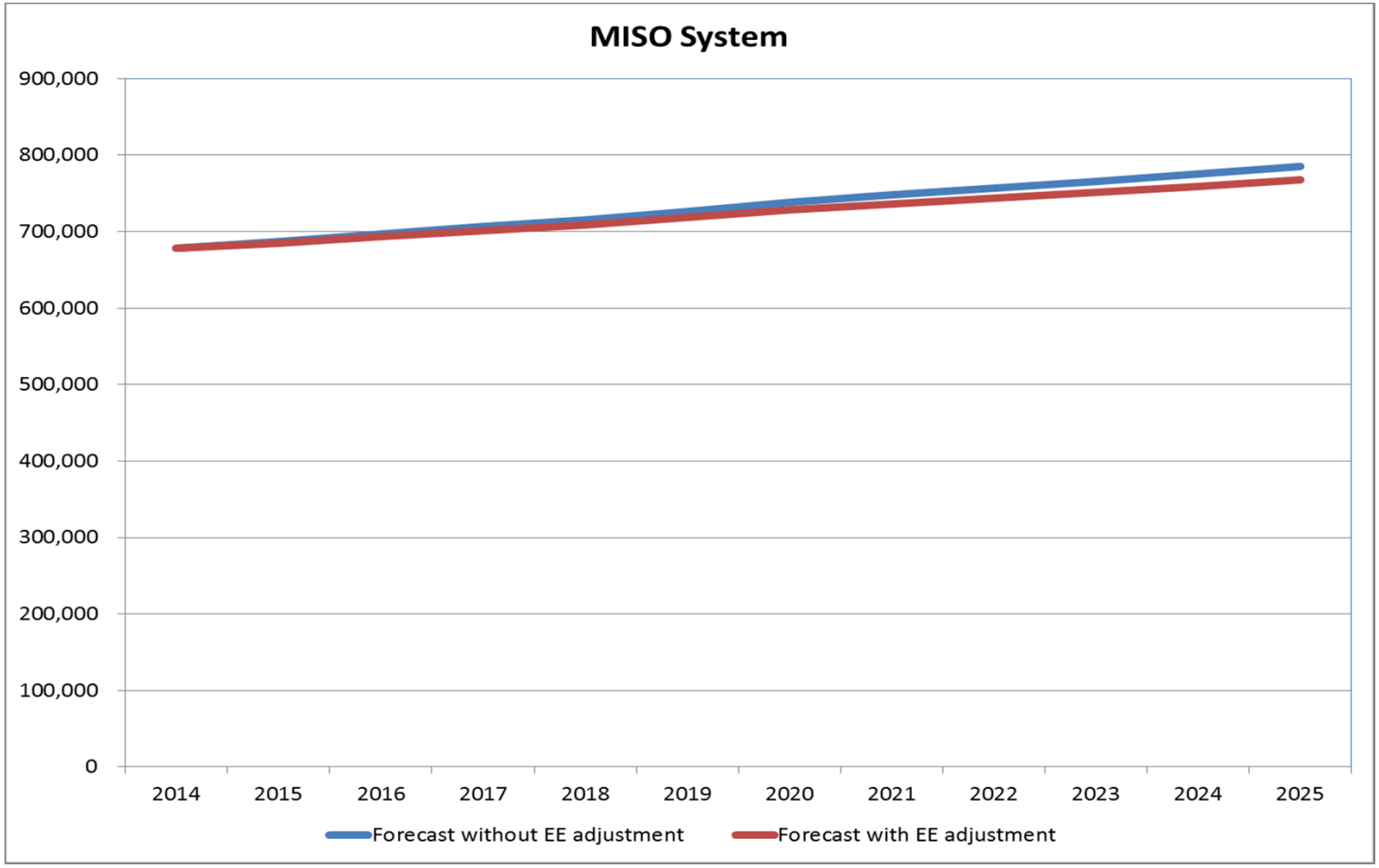
Energy and Peak Demand

- The MISO system energy and peak demand projections here are at the metered load (substation) level
- Energy is the arithmetic sum of the LRZ energy forecasts
- Peak demand is determined using coincidence factors

MISO Energy (Metered Load in GWh)

Year	MISO energy without EE adjustment	MISO energy with EE adjustment
2014	678,488	678,488
2015	686,732	684,470
2016	697,034	693,347
2017	706,381	701,249
2018	715,632	709,026
2019	726,424	718,306
2020	737,872	728,224
2021	747,627	736,440
2022	756,452	743,702
2023	765,542	751,209
2024	775,235	759,288
2025	784,725	767,314
Compound Annual Growth Rates (%)		
2014-2019	1.37	1.15
2014-2025	1.33	1.12
2016-2025	1.33	1.13

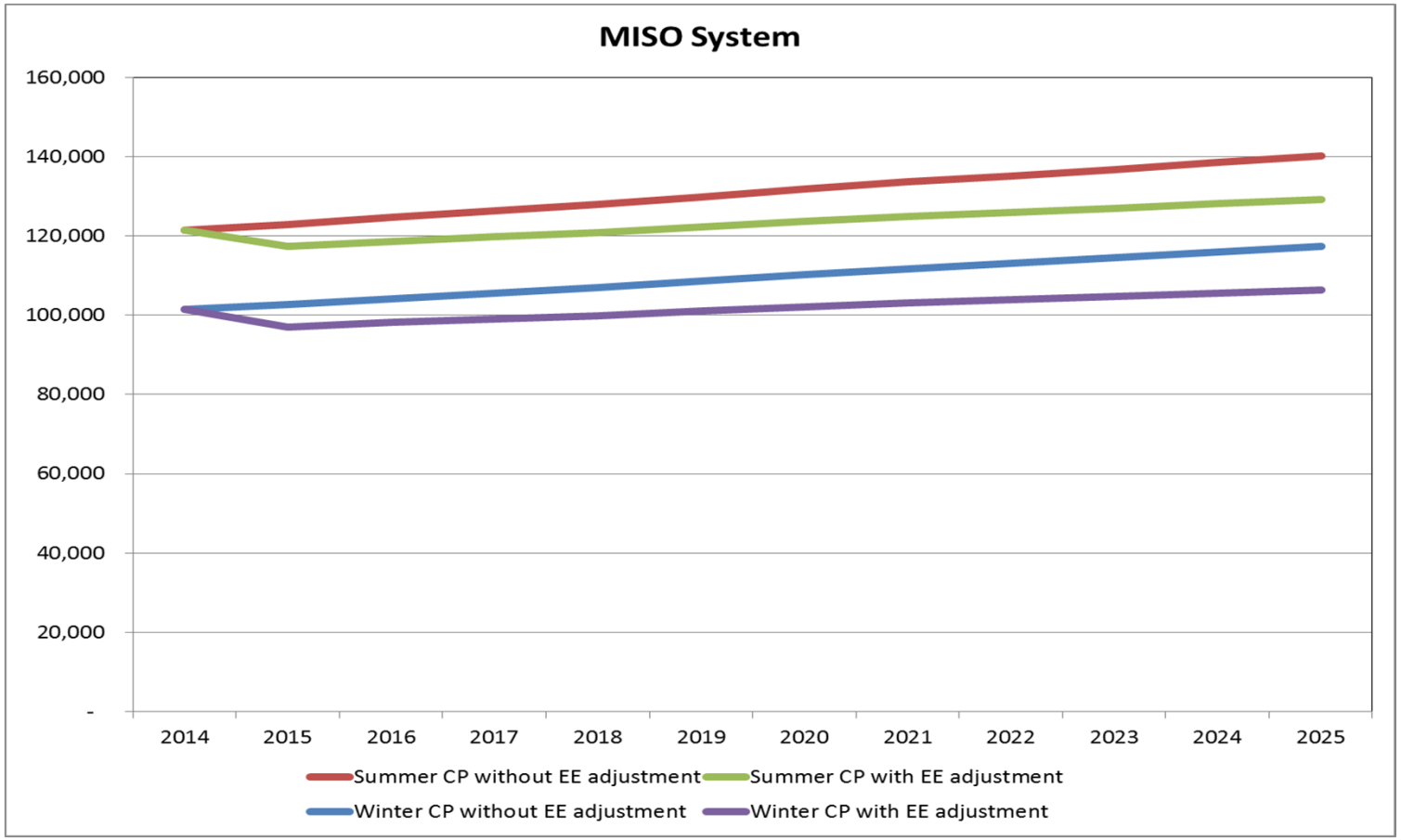
MISO Energy (Metered Load in GWh)



MISO Coincident Peak Demand (Metered Load in MW)

Year	MISO Summer CP without EE adjustment	MISO Summer CP with EE adjustment	MISO Winter CP without EE adjustment	MISO Winter CP with EE adjustment
2014	121,415	121,415	101,453	101,453
2015	122,895	117,302	102,669	97,076
2016	124,695	118,603	104,203	98,111
2017	126,354	119,773	105,595	99,014
2018	127,974	120,894	106,976	99,896
2019	129,868	122,270	108,587	100,989
2020	131,894	123,759	110,291	102,156
2021	133,610	124,948	111,745	103,083
2022	135,150	125,950	113,064	103,864
2023	136,749	126,998	114,420	104,670
2024	138,452	128,139	115,863	105,549
2025	140,123	129,258	117,274	106,408
Compound Annual Growth Rates (%)				
2014-2019	1.36	0.14	1.37	-0.09
2014-2025	1.31	0.57	1.33	0.43
2016-2025	1.30	0.96	1.32	0.91

MISO Coincident Peak Demand (Metered Load in MW)



Comments

- Stakeholder comments are welcome
- Please provide comments by October 20th to allow for incorporation in the final report, which is due November 1st

Contact Information

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