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Discussion of Short-Term Electricity Demand Forecasting Model and Preliminary Results

February 13, 2007

Objective

- Create an hourly model to forecast regional loads 3-5 years forward.
- Create a model that can be used for Resource Adequacy
- Needs to be Hourly
- Needs to accommodate a wide range of historic temperature conditions.

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Definitions

- Weather-normalized load:

  Load under “normal” temperature conditions.

- Temperature-sensitive load:

  Load resulting from temperature deviations from normal temperature.

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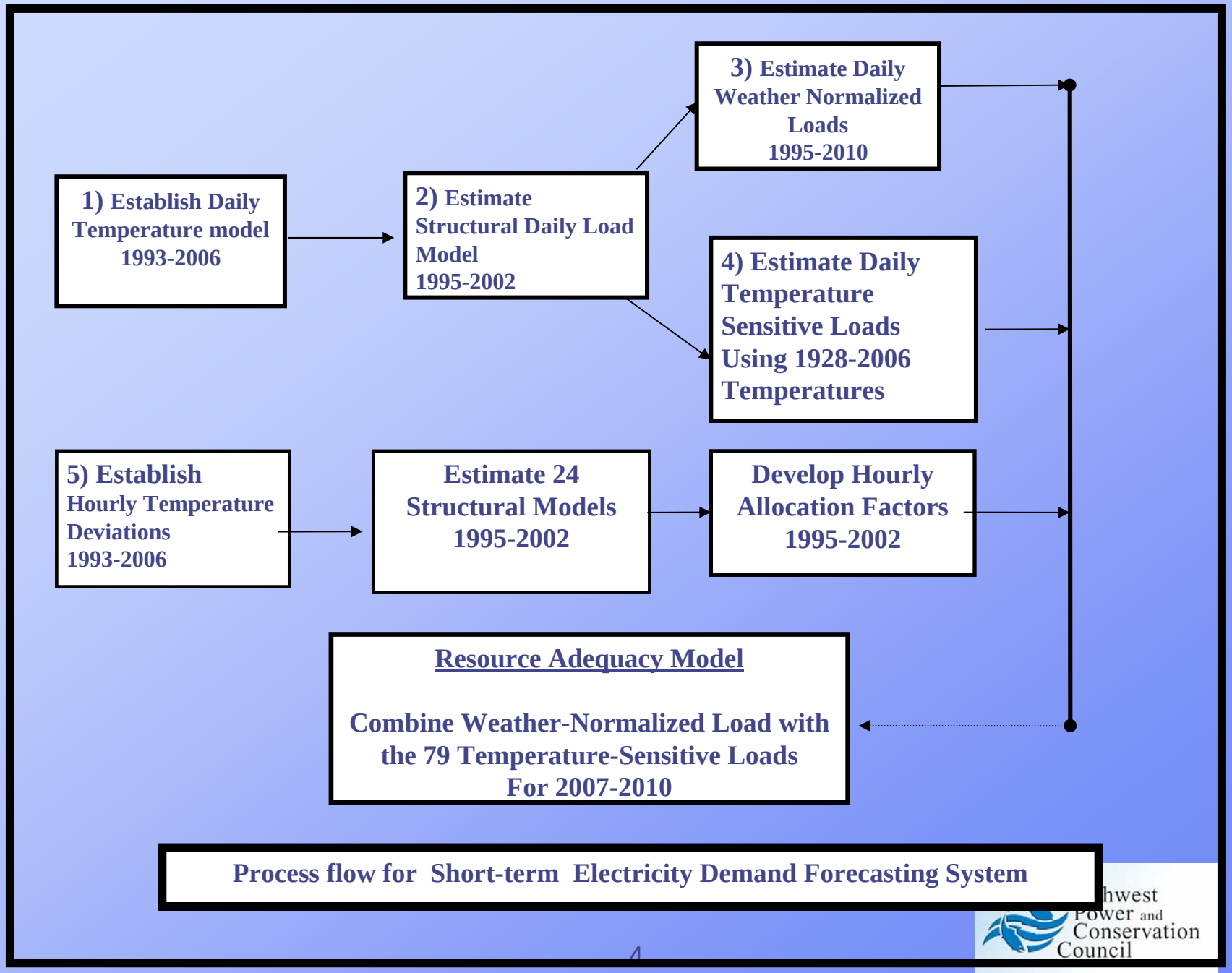

Process flow for Short-term Electricity Demand Forecasting System

Data

Five data sets were used

- Hourly load data for 1995-2002 from Northwest Power Pool
- Hourly temperatures data for 1990-2006 from Western Regional Climate Center
- Monthly employment data for 1995-2006 from Bureau of Labor Statistics.
- Monthly electricity rates data for 1995-2006 from Energy Information Administration
- Hourly Direct Service Industry load data for 1993-2006 from Bonneville Power Administration
- Forecast of regional employment from Global Insight.

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Model Structure

- A structural time series model is adopted to represent the demand for electricity in the region . The general specification of the demand model is represented by **.**
- where: L= f(S, W,DE, I)
- *L* = net average daily electricity load in the region (net of Direct Service Industries)
- *S* = variables depicting seasonal variations in load,
- *W* = weather variables generated via a regression model
- *DE* = demographic and economic variables, and
- *I* = indicator or dummy variables.

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Demographic and Economic Trend Variables

- Regional Employment (seasonally adjusted employment for four states)
- Regional Electricity rate ($/MWH)

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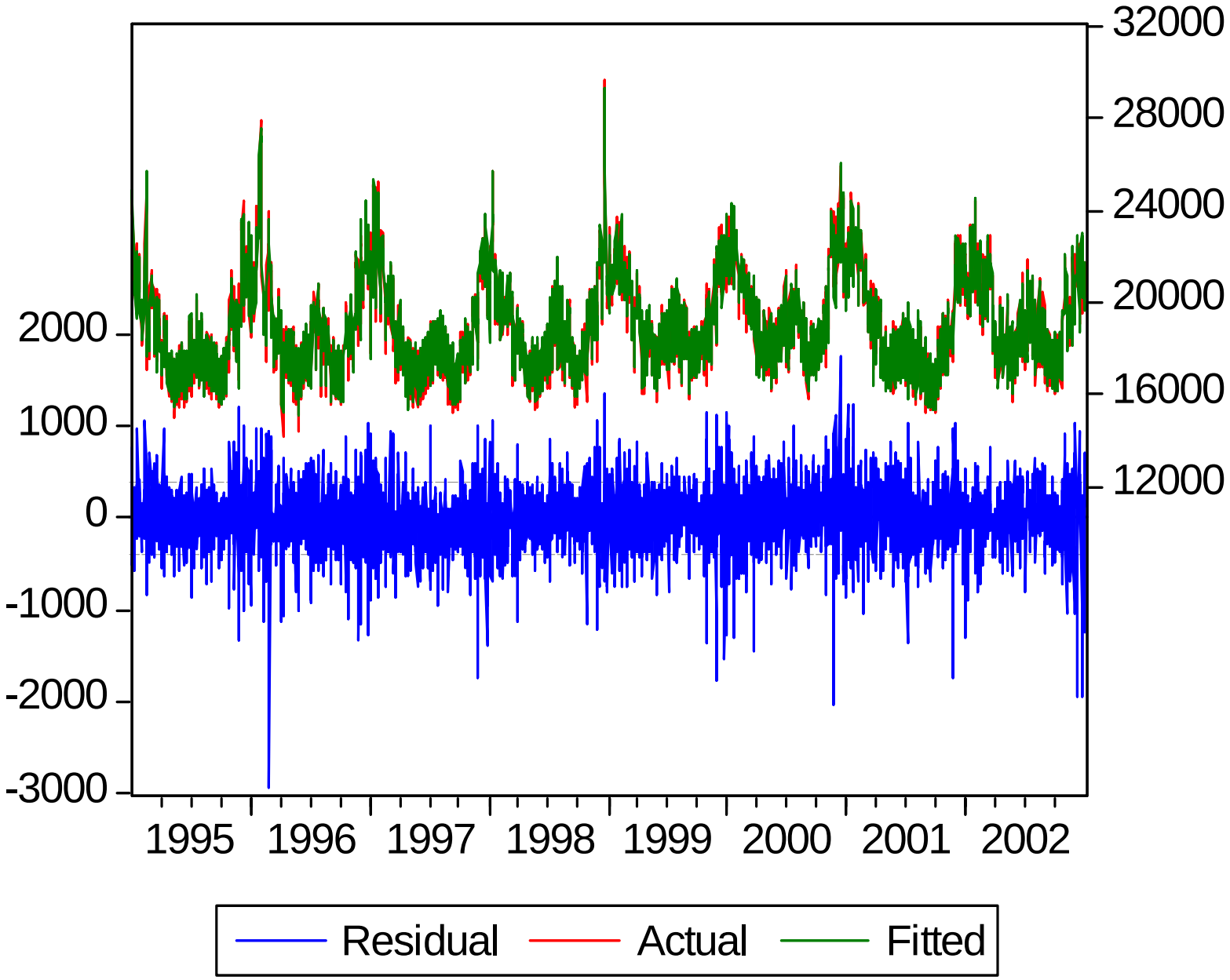
32000
28000
24000
20000
16000
12000
2000
1000
0
-1000
-2000
-3000
1995
1996
1997
1998
1999
2000
2001
2002
Residual
Actual
Fitted

Model Validity

- Mean Absolute Percentage Error (MAPE) of the forecast MAPE was 1.5%.
- Maximum Absolute Percent Error was 15%

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Weather Normalized Load Forecast and comparison to the Long-term Model

	Council's Long-Term Model Forecast					Short-Term Model	(Weather-Normalized)
	Low	Med lo	Medium	Med hi	High	Energy MWa	Peak Load MW
2000			19,187			19,547	25,949
2001			18,671			18,906	23,616
2002			18,696			19,454	23,666
2003			19,124			19,560	23,694
2004			19,699			19,829	23,824
2005	18,738	19,428	20,092	20,732	22,040	20,138	24,057
2006	18,748	19,571	20,343	21,102	22,592	20,408	24,323
2007	18,764	19,727	20,607	21,496	23,170	20,613	24,367
2008	18,778	19,880	20,868	21,901	23,777	20,773	24,664
2009	18,810	20,053	21,151	22,322	24,413	20,919	24,800
2010	18,853	20,242	21,460	22,758	25,078	21,052	24,934

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Estimating Temperature Sensitive Loads

- Decomposing load forecast

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Load Fluctuations due to 1928-2006 Daily Temperature Deviations from Norm (MWa)

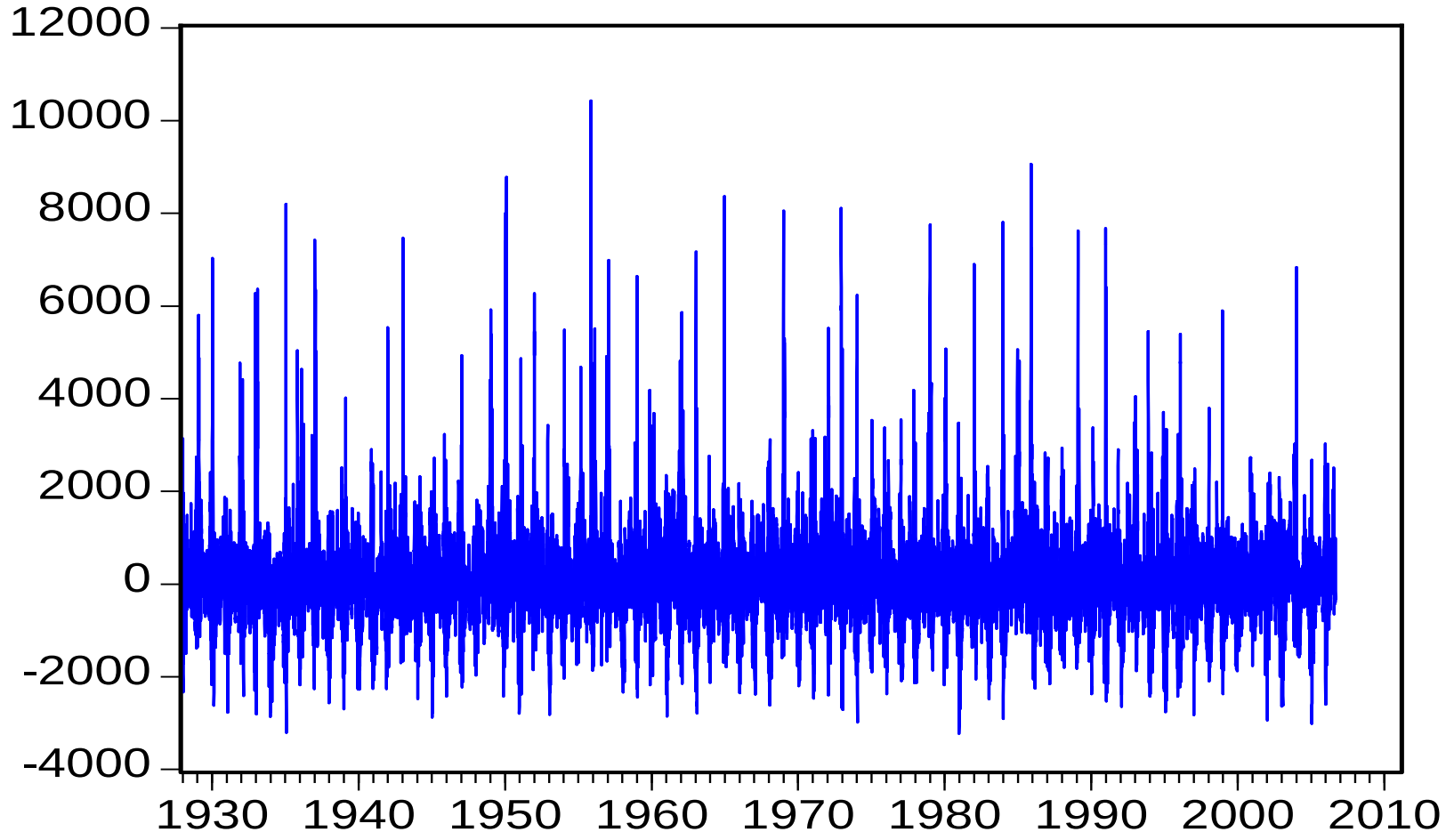

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Table 6 -Change in Temperature Sensitive portion of Regional Load Due to Daily Temperature Deviations

	Deviation of Daily temperature From Conditional Mean	Change in Daily Load (MW)	Temperature Profile Year	Deviation of Daily temperature From Conditional Mean	Change in Daily Load (MW)	Temperature Profile Year
January	-33	8,784	1950	18	(3,205)	1935
February	-30	8,149	1950	16	(2,786)	1963
March	-23	4,685	1955	16	(2,152)	1987
April	-16	3,450	1936	18	(1,443)	1992
May	-12	1,466	1965	17	(554)	1998
June	16	2,178	1992	-11	(646)	1955
July	14	2,449	2006	-12	(1,319)	1986
August	12	1,929	1992	-14	(1,744)	1956
September	-12	1,364	1988	13	(696)	1975
October	-17	4,453	1935	13	(1,430)	1937
November	-26	10,433	1955	13	(2,428)	1995
December	-24	8,365	1964	16	(3,236)	1980

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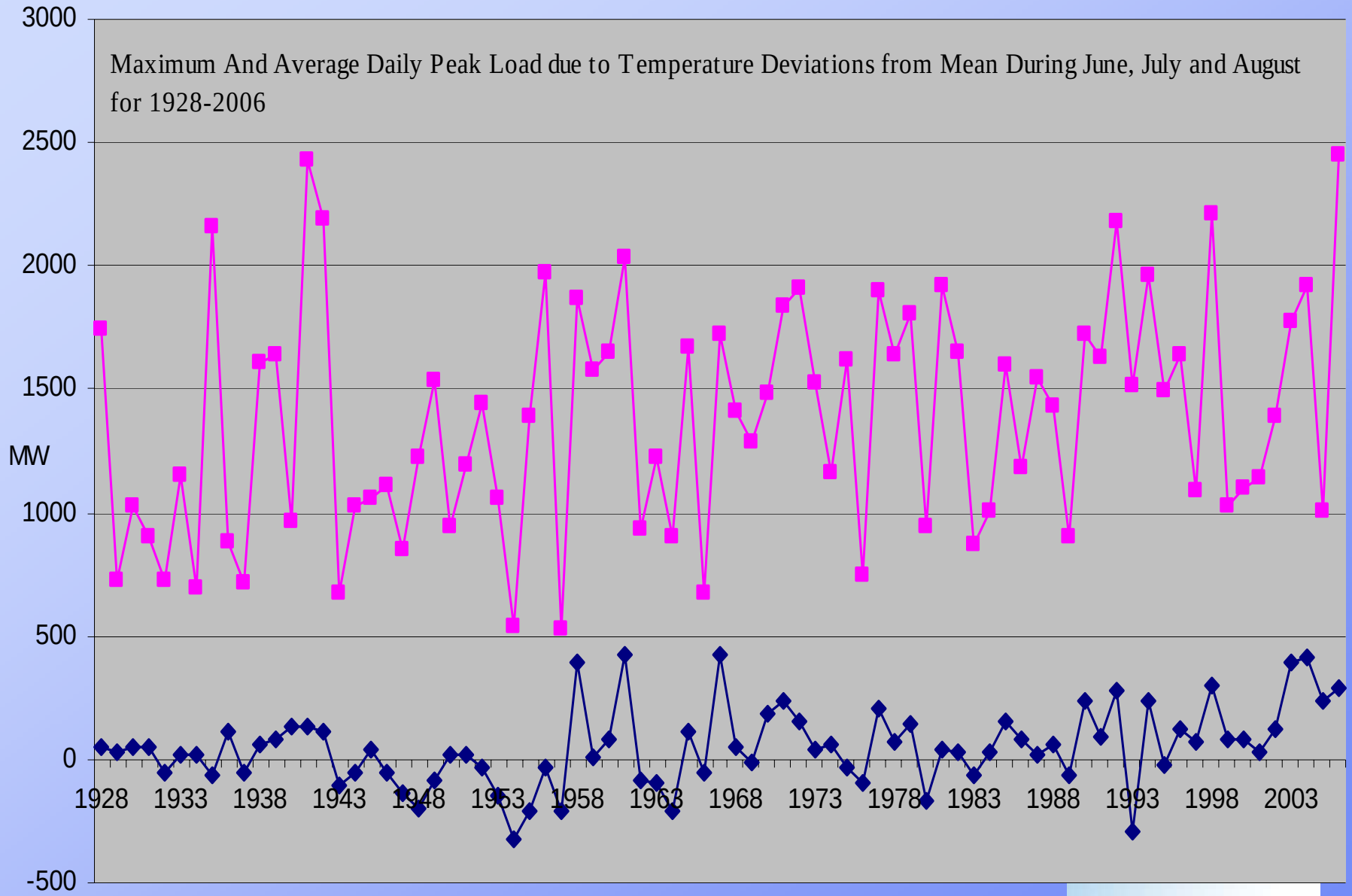

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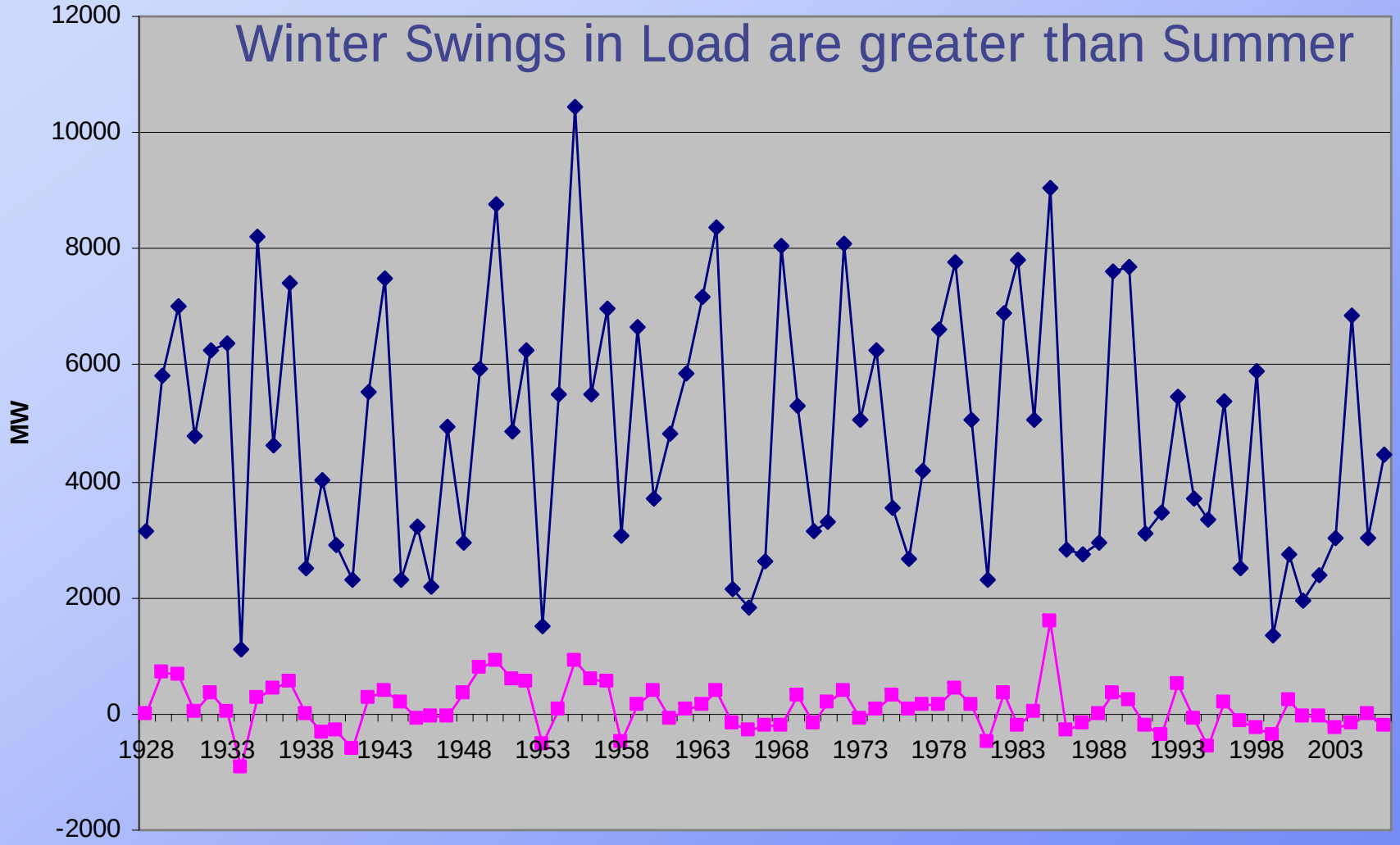
Winter Season Peak and Average Deviations in Load due to Deviations in Temperature



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Hourly Model

- 24 hourly time-series models using approximation approach similar to the daily model.
- Each equation was tested and fitted to hourly data from 1995-2002
- All insignificant variables were removed.

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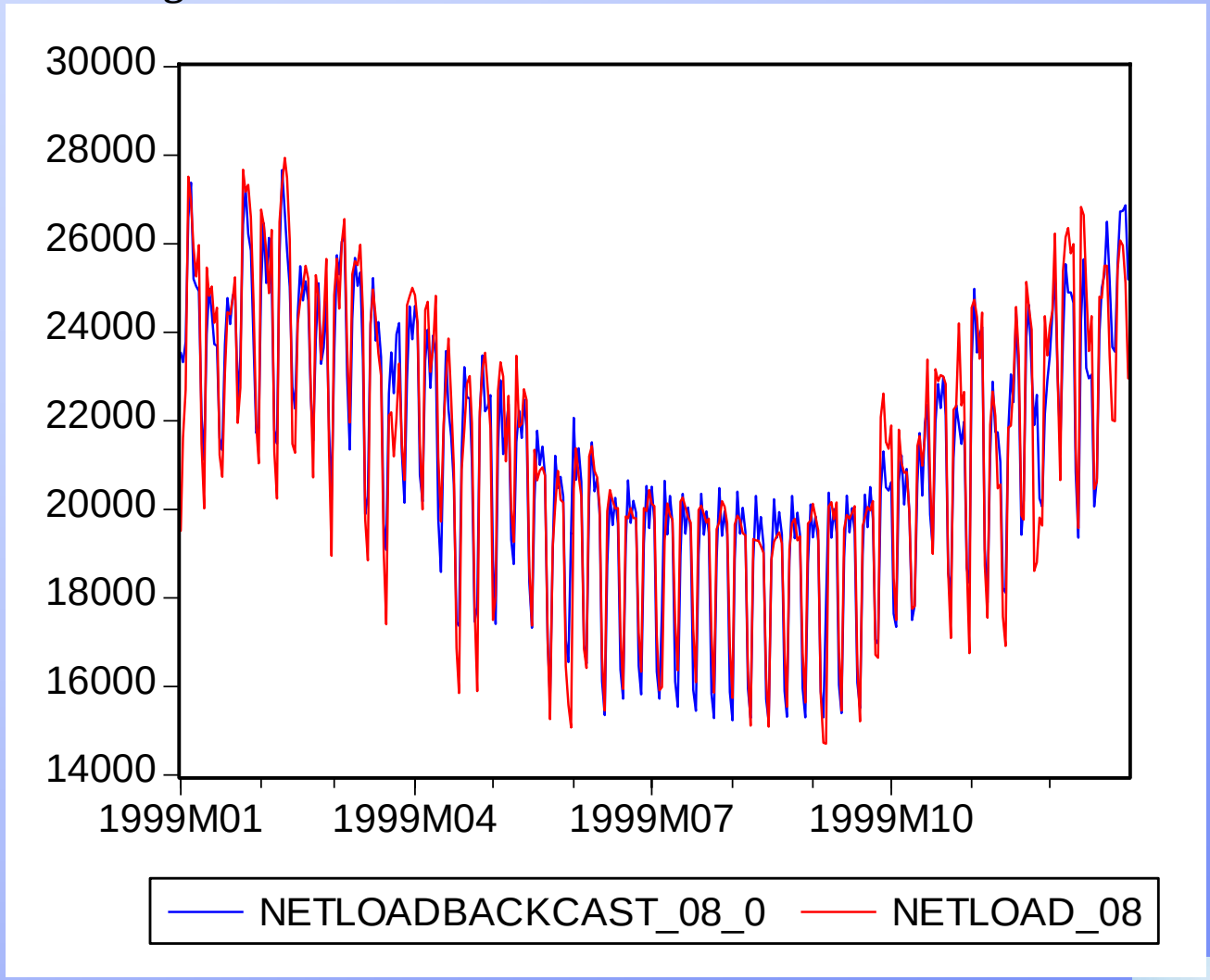
Figure 2- Actual and Backcasted Net load for Hour 8 a.m. for 1999



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Testing the Model

- A comparison of actual and fitted values for 1995- 2002 hourly energy, peak load, peak day and peak hour for each month, shows that:
- MAPE for the energy is less than 0.015%
- MAPE for peak load is about -2.7%.
- Model identified the correct hour for the peak day in 93 out of 96 months tested.

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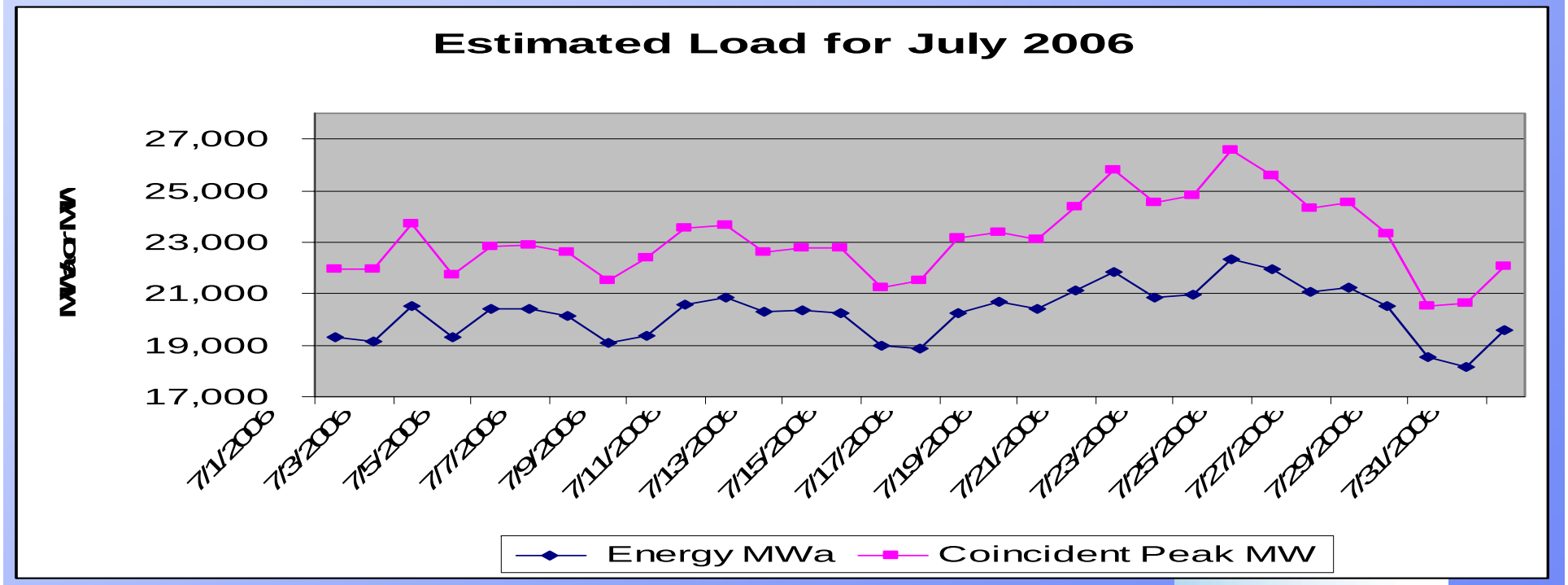
July 2006 Heat wave Test

- Model results shows peak load of 26,500 MW occurred on Monday July 24th at 5 PM.



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July 2006 Test

- Comparison to reported energy and peak for month of July show model results are reasonable.

	Model	NWPP *	Delta
Energy	20,237	20,518	-1.4%
Coincident Peak *	26,564	26,382	0.7%
July 2006 NWPP report		26,920	MW non-coincident
Coincident factor		98%	

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Developing Hourly Allocation Factors

- Using the 24 Hourly Models excluding the economic trend variables, we estimated hourly loads for 1995-2002.
- Then developed average allocation factors for each month, day and hour.

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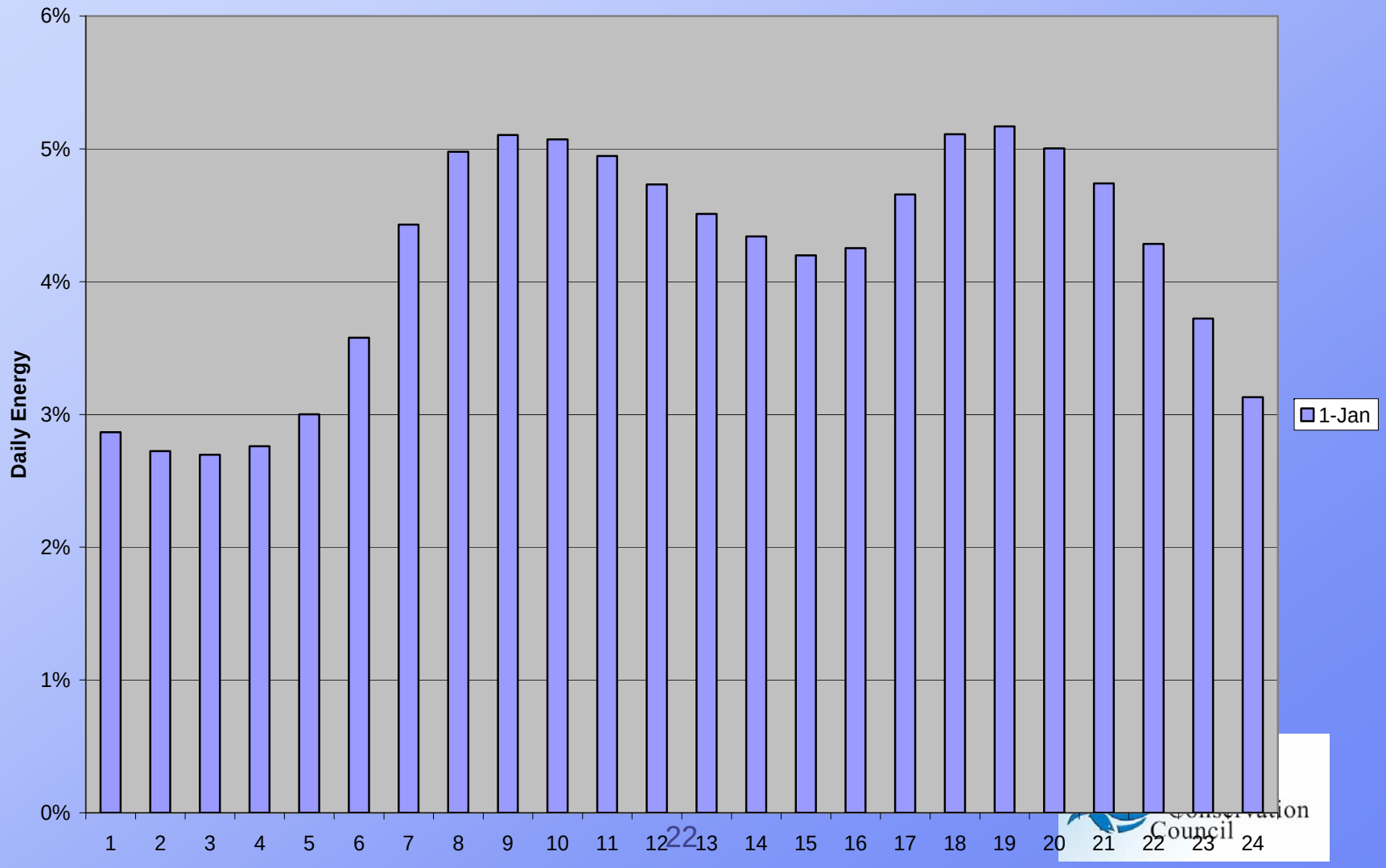
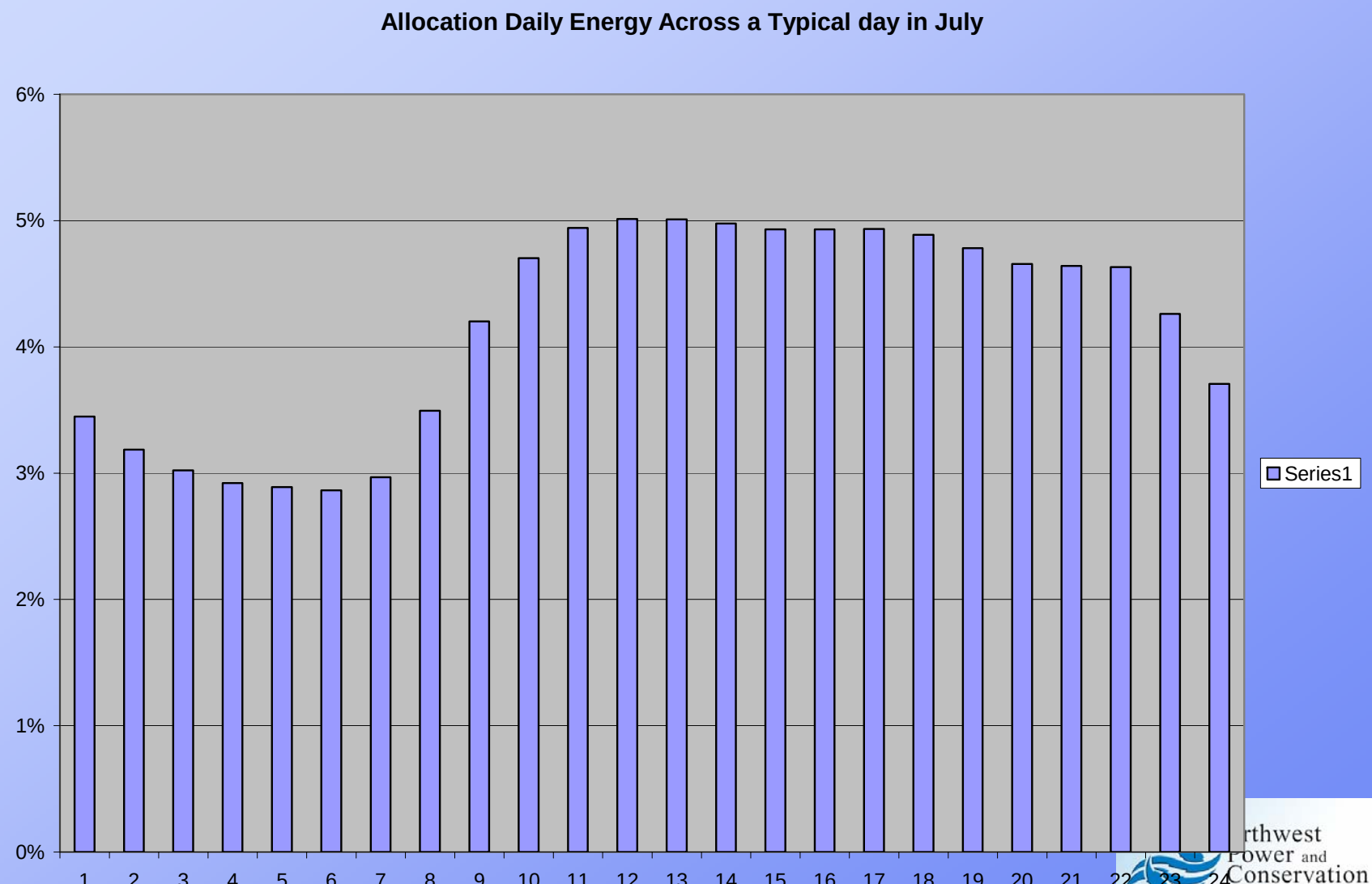
Winter Hourly Allocation Factors

Allocation of Daily Energy into Hourly Energy for a day in January



Summer Hourly Allocation Factors



Application to R.A.

Loads for use in Resource Adequacy are determined in this manner.

- **Forecasted daily weather-normalized (WN) loads are allocated across 24 hours.**
- **The corresponding day's Temperature Sensitive load for 1928-2006 temperature condition is estimated and allocated across 24 hours.**
- **<u>For each WN load forecast we have 79 Temperature Sensitive forecasts</u>**
- **Temp. sensitive hourly load are added to corresponding WN load.**
- **For each month, hourly loads are aggregated across a user defined <u>Sustained Peaking Period</u>.**
- **Monthly peak loads and energy for the Sustained Peaking Period is ranked**
- **4th ranking load for each month (corresponding to 1 in 20 year weather event) are reported for use in Resource Adequacy analysis.**

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Application to R.A.

- **1- Define Sustained Peaking Period (SPP)**
- **2- Determine hourly Weather normalized**
- **3- Determine hourly temperature-sensitive load**
- **4- Determine hourly total load**
- **5- Generate metrics for resource adequacy**
  - Single hour peak load
  - Maximum of average loads
  - Average load
- **6-Rank the Loads**
- Note that the ranking for each measure is independent from the other measures.

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Application of the Model
Resource Adequacy
Sustained Period

Period Definition

Hours to Include in the Sustained Peaking Period Definition

		Month	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Days to include		1	1	1	1	1	1				1	1	1	1	1	
	1=yes	2	1	1	1	1	1				1	1	1	1	1	
Sunday	0	3	1	1	1	1	1				1	1	1	1	1	
Monday	1	4				1	1	1	1	1	1	1	1	1	1	
Tuesday	1	5				1	1	1	1	1	1	1	1	1	1	
Wednesda	1	6				1	1	1	1	1	1	1	1	1	1	
Thursday	1	7				1	1	1	1	1	1	1	1	1	1	
Friday	1	8				1	1	1	1	1	1	1	1	1	1	
Saturday	0	9				1	1	1	1	1	1	1	1	1	1	
		10				1	1	1	1	1	1	1	1	1	1	
		11	1	1	1	1	1				1	1	1	1	1	
		12	1	1	1	1	1				1	1	1	1	1	

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2007 Load Forecast for R.A.

	2007 With 1 in 20 year event		
	Single Hour Peak Load During Sustained Peaking Period	Maximum of Average Load during Sustained Peaking Period	Average Load during Sustained Peaking Periods
	MW	MWa	MWa
January	35,522	31,371	28,885
February	32,468	29,625	26,870
March	29,369	25,834	23,868
April	25,196	22,176	21,380
May	23,593	21,540	21,025
June	24,790	23,369	22,108
July	26,356	24,869	23,628
August	25,622	24,313	23,109
September	23,194	21,786	21,219
October	26,193	22,402	21,373
November	31,030	27,431	24,737
December	35,262	30,159	27,608

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Sensitivity of Loads to S.P.P. Definition

Weekends included	2007 Weekends included			Delta		
	Hour Peak Load During Sustained Peaking Period	Maximum of Average Load during Sustained Peaking Period	Average Load during Sustained Peaking Period	Single Hour Peak Load During Sustained Peaking Period	Maximum of Average Load during Sustained Peaking Period	Average Load during Sustained Peaking Period
	MW	MWa	MWa	MW	MWa	MWa
January	35,522	31,784	28,910	-	412	(184)
February	32,468	29,928	26,344	-	302	(162)
March	29,369	26,189	23,393	-	354	(267)
April	25,196	22,416	21,068	-	240	(295)
May	23,593	21,567	20,509	-	27	(471)
June	24,790	23,369	21,686	-	-	(653)
July	26,356	24,869	23,054	-	-	(545)
August	25,622	24,313	22,737	-	-	(375)
September	23,194	22,319	20,841	-	534	(378)
October	26,193	22,914	21,025	-	513	(584)
November	31,030	27,810	24,262	-	379	(538)
December	35,461	31,863	27,006	199	1,704	(597)

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