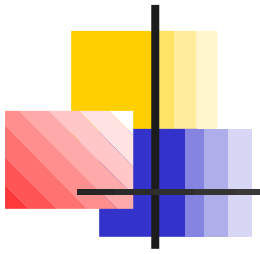


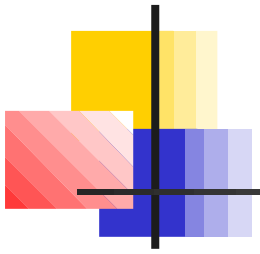
Peak Load Forecasting

Eugene Feinberg

Stony Brook University

Advanced Energy 2009

Hauppauge, New York, November 18



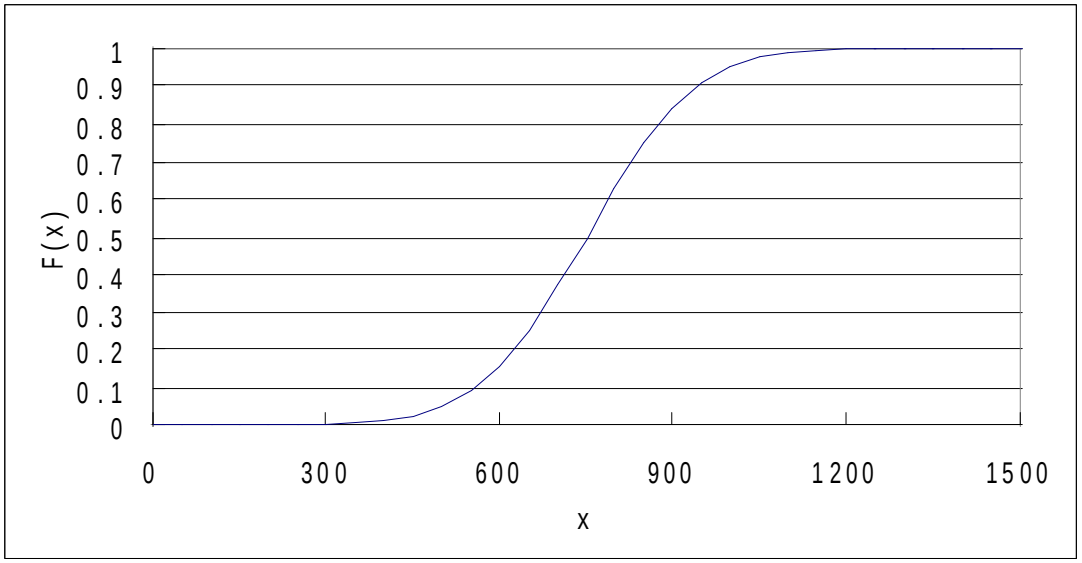
Importance of Peak Load Forecasting

- Annual peak load forecasts are important for planning and, in particular, for securing adequate generation, transmission, and distribution capacities.
- More accurate peak forecasts improve decision making capabilities in capital expenditures and improve reliability of the system.
- Future peak load is not deterministic and it depends on several uncertain factors including weather conditions.

Characterization of Annual Peak Load

- Annual peak load, X, is a random variable and can be characterized by a Cumulative Distribution Function

$$F(x) = P\{X \leq x\}$$



- In this talk we will discuss modeling of annual peak load and the software that implements this modeling for local areas (load pockets).

Traditional Approach

- Also known as Normal Weather, Design Day, or 50/50 approach
- It is difficult to use the past peak load values to predict future peaks because load characteristics change over time (weather and economic condition, population growth, ...).
- A widely used approach is to estimate the level that the peak load will not exceed with the 50% probability.

Normal Weather Approach (Cont.)

- Consider historical peak days for the last n (typically n=30) years, and estimate the average peak weather conditions W_N.

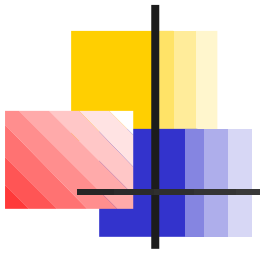
- Present the load as a function

$$Load = F(W, P),$$

W : weather parameters such as temperature, humidity, THI, etc
P : other parameters

- Compute: $$Weather\ Normalized\ Peak\ Load = F(W_N, P_E),$$

W_N : normal weather
P_E : estimation of parameters



Load Models

- We have developed accurate models in the form

$$Load = F(d, h, W, P),$$

where

d : day of the week

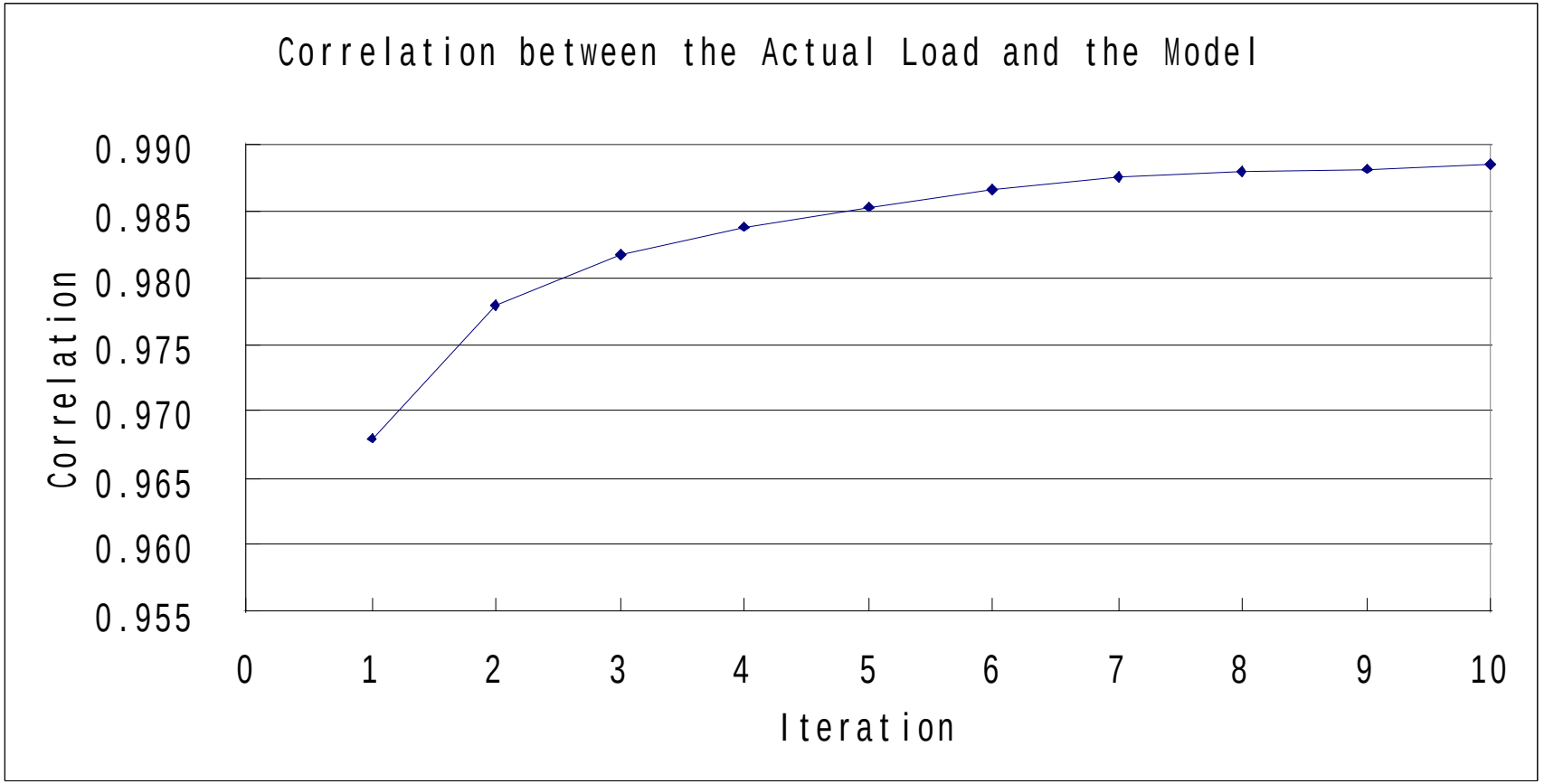
h : hour of the day

W : weather factors and their lagged version, including temperatures, humidity, and sky coverage

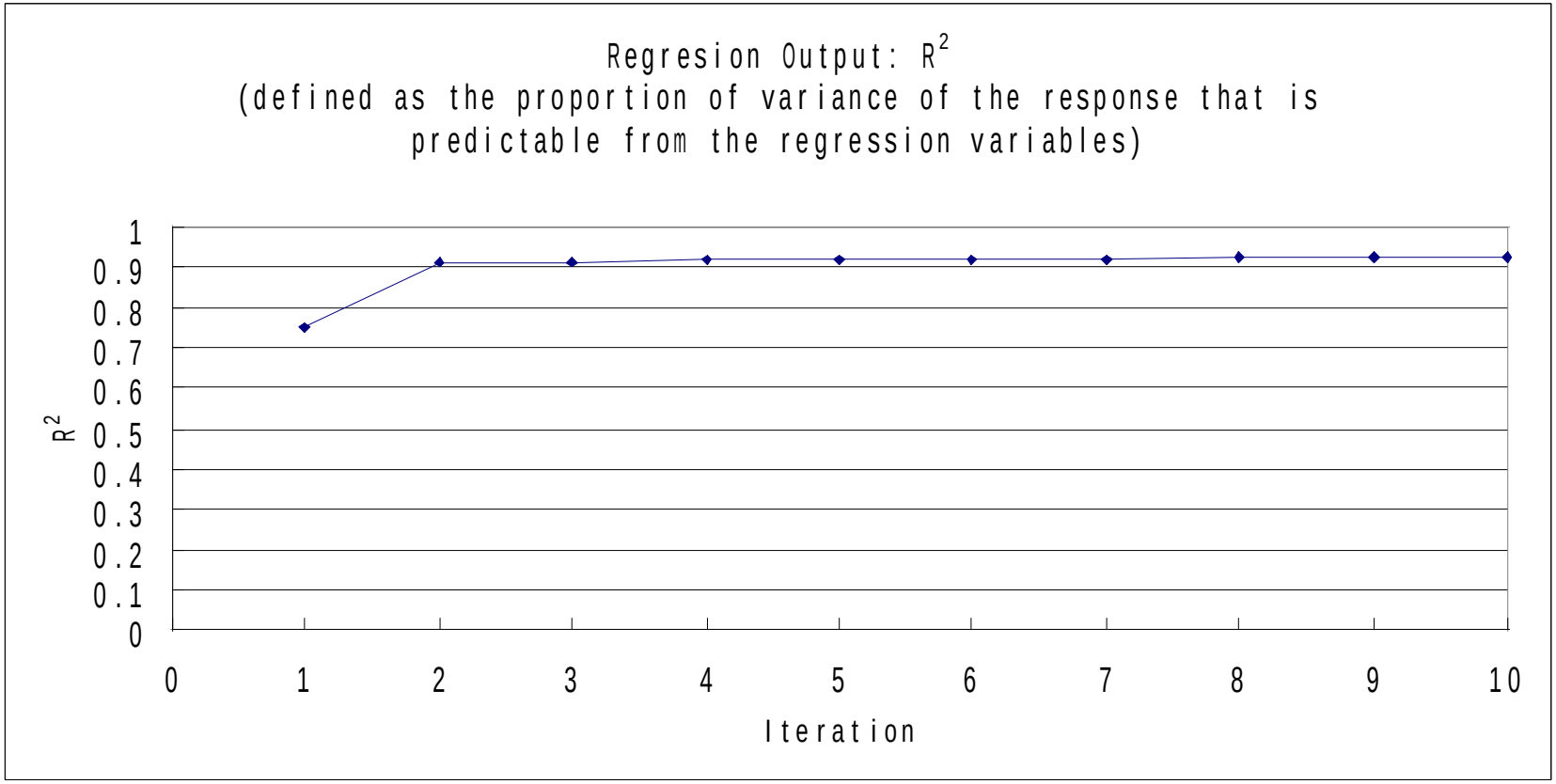
P : other factors

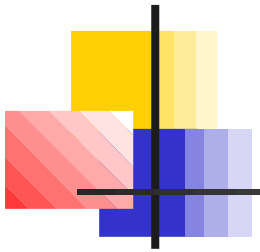
and developed algorithms for their parameter estimation.

Convergence of Algorithms (Correlation)



Convergence of Algorithms (R-Squared)





Our Approach

- Run the model through various weather scenarios and select peak values: L_1, L_2, …, L_n
- The scenarios are actual weather data for previous years (usually last 30 years).
- Use peak values L_1, L_2, …, L_n to estimate the load distribution.

Application to Short-Term Load Forecasting (remark)

- The developed models can also be used for short-term forecasting. The so-called ensemble approach improves the accuracy of load forecasts. This approach is to use models corresponding to different parameters and compute load forecasts as weighted averages of the outputs of these models.

Load Pocket Peak Forecasting Software

- For local areas (load pockets), the software deals with two types of load peaks:

  (i) Peak load for the area

  (ii) Load for the area on the system peak date

- The software analyzes defined load pockets and has a load pocket editor that can define new load pockets and edit existing load pockets.

Load Pocket Peak Forecasting Software

- The software is written in SAS and has a Graphic User Interface written in Visual Basic.
- The software analyzes load and weather data for local areas (load pockets).
- In particular, the software calculates Weather Normalization Factors

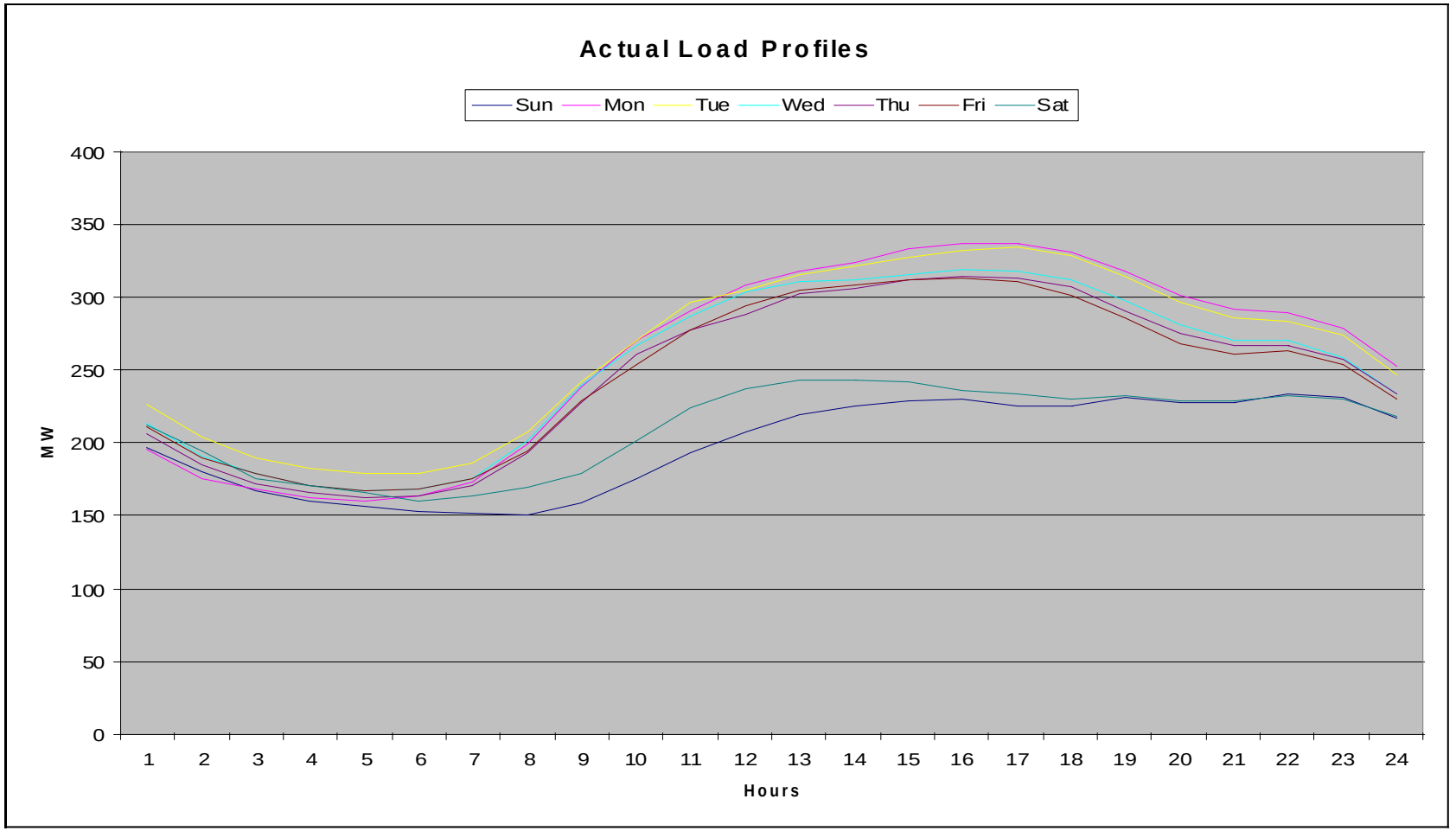
$$WNF = \frac{\text{Normal Load}}{\text{Peak Load}}$$

- It also provides the probability calculator for the next year peak load distributions.

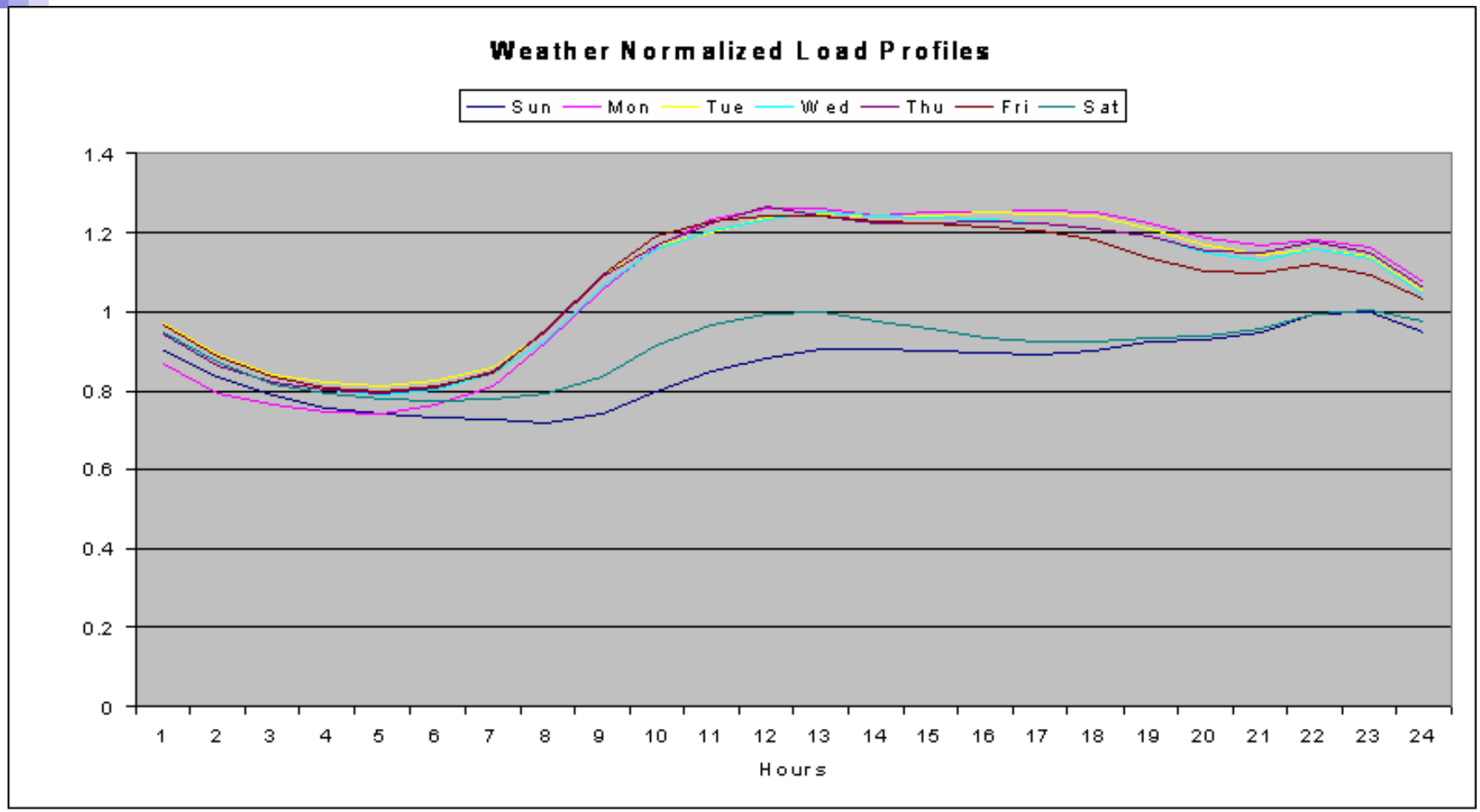
Outputs of Load Pocket Peak Forecasting Software

- Actual Load Shape by day of week and hour
- Weather Normalized Load Shape by day of week and hour
- Actual Load vs Model Load scatter plot
- Calculates Weather Normalization Factors (WNFs)
- Calculates Normalized Weather Parameters
- Calculates System and Pocket Peak Load Distributions

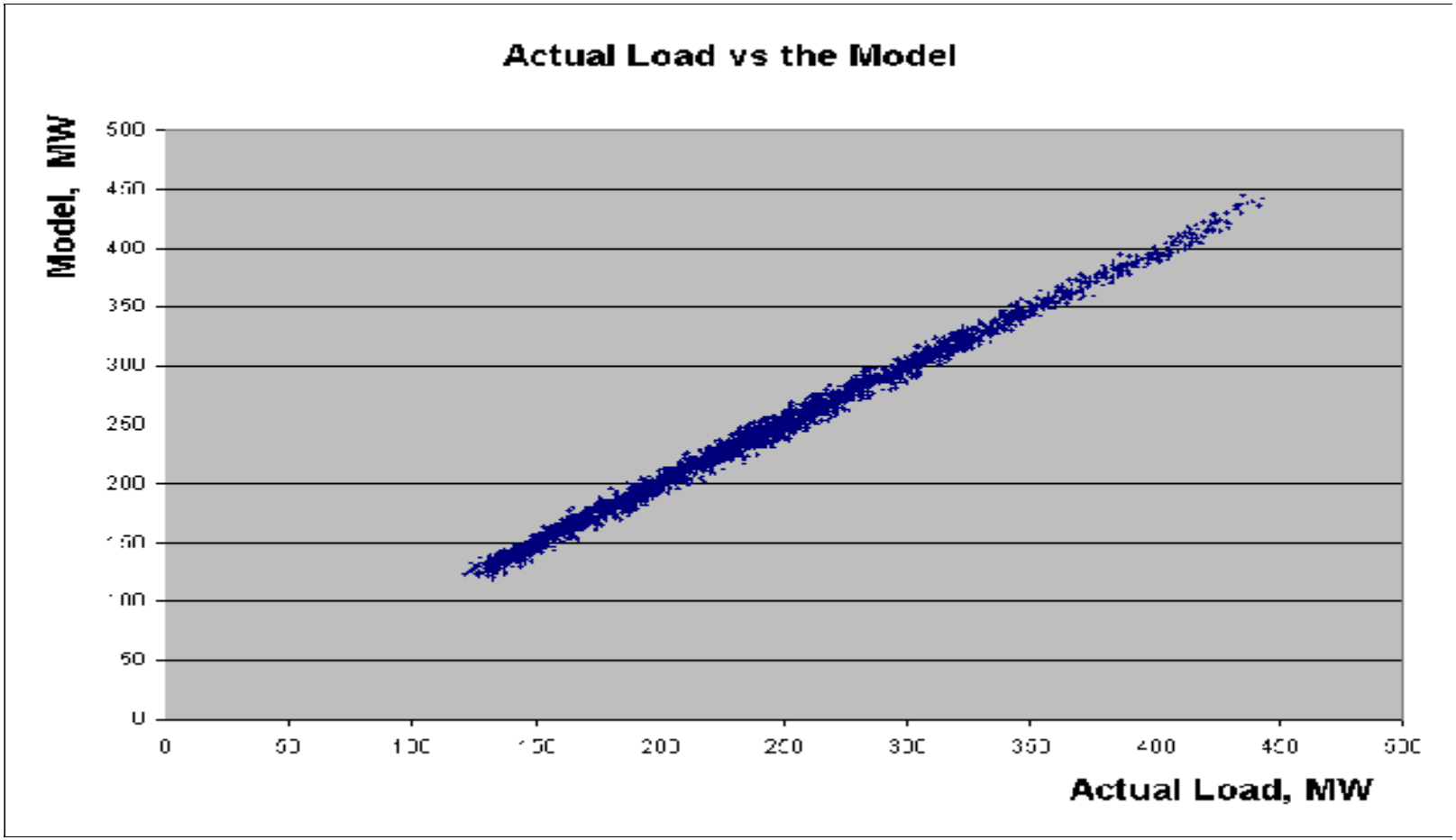
Actual Load Profiles



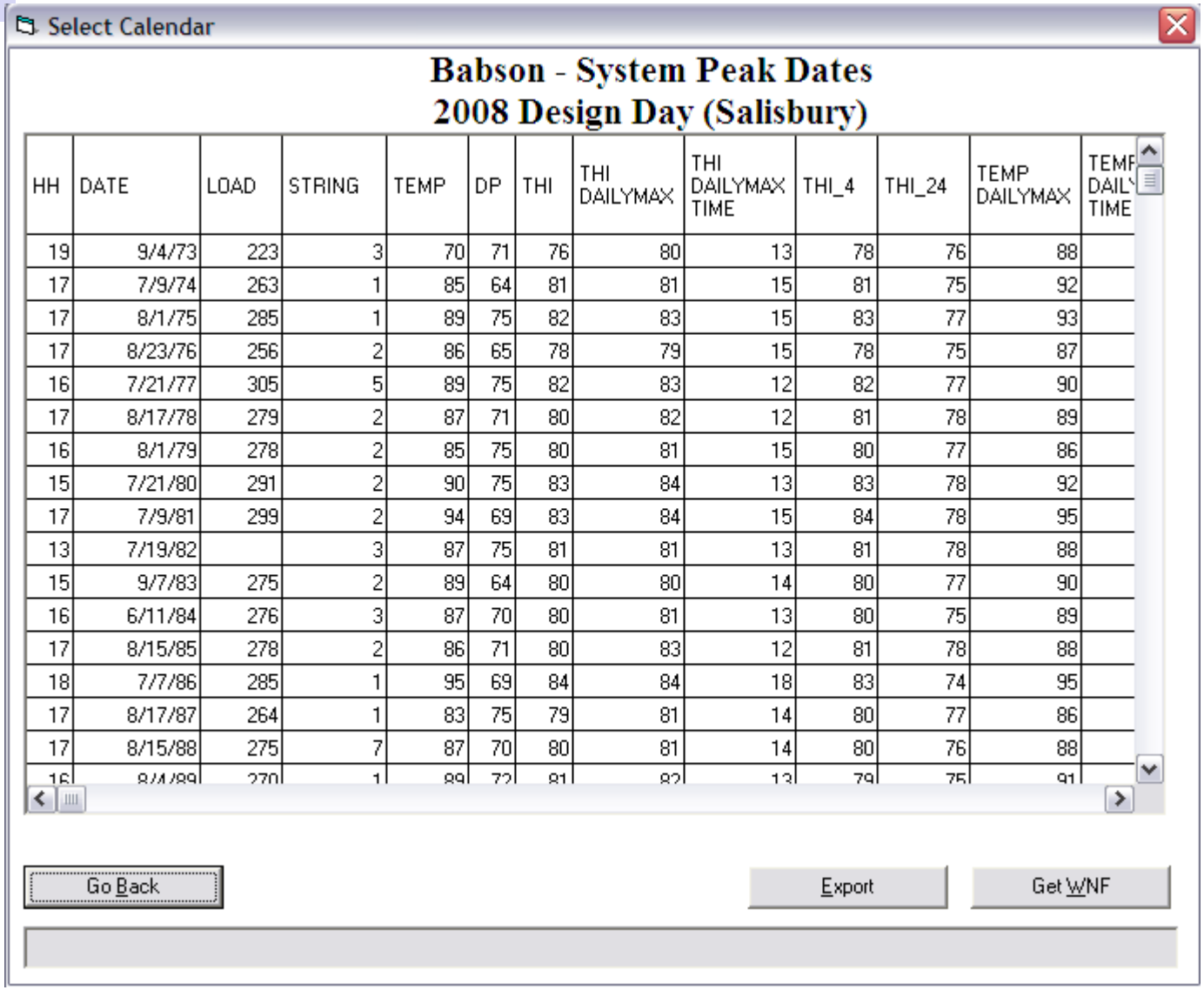
Weather Normalized Load Profiles



Scatter plot of the actual load vs the model

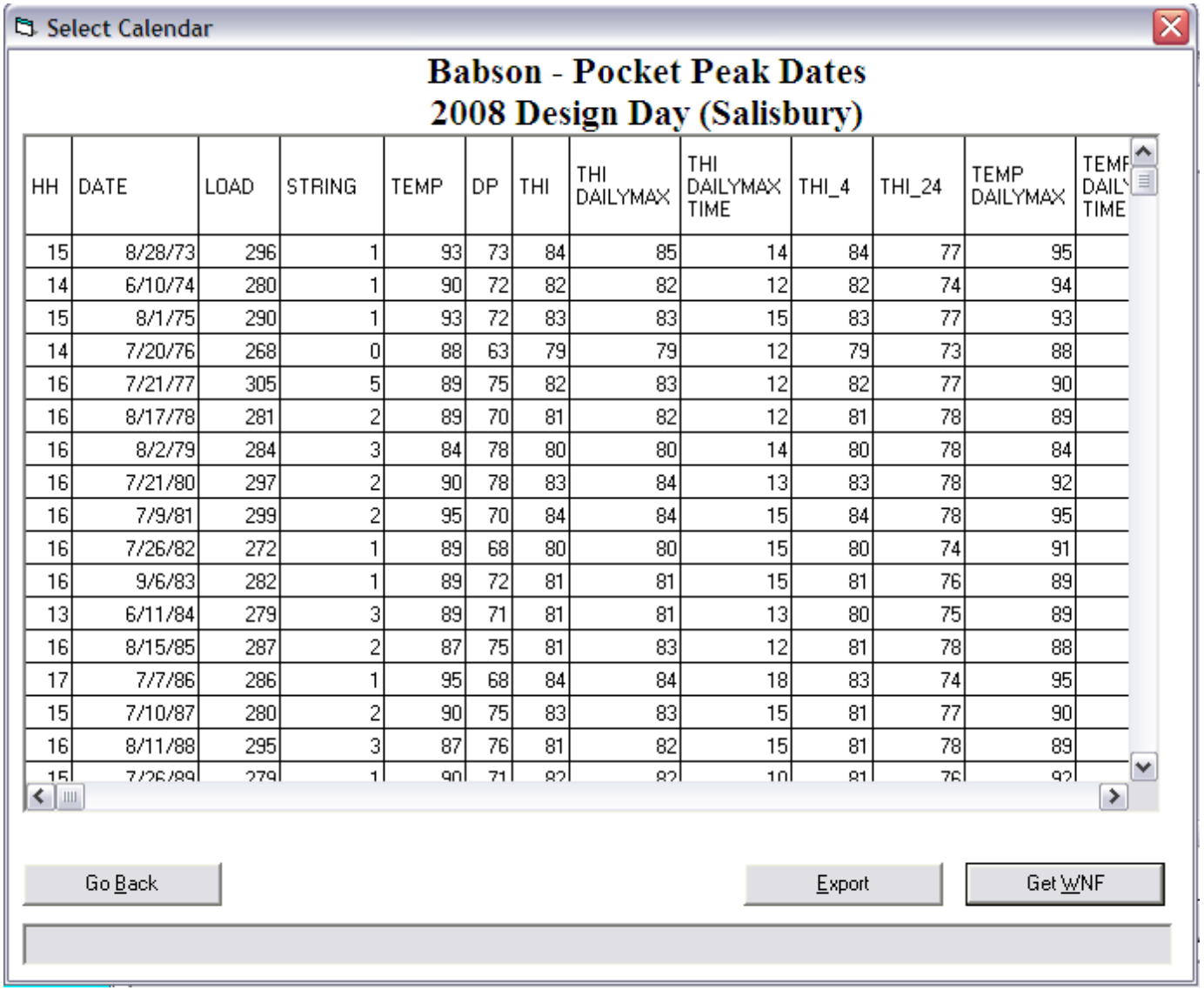


System Peak Dates



HH	DATE	LOAD	STRING	TEMP	DP	THI	THI DAILYMAX	THI DAILYMAX TIME	THI_4	THI_24	TEMP DAILYMAX	TEMP DAILY TIME
19	9/4/73	223	3	70	71	76	80	13	78	76	88	
17	7/9/74	263	1	85	64	81	81	15	81	75	92	
17	8/1/75	285	1	89	75	82	83	15	83	77	93	
17	8/23/76	256	2	86	65	78	79	15	78	75	87	
16	7/21/77	305	5	89	75	82	83	12	82	77	90	
17	8/17/78	279	2	87	71	80	82	12	81	78	89	
16	8/1/79	278	2	85	75	80	81	15	80	77	86	
15	7/21/80	291	2	90	75	83	84	13	83	78	92	
17	7/9/81	299	2	94	69	83	84	15	84	78	95	
13	7/19/82		3	87	75	81	81	13	81	78	88	
15	9/7/83	275	2	89	64	80	80	14	80	77	90	
16	6/11/84	276	3	87	70	80	81	13	80	75	89	
17	8/15/85	278	2	86	71	80	83	12	81	78	88	
18	7/7/86	285	1	95	69	84	84	18	83	74	95	
17	8/17/87	264	1	83	75	79	81	14	80	77	86	
17	8/15/88	275	7	87	70	80	81	14	80	76	88	
16	8/4/89	270	1	89	72	81	82	13	79	75	91	

Pocket Peak Dates



HH	DATE	LOAD	STRING	TEMP	DP	THI	THI DAILYMAX	THI DAILYMAX TIME	THI_4	THI_24	TEMP DAILYMAX	TEMP DAILY TIME
15	8/28/73	296	1	93	73	84	85	14	84	77	95	
14	6/10/74	280	1	90	72	82	82	12	82	74	94	
15	8/1/75	290	1	93	72	83	83	15	83	77	93	
14	7/20/76	268	0	88	63	79	79	12	79	73	88	
16	7/21/77	305	5	89	75	82	83	12	82	77	90	
16	8/17/78	281	2	89	70	81	82	12	81	78	89	
16	8/2/79	284	3	84	78	80	80	14	80	78	84	
16	7/21/80	297	2	90	78	83	84	13	83	78	92	
16	7/9/81	299	2	95	70	84	84	15	84	78	95	
16	7/26/82	272	1	89	68	80	80	15	80	74	91	
16	9/6/83	282	1	89	72	81	81	15	81	76	89	
13	6/11/84	279	3	89	71	81	81	13	80	75	89	
16	8/15/85	287	2	87	75	81	83	12	81	78	88	
17	7/7/86	286	1	95	68	84	84	18	83	74	95	
15	7/10/87	280	2	90	75	83	83	15	81	77	90	
16	8/11/88	295	3	87	76	81	82	15	81	78	89	
15	7/26/89	279	1	90	71	82	82	10	81	76	92	

Weather Normalization Factors Pocket WNFs

Babson: Pocket Peak Load

2008 Design Day (Salisbury)

TEMP	91
TEMP_DAILYMAX	92
TEMP_DAILYMAX_HOUR	14
STRING	2
THI	82
THI_DAILYMAX	83
THI_4	82
THI_24	77

Get Peak Distribution

Export

Go Back

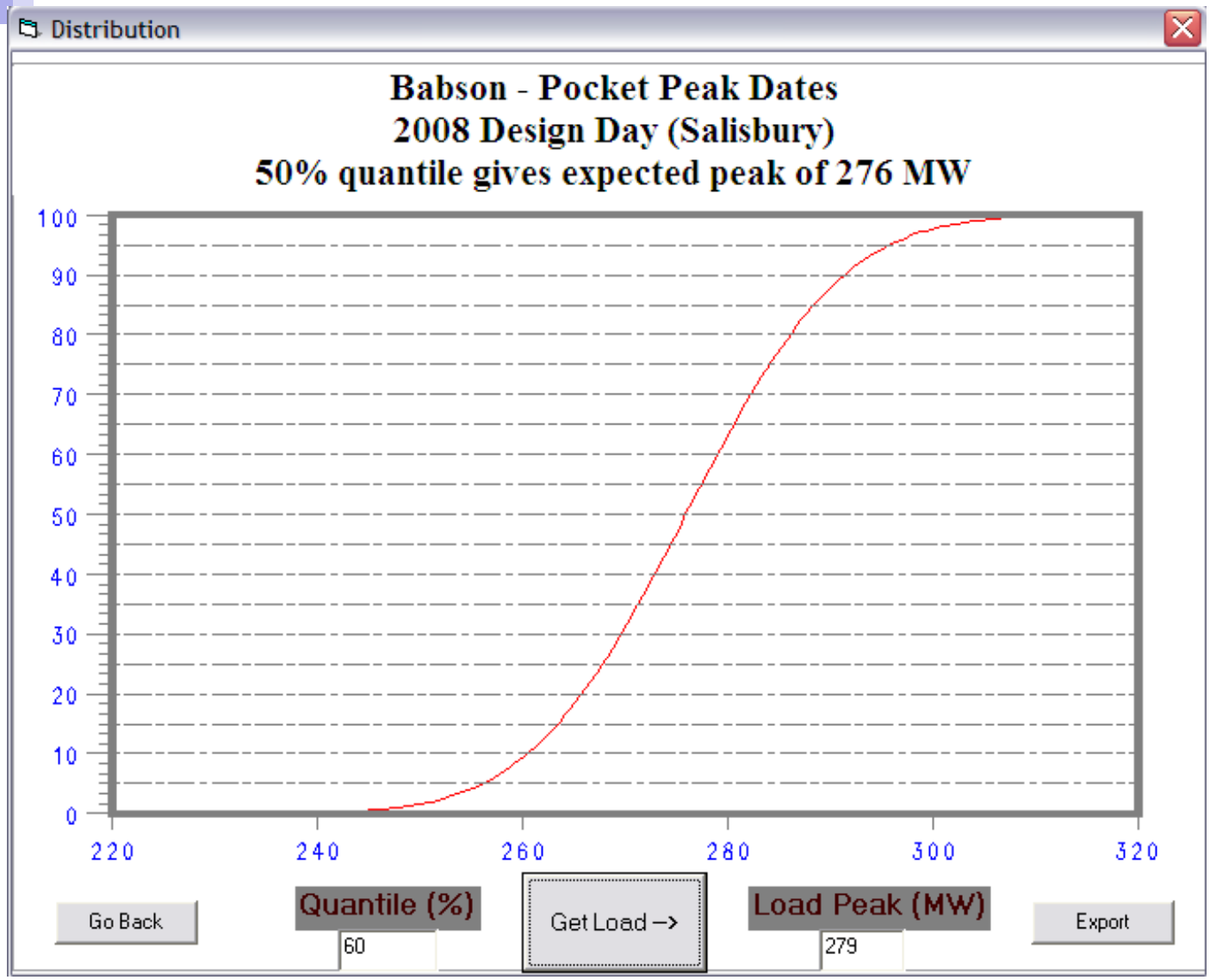
LOADS AND WNFS AT POCKET PEAK DAYS

YEAR	DESIGN DAY LOAD	PEAK LOAD	WNF	Date	Hour
1998	291	303.5	0.9588	7/22/1998	15
1999	308	324.5	0.9492	7/6/1999	16
2000	316	300.5	1.0516	8/7/2000	16
2001	330	345.3	0.9558	8/8/2001	16
2002	324	326.8	0.9913	7/29/2002	17
2003	347	341.8	1.0153	6/26/2003	17
2007	292.7	285.5	1.0251	8/8/2007	17

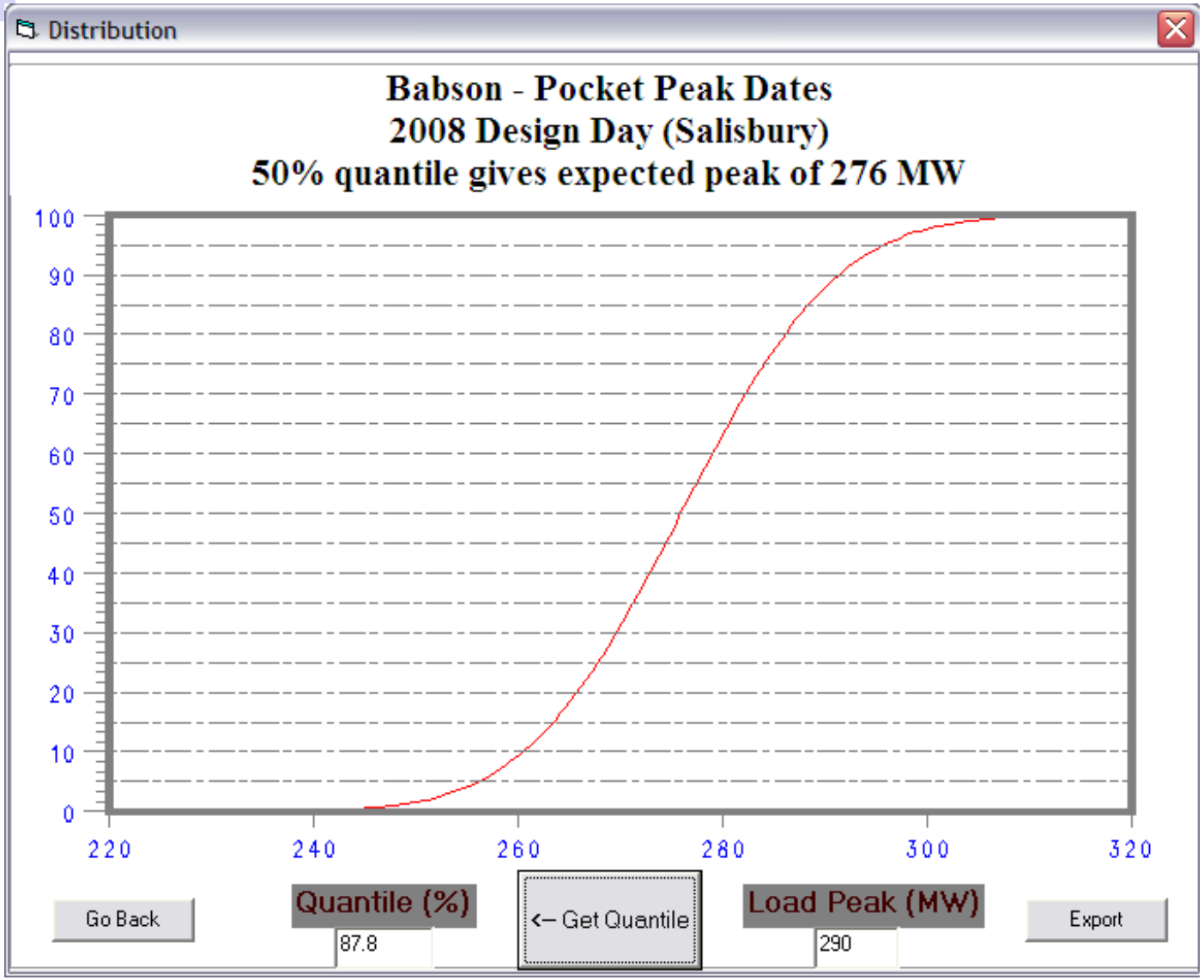
TRENDS

Year	Trend
2001 - 2002	1.0584
2002 - 2003	1.026
2003 - 2004	1.0443
2004 - 2005	0.9818
2005 - 2006	1.0615
2006 - 2007	0.9428
2007 - 2008	0.9428

Peak Distribution Calculator



Peak Distribution Calculator (Cont.)



Conclusions

- We presented the methodology and software for estimating peak loads for arbitrary percentiles (not only 50/50 scenarios) and for computing Weather Normalized Factors (WNFs) based on local weather conditions.