Short Term Forecast of the Load Demand in Victoria

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Abstract: Reforms in the electricity market involved a horizontal division of the integrated utilities and created independent companies in generation and retail. Short term load forecasting has a central role in the operation, security and planning of electric power systems. The forecasting technique of time-series regression analysis was used to develop an equation for every three-hourly period of working and non-working days. As a result, 16 equations were implemented to short-term forecast the load demand in Victoria with a high degree of accuracy. The model was tested for South Australia and New South Wales and performed with similar results, within a short computational time. This fact proves the reliability of the model, taken into consideration that there are huge differences between these states regarding area, climatic conditions, electricity consumption, etc. This methodology can be extended to use 48 half-hour periods and could have superior results.

Keywords: Modelling; Load demand; Forecasting; Electricity

1. INTRODUCTION

The energy sector is very important for the Australian economy and in the last years this industry has undergone rapid changes. Reforms in the electricity market involved a horizontal division of the integrated utilities to create independent companies in generation and retail.

The electricity market differs radically from other markets because it is impossible to show which generator produce the electricity consumed by a specific customer and electricity cannot be stored economically. As a result of this, a wholesale market where all the electricity is pooled and scheduled to meet the demand is used. Competitive electricity markets are now in place in many countries like Chile, Great Britain, New Zealand, Norway and some states from United States of America.

Victoria followed the United Kingdom as a model for the energy privatization, becoming a leader in Australia. Victoria Pool (VicPool) Market started to operate on 1st July 1994.

Competition was introduced in both generation and retail supply. Now, competition sets the price of the electricity.

The wholesale electricity tariffs were separated into charges for the electricity consumed (determined by the competition) and the use of the electricity networks (regulated).

The National Electricity Market (NEM) was created on 13 December 1998 [NEMMCO, 2001a]. The participating states in the NEM are Victoria, South Australia, NSW, ACT, and Queensland. Tasmania may join the market when the Basslink project is finished, in 2004. At this stage, Western Australia and Northern Territory are not involved in the national market.

As shown in the Code, the National Electricity Market Management Company (NEMMCO) is managing the pool across all the interconnected states, by coordinating the dispatch and the spot market. The market customers submit their demand levels and generators are competing by offering their available capacity at different price levels. Generators can bid only one 10-band price, and during the day they can rebid the quantities they are offering.

The principal objective of the NEMMCO is to minimize the cost of meeting the load demand based on the offer and bid prices, under a safe, reliable and continuous process.

This paper present the model that was developed to forecast the load demand by three-hourly periods, in Victoria.

2. IMPORTANCE

The term 'load demand' includes electricity consumption and peak or maximum demand.

Because electricity cannot be economically stored, electricity supply and consumption must be balanced and matched instantaneously in order to provide electricity at safe and acceptable quality standards. Consequently, the accurate forecast of load demand is essential for each participant in the spot market.

If the demand exceeds supply, due to inaccurate forecasts, then the price is set to a Value of Lost Load (VoLL), which is currently set equal to 5,000 $/MWh and it is proposed to be increased to 10,000$/MWh in April 2002. For that reason, it is a heavy responsibility for the supplier to have accurate forecast demand in order to meet the demands of the customers in a reliable and cost efficient way.

Short-term forecasts of electricity demand for each period are essential in planning for an adequate electricity supply. These forecasts will indicate how much electricity is needed and therefore how much capacity will operate. The generators need time to start their units so the unexpected demand cannot be matched instantaneously. Also, it is important for the planning of the maintenance of the generators and the construction of their dispatch offer and bids for the next day.

3. MODEL

3.1 Data

The Victorian Power Exchange (VPX) has publicly available half-hourly electricity data for Victoria. For this model data from 1st July 1996 until 30 June 2000 was used. The half-hourly electricity was aggregated in order to obtain three hourly data (MW) for this study.

Also, maximum and minimum three hourly temperatures were obtained from the Australian Bureau of Meteorology for the same period. Melbourne, the major regional electricity center is used as the weather reference for Victoria.

Victoria, a state with an area of 227,600 square Kilometers and a population of 4.7 millions people, is a summer peak type of system.

In the financial year 1999/2000 the summer peak was 8.8% higher than in 1996/97 and the total electricity consumption has increased by 10.3% [NEMMCO, 2001b].

For the purpose of this study data was split in two sets:

- Model construction data set: the period between 1st July 1996 and 31 Dec 1999.

- Testing data set: the period between 1st Jan 2000 and 30 June 2000.

The most important factors that influence the daily load consumption are:

- Weather (temperature, humidity).

- Seasonal changes (summer or winter peaks).

- Type of load electricity (comercial, industrial or residential).

- Public holidays.

- Economic growth.

- Special events: strikes, industrial accidents, big sportive and cultural events, system outages, government interventions, etc,

Further details are available in Bunn and Farmer [1985].

In particular, there is a strong relationship between load demand and temperature. During summer or winter, a hot or a cold front air, can influence an increase in the load demand of up to 30% [Cogen, 1998].

This strong relationship between load demand and temperature can be seen in Figure 1. Load demand is indirect proportional with winter temperatures and direct proportional with summer temperatures.

The non-linear regression analysis also confirmed that temperature is a major factor among all the variables, which is affecting the load demand.

The load demand has a strong seasonal cycle and therefore unique variables were used in the regression to denote different seasons [Matthew and Carpinella, 1988].

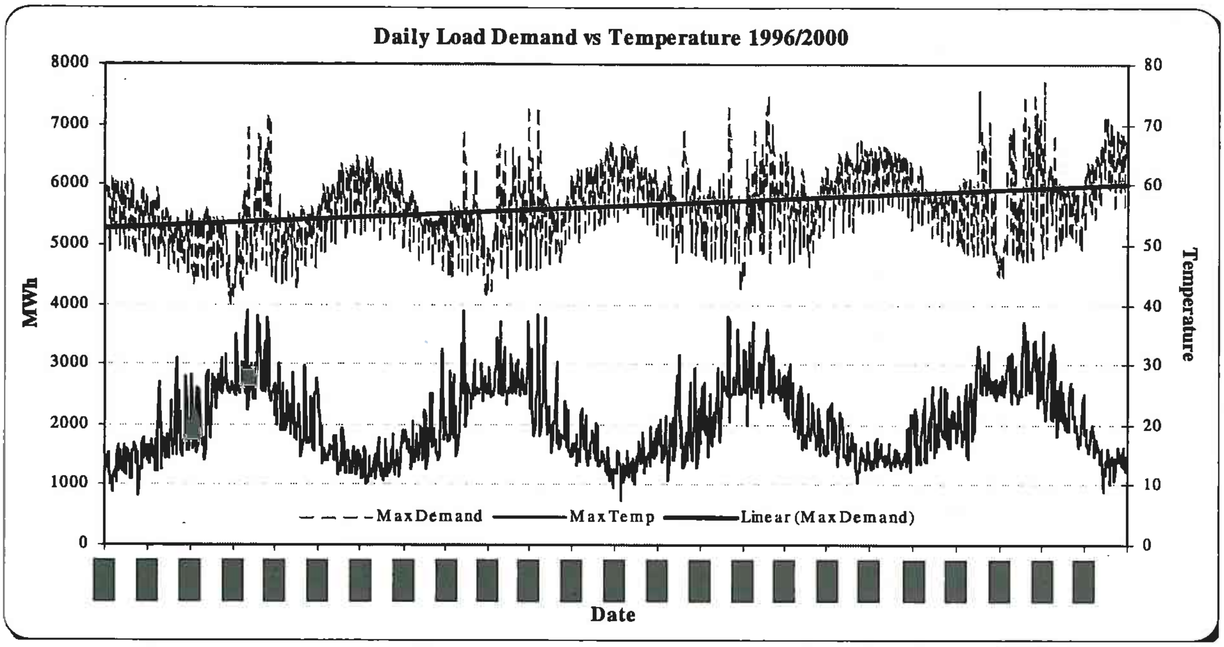

Figure 1. Daily Load Demand vs. Temperature

Figure 2 shows that there are day-to-day fluctuations of the load demand. Summer days have a different pattern comparing with the days of the other seasons. Also, the load demand substantially varies from hour to hour and between working and non-working days.

The model is divided into:

- Working days model: Monday to Friday, except public holidays.
- Non working days model: weekends and public holidays.

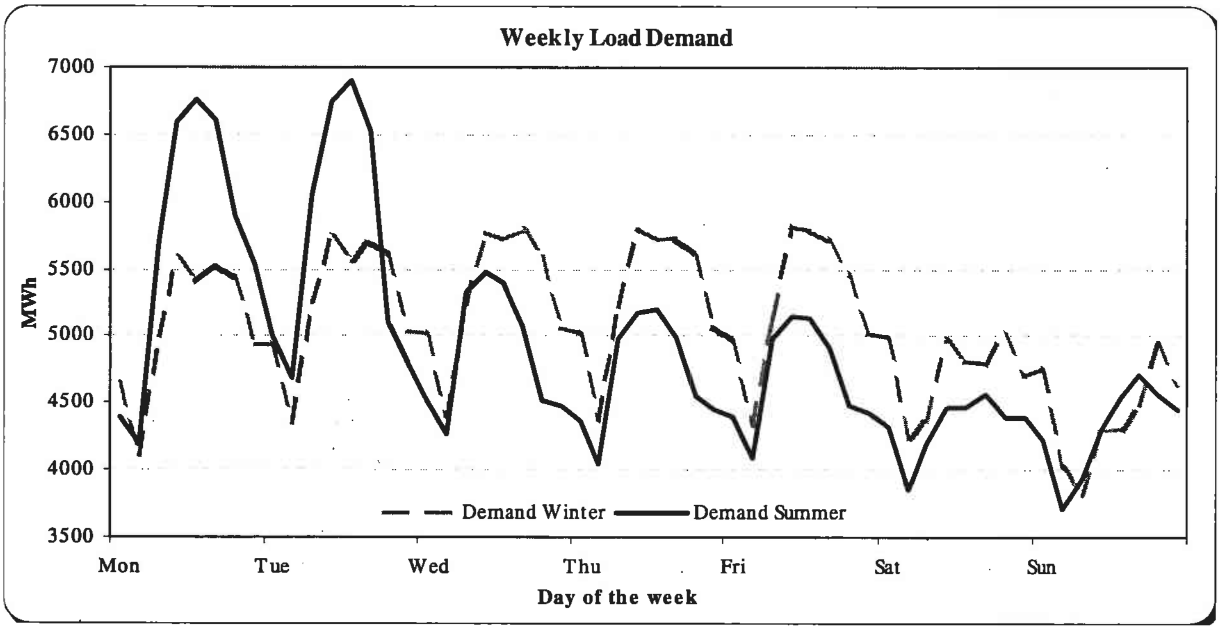

Figure 2. Weekly Load Demand

The forecasting technique of time-series non-linear regression analysis was used to develop an equation for every three-hourly period of working and non-working days [Granger and Newbold, 1986].

As a result, 16 equations were implemented to short-term forecast the load demand in Victoria.

3.2 Results

Some of the key statistics chosen for analysing this model are: R^2, R^2-adjusted, Standard Deviation (SD) and Mean Absolute Percentage Error (MAPE), shown in Makridakis et al. [1983]. The MAPE results are presented in Table 1 while Figure 3 represents the percentage errors of the load demand forecast for first month, January 2000.

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Table 1. MAPE

MAPE			
Period	Working Day	Non-Working Day	All
1-Jul-96 to 31-Dec-99	1.5%	1.8%	1.6%
1-Jan-00 to 30-Jun-00	1.8%	2.4%	2.1%
1-Jul-96 to 30-Jun-00	1.6%	1.9%	1.7%

Table 2 presents summary statistics for the testing period. All the statistics parameters, show that the model is performing with good results; the load demand is forecast with an average R^2-adjusted = 92.5 and R^2 = 92.7%.

Inherent variability of the load demand forecast is determined by:

- Temperature accuracy.
- Random effects: decisions within factories, companies or houses became random events, which affect the load demand.
- Special events: unpredictable strikes, industrial accidents, system outages, government and NEMMCO interventions, etc.
- Demand side management and electricity curtailment programs, which are not public available.

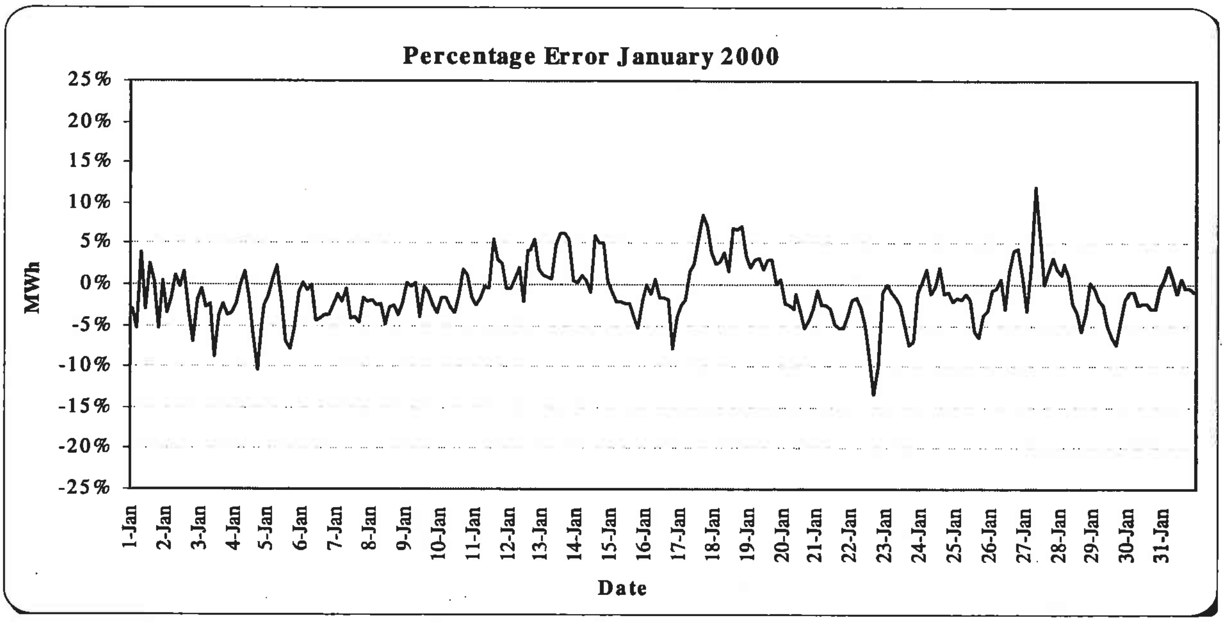

Figure 3. Percentage errors for January 2000

Advantages of the model:

- Reliability, this methodology was tested on South Australia and New South Wales and the performances were similar.
- Adaptiveness, the changes can be tracked automatically in the overall model.
- Recursiviness, as new data becomes available, load demand forecast can be re-computed easily.
- Computational time, the whole methodology is economical with respect to the execution time.

Table 2. Summary statistics 1 Jan 2000 to 30 June 2000

	1 Jan 00 - 30 June 00							
	Period 1	**Period 2**	**Period 3**	**Period 4**	**Period 5**	**Period 6**	**Period 7**	**Period 8**
	ACTUALS							
25th Percentile	4683	4234	4694	5045	5050	5080	5070	4791
75th Percentile	5155	4679	5767	6094	6055	6063	5967	5360
85th Percentile	5362	4772	5947	6247	6255	6358	6144	5528
95th Percentile	5537	4911	6101	6584	6641	6753	6467	5704
97.5th Percentile	5598	4956	6192	6701	6993	6996	6512	5771
99th Percentile	5632	5050	6266	6870	7149	7265	6545	5809
99.5th Percentile	5646	5082	6339	7008	7231	7307	6610	5812
99.9th Percentile	5649	5094	6480	7177	7393	7534	6842	5815
Average	4939	4438	5247	5592	5593	5624	5507	5077
Median	4905	4460	5377	5697	5699	5677	5533	5079
Mean of top 1%	5648	5089	6417	7102	7321	7433	6739	5814
Maximum	5650	5097	6515	7219	7433	7591	6900	5816
Minimum	4125	3529	3517	3758	3714	3875	4006	4097
Standard Deviation	332	319	670	673	712	708	580	386
Skewness	0.28	-0.30	-0.53	-0.35	-0.10	0.06	-0.09	-0.02
Kurtosis	-0.57	-0.34	-0.75	-0.44	-0.34	-0.34	-0.60	-0.73
	FORECASTS							
25th Percentile	4758	4282	4745	5118	5077	5175	5122	4862
75th Percentile	5138	4682	5742	6045	6011	6044	5849	5321
85th Percentile	5349	4776	5892	6194	6166	6231	6120	5515
95th Percentile	5496	4901	6116	6406	6602	6661	6381	5676
97.5th Percentile	5530	4947	6163	6713	6882	7085	6456	5763
99th Percentile	5581	4978	6307	6927	7159	7170	6517	5821
99.5th Percentile	5603	5050	6400	6944	7232	7219	6620	5827
99.9th Percentile	5653	5057	6536	7052	7242	7305	6694	5829
Average	4953	4461	5254	5615	5608	5662	5523	5086
Median	4908	4468	5426	5755	5760	5746	5526	5067
Mean of top 1%	5631	5054	6476	7004	7238	7267	6662	5828
Maximum	5666	5059	6570	7079	7245	7326	6713	5829
Minimum	4224	3611	3376	3870	3617	3856	4216	4078
Standard Deviation	300	293	645	616	666	636	513	353
Skewness	0.31	-0.28	-0.52	-0.39	-0.30	-0.01	0.05	0.05
Kurtosis	-0.49	-0.37	-0.60	-0.35	0.01	-0.10	-0.58	-0.44
	DIFFERENCES: ACTUALS - FORECASTS							
25th Percentile	-75.00	-48.00	-51.00	-73.00	-27.00	-95.00	-52.00	-71.00
75th Percentile	17.00	-3.00	25.00	49.00	44.00	19.00	118.00	39.00
85th Percentile	13.00	-4.00	55.00	53.00	89.00	127.00	24.00	13.00
95th Percentile	41.00	10.00	-15.00	178.00	39.00	92.00	86.00	28.00
97.5th Percentile	68.00	9.00	29.00	-12.00	111.00	-89.00	56.00	8.00
99th Percentile	51.00	72.00	-41.00	-57.00	-10.00	95.00	28.00	-12.00
99.5th Percentile	43.00	32.00	-61.00	64.00	-1.00	88.00	-10.00	-15.00
99.9th Percentile	-4.00	37.00	-56.00	125.00	151.00	229.00	148.00	-14.00
Average	-14.00	-23.00	-7.00	-23.00	-15.00	-38.00	-16.00	-9.00
Median	-3.00	-8.00	-49.00	-58.00	-61.00	-69.00	7.00	12.00
Mean of top 1%	17.00	35.00	-59.00	98.00	83.00	166.00	77.00	-14.00
Maximum	-16.00	38.00	-55.00	140.00	188.00	265.00	187.00	-13.00
Minimum	-99.00	-82.00	141.00	-112.00	97.00	19.00	-210.00	19.00
Standard Deviation	32.00	26.00	25.00	57.00	46.00	72.00	67.00	33.00
Skewness	-0.03	-0.02	-0.01	0.04	0.20	0.07	-0.14	-0.07
Kurtosis	-0.08	0.03	-0.15	-0.09	-0.35	-0.24	-0.02	-0.29

4. CONCLUSIONS

The commencement of NEM on 13 December 1998 was a pivotal event in the evolution of Australia's electricity industry. In this way, the pressure of having high accurate load demand forecast has increased for both the retail and generator companies.

The wholesale pool provides competitive pressure on the generators and the retail businesses are operating in a competitive market. At this stage, the microeconomic reform process in the Australian energy market is advanced and increased competition is expected to remain the main driver of this reform process.

A practical methodology for short term forecasting of load demand in Victoria has been described.
The model forecasts the load demand curves based on three-hourly periods. It is design to handle effects such as: working days, public holidays and weekends, trend, annual seasonal, weekly and daily cycles, special events, etc.

All the statistics chosen for analysing this model as: MAPE, R^2, R^2-adjusted, SD, show good results. The model presented in this paper performed with a high level of accuracy, a total average R^2-adjusted = 92.5 and $R^2 = 93\%$.

A feature attribute of this model is that we have a continuous forecast of the load demand even if the next day is a working or non-working day.

There are a series of factors, which determine the inherent variability of the load demand forecast as: temperature accuracy, random effects, special events and demand side management and electricity curtailment programs. It is recognised that demand side management and electricity curtailment programs will have a wider use in electricity market, in the next years.
As a consequence, the load demand forecast will be influenced negatively if the figures related with these programs will remain unknown.

As new data becomes available, the load demand forecast is recomputed and the coefficients of the models automatically recalculated.

The model was tested for South Australia and New South Wales and performed with similar results.
This fact proves the highly reliability of the model, taken in consideration that there are huge differences between these states regarding area, climatic conditions, electricity consumption, etc.

This methodology can be extended to use 48 half-hour periods and could have superior results.

5. REFERENCES

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