Operating Code 1:
Demand Forecast

By :

NOOR HAFIFI BIN JALAL

KeTTHA
KEMENTERIAN TENAGA, TEKNOLOGI HIJAU DAN AIR

Suruhanjaya Tenaga

The Malaysian Grid Code Awareness Programme Funded by
Akaun Amanah Industri Bekalan Elektrik (AAIBE)

Presentation Outline

- Introduction
- Short Term Forecasting Process in TNB
  - ISO Processes
  - Demand Profile Analysis
- Methodology and Tools
  - Regression using MetrixND
- Forecast and Performance

Introduction

- OC 1 is concerned with demand forecasting for operational purposes.
- OC 1 outlines the obligations of GSO and users on the preparation of Demand Forecast of Active Power, Active Energy and Reactive Power on the Transmission System.
- Set out time scales within the Operational Planning and Operational Control periods.

Introduction (cont.)

- Operational Demand Forecast covers:
  - Day-ahead demand forecast – half-hourly
  - Week-ahead demand forecast – half-hourly
  - Month to Four Months-ahead demand forecast-hourly
  - Special day/week/season demand forecast
  - 5 years-ahead demand forecast
    - hourly (based on the long-term demand forecast prepared by the Grid Owner while formulatingtheSystemDevelopmentPlan)

Objectives

- To enable matching of Generation and Demand in operation
- To ensure the provision of data to the GSO for operation purposes
- To provide for the factors to be taken into account by the GSO when Demand forecasting is conducted in operation

Scope

Applies to:

- GSO
- AllGeneratorswithCDGUs
- AllGeneratorswithGeneratingUnitsnotsubjecttoDispatchby theGSO,withtotalon sitegenerationcapacityequaltoorabove 30MWandwheretheGSOconsidersitnecessary
- Directly Connected Customers where the GSO considers it necessary
- NetworkOperators
- Distributors
- DirectlyConnectedCustomerswhohaveagreedto participatein Demandcontrol
- InterconnectedParties.

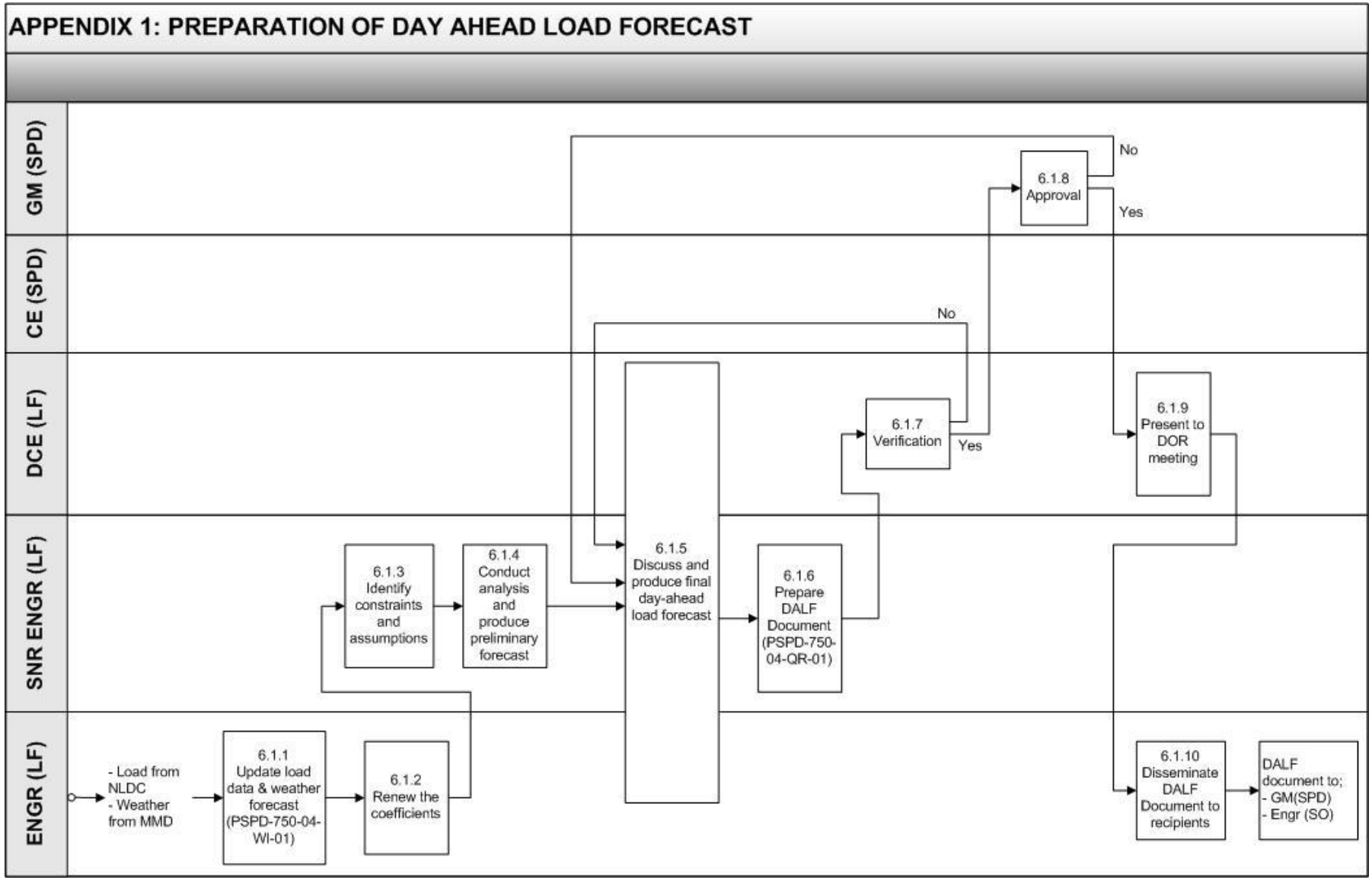
Short Term Forecasting Process in TNB

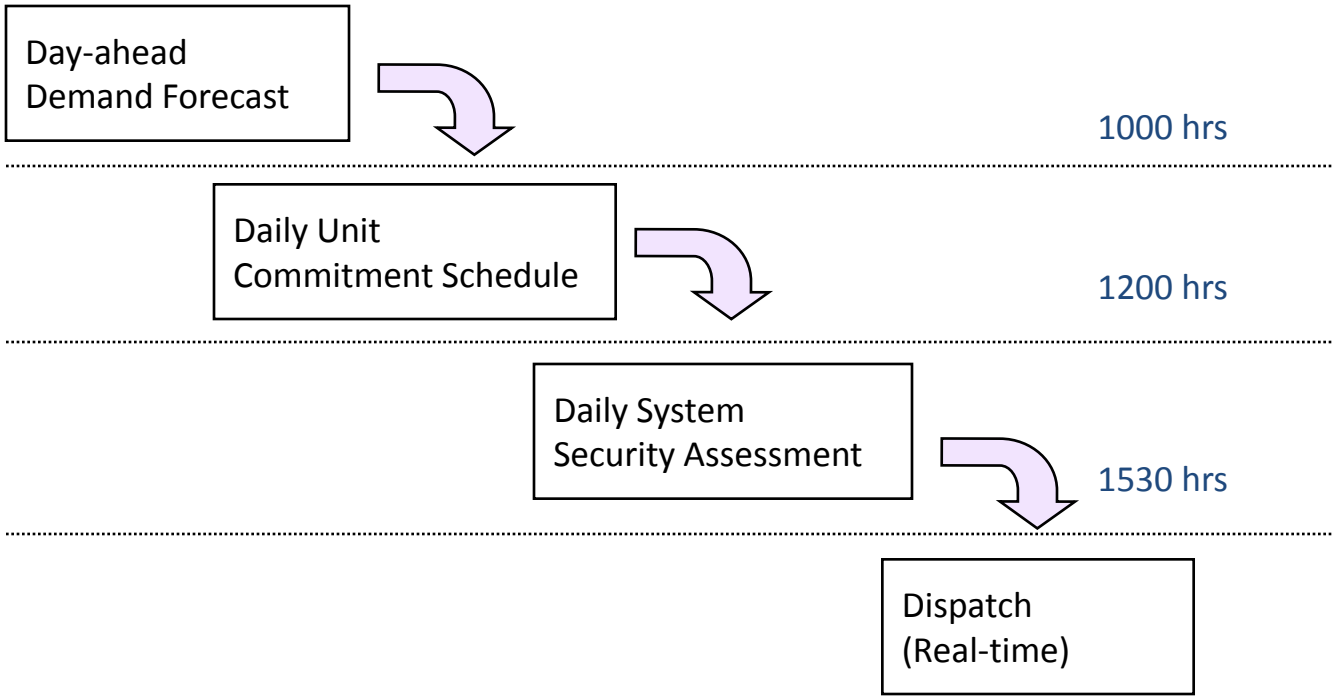
The Malaysian Grid Code Awareness Programme Funded by Akaun Amanah Industri Bekalan Elektrik (AAIBE)

Day-ahead Demand Forecast

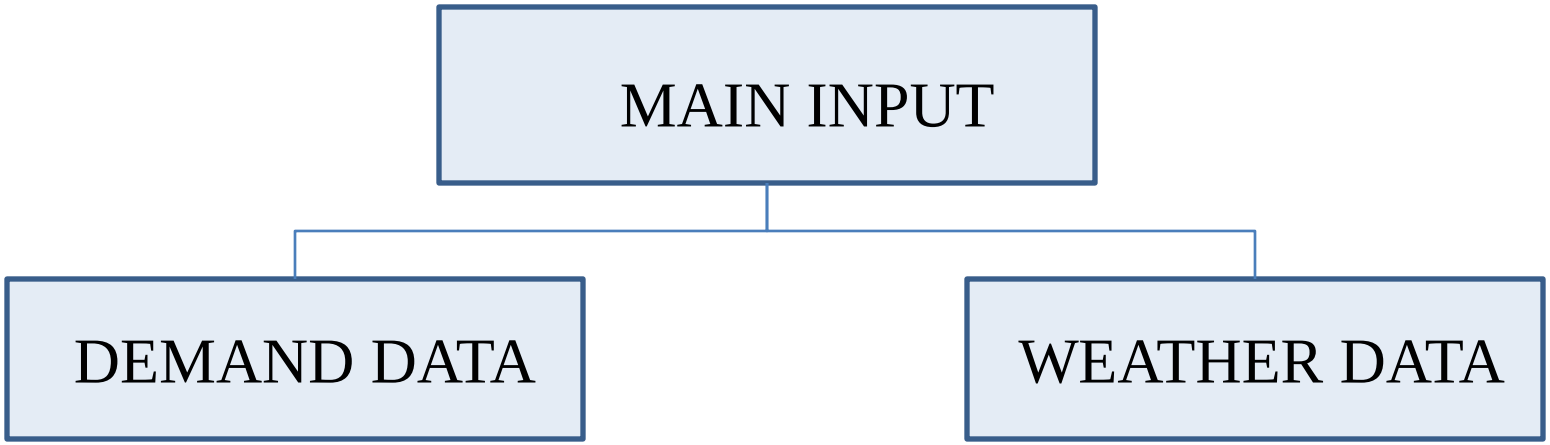
- Consists of half-hourly demand forecast (00:30 to 24:00) and total energy forecast for the next day
  - National grid demand forecast
  - Regional demand forecasts (Northern, Central, Southern & Eastern regions)
- Used in power system operation planning and real time operation:
  - Scheduling, unit commitment and dispatching of generating units
  - Outage management of generating units
  - Outage management of transmission grid network
  - Power system security assessments
  - Fuel requirements and nominations, etc.
- The day-ahead forecast is carried out daily by 10 a.m. for the next day's demand.
- This forecast will be reviewed on the day itself, at 8 a.m. and 4 p.m. The forecast for the day can also be updated on half hourly basis at NLDC using ALSTOM forecasting tool.

Day-ahead Demand Forecast ISO Process

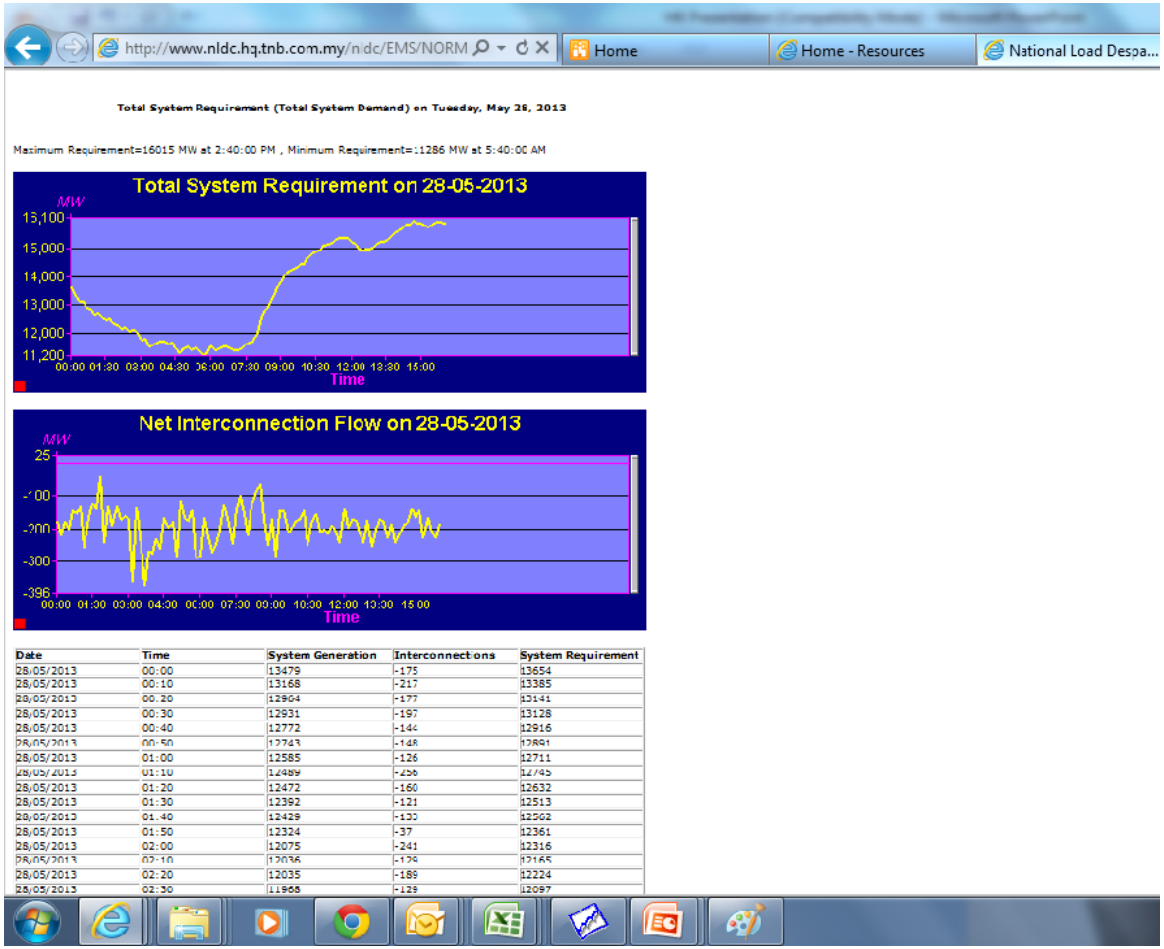



Day-ahead
Demand Forecast
1000 hrs
Daily Unit
Commitment Schedule
1200 hrs
Daily System
Security Assessment
1530 hrs
Dispatch
(Real-time)

Factors



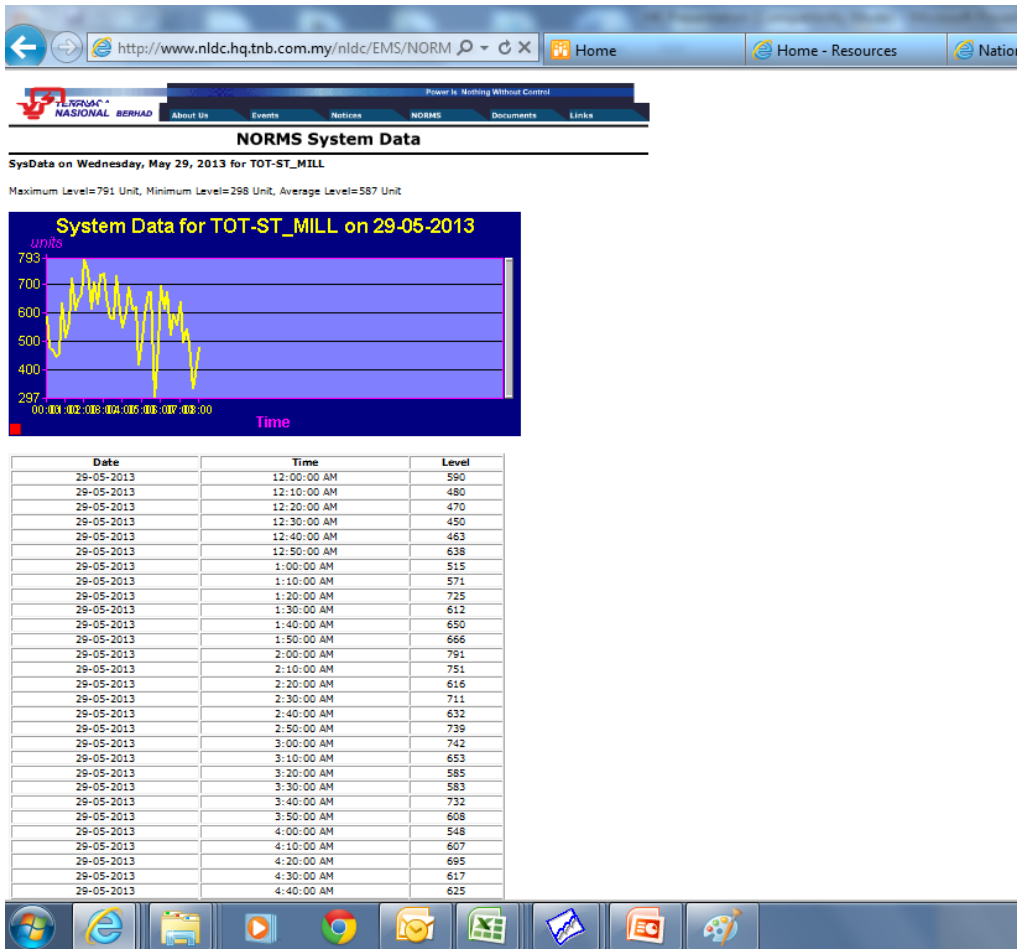
Latest demand From NLDC



- **Sample of data retrieved from NLDC (28 May 2013)**

  - Data is available every 10 minutes
  - Data taken from generators
  - For our forecasting purposes, we will take half-hourly data

Steel mill demand From NLDC



Date	Time	Level
29-05-2013	12:00:00 AM	590
29-05-2013	12:10:00 AM	480
29-05-2013	12:20:00 AM	470
29-05-2013	12:30:00 AM	450
29-05-2013	12:40:00 AM	463
29-05-2013	12:50:00 AM	638
29-05-2013	1:00:00 AM	515
29-05-2013	1:10:00 AM	571
29-05-2013	1:20:00 AM	725
29-05-2013	1:30:00 AM	612
29-05-2013	1:40:00 AM	650
29-05-2013	1:50:00 AM	666
29-05-2013	2:00:00 AM	791
29-05-2013	2:10:00 AM	751
29-05-2013	2:20:00 AM	616
29-05-2013	2:30:00 AM	711
29-05-2013	2:40:00 AM	632
29-05-2013	2:50:00 AM	739
29-05-2013	3:00:00 AM	742
29-05-2013	3:10:00 AM	653
29-05-2013	3:20:00 AM	585
29-05-2013	3:30:00 AM	583
29-05-2013	3:40:00 AM	732
29-05-2013	3:50:00 AM	608
29-05-2013	4:00:00 AM	548
29-05-2013	4:10:00 AM	607
29-05-2013	4:20:00 AM	695
29-05-2013	4:30:00 AM	617
29-05-2013	4:40:00 AM	625

- **Sample of data retrieved from NLDC (29 May 2013)**
  - Data is available every 10 minutes
  - Data taken from 8 major steel mills which are connected directly to the grid via 132kV and 275kV feeder

List of Steel Mills

Voltage	Company
275kV and 132kV	Megasteel
132kV	Orna Steel
132kV	Amsteel
132kV	Malayawata
132kV	Antara Steel
132kV	Perwaja Steel
132kV	Malaya Steel Work

Weather Data From MMD

Ramalan Suhu dan Jumlah Hujan setiap Jam bagi Subang
(Penghantaran melalui emel tx_wf@tnb.com.my pada 0700 LT)

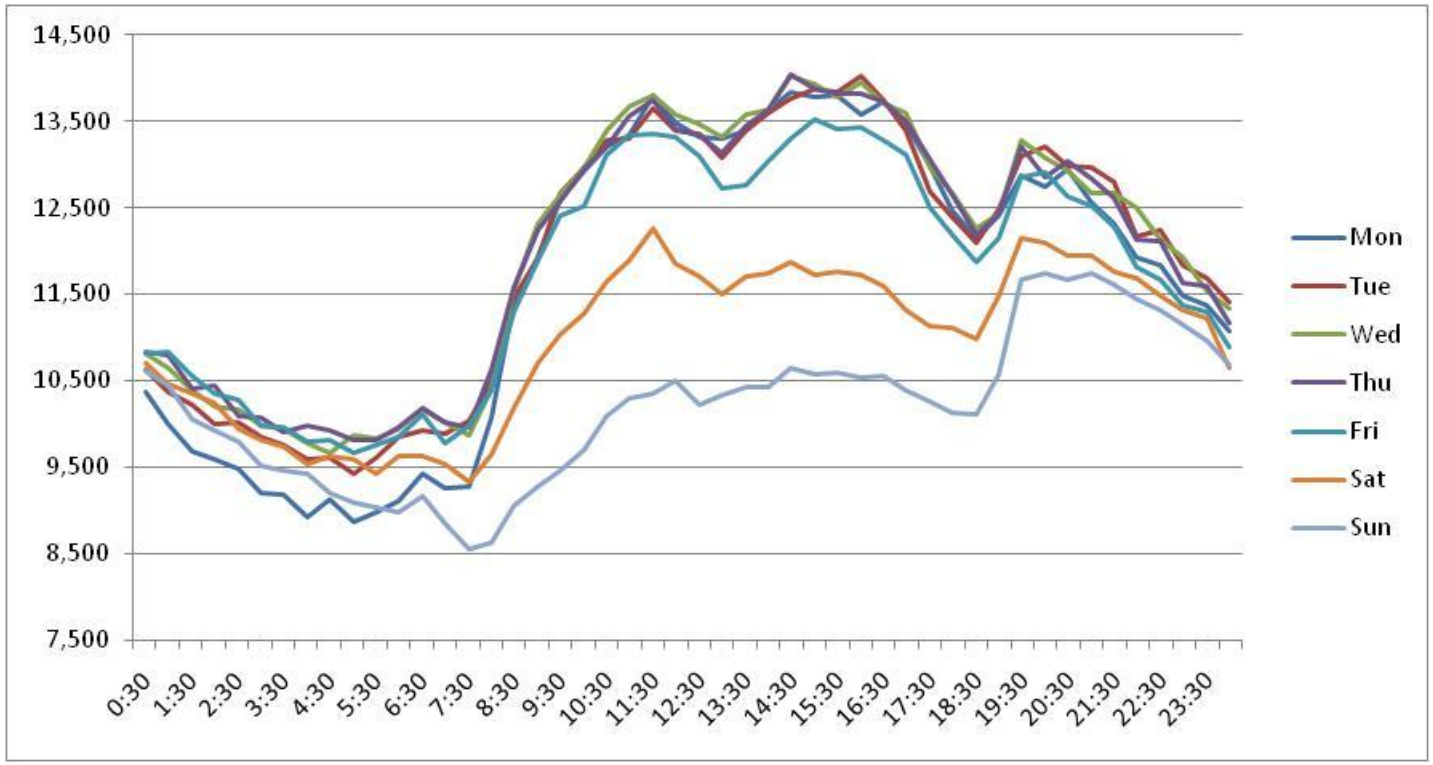
Tarikh	Masa (LT)	Suhu(°C)	Jumlah hujan(mm)
29 May 2013	0800	**25**	**0**
	0900	**26**	**0**
	1000	**28**	**0**
	1100	**30**	**0**
	1200	**31**	**0**
	1300	**32**	**0**
	1400	**33**	**0**
	1500	**34**	**0**
	1600	**32**	**0.2**
	1700	**30**	**1.0**
	1800	**28**	**0.4**
	1900	**28**	**0.6**
	2000	**27**	**0.8**
	2100	**27**	**0.1**
	2200	**27**	**0.1**
	2300	**27**	**0**
	0000	**27**	**0**
	0100	**26**	**0**
	0200	**26**	**0**
	0300	**26**	**0**
	0400	**26**	**0**
	0500	**25**	**0**
	0600	**25**	**0**
	0700	**25**	**0**
30 MEI 2013	0800	**26**	**0**
	0900	**28**	**0**
	1000	**30**	**0**
	1100	**31**	**0**
	1200	**32**	**0**
	1300	**33**	**0**
	1400	**34**	**0**
	1500	**33**	**0**
	1600	**33**	**0**
	1700	**32**	**0**
	1800	**31**	**0**
	1900	**29**	**0**
	2000	**28**	**0**
	2100	**28**	**0**
	2200	**27**	**0**
	2300	**27**	**0**

- **Sample of data retrieved from MMD (29 May 2013)**
  - Send by email very morning before 8 a.m.
  - Hourly weather data in Microsoft Word format
  - Stored in excel, accessible by forecasting tool MetrixND

Demand Profile Analysis

- **Daily demand Profile:**
  - Typical daily demand profile
    - Comparison between days of the week demand profiles
  - Hot day vs. Wet day demand profile
    - Weather impact on demand profile
  - National holidays impact on electricity demand
    - Various national holidays impact on demand demand
  - State holidays impact on national electricity demand
    - Impact from state holidays of each region on the demand
  - Festive week demand profile
    - Comparison between two major festivals: Hari Raya and Chinese New Year
- **Steel Mill demand Profile**

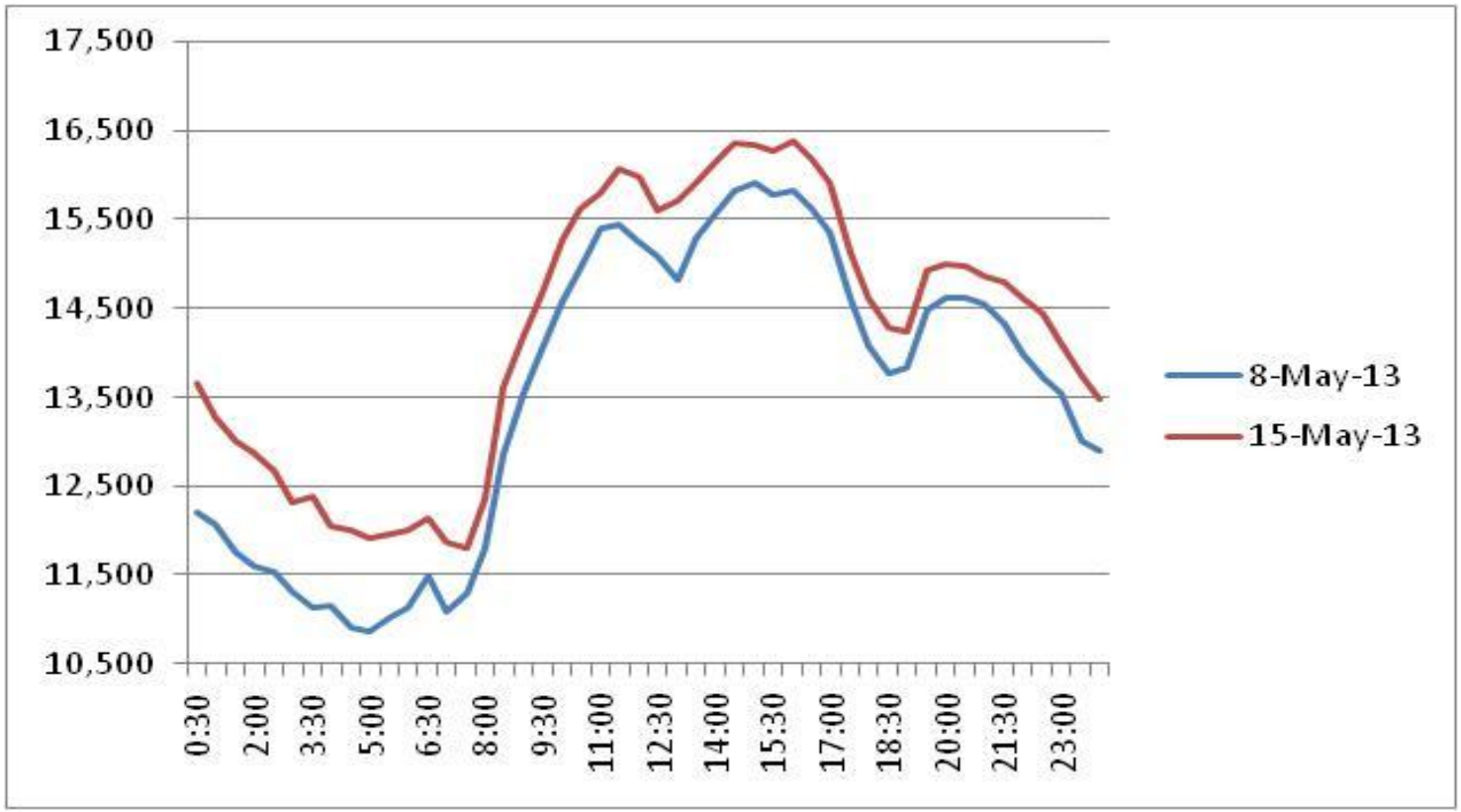
Daily Demand Profiles



Maximum demand : 15,652 MW 13/5/2013

Maximum energy : 345.254 GWh 25/6/13

Hot and Wet Day Profiles

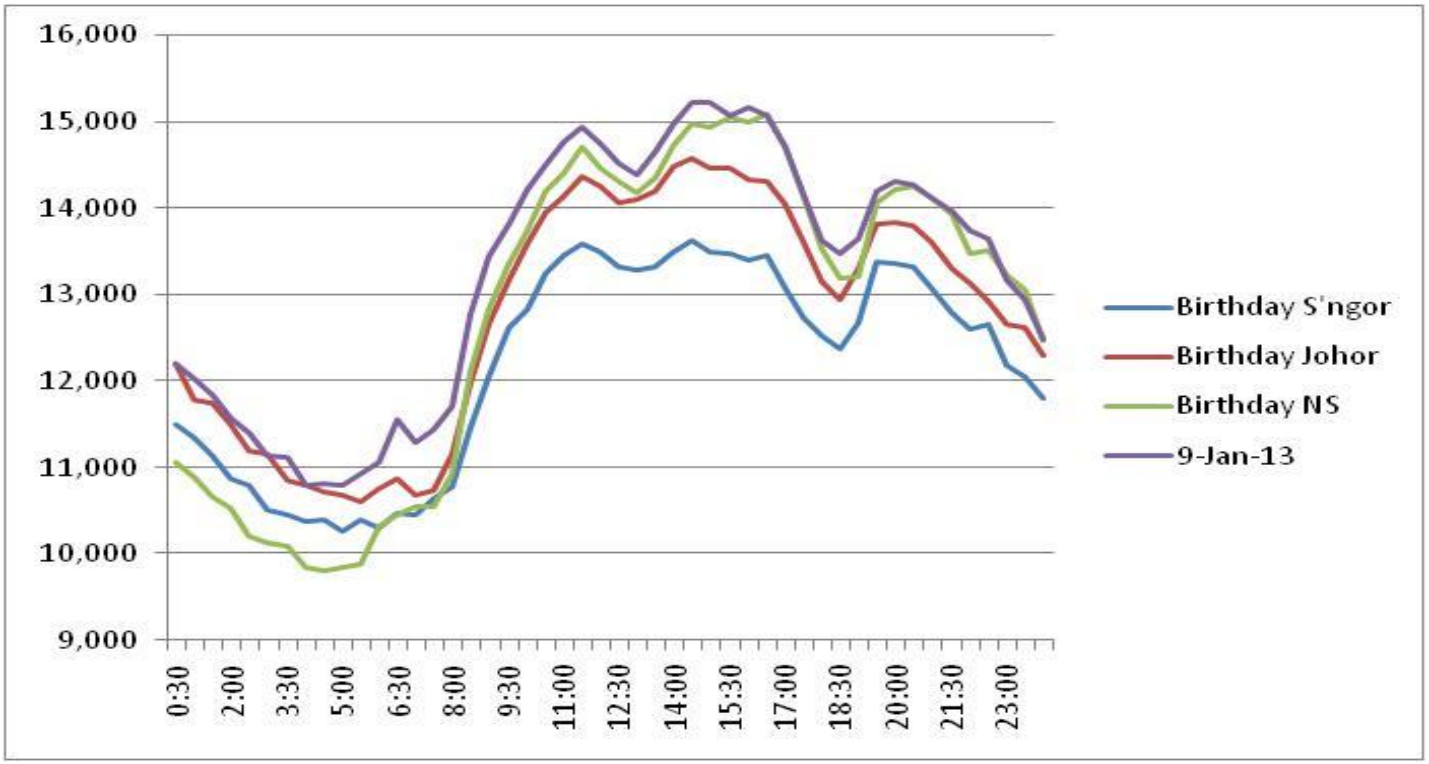


The variation in demand pattern is highly driven by the weather

Public Holidays

Depending on how much they are celebrated

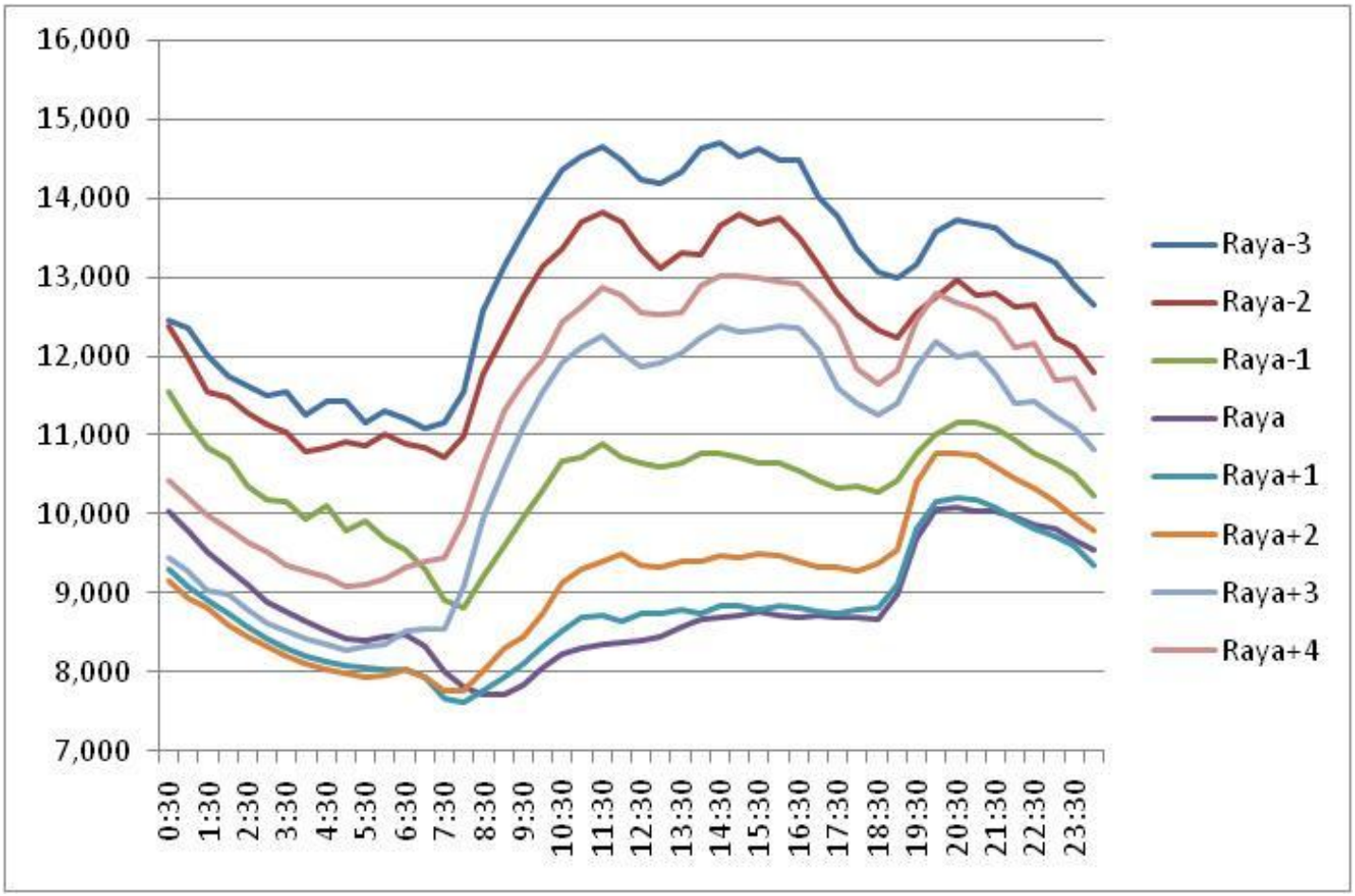
State Holidays



Depending on how much the state consumes electricity

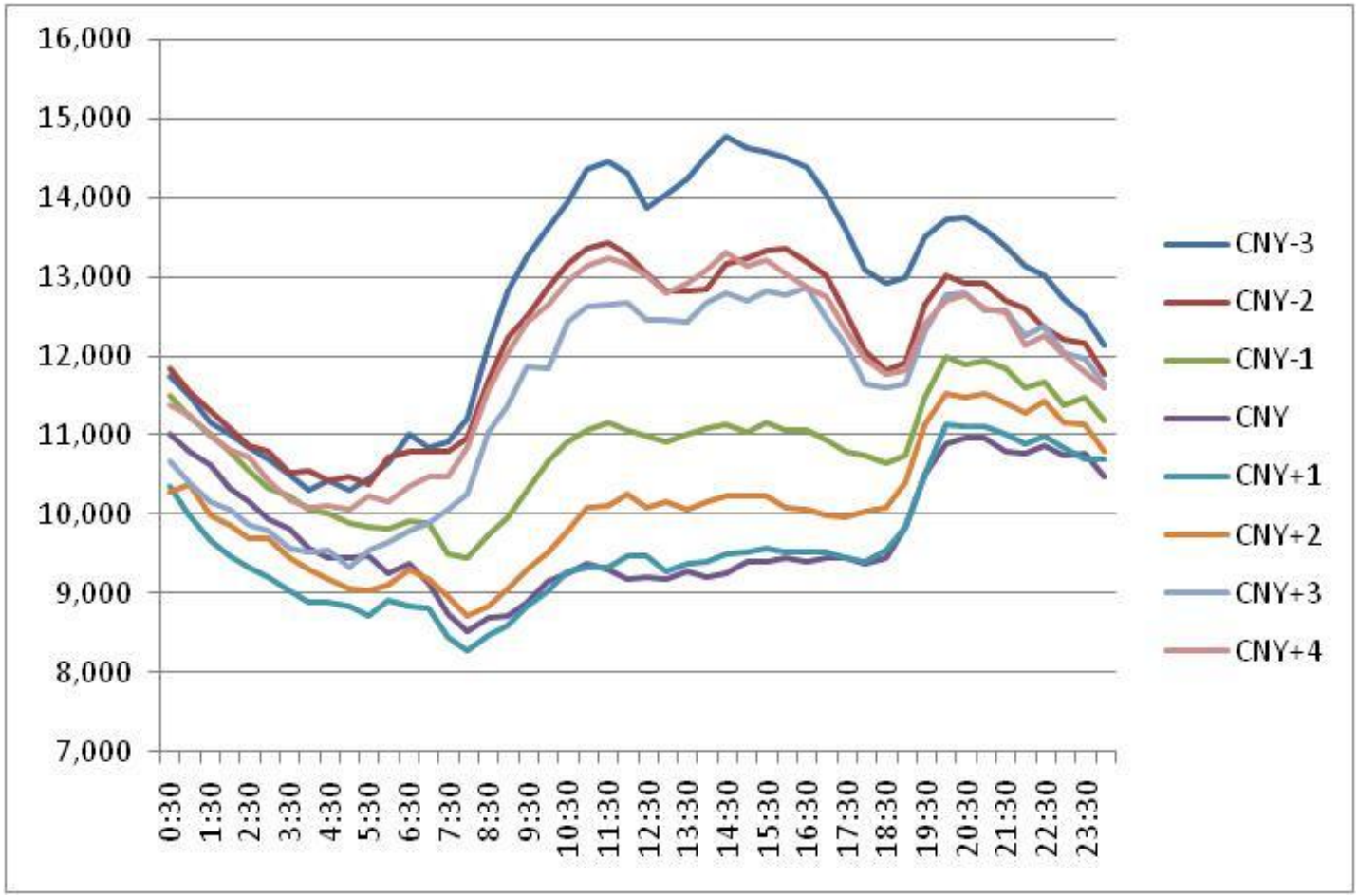
Selangor is the largest electricity consumer in Peninsular Malaysia

Festive Week Profile



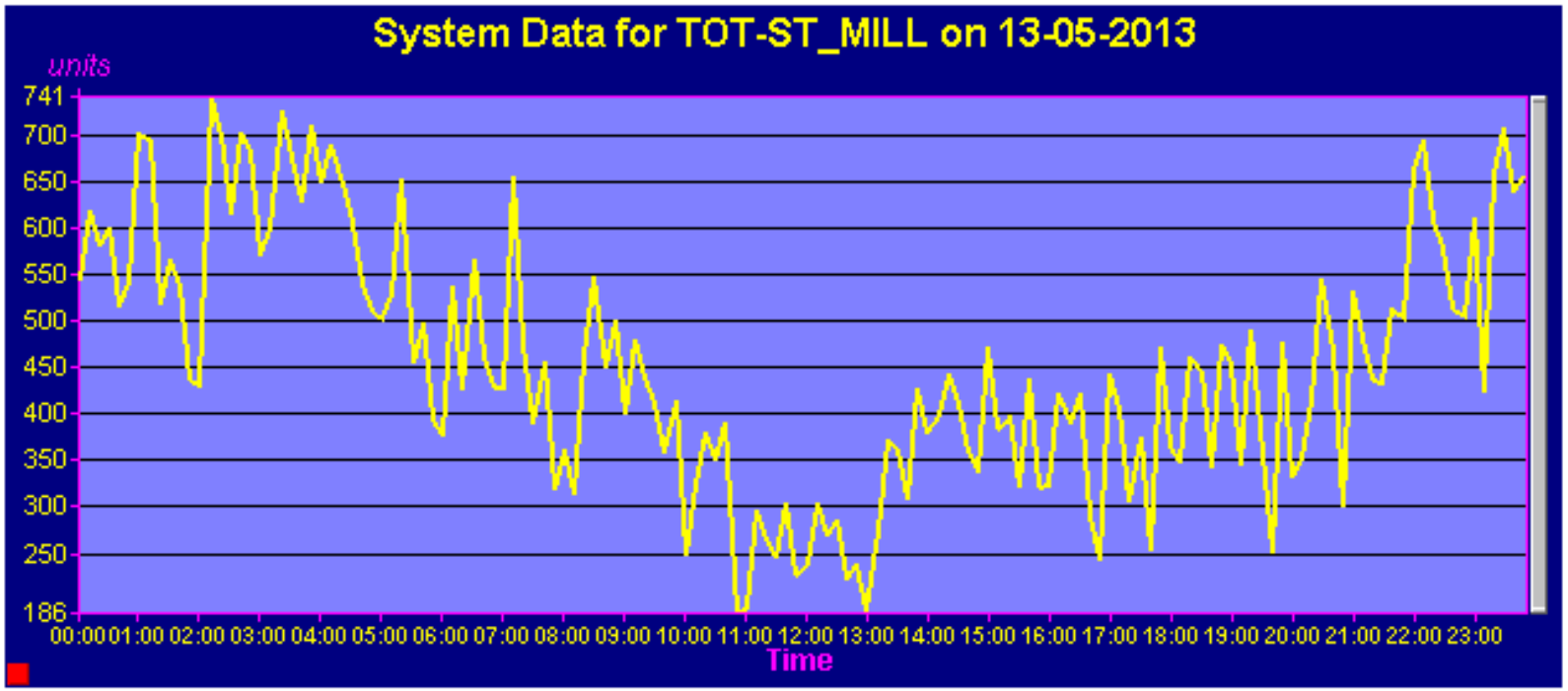
- Festive week daily demand Profile:
  - Hari Raya Puasa 2012

Festive Week Profile



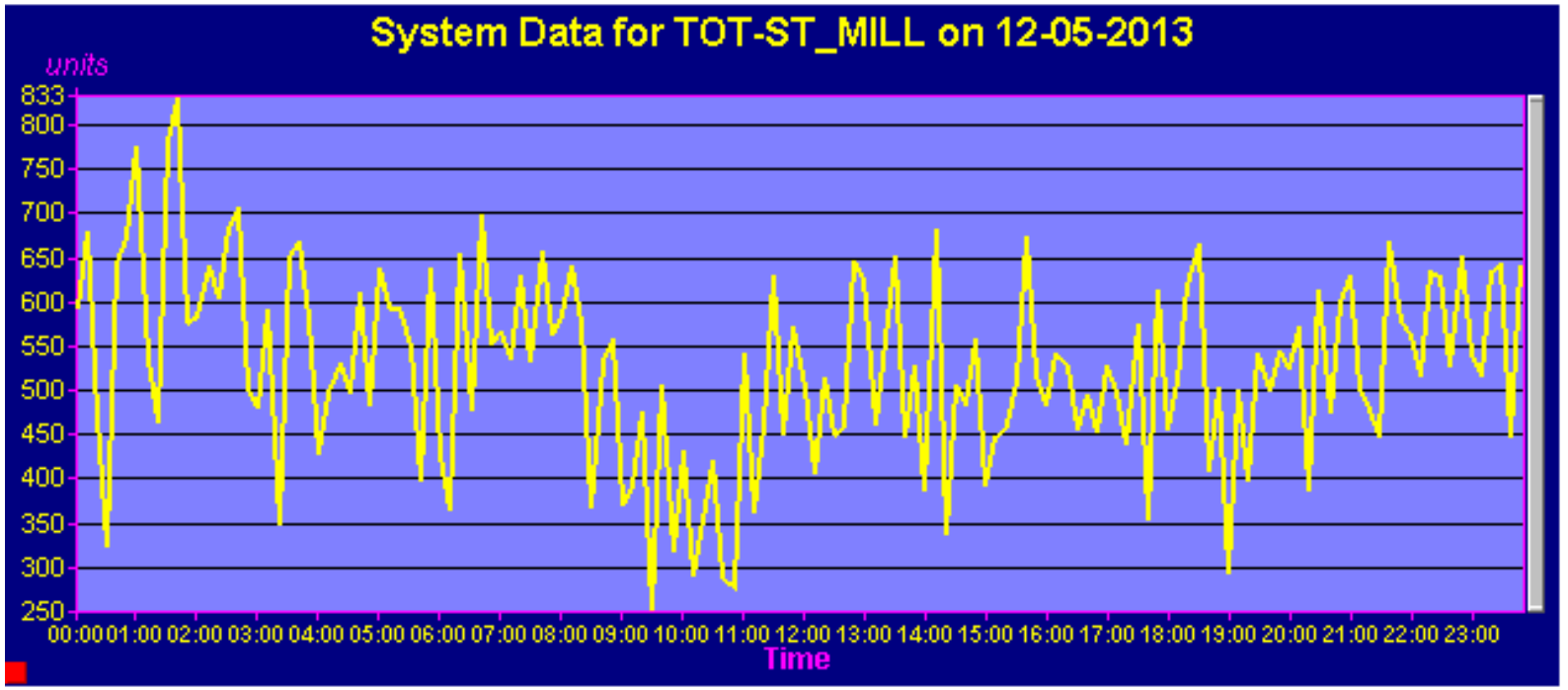
- Festive week Daily demand Profile:
  - Chinese New Year 2013

Steel Mill demand Profile



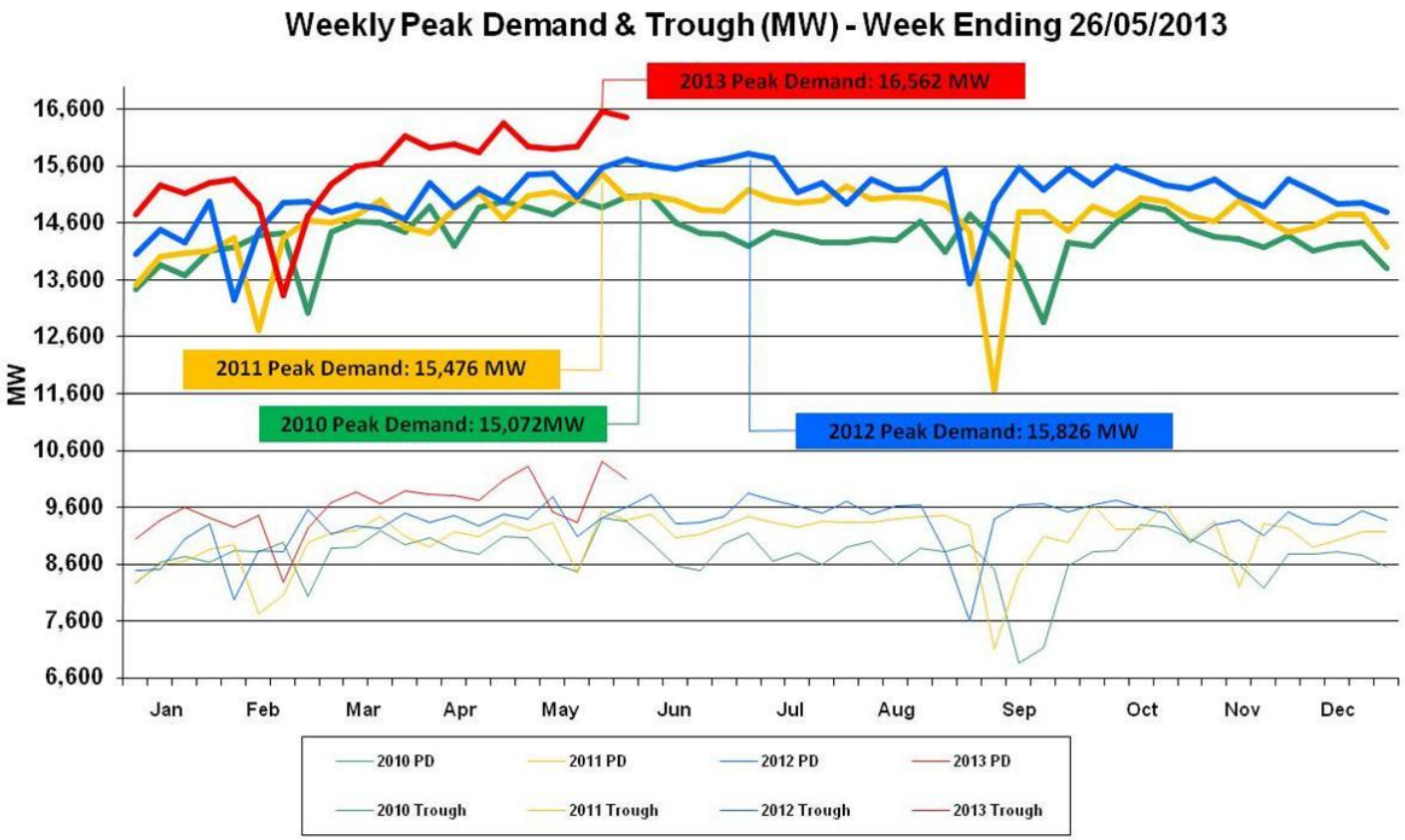
- Typical weekday profile (13 May 2013)

Steel Mill demand Profile



- Typical Sunday profile (12 May 2013)

Weekly MD For 2010 - 2013



Weekly Maximum Demand (MD) trend for the past 4 years

Historical & Future MD

Year	Generation GWh	Growth %	Peak Demand MW	Growth %	MW Increase
2003	73,795	7.1%	11,329	5.1%	546
2004	79,022	7.1%	12,023	6.1%	694
2005	83,303	5.4%	12,493	3.9%	470
2006	86,472	3.8%	12,990	4.0%	497
2007	90,283	4.4%	13,620	4.8%	630
2008	94,370	4.5%	14,007	2.8%	387
2009	92,623	-1.9%	14,245	1.7%	238
2010	100,991	9.0%	15,072	5.8%	827
2011	103,354	2.3%	15,476	2.7%	404
2012	106,884	3.4%	15,826	2.3%	350
2013	111,129	4.0%	16,703	5.5%	877
2014	115,115	3.6%	17,275	3.4%	572
2015	118,886	3.3%	17,813	3.1%	538
2016	123,039	3.5%	18,407	3.3%	594
2017	127,258	3.4%	19,008	3.3%	601
2018	131,551	3.4%	19,619	3.2%	611
2019	135,919	3.3%	20,238	3.2%	620
2020	140,359	3.3%	20,867	3.1%	628

Based on the Electricity Demand Forecast May 2013

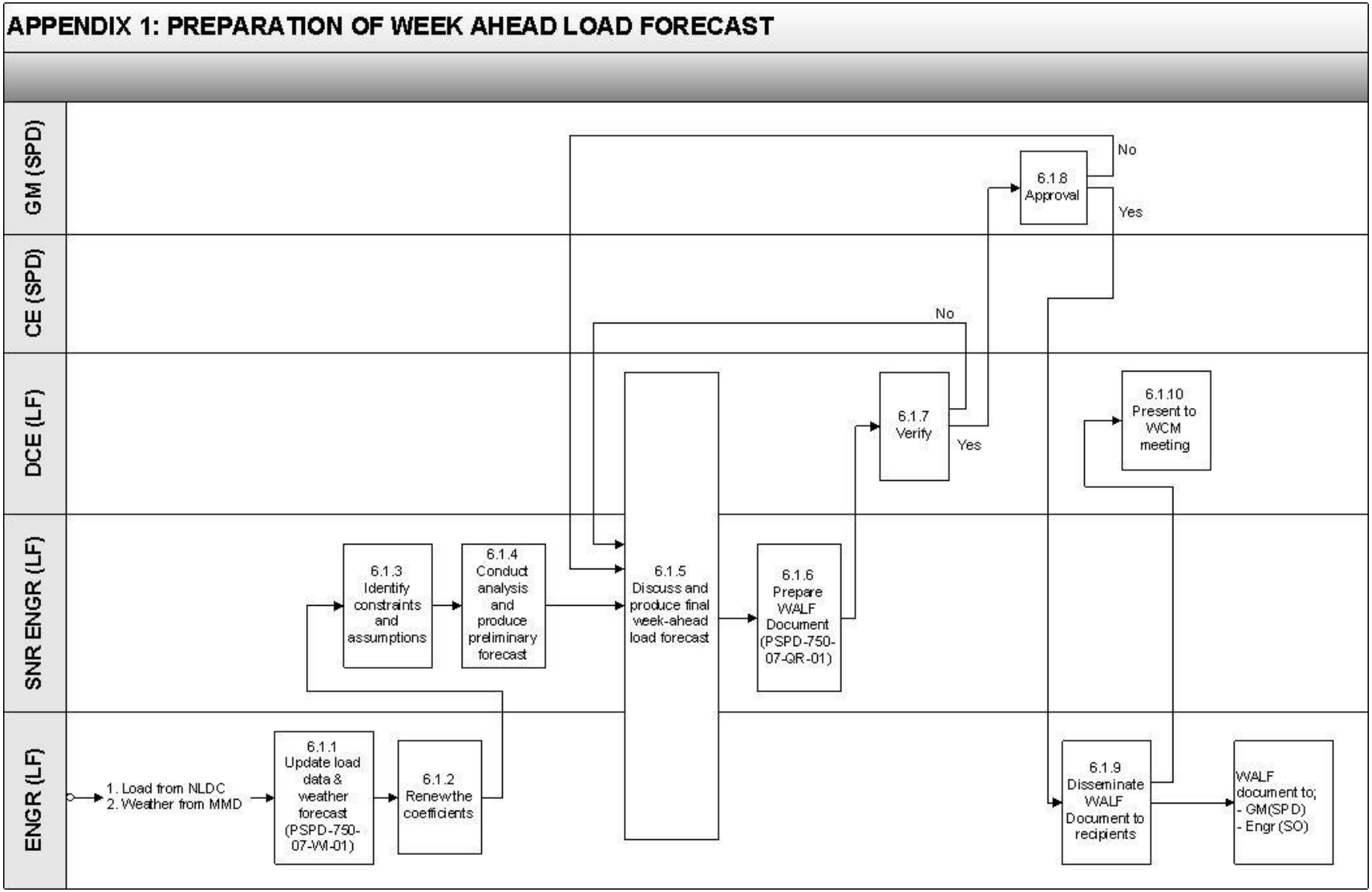
Week-ahead Demand Forecast

- Consists of hourly demand forecast (24 hrs x 7 days)

- Used in power system operation planning:
  - Scheduling and unit commitment of generating units
  - Outage management of generating units
  - Outage management of transmission grid network
  - Power system security assessments
  - Fuel requirements and nominations, etc.

- Conducted weekly before 3 p.m. on Wednesday
- To be presented in the Weekly Coordination Meeting on Thursday at 3 p.m.

Week-ahead Demand Forecast



Month to Four Months-ahead Demand Forecast

- Consists of hourly demand forecast (24 hrs x 30 days x 4 months)

- Used in power system operation planning:
  - Scheduling and unit commitment of generating units
  - Outage management of generating units
  - Outage management of transmission grid network
  - Power system security assessments
  - Fuel requirements and nominations, etc.

- Conducted monthly before end of every month

5 years-ahead Demand Forecast

- Consists of hourly demand forecast (24 hrs x 365 days x 5 yrs)

- Used to prepare:
  - 5-year Generation Operation Plan for capacity adequacy planning
  - 2-year System Operation Plan for system operation and security planning
  - Fuel requirement
  - Resource planning

Methodology

The Malaysian Grid Code Awareness Programme Funded by
Akaun Amanah Industri Bekalan Elektrik (AAIBE)

Introduction

- Quantitative methods have been shown to be helpful in making better predictions about the future course of events.
- However, there is a rich history of forecasting based on subjective or judgmental methods, most of which remain useful today.
- Combine original quantitative forecast with the corresponding judgmentally adjusted forecasts.
- Implies 3 steps: Make quantitative forecast, allow for judgmental adjustment, then combine both forecasts.

Linear Regression

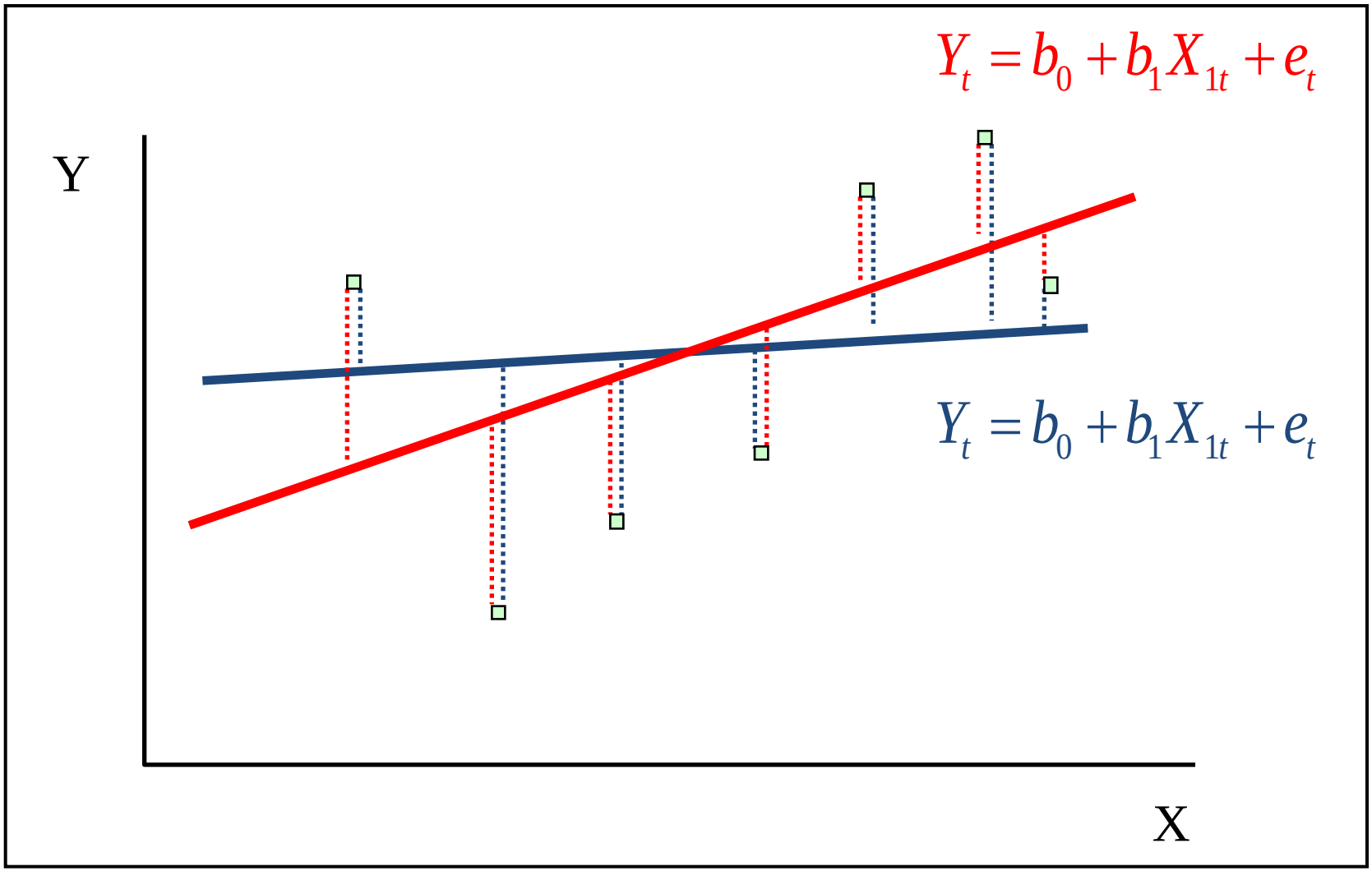
- Specification of the Model:

- Estimated Regression Model:

$$Y_t = b_0 + b_1 X_{1t} + b_2 X_{2t} \ldots + b_k X_{kt} + e_t$$

$$\hat{Y}_t = \hat{b}_0 + \hat{b}_1 X_{1t} + \hat{b}_2 X_{2t} \ldots + \hat{b}_k X_{kt}$$

Depiction of Estimation



Estimation Solution

In two dimensions, minimize the objective function with respect to B_0 and B_1:

$$Q = \sum_{t=1}^{N} \hat{e}_t^2 = \sum_{t=1}^{N} \left(Y_t - B_0 - B_1 X_t\right)^2$$

Take Derivatives and set equal to zero:

$$\frac{\delta Q}{\delta B_0} = -2\sum_t (Y_t - B_0 - B_1 X_t) = 0$$

$$\frac{\delta Q}{\delta B_1} = -2\sum_t X_t (Y_t - B_0 - B_1 X_t) = 0$$

Reduces to the "normal equations":

$$\sum_t Y_t = nB_0 + B_1 \sum_t X_t$$

$$\sum_t X_t Y_t = B_0 \sum_t X_t + B_1 \sum_t X_t^2$$

Solve the system of equations for B_0 and B_1

Estimation Solution

In multiple dimensions, parameters are found using matrix mathematics:

$$Y = \begin{bmatrix} Y_1 \\ Y_2 \\ \dots \\ Y_n \end{bmatrix} \quad X = \begin{bmatrix} 1 & X_{1,1} & X_{1,2} \\ 1 & X_{2,1} & X_{2,2} \\ \dots & & \\ 1 & X_{n,1} & X_{n,2} \end{bmatrix} \quad X^T = \begin{bmatrix} 1 & 1 & \dots & 1 \\ X_{1,1} & X_{2,1} & \dots & X_{n,1} \\ X_{1,2} & X_{2,2} & \dots & X_{n,2} \end{bmatrix} \quad B = \begin{bmatrix} B_1 \\ B_2 \\ \dots \\ B_n \end{bmatrix}$$

$$Y = BX$$

$$X^T Y = X^T XB$$

$$(X^T Y)(X^T X)^{-1} = B(X^T X)(X^T X)^{-1}$$

$$(X^T Y)(X^T X)^{-1} = B$$

A solution can be found if the inverse of $X^T X$ exists

Advantages of Regression

- Model includes explanatory variables (drivers)
- Parameters provide information about the process (e.g., price elasticities)
- Forecasts can account for major changes in drivers
- Alternative scenarios can be evaluated
- Caveats:
  - Structural changes complicate the forecaster's work
  - You still need to have forecasts of the drivers

Application to TNB Demand Forecasting

Regression Model

KeTTHA
KEMENTERIAN TENAGA, TEKNOLOGI HIJAU DAN AIR

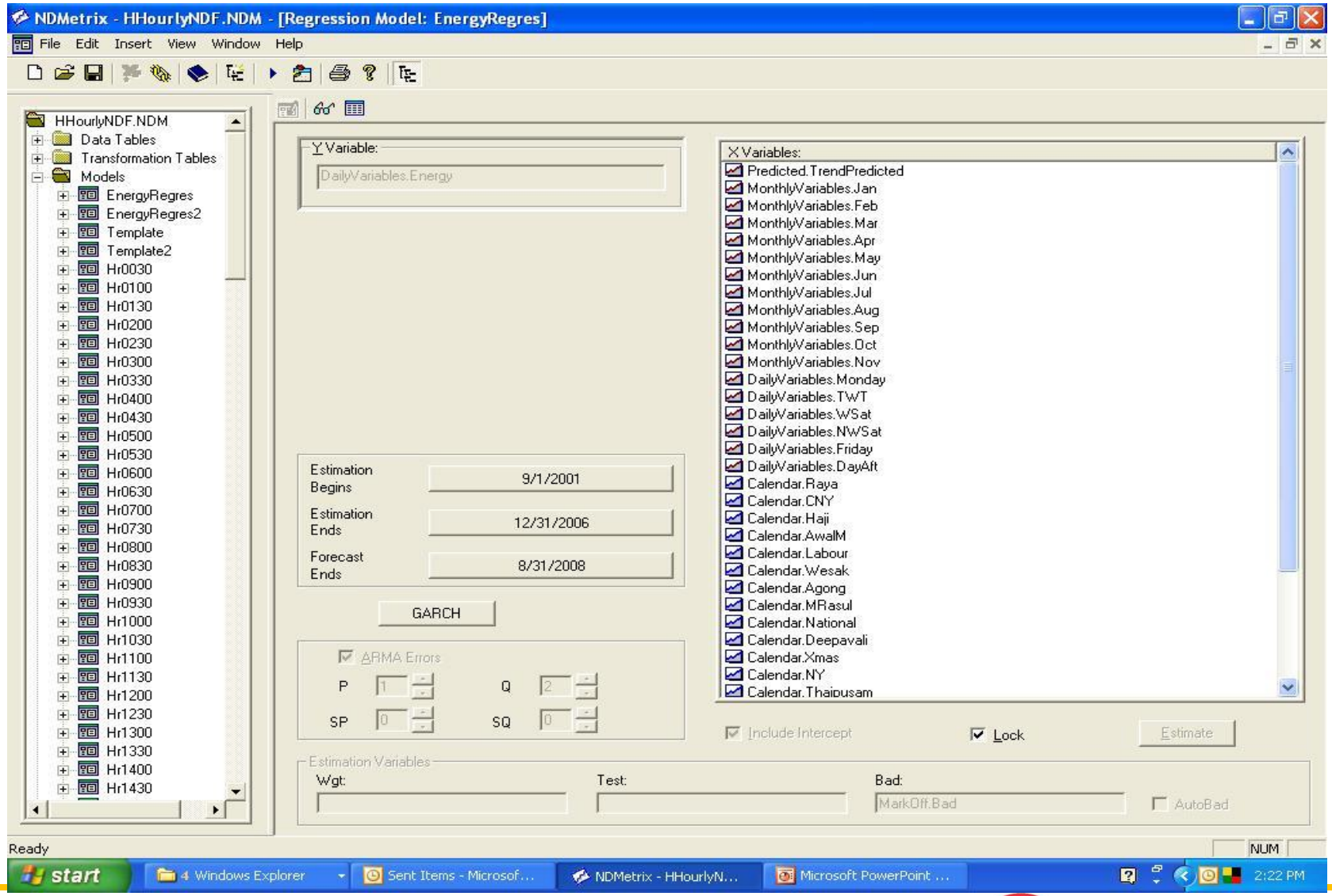
Suruhanjaya Tenaga

The Malaysian Grid Code Awareness Programme Funded by Akaun Amanah Industri Bekalan Elektrik (AAIBE)

Our Model

- We utilize multiple regression model to forecast our demand which comprises of the following variables:
  - Day-of-the-Week Binary Variables
    - Mon, TWT, Friday, Saturday
  - Monthly Variables
    - Jan, Feb, Mac, Apr, May, June, July, Aug, Sept, Oct, Nov
  - Holiday Binary Variables
    - Major holidays – Raya, CNY
    - National holidays – New Year, Christmas, Labour Day
    - State holidays – Thaipusam, Sultan's Birthday & etc.

Our Parameters



Forecast and Performance

KeTTHA
KEMENTERIAN TENAGA, TEKNOLOGI HIJAU DAN AIR

Suruhanjaya Tenaga

The Malaysian Grid Code Awareness Programme Funded by Akaun Amanah Industri Bekalan Elektrik (AAIBE)

Day-ahead Forecast Sample Output

- **Sample of Day-ahead Daily Forecast Report (23 May 2013)**

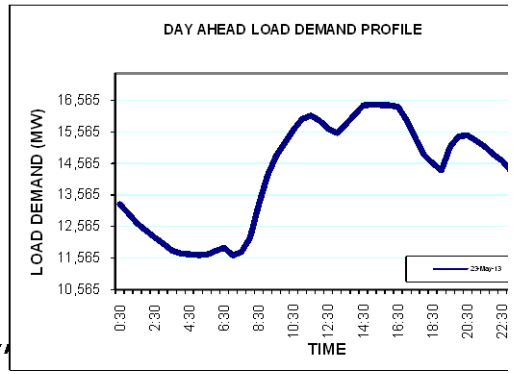
  - Half hourly demand figures from 00:30 to 24:00
  - Graph for consistency checks
  - Demand summary for maximum demand of the day and daily energy generation requirement
  - Three cities weather forecasts used in forecasting assumptions are also summarized in a table

TENAGA NASIONAL BERHAD (20866-W)

DEMAND FORECAST SECTION
SYSTEM PLANNING & DEVELOPMENT

TIME	DEMAND (MW)
0:30	13,272
1:00	12,982
1:30	12,667
2:00	12,441
2:30	12,223
3:00	12,025
3:30	11,800
4:00	11,706
4:30	11,682
5:00	11,660
5:30	11,665
6:00	11,789
6:30	11,890
7:00	11,650
7:30	11,759
8:00	12,201
8:30	13,275
9:00	14,185
9:30	14,811
10:00	15,223
10:30	15,644
11:00	15,981
11:30	16,081
12:00	15,924
12:30	15,663
13:00	15,534
13:30	15,809
14:00	16,107
14:30	16,408
15:00	16,434
15:30	16,418
16:00	16,414
16:30	16,364
17:00	15,933
17:30	15,370
18:00	14,832
18:30	14,573
19:00	14,341
19:30	15,097
20:00	15,429
20:30	15,455
21:00	15,290
21:30	15,097
22:00	14,851
22:30	14,650
23:00	14,325
23:30	14,099
0:00	13,834

DAY AHEAD DEMAND FORECAST FOR Thu 23-May-13



	MW	TIME
MD	16,434	15:00
TROUGH	11,650	7:00

ENERGY 341.43 GWh

DAY AHEAD WEATHER FORECAST SUMMARY

TOWN	MORNING	AFT.	NIGHT	MIN	MAX
KL	C	TS	C	25	34
GEORGETOWN	F	F	F	25	33
JB	R	TS	F	24	32

F - Weather Fair C - Cloudy
TS - Thunderstorm R - Rain

NOTE

Forecast prepared with information available as at 0900hrs on 22-May-13

Prepared by	Noor Hafili Jalal		Senior Engineer (LF)	22-May-13
Checked by	Mohd Fuad Jamaludin		Dep. Chief Engineer (LF)	22-May-13
Approved by	Charan Jit Singh		Senior General Manager (SB)	22-May-13

Week-ahead Forecast Sample Output

- **Sample of Week-Ahead Forecast Report (Week 22-23 2013)**

  - Hourly forecast figures for two weeks
  - Used for generator outage and transmission outage and production planning

TENAGA NASIONAL BERHAD (20866-W)

SYSTEM PLANNING & DEVELOPMENT (LOAD FORECAST SECTION)
WEEK AHEAD DEMAND (MW) FORECAST

WEEK 22/13

DAY HRS/DATE	Sat 25-May	Sun 26-May	Mon 27-May	Tue 28-May	Wed 29-May	Thu 30-May	Fri 31-May
0:00	12,483	13,371	12,870	13,935	13,866	13,861	14,085
1:00	12,065	12,730	12,047	13,061	13,136	13,165	13,189
2:00	11,688	12,285	11,688	12,655	12,693	12,735	12,710
3:00	11,274	11,849	11,277	12,212	12,251	12,291	12,241
4:00	11,082	11,588	11,146	11,953	11,975	11,994	11,946
5:00	10,945	11,369	11,000	11,801	11,820	11,824	11,769
6:00	11,153	11,202	11,107	11,892	11,929	11,924	11,847
7:00	10,955	10,891	11,162	11,767	11,782	11,769	11,645
8:00	10,846	10,691	12,059	12,392	12,384	12,393	12,191
9:00	12,135	11,011	13,997	14,160	14,147	14,158	13,929
10:00	13,058	11,688	14,963	15,177	15,199	15,201	14,957
11:00	13,677	12,249	15,754	15,834	15,838	15,890	15,634
12:00	13,777	12,371	15,745	15,792	15,801	15,830	15,599
13:00	13,548	12,187	15,424	15,385	15,385	15,414	14,984
14:00	13,917	12,399	16,010	16,033	16,050	16,055	15,320
15:00	14,057	12,563	16,354	16,418	16,422	16,434	16,001
16:00	14,061	12,564	16,425	16,431	16,429	16,462	16,056
17:00	13,692	12,241	15,957	15,991	15,997	16,039	15,654
18:00	13,086	12,210	14,560	14,693	14,699	14,718	14,485
19:00	13,012	12,189	14,236	14,392	14,404	14,402	14,139
20:00	14,280	13,512	15,403	15,439	15,461	15,478	15,235
21:00	14,157	13,614	15,352	15,371	15,386	15,394	15,132
22:00	13,992	13,498	14,927	14,955	14,956	14,959	14,706
23:00	13,789	13,255	14,486	14,576	14,524	14,551	14,299
MD	14,280	13,614	16,425	16,431	16,429	16,462	16,056
ENERGY	306.73	293.53	333.95	342.32	342.54	342.94	337.75

WEEK 23/13

DAY HRS/DATE	Sat 1-Jun	Sun 2-Jun	Mon 3-Jun	Tue 4-Jun	Wed 5-Jun	Thu 6-Jun	Fri 7-Jun
0:00	13,913	13,079	12,760	13,937	13,879	13,861	14,094
1:00	13,144	12,548	11,937	13,055	13,124	13,216	13,169
2:00	12,595	12,060	11,503	12,643	12,700	12,739	12,722
3:00	12,285	11,641	11,188	12,220	12,263	12,274	12,242
4:00	11,807	11,232	11,064	11,936	11,994	11,983	11,950
5:00	11,626	11,111	10,893	11,801	11,829	11,820	11,777
6:00	11,593	11,141	11,008	11,889	11,931	11,923	11,864
7:00	10,851	10,684	11,064	11,762	11,784	11,783	11,651
8:00	9,792	10,044	11,898	12,381	12,390	12,383	12,190
9:00	10,161	10,348	14,007	14,138	14,134	13,817	13,920
10:00	10,808	11,115	14,956	15,188	15,192	14,840	14,964
11:00	11,482	11,809	15,738	15,826	15,831	15,395	15,624
12:00	11,626	11,970	15,750	15,785	15,804	15,479	15,602
13:00	11,510	11,811	15,435	15,367	15,380	15,066	14,975
14:00	11,657	11,983	16,007	16,032	16,043	15,663	15,330
15:00	11,687	12,158	16,340	16,396	16,413	16,231	16,001
16:00	11,742	12,261	16,428	16,437	16,421	16,250	16,052
17:00	11,484	12,047	15,965	15,985	15,990	15,687	15,663
18:00	11,617	12,089	14,558	14,685	14,710	14,528	14,480
19:00	11,732	12,362	14,224	14,397	14,395	14,384	14,132
20:00	12,823	13,303	15,422	15,428	15,479	15,474	15,241
21:00	12,892	13,410	15,356	15,386	15,384	15,396	15,121
22:00	12,822	13,305	14,910	14,946	14,965	14,971	14,718
23:00	12,672	13,189	14,490	14,555	14,522	14,539	14,491
MD	13,913	13,410	16,428	16,437	16,421	16,250	16,052
ENERGY	284.32	286.70	332.98	342.18	342.56	339.70	337.97

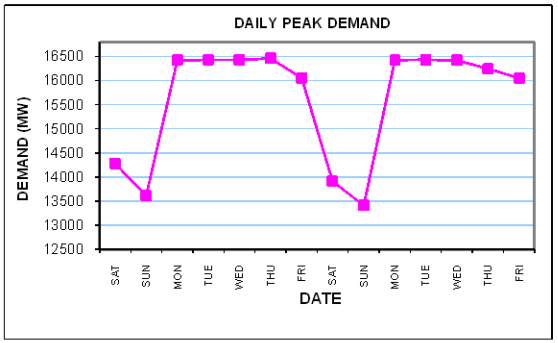
Week Ahead Weather Forecast Summary

TOWN	MORN.	AFT.	NIGHT	MIN	MAX
Kuala Lumpur	F	TS	F	26	34
Georgetown	F	F/R	F	25	33
Johor Bahru	F	TS	F	24	33

Remarks/ Holidays
1-Jun-13 Bday Agong
6-Jun-13 Isra' Mikraj

Forecast prepared with information available as at 1600 hrs on 21-May-13

	Name	Initial	Designation	Date
Prepared by	Noor Hafili Jalal		Senior Engineer (LF)	21-May-13
Checked by	Mohd Fuad Jamaludin		Dep. Chief Engineer (LF)	21-May-13
Approved by	Charan Jit Singh		Sen.Gen. Manager (SB)	21-May-13

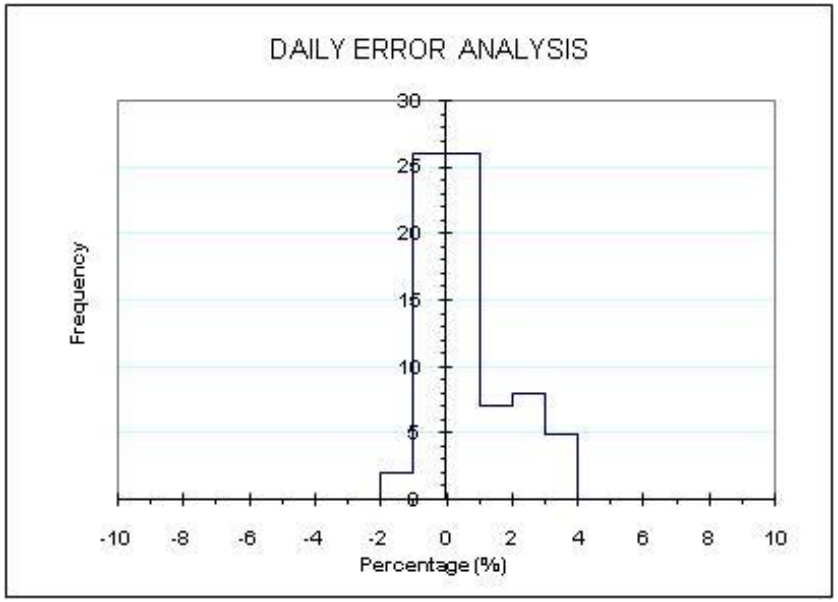


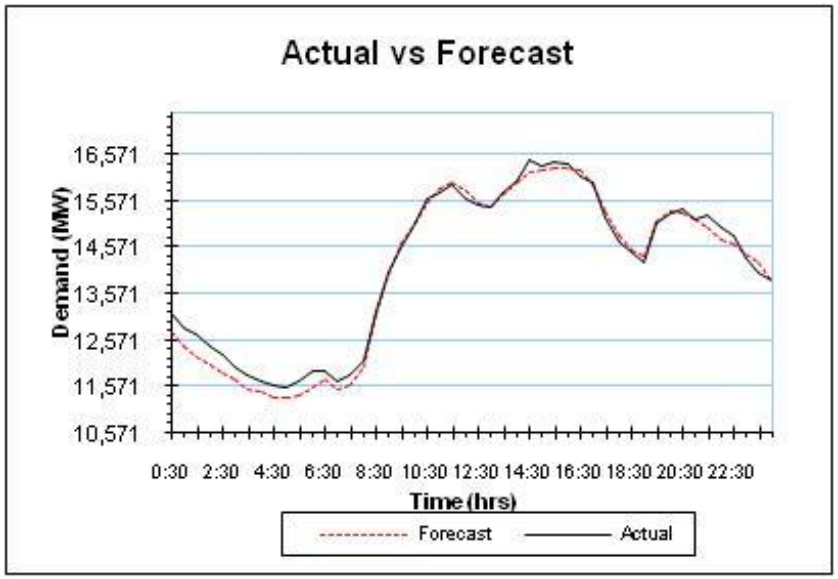
Accuracy and Performance (Daily)

- **Sample of Day-Ahead Daily Error Analysis (21 May 2013)**

  - Annual KPI MAPE<2.6%
  - Normal MAPE for weekdays (including 0800hrs revision) normally <2.0%
  - >95% falls between ±3%

ERROR	(%)
MAPE	1.23%
ENERGY	-0.48%
MD	1.03%
LF	-1.53%
AV ERROR	0.84%
RMSE (MW)	205
$RMSE_{6p}$ (MW)	128

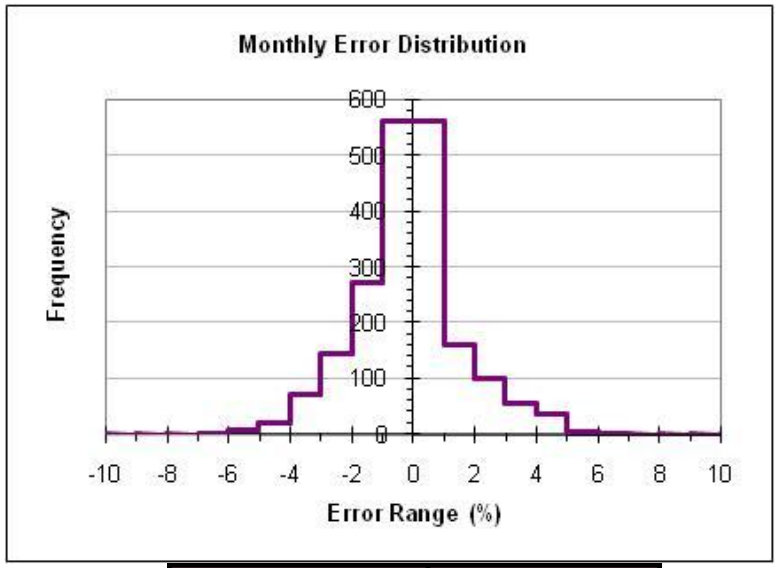




Accuracy and Performance (Monthly)

- **Sample of Day-Ahead Monthly Error Analysis (April 2013)**

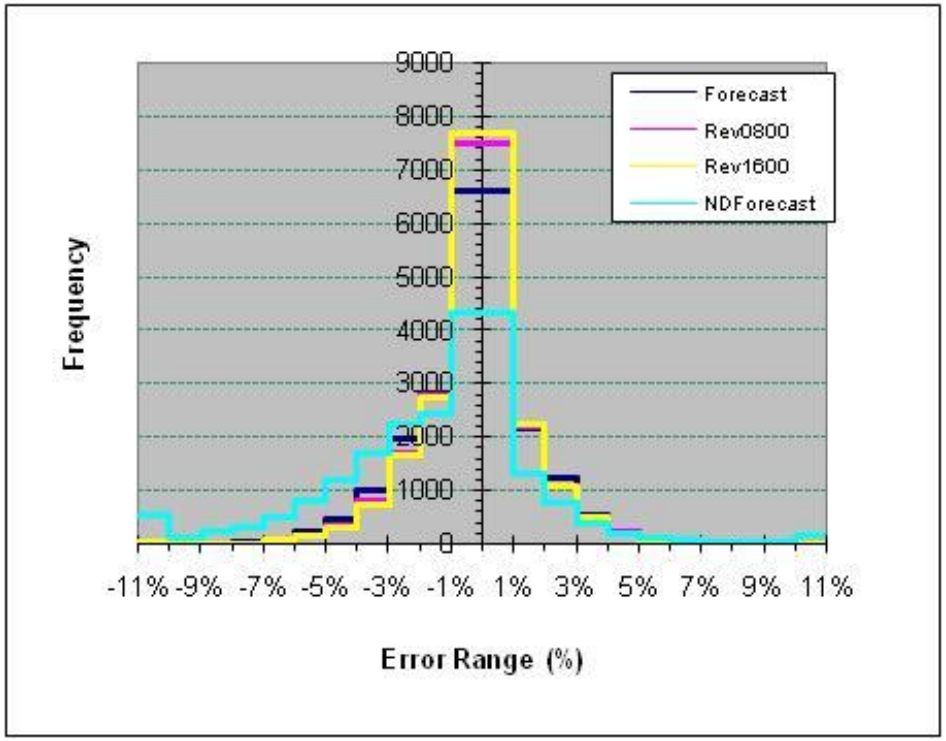
  - Normal MAPE for weekdays (including 0800hrs revision) normally <1.5%; 1.59% MAPE for Apr '13
  - >80% falls between ±3%
  - Larger error experienced during national and state holidays due to additional uncertainty added to demand characteristics



Category	Frequency
x <= -5%	10
-5%<x<=-3%	93
-3%<x<=-2%	146
-2%<x<=-1%	272
-1%<x<= 1%	561
1%<x<= 2%	161
2%<x<= 3%	99
3%<x<= 5%	90
x >= 5%	8

Accuracy and Performance (Yearly)

- **Sample of Day-Ahead Yearly Error Analysis (FY2012)**
  - Comparison between four sets of forecasts produced in FY12



	Forecast	Rev0800	Rev1600	NDForecast
x<-10%	22	21	21	534
-10%<=x<-5%	343	256	243	1965
-5%<=x<-3%	1466	1163	1052	2906
-3%<=x<-2%	1968	1717	1649	2257
-2%<=x<-1%	2821	2768	2763	2450
-1%<=x<=1%	6631	7518	7688	4341
1%<x<=2%	2155	2202	2246	1335
2%<x<=3%	1221	1095	1101	780
3%<x<=5%	792	733	710	573
5%<x<=10%	144	90	90	268
x>10%	5	5	5	159
Total	17568	17568	17568	17568

Error Summary	DA	R0800	R1600	NDF
MAPE	1.71%	1.55%	1.51%	3.16%
Energy	1.82%	1.65%	1.61%	3.19%
Daily MD	-0.40%	-0.31%	-0.27%	-1.86%

THANK YOU

KeTTHA
KEMENTERIAN TENAGA, TEKNOLOGI HIJAU DAN AIR

Suruhanjaya Tenaga

The Malaysian Grid Code Awareness Programme Funded by Akaun Amanah Industri Bekalan Elektrik (AAIBE)