TRANSPOWER

GL-SD-204 Load Forecast Methodology and Processes

AN OVERVIEW OF THE PROCESSES AND METHODOLOGY USED BY THE SYSTEM OPERATOR TO PREPARE THE FORECAST OF DEMAND

System Operator

Transpower New Zealand Limited

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Version	Date	Change
3.0	17/6/14	Reissued, link to EA site "conforming and non-conforming GXP's changed.
4.0	17/3/16	Cyclic review completed, reissued with no change
5.0	13/5/19	Cyclic review completed, information about weather data updated.
6.0	15/12/20	Removed section 3.2.2. which referred to historical use of MV90 data and minor other changes made.
7.0	21/1/21	Update to section 4.1 to clarify calculation of BLPFs for GXPs with Type-B cogeneration.
8.0	18/2/2022	Updated for the introduction of the Critical ESB interface that enables the load forecasts from external forecast agents to be used in the Market System
9.0	12/10/2023	Updated to provide overview and reflect changes as a result of introducing a Load Forecasting agent
10.0	8/07/2025	Cyclic review completed, updated to reflect ongoing accuracy analysis and correspondence with Load Forecasting provider

IMPORTANT

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1 INTRODUCTION

The Electricity Industry Participation Code requires the System Operator to disclose the processes and methodology used to prepare the demand forecast to the Electricity Authority and to the public.

This document provides an overview of:

- The Energy Management System (EMS)[1] Load Forecast tool, and its major sources of data, processing and output.
- The Critical ESB and the ability to import a load forecast from a forecasting agent
- What the outputs of the Medium Term Load Forecast (MTLF) are used for.
- How information from the MTLF is used in the market schedules.

[1] Not to be confused with Energy Market Services

2 Overview of how the load forecast is prepared

The system operator forecasts demand (load) at a national, island, regional, and grid exit point (GXP) level, for 14 days ahead in half hour periods[2]. The load forecast is a key input into the market schedules which produce a forecast of market prices, expected generation, and reserves requirements which look ahead up to 7 days at each GXP in half hour blocks called trading periods. These market schedules are a key part of the market design, they ensure the market is co-ordinated in an efficient and reliable way.

Each GXP is classified as either having non-conforming, or conforming load based on its load profile, and the methodology to forecast load at each GXP differs based on this classification. This classification is made by the Electricity Authority in accordance with Schedule 13.7 of the Electricity Industry Participation Code. A list of the classification of each GXP can be found on the *Electricity Authority's website*.

2.1 Non-Conforming Load

2.1.1 Type of load at Non-Conforming GXP

Load at a non-conforming GXP does not follow a pattern, and therefore is difficult to forecast. Typically these are GXPs that are supplying large demand users whose consumption patterns are driven by industrial processes. See example of non-conforming load profile in Figure 1.

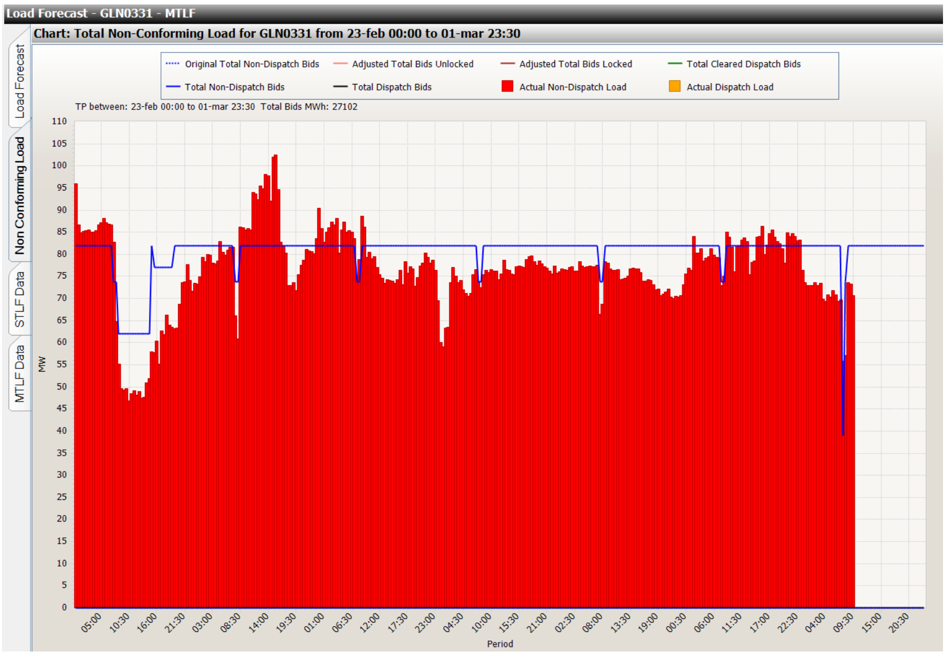


Figure 1

2 The load is forecast in half hour blocks, matching trading periods. Trading periods are the blocks of time trading generation is traded on the spot market on.

2.1.2 Forecasting load at a Non-Conforming GXP

Because non-conforming load is unpredictable, the purchasers of load at each GXP provide their forecast of load over the next 36 hours to the system operator via load bids[3]. Rollover[4] bids are used from 36 hours to 7 days but they can be adjusted by the purchaser. Between 7 days and 14 days, the bids from most recent 7 days are used if valid, or a hard coded value that reflects typical offtake.

Each bid at a non-conforming GXP is aggregated up to provide a total forecast of load at the GXP in half hour trading periods. The total load forecast at each GXP is then used in forming the market schedules.

2.2 Conforming Load

2.2.1 Type of load at Conforming GXP

Load at conforming GXP's is load that follows a predictable pattern such as suburban or commercial areas. This type of load tends to be driven by heating or lighting. By correlating historical load with historical weather an accurate forecast can be determined. See example of conforming load profile in Figure 2.

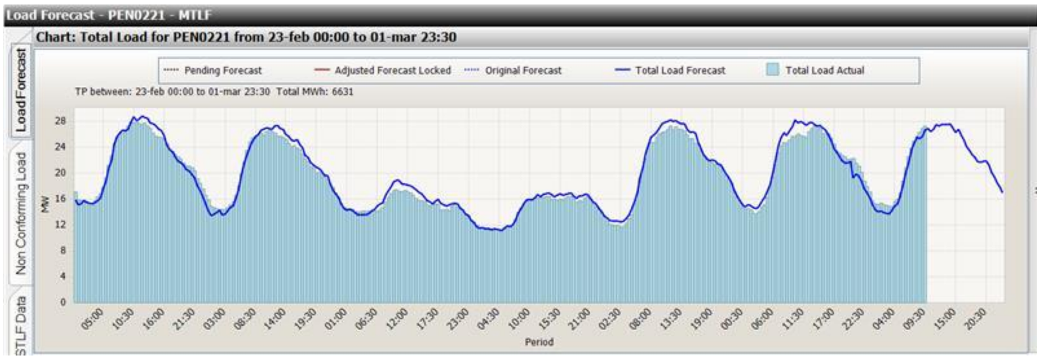


Figure 2

2.2.2 Forecasting conforming load GXP

The load forecast for conforming loads is referred to as the medium term load forecast (MTLF). There are three key steps in forming the MTLF.

2.2.2.1 Step 1: Creating a regional conforming load forecast based on forecast weather and load history

Forecasting conforming load is complex and requires specific forecasting models. In general these can either be procured as an application owned and operated by the system operator or procured as a service. When procuring as a service generally a forecasting agent will produce and deliver a load forecast for Transpower's use via a secure file transfer protocol (sFTP), or Application Programming Interface (API).

Forecasting tools model load at 10 different regions using inputs such as weather forecasts and load data. This produces a load forecast in half hour blocks looking ahead 14 days at 10 different load forecast regions. See breakdown of load forecast regions and data source used to model load in the Appendix.

The system operator can use a load forecast model generated from the load forecast tool embedded in its Energy Management System (EMS) to perform modelling or import a load forecast via its Critical Enterprises Service Bus

[3] Load Bids are submitted through WITS

[4] Rollover bids, when the most recent load bid from the same time period last week becomes the default bid. Rollover Bids can be adjusted by purchasers.

Interface[5] (ESB interface). Only one forecast model can be used at any one time. If an external forecasting agent is being used, then the EMS load forecast tool is maintained as a backup tool requiring approximately 2-4 hours to turn on. The forecasting agent's model is significantly more accurate than the EMS tool, even at 6 hours out compared to the EMS forecast for the next trading period, so it is not critical to switch to the EMS tool immediately in case the agent's model stops updating. Based on the accuracy of forecasting agents compared to the EMS tool Transpower will be using a forecast from an agent. See Figure 3 in Appendix A for diagram of information flows.

2.2.2.2 Step two: Breaking the regional forecast down into a load forecast at each GXP.

The load forecast for each region is broken down to GXP level using Bus Load Participation Factors (BLPFs). A BLPF allocates the regional load forecast for every half hour period looking ahead 7 days. This allocation is based on the previous week's percentage of offtake of measured load data within the load forecast region.

$$Period\ BLPF = \frac{Last\ Week\ measured\ half\ hourly\ load\ (GXP)}{Last\ week\ measured\ half\ hourly\ load\ (region)} \times Forecast\ region\ load\ for\ period$$

BLPFs are automatically adjusted in planning time[6] to account for situations where the BLPF does not represent the expected load, for example, due to outages or load shifting. They can also be manually modified if needed, two common examples are:

- a BLPF can also be 'zeroed' for the duration of an outage to represent a forecast of 0 MW for periods when the GXP is disconnected;
- a BLPF can also be modified for situations where some load is shifted from one GXP to another, e.g. from FHL0331 to WTU0331 during an outage of a FHL transformer.

The load is then used as a key input in calculating the market schedules which ensure an efficient and reliable supply of electricity.

2.2.2.3 Step three: Aggregating up

The load at the 10 regions is aggregated up to form national and island load totals.

The figures 3 - 6 below are examples of the load forecast at each step.

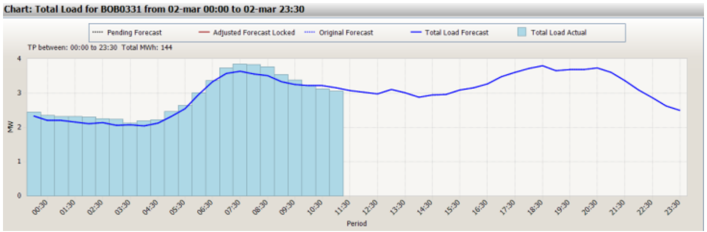


Figure 3 - Example of forecast at a GXP

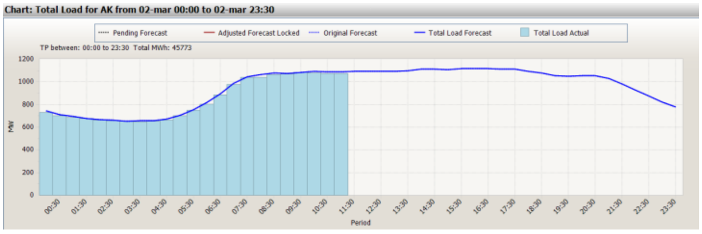
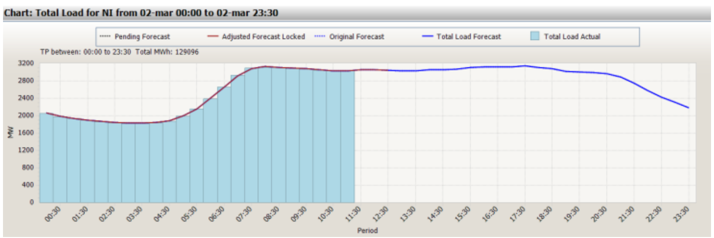
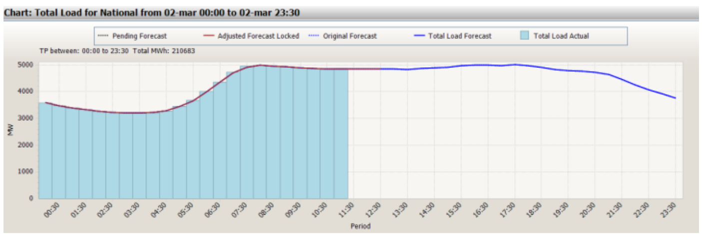


Figure 4 - Example of a forecast at a regional level





[5] This allows external files to be imported into the Transpower Energy Management System

[6] Up to two weeks in advance of real-time.

Figure 5 - Example of the forecast at an island level

Figure 6 - Example of the forecast at a national level

2.2.3 Monitoring and adjusting the load forecast

Real-time staff can access graphical and tabular views of the load forecast for up to 14 days ahead via the Market Operator Interface (MOI).

Measured actual loads are also stored in the market system and provide real-time staff with a view of how the load forecast is tracking against actual load. The load forecast can be manually adjusted by real-time staff if the forecast is significantly different to the actual load.

Real-time staff monitor the MTLF every half hour (i.e. when an updated MTLF is available). Other triggers for real-time staff to monitor the MTLF and adjust it where required include:

- Constraints binding in the schedule but no associated violations in the Realtime Contingency Analysis (RTCA) tool;
- Violations in RTCA but no associated constraints binding in the schedule;
- HVDC not running to schedule;
- Inaccurate Non-Response Schedule Short (NRSS); and
- Weather or load patterns significantly different from normal.

Actions that Realtime staff can take to correct the MTLF include:

- Correcting the regional level trend;
- Correcting the island level trend; and
- Adjusting the BLPFs.

If demand starts tracking above or below expectations, the load forecast information will adjust as soon as an override is entered by a user. Real-time staff can scale load forecast information at the regional level and island level by trading period, any adjustment can be removed. The regional/island level load forecast can be scaled up or down by a specified number of MW or by a percentage of the existing forecast. Realtime staff also can adjust the BLPFs described in section 2.2.2.2. This has the effect of redistributing the load within the entire load area, rather than adjusting the load forecast information at the GXP level to a specific value. The updated information will be picked up in the latest schedule (manual or automatic).

If real-time staff do not intervene, the load forecast will self-adjust over a small number of trading periods, if the actual load diverges from forecast..

The raw forecast and any adjustments are archived in the system operator's data warehouse daily.

2.2.4 Presenting information to the market

The most recent update to the load forecast[7] at each confirming and non-conforming GXP is then used as an input in the market schedules. These in turn are published to the Wholesale Information and Trading System (WITS), and inform the market of expected load, prices, generation dispatch, and constraints. This ensures an efficient and reliable supply of electricity. The market schedules are updated and published to WITS as per Table 1 below.

Table 1

Forecast Timeframe	Market Schedule Name	Frequency of update
4 hours ahead	Non-Response Schedule Short (NRSS) / Price Responsive Schedule Short (PRSS)	Every half hour
36 Hours ahead	Non-Response Schedule Long (NRSL) / Price Responsive Schedule Long (PRSL)	Every second hour (even hours)

[7] After factoring any adjustments by operations staff

7 days ahead	Week-ahead Dispatch Schedule (WDS)	Once per day – between 2 and 3am

All schedules use the load forecast, but the price-responsive schedules (PRSS/PRSL) also add or subtract load due to price through difference bids if it is at a conforming GXP, through nominated bids if it is a non-conforming GXP[1], or Dispatchable Demand (DD) bids if it is a Dispatch Capable Load Station (DCLS). For example, at $1000/MWh a participant may choose to consume 0 load, but at $500/MWH they may choose to consume 50 MW. The Load forecast at the GXP in the PRSS/PRSL schedule would only forecast the load expected based on the price at the GXP. But the non-responsive schedules (NRSS/NRSL) would factor in the maximum load indicated at any price in the bid[8].

Table 2 below describes how the load forecast is used in the market schedules.

Table 2

GXP Type	Week-ahead dispatch schedule (WDS)	Non-Response Schedule short and long (NRSS/NRSL)	Price-Responsive Schedule short and long PRSS/PRSL)
Conforming GXPs	Load Forecast	Load Forecast	Load Forecast +/- cleared difference bids
Non-conforming GXPs	Sum of nominated bid quantities	Sum of nominated bid quantities	Cleared nominated bids at each price
DCLS GXPs	Sum of cleared DD bids at each price	Sum of cleared DD bids at each price	Sum of cleared DD bids at each price

Market participants use the Market Schedules to inform their operational and financial decisions. A well-informed market leads to more efficient and reliable market outcomes[9].

[8] Non-Responsive schedule are used as difference bids or nominated bids are indications only and not dispatchable or enforceable under the code.

[9] Assuming the economic principle of perfect information applies

3 Appendix - Detailed information

3.1 High level diagram of information flows

The system operator can choose to use a load forecast tool embedded in its core SCADA system (EMS load forecast tool) or can import a load forecast from an external forecasting agent. Any forecast agent would be sourced via a tender process which would outline the expectations on the forecasting agent for the length of the contract. Any agreement with a forecasting agent will have a defined service levels such as accuracy and availability. If the system operator is importing a load forecast then the EMS load forecast tool is maintained as a backup tool.

The information flows are shown in Figure 7:

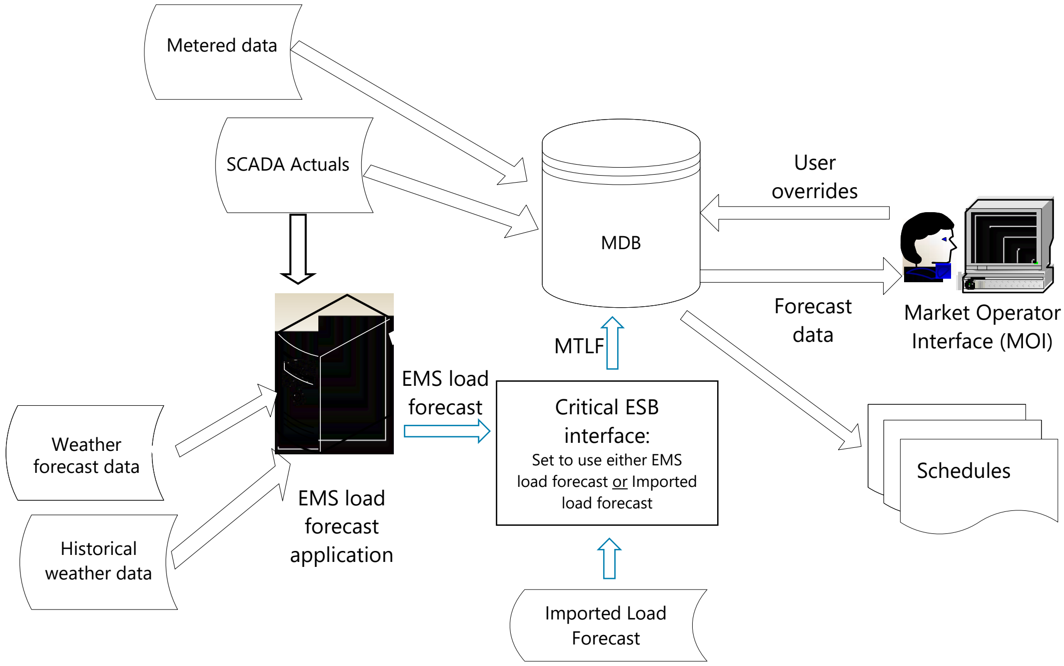


Figure 7

3.1.1 Critical ESB interface

The Critical ESB interface receives the Load Forecast from the EMS LF application, but it can also receive load forecasts generated externally by a forecasting agent. The interface can select either the forecast from the load forecasting agent <u>or</u> the EMS LF application. The selected load forecast is then transferred to the MDB where it is presented to operators via the MOI and used as an input when calculating the market schedules. The market schedules are then presented to Market Participants on WITS.

If the interface is set to select a forecast from a load forecasting agent, the load forecast generated by the EMS LF application is retained as a backup. This adds redundancy if there is a disruption to forecasts produced by the load forecasting agent.

3.2 DATA SOURCES USED IN FORECASTING MODELS

3.2.1 Data sources used by forecasting agent

The data and modelling methodology of those data sources by any load forecast agent remains their intellectual property (IP). In selecting a load forecasting agent the system operator will go through a procurement process which outlines Transpower requirements.

3.2.2 Data sources used in EMS load forecast model

The EMS Load Forecast (LF) application runs in the production EMS environment and uses aggregate load and weather data to forecast aggregate regional conforming load on a half-hourly basis to produce a MTLF.

3.2.2.1 Weather data

Forecast and actual weather data comes from the MetService as plain text files. Forecast files arrive hourly and contain hourly area forecasts for the next 15 days. Actual weather data files arrive once a day just after midnight and contain hourly area weather observations for the previous day.

The weather parameters include ambient temperature and wind speed for each forecast area. All areas utilise temperature, however only Wellington (WN), Christchurch (CH) and West Coast (WC) areas factor wind speed data as an input into forecasting load. This is because these regions have a higher correlation between wind speed and load.

History of weather actuals data is maintained within the production EMS environment for the same duration as the average load data.

3.2.2.2 Load data

Load data comes directly from SCADA, where the instantaneous telemetered MW values representing off-take are aggregated to the GXP level within a station (e.g. ALB0331, SFD2201, ADD0661) and then up to the forecast area level aggregates. These are used within SCADA to produce an average for each half hour.

The LF application maintains an online history within the production EMS environment of the 30-minute load averages for one year.

3.3 BREAKDOWN OF LOAD FORECAST REGIONS

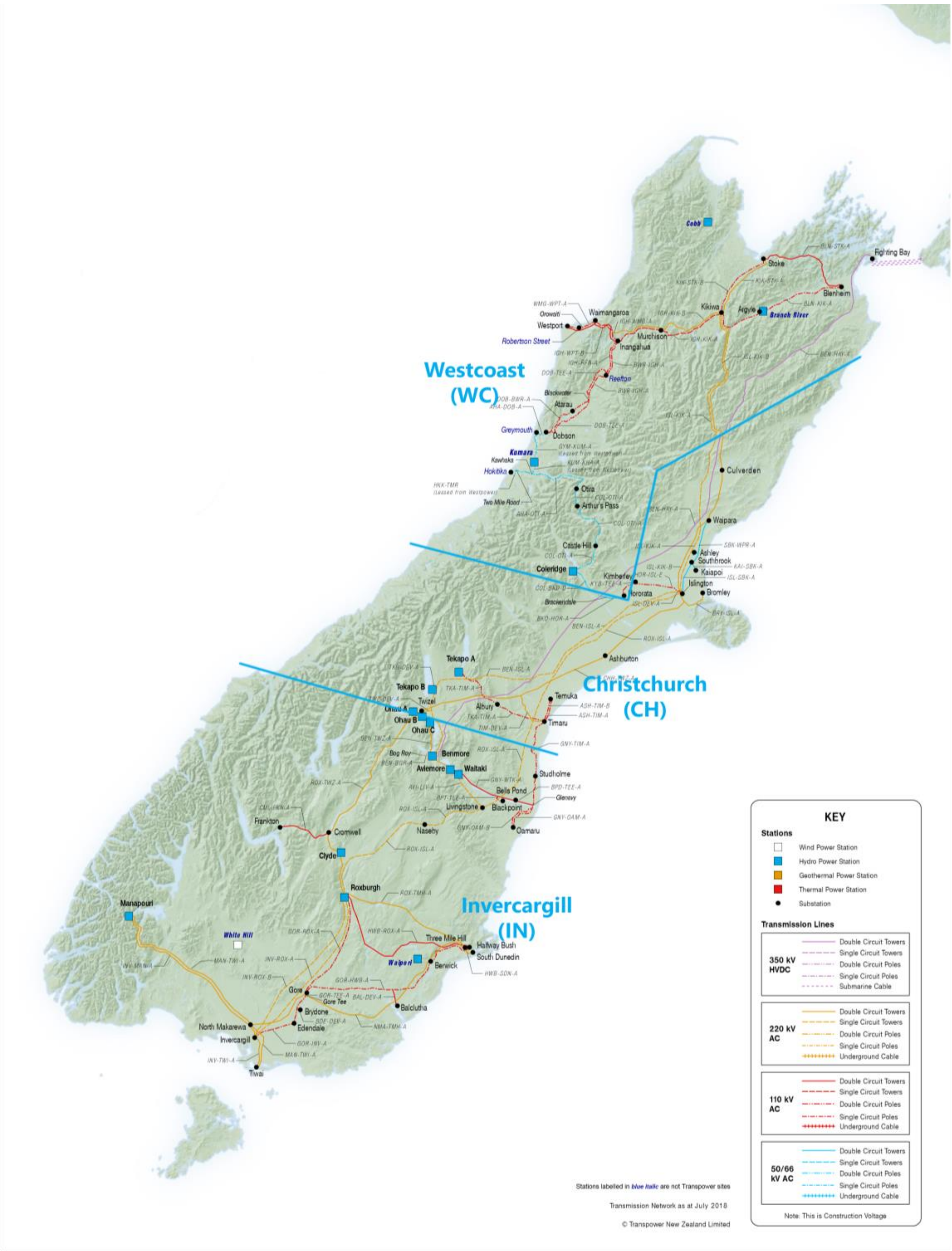
The load forecast[10] is produced at an area (regional) level. This aggregation is intended to reduce or smooth the variability in the input data in order to improve the forecast accuracy.

There are ten forecast areas currently in use. The diagrams below illustrate the North Island and South Island load area designations.

Note: Non-conforming GXPs are not included in the area level forecast.

[10] Both the EMS Load forecast tool, or a load forecast provided by an agent must fit the same regions


Northland
(NL)
Auckland
(AK)
Bay of Plenty
(BP)
Hamilton
(HM)
Napier
(NR)
Palmerston North
(PN)
Wellington
(WN)


Westcoast
(WC)
Christchurch
(CH)
Invercargill
(IN)
KEY
Stations
Wind Power Station
Hydro Power Station
Geothermal Power Station
Thermal Power Station
Substation
Transmission Lines
350 kV HVDC
220 kV AC
110 kV AC
50/66 kV AC
Double Circuit Towers
Single Circuit Towers
Double Circuit Poles
Single Circuit Poles
Submarine Cable
Underground Cable
Note: This is Construction Voltage
Transmission Network as at July 2018
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3.4 COMPUTATION PROCESS AND MAINTENANCE OF THE EMS LOAD FORECAST TOOL

Due to the higher accuracy of load forecast models provided by forecasting agents, it is unlikely the EMS tool will be the primary load forecasting tool. If a forecasting agent is being used the EMS tool is retained as a backup tool therefore it is maintained and monitored so it can be operational within 2-4 hours during business hours. As per PR-SH-229, the accuracy of the EMS load forecast needs to be checked before it being used as the primary load forecast.

Because the EMS tool is an application that is operated within Transpower's Energy Management System its computation and maintenance processes are Transpower's to perform. These are outlined below.

The MTLF is computed automatically every 30 minutes shortly after the half-hour[11] to guarantee that the most recent load averages have been updated. Overall, the forecast spans 15 days, including the current day, and the forecast for each area is made up of several components:

Forecast Component	Description
Long Term	Longer term seasonally dependent component of load. The long-term component takes the previous few months load data and applies an exponential-type weighting factor, so that older data has a lower weighting that more recent data. Data is 'segmented' to group days with similar load profiles together to improve the load forecast. For example, the 4-day period from Mon 12:00 to Fri 12:00 forms one group. Sat and Sun are considered as separate days.
Short Term	Short term component representing localised variations. The short-term component looks at the last few days of load data and applies a correction based on short term load trends.
Weather Dependent	Component of load that correlates with observed weather. The weather-based component uses a quadratic relationship between load and weather data to further refine the load forecast.
Refined	Refined component produced for the current calendar day only, based on the observed divergence of the actual load from the forecast. The refined component compares the actual load and the forecast load for a given trading period and refines the subsequent half hourly loads based on the difference. This component can only be calculated once the first set of actual data for the day has been retrieved (i.e. after 00:30)12.

The EMS LF application builds and maintains the correlation coefficients necessary for each of the components above based on its one-year online history. Weather profiles are also constructed based on the weather history and are used to fill the periods between the forecast points[13] and extend the weather forecast data beyond the window provided by the MetService.

3.4.1 Daylight Savings

Daylight savings is implemented in the sense that there is explicit handling of the extra/missing hour on the daylight savings transitions. However, because load behaviour changes after a daylight savings transition, it may take some time[14] before the change in observed load behaviour significantly affects the forecast.

[11] Usually 90 seconds after the half-hour

[12] This results in a 'bump' in the forecast as it transitions through midnight and can mean that the first trading period of the day is computed with a more inaccurate load forecast unless a co-ordinator intervenes.

[13] There is 1 point to fill in between each of the official forecast values, to convert hourly weather data to half-hourly forecast points.

[14] A week or more

3.4.2 Maintenance

The following maintenance is performed for the EMS LF application:

Event	Maintenance Description
Public Holidays	Holidays generally have a significantly different load shape and need to be identified in advance. The EMS LF application allows a schedule of forward-looking holidays to be maintained for each forecast area, with the schedule specifying how the area should be modelled for each holiday. Generally, holidays are specified to be treated as if they were a Sunday.
Abnormal Load Events	Occasionally, widespread outage events can have a significant impact on the actual load measured for one or more forecast areas which affects the calculation of the correlation coefficients. Such days and forecast areas can be excluded from the historical actual load input into the model.
School Holidays	Weekdays during school holiday periods generally have a different load shape. This can negatively impact load forecast accuracy, particularly in the first week of the school holidays, and the first week of the school term. Since 2018, we have accounted for this during the April, July, and October school holidays periods by temporarily adjusting the historical actual load input to the LF model before and after these periods. Due to the manual and time-consuming process to adjust the forecast to match the school holiday load profile in the EMS tool, this adjustment will only be completed if the EMS load forecast tool is the system operators primary load forecast tool.

3.4.3 Operations and maintenance of a forecasting agent's model

The computation and maintenance of models by any load forecast agent remains their intellectual property (IP). In selecting a load forecasting agent, the system operator will go through a procurement process which outlines Transpower requirements. The Market Operations team will also monitor load forecast accuracy at least monthly, and discuss outliers or potential issues with the provider when they become apparent. The Market Operations team will also raise and discuss any issues with the external load forecast provider brought up by NCC.

4 GLOSSARY

Acronym	Definition
EMS	Energy Management System A collection of computer software applications used to monitor and control a power system.
BLPF	Bus Load Participation Factor Ratios used by the system operator to break the area level forecast produced by the Load Forecast application down to GXP level for use in the market schedules.
GXP	Grid Exit Point A point of connection where electricity may flow out of the grid.
LF	Load Forecast
MDB	Market Database The Market Database provides live data storage of the inputs and outputs of the Market System model and its related transactional data.
MTLF	Medium Term Load Forecast It is the forecast of demand prepared by the system operator for use at conforming GXPs in accordance with 13.7A of the Electricity Industry Participation Code.
MV90	Revenue meter load data
RTU	Remote Terminal Unit The processor at the outstations of a SCADA system. It transmits or receives data to or from an area operating centre or service centre.
SCADA	Supervisory Control and Data Acquisition The monitoring and remote control of equipment from a central location using computers.
SPD	Scheduling, Pricing and Dispatch A computer system used to calculate the schedules and prices for the New Zealand Electricity Market and the reserves market. It also calculates dispatch instructions for realtime dispatch.
WITS	Wholesale and Information Trading System. The platform operated by NZX where all offers of generation and bids for load are submitted. The platform is also were all market information is provided to market participants. Access to WITS is free.