Electricity Risk Curve and Simulated Storage Trajectories Assumptions

System Operator

Security of Supply

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IMPORTANT

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Version History

Date	Change
20 May 2020	Initial release. This paper combines assumptions for ERCs and SSTs. Assumptions that are more easily presented as a table or must be more regularly updated are now included in the Electricity Risk Curve and Simulated Storage Trajectories Assumption Spreadsheet.
26 August 2020	Added section on Floors and Buffers.
22 December 2020	Clarified and updated Thermal Fuel and Operational Limitations assumptions.
16 April 2021	Clarified demand assumptions.
12 May 2021	Clarified ERC generation derating and SST forced generation outage assumptions.
19 June 2023	Updated to reflect the changes in the 2023 Security of Supply Forecasting and Information Policy (SOSFIP)

Contents

1.0 Introduction

Transpower, in its role as the System Operator, aims to provide high quality security of supply related information. This includes Electricity Risk Curves (ERCs) and Simulated Storage Trajectories (SSTs).

ERCs illustrate hydro storage levels over a calendar year and indicate the risk of a future shortage given a standardised set of assumptions. SSTs project a range of future hydro storage trajectories. These projections are based on recorded hydro inflow sequences since 1931 and a complex model of today's power system and electricity market.

This paper, and the accompanying Assumptions Spreadsheet, present the assumptions used to derive the ERCs and SSTs. Assumptions will be updated as new information becomes available.

The System Operator invites comments and feedback on these assumptions. All feedback should be directed to Market Operations Mailbox, market.operations@transpower.co.nz.

1.1 Electricity Risk Curve and Simulated Storage Trajectories Assumption Spreadsheet

The Electricity Risk Curve and Simulated Storage Trajectories Assumptions Spreadsheet ("the Assumptions Spreadsheet")[1], accompanying this paper, contains information that is updated regularly, including:

- Demand assumptions
- Supply assumptions
- Planned generator outages
- HVDC outages
- Thermal fuel generation and constraints

[1] Assumptions Spreadsheet.

2.0 Electricity Risk Curve Assumptions

This section details the assumptions the System Operator has used to derive the ERCs.

2.1 Demand Assumptions

The ERCs are based on monthly forecast demand by Island, as detailed in the Assumptions Spreadsheet. Forecast demand excludes transmission losses and includes demand served by larger, modelled embedded generation (see Section 2.2). Forecast demand will be updated at least annually.

The ERCs are derived assuming forecast demand is reduced by 2% to account for price responsive demand reduction during a security of supply emergency.

2.2 Supply Assumptions

The capacity and generation profile of all generation modelled over the period of analysis are detailed in the Assumptions Spreadsheet. This will be updated if the System Operator is advised or becomes aware that:

- New generation plant will be commissioned over the period of analysis. Only committed, actively progressed new generation projects will be included.
- Existing generation will be decommissioned.

2.3 Hydro Storage

Potential hydro generation or hydro storage equates to a volume of water stored within one of the hydro lakes or catchments around the country, and it is typically expressed in terms of potential energy measured in gigawatt hours (GWh). The aggregated hydro storage in New Zealand, coupled with the capability of non-hydro generation, is an extremely important measure of the capability of the New Zealand power system to accommodate hydro inflow uncertainty, the greatest source of variability, and meet future demand. Consequently, the level of hydro storage is an important companion to the ERCs themselves.

The most important features of hydro storage are summarised below.

2.3.1 Monitoring of storage

The System Operator reports on aggregate available hydro storage relative to the ERCs using data from NZX, available through NZX Hydro[2], and information supplied by consent owners regarding contingent storage. Available storage (as defined in the Security of Supply Forecasting and Information Policy) is defined as controllable and available for generation of electricity from Lakes Tekapo, Pukaki, Te Anau, Hawea and Manapouri for the South Island; and Lakes Taupo, Tekapo,

[2] NZX Hydro website.

Pukaki, Te Anau, Hawea and Manapouri for New Zealand, and includes all contingent storage (assumes access conditions will be met).

2.3.2 Hydro conversion efficiency

In order to derive the ERCs it is necessary to make assumptions about the conversion efficiency of stored hydro to electrical power for each hydro-electric scheme. The System Operator uses conversion efficiencies to align with those used in NZX Hydro.

2.3.3 Contingent hydro storage

The System Operator has implemented a two-fold categorisation of hydro storage: controlled storage and contingent storage:

- **Controlled hydro storage** means any hydro storage that is controllable and available for generation of electricity from Lakes Tekapo, Pukaki, Te Anau, Hawea and Manapouri for the South Island, and Lakes Taupo, Tekapo, Pukaki, Te Anau, Hawea and Manapouri for New Zealand, but excludes contingent hydro storage.
- **Contingent hydro storage** means hydro storage that is available for the generation of electricity only under emergency conditions or specifically to mitigate a risk of shortage.

Consented contingent storage known to the System Operator at the present time is:

- Lake Hawea: estimated 67 GWh of contingent storage
- Lake Pukaki: estimated 545 GWh of contingent storage
- Lake Tekapo: estimated 220 GWh of contingent storage between 1 October and 31 March; at all other times this storage is treated as controlled storage

Based on information provided by consent owners the following quantities of contingent storage are defined as available:

Table 1: Available contingent storage

Source of contingent storage	Available quantity (GWh)	Notes
Lake Tekapo	220	Assumed to be all available.
Lake Pukaki	545	Assumed to be all available.
Lake Hawea	67	Assumed to be all available.

2.4 Planned Outages

In determining the ERCs, the System Operator has assumed there will be no planned outages, except those considered critical for the ongoing safe operation of the plant, those with a long associated contingent return to service period or those that have been fully committed and cannot be deferred.

Specific planned outages that have been assumed can be found in the Assumptions Spreadsheet.

2.5 Forced Generation Outages

The System Operator has assumed a 3% factor on all thermal and geothermal capacity to reflect forced outages when deriving the ERCs.

2.6 Generation De-ratings

Resource Consent limitations, temporary engineering issues with plant, and operational factors can all cause plant capacity to be de-rated. The following plant de-rating assumptions are used to derive the ERCs:

- Short notice maintenance outages: one Huntly unit is assumed to be out of service for maintenance three weekends in five. This assumption applies regardless of the number of Huntly units available for generation.
- Ancillary services requirements: total thermal generation has been de-rated by 21MW at all times to reflect spinning reserve (16MW) and frequency keeping (5MW) requirements.
- The ability to generate from Ohau A at the lower bounds of contingent storage lake levels has been lowered by restricting the outflow of water from Lake Pukaki.

2.7 Transmission Assumptions

The Energy Link model includes a comprehensive nodal representation of the electricity system. This model attempts to approximate the physical characteristics of the grid to ensure transmission losses[3], constraints and limits within the grid are correctly accounted for when deriving the ERCs.

The current grid assumptions, including line information, constraint equations and future upgrades, includes a total of 316 lines and 224 nodes. Grid assumptions are available upon request.

2.7.1 Security constraints

The model includes security constraints[4] that have the potential to constrain generation in a dry year. The following table outlines the constraint equations and the transfer limits for each constraint. The pre-contingent steady state power flow on the two circuits listed must not exceed the transfer limit given.

[3] Transmission losses are modelled and accounted for; distribution losses are not (because the demand used is at the GXP level).

[4] The security constraints are sourced from the system operator's System Security Forecast.

For example, power flow from Hamilton to Karapiro on the circuits HAM_KPO2.2 multiplied by a factor of -1.06, plus the power flow from Hamilton to Karapiro on the circuit HAM_KPO1.2 multiplied by a factor of -0.89, must not exceed 60MW (summer rating).

Table 2: Security constraints included in ERC modelling

Constraint	Transfer Limit		
	Summer	Shoulder	Winter
0.86*BOB_OTA2.2 + 1.09*BOB_OTA1.2	121		
-1.06*HAM_KPO2.2 + -0.89*HAM_KPO1.2	60	67	74
-1.05*HAM_KPO2.1 + -0.89*HAM_KPO1.1	63	67	73
-1.24*OHK_WRK.1 + -1.01*ATI_WKM.1	427	444	462
-1.03*KIN_TRK1.2 + -1.02*KIN_TRK2.2	51	57	64
-1.36*BRK_SFD1.1 + -0.42*BRK_SFD2.1	327		
RDF_T3 + RDF_T4	129		
-1.04*FHL_RDF2.1 + -0.92*FHL_RDF1.1	52	59	66
-1.28*BPE_TKU1.1 + -0.5*BPE_TKU2.1	410	424	444
1.4*RPO_TNG1.1 + -0.24*BPE_TKU2.1	342	378	415
1*BPE_WDV1.1 + -0.04*HAY_LTN1.1	55	55	64
1*BPE_HAY1.1 + 1*BPE_HAY2.1 + -1*HAY_LTN1.1 + 1*BPE_WIL1.2 + -1*MGM_WDV1.1	1046		
1*LIV_NSY.1 + -0.42*CYD_TWZ1.2	304		
-1.23*AVI_BEN2.1 + -0.89 * AVI_BEN1.1	255	278	302
-1.12*GOR_ROX.1 + -0.06*INV_ROX1.1	77	n/a	n/a
-1.05*EDN_INV.1 + -0.65*GOR_ROX.1	77	n/a	n/a

Note, the Energy Link model aggregates parallel transmission branches into a single branch – as a result some of the above constraints have been modelled as branch limits rather than equation constraints.

2.8 HVDC Assumptions

- Maximum north (BEN_HAY) transfer 1000 MW (sent)
- Maximum south (HAY_BEN) transfer 550 MW (sent)

Along with the above ratings, planned HVDC outages have been extracted from the Planned Outage Coordination Process (POCP) website[5] and used as an input into the modelling.

Specific HVDC outages can be found in the Assumptions Spreadsheet

2.9 Market Behaviour and Generation Dispatch

In order to derive the ERCs, it is necessary to make assumptions about the merit order of electricity generating plant.

It is also necessary to make assumptions about the merit order of hydro generation between the North and South Island. For example, deciding what preference, if any, we place on storage in Lake Taupo versus storage in the South Island. For the purpose of deriving the ERCs, the water value of each storage lake has been calculated and storage is dispatched according to this value. This optimisation of water use is carried out at the national level (i.e., the use of storage is optimised across the country for both the NZ and SI ERCs).

2.9.1 Percentage risk modelling

The electricity percentage risk curves show the estimated risk of our hydro lakes running out of hydro storage. Hydro storage is the volume of water in our hydro lakes that can be used for hydro electricity generation. If there is no hydro storage, then electricity supply shortages are likely. For the percentage risk modelling market behaviour that conserves hydro storage as much as possible is used.

We publish the 1%, 2%, 4%, 6%, 8% and 10% risk levels. If hydro storage drops to the 1% Electricity Percentage Risk Curve, for example, this means that there is a 1% risk that hydro storage will drop to zero at some point within twelve months based on historic inflow data. Percentage Risk modelling is also utilised to determine the stop and start triggers for an OCC respectively and the Contingent Storage Release Boundaries which are represented by the 4%, 8% and 10% ERCs. This is further explained in Section 2.9.2.

[5] POCP Website

2.9.2 10% Electricity Risk Curve – Emergency status and trigger for an Official Conservation Campaign

The 10% ERC represents the 10% risk of future shortage based on the assumptions contained in this document and is titled Emergency Status in the Emergency Status information.

If available storage reaches the 10% ERC it does not immediately mean Emergency status will be declared, nor will it guarantee an OCC will be initiated. The Code states that an OCC can only be initiated if available storage is at the Emergency curve *and* expected to remain at or below the curve for at least 1 week.

The 10% ERC is derived using the percentage risk modelling market behaviour and generation dispatch assumption.

2.9.3 Electricity risk status curves

The electricity risk status curves determined by building upon the percentage risk modelling. The electricity risk status curve that are produced are the Normal, Watch, Alert and Emergency curves. From 1 June 2023 the electricity risk status curve boundaries represent:

- Normal: available hydro storage that is greater than the watch status curve.
- Watch: the greater of the 1% electricity risk curve or the associated floor.
- Alert: the greater of the 4% electricity risk curve or the associated floor.
- Emergency: the greater of the 10% electricity risk curve or the associated floor.

The floor is equal to contingent storage that is associated with each risk status and higher risk statuses plus a 50MW buffer as described in Section 2.9.4.

2.9.4 Floors and Buffer

2.9.4.1 Floors

An outcome of including contingent storage in the ERC and release boundaries, is the requirement of a floor to remove the potential of the ERC being below the level of available contingent storage and creating an infeasible result. The floors are equal to the amount of contingent hydro storage linked to that electricity risk curve plus any linked to electricity risk curves representing higher levels of risk.

They are therefore provided as follows:

- 1%, 2%, 4%: 398 GWh + 220 GWh between 1 October and 31 March
- 6%, 8%, 10%: 214 GWh

2.9.4.2 Buffer

The buffer is a value of 50GWh that is added to the floor to manage a potential risk in periods where storage is low, but the risk of shortage is also low i.e. the summer period. At this point the ERC modelling anticipates imminent inflows based on measurements from previous years.

The buffer then allows release of contingent storage before all available storage is consumed. This is important as contingent storage would otherwise be inaccessible because island-wide or national storage has not fallen to the contingent storage release boundary. This could result in load curtailment at a relatively low level of security of supply risk which is undesirable.

2.10 Thermal Fuel Validation Methodology

ERCs are derived assuming generation assets are not subject to constraints on the availability of thermal fuel, including delivery constraints, unless reasonably reliable information is known that indicates otherwise[6].

When preparing ERCs we check that there is enough thermal fuel - accounting for known constraints - for the expected quantity of thermal generation. If there is insufficient thermal fuel available, the maximum available capacity of thermal generation will be derated in the ERC model.

This process is as follows:

1. As a standing assumption, we limit generation from the Whirinaki diesel station to 60 GWh over a six-month period.[7]
2. We determine the likely quantity of other thermal generation required for the modelled storage trajectories that set the ERC values. ERC storage trajectories assume that thermal generation will operate at its maximum capacity (subject to outages) in order to conserve water.
3. We convert this thermal generation to fuel consumed per month. We assume that the Huntly Rankine units will run, in the first instance, on coal.
4. We compare fuel consumption for thermal generation to expected gas and coal supplies, accounting for:
    a. Gas or coal demand that is capable of being made available for electricity generation using the process as described below
    b. Gas or coal demand that is unlikely to be made available for electricity generation (e.g. residential gas users)
    c. Gas and coal storage inventories.
    d. Gas and coal inventory drawdown rates and coal replenishment rates.
5. If there is insufficient gas and coal to supply the thermal units, we derate the maximum available capacity of thermal generation assumed for the ERCs so that it is consistent with estimated available gas and coal availabilities.

In determining the types of gas that is available for increased electricity generation (due to reallocation of gas from industrial users), we consider type 1 and type 2 responses as defined in the SOSFIP. These type 1 and type 2 responses are not intended to reflect the normal reductions in gas

[6] See Security of Supply Forecasting and Information Policy, cl. 6.

[7] Contact Energy state this is an estimate based on current modelling. Contact makes no representations about the accuracy of this information or takes any responsibility for any inaccuracies.

usage from industrial users (for example due to maintenance outages). Therefore, these normal outage-type demand reductions at industrial gas users will be modelled as part of the industrial user gas demand forecast (and not through type 1 or type 2 response). During these outages, the unused industrial gas will be available for potential electricity use unless indicated otherwise to the system operator.

The assumptions that are used in this process will be estimated using the best possible information available but may change over time as new information becomes available. Unless there is good reason to do otherwise, we will only assess thermal fuel constraints in the short term, consistent with the availability of robust thermal fuel supply information. This process is dependent on commercially sensitive information obtained from our stakeholders. We are therefore unable to disclose the full set of assumptions used.

The Assumptions Spreadsheet shows approximate coal and gas consumption for the Electricity Risk Curve analysis and any thermal constraints that have been applied.

3.0 Simulated Storage Trajectories Assumptions

This section details the assumptions the System Operator has used to derive SSTs, where these differ from those used for the ERCs.

3.1 Demand Assumptions

The SSTs are derived using the same demand forecast as for the ERCs. Adjustments are made, as follows, to account for price responsiveness and the impact of an official conservation campaign. Where a storage trajectory is:

- Above the 1% ERC, no adjustments to the demand forecast are made.
- Between the 1% and 10% ERCs, forecast demand is reduced by 2%.
- Below the 10% ERC, forecast demand is reduced by 4%.

The demand assumptions can be found in the Assumptions Spreadsheet.

3.2 Planned Outages

To derive the SSTs, outages are limited to plant that is large enough to have a meaningful impact on GWh and that last longer than one day. Planned outages are extracted from the Planned Outage Coordination Process (POCP) website[8] at the beginning of the month and are used as an input into the modelling.

Transpower has assumed that whilst hydro storage remains above the 10% ERC, all the outages notified in POCP will proceed (and hence all are modelled in the storage simulation).

When storage is less than the 10% ERC no planned outages are included in the model. It is assumed that there will be capability, and incentive, for generators to defer planned outages during times of limited hydro storage.

Detailed information on the outages modelled is available upon request.

3.3 Forced Generation Outages

SSTs are derived assuming that there are no forced generation outages.

3.4 HVDC Assumptions

HVDC outages are assumed to be the same used to derive the ERCs. If storage is less than the 10% ERC all planned outages will be cancelled.

[8] POCP Website

3.5 Market Behaviour

Market behaviour is assumed to reflect a merit order for generating plant that uses historical bids and offers and a complex water value calculation. The detail of these assumptions is contained within the Energy Link market model.

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