Hydro Supply Security Test

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Contents

1. Introduction and purpose of this document

1.1 Introduction

1.1.1 Hydro supply security (HSS) test is similar but not exactly the same to the current process that the SO employs to produce hydro risk curve (HRC).

1.1.2 HSS test employs a SPD-like energy model to calculate the power-flow and losses. Only energy market is included in this model. Reserve and Frequency markets are not included.

1.1.3 HSS test applies a deterministic methodology to calculate the risk of storable hydro supply shortage by assuming that storable hydro is treated as last resort of energy supply. The deterministic methodology is applied in an attempt to make the model transparent, comprehensible and usable to wider group of market participants.

1.1.4 The Authority realizes the shortcomings of this methodology in failing to imitate the actual supply behaviours, demand response, effect of ancillary market and etc… These shortcomings are offset with the transparency, comprehensibility and simplicity.

1.1.5 While this test does not produce the accurate risk of hydro supply for the above reasons, it sets the lower bound of hydro risk curve.

1.2 Purpose of this document

1.2.1 This document summarises the methodology applied for HSS test, input assumptions and the guide to run HSS test.

2. Methodology, Input and Assumptions

2.1 Methodology

2.1.1 The basic inputs for this process are transmission data, demand data, supply data and hydro inflow data. More details about these inputs will be mentioned in later sections of this document.

2.1.2 Transmission, demand and supply data are processed to create deterministic data (branch data, branch group constraints, GXP load, and energy offer) for 3-hour periods and input into SPD-like energy model. The SPD-like energy model will produce the daily generation of all supply sources.

2.1.3 For each inflow sequence and each island, the daily inflow is added to the initial storage and daily storable hydro generation output is subtracted from initial storage taking into account the difference between calculated and simulated run of river generation output which are linked to certain inflow by empirical relationships.

2.1.4 Initial NI and SI storages are zero for the first day of simulation. For the following days, Initial NI and SI storages are respectively equal to Daily NI and SI storage of the previous day.

2.1.5 Daily NI storage is calculated as Initial NI storage + total NI daily inflow – total NI hydro generation output.

2.1.6 Daily SI storage is calculated as Initial SI storage + total SI daily inflow – total SI hydro generation output.

2.1.7 For each inflow sequence, each day and each island, the minimum initial storage is calculated as initial storage of that day minus the lowest daily storage of the following 365 days.

2.1.8 Fifteen highest minimum initial storages are used to fit a log function relationship of the form $y = a * \log(x) + b$ where y is the storage level corresponding to risk level x (expressed as a fraction). Y is the hydro risk curve for risk level x.

2.2 Transmission Data – Grid Data

2.2.1 Transmission grid data include branch data and branch group constraints. Branch data contains all the information of transmission branch (circuit). Branch group constraints define the security limit of a group of branches.

2.2.2 The basic data of a branch are branch name (Branch_Id), branch-from-node (Bus_IdFrom), branch-to-node (Bus_IdTo), branch rating area (North, South or HVDC), branch status (open or close), branch capacity, branch resistance, branch susceptances, branch fixed loss, HVDC branches (0 or 1), branch's number of loss tranches (use to estimate loss piecewise linear function).

2.2.3 A branch group constraint is define by sense (>= , <= or =), limit (Right hand side, included branches and coefficient of each included branch.

2.2.4 Transmission grid data is estimated base on SPD diagram and branch data information published on EM6 website and SO website. This transmission data are detailed up to Node level (not Bus level as currently modeled in SPD). The detailed level is similar to SPD transmission data pre-MSP.

2.2.5 Branch group constraints are applied as described in the SO's HRC assumptions document.

2.3 Demand Assumptions

2.3.1 The HRC model assumes that there are eight 3-hour periods in a day. The GXP demand (MW) during each period of a day is calculated based on the total monthly demand forecast (GWh/month) for each island as following:

Let's call:
g: GXP
t: trading period t
d: day in a week (Sunday to Saturday)
m: month

For each island:

$$GXPDemand_{g,t,d,m} = \frac{MonthlyDemand_m}{Numberofbaseday_m} \times BaseDayRatio_{d,m} \times PeriodRatio_{t,d,m} \times GXPRatio_{g,t,d,m} \times 1000/3$$

$$Numberofbaseday_m = \sum_d BaseDayRatio_{d,m}$$

$$BaseDayRatio_{d,m} = \frac{Average\ Daily\ Load\ of\ WeekdDay\ d\ in\ month\ m}{Average\ Daily\ Load\ of\ Sunday\ in\ month\ m}$$

$$PeriodRatio_{t,d,m} = \frac{Average\ Period\ Load\ of\ Period\ t\ of\ WeekdDay\ d\ in\ month\ m}{Average\ Daily\ Load\ of\ Weekday\ d\ in\ month\ m}$$

$$GXPRatio_{g,t,d,m} = \frac{Average\ Load\ at\ GXP\ g\ of\ Period\ t\ of\ WeekdDay\ d\ in\ month\ m}{Average\ Island\ Load\ of\ Period\ t\ of\ WeekdDay\ d\ in\ month\ m}$$

Where:

$GXPDemand_{g,t,d,m}$: Demand at GXP g, for period t, on day d of the week, in month m (MW)

$MonthlyDemand_{g,t,d,m}$: Forecasted Monthly Demand in month m (GWh)

$Numberofbaseday_m$: equivalent number of Sunday in month m

$BaseDayRatio_{d,m}$: average ratio of demand on day d to demand on Sunday in month m – calculated using historical demand data.

$PeriodRatio_{t,d,m}$: average ratio of demand of period t on day d to daily demand – calculated using historical demand data.

$GXPRatio_{g,t,d,m}$: average ratio of demand of GXP g to island demand for period t on day d of month m – calculated using historical demand data.

2.4 Supply Assumptions

2.4.1 The supply sources are divide into five different type.

2.4.2 Type-1 is the must-run supplies.

(a) The outputs of these supply sources are profiled outputs. The profiled outputs are estimated as average of past five year generation data (except for wind farm). Wind farms' outputs are calculated as certain percentage of capacity (capacity factors). Profiled output generation plants offer at $0/MWh in HSS model.

(b) Note that Argyle, Cobb and Coleridge are assumed profiled output plants because no separate data of inflows and storages are available for these schemes. However, during the HRC calculation process, the outputs of these three generators are included in SI hydro output.

(c) Matahina, Waikaremoana, Mangahao, Patea, Wheao, Mangaio, and Waipa are small hydro schemes in NI. The output of these generation schemes are included in NI hydro output in the HRC calculation process.

2.4.3 Type-2 supply sources are NI thermal generation plants.

(a) These include Huntly (HLY), Southdown (SWN), Otahuhu (OTC), Stratford (TCC), Stratford peakers and Whiniraki (WHI).

(b) Based on the gas and coal supply assumption, there is no limit of generation output from HLY, SWN and WHI except for capacity limits and outages. HLY, SWN and WHI are assumed to offer full capacity (taken into account outage and other constraints) at $1/MWh. This is to make sure that Type-1 supply is used before Type-2 supply.

(c) Because of limitation in gas supply for Contact, Otahuhu, Stratford and Stratford peakers are treated differently. OTC and TCC are assumed to offer full capacity (taken into account outage and other constraints) at $3/MWh. This is to make sure OTC and TCC is used before Type-3 supply but after HLY, SWN and WHI being used up. The end result will be checked to see if the total gas usage exceed gas supply assumption.

(d) Because of the limit of available gas, OTC and TCC are assumed to offer 360 MW each during daytime and 200 MW each during night time.

(e) SFD peakers are not included because there will not be enough gas to run theses peakers given the above assumptions.

2.4.4 Type-3 supply sources are big run-of-river hydro plants

(a) Type-3 supply sources includes Tokaanu (TKU), Rangipo (RPO) and Manapouri (MAN). In HRC model of SO, TKU and RPO outputs are assumed to be linked to Taupo inflow. MAN output is dependent on MAN inflow and storage. However, the system operator's HRC assumptions do not describe in details these relationships.

(b) To simplify the matter, TKU and RPO are assume to offer at full capacity at $5/MWh. This is to make sure that Type-3 supply is used before Type-4 supply but after Type-2 supply is used up. The output of these generation schemes are included in NI hydro output in the HRC calculation process.

(c) MAN is assumed to offer at full capacity at $10/MWh. This is to make sure that MAN supply is used before Type-4 supply but after TKU and RPO supply is used up. The output of MAN generation scheme is included in SI hydro output in the HRC calculation process.

2.4.5 Type-4 supply sources are Waikato generation plants. Waikato scheme is storable hydro in NI

(a) Waikato scheme includes eight hydro plants. All of these plants are assumed to offer full capacity at $20/MWh. This is to make sure Waikato will be the last resource in NI but will be dispatched first before SI storable hydro (Type-5).

(b) A set of constraints in HRC model will make sure that all generation plants in the same river chain will be dispatched proportionally equally.

(c) The total output of Waikato generation scheme is included in NI hydro output in the HRC calculation process.

2.4.6 Type-5 supply sources are Waitaki and Clutha generation plants. Waitaki and Clutha schemes are storable hydro in SI.

(a) Waitaki scheme includes eight hydro plants in central SI and Clutha Scheme includes two hydro plants in lower SI. All of these plants are assumed to offer full capacity at $40/MWh. This is to make sure Waikato will be the last resource in NI but will be dispatched first before SI storable hydro (Type-5).

(b) A set of constraints in HRC model will make sure that all generation plants of storable schemes in the SI will be dispatched proportionally equally.

(c) The total output of Waitaki and Clutha generation schemes is included in SI hydro output in the HRC calculation process.

2.5 Simulation Run

2.5.1 The simulation is run day by day. The output will be used to calculate the total NI Hydro output and SI hydro daily output (Waitaki, Clutha and Manapouri)

2.5.2 Total NI daily hydro output is the summed output of Waikato, Rangipo, Tokaanu, Matahina, Waikaremoana, Mangahao, Patea, Wheao, Mangaio, and Waipa.

2.5.3 Total SI daily hydro output is the summed output of Waitaki, Clutha, Manapouri, Argyle, Cobb and Coleridge.

2.6 HRC Calculation – Mode 1

2.6.1 Comit hydro inflow data are used.

2.6.2 SI HRC:

(a) SI total daily hydro generation output is equal to the total of daily output of Waitaki, Clutha and Manapouri schemes.

(b) SI total daily hydro inflow is equal to the total of daily hydro inflow of Waitaki, Clutha and Manapouri schemes.

(c) SI daily end storage is equal to SI daily initial storage plus SI total storable daily inflow and minus SI total daily hydro generation output.

(d) For each day and each hydro sequence, the minimum SI initial storage is equal to SI daily initial storage of that day minus the minimum SI storage of 365 following days.

(e) For each day, the 15 highest minimum SI initial storages of all hydro sequences are used to fit a log function of the form $y = a * \log(x) + b$ where y is the storage level corresponding to risk level x (expressed as a fraction)

(f) The SI hydro risk for each risk value (1%, 2%, 4%, 6%, 8% and 10%) is extrapolated or interpolated using the log function above.

2.6.3 NZ HRC

(a) Before calculating NZ HRC, NI daily minimum storage is calculated for each hydro sequence with the assumption that NI transferring energy to SI as much as possible.

(b) NI total daily hydro generation output is equal to the total of daily output of Waikato scheme.

(c) NI total daily hydro inflow is equal to the total of daily hydro inflow of Waikato scheme.

(d) Rangipo and Tokaanu generation outputs are linked to Taupo inflow.

(e) NI daily end storage is equal to NI daily initial storage plus NI total storable daily inflow and minus NI total daily hydro generation output.

(f) For each day and each hydro sequence, the minimum NI initial storage is equal to NI daily initial storage of that day minus the minimum NI storage of 365 following days.

(g) For each day and each hydro sequence, the minimum NZ initial storage is equal to SI minimum initial storage plus the higher of NI minimum initial storage and zero

(h) For each day, the 15 highest minimum NZ initial storages of all hydro sequences are used to fit a log function of the form $y = a * \log(x) + b$ where y is the storage level corresponding to risk level x (expressed as a fraction)

(i) The NZ hydro risk for each risk value (1%, 2%, 4%, 6%, 8% and 10%) is extrapolated or interpolated using the log function above.

2.7 HRC Calculation – Mode 2

2.7.1 Comit hydro inflow data are used.

2.7.2 SI HRC:

(a) SI total daily hydro generation output is equal to the total of daily output of Waitaki, Clutha, Manapouri, Argyle, Cobb and Coleridge scheme.

(b) SI total daily hydro inflow is equal to the total of daily hydro inflow of all SI inflows.

(c) SI daily end storage is equal to SI daily initial storage plus SI total storable daily inflow and minus SI total daily hydro generation output.

(d) For each day and each hydro sequence, the minimum SI initial storage is equal to SI daily initial storage of that day minus the minimum SI storage of 365 following days.

(e) For each day, the 15 highest minimum SI initial storages of all hydro sequences are used to fit a log function of the form $y = a * \log(x) + b$ where y is the storage level corresponding to risk level x (expressed as a fraction)

(f) The SI hydro risk for each risk value (1%, 2%, 4%, 6%, 8% and 10%) is extrapolated or interpolated using the log function above.

2.7.3 NZ HRC

(a) Before calculating NZ HRC, NI daily minimum storage is calculated for each hydro sequence with the assumption that NI transferring energy to SI as much as possible.

(b) NI total daily hydro generation output is equal to the total of daily output of Waikato, Rangipo, Tokaanu, Matahina, Waikaremoana, Mangahao, Patea, Wheao, Mangaio, and Waipa scheme.

(c) NI total daily hydro inflow is equal to the total of daily hydro inflow of all NI inflows.

(d) NI daily end storage is equal to NI daily initial storage plus NI total storable daily inflow and minus NI total daily hydro generation output.

(e) For each day and each hydro sequence, the minimum NI initial storage is equal to NI daily initial storage of that day minus the minimum NI storage of 365 following days.

(f) For each day and each hydro sequence, the minimum NZ initial storage is equal to SI minimum initial storage plus the higher of NI minimum initial storage and zero

(g) For each day, the 15 highest minimum NZ initial storages of all hydro sequences are used to fit a log function of the form $y = a * \log(x) + b$ where y is the storage level corresponding to risk level x (expressed as a fraction)

(h) The NZ hydro risk for each risk value (1%, 2%, 4%, 6%, 8% and 10%) is extrapolated or interpolated using the log function above.

2.8 HRC Calculation – Mode 3

2.8.1 Spectra hydro inflow data are used.

2.8.2 SI HRC:

(a) SI total daily hydro generation output is equal to the total of daily output of Waitaki, Clutha and Manapouri schemes.

(b) SI total daily hydro inflow is equal to the total of daily hydro inflow of Waitaki, Clutha and Manapouri schemes.

(c) SI daily end storage is equal to SI daily initial storage plus SI total storable daily inflow and minus SI total daily hydro generation output.

(d) For each day and each hydro sequence, the minimum SI initial storage is equal to SI daily initial storage of that day minus the minimum SI storage of 365 following days.

(e) For each day, the 15 highest minimum SI initial storages of all hydro sequences are used to fit a log function of the form $y = a * \log(x) + b$ where y is the storage level corresponding to risk level x (expressed as a fraction)

(f) The SI hydro risk for each risk value (1%, 2%, 4%, 6%, 8% and 10%) is extrapolated or interpolated using the log function above.

2.8.3 NZ HRC

(a) Before calculating NZ HRC, NI daily minimum storage is calculated for each hydro sequence with the assumption that NI transferring energy to SI as much as possible.

(b) NI total daily hydro generation output is equal to the total of daily output of Waikato scheme.

(c) NI total daily hydro inflow is equal to the total of daily hydro inflow of Waikato scheme.

(d) Rangipo and Tokaanu generation outputs are equal to tpd (Tongariro power development) inflow.

(e) NI daily end storage is equal to NI daily initial storage plus NI total storable daily inflow and minus NI total daily hydro generation output.

(f) For each day and each hydro sequence, the minimum NI initial storage is equal to NI daily initial storage of that day minus the minimum NI storage of 365 following days.

(g) For each day and each hydro sequence, the minimum NZ initial storage is equal to SI minimum initial storage plus the higher of NI minimum initial storage and zero

(h) For each day, the 15 highest minimum NZ initial storages of all hydro sequences are used to fit a log function of the form $y = a * \log(x) + b$ where y is the storage level corresponding to risk level x (expressed as a fraction)

(i) The NZ hydro risk for each risk value (1%, 2%, 4%, 6%, 8% and 10%) is extrapolated or interpolated using the log function above.

2.9 HRC Calculation – Mode 4

2.9.1 Spectra hydro inflow data are used.

2.9.2 SI HRC:

(a) SI total daily hydro generation output is equal to the total of daily output of Waitaki, Clutha, Manapouri, Argyle, Cobb and Coleridge scheme.

(b) SI total daily hydro inflow is equal to the total of daily hydro inflow of all SI inflows.

(c) SI daily end storage is equal to SI daily initial storage plus SI total storable daily inflow and minus SI total daily hydro generation output.

(d) For each day and each hydro sequence, the minimum SI initial storage is equal to SI daily initial storage of that day minus the minimum SI storage of 365 following days.

(e) For each day, the 15 highest minimum SI initial storages of all hydro sequences are used to fit a log function of the form $y = a * \log(x) + b$ where y is the storage level corresponding to risk level x (expressed as a fraction)

(f) The SI hydro risk for each risk value (1%, 2%, 4%, 6%, 8% and 10%) is extrapolated or interpolated using the log function above.

2.9.3 NZ HRC

(a) Before calculating NZ HRC, NI daily minimum storage is calculated for each hydro sequence with the assumption that NI transferring energy to SI as much as possible.

(b) NI total daily hydro generation output is equal to the total of daily output of Waikato, Rangipo, Tokaanu, Matahina, Waikaremoana, Mangahao, Patea, Wheao, Mangaio, and Waipa scheme.

(c) NI total daily hydro inflow is equal to the total of daily hydro inflow of all NI inflows.

(d) NI daily end storage is equal to NI daily initial storage plus NI total storable daily inflow and minus NI total daily hydro generation output.

(e) For each day and each hydro sequence, the minimum NI initial storage is equal to NI daily initial storage of that day minus the minimum NI storage of 365 following days.

(f) For each day and each hydro sequence, the minimum NZ initial storage is equal to SI minimum initial storage plus the higher of NI minimum initial storage and zero

(g) For each day, the 15 highest minimum NZ initial storages of all hydro sequences are used to fit a log function of the form $y = a * \log(x) + b$ where y is the storage level corresponding to risk level x (expressed as a fraction)

(h) The NZ hydro risk for each risk value (1%, 2%, 4%, 6%, 8% and 10%) is extrapolated or interpolated using the log function above.

3. Major differences between SO's HRC and EA's HSS

3.1 Demand Assumption

3.1.1 In HSS model, the demand is distributed to 3-hour periods. There are 8 periods per day and the simulation is run day by day.

3.1.2 In HRC model, the demand is distributed to 8 blocks per week. The simulation is run week by week.

3.2 NI hydro supply assumptions

3.2.1 In HRC model, small hydro schemes such as Matahina, Waikaremoana, Mangahao, Patea, Wheao, Mangaio, and Waipa are assumed to have profiled output. Tokaanu and Rangipo outputs are assumed to be linked to Taupo inflows.

3.2.2 There is not enough information about the relationship between Tokaanu/Rangipo output and Taupo inflow. To simplify the matter, the HSS model sums NI hydro generation output and inflow respectively. The net difference between total NI hydro inflow and generation output is the increment of NI hydro storage at the end of a day.

3.3 SI hydro supply assumptions

3.3.1 In HRC model, small hydro schemes such as Matahina, Waikaremoana, Mangahao, Patea, Wheao, Mangaio, and Waipa are assumed to have profiled output. Tokaanu and Rangipo outputs are assumed to be linked to Taupo inflows.

3.3.2 There is not enough information about the relationship between Tokaanu/Rangipo output and Taupo inflow. To simplify the matter, the HSS model sums SI hydro generation output and inflow separately. The net difference between total SI hydro inflow and generation output is the increment of SI hydro storage at the end of a day.

3.4 Hydro Inflow data

3.4.1 HSS model and HRC use spectra hydro inflow. However, the two models may have different conversion factors (m3/s → GWh/day).

3.4.2 The HRC's hydro inflow data (in terms of GWh/day) is not available for comparison.

3.5 Simulation Approach

3.5.1 HSS Model try to follow as much as possible the methodology and assumption set out in System Operator's report of Derivation of hydro risk curves. There are many details, which are either too complicated or confidential and therefore not published, in the HRC model.

3.5.2 HSS model apply a very simple method based on the report mentioned above. While HSS model cannot produce the same hydro risk curves as HRC does, HSS model can help general market participant to understand the effect of major factors to SI and NZ HRC.

References

1. Derivation of Hydro Risk Curves – System Operator – September 2011

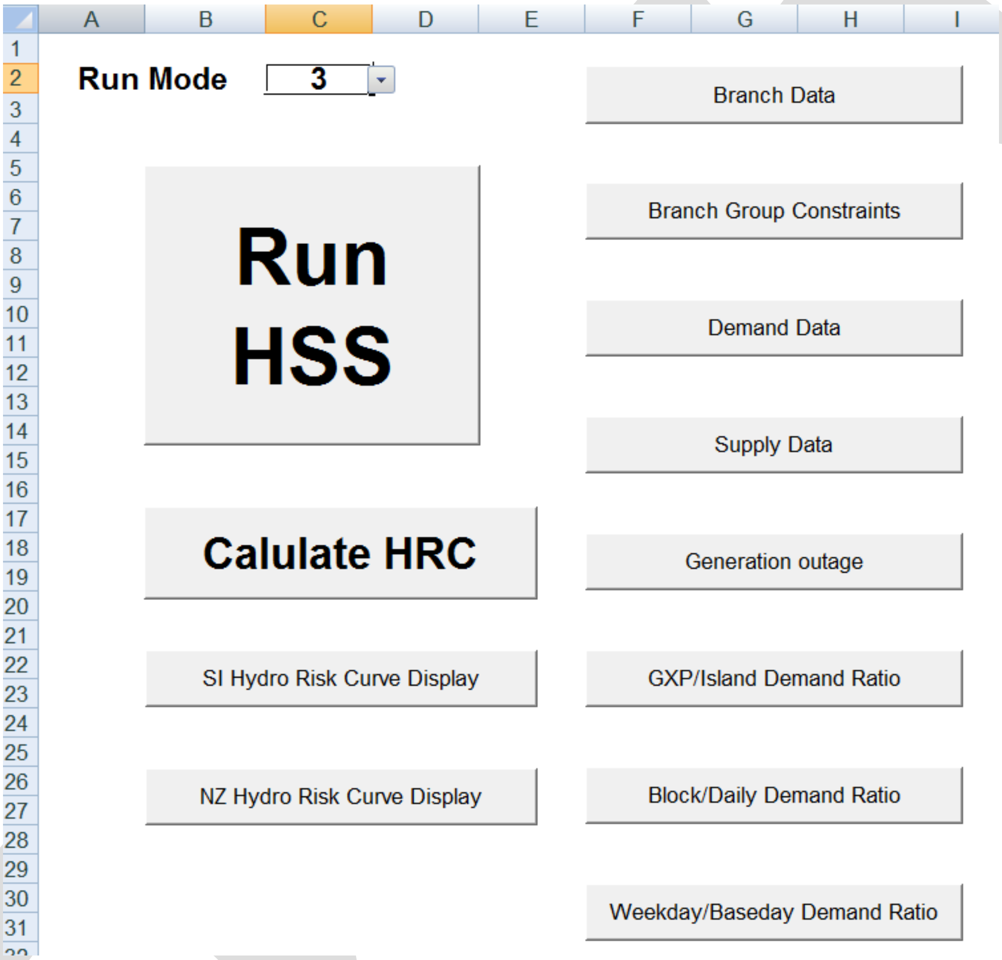
2. Hydro Risk Curve Input Assumption – System Operator – September 2011

Appendices

Appendix A HSS MODEL USER GUIDE (Main Sheet)

A.1 The main excel file used to run HSS model is stored under ***"..\Hydro_Supply_Security" folder***. There is only one HSS_Model.xls excel file in this folder.

A.2 Open this file, select ***"Main"*** worksheet to see all the control buttons as following



A.3 All the buttons on the right column are used to modify input data. The functionality of these buttons will be explained in the following sections.

A.4 To Run the supply-demand simulation, Click on **"Run HSS"** button. The simulation will run in the background. Wait until the run is finished by checking if the popup MS-DOS Window has closed down.

A.5 Select the Run Mode (1,2,3 or 4 – refer to section 2.8) and click on "Calculate HRC" button to calculate HRC based on the selected mode.

A.6 To display the HRC curve, click on one of the two buttons on bottom left accordingly.

Appendix B HSS MODEL USER GUIDE (Branch Data)

B.1 To modify grid configuration, click on “**Branch Data**” button. “Branch Data” worksheet will be displayed and user can view and/or edit branch data.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Branch Id	Bus IdFrom	Bus IdTo	RATINGAREA_ID	Status	Summer	Winter	Shoulder	B	R	HVDC	Fixed Loss	NUM_LOSS_BRANCHES
2	ABY_T2.T2	ABY1101	ABY0111	SOUTH	C	6.3	6.3	6.3	0.69982	0.168644	0	0.0218	3
3	ADD_ISL1.1	ISL0661	MLN0661	SOUTH	C	143.31	174.8	159.93	30.69005	0.00443	0	0	3

B.2 Branch data include:

(a) Branch_id: Branch name.

(b) Bus_IdFrom: BusID of the sending node.

(c) Bus_IdTo: BusID of the receiving node.

(d) RATINGAREA_ID: **NORTH** if the branch is in North Island, **SOUTH** if the branch is in and **HVDC** if the branch is DC branch.

(e) Status: C = Closed (in service), O = Opened (out of service)

(f) Summer, Winter and Shoulder: Branch capacity for each rating season.

(g) B: branch susceptances.

(h) R: branch resistance.

(i) HVDC: 0 = AC branch, 1 = DC branch

(j) Fixed Loss: branch’s fixed loss

(k) Number_Loss_Branches: number of loss tranches applied to a branch for piecewise linear function of variable branch loss.

Appendix C HSS MODEL USER GUIDE (Branch Group Constraint)

C.1 To modify branch group constraints, click on “**Branch Group Constraints**” button. “Branch_Group_Constraints” worksheet will be displayed and user can view and/or edit branch group constraint data.

C.2 Branch Group Constraint data include two table. The first table define the sense and limit of the constraint. The second table define the branch components and coefficient factors. Below is an example

BranchConstraint	Sense	Limit
HLY_SFD_Stability_P	-1	550
NSY_ROX_1_P	-1	282.8
WELLINGTON_STABILITY_P	-1	890
DC_North_Max	-1	700
DC_South_Max	-1	489

BranchConstraint	Branch	Factor
HLY_SFD_Stability_P	HLY_SFD.1	-1.00
HLY_SFD_Stability_P	SFD_TMN1.1	-1.00
NSY_ROX_1_P	CYD_TWZ1.1	-0.34
NSY_ROX_1_P	NSY_ROX.1	-1.33
WELLINGTON_STABILITY_P	BPE_HAY1.1	1.00
WELLINGTON_STABILITY_P	BPE_HAY2.1	1.00
WELLINGTON_STABILITY_P	BPE_WIL1.2	1.00
WELLINGTON_STABILITY_P	HAY_LTN1.1	-1.00
DC_North_Max	BEN_HAY1.1	1.00
DC_North_Max	BEN_HAY2.1	1.00
DC_South_Max	HAY_BEN2.1	1.00

C.3 The data in the above example shows the definition of constraint HLY_SFD_Stability_P: -1 * HLY_SFD.1 + -1 * SFD_TMN1.1 <= 550

C.4 Sense: -1 (<=), 1 (>=), 0 (=).

Appendix D HSS MODEL USER GUIDE (Demand Data)

D.1 To modify demand data, click on “**Demand Data**” button. “Demand Data” worksheet will be displayed and user can view and/or edit monthly island demand forecast. The demand forecast includes 2% load reduction during dry year.

D.2 Assumption of Tiwai load can be view and/or edit from this worksheet.

Month	North Island (GWh)	South Island (GWh)
Sep-11	2,095	1,233
Oct-11	2,090	1,239
Nov-11	1,990	1,230
Dec-11	1,925	1,205
Jan-12	1,925	1,179
Feb-12	1,832	1,138
Mar-12	2,056	1,267
Apr-12	1,988	1,201
May-12	2,182	1,282
Jun-12	2,294	1,341
Jul-12	2,374	1,383
Aug-12	2,346	1,354
Sep-12	2,132	1,260
Oct-12	2,127	1,265
Nov-12	2,025	1,257

Tiwai Load (MW)
550

Appendix E HSS MODEL USER GUIDE (Supply Data)

E.1 To modify Supply data, click on "**Supply Data**" button. "Supply Data" worksheet will be displayed and user can view and/or edit supply assumption. There are two tables in Supply Data sheet.

E.2 The first table include column A and B of Supply Data sheet. This table contain the type of each generation scheme. (Refer to section 2.4)

E.3 The second table contains the other data of each scheme such as separate generation offers (generation station), connecting Node (Bus) and capacity or profiled output of each generation offer.

Scheme	Type
Mokai	1
Ohaaki	1
Poihipi	1
Wairakei	1
Kawerau	1
Ngawha 2	1
Tauhara binary	1
Nga Awa Purua	1
Kaponga	1
Kinleith	1
Whareroa	1
Te Rapa	1
Matahina	1
Waikaremoana	1
Mangahao	1
Patea	1
Wheao	1
Mangaio	1
Waipa	1
Argyle	1
Cobb	1
Coleridge	1
Tararua_I_II_III	1
Te Apiti	1
West Wind	1
Te Uku	1
Te Rere Hau (stage 2)	1
Mahinerangi	1
White Hill	1
Huntly (units 1-4)	2
Huntly U5 (e3p)	2
Huntly U6 (P40)	2
Otahuhu B	2
TCC	2
Whirinaki	2
Stratford peaker 1	2
Stratford peaker 2	2
Southdown	2
Rangipo	3
Tokaanu	3
Manapouri	3
Waikato	4
Waitaki	5
Clutha	5

Note:

Type 1: Profiled output plant/scheme

Type 2: NI thermal generation plants

Type 3: Hydro generation plants which have daily output linked to certain inflow.

Type 4: NI Hydro storable scheme.

Type 5: SI Hydro storable scheme

Scheme	Offer	Node	Capacity/ Profiled Output
Mokai	WKM2201 MOK0	WKM2201	99.278
Ohaaki	OKI2201 OKI0	OKI2201	49.131
Poihipi	PPI2201 PPI0	PPI2201	39.871
Wairakei	WRK2201 WRK0	WRK2201	158.032
Kawerau	KAW1101 KAG0	KAW1101	89.848
Ngawha 2	KOE0331 NGA0	KOE0331	13.5
Tauhara binary	WRK0331 TAA0	WRK0331	20.133
Nga Awa Purua	NAP2201 NAP0	NAP2201	137.139
Kaponga	KPA1101 KPI0	KPA1101	14.689
Kinleith	KIN0112 KIN0	KIN0112	29.436
Whareroa	HWA1102 WAA0	HWA1102	14.672
Te Rapa	TWH0331 TRC1	TWH0331	25.799
Matahina	MAT1101 MAT0	MAT1101	43.583
Waikaremoana	TUI1101 TUI0	TUI1101	53.86
Mangahao	MHO0331 MHO0	MHO0331	14.378
Patea	HWA1101 PTA0	HWA1101	11.452
Wheao	ROT1101 WHE0	ROT1101	12.286
Mangaio	RPO2201 MGA0	RPO2201	1
Waipa	WAI1101 WAI0	WAI1101	4
Argyle	ARG1101 BRR0	ARG1101	5.494
Cobb	COB0661 COB0	COB0661	19.521
Coleridge	COL0661 COL0	COL0661	28.088
Tararua_I_II_III	TWC2201 TWF0	TWC2201	69.1
Te Apiti	WDV1101 TAP0	WDV1101	40.0
West Wind	WWD1102 WWD0	WWD1102	61.5
Te Uku	TWH0331 TUK0	TWH0331	27.5
Te Rere Hau (stage 2)	TWC2201 NZW0	TWC2201	8.6
Mahinerangi	ROX1101 MAH0	ROX1101	14.4
White Hill	NMA0331 WHL0	NMA0331	25.1
Huntly (units 1-4)	HLY2201 HLY0	HLY2201	972
Huntly U5 (e3p)	HLY2201 HLY5	HLY2201	385
Huntly U6 (P40)	HLY2201 HLY6	HLY2201	50
Otahuhu B	OTA2202 OTC0	OTA2202	390
TCC	SFD2201 SPL0	SFD2201	380
Whirinaki	WHI2201 WHI0	WHI2201	156
Stratford peaker 1	SFD2201 SPL21	SFD2201	100
Stratford peaker 2	SFD2201 SPL22	SFD2201	100
Southdown	SWN2201 SWN0	SWN2201	175
Rangipo	RPO2201 RPO0	RPO2201	120
Tokaanu	TKU2201 TKU0	TKU2201	240
Manapouri	MAN2201 MAN0	MAN2201	728
Waikato	ARA2201 ARA0	ARA2201	79
Waikato	OHK2201 OHK0	OHK2201	106
Waikato	ATI2201 ATI0	ATI2201	80
Waikato	WKM2201 WKM0	WKM2201	100
Waikato	MTI2201 MTI0	MTI2201	360
Waikato	WPA2201 WPA0	WPA2201	60
Waikato	ARI1101 ARI0	ARI1101	182
Waikato	KPO1101 KPO0	KPO1101	96
Waitaki	TKA0111 TKA0	TKA0111	23
Waitaki	TKB2201 TKB0	TKB2201	160
Waitaki	OHA2201 OHA0	OHA2201	260
Waitaki	OHB2201 OHB0	OHB2201	210
Waitaki	OHC2201 OHC0	OHC2201	210
Waitaki	BEN2201 BEN0	BEN2201	540

Appendix F HSS MODEL USER GUIDE (Generation Outage Data)

F.1 To modify generation outage data, click on "**Generation outage**" button. "Generation outage" worksheet will be displayed and user can view and/or edit generation outage assumption.

F.2 The generation outage data are processes based on POCP outage data. Only thermal generation outage is of concern because the model assumes that storable hydro generation will be the last to be dispatched.

F.3 There are four columns in the generation outage table, the first column is the outage offer (generation station). The second and third columns contain the start and end date of the outage. And the last column contain the outage's derating data (the reduced in capacity).

Offer	Start	End	Derating (MW)
HLY2201 HLY0	26/08/2011 0:00	30/10/2011 0:00	245
HLY2201 HLY5	5/11/2011 0:00	12/11/2011 0:00	400
HLY2201 HLY0	18/11/2011 0:00	14/05/2012 0:00	243
HLY2201 HLY0	18/11/2011 0:00	28/11/2011 0:00	243
HLY2201 HLY0	9/12/2011 0:00	20/12/2011 0:00	243
HLY2201 HLY0	27/12/2011 0:00	30/12/2011 0:00	243
HLY2201 HLY0	7/01/2012 0:00	18/01/2012 0:00	243
HLY2201 HLY0	20/01/2012 0:00	22/01/2012 0:00	243
HLY2201 HLY0	24/01/2012 0:00	27/01/2012 0:00	243
HLY2201 HLY0	23/03/2012 0:00	25/03/2012 0:00	243
HLY2201 HLY0	11/05/2012 0:00	13/05/2012 0:00	243
HLY2201 HLY0	1/06/2012 0:00	3/06/2012 0:00	243
HLY2201 HLY5	13/10/2012 0:00	22/11/2012 0:00	400
HLY2201 HLY0	4/12/2012 0:00	31/12/2014 0:00	243
NAP2201 NAP0	15/01/2012 0:00	29/01/2012 0:00	140
NAP2201 NAP0	19/11/2012 0:00	25/11/2012 0:00	140
SWN2201 SWN0	2/09/2011 0:00	2/09/2011 0:00	50
SWN2201 SWN0	29/09/2011 0:00	6/10/2011 0:00	50
SWN2201 SWN0	14/10/2011 0:00	14/10/2011 0:00	50
SWN2201 SWN0	13/01/2012 0:00	13/01/2012 0:00	50
SWN2201 SWN0	9/03/2012 0:00	9/03/2012 0:00	50
SWN2201 SWN0	4/05/2012 0:00	4/05/2012 0:00	50
SWN2201 SWN0	6/07/2012 0:00	6/07/2012 0:00	50
SWN2201 SWN0	24/08/2012 0:00	24/08/2012 0:00	50
SWN2201 SWN0	1/10/2012 0:00	8/10/2012 0:00	50
SWN2201 SWN0	18/10/2012 0:00	18/10/2012 0:00	50
SFD2201 SPL22	12/06/2012 0:00	12/06/2012 0:00	100
SFD2201 SPL22	14/06/2012 0:00	14/06/2012 0:00	100

Appendix G HRC Results