TRANSPOWER

ELECTRICITY AUTHORITY
TE MANA HIKO

The remaining elements of RTP

Wellington public briefing

29 March 2019

COMPETITION • RELIABILITY • EFFICIENCY

Agenda

Time	Topic	Presenter	Duration
9:00am	**Sign-in / coffee**		15 min
9:15am	Welcome / Health and safety	Tim Street / John Clarke	15 min
9:30am	RTP project status update	Peter Deefholts	10 min
9:40am	Recap on work to date	Justin Wood	20 min
10:00am	**2 minutes silence for victims of Christchurch terror attack**		
10:02am	Design for dispatch-lite	Chris Otton	20 min
10:20am	Setting scarcity pricing values	David Hunt	15 min
10:35am	**Morning Tea**		25 min
11:00am	Reserve scarcity pricing	Justin Wood	60 min
12:00	Morning session wrap up	Tim Street	5 min
12:05pm	**Lunch**		40 min
12:45pm	Reserve scarcity pricing scenarios	Ramu Naidoo	90 min
2:00pm	Wrap up	Tim Street	5 min

Welcome and introduction

This briefing is being recorded

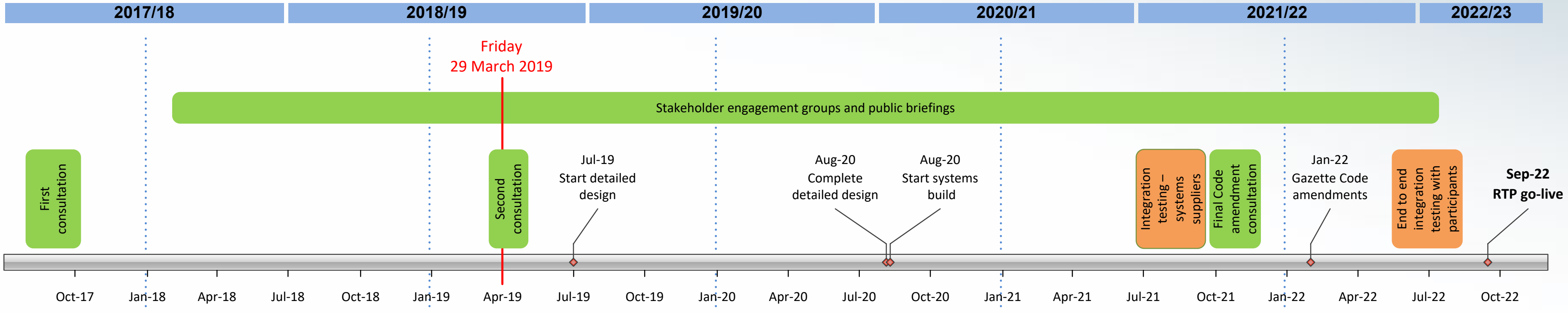
We will publish video and the slides

Purpose of today's briefing

Project status

- **RTP funding has been approved by Cabinet**
  - Provides funding to enable the capital phase of the project to commence
- **Capital phase is planned to commence in July 2019**
  - Decision paper for the entire RTP design will be considered by the Board in June 2019
  - Authority is then able to approve the capital phase of the project
  - Capital phase runs through to delivery of RTP in late 2022
- **Engagement groups**
  - Will operate as key interface between the project team and industry during the next three years
  - A number of subject area engagement groups will be formed to focus on specific areas

Project timeline



TRANSPOWER

ELECTRICITY AUTHORITY
TE MANA HIKO

Current overall status of RTP's design

COMPETITION • RELIABILITY • EFFICIENCY

Current overall status after considering submissions and further design work

Most design elements 'upheld'

some reworked

consulting on three

Current status of design elements

Most design elements 'upheld'

some reworked

Current status of design elements

Real-time 'dispatch prices' produced by real-time dispatch schedule

Interim prices the time-weighted average of dispatch prices visible on WITS in trading period

- Dispatch prices apply from the moment they're visible until replaced

Pricing manager disestablished; clearing manager calculates interim prices

Current status of design elements

Assign default scarcity pricing to all forecast demand in three blocks

- Clarifying: non-conforming load bids are not used in dispatch schedule or to set dispatch prices in any way (earlier Code amendment had error)

Move to bottom-up load forecast using ION meters as primary input

- System operator to publish process used for this short-term load forecast

Current status of design elements

Disconnected nodes assigned a proxy price

- Refined to now be price of the electrically-nearest live node

Dispatchable demand moves to the real-time dispatch schedule

Electronic rebidding and reoffering within the trading period (under same restrictions as today)

Current status of design elements

Forward schedules aligned with dispatch schedules

Constrained payments use last good offer/bid in trading period

Pricing falls back to PRS during market system outages

Current status of design elements

Loss & constraint excess apportioned from dispatch schedules

Discontinue current 5-minute ex-post ‘RTPs’

The system operator’s process for instructing distributors to shed load will not change (directly)

- System operator will provide better clarity on operational practises

Current status of design elements

The cumulative price limit will be removed

- Clarifying: the limit does not guarantee lower prices today; it does not restrain the financial impact of shortage

No intervention for high spring-washer situations

- cannot reliably be detected in real-time (and the process today is just an indication)
- any attempt to intervene in real-time would potentially undermine both operational security and price certainty.

Current status of design elements

Pricing errors: combining increased automated checking with manual claim process

- System operator's post-schedule check will be strengthened
- Definition of pricing error clarified
- Manual claim process: investigated by system operator, Authority makes decision

The last pieces of the puzzle

We're consulting further on three remaining design elements:

- dispatch-'lite', now expanded to include smaller generators
- a process for reviewing actual dollar amount for scarcity pricing values
- handling reserve shortfalls

consulting on three

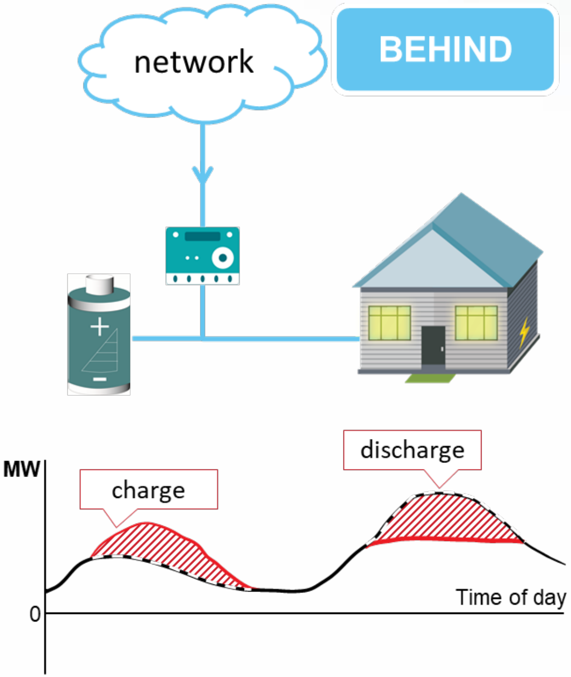
TRANSPOWER

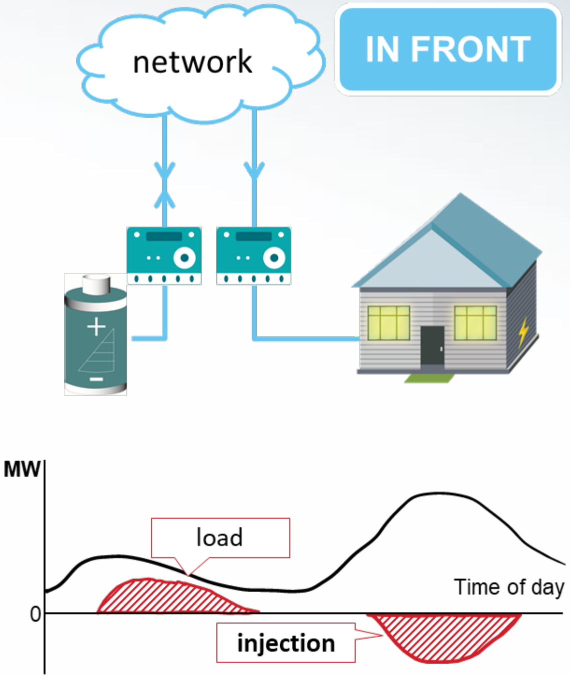
ELECTRICITY AUTHORITY
TE MANA HIKO

Recasting 'dispatch-lite'

COMPETITION • RELIABILITY • EFFICIENCY

Who is 'dispatch-lite' for?





Why 'dispatch-lite'?

Encourage smaller demand and generation participants to take part in price discovery process

- More accurate forward pricing schedules
- More efficient price based decision making
- Ability for smaller participants to take part in price setting

Dispatch notification purchaser / generator

Feature	Dispatch notification generation	Dispatch notification purchaser
Eligibility	Up to 30 MW capacity, at system operator's discretion	No maximum capacity limit, but at system operator's discretion
Need for telemetry (SCADA)	Not generally required, though the system operator may require it in some circumstances[1]	
Method of dispatch	Dispatch notifications (most likely using web services over public internet)	
Method to say 'no' to dispatch[2]	Reoffering immediately with quantity of 0 MW until end of next gate closure period[3]	Rebidding immediately as nominated non-dispatch bid until end of next gate closure period
Compliance	Assessed monthly retrospectively, comparing metered volume against dispatch notifications (except where saying 'no')	
Constrained on (or off) payments	Not eligible	
When bids/offers are required	Must submit offers for all trading periods	Must submit bids for all trading periods
Ability to withdraw from the dispatch process (outside gate closure)	Submit offer with quantity set to 0 MW for relevant trading periods[4]	Submit nominated non-dispatch bids for relevant trading periods

Dispatch notifications

- Gate closure for bids and offers will be 30 minutes
- Received via standard dispatch services
- Intent not to follow a dispatch notification signalled by re-offer/re-bid within trading period
- Cannot further re-offer/re-bid for the same trading period nor the following trading period
- Ineligible for constrained on and off payments
- Persistent non-compliance will be investigated by the system operator

Dispatch notification purchaser

- Allows spot price purchaser to manage exposure
- Could be a consumer or a retailer but must purchase from the Clearing Manager
- Must be able to identify and shed discretionary load within the dispatch timeframe

Dispatch notification generator

- Must be <30MW export capacity
- Allows simplified access to spot pricing and price discovery process
- No additional testing requirements for existing plant
- New plant may be required to undergo some system operator commissioning tests

Setting scarcity values

Scarcity values – what do we mean?

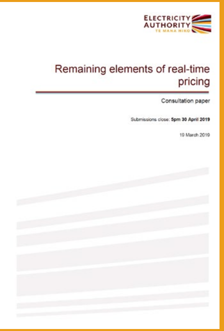
- $ values and MW quantities for:
  - Default scarcity price curves in energy deficits
  - Risk violation curves in instantaneous reserve shortfalls

Scarcity values – why are they important?

- Operational and investment signals – demand and generation
- Reliability impacts
- Price impacts

Scarcity values - status

Initial values


ELECTRICITY AUTHORITY

Remaining elements of real-time pricing

Consultation paper

Submissions close: 5pm 30 April 2019

19 March 2019

Design phase

Go-live values

Before 2022

Periodic reviews

At least five yearly

How will scarcity values be determined?

Same framework as used in 2011 to set current values

Primary approaches

- Estimated costs to consumers of curtailment / reserve shortfalls
- Estimated break-even revenue for last-resort provider

Cross-checks

- NZ demand-side bid data
- Scarcity values in other markets e.g. Australia, Singapore

How will scarcity values be determined (cont'd)

Consultation

- Authority intends to consult on analysis and draft values

Judgement

- Distinct approaches likely to yield differing (but overlapping) scarcity value ranges
- Scarcity values (energy, IR) need to work as a 'package'
- Degree of judgement will be required to determine final values

Reserve scarcity pricing under RTP: the risk-violation curve

COMPETITION • RELIABILITY • EFFICIENCY

Outline

- Quick background on handling reserve shortfall today
- The challenge: putting ‘real’ prices on reserve shortfalls in real-time
- Introducing our proposed risk-violation curve
- The trade-offs and judgements in choosing the curves

We sacrifice reserve cover to avoid load shedding

Offered supply not enough to meet expected demand + full reserve cover

Sacrifice (spinning) instantaneous reserve to provide energy

Accept an elevated security risk to avoid certain load shedding now

Reserve shortfall is an outcome of co-optimisation

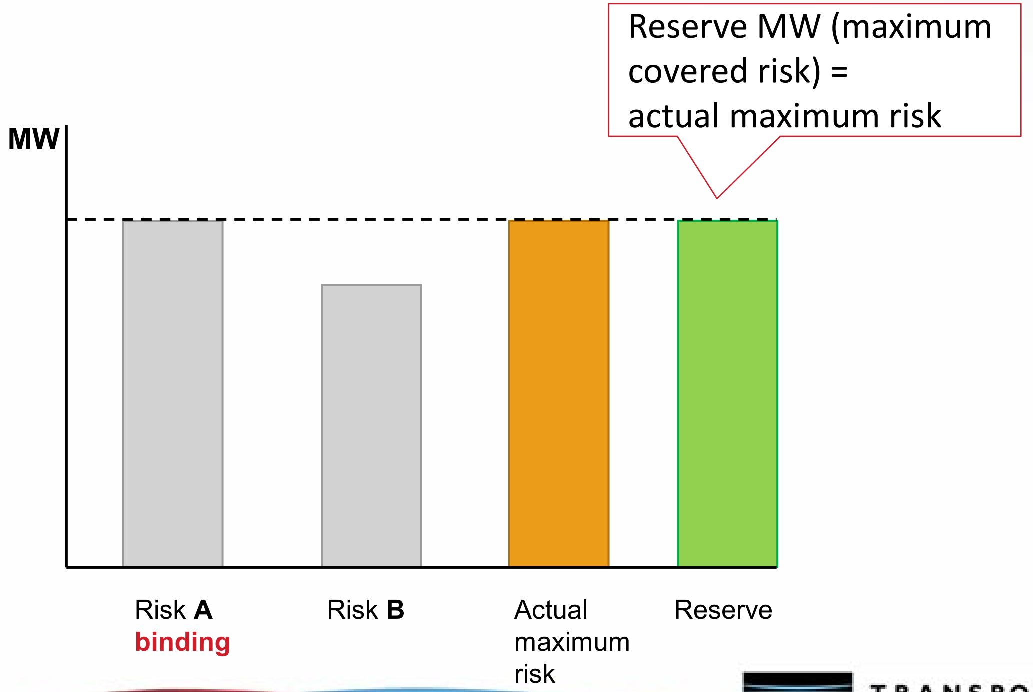
SPD finds the least-cost dispatch solution for expected load:

- optimising generator offers, dispatchable demand bids, reserve offers
- subject to model constraints, and their constraint violation penalty (CVP) prices
- reserve is determined dynamically for each trading period

Reserve shortfalls are an inherent outcome of that process, not a manual override or intervention

- CVP for energy deficit ($500k/MWh) >> reserve deficit ($100k/MW/h)
- Reserve shortfall not guaranteed; different offers may give different result

In normal conditions, reserve covers the maximum risk



Key terms

- **Actual maximum risk** = risk source with largest scheduled MW quantity
  - Defines target reserve quantity (assume FIR ~ SIR)
- **Maximum covered risk** = MW quantity of scheduled reserve

Reserve shortfalls may not show up in final pricing

Shortfalls in dispatch schedule (~5 min) = reserve infeasibility

Must be removed manually if occur in interim pricing schedule (30 min)

Virtual reserve provider (VRP): dummy reserve added until solution feasible

Price set to be <u>greater of</u>:

- 3 × highest cleared energy offer
- highest cleared reserve offer (for reserve class)

VRP is a cumbersome manual fix

Manual post-processing, not usable for ex-ante dispatch prices

Prices are also:

- not deterministic; change based on particular offers – dynamic price cap you find out later
- hence (likely) not reflecting economic costs of scarcity

The fundamental principles underpinning RTP

Principle 1: Getting the spot price right is critical to operating the energy-only market efficiently

Principle 2: To achieve Principle 1, the system must always produce a ‘real’ spot price, in real-time

Principle 3: To achieve Principle 2, the system must always produce a result, even when supply is not sufficient

Consequence: To achieve Principle 3, the system should reflect the underlying economic cost of marginal outcomes in the market

Infeasibilities must no longer be possible

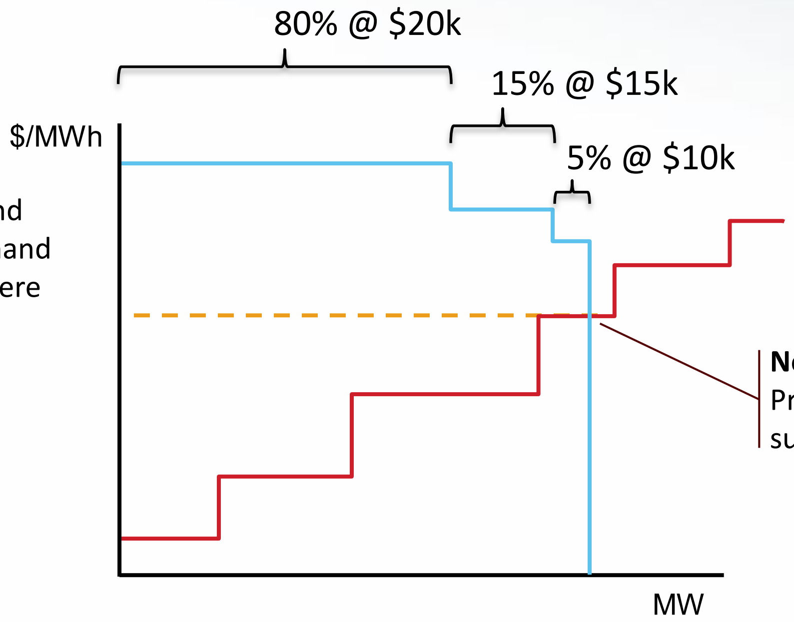
RTP fundamental principles = no more infeasibilities

Two central design elements serve that objective:

- default (energy) scarcity pricing blocks mean all load inputs now have a price
- CVPs for reserve shortfall should now have ‘real’ price

Default scarcity pricing closes the demand curve

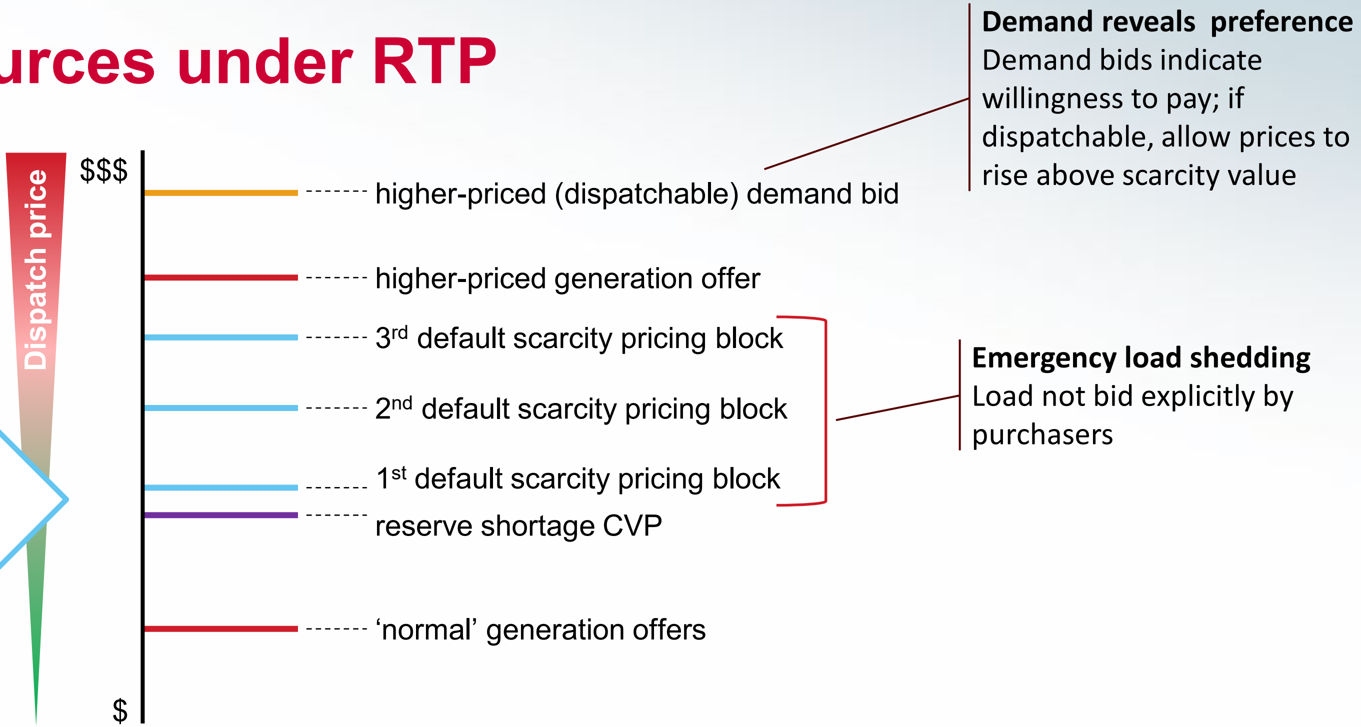
(*) Dispatchable demand further refines the demand curve, but not shown here



Normal dispatch
Price determined by marginal supply offer(*), same as now

TRANSPOWER COMPETITION • RELIABILITY • EFFICIENCY ELECTRICITY AUTHORITY TE MANA HIKO

What we said in 2017: Illustrating the dispatch order of system resources under RTP



Conceptually this is correct (price reserve shortage 'just below' first scarcity block) — but actually doing that is far more complex

What are we trying to do?

Objectives

- Sacrifice reserve before shedding load — integrate scarcity pricing
- But probably not all of it — set some sort of limit
- Reserve prices reflect economic costs

Challenges

We have to be robust to edge cases, even if unlikely

- Handling multiple risk setters — and not suppressing energy prices
- Both FIR and SIR in deficit
- Combinations of the above

Prices during reserve shortfall should reflect scarcity

Prices for energy and reserve during conditions of scarcity:

- Operational in real-time: direct resources to their most valuable use (energy vs. reserve); encourage voluntary demand response
- Investment over time: signal more investment in capacity would be valuable, and support that investment (address the 'missing money problem')

Current ex-post pricing has never really had to tackle this properly…

The problem? Current model using reserve deficit constraints won't work under RTP

Replacing current placeholder CVP values with 'real' economic penalty prices just doesn't work

- Exposes the energy price suppressing effect of multiple risk setters
- Leads to inconsistent, uneconomic, unreasonable outcomes – driven by multiple risk setter effect

We can show you details later

Again, this isn't a price applied to reserve after the fact, it must drive reserve shortfall through co-optimisation

The solution? Move to a 'risk-violation curve'

A risk-violation curve sets a rising price for reserve as the quantity of reserve shortfall grows, representing the increasing economic cost from leaving sources of risk uncovered.

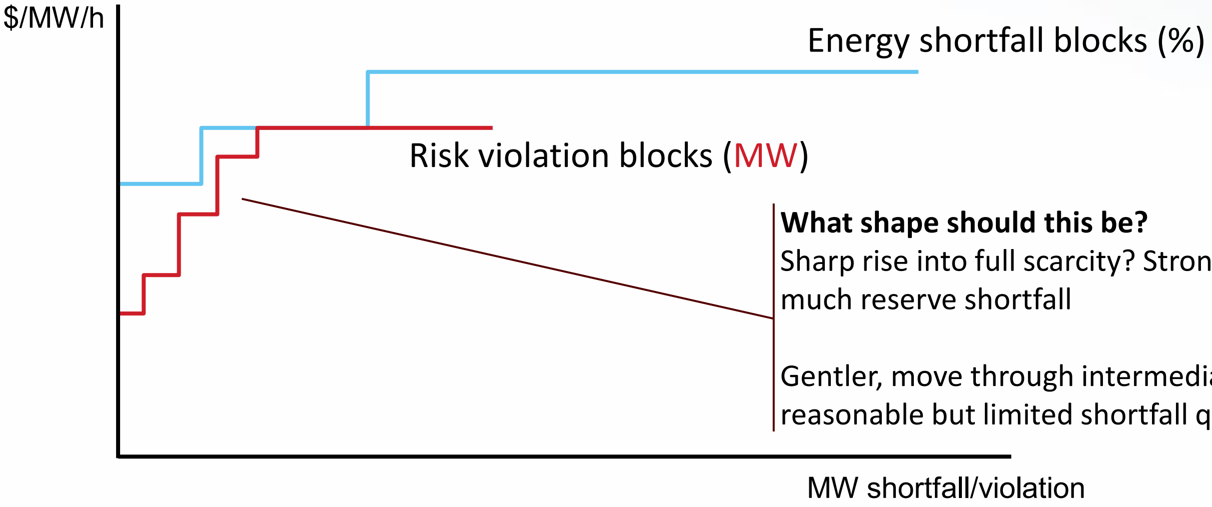
Set SPD penalties on risk violation, not reserve deficit

- elegantly handles multiple simultaneous risk-setters

Integrate reserve shortfall with load shedding via price-quantity steps

- refinement of RTP's overarching principle of a demand curve with embedded scarcity pricing
- load shedding would now occur before all reserve is exhausted

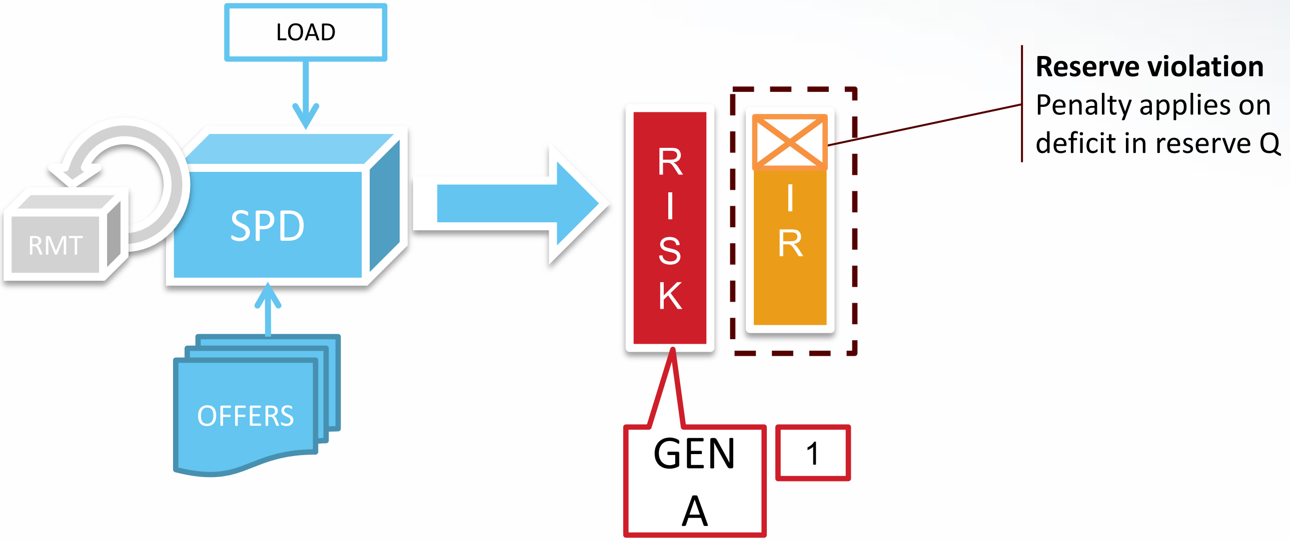
A risk-violation curve extends the concept of embedded scarcity pricing



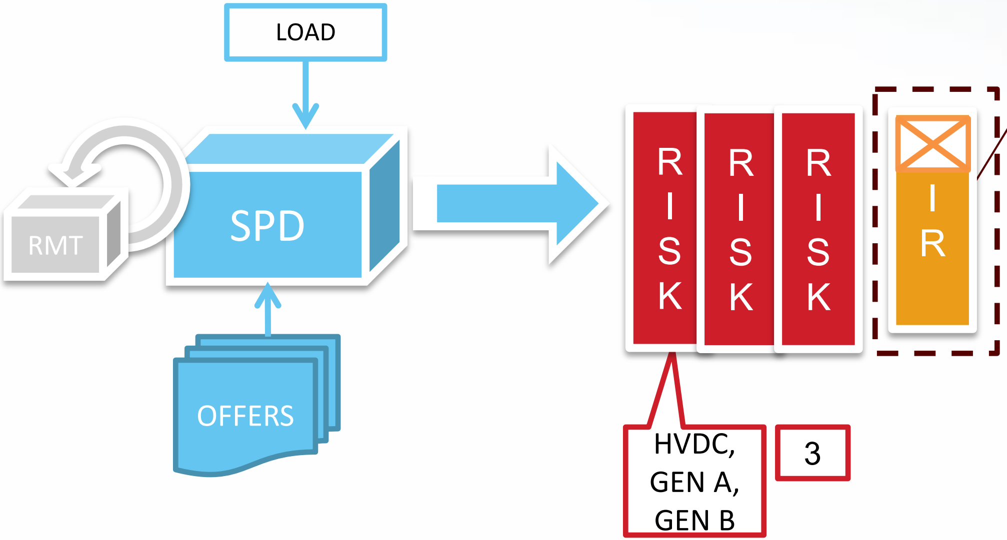
What shape should this be?
Sharp rise into full scarcity? Strong price signal, not much reserve shortfall

Gentler, move through intermediate price level for a reasonable but limited shortfall quantity?

Now: Constraints set on reserve deficit



Now: Constraints set on reserve deficit



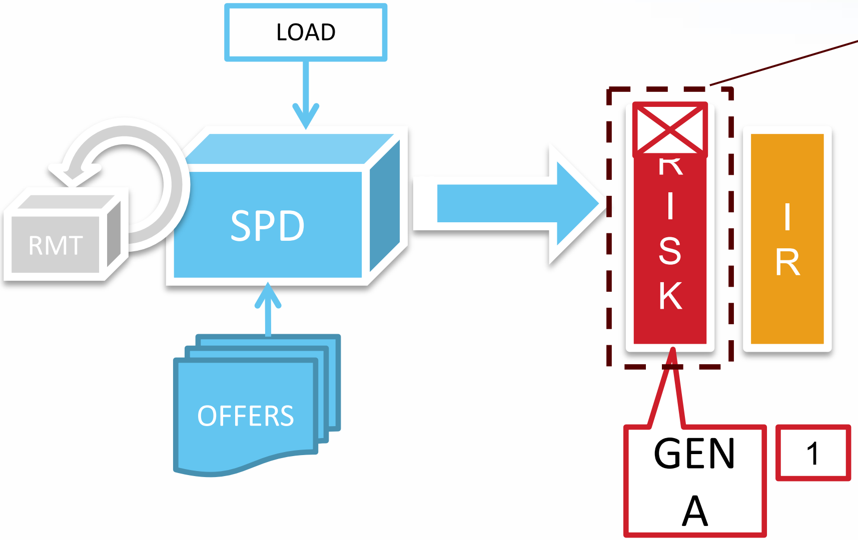
Reserve Q set by largest binding risk
Q not directly affected by multiple risk setters

Likelihood of CE triggering AUFLS is now greater

If used for RTP…

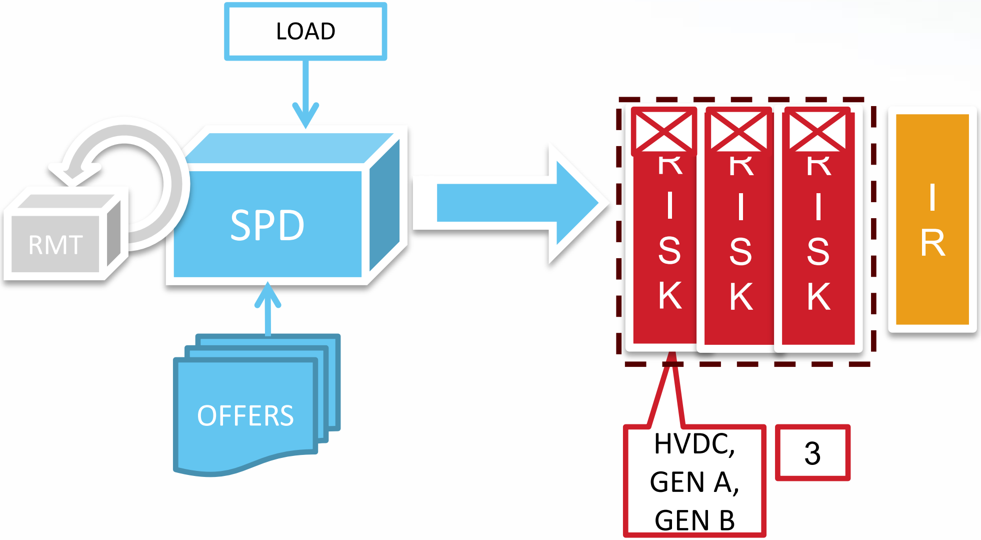
- If set CVP $4.5k (allow res. shortfall), energy offers > $1.5k would not be scheduled

Proposed: Constraints set on risk violation



Risk violation
Penalty applies on violating risk

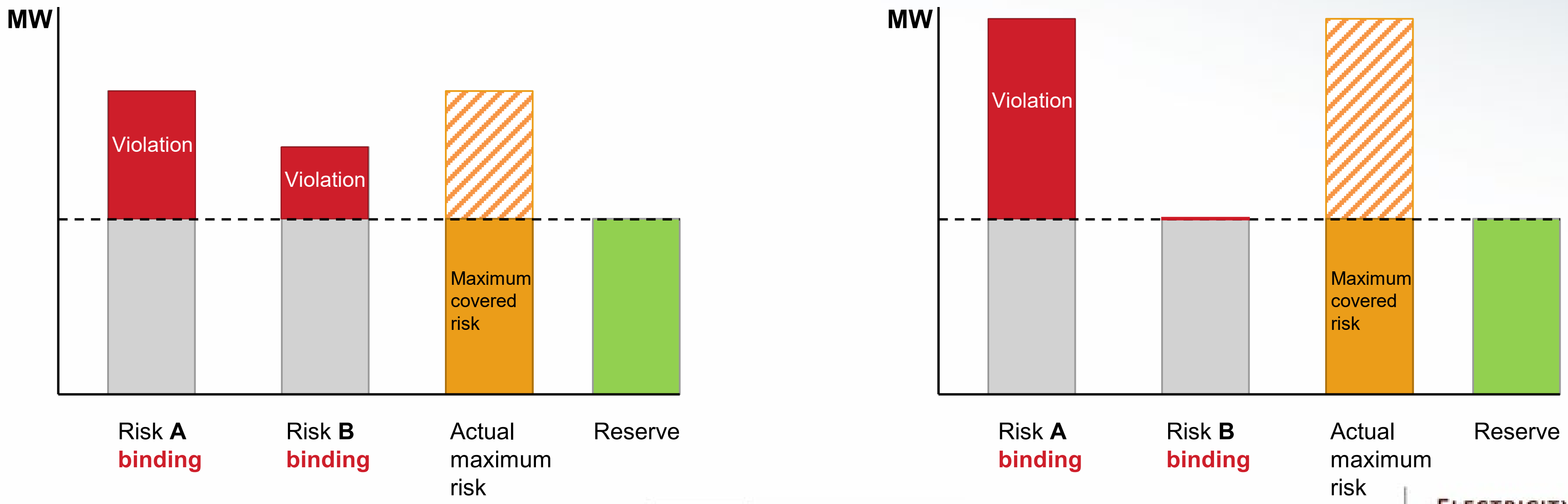
Proposed: Constraints set on risk deficit



Key result

- If multiple risks optimal solution, $reserve rises > $energy, reflecting value to system of 1 more MW reserve
  - 3 risks means 1 MW reserve frees up 3 MW of energy

Risks scheduled *at or above* maximum covered risk would now be binding



A risk-violation curve is a robust solution

We developed an innovative and we think elegant solution

- A strong and future-proof framework
- Made a ‘bug’ into a feature (handling multiple risk-setters)
- Cements and strongly adheres to the Principles above – get the prices right

Curves based on economic cost → SPD trades these off → Outcomes economically justifiable

A risk-violation curve markedly improves on the status quo

Not arbitrarily devaluing energy vs. reserve, or using ‘made up’ numbers

No longer masking actual conditions on the power system (changes in uncovered risk)

Now pricing the extent of uncovered risks, for each such risk

Risks are optimised accordingly

Participants can trade around these characteristics

Configuring the curves requires trade-offs

High $	Factor affected by price	Low $
stronger	strength of scarcity price signal	weaker
weaker	restraint on higher-priced offers	stronger
less likely	chance of reserve shortfall before energy deficit	more likely
less likely (only one)	chance of both FIR and SIR violation	more likely (both)
less likely	chance of multiple risks binding	more likely

High Q	Factor affected by quantity	Low Q
larger	size of reserve shortfall	smaller
stronger	restraint on higher-priced offers	weaker
more likely	chance of triggering AUFLS	less likely

Configuring the curves requires trade-offs

The consultation paper gives details of our modelling and the version we propose to adopt

- We'll go into this in the last session, with some worked examples
- We'll publish modelling results and supporting material along with these slides

Again, we would review the dollar values further before RTP goes live, and as part of the 5-yearly scarcity pricing review

TRANSPOWER

ELECTRICITY AUTHORITY
TE MANA HIKO

Reserve scarcity pricing modelling scenarios

COMPETITION • RELIABILITY • EFFICIENCY

Content

- Background
- What’s wrong with the current process
- The proposed process
- Recap on risks and reserves
- Illustrative examples
- Simulation and sensitivity results using historic market cases
- Conclusion

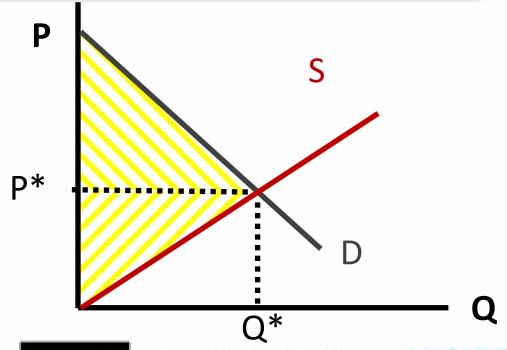
Optimising energy – reserve – risk dispatch and pricing

Optimally dispatches energy, reserves and the actual maximum risk in the NZ electricity market and calculate the prices

Inputs:

- Offers and bids from market participants for energy and reserves
- Reserve adjustments
- Generators limits, ramp rates
- Transmission network limits
- Other constraints
- Forecast demand

→ **Scheduling, Pricing and Dispatch (SPD)** → Energy and reserves dispatch and their corresponding prices



Simultaneously clears markets for energy at every market node and for two reserve products in each island

Infeasible solutions

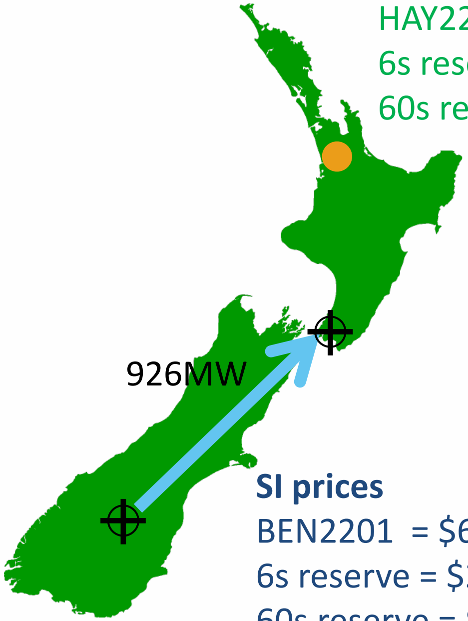
- Sometimes SPD is unable to satisfy all the constraints simultaneously
- Constraint Violation Penalties (CVP) control the violation of constraints → set to high $ value to clear all market resources first
- Currently CVP for not satisfying the reserve requirement constraint is $100k/MWh
- Would violate the reserve constraint if the cost to the system of satisfying the reserve constraint exceeded $100k/MWh

Impact of infeasible solutions on prices

- During constraint violation situations (infeasibility situation) the market prices are affected by the CVPs
- Since CVPs are not “economic” but rather “infeasibility indicators” they are not used for settlement prices
- Additional, ex-post manual process is used to remove these infeasibilities
- This manual process becomes an issue when wanting to calculate prices in real-time

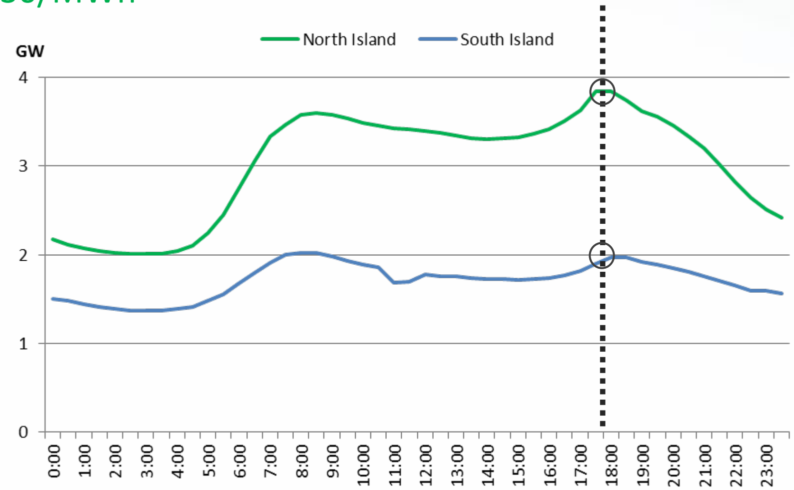
Example: RTD solve - 23 April 2018 18:01

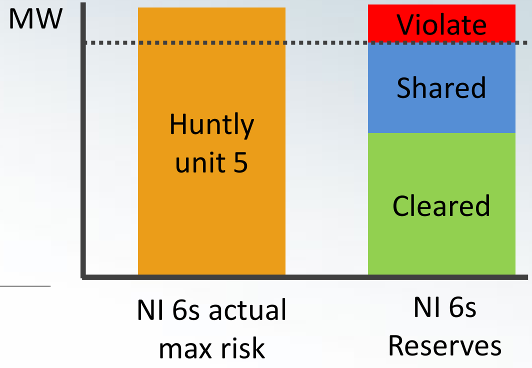
NI prices
HAY2201 = **$100,243/MWh**
6s reserve = **$100,000/MWh**
60s reserve = $230/MWh



SI prices
BEN2201 = $66/MWh
6s reserve = $20/MWh
60s reserve = $30/MWh

Final NI Price (18:00)
HAY2201 = $2.4k/MWh
6s reserve = $2.2k/MWh
60s reserve = $20/MWh





Re-iterating the desirable outcomes of RTP

Gives participants certainty when responding to scarcity

Produce during real-time ✓

Price signals reflecting scarcity situation ✓

<u>Short-term:</u>
Price signals to respond to scarcity situation

<u>Longer-term:</u>
Price signals to invest in additional resources

Why can't we use the current process?

Produce during real-time

Relies on the ex-post process to resolve infeasibilities

Price signals reflecting scarcity situation

Energy prices during scarcity can be suppressed during certain conditions

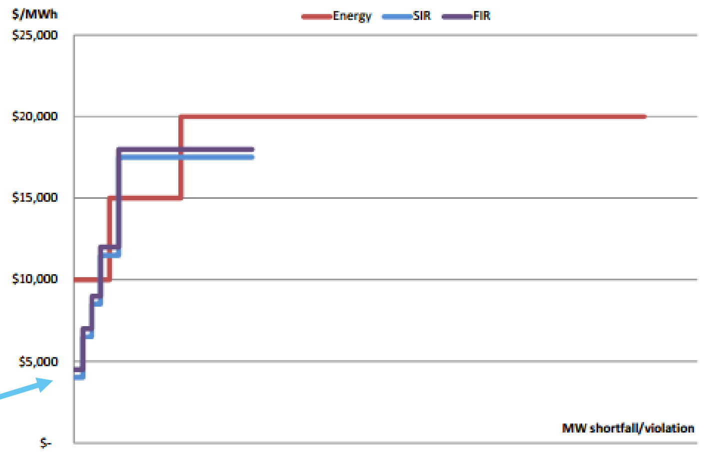
Proposed change to implement reserve shortfalls in RTP

Status quo		Proposed
CVPs indicating infeasibility situation	→	Violation curves reflecting economic costs

Economic trade-offs during reserve shortfall in RTP

- Actionable prices need to be calculated in real-time all the time
- CVPs can no longer be just “indicators” but need to reflect economic costs and trade-offs

Status quo CVPs
Energy deficit: $500k/MWh
Reserve violation: $100k/MWh



Prefer some reserve shortfall before energy

Second proposed change to implement reserve shortfalls in RTP

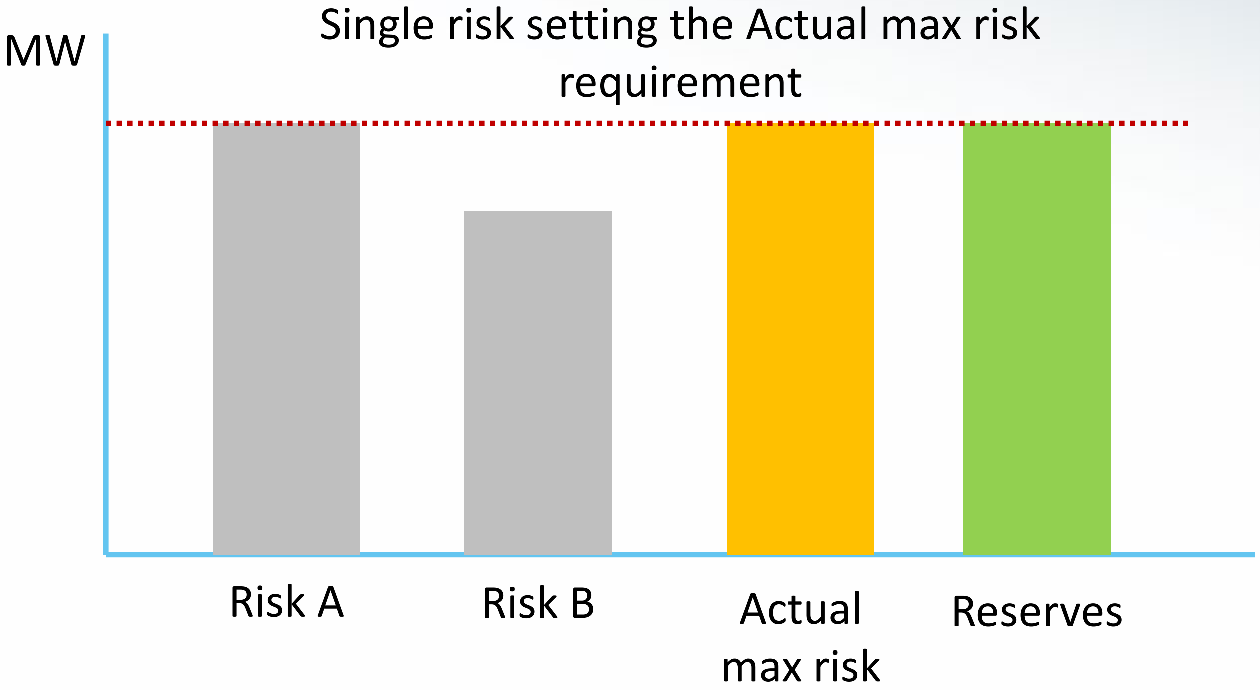
- Reducing CVPs to reflect economic costs highlighted an issue with the current SPD reserve violation model
- Triggered a second change

Status quo		Proposed
Reserve violation model	→	Risk violation model

Recap – Risks and reserves

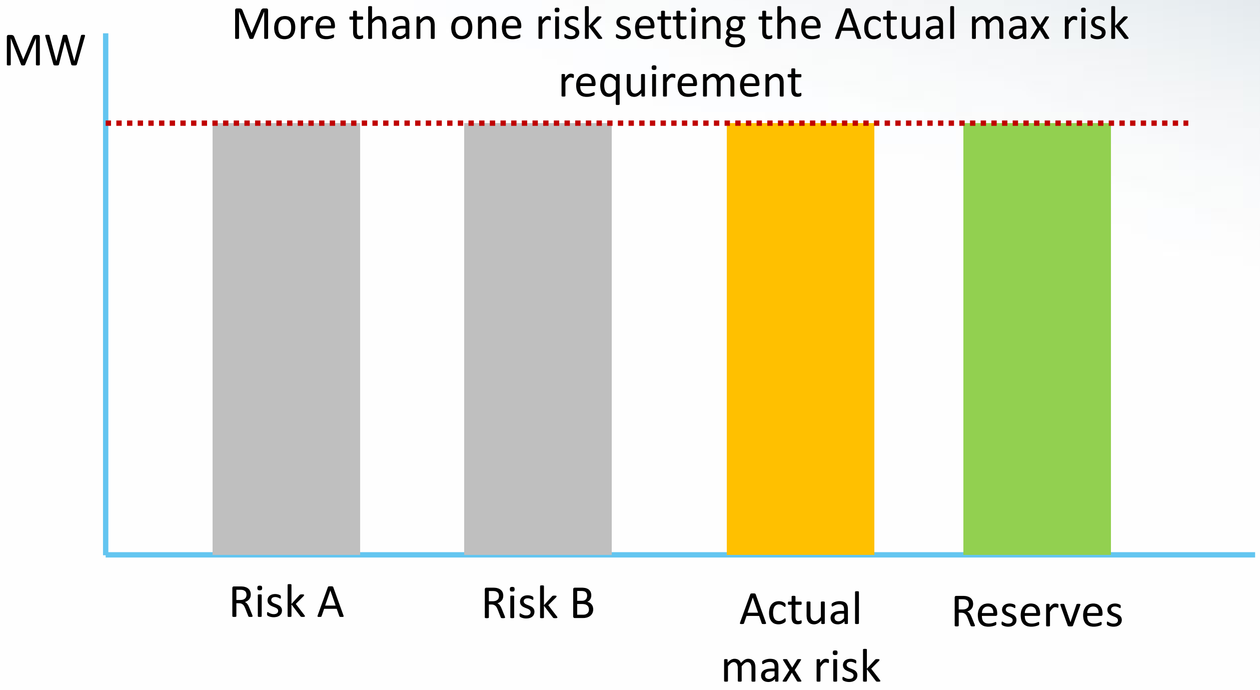
- SPD co-optimises energy, reserves and risks
- The Actual Maximum Risk for both Fast (6s) and Sustained (60s) reserves is determined for each island
- 6s and 60s reserves are cleared by SPD in each island to cover the Actual Maximum Risk
- Sometimes there can be more than on risk that is setting the Actual Maximum Risk (e.g. Huntly unit 5 and the HVDC single pole risk in the NI)
- The reserve CVP is applied to the quantity of the Actual Maximum Risk not covered by reserves (Reserve violation model)

Recap – Single binding risk



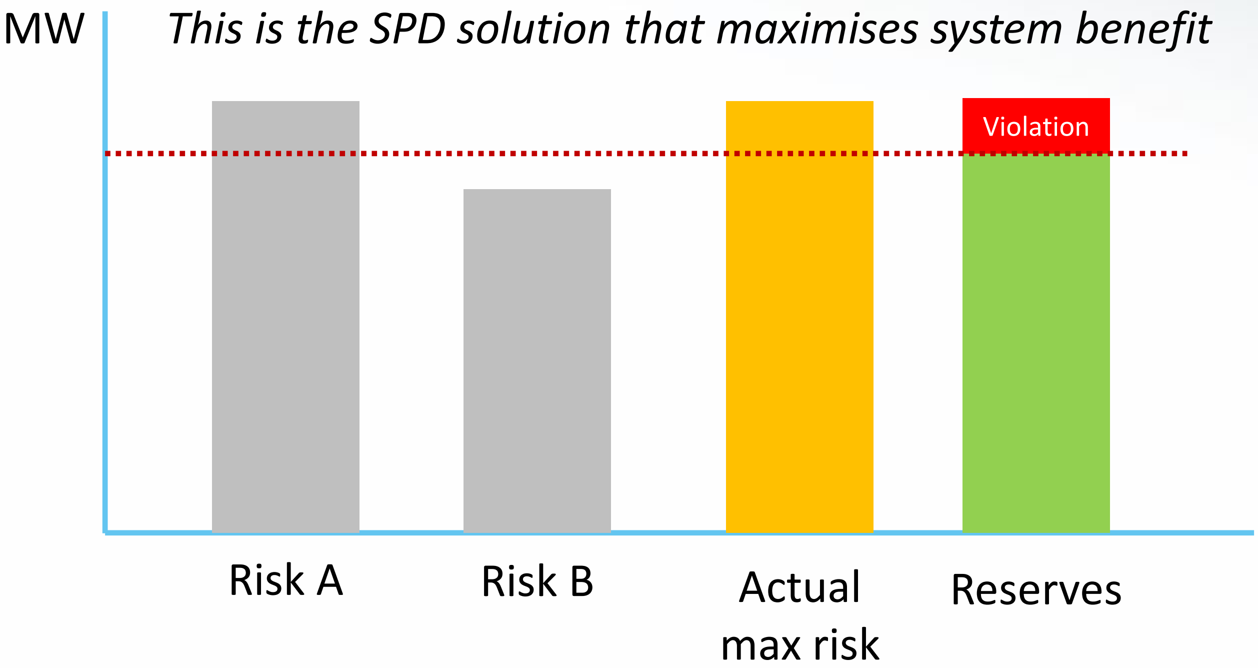
Reserves cleared to cover the Actual max risk

Recap – Multiple binding risks



SPD determines the number of binding risks based on costs and requirements that maximises system benefit

Recap – Single binding risk with violation

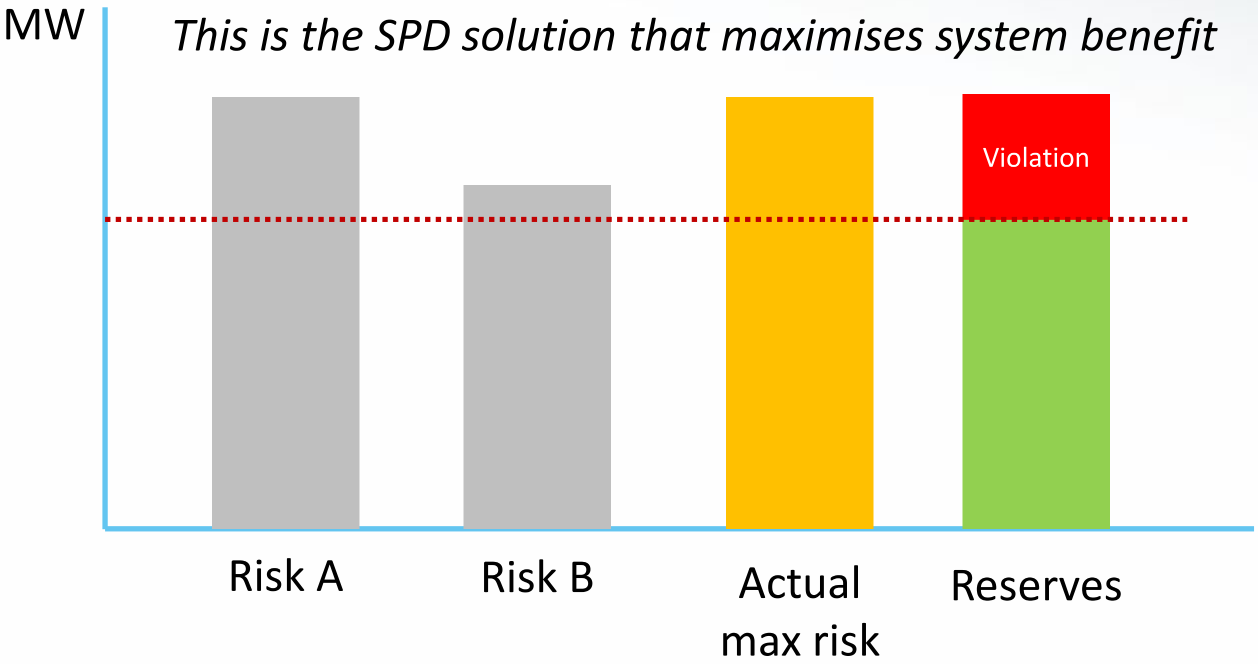


$P_{reserve}$ = CVP ~ P_{energy}

1MW of energy offered into the market can reduce Risk A output by 1MW and reduce violation by 1MW

1MW of reserve offered into the market can reduce violation by 1MW

Recap – Single binding risk with multiple risk violation

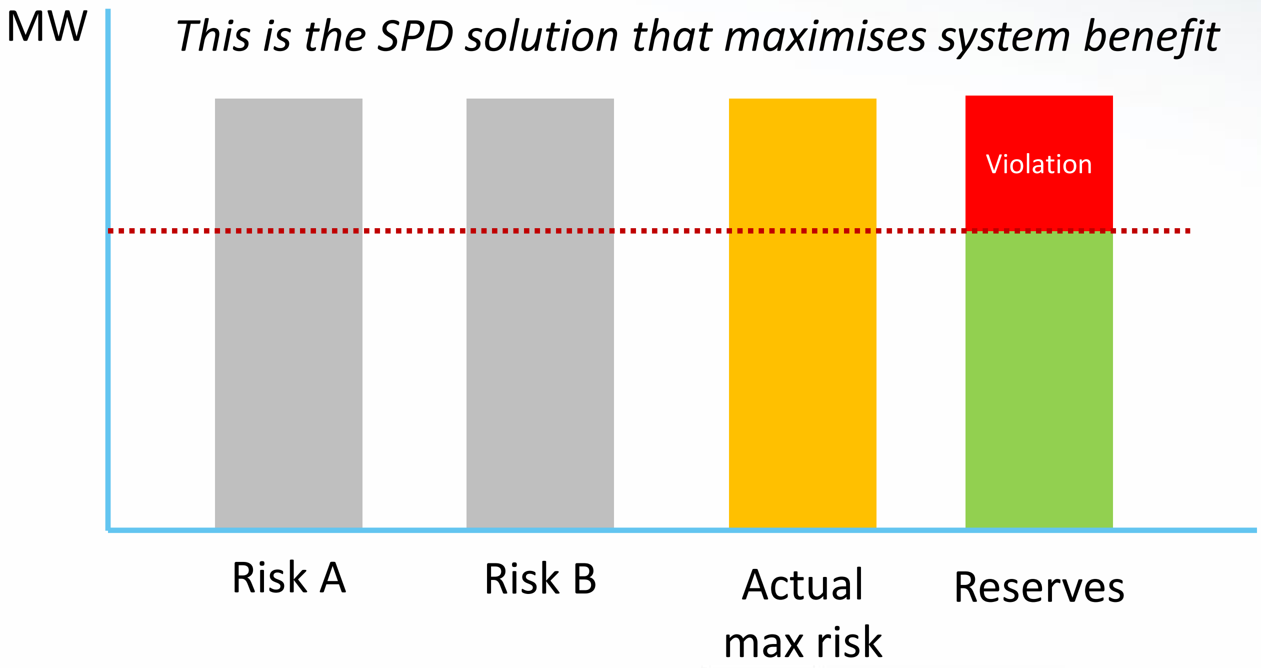


$P_{reserve} = CVP \sim P_{energy}$

1MW of energy offered into the market can reduce Risk A output by 1MW and reduce violation by 1MW

1MW of reserve offered into the market can reduce violation by 1MW

Recap – Multiple binding risks with violation



Energy price = 0.5 x Reserve price

1MW of energy offered into the market can reduce Risk A and B output by 0.5MW each and reduce violation by 0.5MW

1MW of reserve offered into the market can reduce violation by 1MW

Issues with the current reserve violation exposed when reducing CVPs

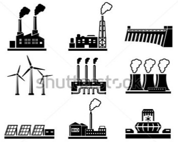
- Under status quo, reserve CVP applied to reserve violation
- Can suppress energy prices when there are multiple binding risks
- Becomes an issue when CVPs reduced from “infeasibility” indicators to reflecting economic costs
- Suppressed energy price increases likelihood of un-dispatched resources during reserve shortfall situations and affects both operational and investment signals

Three binding risk setters - Offered

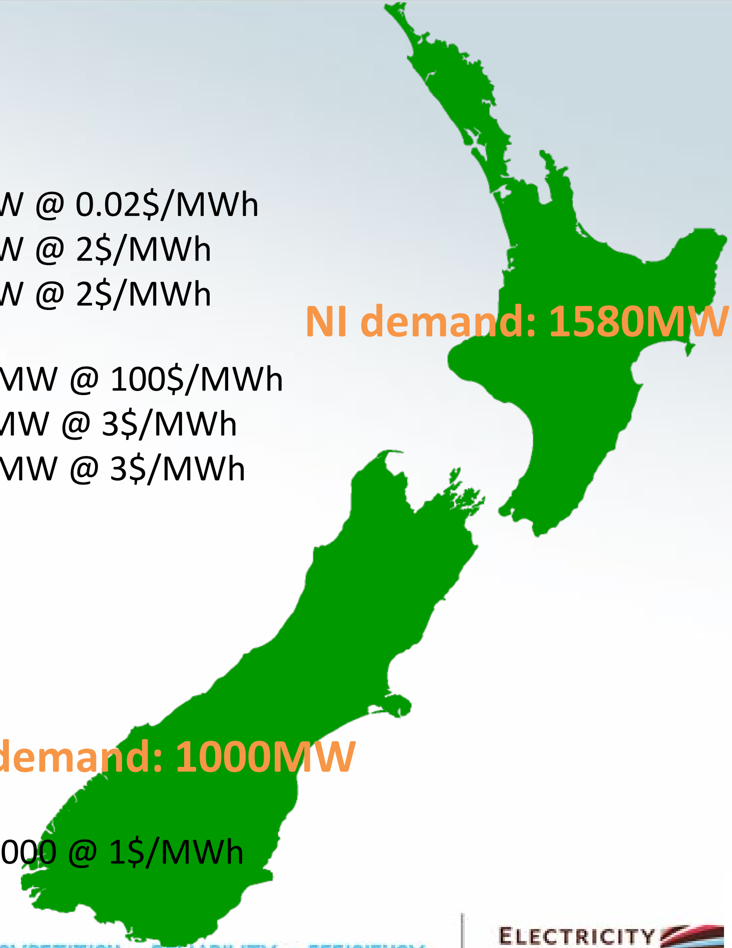
ENRG: 350MW @ 0.01$/MWh
FIR : 20MW @ 1$/MWh
SIR : 30MW @ 1$/MWh

ENRG: 100MW @ 3k$/MWh

ENRG: 350MW @ 0.02$/MWh
FIR : 20MW @ 2$/MWh
SIR : 30MW @ 2$/MWh



ENRG: 1100MW @ 100$/MWh
FIR : 200MW @ 3$/MWh
SIR : 300MW @ 3$/MWh



NI demand: 1580MW

SI demand: 1000MW

ENRG: 3000 @ 1$/MWh

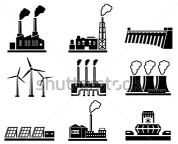
Violation prices
Energy = $10,000/MWh
FIR = $4,500/MWh
SIR = $4,500/MWh

Three binding risk setters - Cleared

ENRG: **220MW** @ 0.01$/MWh
FIR : **20MW** @ 1$/MWh
SIR : **30MW** @ 1$/MWh

ENRG: **0MW** @ 3k$/MWh

ENRG: **220MW** @ 0.02$/MWh
FIR : **20MW** @ 2$/MWh
SIR : **30MW** @ 2$/MWh



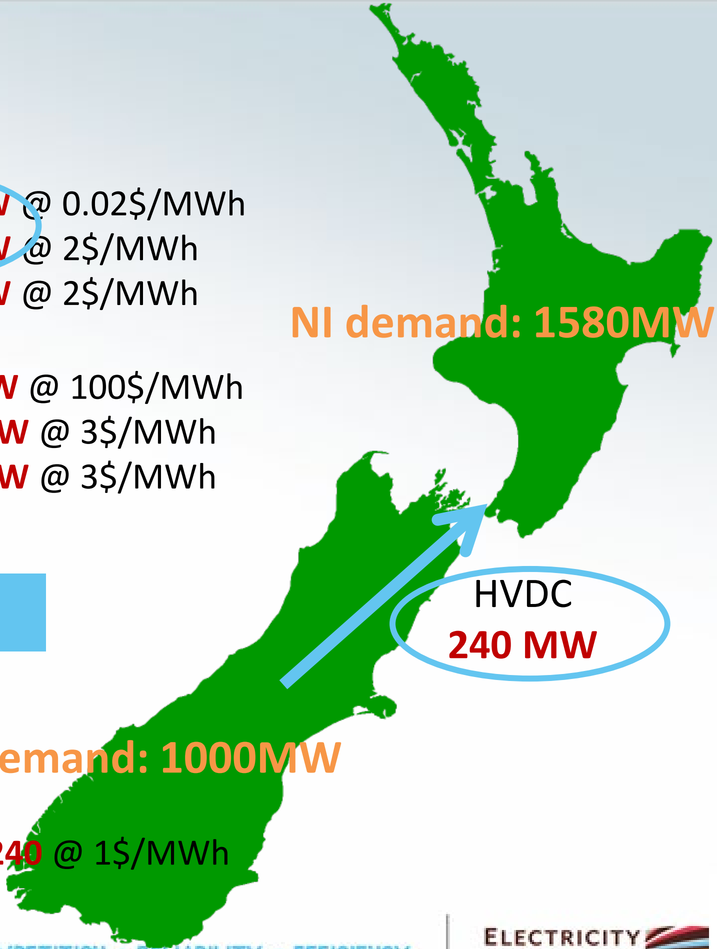
ENRG: **900MW** @ 100$/MWh
FIR : **200MW** @ 3$/MWh
SIR : **190MW** @ 3$/MWh

NI prices
Energy: $100/MWh
FIR: $296/MWh
SIR: $3/MWh

3 binding risks for FIR

Violation prices
Energy = $10,000/MWh
FIR = $4,500/MWh
SIR = $4,500/MWh

ENRG: **1240** @ 1$/MWh

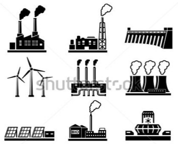


Three binding risk setters – With Violation

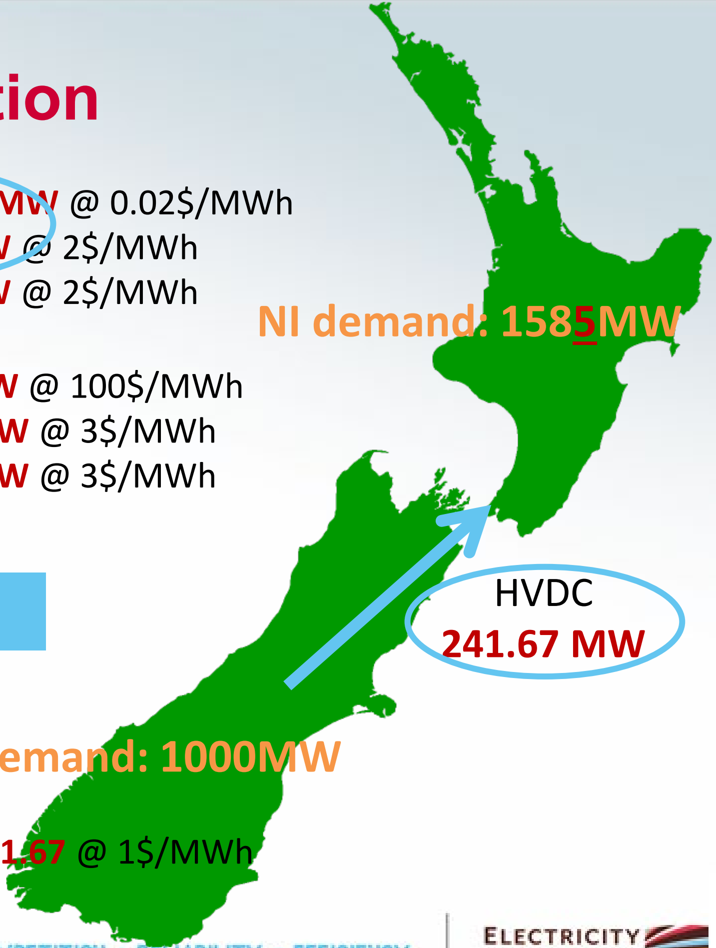
ENRG: **221.67MW** @ 0.01$/MWh
FIR : **20MW** @ 1$/MWh
SIR : **30MW** @ 1$/MWh

ENRG: **221.67MW** @ 0.02$/MWh
FIR : **20MW** @ 2$/MWh
SIR : **30MW** @ 2$/MWh

ENRG: **0MW** @ 3k$/MWh



ENRG: **900MW** @ 100$/MWh
FIR : **200MW** @ 3$/MWh
SIR : **190MW** @ 3$/MWh



NI demand: 1585MW

HVDC
241.67 MW

NI prices

Energy: $1501.34/MWh
FIR: $4500/MWh
SIR: $3/MWh

3 binding risks for FIR

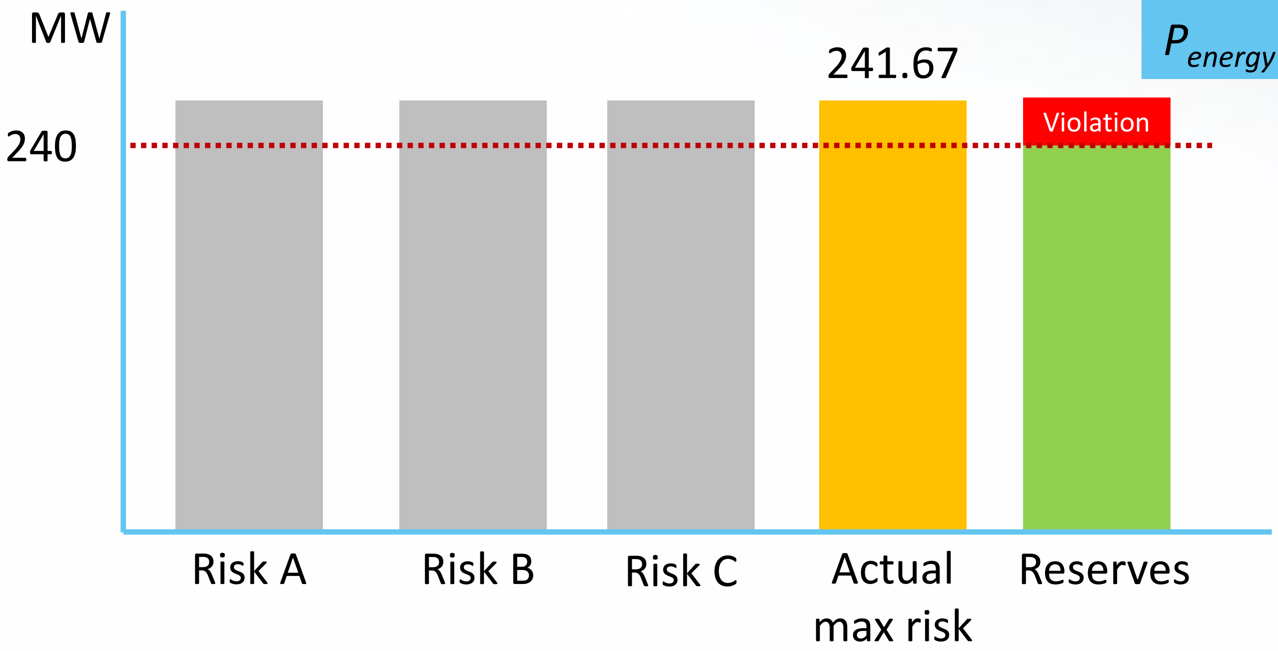
Violation prices
Energy = $10,000/MWh
FIR = $4,500/MWh **[1.67MW]**
SIR = $4,500/MWh

SI demand: 1000MW

ENRG: **1241.67** @ 1$/MWh

Multiple binding risks with violation

$$P_{reserve} = \$4500/MWh$$
$$P_{energy} = \$1501/MWh \sim 1/3 \times P_{reserve}$$



Reserve Violation to Risk Violation Model

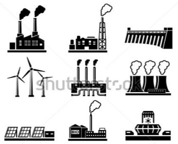
- Violation cost applied to each violated risk

Three binding risk setters (Risk Violation) - A

ENRG: **220MW** @ 0.01$/MWh
FIR : **20MW** @ 1$/MWh
SIR : **30MW** @ 1$/MWh

ENRG: **5MW** @ 3k$/MWh

ENRG: **220MW** @ 0.02$/MWh
FIR : **20MW** @ 2$/MWh
SIR : **30MW** @ 2$/MWh

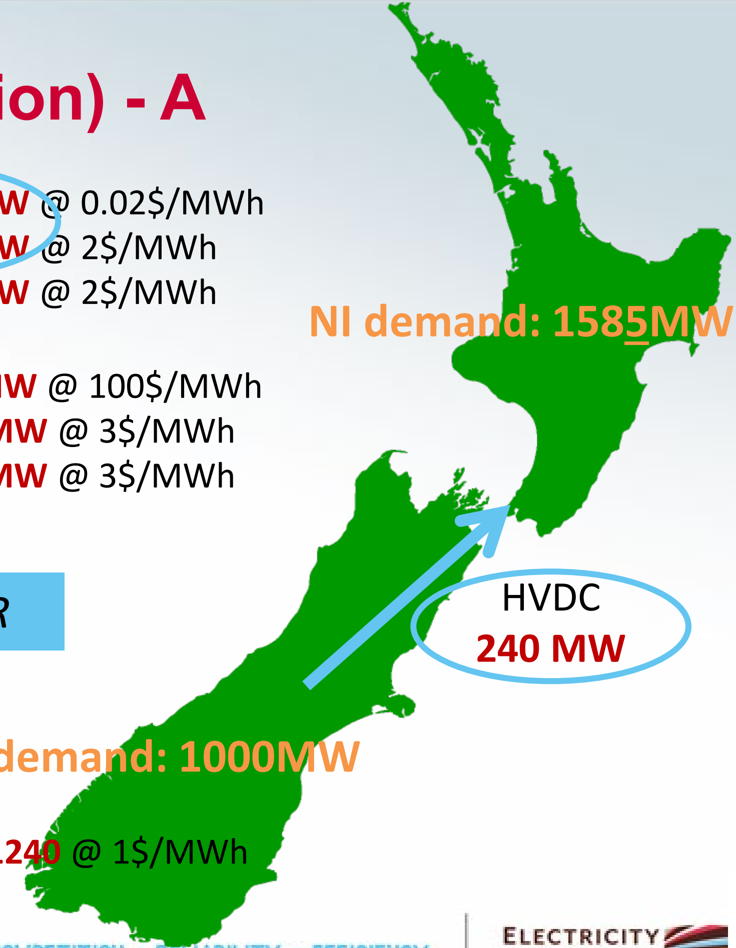


ENRG: **900MW** @ 100$/MWh
FIR : **200MW** @ 3$/MWh
SIR : **190MW** @ 3$/MWh

NI prices
Energy: $3000/MWh
FIR: $8996/MWh
SIR: $3/MWh

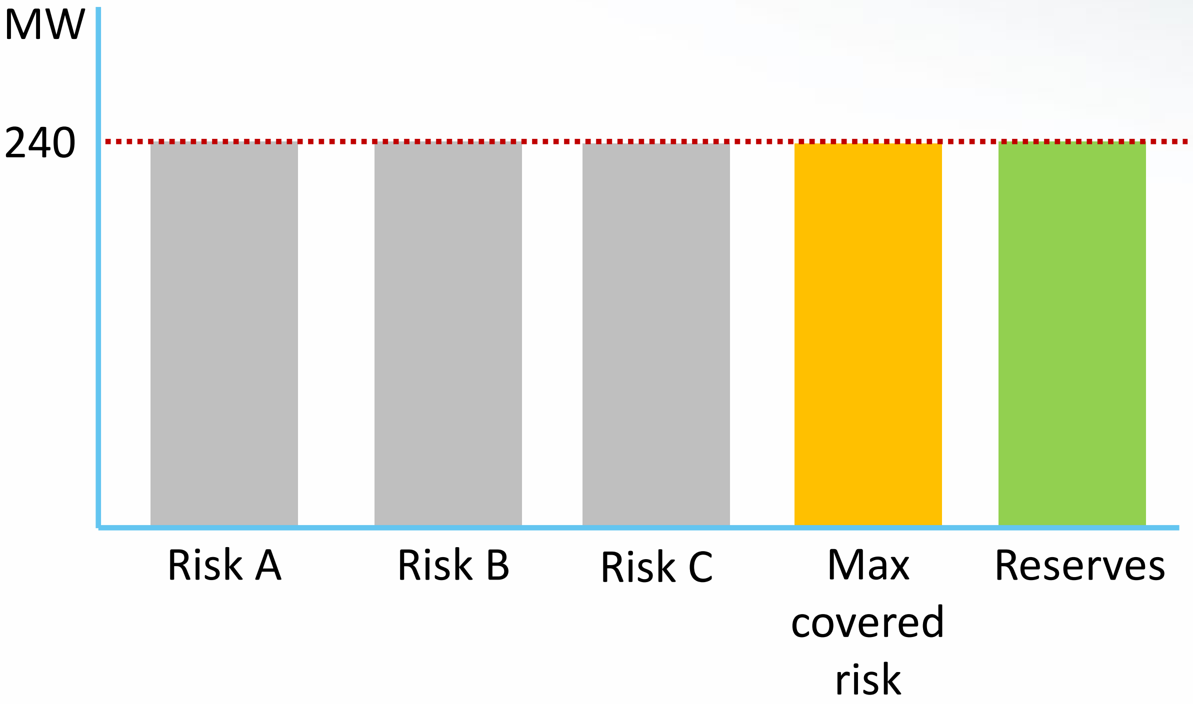
3 binding risks for FIR

Violation prices
Energy = $10,000/MWh
FIR = $4,500/MWh
SIR = $4,500/MWh



TRANSPOWER COMPETITION • RELIABILITY • EFFICIENCY ELECTRICITY AUTHORITY TE MANA HIKO

Multiple binding risks solution - A



1MW of energy offered into the market can reduce $3k/MWh marginal generator by 1MW

1MW of FIR offered into the market can increase each risk by 1MW each and reduce $3k/MWh marginal generator by 3MW

P_{energy} = $3k/MWh ~ 1/3 x $P_{reserve}$

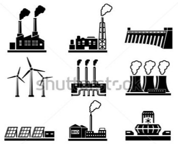
$P_{reserve}$ ~$9k/MWh

Three binding risk setters (Risk Violation) - B

ENRG: **220MW** @ 0.01$/MWh
FIR : **20MW** @ 1$/MWh
SIR : **30MW** @ 1$/MWh

ENRG: **0MW** @ 5k$/MWh

ENRG: **220MW** @ 0.02$/MWh
FIR : **20MW** @ 2$/MWh
SIR : **30MW** @ 2$/MWh



ENRG: **900MW** @ 100$/MWh
FIR : **200MW** @ 3$/MWh
SIR : **190MW** @ 3$/MWh

NI prices

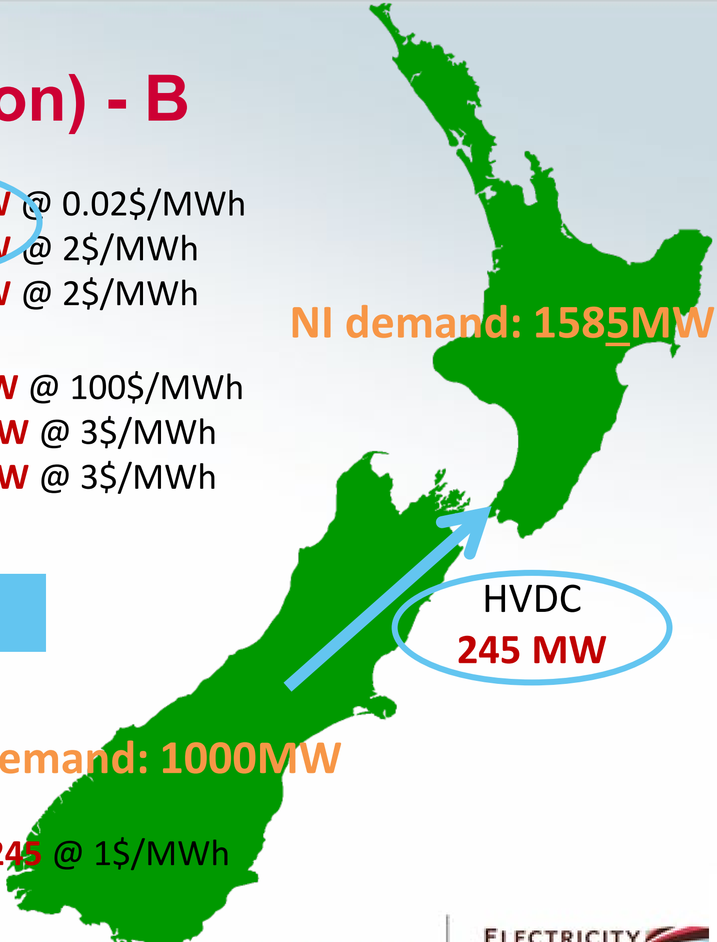
Energy: $4501/MWh
FIR: $13499/MWh
SIR: $3/MWh

Violation prices

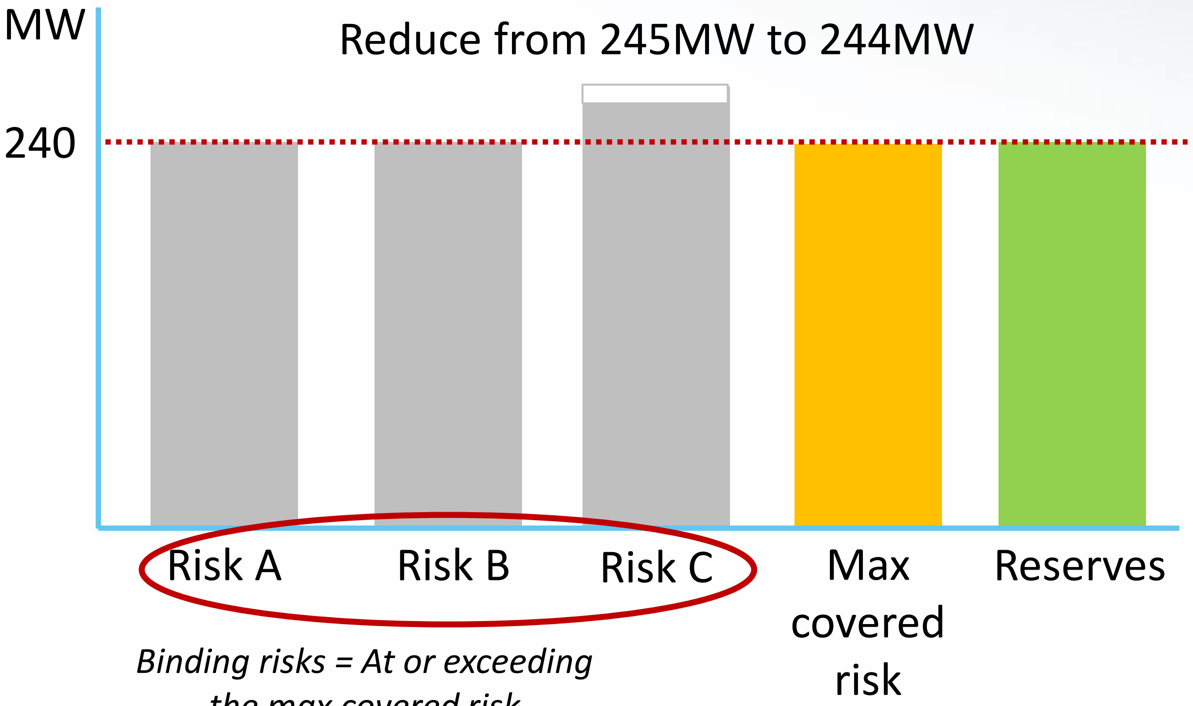
Energy = $10,000/MWh
FIR = $4,500/MWh ***[5MW]***
SIR = $4,500/MWh

3 binding risks for FIR

ENRG: **1245** @ 1$/MWh



Multiple binding risks solution - B

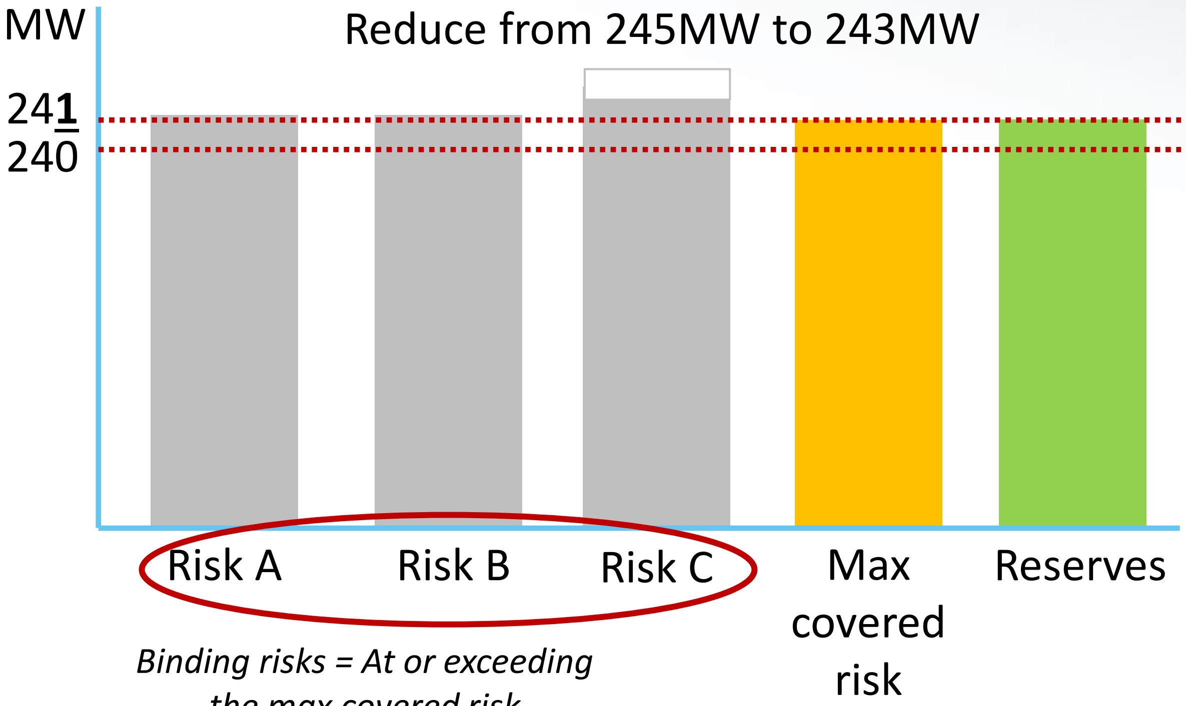


Binding risks = At or exceeding the max covered risk

1MW of energy offered into the market can reduce HVDC by 1MW so reduce risk violation by ~$4.5k/MWh

P_{energy} ~ $4.5k/MWhWh

Multiple binding risks solution - B



Binding risks = At or exceeding the max covered risk

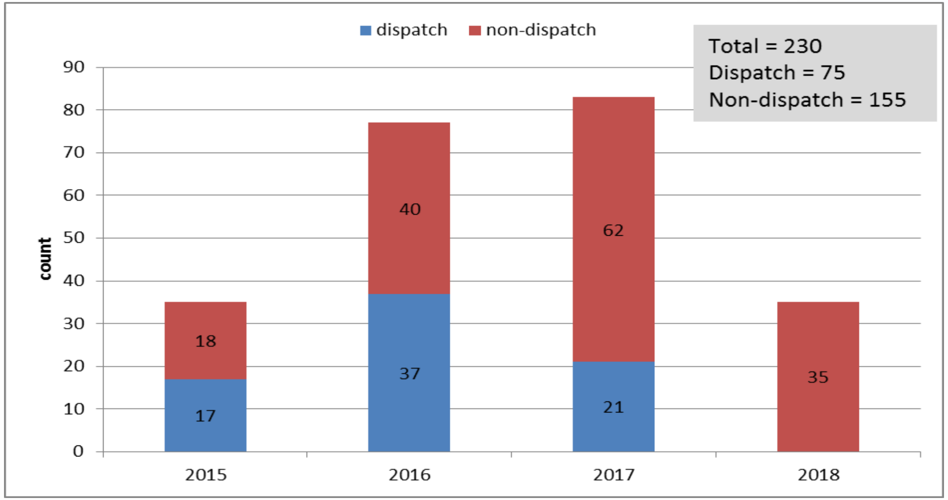
1MW of FIR offered into the market increases available reserves to 241MW.
Can increase each risk A, B and reduce HVDC by 2MW.
HVDC can reduce from 245MW to 243MW with reserves to cover 241MW. So violation reduces by 3MW

$P_{reserve}$ ~$13.5k/MWh
$P_{reserve}$ ~ 3 x P_{energy}

Benefits of moving to the risk violation

- Removes the price suppression of effect on energy prices when there are multiple binding risks
- Maintains the efficient economic trade-offs between energy and reserves reflected by market conditions

Historic dispatch scenario simulations



- Historic 5-minute RTD cases with FIR or SIR price > $3k (scarcity and near-scarcity)
- Only considered solves dispatched to the market

Test violation curves for historic simulations

Energy violation

Tranch	Price	Q (%)
1	10,000	5
2	15,000	15
3	20,000	80

Risk violation (Higher price)

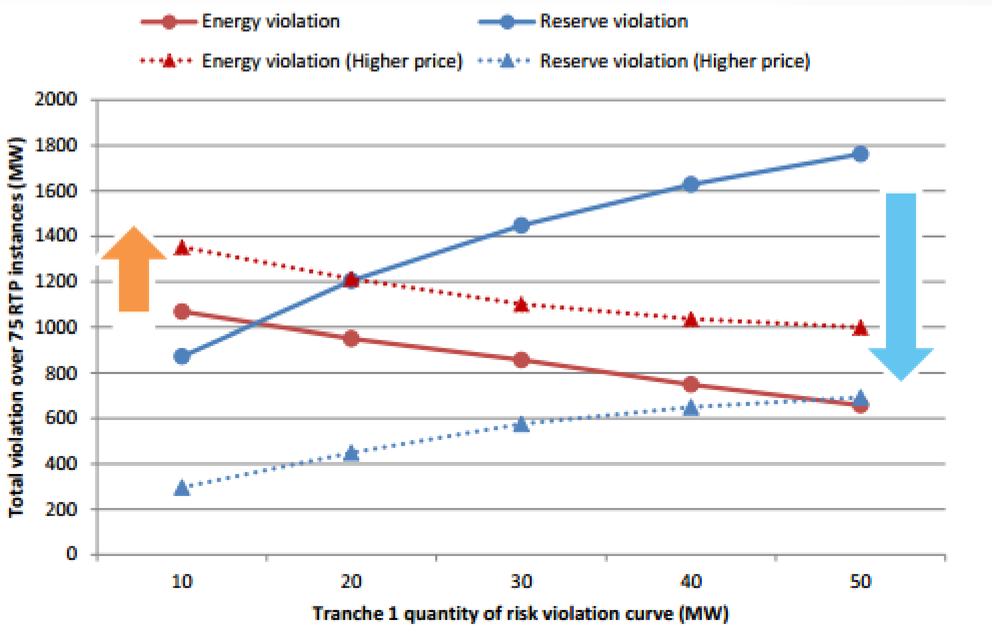
Tranch	6s price	60s price	Q (MW)
1	7,500	7,000	10
2	12,000	11,500	20
3	18,000	17,500	100

Conducted further sensitivity on quantity of Tranch 1

Risk violation (Lower price)

Tranch	6s price	60s price	Q (MW)
1	4,500	4,000	10
2	7,000	6,500	10
3	9,000	8,500	10
4	12,000	11,500	20
5	18,000	17,500	100

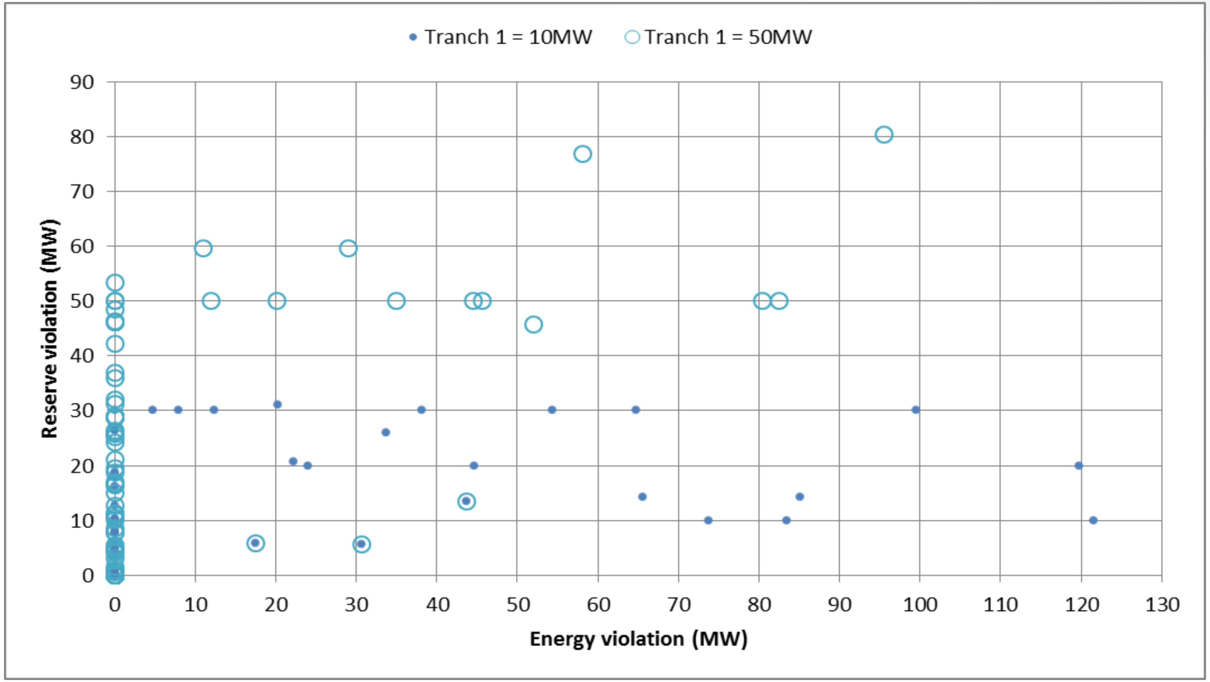
Total energy and reserve violation



Increasing T1 Quantity
Reduces energy violation
Increases reserve violation

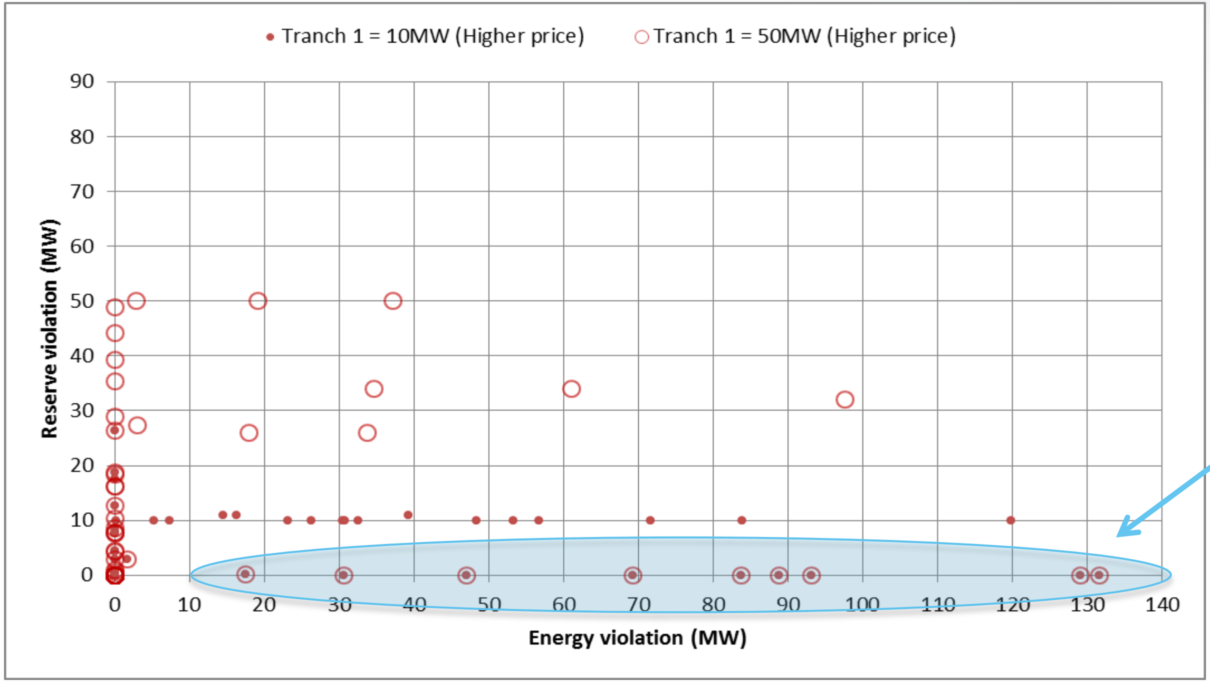
Increasing Price
Increases energy violation
Reduces reserve violation
Increases chance of energy violation before reserve violation (See next slides)

Energy vs reserve violation – Lower priced violation curve



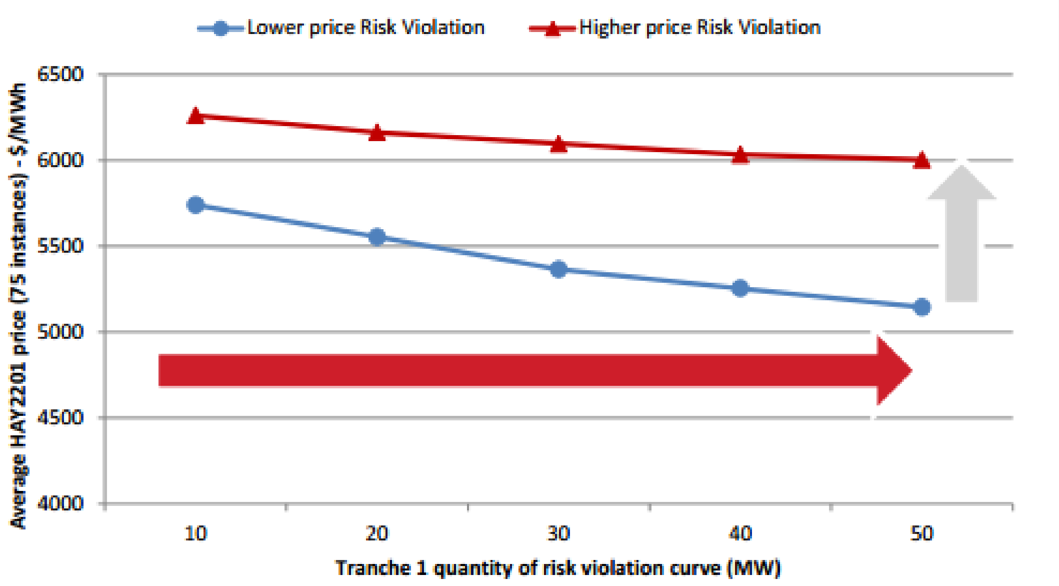
- Largely get reserve violation before energy
- Increasing T1 quantity get a higher level of reserve violation before energy violation

Energy vs reserve violation – Higher priced violation curve



- Increased likelihood of energy violation reserve violation

Energy price impact



Increasing the quantity of low-priced tranches of the risk violation curve reduces the average price for last resort plant

Summary

- Current ex-post approach for managing reserve violation needs to be addressed if moving to real-time pricing
- CVPs need to move from “infeasibility indicators” to reflecting economic costs and encourage efficient operation and investment during reserve shortfalls
- Current reserve violation model can suppress energy prices during periods of reserve shortfall and multiple risk setters which dampens signals for efficient operation and investment
- The risk violation model moves the pricing of violation onto the uncovered risks which addresses the energy price suppression effect
- Settings of the risk violation curve affects the interaction of reserve and energy violation

TRANSPOWER

ELECTRICITY AUTHORITY
TE MANA HIKO

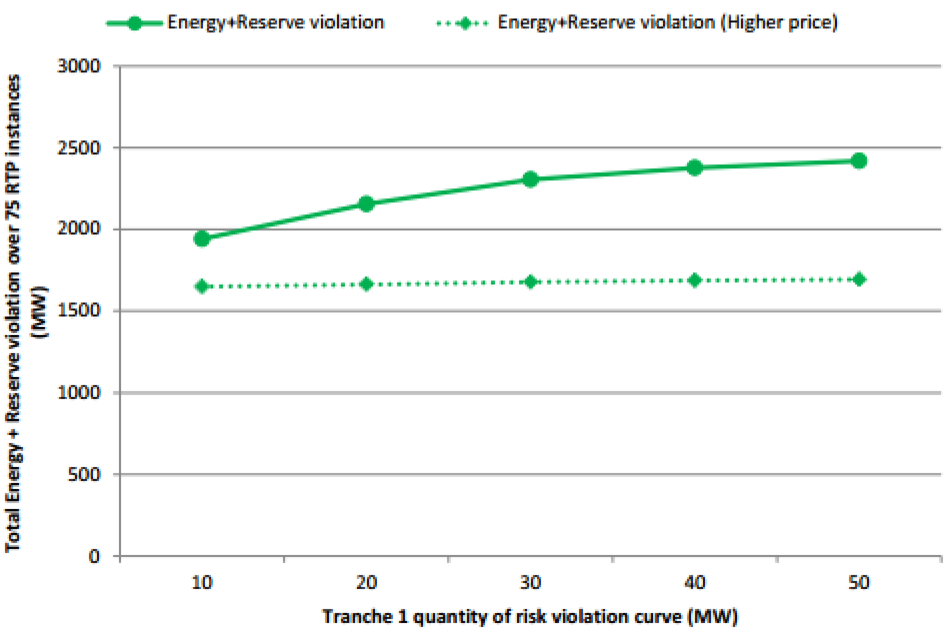
Thank you

TRANSPOWER

ELECTRICITY AUTHORITY
TE MANA HIKO

Additional material if needed

Total violation



- Lower risk violation price, greater the total amount of violation
- Violation incurred ahead of using higher-priced market resources