First Mover Disadvantage – How Big?

September 2021

Summary

This note provides an indication of how material the first mover disadvantage (FMD) problem could become over the coming 15 years. It aims to provide an indication of the scale of investment that could encounter a "Type Two" FMD (FMD-II) challenge, which is where a first mover wanting a connection of size 'C' does not want to carry the upfront cost of larger connection (of size 'C+X') designed to accommodate future movers.

The FMD-II challenge has not been significant in the past because the level of investment has been very small. This is forecast (by Transpower, the Climate Change Commission and others) to change as New Zealand pursues electrification-driven decarbonisation.

	Past (2006 - 2020)	Future (2021 - 2035)	Difference
Energy growth (TWh)	0.5	11.0	2135%
New capacity (MW)	2,102	5,199	247%
New renewable capacity (MW)	1,302	5,199	399%
Renewable investment ($m)	4,235	10,076	238%

Notes:

* Figures exclude rooftop solar

Using the CCC model, the coming 15 years will see a stark increase in growth-driven investment in new generation capacity. This increased investment means we can expect more generation projects to encounter FMD-II challenges. To estimate how much, we have developed judgement-based assumptions by generation technology type for:

- connection costs as a share of generation project costs, and
- portion of projects for which multi-mover dynamics may be material.

Applying these assumptions, we estimate over $500m of grid investment over 15 years supporting ca. $4bn of generation investment in ca. 2,000MW of capacity. This is around 40% of forecast generation investment but under 10% of total grid investment over the same period.

We expect *FMD-II* challenges would delay multi-mover projects, shifting their timing back relative to more straightforward projects. In other words, this would change the merit order for new generation. This could produce a more costly build schedule, which would drive electricity prices slightly higher at times.

A more significant problem could arise for electrification projects. Process heat electrification is forecast to account for 28% of new demand over the next 15 years. The scale of connection investment associated with this is more difficult to estimate so we have simply assumed it is commensurate with the associated generation connection investment.

Process heat electrification is more likely to encounter FMD-II challenges, so altogether we estimate over $300m of grid investment could be impacted supporting over 2,600 GWh of process heat electrification.

In this case, the impact may be more severe as process heat users would either delay conversion plans or opt for alternatives that are easier and lower cost individually but more costly in aggregate.

Introduction

Transpower is proposing changes to the methodology for allocating the costs of connection charges to address the *type two first mover disadvantage* (FMD-II) problem. This is where:

- a party wants to establish a connection to the grid with capacity C
- in anticipation that others will want to use the connection in the future, Transpower believes it would be efficient to build a connection with capacity C+X
- the prospect of bearing the cost of X up-front deters the first mover from connecting, even though they should enjoy lower costs overall if later movers do connect in future.

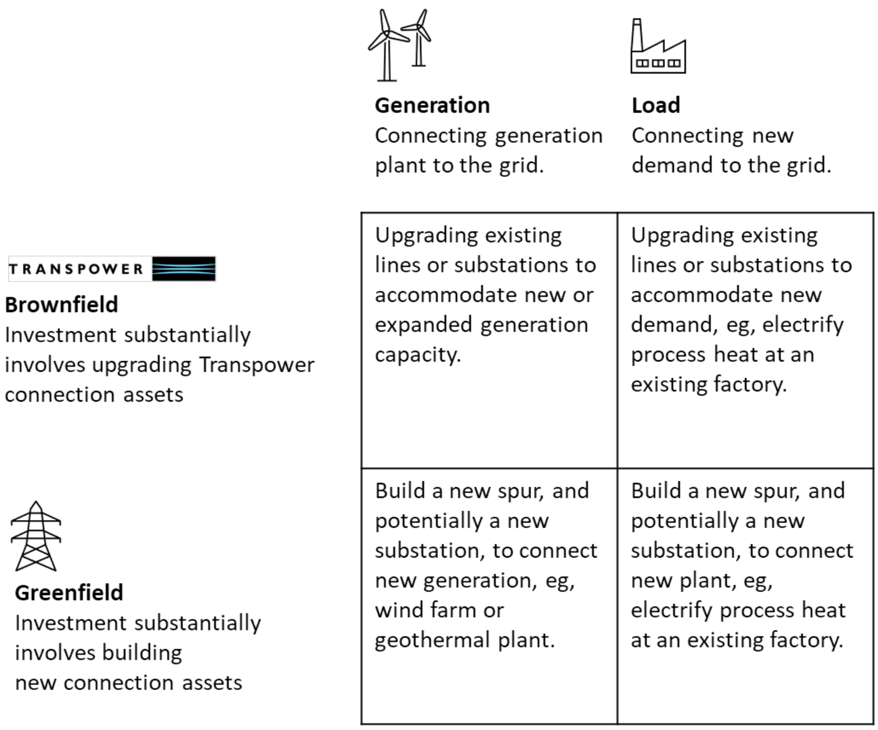
Transpower proposes to socialise the cost of X across all connection customers. This proposal is in the context of expectations that:

- incidence of FMD-II problems will grow in scale due to looming electrification and associated generation build, and
- FMD-II may become a sizeable barrier to electrification, and hence to New Zealand's decarbonisation goals.

There is widespread agreement that an FMD-II challenge may exist in theory, but little information available on the likely scale of the problem. This note attempts to provide some sense of scale.

Types of Connection Investment

The following diagram categorises connection investments for our purposes.



This note does looks at generation and load separately but does not separate brownfields from greenfields.

Area 1 – generation connection

The table below shows three generation build forecasts from two relevant sources:

- two scenarios built using Climate Change Commission (CCC) models
- the base case scenario from Transpower's Te Mauri Hiko strategy.

	NZCCC		Transpower
	Tiwai Goes	**Tiwai Stays**	**TMH base**
2021 energy (TWh)	43	43	43
2035 energy (TWh)	50.3	54.6	54.5
Rooftop solar growth (TWh)	0.5	0.5	2
Remaining generation growth (TWh)	6.8	11.0	9.5
Remaining generation growth (TWh)	16%	26%	22%

Notes:

* TMH figures are for the base 'accelerated electrification' scenario
* TMH solar figure is for distributed (not just rooftop)
* Figures do not all sum due to rounding

The Transpower and CCC modelling are very similar, and both show significant generation growth over the coming 15 years (and beyond). For the remainder of this note we use the CCC "Tiwai Stays" scenario.

The scale of energy growth and investment in renewables across the coming 15 years are forecast to be much higher than the previous 15 years, as shown below.

	Past (2006 - 2020)	**Future (2021 - 2035)**	**Difference**
Energy growth (TWh)	0.5	11.0	2135%
New capacity (MW)	2,102	5,199	247%
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Notes:

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Key observations are:

- for the 'past' period, net energy growth has been very small and the main driver for capacity investment has been to replace retired thermal generation – ie, it has been a period of generation renewal rather than expansion
- for the past period, nearly 40% of new capacity was non-renewable generation, which generally has lower associated connection investment
- the future period is very different, with strong demand growth and 100% renewable generation build
- for the future period, renewable investment is almost four times higher than the past period in capacity terms, and nearly 2.5 times higher in dollar terms.

The following table summarises key information from the CCC scenario about investment in each type of generation technology across the coming 15 years.

Technology	Capacity Added (MW)	Investment ($M)
Geothermal	276	1,289
Wind	3,470	6,741
Utility solar	1,393	1,759
Hydro	61	286
TOTAL	5,199	10,076

Note:

* Figures do not sum due to rounding

The capital costs above are inclusive of grid connection costs. In practice, connection costs vary widely between projects – depending on factors such as distance, terrain, existing substation configuration, and voltages. These variations in connection cost are one of the factors that influence the merit order in which new generation is built, alongside factors such as resource quality, consentability and proximity to demand.

In a similar vein, whether a generation project will encounter multi-mover coordination challenges is very situation specific. Generally, the likelihood is higher for technologies that involve energy resources that are:

- remote from existing high-capacity transmission lines
- extensive within a region – ie, there are resource-rich regions
- suited to grid-scale developments.

Wind is the technology that more strongly matches these characteristics, though other technology types can encounter multi-mover coordination dynamics too.

Finally, we want to focus in on projects for which substantial connection investment is likely to be involved. This is most likely for multi-mover projects that are remote from the grid, or near existing export-constrained connection assets.

In summary, to develop a view of the potential scale of the FMD-II issue we need to make assumptions by technology type about:

- connection cost as a portion of total project cost (on average)
- portion of projects for which multi-mover dynamics might be material.

The table below summarises our assumptions, all of which are judgement based.

Technology	Connection cost (%)	MM challenge (%)
Geothermal	10%	20%
Wind	15%	50%
Utility solar	5%	25%
Hydro	10%	25%

To provide some context on the assumptions above:

- geothermal projects have high capacity factors and local siting flexibility (ie, move steam vs. move electricity). They are centred in the Central North Island but distributed across steam fields. There is existing transmission infrastructure throughout the region.
- wind projects have low capacity factors, and prime resources can be remote from the grid and extensive enough to support multiple large developments
- utility solar projects have low capacity factors unless combined with storage, have good siting flexibility and scalability.

The following table uses the assumptions above to estimate how much transmission and generation investment may encounter FMD-II challenges over the coming 15 years.

Technology	Connection cost ($M)	MM (%)	MM ($M)	Capacity (MW)	Gen Investment ($M)
Geothermal	129	20%	26	55	258
Wind	1,011	50%	506	1,735	3,371
Utility solar	88	25%	22	348	440
Hydro	29	25%	7	15	72
TOTAL	1,257	41%	561	2,154	4,140

Notes:
* The percentage figure in the total row is on a capacity basis – ie, how much new capacity is likely to encounter FMD-II challenges

As a guide to interpreting the table, it is showing for the coming 15 years that for wind generation:

- total investment in connecting generation to the grid is forecast at $1.0bn
- 50% of that grid investment (or $0.5bn) may encounter FMD-II challenges
- those connections would support ca. $3.4bn of investment to deliver ca. 1,700 MW.

Across all technologies, the impacted generation is ca. 2.2 GW, or around 40% of forecast additional capacity over the period.

The following table compares the FMD-II connection capex forecast with other relevant Transpower forecasts.

Investment type	$M	%
Generation connection (all)	1,257	16%
FMD-II gen connection	561	7%
Major capex	1,317	17%
Listed capex	734	9%
Base capex	4,578	58%
TOTAL	7,885	100%

Notes:
* This table excludes any non-generation connection investment, so total may be higher than shown
* Other capex figures are sourced from Transpower's 2020 Integrated Transmission Plan, which uses business-as-usual demand forecasts not aligned with Te Mauri Hiko. We would expect Te Mauri Hiko-

consistent forecasts would likely have more major capex, less base and listed capex, and more capex in total

In summary, the FMD-II issue for generation may impact:

- a relatively small (ca. 7%) share of Transpower's overall investment programme
- a sizeable share (ca. 40%) of forecast new generation investment.

For further context, around $2bn of major and listed capex would be subject to the full benefit-based pricing methodology over the period. At $0.5bn, the FMD-II generation connection investment is nearly 25% of that amount.

Area 2 – Process heat electrification

The generation investment explored above is driven by a mix of demand drivers, with the major components being:

- "normal" organic demand growth – 2,400 GWh (23% of new demand)
- transport electrification – 5,200 GWh (49%)
- process electrification – 3,000 GWh (28%).

Note that the percentage figures relate to the energy contribution, not adjusted for capacity or technology type.

Process electrification is the item most likely to encounter FMD-II challenges because:

- it involves step changes in demand. For example, Transpower estimate that 'easy' process heat electrification could add 20% to existing demand in the east Waikato, with 'deep' electrification adding considerably more,[1] and
- sites are typically nearby existing grid connection infrastructure, such that upgrading existing connection assets (ie, brownfields) is likely to be a major component of the most efficient connection option.

As counter points:

- Transpower suggest that relocating the site will be more attractive than building a long connection line for some very large electrification projects
- small-scale sites are most likely embedded in the distribution network and are unlikely to directly bear the full cost of any transmission grid upgrade for which they are an exacerbator.

As with generation, the amount of investment in connection assets needed to enable process heat electrification is very situation specific. It depends on factors such as the distance back to an interconnected part of the grid, existing connection asset headroom, voltage level, amount of sharing with other load parties.

To provide a sense of scale, we have used two key assumptions:

- that process heat electrification will drive a similar amount of connection investment overall as the associated generation investment.

  Over the forecast horizon, we previously estimated generation connection investment of $1.3bn. As such, we assume process heat connection investment is on the order of (28% x $1.3bn) $0.35bn

- that 90% of process heat electrification will encounter a multi-mover challenge.

[1] See appendix for more information on the East Waikato case study.

Over the forecast horizon, this translates to (90% x $0.35bn =) $0.32bn of connection investment, which would support 2,660 GWh of process heat electrification.

From the above, FMD-II challenges could impact around 25% of forecast new electricity demand.

Appendix – East Waikato Case Study

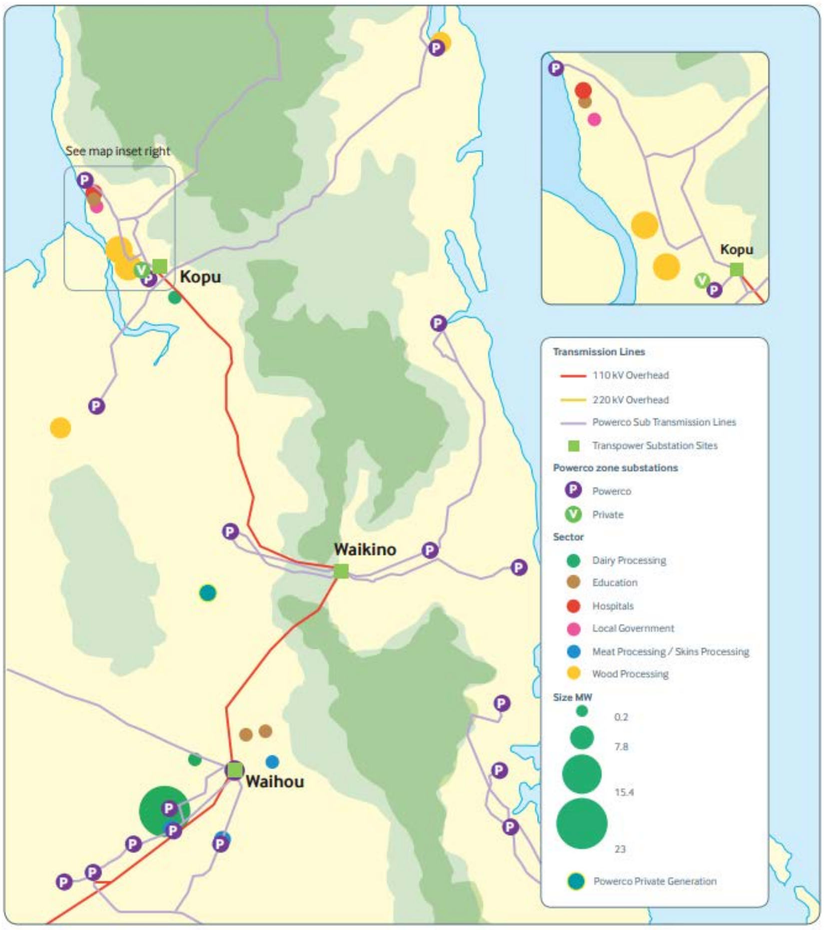
Transpower's Te Mauri Hiko paper on process heat has a case study of the eastern Waikato. For reference, the full report is here. In summary, it covers a case study where:

- Transpower has a long connection spur from Hamilton to Kopu
- the spur has four GXPs, with Powerco the only customer
- the spur is at capacity, but low-cost investment will buy a few more years of normal growth
- "Easy" industrial electrification could add 40MW to the existing 186MW load (ie, >20% uplift)
- "Deep" electrification could add much more and would likely entail direct transmission connection for some industrial sites (ie, new transmission customers)
- Potentially, a big upgrade could be an efficient answer to accommodating electrification of 12+ industrial sites in the region (see map below) plus organic growth
- Alternatively, local generation (such as utility solar) could reduce or eliminate the need for grid upgrade.

This example encompasses genuine uncertainty about need and solution, a step change in scale given decarbonisation, and the possibility of an industrial customer facing an FMD problem if it wants to grid connect but would trigger a major upgrade in the process.

This is a brownfields example – there is unlikely to be a merchant/contestable transmission investment solution that could compete with upgrading Transpower's existing connection assets.

Figure 7: Capacity of heat-based, non-electric processes that could potentially be converted to electricity in the Thames Valley Area[17]



[17] Note that the load indicated in the chart is not the full heating and process loads of the various plant. Instead, it refers to that portion of the process load that would likely be relatively easy and efficient to convert to electricity in the first instance.