Congestion management Technical Working Group

Working paper – ESB thinking on physical access models

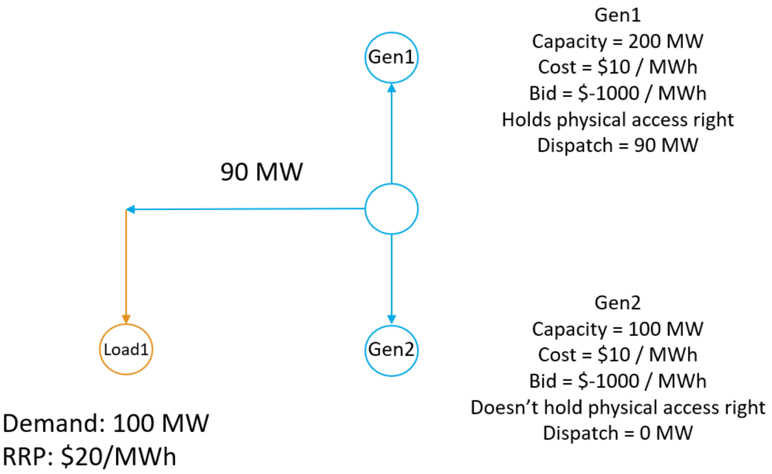
1. Purpose of paper

The purpose of this paper is to set out for discussion the ESB's thinking with respect to physical access models. This paper is intended to inform the working group's discussion of which models should be taken forward as part of the detailed design process.

2. Overview of physical access models

Under a physical access model, participants are allocated a right to have their supplies scheduled, or transported, over a specific network element or group of network elements. In periods of congestion, where the specific network element reaches its limit, the participants (generators) that hold the physical access rights will be preferentially dispatched above other congestion-causing generators that do not hold a right. An example of how this works can be seen in figure 1 below.

Figure 1: Physical access right holder gets preferential dispatch when there is congestion

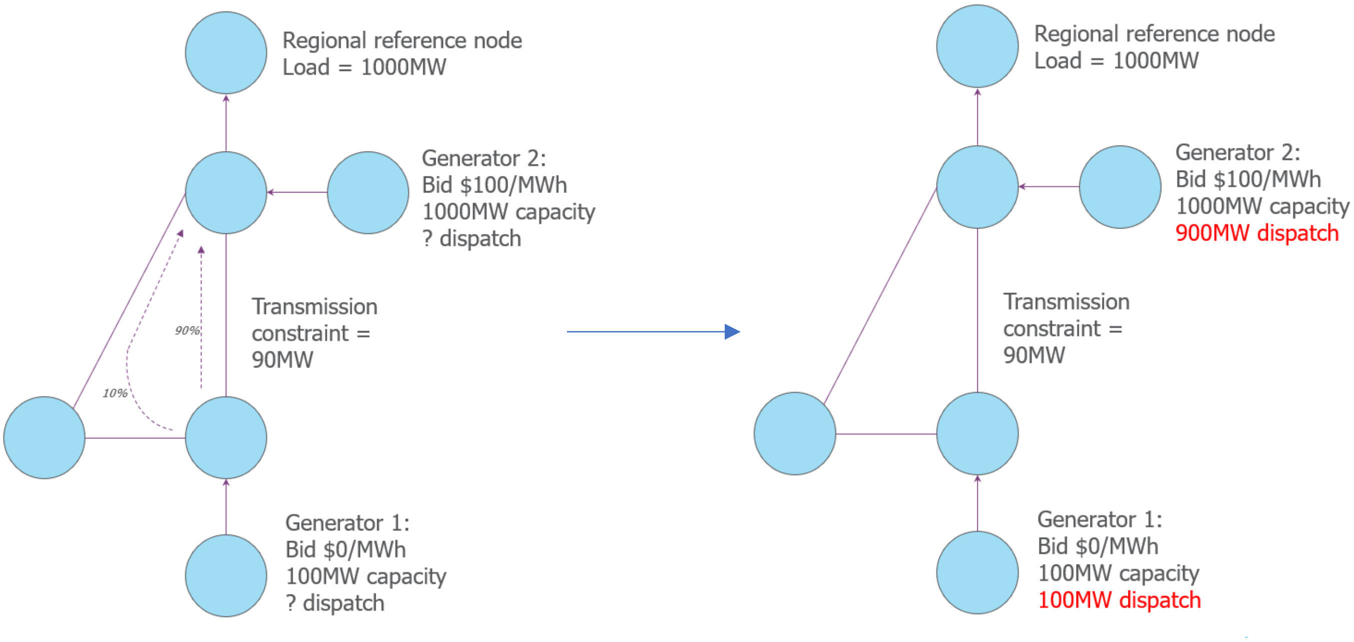


In this example, the constraint occurs on a radial line, meaning that there is only one way for the electricity to flow. A physical access model is workable in a radial situation, and in the example above, generator 1 is preferentially dispatched due to it holding the physical access right for the particular network element.

3. Physical access models in the presence of meshed networks

The electricity network is not a radial network. There are numerous parts of the network where the network is "meshed", meaning that there is more than one path over which electricity can flow from point A to point B. In this situation, an injection of electricity at one node will have an impact on all paths that the electrons flow over between point A and point B. This is because electricity flows are governed by Kirchhoff's laws, resulting in electricity flow "splitting" at every junction in the network. This is demonstrated in figure 2 below.

Figure 2 Kirchhoff's laws dictate the flows of electricity across the network, and around a loop.



In this example, the electricity generated from generator 1 takes two routes to the load. 90% of the generation flows north, and the remaining 10% flows west and then north-east, the long way around the loop.

For this example, we assume that there is a transmission constraint of 90 MW on the "north" route. This translates into a constraint equation in the dispatch engine as follows:

$$90\% \times G1 <= 90 \text{ MW}$$

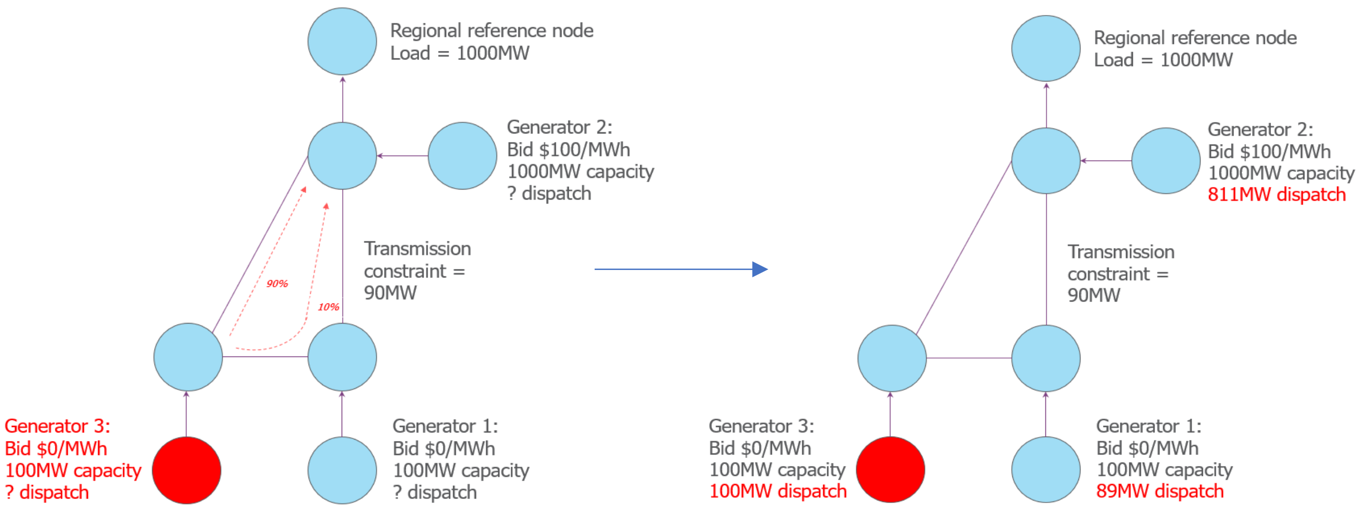
Which is written in the form of:

Participation factor x generator dispatch target <= the limit of the line

In order to balance supply and demand, the dispatch engine dispatches 100MW of generator 1, as this is within the limit of the constraint, and 900MW of generator 2.

Problems begin to arise when there is further investment behind the constraint. In this case, assume a third generator wants to connect to the network, as shown in figure 3.

Figure 3 Additional capacity behind the constraint



In this example, 90% of the output of generator 3 flows north east, directly to load. The remaining 10% goes east, and then north.

The constraint from the first example now becomes:

$$90\% \times G1 + 10\% \times G3 <= 90 \text{ MW}$$

The lowest as-bid cost solution to this problem therefore becomes:

- **G1** is dispatched for 89 MW (down from 100 MW)
- **G2** is dispatched for 811 MW (down from 900 MW)
- **G3** is dispatched for 100 MW (up from zero)

The overall cost of dispatch has reduced as generator 2 is dispatched for less. This means that investment in generator 3 may be efficient, however the access of generator 1 is constrained down by 11 MW.

A physical access regime would solve this problem through one or more of the following options:

- Banning generator 3 from connecting (despite the fact that such a connection could be efficient)
- Limiting generator 3's dispatch (despite the fact that this would be inefficient)
- A close enough is good enough approach, whereby if the access of generator 1 is only disrupted slightly, then generator 3 is allowed to connect and dispatch
- Inefficiently building transmission to alleviate the constraint.

There are negative outcomes associated with each of these approaches.

4. Experience of physical access models in other jurisdictions

Physical access regimes have been studied, and in some cases adopted, from the inception of liberalised power markets. Two specific examples are the electricity markets of Alberta and Western Australia.

Alberta has a policy of zero congestion. The approach taken in Alberta is that any congestion on the network is an impediment to wholesale competition in electricity generation. When the network becomes congested, higher price generators must be dispatched “out of merit” in order to balance supply and demand. In this case, it is possible for all generators in the system to compete on bids/offers. Physical access is essentially granted based on the results of the dispatch engine.

There are a number of studies and reports that question the overall efficiency of this approach. The University of Calgary (2009) suggested that there are very ineffective signals presented to generators about where it is most efficient to locate plant. The Fraser Institute commented that just as building a 20-lane highway to eliminate all traffic congestion would be inefficient, constructing transmission lines to eliminate all congestion is uneconomic. The marginal cost of eliminating all congestion is greater than the marginal benefit of doing so. It should be noted that whilst this approach has been costly, Alberta’s policy of zero congestion enabled low-cost plant full access to load on the grid, making a physical access model workable.

Western Australia’s South West Interconnected System (SWIS) was operated as a notionally unconstrained access regime, where generators were granted firm access rights through their access contracts with Western Power. This encountered challenges when contracted network capacity reached system limits, leading to various bolt-on solutions.

As a result of the challenges encountered under a physical access regime, the SWIS is being converted to an open access regime, commencing October 2023, coincident with the introduction of a security-constrained, co-optimised real time market.

The original access arrangements for generators in the SWIS included a declared sent out capacity (DSOC), which required Western Power to provide the generator with access to that level under system normal conditions. This implied a ‘do no harm’ arrangement for new connections, which must fund augmentation as necessary to avoid impinging upon existing access rights.

New connecting parties were offered the choice of:

- A reference service, which may entail substantial deep connection costs (potentially $100 of millions) or
- A non-reference service, which may entail reduced access rights (i.e. curtailment).

Once the network was full, connecting generators were faced with extremely high deep connection costs in order to receive firm access. Non-reference services (i.e. agreeing to curtailment) generally included a post-contingent runback on a “last-in, first out” basis. The proliferation of post-contingent runback schemes reached its limit in terms of complexity, leading to the introduction of pre-contingent runback arrangements. Key criticisms of this approach were that curtailments based on access contracts resulted in less efficient dispatch, and curtailment driven by off-market arrangements degraded the accuracy of pre-dispatch forecasts.

The academic literature has identified a number of further challenges for physical access regimes in the presence of congestion and loop flows. For instance, Hogan (2019) suggested that the physical access arrangements given effect via contractual arrangements between parties created material market externalities, as individual bilateral transactions would interfere with all other transactions. Joskow (2000) noted that because an injection at one node of the network and equal withdrawal at another node affects the flows through all links, the ISO must verify that the players scheduling bilateral trades must also possess the relevant physical rights on the network links. Finally Giusu Squicciarini (2003) noted that physical transmission rights are inconsistent with economic dispatch.

5. ESB view of the key challenges and potential solutions

There are a number of issues associated with physical access models that will need to be thought through if such models are to be developed in the NEM.

- Inefficient transmission investment: One way to ensure that a physical access rights can be honoured under a physical access model is to remove any congestion that may impinge on the access of right holders. This may lead to an overbuild of transmission relative to the least-cost development of the system.
- Slow/complex connections process: A second way to ensure the firmness of physical access rights is to include the need to maintain these rights in the connections process. This can either mean limiting or banning connections, introducing connection fees for network augmentation or introducing complicated runback schemes to ensure existing physical rights are not impinged upon.
- Barriers to entry: It has been anecdotally reported in WA that the connections process was the greatest barrier to entry to new investment. This barrier is somewhat of a necessity to a physical access regime in order to ensure that the existing rights are not harmed by further connections.

There are some approaches to deal with the problems raised above. Firstly, in relation to the introduction of network fees, problems have historically occurred when connecting parties had to pay to remedy the marginal impact of their connection. In practice, this means that the cost of connecting is very low until the capacity of the network is reached. At this point, the cost of connection can increase dramatically, depending on the size of the network augmentation necessary to ensure the impact of the connection does not harm existing generators.

A solution to this issue may be an administratively determined connection fee that can better reflect the long-run cost of a generator connecting to a certain part of the network.

A second potential solution could be to implement a financial compensation mechanism as opposed to a physical mechanism. This would mean that new connecting generators who may harm the access of existing generators could enter into an agreement to financially compensate the existing generators for any periods where they are constrained off due to the new connection.

The ESB notes that both solutions involve a shift away from a ‘pure’ physical access model.