Congestion management Technical Working Group
Working paper – Connection fees

Purpose of paper

This paper seeks to progress the design of the connection fees model as a measure to drive efficient and coordinated supply-side investment. It considers:

- What metric should be used as the basis for calculating connection fees?
- Measuring the congestion impact of a proposed project
- When are connection fees calculated?
- Methodology used to calculate connection fees
- Treatment of renewable energy zones (REZs).

Context

The ESB is working with stakeholders, seeking to establish appropriate a regime which better manages network congestion in both the investment timeframes and in real time. One shortlisted option being pursued in the investment timeframe is the introduction of connection fees.

A well-designed regime could determine connection fees for projects which would provide incentives for efficient location and design of the project; i.e. incentivise developers to minimise the unit connection cost and, in doing so, progress projects of the right design and scale at the right location on the grid. Such a regime would provide opportunities for developers to innovate, and in doing so, provide long term benefits to customers through the efficient utilisation of the grid and development of the power system.

To assist intending participants, any connection fee regime should be based on a clear, transparent process which allows them to identify prospective projects early in the development process. The process also needs to be:

- Repeatable and able to be predicted by participants or their advisers
- Consistent with other post 2025 design measures
- Provide for jurisdictional polices, especially those in regard to REZs.

Background

A level of congestion will be characteristic of the future, high renewables grid. The cost of transmission is high and the target has to be an "efficient" level of congestion, not the elimination of congestion. The efficient level of congestion should be consistent with an overall lowest cost power system that reliably and securely meets customers needs and delivers on governments emission reduction objectives.

Congestion levels have been increasing in the NEM over recent years which is both consistent with those expectations and international experience in grids with significant penetration of variable renewable generation. There have also been examples where parties connecting to the grid have been hit with lower marginal loss factors and higher levels of grid congestion than expected. It is notable that the impact of congestion does not fall equally on all participants, exacerbating the financial cost for some projects.

A key need is to ensure the grid is augmented and expanded concurrent with the connection of large amounts of new generation. The ESB developed the 'actionable ISP' rules to streamline the approval process for transmission projects identified as being on the optimal development path in the ISP. The AEMC have also introduced a new regime for system strength which provides a more proactive approach to resolving issues before they become problematic. Further enhancements to the regulatory arrangements for transmission are under consideration and governments have jointly committed to support the implementation of key transmission projects.

The ESB is considering a range of options to ensure the enhanced grid is developed and operated efficiently. The introduction of connection fees is one option being considered to drive investment efficiency. It is challenging to design a connection fee which captures the complexity of the future power system operation and the level of congestion experienced by individual participants. The impacts of a project will depend upon the proposed project's location, scale and the profile of its output. It will also be highly dependent on other projects which may connect to the grid which share critical transmission paths to customers. While challenging, it is important that any connection fee reflects these impacts on the grid and thereby gives potential investors the incentive to consider the location of their project, the technology or mix of technologies they intend to connect. At a micro level, it should also drive the detailed design of the connecting plant.

Any such regime needs to be supported by enhanced information both to guide longer term project development and to maintain a focus on the actual impacts of congestion, their cause and the potential to efficiently relieve congestion. Options for enhanced information are considered in the accompanying working paper on congestion zones.

What metric should be used as the basis for calculating connection fees?

A fee could be calculated in different ways to achieve the objective of providing an efficient signal to investors. The ESB is considering the following three potential approaches. The fee could be calculated based on:

1. the long run incremental cost on the network of hosting a particular generator at a particular location
2. the NPV of expected future congestion the connecting party could expect to face, or
3. the incremental change in the cost of congestion across the grid driven by the connection and operation of a new generator.

Option 1: Long run incremental cost on transmission

The AEMC detailed a long run incremental (LRIC) cost calculation methodology in Chapter 6 and appendix C of their final report on OFA. Such an approach normally requires setting a generator access standard to which TNSPs must comply. The long run incremental cost of connecting a new generator would then reflect the NPV of the increased network expenditure required to ensure that the generator access standard was maintained with that additional generator connected.

In theory, calculating the LRIC would require detailed future plans and forward costs for the network with and without each connecting generator. This would create an impossible administrative burden on the party responsible for the calculation and impact on the timeliness of the connection process. It would also likely give erratic results given the lumpy nature of transmission investment. As such, actual implementations of LRIC have used a form of proxy to approximate the actual cost. It is also not clear how an efficient generator access standard would be defined and whether a single standard would even be appropriate.

The NEM has a planned approach to the efficient expansion of the network on a holistic basis. This provides for the efficient development of the grid as a whole rather with the justification of individual elements of the grid based on the range of benefits that element brings as part of the network including through connecting renewables, facilitating trade between regions and supporting access to pumped hydro storage. Accurately assigning the cost to a specific generator would be difficult.

Option 2: NPV of future congestion on the connecting generator

The fee could be designed to reflect the NPV of the forecast congestion cost on the proposed project. This would require price modelling of a base case with the proposed connecting party included. The definition of the base case is important and would most logically be derived from the ISP. The plant included in the base case would include all plant in service or committed at the time and likely also need to include the planned future capacity of declared REZs. The modelling would be undertaken assuming short run marginal cost bidding and hence outcomes would closely reflect underlying costs.

The NPV cost calculated would reflect the value of residues which would need to be assigned, or reassigned, to the connecting party if it connected. Further work is required on the detail of such an approach, but it would offer a direct measure of economic cost and reduce the administrative overhead compared to an LRIC calculation. By choosing the right project size and location, the fee could be minimised. By refining the project characteristics, the value per dollar paid for connection at a site could be optimised.

Option 3: NPV of the cost of future increased congestion on all generators

The fee calculated under Option 2 would reflect the future cost of connection on the connecting party. However it would not include the increased cost of congestion on all other participants in the market. As such, a developer could accept the connection fee and implement their project despite the project reducing access and increasing costs for a range of existing participants. Certain sites may impose significant congestion on others while bearing proportionately less itself due to the 'winner takes all' issue with the current market design.

Alternately the fee could be designed to reflect the incremental change in congestion across all participants driven by the connection and operation of the proposed new project. This would require a similar approach to Option 2 although costs would need to be modelled for both the base case and the base case with the proposed new project. The connection fee would then be the NPV of the incremental cost of congestion between the base case and the case with the proposed project summed across all participants. This affords the same opportunities and incentives for participants to search out efficient projects but would increase the connection fee. The connection fee calculated in this manner should have a close relationship to the LRIC in an optimally planned network as the aggregate cost of congestion for a marginal plant is a measure of the marginal value of relieving congestion. In an optimal development path, the marginal cost of expanding the grid should be equal to the marginal value of relieving congestion.

For discussion

The TAR team's preliminary thinking is that the connection fee should aim to reflect the impact the connecting generator has in increasing congestion on the grid.

A further question is whether the connection fees should reflect inter-regional congestion or only intra-regional congestion. The current market design already provides signals with respect to inter-regional congestion.

Box 1 - Intra versus inter-regional congestion

If the connection fee is designed to reflect the cost of congestion either on the proposed connecting project or on the market, there remains the question as to whether that is all congestion or only intra-regional congestion. The treatment of interconnectors in congestion management is the subject of work in other workstreams. Connection of additional generation will often be on augmentations to the national network which are also interconnectors. In this context, the connection of a new generator in one region may often be electrically close to another region and their operation could increase congestion both within the region they are located in and on the inter-connector to an adjacent region.

Under the current market design, financial access to interconnectors is auctioned through well established process. On that basis, it could be argued that only intra-regional congestion should be considered in the calculation of the connection fee. The current arrangements also tend to prioritise regional access and provide the remaining capacity to interconnectors.

Further work is required on the treatment of interconnectors in operational timeframes and in order to form a view on the preferred approach for the calculation of connection fees.

Measuring the congestion impact of a proposed project

Projections of congestion impacts for future investment in connecting plant could be measured in a number of ways, including:

- In terms of the MWhs or percentage of time the prospective connection point is likely to be constrained with respect to its regional reference node (RRN) at the margin
- The percentage of time that a prospective additional plant could expect to be constrained
- The percentage of revenue that a prospective additional plant could expect to lose as a result of network constraints
- Projecting a 'hosting capacity' for the connecting plant
- Providing the connection fee for a 'standard' project at a range of connection points across the national grid.

Measuring the marginal level of congestion at potential connection points in the grid on the optimal development path is mathematically straightforward and would likely provide useful information, at least in terms of the relative attractiveness of connecting in different areas of the grid in different years. Keeping to physical measures would also be simpler than modelling price.

However, the marginal cost of an additional kW at each point on the grid does not reflect the congestion which might be experienced by a particular generator of a particular size. Alternately the impact of connecting a particular type and size of new generator at various prospective locations could be quantified in terms of MWhs, hours of congestion or the percentage of energy constrained. This would provide information of more direct use but targeted to the defined standard connecting plant. It would also involve considerable additional computation.

Measuring congestion in physical terms will always have limitations. With the growth of renewable generation, while more congestion is expected, that may often occur at times where the value of energy is low. A financial measure of congestion may therefore be more valuable than a physical measure. A focus on maximising value rather than physical access is also likely to be more consistent with the NEO and optimising the value of the transmission system.

The definition of a hosting capacity at various points on the grid would have some attraction. That gives further information to potential investors as to the likely scale of projects which would be attractive at various connection points. Determining a hosting capacity is also required where jurisdictions use a physical limitation on connection in a REZ. However the hosting capacity at a connection point depends upon the mix of plant connecting at that point with an optimal mix of wind, solar, storage and controlled load delivering a higher hosting capacity than a REZ populated with a single generator type would allow to economically connect. The hosting capacity of a point is also a matter of the competitiveness of the resource and the planned project, which should be decided by project proponents. The competitiveness of project may also change over time as unit costs fall and technology improves. Despite these difficulties, it is worth pursuing the issues and seeking to devise a methodology for arriving at an indicator of hosting capacity. The TAR team's working paper on Congestion Zones dives into the detail of this issue, namely how to calculate the hosting capacity of the network and supporting information that may be useful to investors.

If the incentive to efficient locational investment is the connection fee, the most targeted information would be as directly related to that as possible. While it would not be possible to determine the exact fee which would apply to a specific project, it could be useful to publish the fee that would apply to a defined 'standard project'. Such information would be only correct for the standard project and defined baseline but, by publishing the information on the same project at connection points across the national grid, could be useful to show the comparative costs for connection at different locations even though actual connection costs would be different. This would involve considerable additional computation but may be able to be undertaken with or immediately after the publication of the ISP. An alternate option would be to publish all data needed to allow third parties to estimate the connection fee for any candidate projects they are considering.

For discussion

The TAR team's preliminary thinking is that for the purposes of calculating connection fees, the congestion impact of a proposed project should reflect its financial impact, some of which could be directly inferred from planning work already undertaken.

It would be helpful to publish projected connection fees for one or more "standard projects" at specified locations. The TAR team would like to explore the TWG's views on:

- what a "standard project" might look like
- whether the information should be provided at the level of a congestion zone, or whether more granular information is required.

When are connection fees calculated?

There would be advantages in developing pre-defined connection fees which would be known to potential investors well in advance of their connection. However the impacts of a project on the grid will be dependent on the specifics of the proposed connecting plant and hence:

- The scale of the project
- The technology or mix of technologies proposed and hence the profile of it's use of the grid
- The detailed location of and connection to the grid
- The timing of the project and hence other generation connected, or already committed to connect, to the grid.

It is important that the connection fee provide an efficient cost signal. The intent of imposing a connection fee is not that intending parties would passively accept the fee but rather that they would seek to optimise the project costs including the connection fee. This would lead to them seeking to limit the size of the fee or rather, maximise the value of the project overall. We expect this is most important for renewable projects which have high capital costs and very low ongoing costs. The competitive market pressures would then drive parties to optimise capital costs to minimise the long run cost of supply. The NEM has also seen individual projects of large scale which would have significant impact on the use of the grid and the congestion experienced by any subsequent project. This then argues against a pre-determined fee calculated on a simplified, non-specific basis.

The ESB's preliminary view is that the connection fee should be a bespoke calculation on the specific project made late in the connection process but prior to final commitment by the proponent. Given the actual fee under such an approach would not be precisely known until late in the project development, market participants should be well informed ahead of time through the planning processes of the future congestion costs at different locations across the grid to aid participants to identify the more attractive projects. The process to calculate the final fee should be clearly defined such that prospective participants, or their advisers, are able to closely replicate the calculation and optimise their projects.

Further work is required on the detailed timing of the connection process incorporating the detailed timing of the connection fee determination. Once determined, there would need to be time period within which the connection fee was accepted and the project committed. If not committed within a reasonably tight period, the connection fee determination might expire and require recalculation. If this type of process was not included, it would disadvantage subsequent projects and drive incentives for parties to define projects and then hold those to on sell later.

For discussion

The TAR team's preliminary thinking is that:

- the actual connection fee applying to any project be specifically calculated for that project immediately prior to finalising a connection agreement
- proponents of projects should have access to planning information on future congestion costs across the grid and a clearly defined process for calculating connection fees.
- a connection fee, once determined, would need to be accepted and the project committed within a reasonable timeframe or that determination would expire and need to be remade.

Methodology used to calculate connection fees

In seeking to reflect the change in the NPV cost of congestion as a result of a connection, it is proposed to use market modelling. To ensure the process was clear and repeatable, it is considered that the modelling would be limited to a single base case and limited number of years. This would also reduce the resources needed to calculate the fee and minimise the risk that the fee calculation process would extend the time to receive and offer to connect. A single base case should also be adequate to appropriately drive the project optimisation process undertaken by the proponent as it should reflect project relativities.

The modelling should be based on the ISP as this incorporates an overall view of the future system development including generation, storage and network investment. It also incorporates jurisdictional policies and hence integrates those into the overall system. A baseline market model would be required which reflects a most likely, or central case, in the ISP. The baseline case would need to:

- cover the next twelve years given rising uncertainty during and beyond that period and an objective to reflect impacts over the first 10 years of a typical project
- include existing and committed plant and any designated REZ generation for each year
- include existing and committed network investment along with transmission projects defined in the optimal development path
- model outcomes in terms of dispatch and pricing, assuming participants bid their short run marginal cost

A second case would then be run for the same years but including the generation of the participant seeking connection. This case would need (as an input) the output level and profile of the proposed project and at the chosen network location. Additional or modified constraint equations would be required which incorporate the impact of that project on the secure transfer capacity of the network. That capacity would also be bid at its short run marginal cost. For more complex hybrid projects and especially those including storage, that may need to incorporate a cost profile.

The additional generation would be offset by a reduction in other generation, based on their SRMC. The connection fee would not take account of these market impacts but focus solely on congestion costs. Depending upon the connection fee design chosen, the fee would reflect:

- The NPV of the difference in total congestion costs between the two models;
- The NPV of congestion on the connecting party across all constraints; or
- The NPV of congestion on the connecting party across all intra-regional constraints

The connection fee is expected to be high in some locations and low in others. This would incentivise connecting parties to refine proposed projects in some cases and abandon them in others. In doing so, it would provide a level of protection to all investors that poorly located projects which had a high congestion impact would be unlikely to progress.

With a fee based on calculating the impact of a project on total congestion, it is possible that the fee could be negative if the applicant is seeking to connect with favourable technical characteristics at a favourable location which enhanced transfer capacity on key links or for storage projects. Further consideration is required of this and especially of the treatment of storage.

For discussion

The TAR team's preliminary thinking is that the connection fee should be determined by market modelling leveraging the work in the ISP but reflecting a single base case and limited time period.

Further work is required to develop up a process and modelling should be undertaken to test and refine the methodology. The methodology will need to make trade-offs in relation to:

- Timeliness vs accuracy and
- Flexibility vs predictability.

The process is plan driven and determines a price based on projected outcomes which are inherently uncertain. This impact will be (artificially) limited by constraining the calculation to a single base case and limited time period. While accepting the calculation of the cost of future congestion will not be exact, will it still be appropriate to incentivise the efficient connection of efficient projects? Will it ensure efficient utilisation of the expanded national grid while protecting investors from the later connection of poorly chosen projects which have a major impact on congestion?

Competition can drive dynamic efficiency and through the ongoing development of technology, provide benefits to customers. The design of the access regime, and in this case the calculation of a connection fee, needs to ensure it is not unreasonably restricting competition on incumbents. In particular, the calculated price needs to identify the impact on network access and congestion costs as a result of the new connection. It should not reflect additional curtailment that occurs at times when the value of energy is forecast to be zero or negative.

Other key design considerations

Measures to mitigate congestion impact/connection fee

The cost calculated would be very dependent on the projected generation profile of the connection applicant. This would require a determination of the expected output profile of the proposed plant connecting. The scheme should allow applicants to propose hybrid plants or with controls which could modify the output profile and hence reduce their connection cost. This raises questions as to how such arrangements might be proposed, evaluated and complied with.

Queuing issues

Connection fees calculated in the manner proposed would be scale dependent and likely very non-linear, rising quickly in congested areas as further generation connects. This will lead to a queueing issue where the first mover will have a significant commercial advantage. Further consideration is required on measures to manage queues and any mechanism to introduce auctions where there is strong interest in connection within a particular area.

Who does the fee apply to?

The proposed process for the calculation of the connection fee is based on assessing the impacts of congestion on scheduled and semi-scheduled plant connected to the transmission system. However, distributed energy resources are expected to be a major component of the future power system. Unscheduled plant is currently not centrally dispatched and so is not constrained subject to market constraints. The arrangements need to avoid bias and minimise the risk of perverse outcomes if a scheduled generator faces a connection fee while non-scheduled and distributed resources do not.

The TAR team is keeping the application of connection fees to storage under review. As the impact of storage on congestion depends on how it behaves in operational timeframes, it will be necessary to take into account the incentives created by the operational timeframe model. In investment timeframes, the connection fee methodology could determine a payment (negative fee) to proponents of storage based on their overall impact in reducing congestion or impose no fee and rely on other mechanisms (such as the congestion relief market) to incentivise efficient investment in storage. The equal treatment of storage as part of a hybrid connection and of standalone storage also needs to be considered.

Treatment of REZs

The ISP proposes various REZs for development over time to provide for more efficient and effective connection of renewables to the grid. The ISP has taken into account the location and scale of these REZs and optimal development path arising from the ISP implicitly includes efficient transmission development to support those REZs. Jurisdictions have, or are considering, schemes to provide for the development of REZs in their regions.

While the particular arrangements will vary between states, they offer opportunities for more efficient connection of large-scale renewable generators. Given there is expected to be a detailed framework in place for the development of REZs in at least a number of jurisdictions, the extent to which the connection fee arrangements apply to parties in designated REZs needs to be considered.

It is expected that a REZ will be designed to host a defined level of capacity, albeit that capacity will be defined based on a mix of different generation and storage technologies. The hosting capacity is also likely to be refined based on the specific projects which connect in that zone. Congestion within a REZ with that designated generation and storage in place is expected to be limited to an acceptable level through the design of the in-REZ network. It is expected that this acceptable hosting capacity will be met within the REZ through a jurisdictional process. Ideally this would be an auction process with proceeds returned to customers through lower transmission charges.

While access with each REZ can be managed through a jurisdictional REZ arrangement, the overall value of a REZ is subject to the broader access to the national grid which they provide. Under the current open access regime, participants could choose to connect to the grid at any point outside the REZ. In many cases, that connection could reduce the access available to parties in the REZ and degrade the value of connecting within the REZ. It is also possible that a well-placed connection outside of the REZ could gain preferential access in dispatch.

Our current view is that provision should be made in the connection fee calculation process for REZs which have been identified in the ISP and declared under a jurisdictional scheme. This would, in effect, reserve a level of capacity for designated REZs. Parties connecting inside a REZ should be exempt from connection fees but subject to jurisdictional processes to connect in a REZ. Ideally that would implicitly or explicitly include a connection fee through the use of competitive auctions to fill a REZ.

For discussion

The TAR team's preliminary thinking is that:

- Where a REZ has been identified in the ISP and declared under a jurisdictional scheme, forecast levels of transmission hosting capacity available to REZ generators should be maintained for the purposes of calculating connection fees
- Parties connecting in a REZ should be subject to the arrangements within that REZ and be exempt from the general connection fee regime.