Real Option in Transmission Planning: Enhancing Regulatory Investment Test in Australia

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Transmission planning traditionally followed a highly deterministic, technically focused load flow-centric approach. Planning engineers up until the last decade typically developed a transmission plan purely based on meeting (n-1) security to match a generation expansion plan – an approach that is in fact still prevalent in several countries, especially developing countries. The focus since 2000 has shifted increasingly to take into account the requirements of deregulated electricity markets wherein the generation decisions are decentralised and planners have the onus to second-guess a generation plan to develop and maintain a secured transmission system [1-2]. However, a significant part of this work had largely maintained a deterministic approach. Although economic crisis in the late nineties, climate change and renewable related policies started to introduce significant level of uncertainties, these were often handled using deterministic scenarios.

An arcane aspect of a deterministic approach is that it does not do much justice to the flexibility that transmission renders to generation development. A robust transmission network, for instance, can partially offset the uncertainties associated with generation development. This flexibility value, or what is formally been labelled as "option value" of transmission has been largely ignored in transmission planning. Although Hedman et al [3] had undertaken a review of real option applications to transmission planning relatively recently in 2005, the list of practical applications was very thin.

The Australian Energy Regulator had formally included option value in cost-benefit analysis framework in July 2010 [4] known as the Regulatory Investment Test for Transmission or RIT-T. However, the conceptual issues around its practical implementation are still in formative stage. In 2011 NERA presented an example based on the RIT-T framework [5] as part of a RIT-T guideline published by Grid Australia, but no practical applications of this have yet emerged.

The academic literature has progressed in more recent years. Garcés et al [6] developed a stochastic programming approach that effectively is a real option framework, although the paper does not explicitly label it so, nor attempts to value flexibility as a separate component.

There are more recent real option applications to transmission planning although the conclusions from these applications appear to be remarkably different. We highlight two significant applications in particular. Hendrik and Hobbs [7] have introduced a formal two-stage stochastic program in which transmission planner makes investment decisions in two time periods, each time followed by a market response. In the second period, there is less uncertainty than in the first, as the planner knows which of the scenarios has been realized, but the set of options open to the planner in the second period is constrained by the first-period decisions. Their application for Great Britain system concluded that option value of transmission projects is only 0.12% of the total investment. Ramanathan and Varadan [8] also discusses a more general set of approaches to transmission planning using Monte Carlo based approach. Their approach utilises a binomial tree for the evolution of NPV simulated through repeated applications of Monte Carlo simulation at each time step. They have noted that "...*in large investments value of real options could potentially change the investment decision*" and "*Real options could result in drastically different decisions*." There are more applications over the last two years published in a range of electricity and operations research journals with conclusions that produce a wide range of outcomes.

Our proposed work has two broad objectives:

- Our work will firstly provide a review of the recent applications of real options in the academic and industry literature with a view to characterise the outcomes on value of flexibility, namely the nature and magnitude of uncertainties represented, the methodology and specifically the assumptions that have been used to derive option value, and the broad conclusions on significance of option value, i.e., whether they are high enough to change the underlying investment decisions. Our key emphasis is to identify the drivers of option value and how the recent research efforts have led to significantly different conclusion using different methodology and/or assumptions. It will be a useful step from a practical application point of view;
- Develop a high level case study for the Australian National Electricity Market (NEM) to develop option value of large interconnection projects that effectively develop strong inter-regional transmission network across all Eastern States. We will use a two-stage as well as multi-stage stochastic programming model following Hendrik and Hobbs [7] and Neufville [9]. In particular, we will investigate the uncertainties that the NEM is currently facing in terms of drastically different generation development options that may eventuate including a continuation of dominance of coal versus a transition to a low carbon power system. There are also considerable different paths within the low carbon option including a renewable-centric development and other technologies, such as carbon capture and storage, each of which may have very different location, cost and price implications. The basic hypothesis we would like to test using a stylised representation of the zonal NEM is as follows: *does a large-scale transmission project that significantly enhances transmission capability across the zones has a significant option value that a traditional application of the deterministic approach misses?* The previous application of the RIT-T has found large-scale transmission projects such as the NEMLink [10] has insufficient benefits relative to justify its cost. The methodology largely relied on deterministic approaches and did not include option value. Our objective is to specifically explore if the option value can be significant in light of the significant uncertainties around generation development both in terms of technology and location.

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