TOOLS FOR ECONOMICALLY OPTIMAL TRANSMISSION DEVELOPMENT PLANS

(A Précis: The full article is available to members in the April 2014 edition of Electra)

WG C1.24

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Transmission planning involves developing reliable, cost effective, and optimised solutions to address transmission system constraints. These plans must take into account uncertainty around load, generation, reliability requirements, market design, and regulatory approval processes.

Traditional transmission planning practices tend to focus on identifying least cost transmission system developments delivering sufficient transmission capacity to maintain expected levels of supply reliability and power system security. Increasingly transmission planners are being asked to consider the economic benefits and market impacts in justifying transmission developments.

The economic benefits delivered by transmission developments are often referred to as market benefits recognising that they arise through the impact of the transmission development on participants in the electricity market. Market benefits can be summarized within separate, but not necessarily independent, effects:

1. strategic effect, where market competitiveness is increased, and
2. substitution effect, whereby lack of local generation is replaced by cheaper, imported power by eliminating transmission bottlenecks.
3. Other market benefits include reduced environmental impacts (including carbon emissions), increased reliability, system loss reduction, and fuel cost reductions.

Market benefits are determined through increasingly complex analysis which considers the interaction between transmission, generation, and demand across future scenarios. The scenarios considered must be sufficiently diverse to provide confidence that the transmission plans are robust allowing for uncertainty in future generation investments and load developments.

Assessing market benefits is further complicated in the deregulated environments that exists in many countries today. The deregulated power industry has generally separated the role of planning the transmission system and the role of planning generation developments. Not only are the roles allocated to separate commercial entities, often there are multiple potential generation developers further complicating the task of coordinating transmission and generation development.

WG Scope

It is in this context that WG C1-24 was formed to draw together international experts with the aim of examining the tools and procedures for determining the economic benefits delivered by transmission systems developments.

The WG focused on tools and methods for assessing the system wide economic benefits delivered by transmission developments as it is those benefits that are generally specified in economic regulatory investment tests.

A key aim of the WG was to review world-wide transmission planning practices, particularly in the area of quantifying the economic benefits of transmission developments. This was achieved by conducting a survey of international practice and supplementing the survey with insights drawn from case studies from particular countries. The survey was sent to international experts known to WG members and explored current practices relevant to determining economic benefits of transmission expansion. Respondents were asked to answer questions based on their current planning practices as well as their future desired practice.

This Technical Brochure (TB) documents the work completed by CIGRE WG C1-24, which studied the need for new tools and techniques to assist in developing economically justified transmission development plans.

Structure of the TB

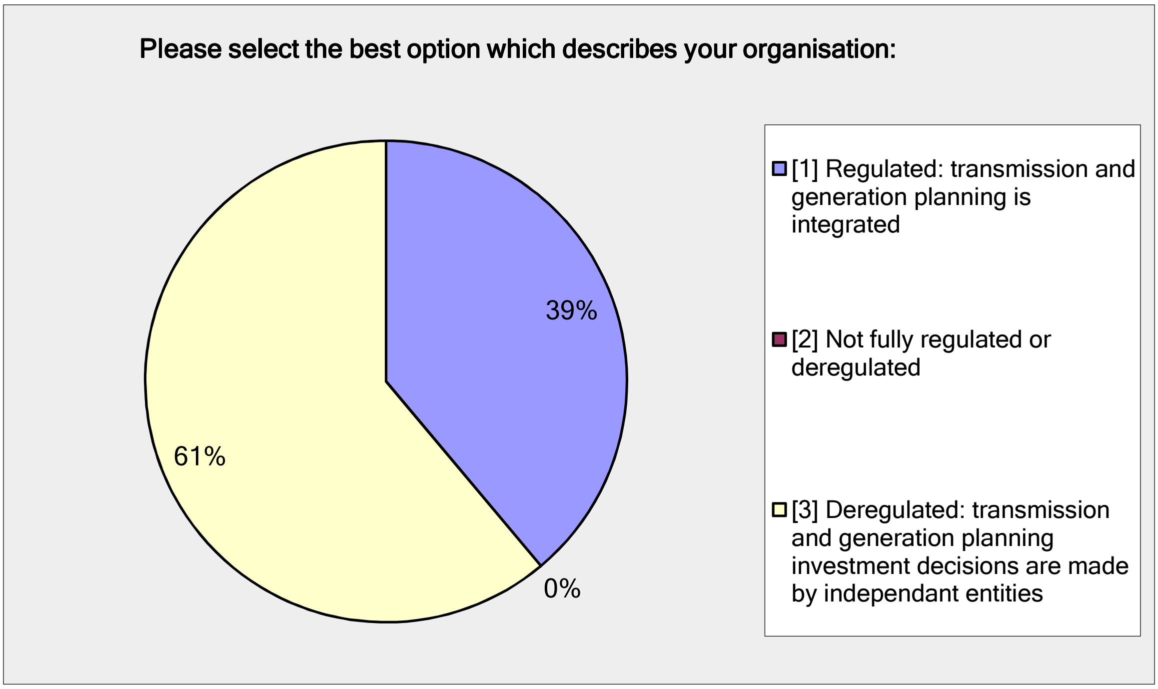
The TB has six chapters presenting the following information:

- Chapter 1 introduces the scope of work, the approach adopted by the working group and presents contextual information linking the WG activities to the work of previous Cigre WG's and other current WG's;
- Chapter 2 provides theoretical information on transmission expansion planning (TEP) and the various approaches that have been studied. The chapter also provides an illustration of the market benefits transmission augmentations can deliver and a theoretical definition of how those benefits arise.

- Chapter 3 describes the approach taken to develop the survey leveraging insights gained from various case studies from different countries.
- Chapter 4 presents the survey responses particularly examining the reported current practices.
- Chapter 5 presents further analysis of the information gathered identifying a framework for processing the survey results to identify potential gaps, gaps, established and accepted practice and best practice analysis methods.
- Chapter 6 presents conclusions and recommendations for future work.

Key Finding

The survey collected data from organisations involved in transmission planning in Europe, Africa, Asia, Australasia, and North and South America. There were 18 respondents in total, each from an organization that creates transmission reinforcement plans. The jurisdictions the respondents operate in have a 40:60 split between integrated transmission and generation planning and separate transmission and generation planning.



The survey sought information on the techniques employed to calculate economic benefits of transmission across three different planning horizons:

- 0-5 years – the Project Justification Phase
- 5-15 years - the Revenue Forecasting Phase
- Beyond 15 years – the Strategic Planning Phase

The three horizons were considered to identify whether approaches adopted for the different planning horizons varied significantly. A consistent trend that emerged from the respondents is that more detailed analysis of benefits is undertaken as part of project justification studies than in those studies assessing potential investments further into the future.

The survey asked about current practices across 17 different aspects concerning the calculation of economic benefits of transmission augmentations. The 17 aspects collectively explored the following topics:

- Range of benefits captured;
- Modelling approaches;
- Treatment of uncertainty;
- Impact of industry structure (differences between regulated and deregulated);
- Differences between approaches used in different time horizons,

Respondents were asked to not only disclose their current practices but to also indicate their desire to change their current approach. Respondents tended to favour migrating towards using more sophisticated analysis techniques however it was difficult to identify clear trends from the raw survey responses.

By combining information on the strength of the desire for change with the number of participants already implementing that desired approach those aspects of TEP methods considered to represent best practices and gaps in current practice were identified:

- A practice which is already used by a high proportion of respondents, and is desired by many of the respondents not already using it was deemed to be a ‘best practice’. While a practice may be a ‘gap’ within particular organisations, if a significant number of respondents are already experienced with that approach, it is not a gap from an industry perspective. Rather, there may be scope for improved sharing of experience and tools within the industry.
- Practices currently used by few or no respondents, but which many respondents desire to use are gaps – both for individual organisations and the industry generally. These are areas in which the survey implies there would be value in the industry developing expertise and tools.

Analysis of the survey results sought to differentiate "established and accepted practice" from "best practice" approaches for determining economic benefits of transmission:

- "Established and accepted practices" are those approaches already in use by a significant number of survey respondents and with few respondents indicating a strong desire to change those approaches;
- "Best practices" are those approaches already used by a significant number of respondents and others expressed a strong desire to adopt them.

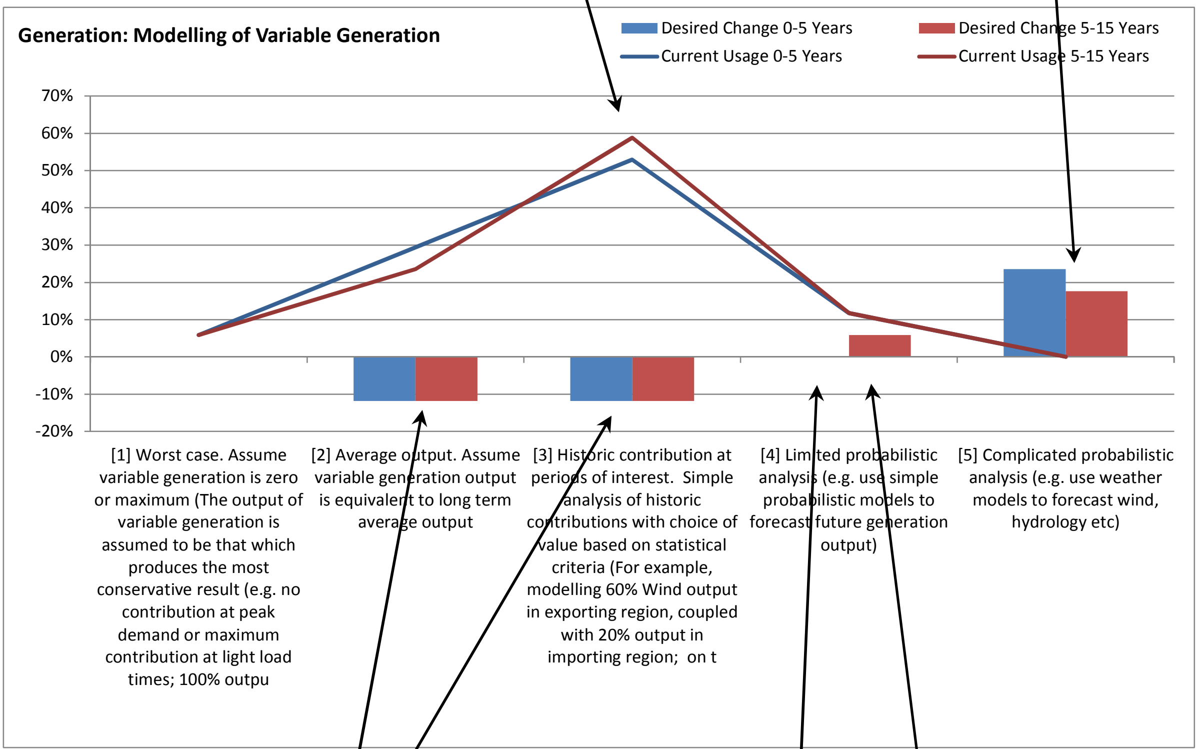
Classifying aspects of cost-benefit analysis		Desire for change amongst survey respondents	
		Low Proportion	High Proportion
Existing practice amongst survey respondents	Low Proportion	Potential Gaps	Gaps
	High Proportion	Established & Accepted Practice	Best Practice

The survey responses for a particular planning horizon were analysed and the responses presented on a heat map to visualise those aspects that represented the strongest best practice characteristics and gaps in current practice.

The survey questions identified as yielding either a gap or an example of best practice were further analysed by considering the expressed desire for change, the current practice and desired practice. The following figure illustrates a typical chart generated for this analysis.

The existing practice is represented using the traces (blue for the 0-5 year assessment window, red for 5-15 year studies). In this example "historic contribution at periods of interest" is the dominant existing approach, currently used by over 50% of respondents.

Desired change is denoted by the solid bars. A positive bar indicates that more respondents aspire to using this approach then presently do. In this example, 23% respondents desire to use "complicated probabilistic analysis" for 0-5 year studies, 18% for 5-15 year studies.



A negative bar indicates that some respondents who currently use this approach desire to use a different approach. In this example, 11% of respondents desire to move on from "average output" and a further net 11% wish to move on from "historical contribution at periods of interest".

The bars show the <u>net</u> desired change for each practice. If the number of respondents who desire to change to a particular practice is the same as the number who wish to change away from that practice, zero net change will be shown.

The indicated desire for change to is in addition to the existing practice. In this example, 6% of respondents desire to use "limited probabilistic analysis" for 5-15 year studies <u>in addition to</u> the 12% of respondents who already use this approach.

The clearest ‘best practice’ areas identified are:

- **Generation Fuel Cost Sensitivity and Forecasting**.
- **Full AC OPF Network Representation**.
- **Consider Environmental Benefits**..
- **Complicated Generator Availability Modelling**.

The survey identified a number of areas in which there is a significant desire to adopt a more sophisticated level of analysis when assessing the economic benefits of TEP. The three biggest gaps reported were the lack of:

- **Robust and transparent input data.**
- **Complicated probabilistic analysis of variable generation, especially intermittent forms such as wind and solar.**
- **More sophisticated modelling of electricity pricing on demand**..

Other areas identified as ‘gaps’ reflect the desire to adopt:

- More sophisticated losses calculation and integration into studies
- Representative weather-correlated demand scenarios
- Monte Carlo Outage Modelling
- Weighted Demand Diversity Scenarios
- Iterative Transmission Expansion Modelling

Recommendations for Further Work

The full paper presents more detail on findings and recommendations for future work and study focus areas including monitoring and disseminating Best Practice and identifies some Key gaps that may be addressed.