NEW ZEALAND SMART GRID FORUM

Architecting a future electricity system for all New Zealanders

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Input Methodologies Review - invitation to contribute to problem definition

The Smart Grid Forum was commissioned by ENA and MBIE in late 2013 to explore issues related to the development of smart grids in New Zealand. The Forum is unlike similar groups overseas in many respects: it has a diverse membership including many organisations from outside the electricity industry, has a strong consumer-focus, is lightly resourced and is not directed at the implementation of a specific government policy such as decarbonisation or technology export.

As a result of this, the Forum's work has the credibility of genuine independence and diversity. It has been influential in the development of early thinking about the impact of new technologies on the NZ power system and describing a vision of smart grid development that emphasizes customer choice and benefit over central planning and government intervention.

The Commission has been an observer to the Forum's work since its inception and we have benefitted from its involvement. Given the diversity of our membership, we have limited our comments on the *Input methodologies review - Invitation to contribute to problem definition* document to Topic 4: The future impact of emerging technologies in the energy sector. Individual forum members may, of course, make their own submissions on other topics in their own right.

Drivers for change

The Forum's Vision for Smart Grids in New Zealand[1] is that

> *In 2050, NZ will have leveraged the opportunities made available from emerging smart grid technologies and practices to the benefit of electricity consumers and New Zealand's prosperity and productivity as a whole.*

The supporting commentary for this Vision is that it is based on our current market-led approach:

> *New Zealand's electricity industry is one of many in which competition and choice is used where possible to give customers access to the services they want at competitive prices. Competition is well established for the production and retail of electricity.*

The commentary also points out that NZ's customer-led approach is in contrast to smart grid takeup in most other countries, where:

> *A specific issue, often the need to reduce carbon emissions to a certain level by a certain date, generally triggers other countries' interest in smart grids. These countries have often developed scenarios that pick such a future state and explain how it could be achieved.*
>
> *The context in NZ is different: there is no one defining issue, indeed the NZ electricity sector has already achieved approximately 80% renewable electricity generation without the need for subsidies. Nonetheless, we face the opportunity and challenges of allowing firms and customers to adopt new technologies and operating practices without constraint or adversely affecting others.*

Further, the Forum has identified the risks of unintended consequences from regulatory intervention. Reflecting on the contrast between the market-led rollout of smart meters in New Zealand and the regulated rollout of smart meters in Victoria, we conclude

> *The Victorian experience is an example of how government control and prescription can run counter to the public interest where fast-changing technologies and services are concerned. The Australian Energy Regulator is moving to introduce contestability in meter provision, and other Australian states are looking towards market-led investment as a preferred alternative.*[2]

Our initial conclusion (first year report, page 15) is that

> *At this point there is no clear problem that would justify changing the existing regulatory governance structure. Indeed, in the domain of fast-changing technology a market-led approach, relying on market participants and customers to choose if and when to invest is likely to be the most dynamically efficient.*

While electricity distributors and Transpower may be successful participants in new markets for smart technology solutions, it will be important that they are able to do so on the same terms as any other actor – neither advantaged nor precluded from entry. The interplay between these

[1] Available at http://www.med.govt.nz/sectors-industries/energy/electricity/new-zealand-smart-grid-forum/meeting-4/workstream-b-vision.pdf
[2] Smart Grid Forum, First Year report to the Minister of Energy. P.12

solutions and regulated line function services will be a relevant consideration for the Input Methodologies review, as the Commission identifies in its discussion of the scope of regulated services in section 221 of the *Invitation* document.

Approach

Our submission follows the structure in section 246 of the *Invitation* considering:

- Prospects for change in electricity systems in New Zealand from these developments
- What changes have you seen anticipation or in response to these developments in New Zealand?
- Given the current level of uncertainty, how does the value of waiting to get more certainty compare with the risks of maintaining the status quo?
- Are there any no-regret measures we could take now?
- How this topic translates to specific issues for electricity (and where relevant gas) lines businesses
- Any other experience (domestic or international) you think would be relevant in addressing any issues relevant to this topic
- Problem definition and potential solutions

We have attached a copy of our first year report to the Minister of Energy and referenced discussions in it in our answers below.

Prospects for change in electricity systems in New Zealand from these developments

At the Forum's suggestion, the Electricity Networks Association has commissioned the localisation of an analysis tool, "Transform", to evaluate the effect of a range of possible future scenarios of new technology uptake on electricity distribution systems in New Zealand. The Commission refers to this in footnote 110 of the *Invitation* paper. The Transform model abstracts actual network data from almost all New Zealand EDBs and three future scenarios for new generation, electricity end use and technology uptake. We expect ENA to share the Transform results with the Commission once complete, but the scenarios are relevant to its investigation of the prospects for change in NZ electricity systems and their timing, although it is important to recognise the approach is not a forecast of the future.

Two of the 3 scenarios are based on the EDGS "Mixed Renewables" and "Global Low Carbon" futures. These are the only EDGS that make explicit assumptions about new technology uptake at the perimeter of the distribution system – including PV generation, battery storage and electric vehicles. The third: "High Uptake of New Technology" was developed specifically for the Transform project by specialists from the Smart Grid Forum's member organisations. Details of the scenarios are documented in the paper *SGF/ENA Scenarios for the NZ Transform Project*[3].

The "high uptake of new technology" scenario is largely an exploration of the result of sustained exponential cost reductions in PV and storage technologies, drawn from the work of Tony Seba whose work is referenced in footnote 109 of the Commission's *Invitation* paper. Seba's thesis is that the costs of solid state technologies, such as solar panels and batteries, decline exponentially

[3] Available at http://www.med.govt.nz/sectors-industries/energy/energy-modelling/modelling/electricity-demand-and-generation-scenarios/draft-edgs-2015-submissions/NZ%20Smart%20Grid%20Forum%20-%20Transform%20Modelling%20Paper.pdf

and will continue to do so indefinitely. He contrasts this with the observation that the costs of electro-mechanical technologies, such as conventional generation plant fall linearly – reflecting improvements in total factor productivity.

The EDGS "Global low carbon emissions" scenario is intended to describe a "high" uptake of solar PV and forecasts 1.2GW installed by 2050. By contrast, the SGF's "high uptake" scenario forecast is twice that at over 2.5GW by 2050.

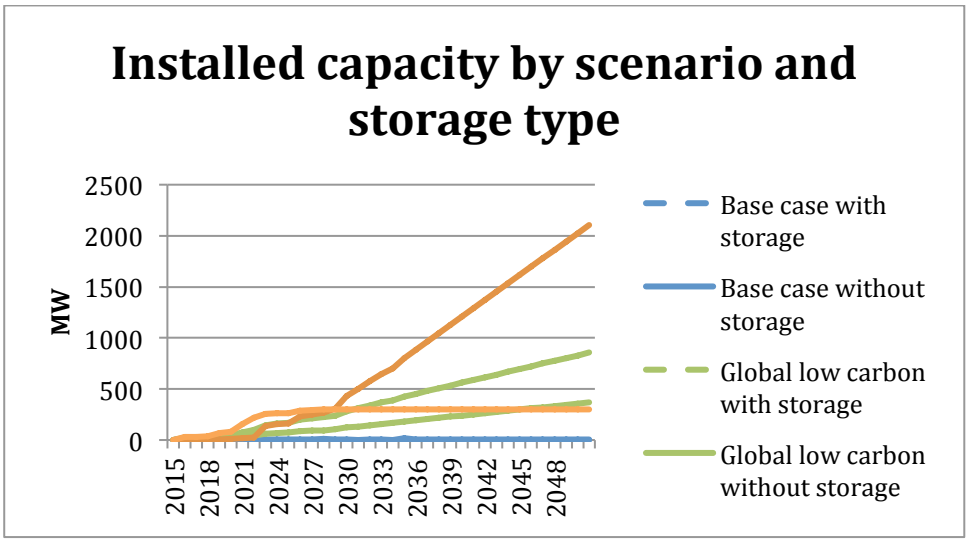
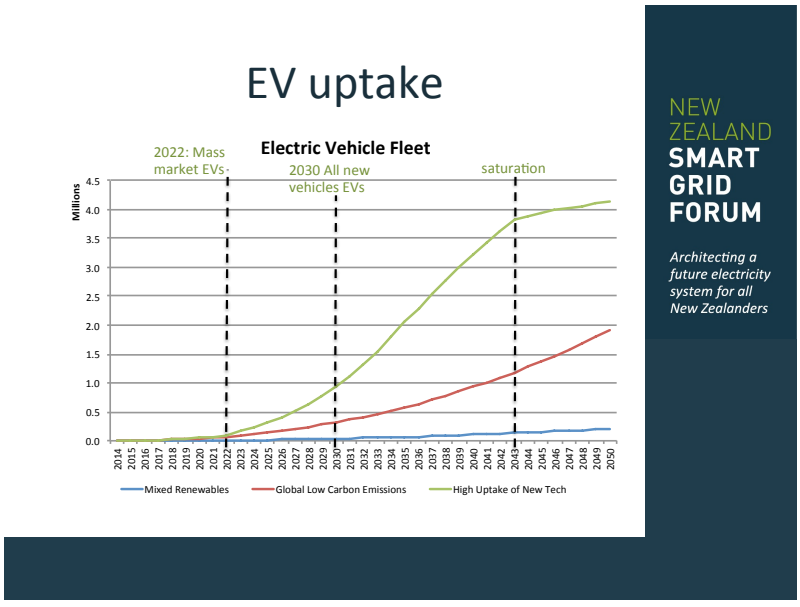


Figure 1 - Transform project scenarios for PV capacity ("with" and "without" lines are not cumulative - add dashed and continuous line values together for total capacity under each scenario)

Using the same battery cost projections, the "high uptake of new technology" scenario assumes that all an increasing proportion of new vehicles entering the light vehicle fleet are electric from 2022 and that all new light vehicles are electric from 2030. Cycling these assumptions through a fleet replacement model results in the conclusion that all light vehicles in NZ will be electric in 2042. This is more than 4 times higher than the "high" scenario of 931,000 electric vehicles by 2040 in the EDGS.



In terms of the impact on electricity distributors (and the scope of their activities under the IM regime), discussions with electricity distributor members of the have pointed to inevitable changes, such as:

- Reinforcement of LV networks to deliver PV export and/or EV charging;
- Improved SCADA and network management system capability; and
- Exploration of demand side management to deliver benefits from new technologies.

What changes (if any) have you implemented (or seen) in anticipation or in response to these developments in New Zealand?

The EDGS note that electricity consumption and production have stopped following the long-term trends that they have for decades. The Forum's recent first year report notes (page 9):

> *in November 2014, the Forum referenced a Sustainable Energy Association of New Zealand report which reported prices for photovoltaics had dropped 65% in three years and installations had risen to around 40 homes a month. Recent data from the Electricity Authority[4] shows residential connections of photovoltaics are rising at closer to 200 a month.*

Tony Seba's projections have recently been supported by an independent review of battery cost estimates reported between 2007 and 2014

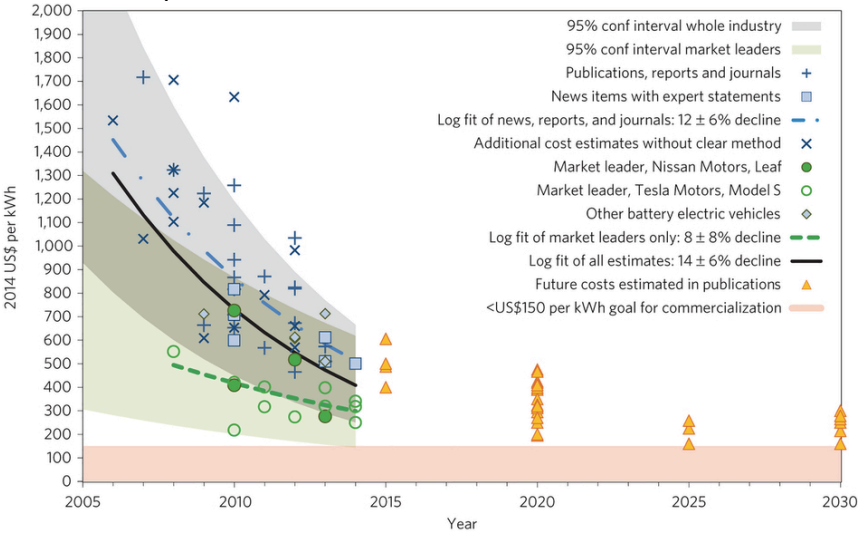


Figure 1 - Cost of Li-ion battery packs - Source Nature Climate Change

The study concludes that *the costs of Li-ion battery packs continue to decline and that the costs among market leaders are much lower than previously reported. This has significant implications for the assumptions used when modelling future energy and transport systems ..*[5]

The point of inflexion in what appears to be an exponential (hockey stick) curve is, of course, impossible to predict. What is clear to our members is that the market is changing!

[4] Electricity Authority, Installed Distributed Generation Trends
[5] Rapidly falling costs of battery packs for electric vehicles, Nature Climate Change, March 2015

The Forum's work to date and in the immediate future has focused on gaining a better understanding the implications of new technologies and the ways in which customers are likely to take advantage of them.

Distributor members have acknowledged the implication of these changes to better understand the capability of LV networks. Again, work is progressing in this area – in particular how those networks can host customer investments in PV generation

One specific consideration for the IM Review may be that with increasing uncertainty comes an increasing emphasis on long term risk assessment. The Forum has not considered this explicitly in the context of the IMs but there could be many ways in which this was achieved, whether informally or within formal cost benefit analysis.

Given the current level of uncertainty, how does the value of waiting to get more certainty compare with the risks of maintaining the status quo?

Emerging smart grid technologies such as rooftop photovoltaics, home energy management systems and battery storage have the potential to benefit New Zealand and New Zealand electricity consumers through increased efficiency and choice.

Section 2 of the Forum's first year report notes that, to date in New Zealand, the approach to introducing new smart grid technologies, notably smart metering, has relied on market investment rather than a centrally-planned implementation model. The Forum recognises that a market-led model has advantages but there are potential coordination challenges and the risk of customer benefits being delayed or compromised.

We have studied the approach taken to smart grid implementation in Australia where commentators such as the Grattan Institute[6] have argued that waiting to change commercial and regulatory settings has had significant negative costs to the Commonwealth as any business making long term investments cannot wait for certainty about the future before making decisions.

The Forum's work supports the Commission's own view that the future for the NZ electricity industry will be considerably more uncertain than in the past. Given the Commission's interest in benefit to consumers over the longer term the IMs should acknowledge this increased uncertainty and create incentives to enable regulated businesses to make appropriate responses in light of it, including developing an understanding of the impact of new technologies and emerging options for network management.

Multi-party projects

For example, there may be problems around multi-party involvement where benefits are shared by several participants, or where there are system-wide access or data exchange problems to resolve.

The Forum has looked at these issues in a set of papers from different perspectives:

[6] *Sundown, sunrise - How Australia can finally get solar power right*, Tony Wood and David Blowers: Grattan Institute, May 2015

- Looking at lessons learned from recent market-led investments to identify potential issues - Learnings from Market Investment in Ripple Control and Smart Meters,
- Reviewing a mandated, state government-led smart metering programme - Overview of Victorian Smart Meter Programme, and
- Identifying potential issues that might require coordination and reviewing models used in liberalised markets to implement complex infrastructure involving multiple parties - Coordination Models and Issues, Discussion Paper.

To avoid regret in the face of an uncertain future, there may be opportunities to use the Input Methodologies to facilitate the discovery of solutions that maximize public benefit across multiple parties before irreversible capital is committed.

Pilots

Expert advice to the Forum from John Scott has been that the practical difficulties of evolving operating models and integrating new technologies and operating practices should not be underestimated and can take a long time. Electricity networks will need new skills and capabilities to integrate smart solutions and technologies but practical trials will be needed to demonstrate how smart solutions can work and how they can become part of "business as usual" before they are capable of deployment at scale. If regulatory settings do not provide for such pilots or trials then businesses may be deterred from undertaking them.

Are there any no-regret measures we could take now?

One recommendation from the Forum to the Minister is that *Government establishes an information and advisory service to help consumers understand and compare the opportunities for new smart grid technologies and changing commercial arrangements*[7]. The electricity industry, including the parts covered by the IMs will need to work with all stakeholders ensure everyone is fully informed about the options open to them and has the right incentives and ability to take advantage of them.

Scenarios

While scenarios do not form a part of the Input Methodologies, it may be that they could be better integrated to future-proof the decisions that regulated entities make today. The EDGS were originally developed as an input to transmission investment planning appraisal and approval and this remains their statutory purpose. Nonetheless, the fact that the Transform project has explicitly used two of the scenarios as inputs to what is a sensitivity analysis which will ultimately inform distribution asset management planning points to the wider use of the EDGS in the NZ electricity industry.

Our experience is that, notwithstanding their technical merits, as a result of the extensive consultation carried out in the development of the EDGS and the high profile that results from their formal use for transmission investment approval they have an informal status as the starting point for most analysis of electricity industry futures in New Zealand. It is certainly the case that

[7] SGF First Year report, p. 22

several ENA members currently use the EDGS as one input to their core asset management planning assumptions.

This evolution in the use of the EDGS from its original purpose suggests that there would be value in continuing to develop the model for wider industry stakeholders, such as electricity distribution businesses, even if it is necessary to ringfence such work from the scenarios that support the Transmission Capex IM.

We have submitted this work to MBIE as a part of its current consultation on the 2015 EDGS[8] noting that the EDGS scenarios are important and authoritative beyond their original intent but that they are quite conservative. This may reflect older consensus views from industry analysts that assume linear cost reductions over time rather than sustained exponential improvements and the compounding effect that multiple exponential technologies (in this case solar and storage) have on uptake.

Given the potential impact of a high uptake of new technology on distribution and transmission investment needs, to say nothing of mainframe generation investment, we suggest that it would be prudent to have a scenario that elaborates this, much as our "high uptake of new technology" scenario does. Investors will weight it according to its current probability but given the long-lived and irreversible nature of mainframe electricity infrastructure investment, it is essential for the continued efficiency and international competiveness of the industry that these investors create options to deal with radically different futures now, however low their probability.

Transpower's submission on the EDGS consultation[9] makes a similar point

> *We note that the Smart Grid Forum (SGF) has developed a "disruptive technology" scenario for its own work which is more aligned with mainstream thinking. We suggest that this should be included as an EDGS scenario. Without it, we will have difficulty (without extensively modifying all EDGS scenarios) justifying any transmission investment required in order to enable such a future. If, as the future unfolds, the likelihood of such a scenario changes, we can control how influential it is in our analyses by varying the scenario weightings, i.e. apply a higher weighting if it looks likely, or a lower weighting if it appears unlikely.*

How this topic translates to specific issues for electricity (and where relevant gas) lines businesses

The Minister of Energy wrote to the Forum Chair in December 2014 asking for 'clear conclusions and strong evidence supporting any recommendations' addressing challenges of both:

- how to facilitate sufficient multi-party coordination to achieve national benefits not available to any one party acting alone; and
- maintaining acceptable reliability and supply quality in the face of emerging technologies and behaviours which the existing power system was not originally designed to accommodate.

[8] Available at http://www.med.govt.nz/sectors-industries/energy/energy-modelling/modelling/electricity-demand-and-generation-scenarios/draft-edgs-2015-submissions/NZ%20Smart%20Grid%20Forum.pdf
[9] Available at http://www.med.govt.nz/sectors-industries/energy/energy-modelling/modelling/electricity-demand-and-generation-scenarios/draft-edgs-2015-submissions/Transpower.pdf

The adoption of technologies such as rooftop PV, battery storage, fast EV charging and intelligent home automation systems have the potential to change the way the electricity industry maintains system balance and security, particularly at the distribution level. This brings different quality, reliability and security risks.

The Forum has explored these challenges through a number of papers:

- Issues paper from John Scott - *The Challenge of Disruptive Technologies*,
- System Operator response – *Management of Embedded Technologies*,
- Distributor perspective – *Stability of the NZ electricity grid – cause for concern?*
- Demand side comment from EnerNOC – *Our electricity system is changing*,
- Electricity Authority position paper – *Maintaining reliability in the face of emerging technologies* and
- *Disruptive Technologies - Overview Thoughts* – a summary letter from John Scott reflecting on responses to his issues paper.

Impact of embedded generation on frequency overseas

John Scott, formerly Director of Engineering at National Grid UK and Technical Director of the UK energy regulator OFGEM briefed the Forum in February on emerging challenges caused by unconstrained customer investment in new technologies at the distribution edge ("beyond the meter"). Forum members were particularly interested in an event in 2008 where the near-simultaneous loss of 4 gensets with a combined capacity of around 1.7GW resulted in a drop in system frequency to 49.15Hz.

90 seconds later, system frequency fell again to 48.795Hz when a further 279MW of embedded generation tripped, generation of which the system operator was unaware. John Scott concludes

the real concern here is that a serious event took place that had not been foreseen and was not part of established system modelling. Small distributed generators are generally not 'visible' to a national system operator .. The wake up call was the clear evidence that .. changes span distribution and transmission and are not under the jurisdiction of one party.[10]

NZ situation

Transpower as the NZ system operator has reviewed the UK under-frequency event for the Forum and contrasted UK and NZ industry structures and discusses issues raised by members about the NZ context, identifying issues resulting from the integration of smart grid technologies into today's power system. It concludes[11] that the *current framework for monitoring the addition of new generation and obtaining the necessary information is adequate*. But notes that to *meet its obligations the SO anticipates there will be greater and more frequent exchange of information between participants*, in particular

- *uptake of demand response and response capability (SO, EDBs);*
- *ongoing currency with frequency and fault capability of small scale DG installed in NZ (SO, EDBs);*
- *ongoing EV uptake and capability, as previously outlined (EDBs, SO, GO);*
- *voltage management within distribution networks (EDBs);*
- *impact of distribution network voltage management on GXP voltage management (EDBs, GO, SO);*
- *integrity of protection systems with proliferation of small scale DG (EDBs, GO, SO); and*
- *uptake of stationary storage and utilisation (SO, EDBs).*

Implication for NZ distribution businesses

[10] *The Challenge of Disruptive Technologies*, Chiltern Power. P.6
[11] *Management of Embedded Technologies*, Transpower – System Operator. P. 20

ENA Members on the Forum provided a commentary on the System Operator paper which notes[12] that

- *The information that the SO assumes distribution utilities will be able to provide is not necessarily available to distribution utilities. For example, it is unlikely that distributors will be advised by all consumers who purchase electric vehicles, or even connect a solar system to their house (in spite of this being a requirement). In addition, distributors have little means to track the movement of EVs – either on a day to day basis (EVs are not necessarily only connected at their home base), or when owners move home.*
- *Distributors may have insight into larger distributed generation connection, but may not have the required detail on the frequency response, behaviour under unstable voltage conditions, etc. of the generators.*
- *Distributors are likely to implement various forms of network automation and control to counter the impact of variable local generation, in particular to counter voltage regulation problems. There is no mechanism to ensure that these systems would not compete against similar systems applied by the SO, leading to "hunting" between systems and even greater instability.*
- *At present many distributors are not actively monitoring the performance of low voltage networks, and would not have insight into voltage disturbances – and would therefore not be in a position to manage this (without incurring substantial cost). Many would also not be in a position to model the networks to determine the stage at which newly connected devices could start to contribute materially to system instability.*
- *No consensus exists on how to protect networks (or distributed generators) from inadvertent livening from distributed generation sources, when these networks are deemed to be disconnected. In addition, the required response of such generators to situations where the grid is disconnected is also not defined.*

While none of these changes appear difficult, all will change the current role and obligations of distributors: creating new roles, requiring new skills and tools and adding to the resources that distributors will require to deliver them. This additional responsibility will be relevant to the definition of the services covered by the IMs.

Any other experience (domestic or international) you think would be relevant

As we note in our introductory comments, the drivers for new technologies in the NZ electricity industry are not the same as most other countries where decarbonisation and industrial policy have seen subsidies and incentives to stimulate investment. The Forum has made a strong case against such subsidies and market distortions but this makes anticipating the timing new technology integration more uncertain than overseas. "Roadmaps" for smart grid rollouts from other countries are of limited use in New Zealand if they actually relate to incentivised emissions reduction from the electricity industry. Nevertheless, political change can change this situation quickly even if technical/economic considerations would suggest New Zealand subsidies or market distortions are not necessary.

As the Commission notes in section 243 "Uncertainty appears to be pervasive in this topic area".

Learning from overseas, where subsidies and incentives have accelerated the takeup of new technologies, will not provide NZ with a forecast of the future or a prescription for exactly what network businesses should do, but they will inform businesses about different tools that are

[12] *Stability of the future New Zealand grid – cause for concern?*, ENA Members of Smart Grid Forum. Pp. 6-7

available and demonstrate the potential benefits from adopting new approaches, as well as highlight business risks.

Problem definition and solutions

As the Forum will not meet until after the conference on the Invitation paper, it is not appropriate for us to suggest specific problems with the IMs or tentative solutions to them. The Secretariat does note through, that there is a literature on the treatment of uncertainty in regulation and public investment which may be valuable in developing these themes:

Chapter 4 of the Treasury Working Paper *Contemporary Microeconomic Foundations for the Structure and Management of the Public Sector*[13] (Lewis Evans, Graeme Guthrie and Neil Quigley) considers real options and investment, in particular the value of flexibility in decision-making, quantifying the value of flexibility and the role of real options in public-sector investment decisions.

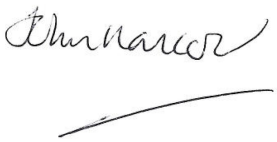
Arthur Grimes provides a specific example of such an approach in the case of the Auckland Harbour Bridge in his Motu paper *Building Bridges: Treating a New Transport Link as a Real Option*[14].

It may be that option theory could be used to provide an analytical framework for the evaluation of infrastructure investments (and more flexible alternative means of achieving the same outcomes) in the face of uncertain demand.

Conclusions

We would be pleased to present to the Commission's conference on July 29 and have invited the Commission to the next full meeting of the Forum on August 4 to develop this discussion.

With best wishes



John Hancock
Secretariat – on behalf of the Smart Grid Forum

[13] Available at http://www.treasury.govt.nz/publications/research-policy/wp/2012/12-01
[14] Available at http://www.motu.org.nz/publications/detail/building_bridges_treating_a_new_transport_link_as_a_real_option1