NEW ZEALAND SMART GRID FORUM

Architecting a future electricity system for all New Zealanders

IRM Modelling and Sector Trends Group
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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.

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 model incorporates network data from 23 New Zealand EDBs and three future scenarios for new generation, electricity end use and technology uptake developed by the ENA Members in conjunction with analysts from Smart Grid Forum member organisations.

Two of the 3 scenarios are based on the EDGS "Mixed Renewables" and "Global Low Carbon" futures but the third, "High Uptake of New Technology" has been developed specifically for the Transform project. Details of the scenarios are attached in the companion paper *SGF/ENA Scenarios for the NZ Transform Project*.

Although the MBIE analysts running the EDGS consultation are familiar with the Transform project scenarios having supported the working group with modeling expertise, this limited submission is provided with a view to raising awareness of the "High Uptake" scenario, its supporting rationale and implications - linked to wider use of the EDGS.

1 Do you agree with this description of the purpose of the EDGS, including the material in the appendix?

As the Consultation Guide notes, the EDGS were originally developed as an input to transmission investment planning appraisal and approval and this remains their statutory purpose, 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.

It is well understood that scenarios are not intended to be accurately predictions of the future but that they are planning tools:

Thinking through [scenario] stories, and talking in depth about their implications, brings each person's unspoken assumptions about the future to the surface. Scenarios are thus the most powerful vehicles I know for challenging our "mental models" about the world and lifting the "blinders" that limit our creativity and resourcefulness.[1]

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 several ENA members currently use the EDGS as an 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 Capex IM.

5 Is the variation in key assumptions consistent with the scenario design and future uncertainty?

The focus of the Forum's work and the related analysis in the Transform project relates to the impact of mass-market adoption of new technologies at the edge of the distribution system:

- distributed supply (for example photovoltaic solar)
- distributed demand (for example electric vehicles and home energy management systems) and
- local storage (in particular low-cost batteries).

The key assumptions in table 5 identifies solar energy as an area of uncertain generation type and the uptake of electric vehicles as an area of uncertainty for demand growth. This is consistent with the modeling work in the Transform project which has identified these two distributed supply and demand technologies as most likely to have a major impact on the operation of the power system.

[1] Peter Schwartz, *The Art of the Long View: Planning for the Future in an Uncertain World*

The EDGS do not consider battery storage explicitly yet early modeling of the integration of battery storage with PV systems suggest that low cost storage is likely to have as great, if not a greater, impact on the uptake of distributed supply as the generation technologies themselves.

We provide more detail in the accompanying paper but to summarise:

- as the Consultation Guide notes in paragraph 156, solar and other renewable generation technologies are not subsidized in New Zealand so the value of local generation is higher for own consumption than export (by a factor of almost 3 at current buy-back rates);
- solar generation peaks during the day when many users are not at home or using electricity, limiting the opportunity for own-consumption;
- storage provides the technology to maximize the own-use of locally generated electricity; and
- once installed, storage can be used to supplement local generation and arbitrage electricity prices which reduces the need for mainframe peaking generation at scale.

The Transform "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 at Stanford University[2]. Seba's thesis is that the costs of solid state technologies such as solar panels and batteries decline logarithmically 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.

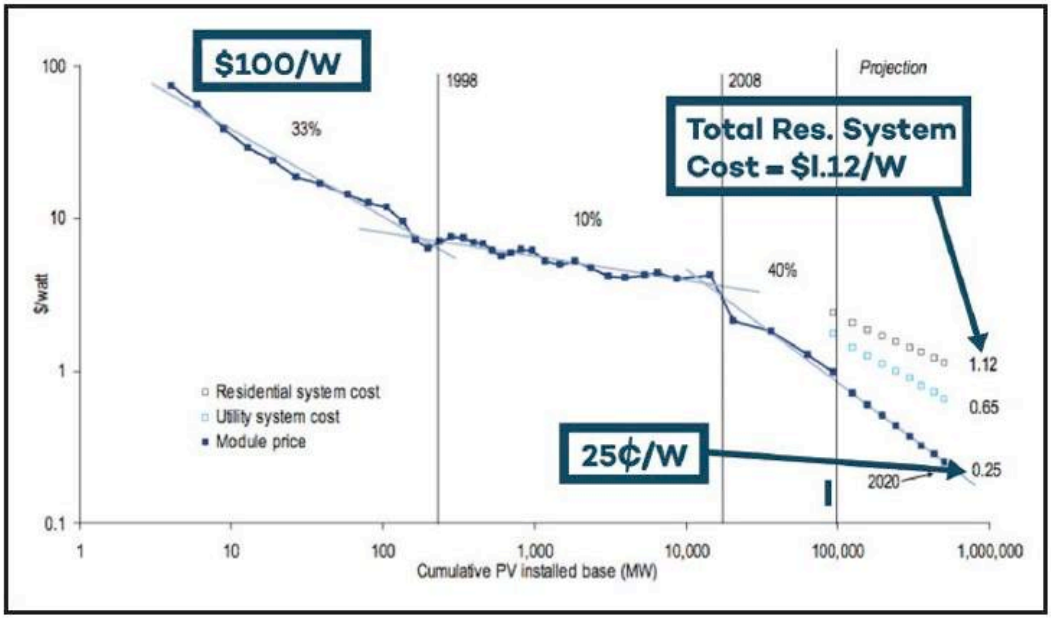


Figure 1 - Solar costs have fallen 154x since 1970 - source Seba

Seba's conclusion is that solar costs will inevitably fall below the cost of mainframe generation net of transport and distribution at which point all new generation will be solar.

Seba's projections for storage costs follow a similar exponential trajectory:

[2] *Clean Disruption of Energy and Transportation*, Tony Seba, 2014

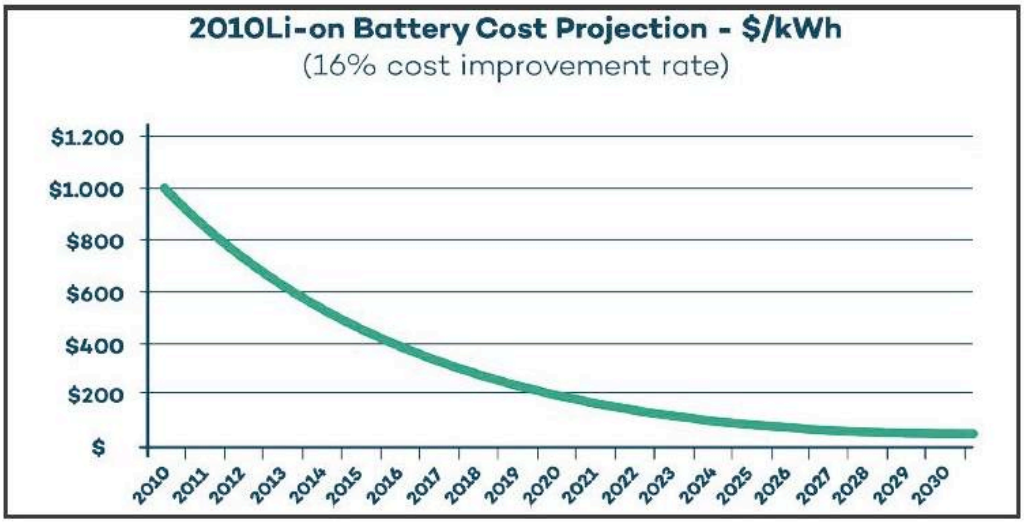


Figure 2 - Li-ion battery cost projection $/kWh - Source Seba

Most published scenario work assumes high battery costs sustained for the medium term, reflecting consensus opinions from 2013. We have observed a dramatic fall in analysts' projections for such costs published since Panasonic and Tesla announced the construction of a large-scale battery manufacturing plant known as the "Gigafactory" which is set to double current battery production worldwide[3], and the response to this announcement from competitors.

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

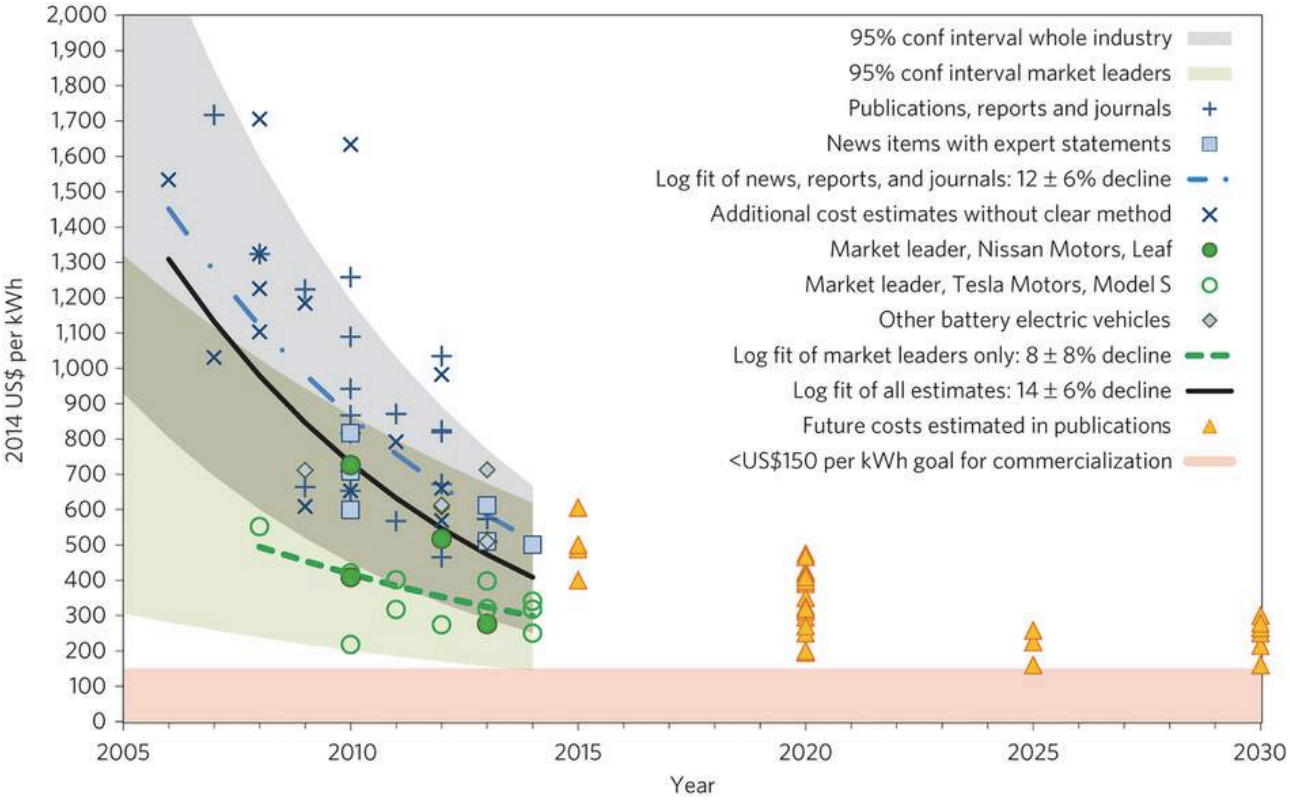


Figure 3 - Cost of Li-ion battery packs - Source Nature Climate Change

[3] http://www.teslamotors.com/blog/panasonic-and-tesla-sign-agreement-gigafactory

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 ..*[4]

In conclusion, while the EDGS "Global low carbon emissions" scenario explores a "high" uptake of solar energy uptake which results in 1.2GW PV installed by 2050. This is barely half the results of the Transform project's modeling which assumes Seba's costs for both PV and storage.

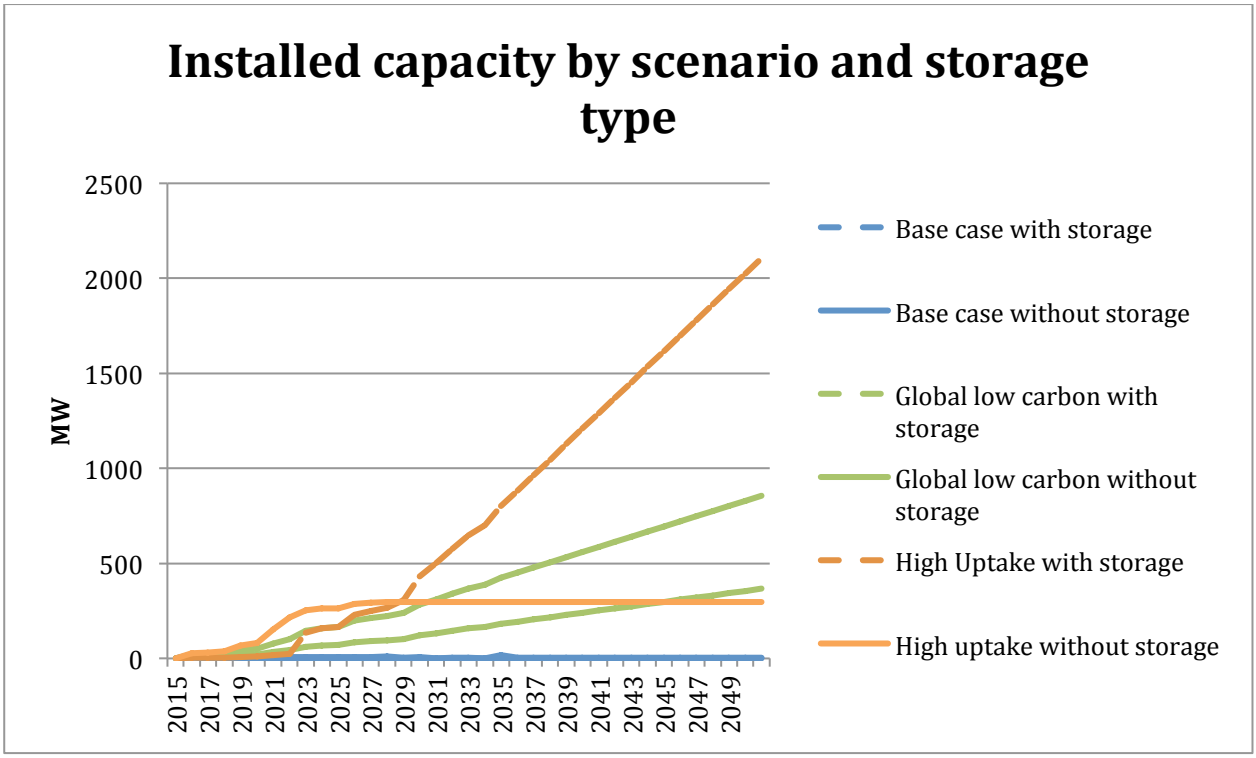


Figure 4 - Transform project scenarios for PV capacity

While it is tempting to treat storage costs as an input to EDGS assumptions around PV price and EV uptake, our experience is that the wider opportunities for storage to replace peaking generation in the electricity system would justify further investigation of the impact of battery prices below $100/kWh on the net system supply and demand scenarios examined in the EDGS.

7 Does the high uptake of electric vehicles (and Solar PV) that are used in our Global Low Carbon Emissions scenario adequately reflect future uncertainty?

By comparison with the Transform project's "high uptake of new technology" scenario, even the "high" projections for installed PV capacity in the EDGS appear conservative, as our answer to question 5 illustrates. 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.

[4] Rapidly falling costs of battery packs for electric vehicles, Nature Climate Change, March 2015

Electric Vehicles are an extreme example of the effect of multiple exponential technologies in a single consumer product, where like-for-like costs will be lower than electro-mechanical equivalents but their consumer utility and performance will be vastly greater – much as a smartphone is not only cheaper than a landline telephone but it does vastly more – integrating location, data communications, movement sensing and so on to support functions that are far more useful than simply remote voice communication. The compound effect of these technology capabilities and cost improvements explains the logarithmic uptake of mobile and smartphones in contrast to landlines:

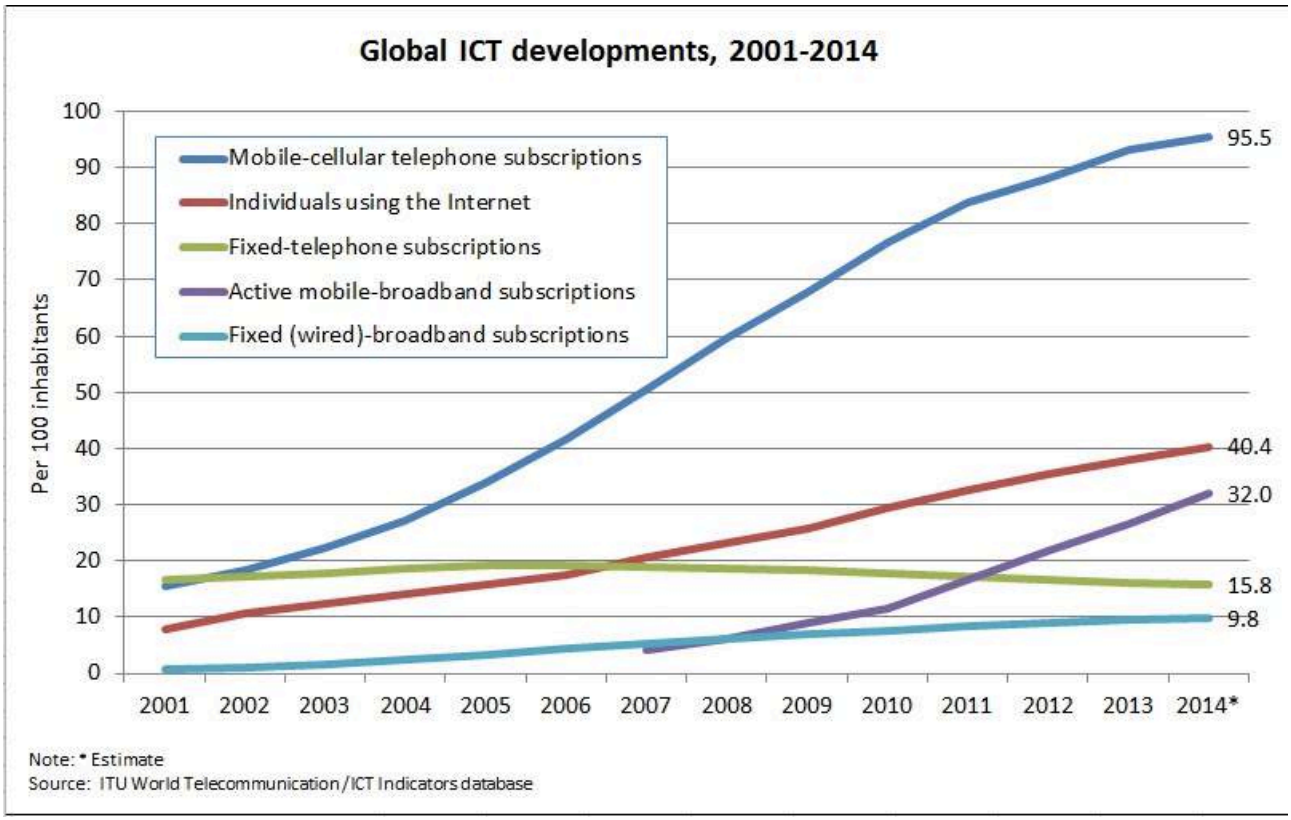
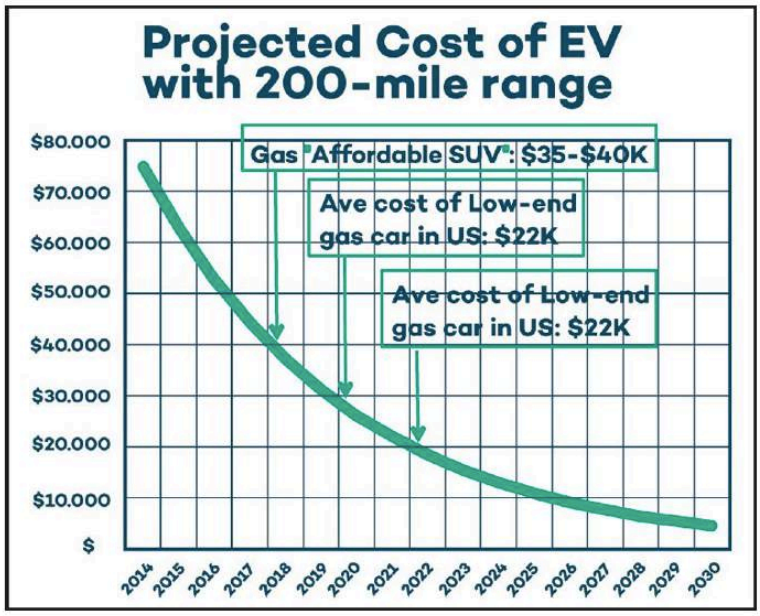


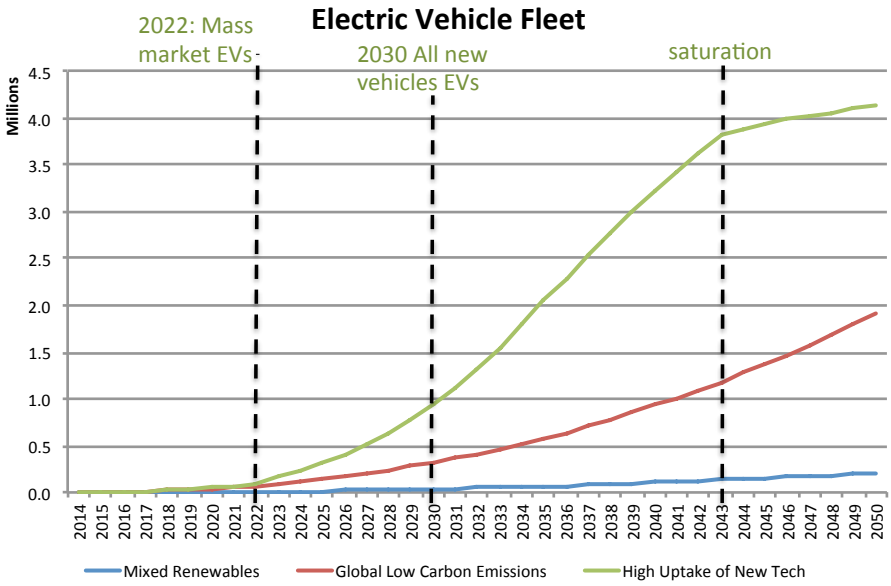
Figure 5 - Relative market share of telecommunication technologies – Source International Telecommunications Union

Seba's projections for EV uptake are a direct function of the battery cost projections above: by 2025, if battery prices fall to $75/kWh, the EV equivalent of a new Toyota Corolla will be cheaper than one with an internal combustion engine.



The Transform project used these cost projections in its "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.

EV uptake



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Summary and conclusion

The EDGS scenarios are important and authoritative beyond their original intent. The expertise of the team that develops them will be central to the development of the industry's preparation for a future that is likely to be radically different from the stable history and technologies that have characterised it to date.

Despite this, the EDGS are quite conservative - given the potential impact of a high uptake of new technology on distribution and transmission investment needs, to say nothing of mainframe generation investment, it would be prudent to have a scenario that elaborates this, much as the Transform project's "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.

Thanks

This submission is an appropriate opportunity for the Transform project team members to acknowledge the work done by the IRM Modelling and Sector Trends team at MBIE which we have reproduced here. Their contribution to the development of scenarios for the Tranform project has been invaluable and insightful throughout.

We would be pleased to provide further elaboration on the submission if helpful.

With best wishes

John Hancock
On behalf of the ENA/Smart Grid Forum Scenarios Working Group
May 2015