Security and Reliability Council

Future scenarios for edge technologies

The growth of edge technologies under different assumptions

22 October 2015

Note: This paper has been prepared for the purpose of the Security and Reliability Council (SRC). Content should not be interpreted as representing the views or policy of the Electricity Authority.

Background

The Security and Reliability Council's (SRC) functions under the Electricity Industry Act 2010 include providing advice to the Electricity Authority (Authority) on reliability of supply.

The Smart Grid Forum (Forum) was commissioned in early 2014 by the Ministry of Business, Innovation and Employment with the support of the Electricity Networks Association (ENA). The Forum's objective is "to advance the development of smart electricity networks in New Zealand through information sharing and dialogue, supported by analysis and by focused work-streams where these are considered to be appropriate."[1]

The Forum presented to the SRC's 1 July 2015 meeting on the security and reliability-related recommendations from the Forum's first year report to the Minister of Energy and Resources.[2] From the SRC's perspective, the most relevant recommendation was that "a permanent but independent reviewer such as the Electricity Authority's independent [SRC] monitors and report on this transition [arising from consumer-driven adoption of opportunities from new technologies] over time."

Paragraph 20 of the draft SRC minutes record that:

> "The SRC agreed that it needs to discuss this issue further. The SRC requested that the [Forum] provide some scenarios that show the expected results of modelled changes that could better inform the SRC about the potential impacts of the technology changes. A [Forum] representative noted that such modelling has already been done, so the scenarios exist."

The purpose of this paper is to present the requested scenarios to inform further SRC discussion about its possible role for monitoring and reporting on the security and reliability implications of the transition to new technologies.

The Authority has several projects that relate to adoption of new technologies

The Authority is cognisant of the potential impacts of customer-driven adoption of new technologies and the importance of having efficient pricing signals in place to enable efficient decision-making by consumers.

The Authority's key project in this regard is the review of distribution pricing. A consultation paper for this project is due to be released shortly that investigates the distribution pricing implications of technologies like photovoltaics, battery storage and electric vehicles.

There are a number of other projects underway that are at least partly motivated by the adoption of new technologies, though mostly any security or reliability concerns run a distant third to the impacts on competition in, and efficient operation of, the electricity industry. Some examples are:

- half-hour switching rules (smart meters)
- greater half-hour reconciliation (smart meters)
- review of the Low Fixed Charge Regulations (photovoltaics particularly)
- review of the distributed generation pricing principles (small-scale generation)
- the retail data project (new consumer services).

[1] For more information about the Forum, including the list of members and meeting minutes, see http://www.med.govt.nz/sectors-industries/energy/electricity/new-zealand-smart-grid-forum

[2] Available from http://www.ea.govt.nz/development/advisory-technical-groups/src/meeting-papers/2015/1-july/

The SRC is being asked to consider its role with respect to monitoring and reporting on the transition to smart grid technologies

The SRC may wish to consider the following questions.

Q1.	Does the SRC agree with the Forum's recommendation that the SRC should monitor and report on this transition over time?
Q2.	If the SRC still agrees it has a monitoring/reporting role to play, what sort of information would the SRC want to monitor to perform this role in the context of security and reliability?
Q3.	What advice, if any, does the SRC wish to provide to the Authority?

Scenarios of consumer investment in new technology

Update for SRC

October 2015

NEW ZEALAND SMART GRID FORUM

Architecting a future electricity system for all New Zealanders

Outline

- MBIE's "EDGS" scenarios
  - Purpose
  - Key uncertainties
  - Assumptions
  - Results
- SGF's "high uptake of new tech" scenario
- Next iteration of EDGS

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EDGS Purpose

- Electricity Demand & Generation Scenarios (EDGS)
  - 8 Scenarios specifying future development of the electricity sector out to 2040 reflecting different uncertainties.
- Regulatory tool
  - Used by Commerce Commission to regulate Transpower's major capital expenditure
    - In the Capital Expenditure Input Methodology Determination (Capex IM) EDGS are used in the "investment test" in which net electricity market benefit is a weighted average across a range of scenarios (the EDGS scenarios are the default)

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Key Uncertainties

- 3 key uncertainties:
  - Type of generation built x 3
  - Demand growth x 2
  - Tiwai Aluminium Smelter x 2

	Scenario
1	Base Case (Mixed Renewables)
2	High geothermal availability
3	High gas availability
4	Global low carbon emissions
5	Lower Tiwai demand
6	Tiwai exit
7	Low demand growth
8	High demand growth

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Assumptions Summary

Inputs varied	Scenario number and name							
	1	2	3	4	5	6	7	8
	Base case (mixed renewables)	High geothermal availability	High gas availability	Global low carbon emissions	Lower Tiwai demand	Tiwai exit	Low demand growth	High demand growth
GDP, population, household numbers	Medium						Low	High
Projection of residential demand per household	Medium						Low	High
Tiwai load from 2017	572			400		0	572	
Geothermal resource availability	Medium	High	Medium	Low	Medium			
Gas supply availability	Medium		High	Low	Medium			
Cost of Wind Generation	Medium			Low	Medium			
Carbon Prices	Medium		Low	High	Medium			
Solar energy uptake (2040)	Medium (185 MW)		Low (96 MW)	High (822 MW)	Medium (185 MW)			
Uptake of electric vehicles (2040)	Medium (108 k)			High (934 k)	Medium (108 k)			
Retirement of old Huntly units	2018, 2020		Late: 2019, 2021	Early: 2017, 2019		Early: 2017, 2017	2018, 2020	
TCC retirement	2024			2022	2024	2022	2024	
Otahuhu B refurbishment	Refurbish 2021			Convert to peaker 2017			Refurbish 2021	

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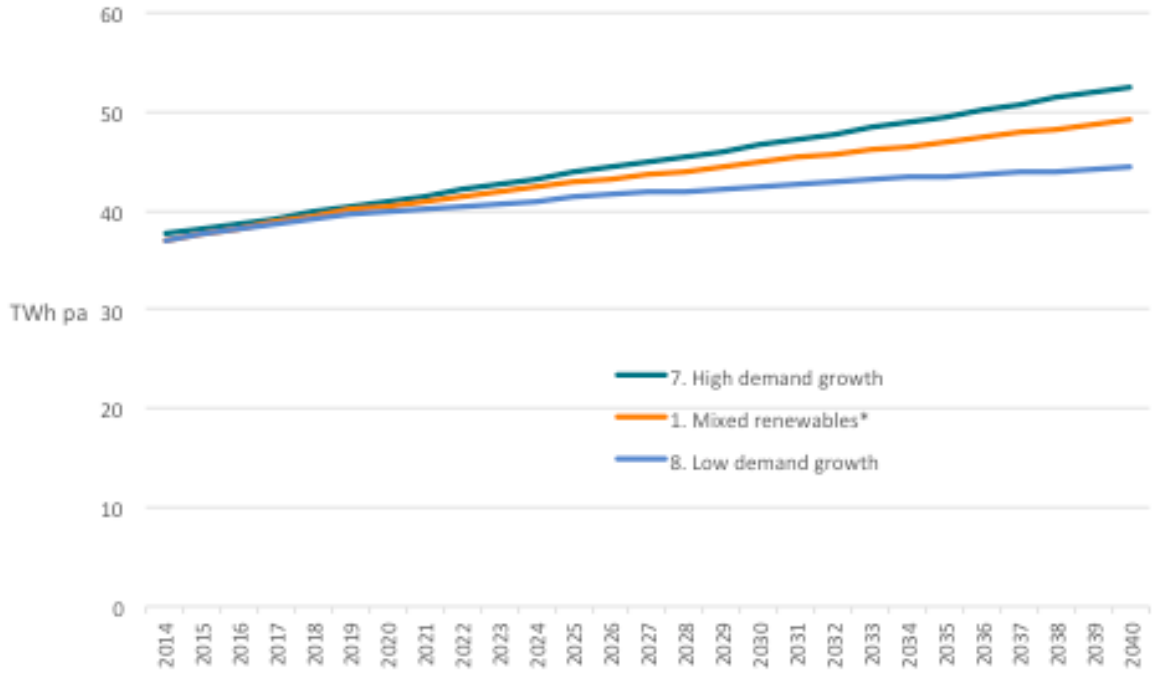
Results - Demand

- Electricity demand grows at 1.1% per annum compared to GDP growth of 2.0% in our base case



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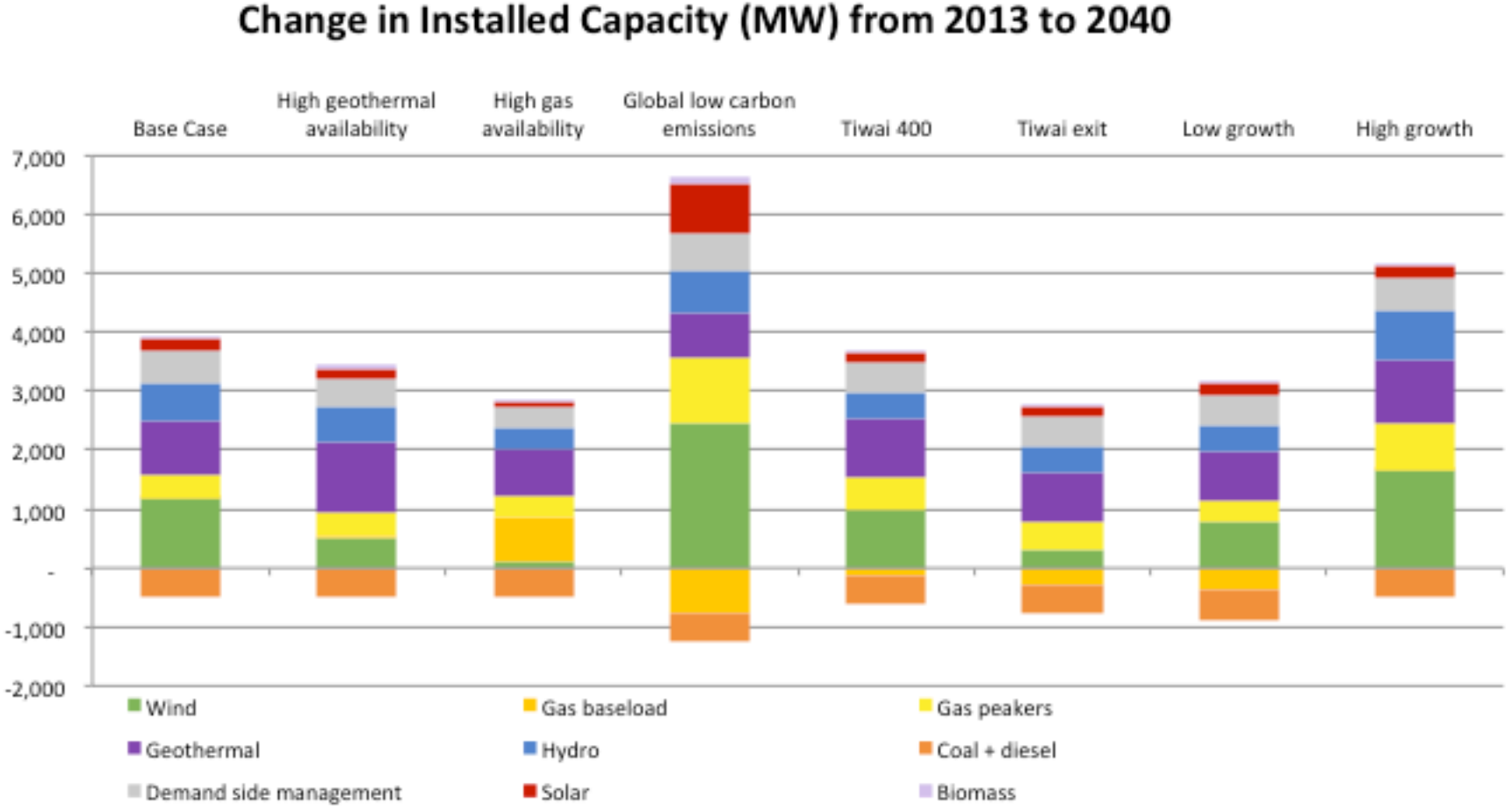
Results – technology type



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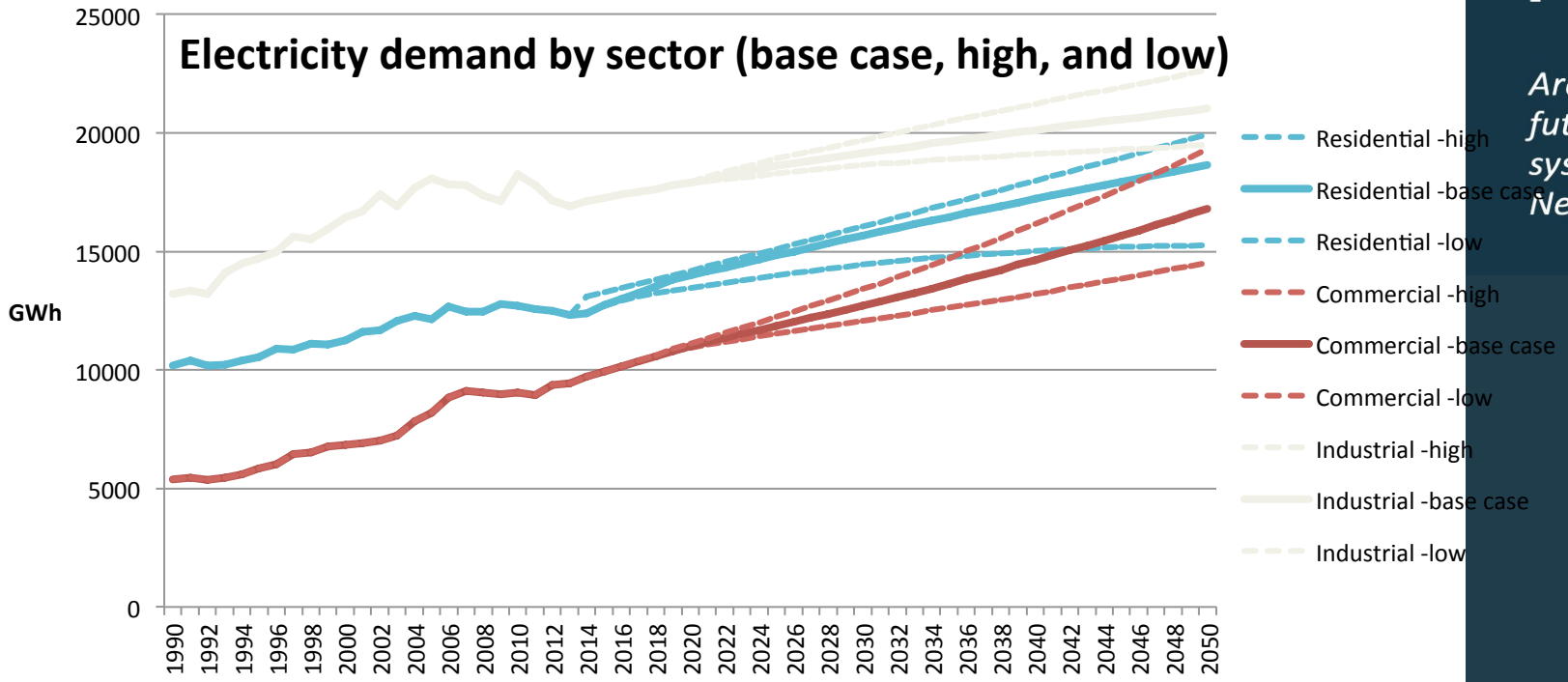
Electricity demand models

- Separate models of electricity demand by sector
  - Residential = # households * demand per household
  - Commercial = f(Commercial GDP)
  - Industrial = f(Industrial GDP and prices)
- NZ GDP growth forecasts mainly driven by commercial sector GDP



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Residential electricity demand forecasts

- Residential demand = #households * demand per household

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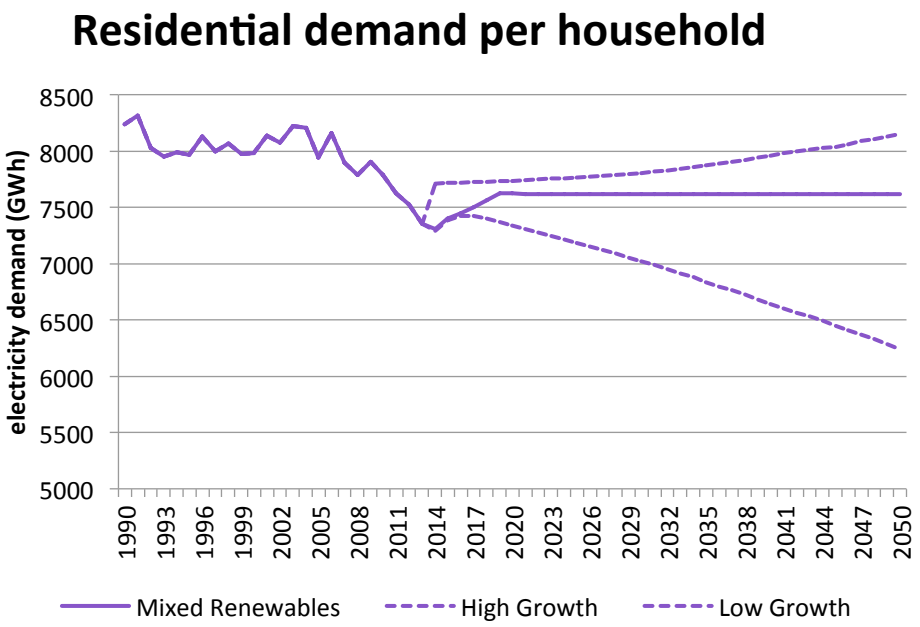
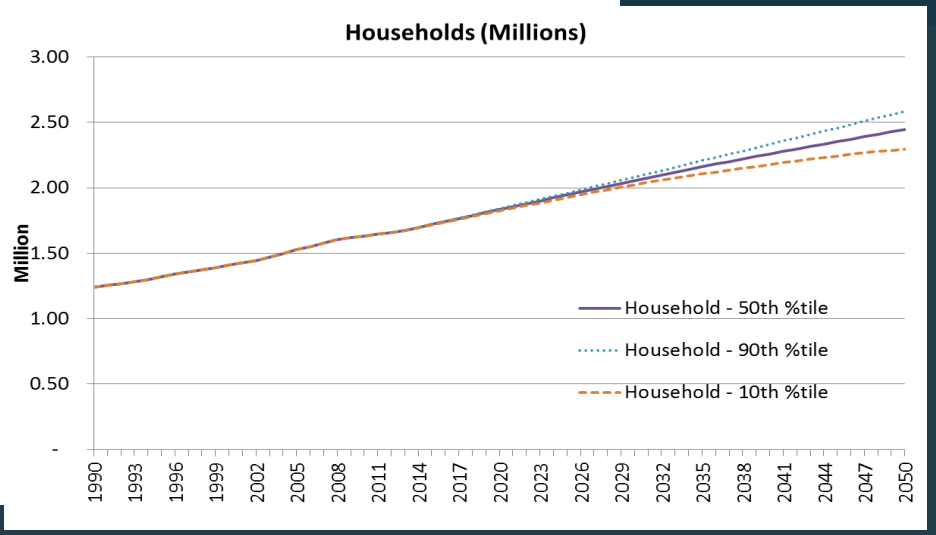
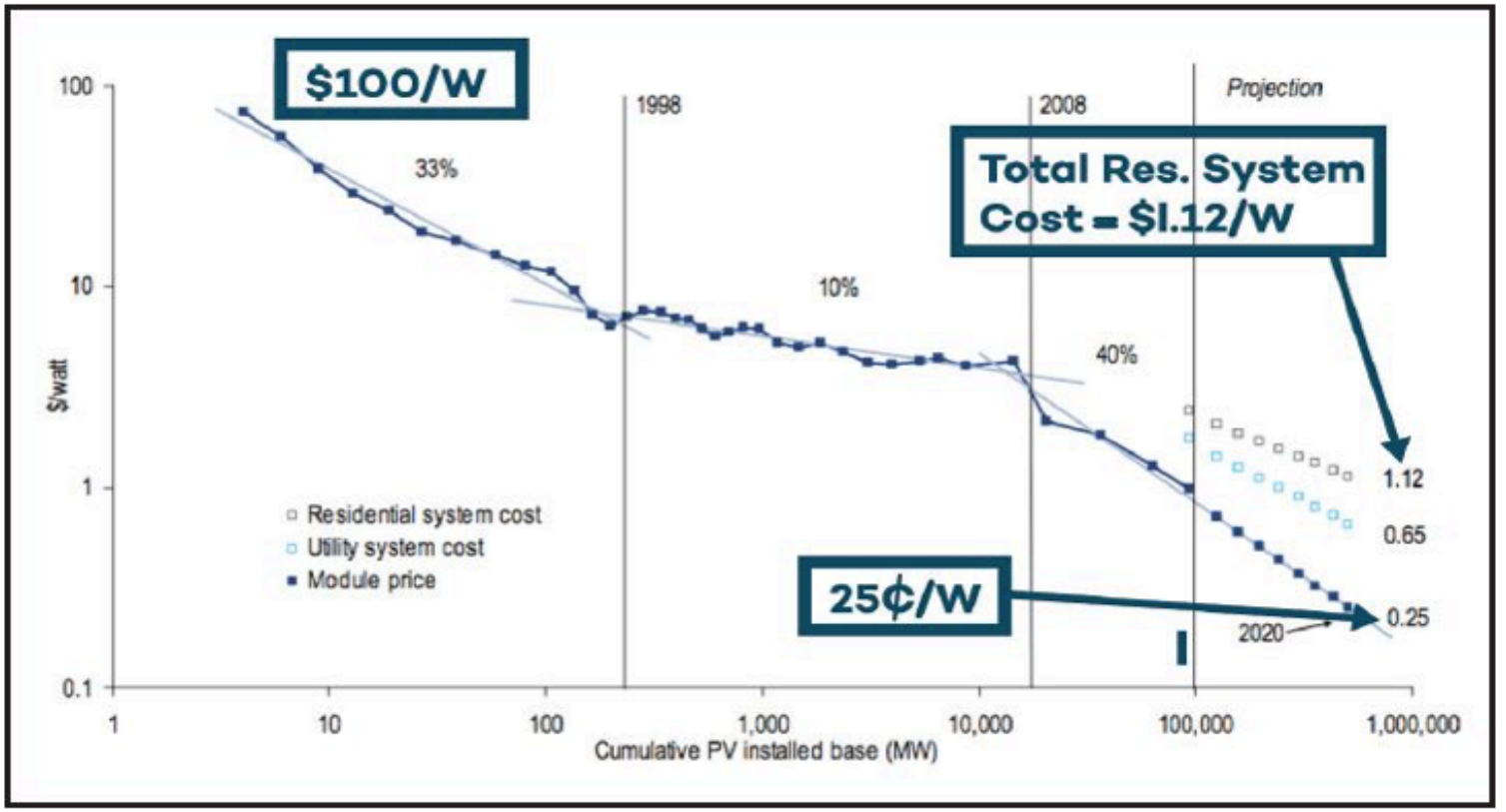




SGF "high uptake" scenario models exponential technologies



Solar panel costs have dropped by a factor of 154 (from $ 100/ W to 65 ¢// W) since 1970.

Source: *Clean Disruption of Energy and Transportation*, Tony Seba.

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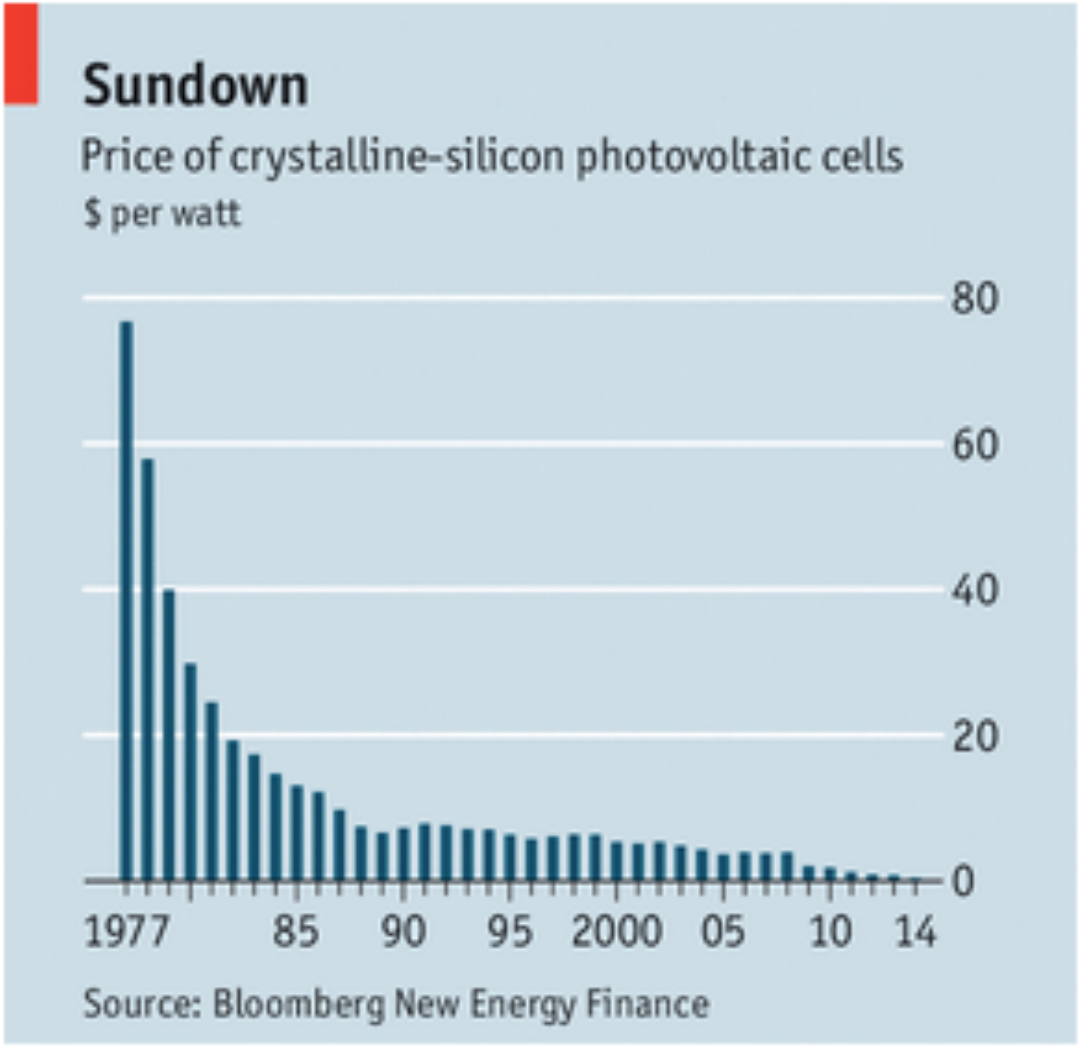
Solar costs remain exponential

Renewable energy

Banishing the clouds



Economist.com

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Batteries cost projections

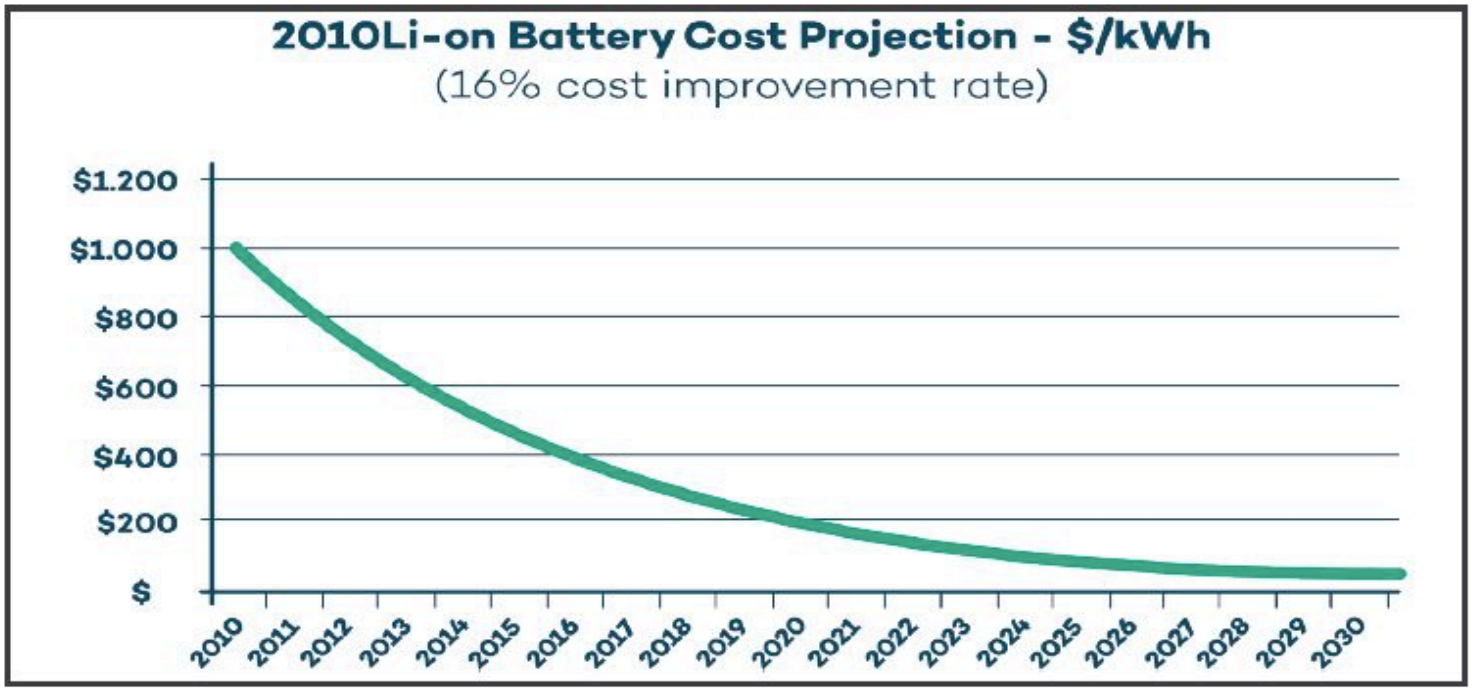

Figure 4.10—Electric vehicle Li-ion battery cost projection in $/kWh. (Tony Seba)

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Cost ($/kWh)	$500	$420	$353	$296	$249	$209	$176	$148	$124	$104	$87	$73

Source: *Clean Disruption of Energy and Transportation*, Tony Seba.

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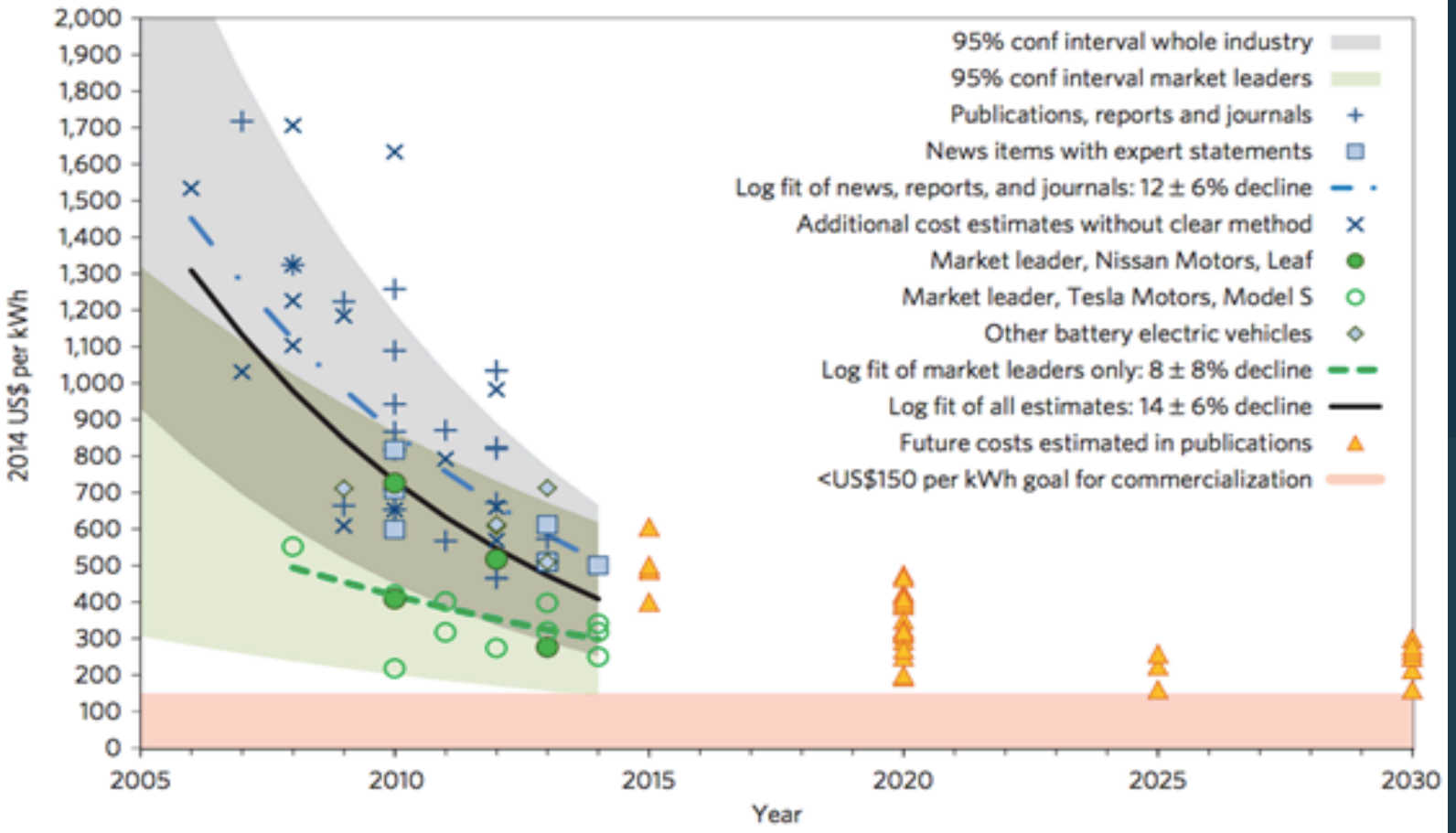
Marginal kWh price of Tesla powerwall is $150



Source: Electric vehicle batteries 'already cheaper than 2020 projections', Nature Climate Change, 23 Mar 2015

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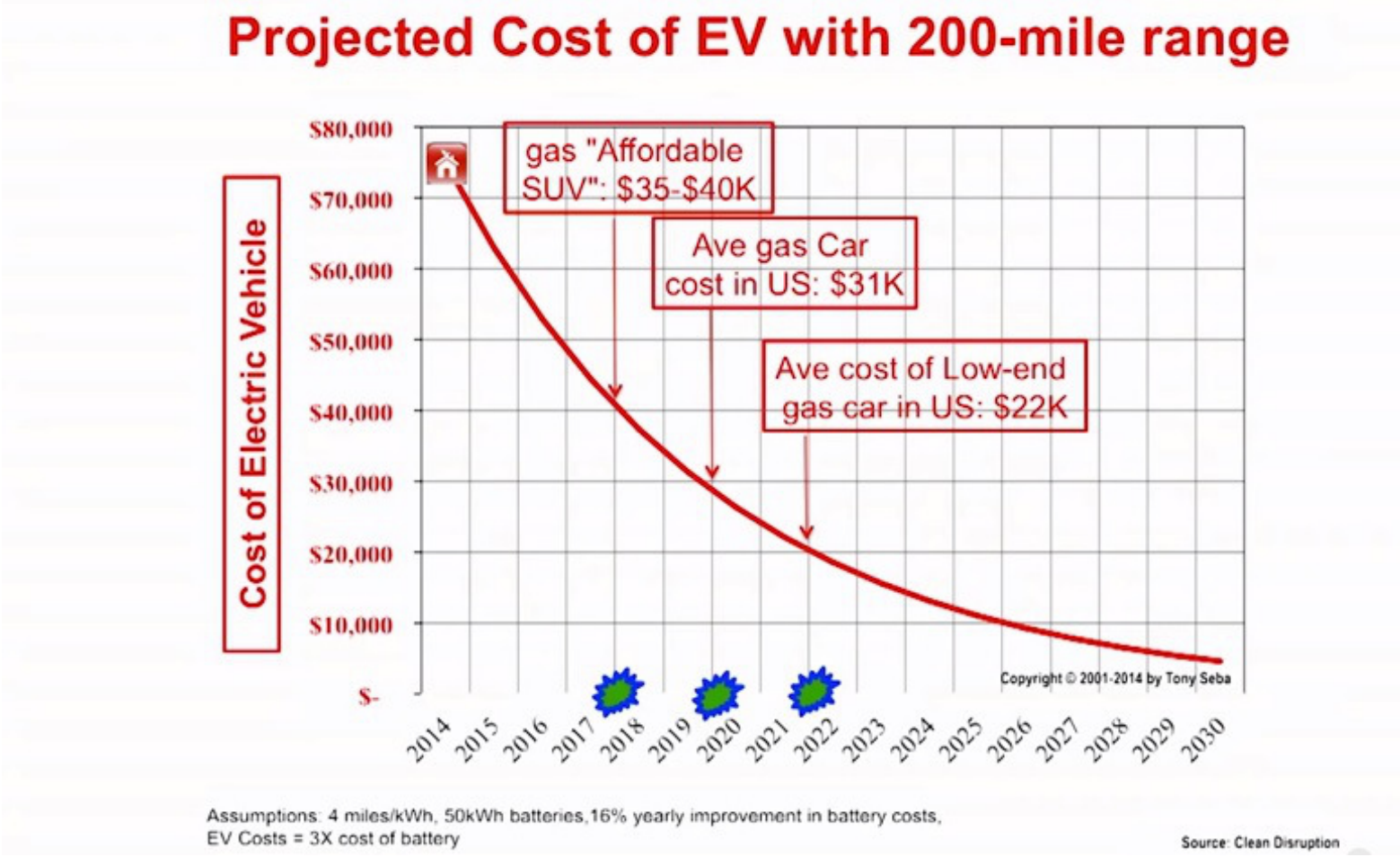
Implies EV cost equivalence by 2022



Source: *Clean Disruption of Energy and Transportation*, Tony Seba.

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SGF's "high uptake of new technology" scenario

- Assumptions
  - In early 2020s battery costs fall to levels that allow cost competitive mass market EVs and solar with storage
  - Time of use pricing drives battery use and smooths impact of solar on distribution system

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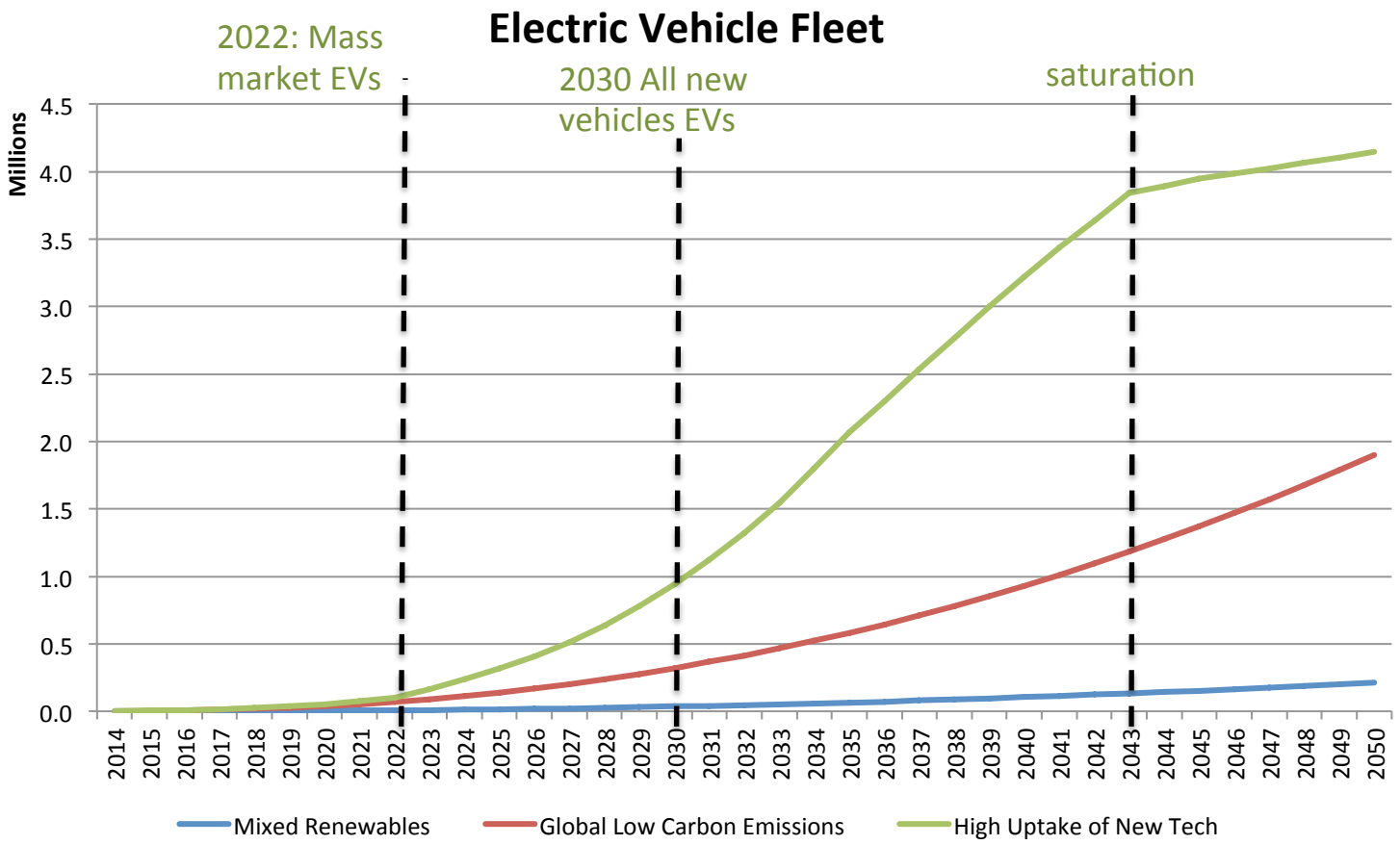
EV uptake



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Solar assumptions

- Financial model
  - Variable costs, buyback rates, capital costs, % of generation consumed onsite, output used to find percentage of households where solar is economic
- Key uptake assumptions

	Residential households	
	Existing	New
MBIE Base Case	15%	30%
MBIE Global low carbon emissions	40%	45%
High Uptake of New Technology	80%	100%

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Solar assumptions

- Storage assumptions
  - Not modelled in MBIE scenarios

		With storage	Without storage
Mixed Renewables		10%	90%
Global Low Carbon Emissions		30%	70%
High Tech uptake	2015-2022	10%	90%
	2023-2028	75%	25%
	2028 onwards	100%	0%

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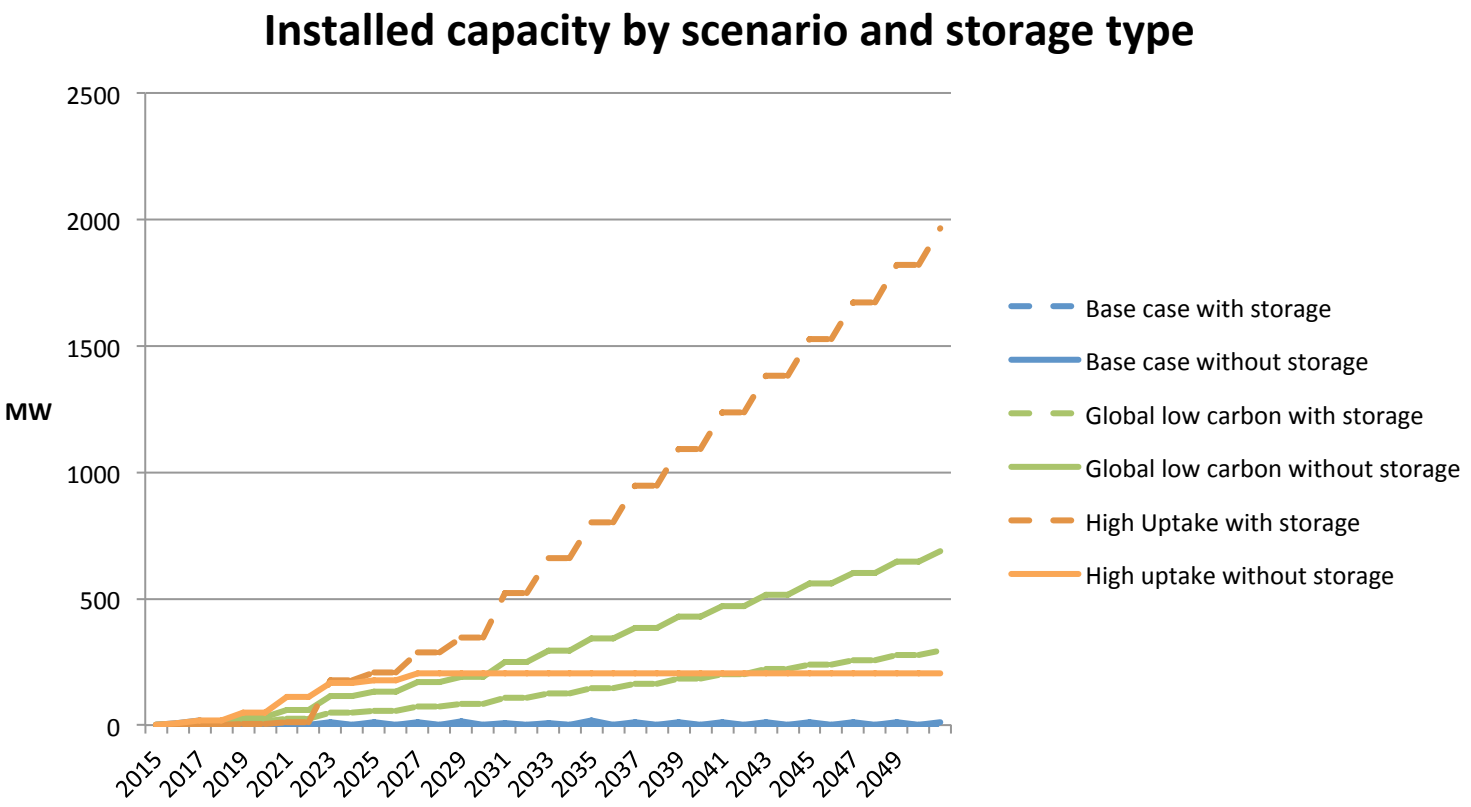
Solar capacity



Add lines together for total by scenario – 2.5GW in 2050 under “high uptake”

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High uptake scenario will be included in future EDGS

- Draft EDGS published 2 April 2015
- Consultation process undergone 14 submissions and 3 cross-submissions
- MBIE response to submissions published 3 July – included commitment to improve scenario design including:
  - Treatment of disruptive technologies
  - Treatment of Tiwai across scenarios
  - Wider spread of Huntly decommissioning

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Future EDGS scenarios

	Scenario	Description
1	Base Case - Mixed Renewables	A "balanced" renewables scenario reflecting moderate GDP growth, current views on relative technology costs and expected fuel costs
2	High Growth	Higher demand due to higher industrial growth driven by dairy and irrigation load. Hydro generation limited by increased competition for water. New build technologies similar to Mixed Renewables, but relatively more wind since there is plentiful resource.
3	High Gas	Sizable discoveries of oil and gas resource are assumed, increasing the supply of gas available for electricity generation.
4	Global Low Carbon Emissions	High global carbon prices and lower cost wind technology are assumed. Higher solar and EV uptake assumed. Geothermal resources are restricted to encourage wind build. Wind is developed alongside geothermal, however geothermal resources are eventually constrained resulting in relatively more wind.
5	Disruptive	Costs of new technology such as solar PV and batteries fall significantly and adoption is widespread. Higher distributed generation and increased household efficiency reduces grid demand.
6	Tiwai Exit	A low demand environment in which the Tiwai Aluminum Smelter closes.

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Future EDGS scenario assumptions

Inputs varied	Scenario number and name					
	1	2	3	4	5	6
	Base Case - Mixed Renewables	High Growth	High Gas	Global Low Carbon Emissions	Disruptive	Tiwai Exit
Population, household numbers and GDP	Medium	High	Medium			Low
Projection of residential demand per household	Medium	High	Medium		V Low*	Low
Tiwai load from 2017	572					0
Geothermal resource availability	Medium	High	Medium	Low	Medium	
Gas supply availability	Medium		High	Low		Medium
Cost of wind generation	Medium			Low	Medium	
Carbon prices	Medium		Low	High	Medium	
Solar energy uptake	Medium		Low	High	V High	Medium
Uptake of electric vehicles	Medium	Medium High	Medium	High	V High	Medium
Retirement of old Huntly units	2018, 2020		Late, post 2025	Early: 2017, 2019		2018, 2020
Other retirement (TCC, Otahuhu)	Moderate	Late		Mid-early	Early	
*low demand in disruptive scenario due to increased efficiency						

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Architecting a future electricity system for all New Zealanders

Impacts of emerging technologies on power system operation in New Zealand

Nyuk-Min Vong & Andrew Gard

SYSTEM OPERATOR

Future of New Zealand power system

- Various studies, reports and market trends indicate that emerging technology penetration into the New Zealand power system will increase

- These technologies will affect the way we operate the power system especially generation dispatch/market and frequency management

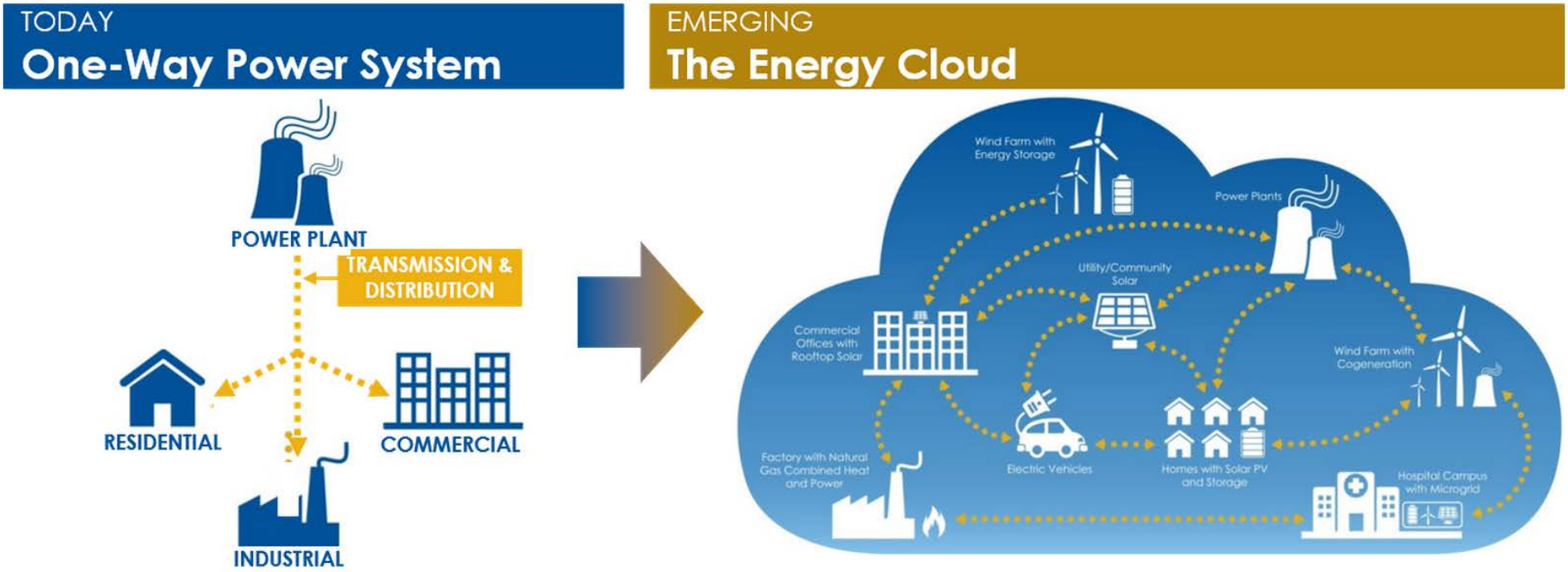
- Voltage management is more a localised problem likely to impact the distribution network more than Transpower's transmission network

- Less predictable power system behaviour

New Zealand Solar Uptake

- The present renewable generation penetration in New Zealand is in the region of 80%
- It is envisaged that in the next five to ten years, the penetration level could be high enough to impact the power system
- The uptake in New Zealand depends on the PV system price and the uptake of Energy Storage System (ESS) or Battery
- MBIE renewable target is 90% by 2025. At present, PV uptake is about 29MW, mostly comprised of residential rooftop type.

Future power system



The 'Energy Cloud' is Transforming the Power Sector By Jan Vrins

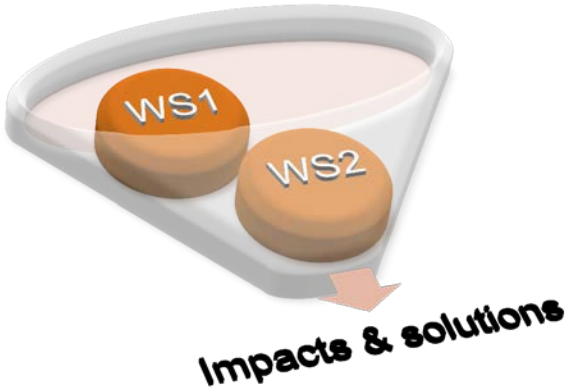
System Operator programme of work

WS1 – System operation

- Renewables & technologies
- Unpredictable & intermittent generation
  - Distorted load curve, load behaviour
  - Wind gust
  - Unpredictable cloudy conditions & solar eclipse
  - Battery charging/discharging cycle
- Reliable ancillary services
  - Inertia
  - Governor response
  - Frequency keeping
  - Reactive power capability
  - Fault current contribution
  - Voltage control

WS2 – System stability

- Stability
  - Voltage stability
  - Transient stability
  - Small signal stability
- Power quality
  - Harmonics
  - Flicker
  - Voltage quality



System Operator programme of work

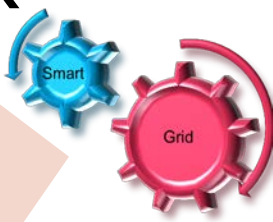
WS3-Market

- Load forecast
- Frequency regulation ancillary services
- Impact on existing generation
- Dispatch – generation & load incl. battery
- Flexible generation
- GXP – load and generation

WS4-Real time (RT) operation

- Wind & solar forecast
- Visibility beyond grid
- RT information – do we need more?
- RT tools to operate PV and battery?
- Operation model - centralize vs distributed?
- Restoration
- Power system models
- So much real time information – situational awareness tool

WS5-Policy and standards



- The Code
- Connection requirements e.g. Fault ride through, secondary risk
- Testing requirements to ensure equipment compliance
- Operation policy & standards
- How much asset information is enough?
- Dispensation & compliance

SO action plan

- Identify the information we need to undertake the work programme
- Engage with Electricity Distribution Businesses (EDBs) and other asset owners
  - availability of information
  - form and transmission of information
- Study the impacts of new emerging technologies
- Build up a knowledge base of the operational characteristics of different technologies
- Share our results
- Work with stakeholders to integrate these technologies into the power system – technical, policies, market, people

SO action plan

- Stay ahead of the game
  - determine the lead time to implement the integration requirements
  - monitor how technologies are developing and unfolding
  - build “just in time” and develop/adapt to suit operational requirements
- Implementation Timeline
  - Workstream 1 complete by Q3 2016
  - Workstream 2 complete by Q1 2017
  - Remaining workstreams Q3 2017

Thank you.