Climate change, demand, and winds part of the story

Andrew Renton Senior Principal Engineer, WEANZ AGM Wellington October 2019

What this paper Is and Isn't

Isn't

- The ultimate answer
- The only solution

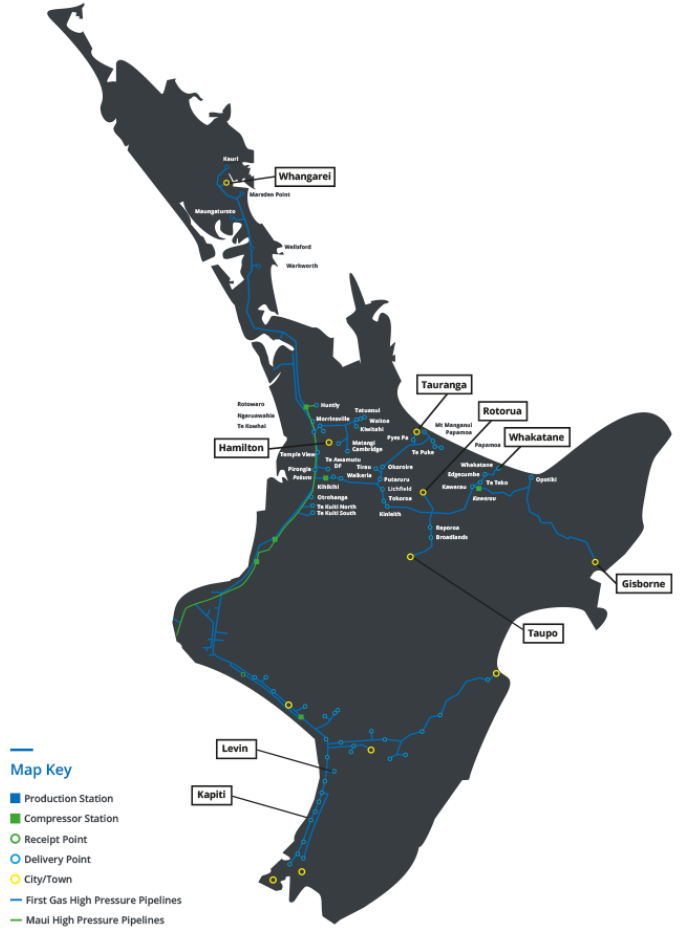
Is

- The issue and system we have
- Having a Goal
- Demand and opportunities
- Where we should focus
- Are things as big and scary as we think

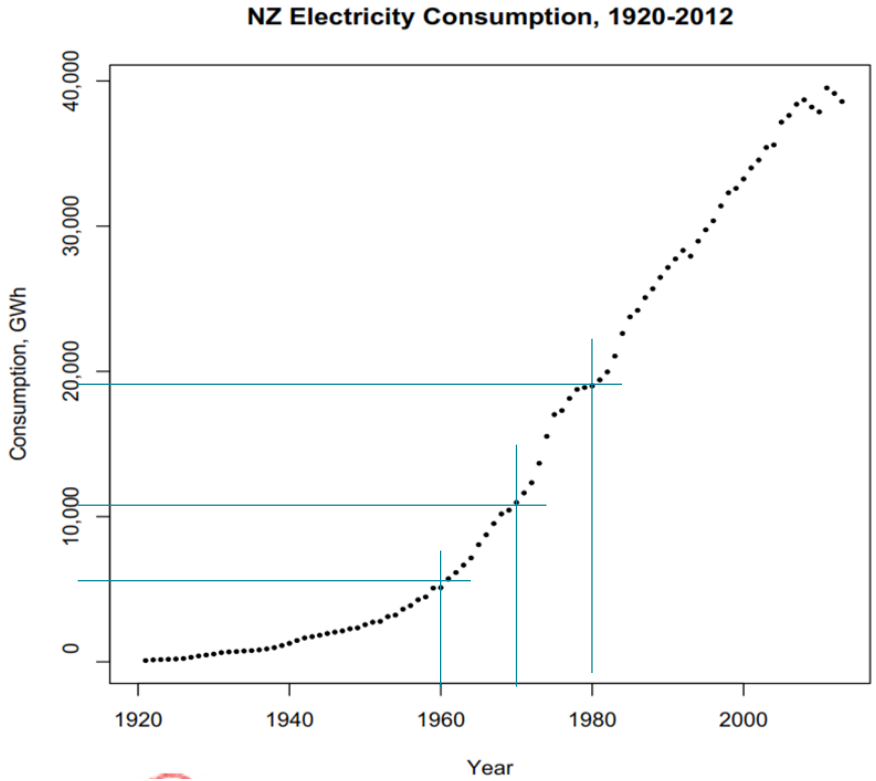
Other Energy Transmission Providers

Firstgas®

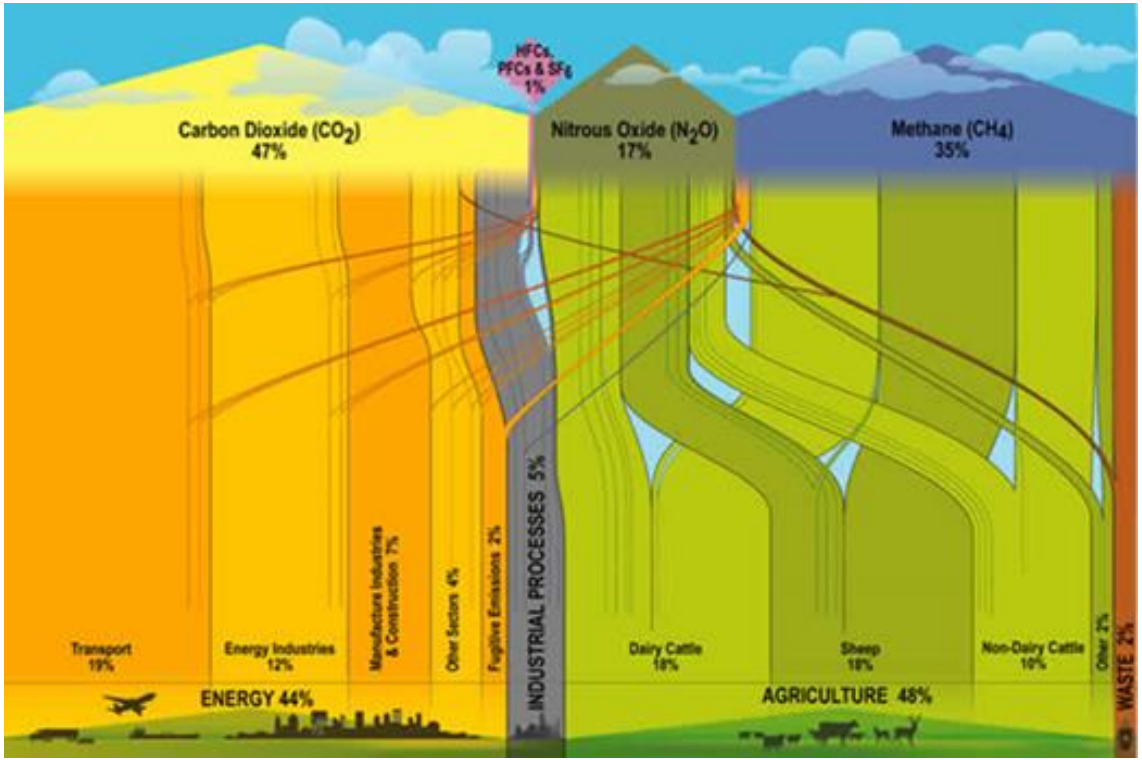
- 60,000 customers
- 2,504 high pressure gas transmission
- 4,800km low pressure gas distribution
- 40 North Island towns and cities



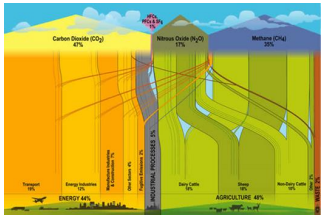
We have seen Change before

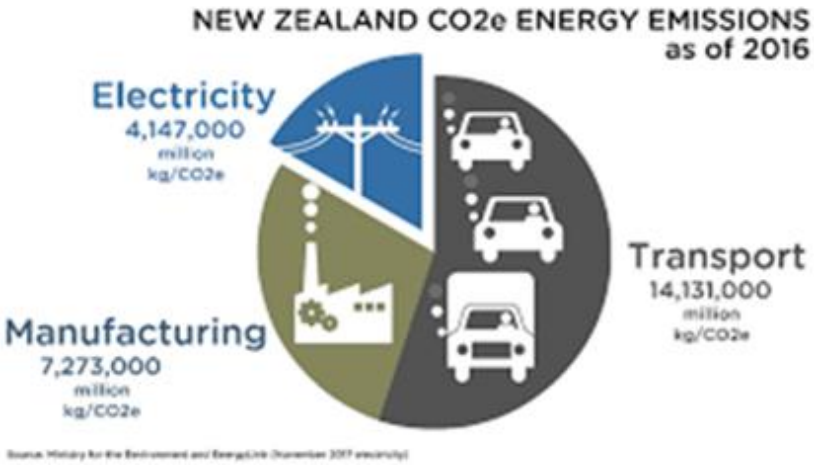


The Issue,


HFCs, PFCs & SF6 1%
Carbon Dioxide (CO_2) 47%
Nitrous Oxide (N_2O) 17%
Methane (CH_4) 35%
Transport 19%
Energy Industries 12%
Manufacture Industries & Construction 7%
Other Sectors 4%
Fugitive Emissions 2%
INDUSTRIAL PROCESSES 5%
Dairy Cattle 18%
Sheep 18%
Non-Dairy Cattle 10%
Other 2%
WASTE 2%
ENERGY 44%
AGRICULTURE 48%

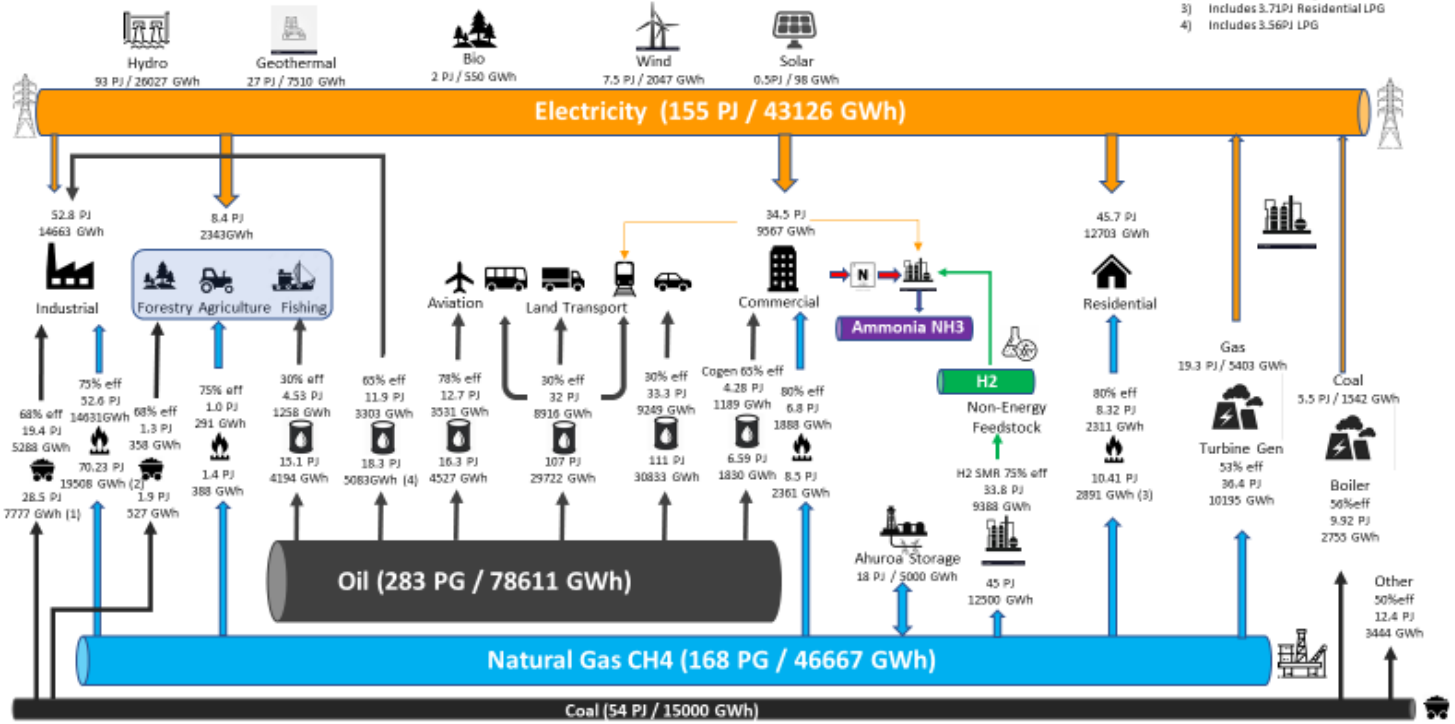
The Issue,

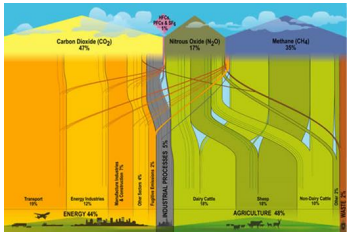


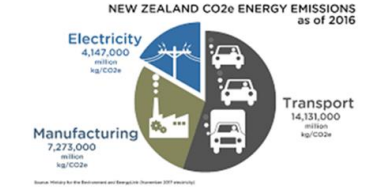

NEW ZEALAND CO2e ENERGY EMISSIONS
as of 2016
Electricity
4,147,000
million
kg/CO2e
Transport
14,131,000
million
kg/CO2e
Manufacturing
7,273,000
million
kg/CO2e

The Issue, the system,

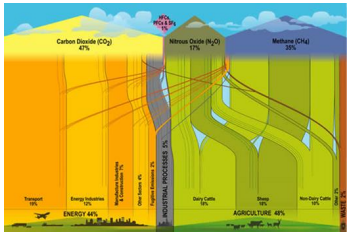
ENERGY VECTORS Electricity, Oil, Gas, Coal



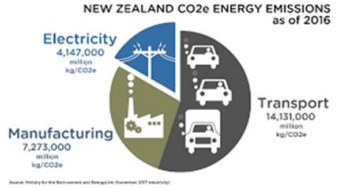


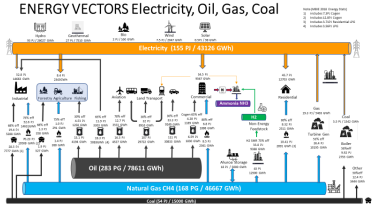


The Issue, the system, the target



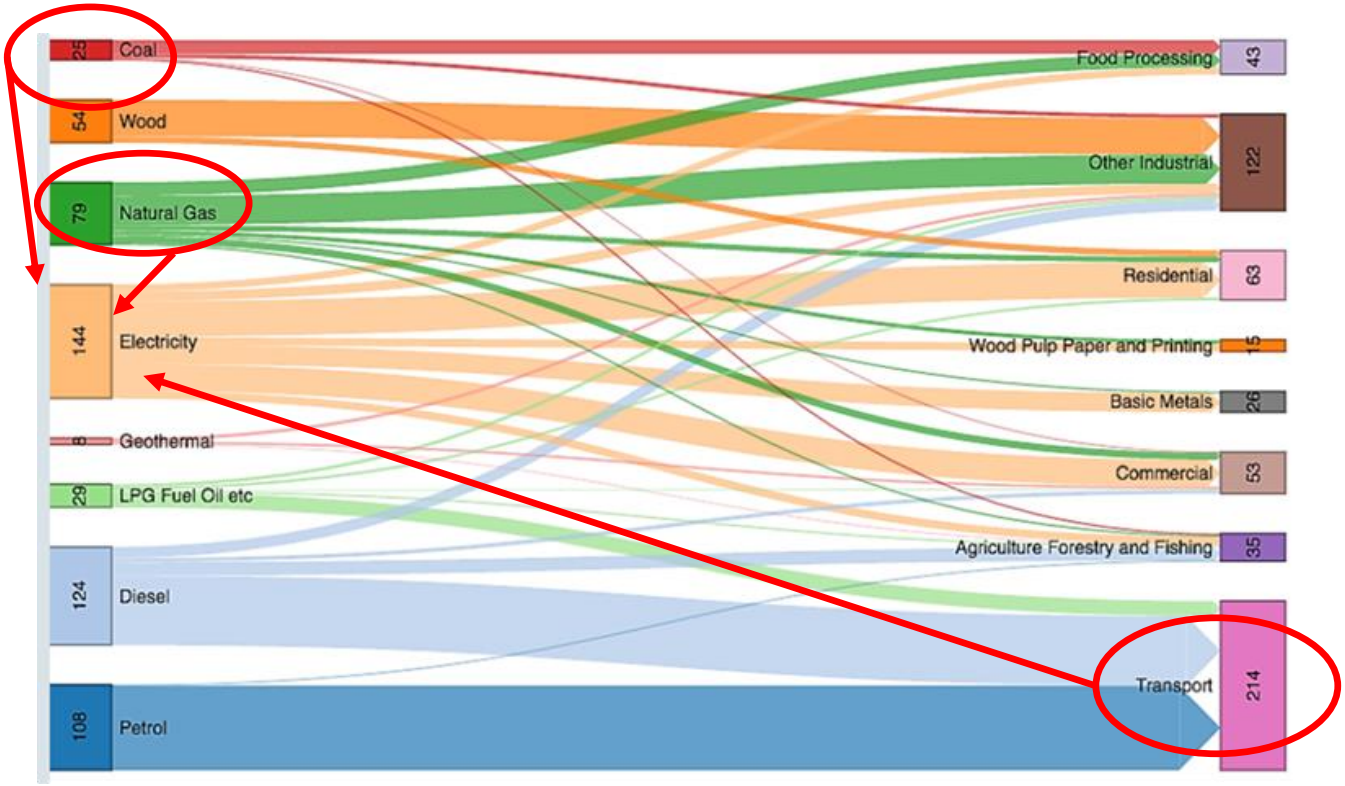
- Carbon neutral energy system
- By 2050
- Meeting dry winter
- Minimising end consumer impacts



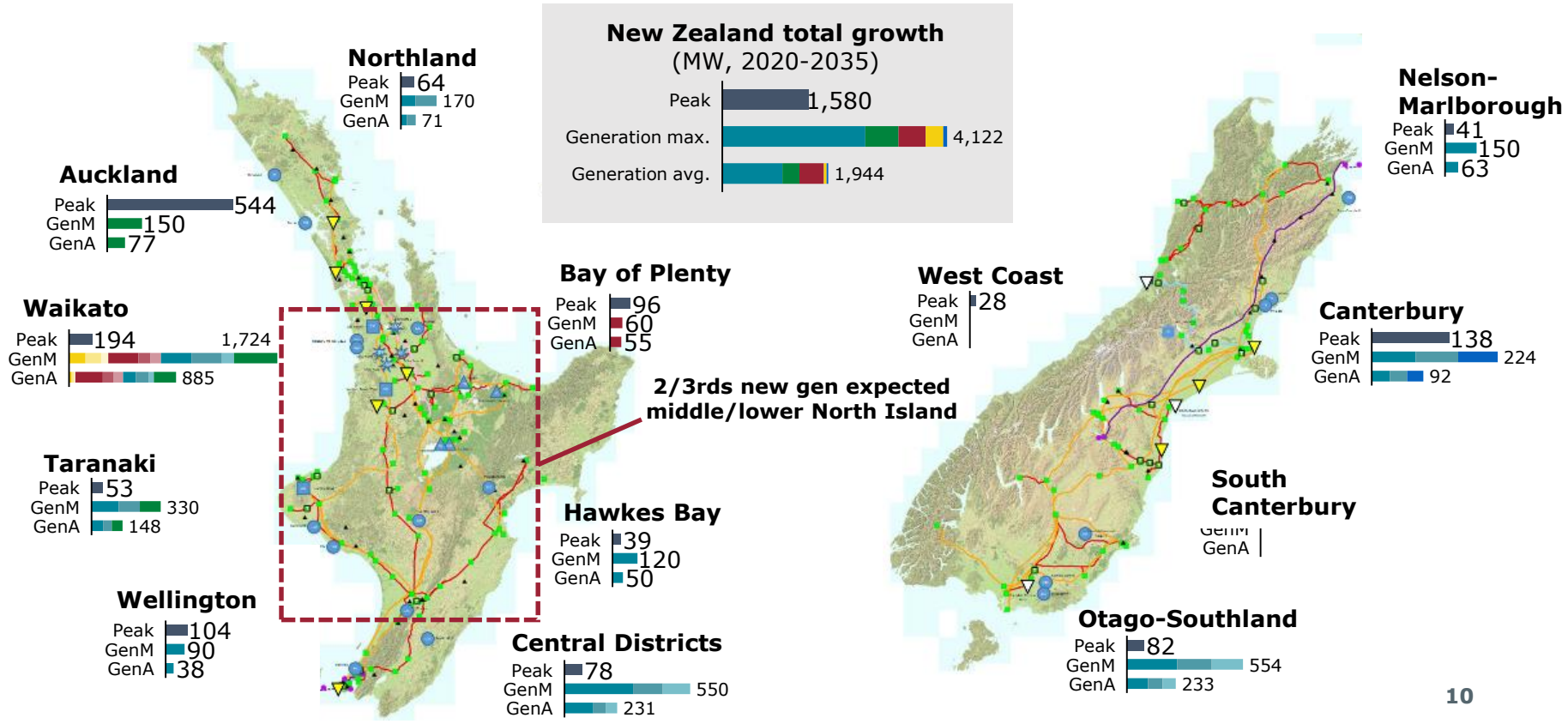


Energy Demand

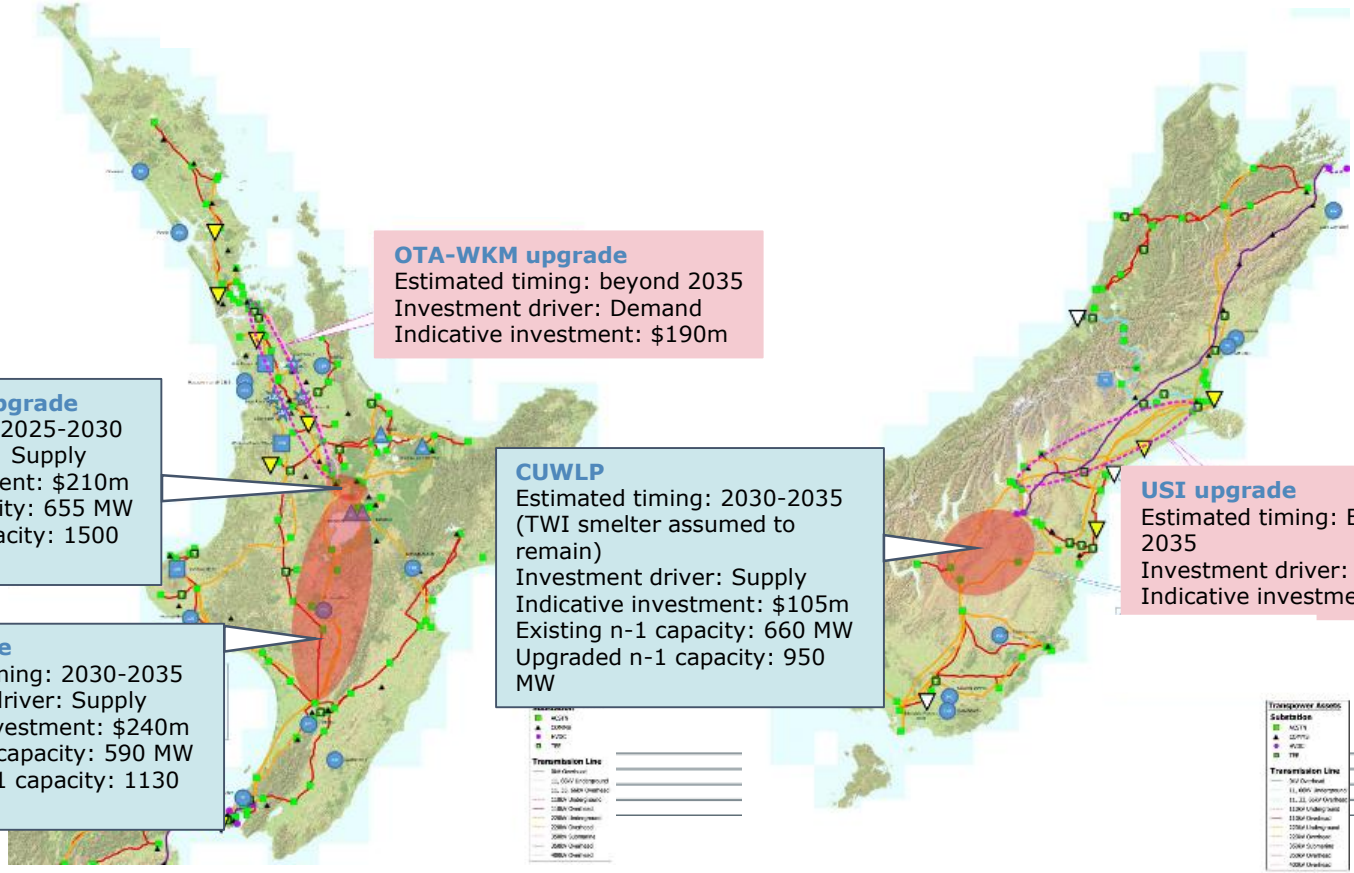
- From 44TWh to 75TWh by 2050
- 144PJ to 270PJ



Various scenarios indicating new supply likely locating near demand growth



Enabling investments to avoid constraints to new supply & demand connections



OTA-WKM upgrade
Estimated timing: beyond 2035
Investment driver: Demand
Indicative investment: $190m

Wairakei Ring upgrade
Estimated timing: 2025-2030
Investment driver: Supply
Indicative investment: $210m
Existing n-1 capacity: 655 MW
Upgraded n-1 capacity: 1500 MW

CUWLP
Estimated timing: 2030-2035 (TWI smelter assumed to remain)
Investment driver: Supply
Indicative investment: $105m
Existing n-1 capacity: 660 MW
Upgraded n-1 capacity: 950 MW

USI upgrade
Estimated timing: Beyond 2035
Investment driver: Demand
Indicative investment: $900m

CNI upgrade
Estimated timing: 2030-2035
Investment driver: Supply
Indicative investment: $240m
Existing n-1 capacity: 590 MW
Upgraded n-1 capacity: 1130 MW

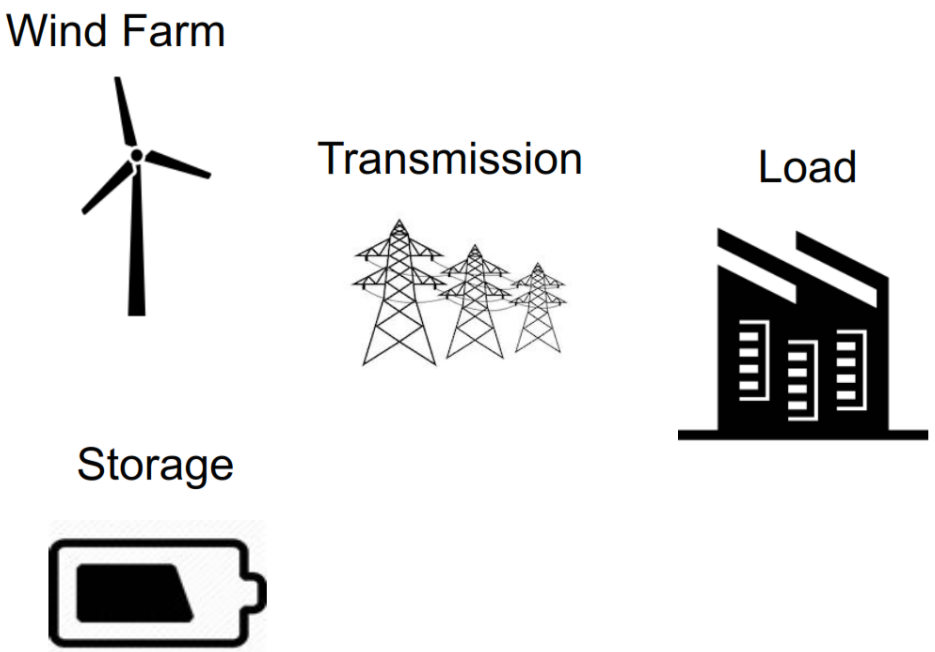
Firming Wind Farm Output

Context

- Firm up the output of a 41% CF wind farm to meet a 50 MW load at 55% & 70% availability (i.e. boost capacity factor)
- Provide 50 MW during peak hours from a 41% CF Wind farm

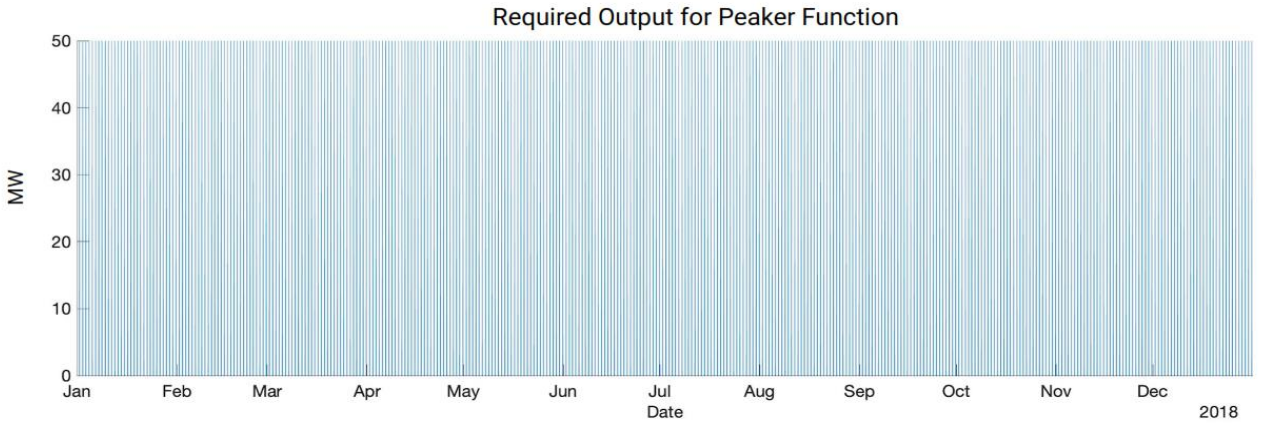
Study question

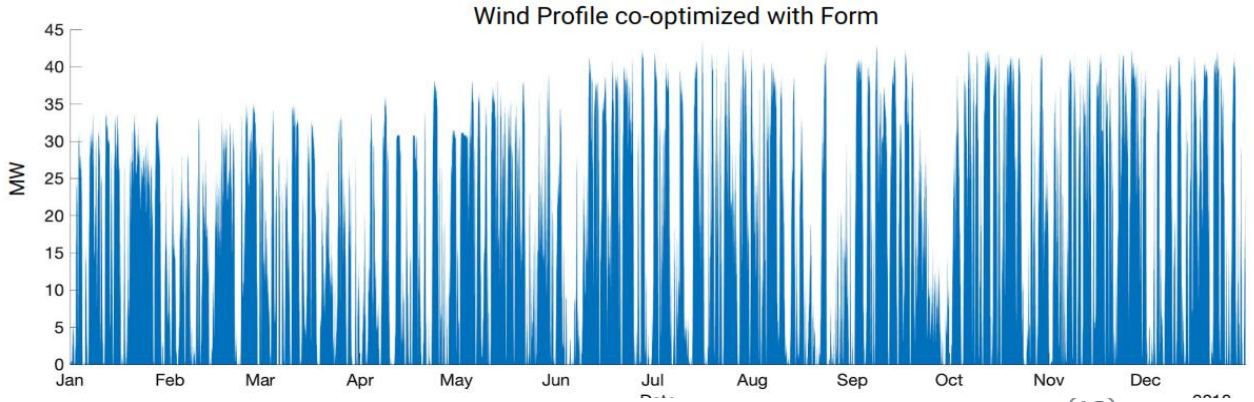
- What is the cost of a wind farm and storage solution to serve load at required availability with:
  - Long Duration Storage
  - Lithium Ion Technology



Comparison Need Vs Actual

Baseline Wind 2016 & Required Output





High Level Results

Based on results for 2016 data

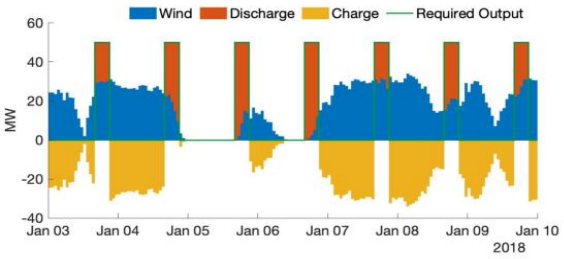
Case	Long Duration Storage			Lithium Ion		
	Wind Farm (MW)	Storage Asset (MW & MWh)	25-year Total Cost of Ownership (USD)	Wind Farm (MW)	Storage Asset (MW & MWh)	25-year Total Cost of Ownership (USD)
50 MW Load, 55% EAF	79	No Build	117,680,000	79	No Build	117,680,000
50 MW Load, 70% EAF	107	19.8 MW, 2,975 MWh	194,720,000	148	5.7 MW, 97 MWh	259,341,000
50 MW Peak Hours Load, 95% EAF	42	41 MW, 6,180 MWh	136,203,000	86	50 MW, 383 MWh	276,177,000
50 MW Peak Hours Load, 100% EAF	44	50 MW, 7,500 MWh	155,614,000	86	50 MW, 714 MWh	388,313,000

Analysis results suggest that Long Duration Storage results in lower overall total cost of ownership, by time-shifting more of the wind output to fill the gaps at a lower energy cost, as compared with a lithium ion battery.

100% Peak Load Availability

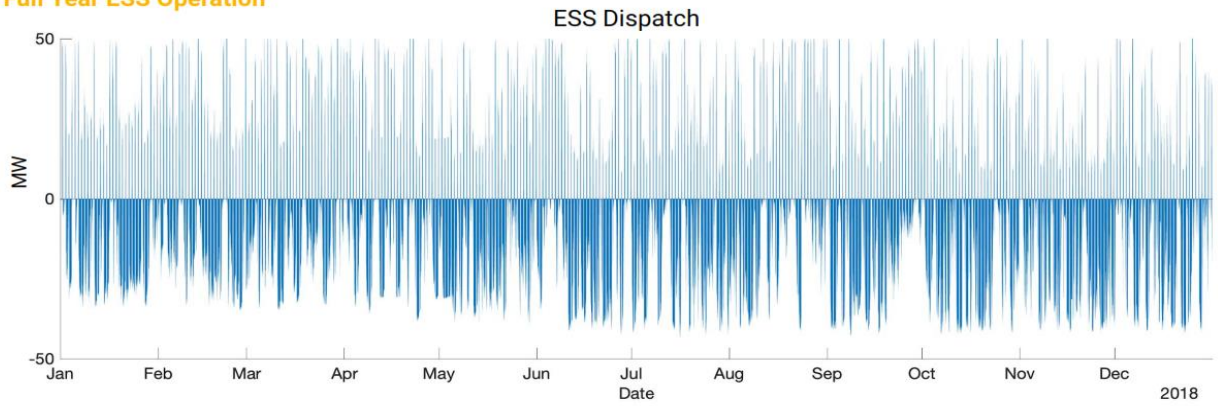
Long Duration Storage

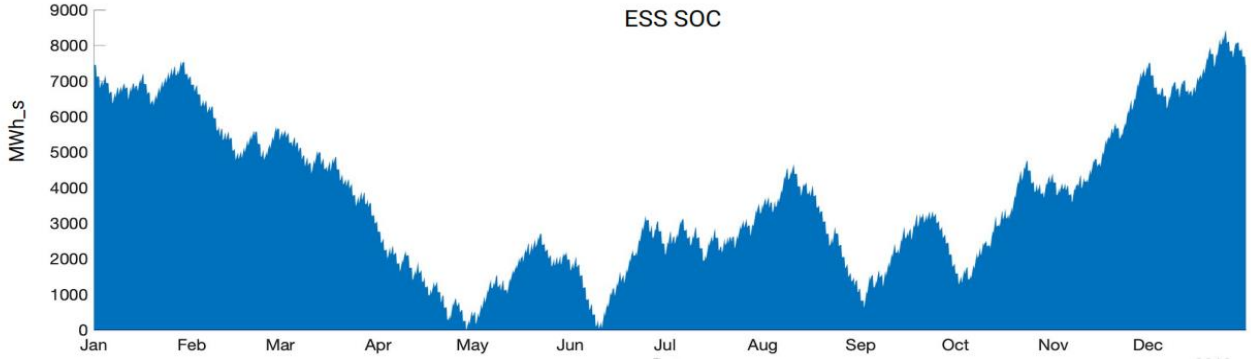
1 Week Detail: Peaker functions is achieved by optimally sizing wind and long duration storage, minimizing wind overbuild and curtailment



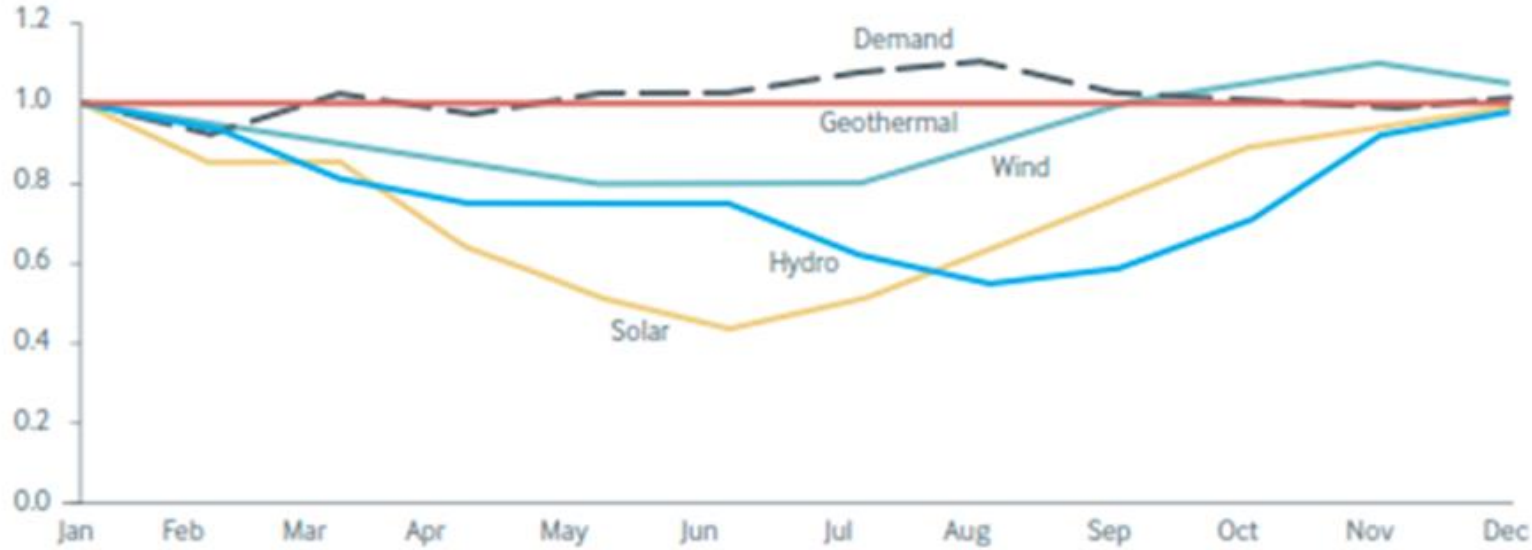
2016 Excess Energy: 0 GWh

Full Year ESS Operation

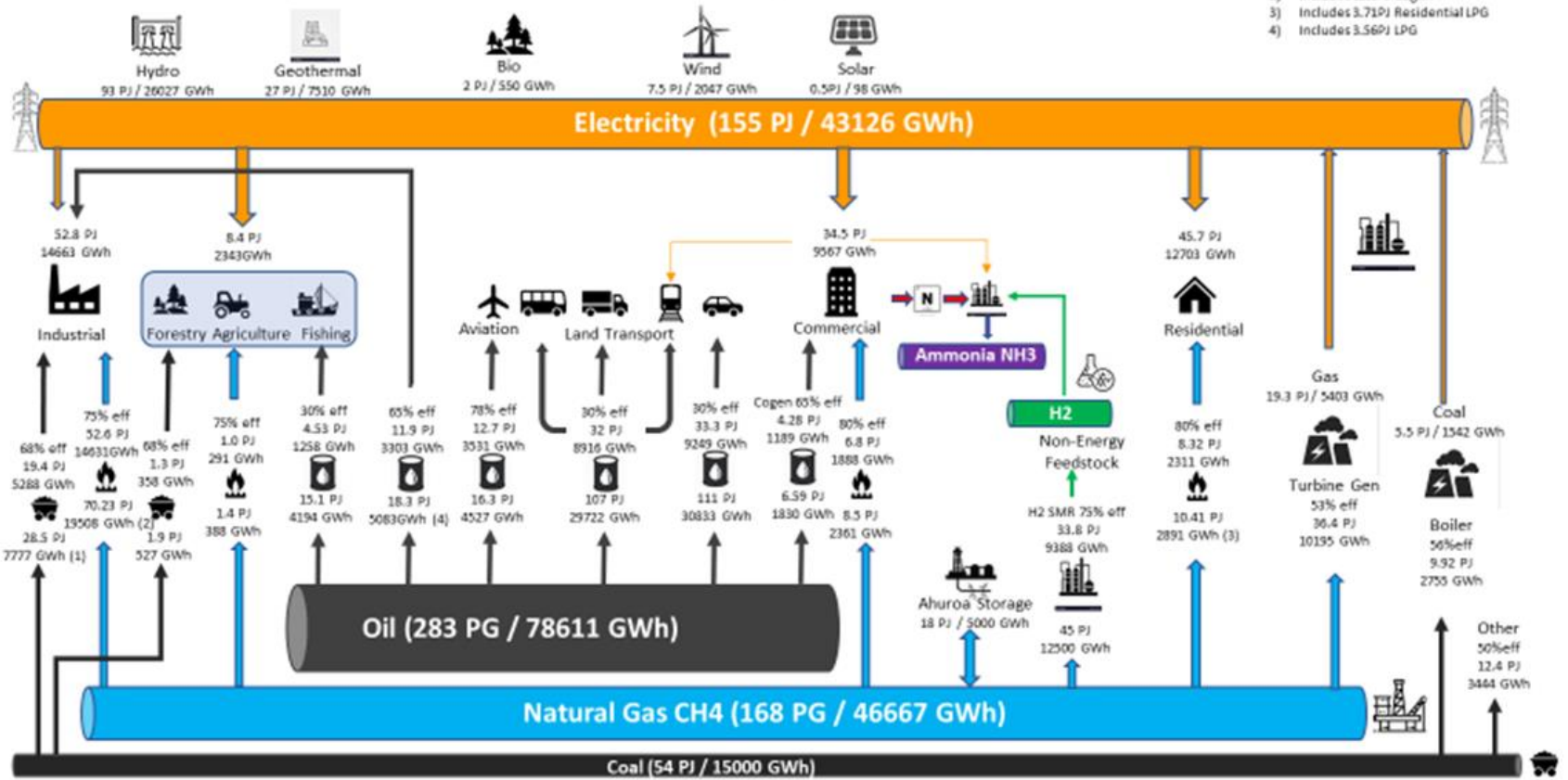




Dry Winter challenge



ENERGY VECTORS Electricity, Oil, Gas, Coal



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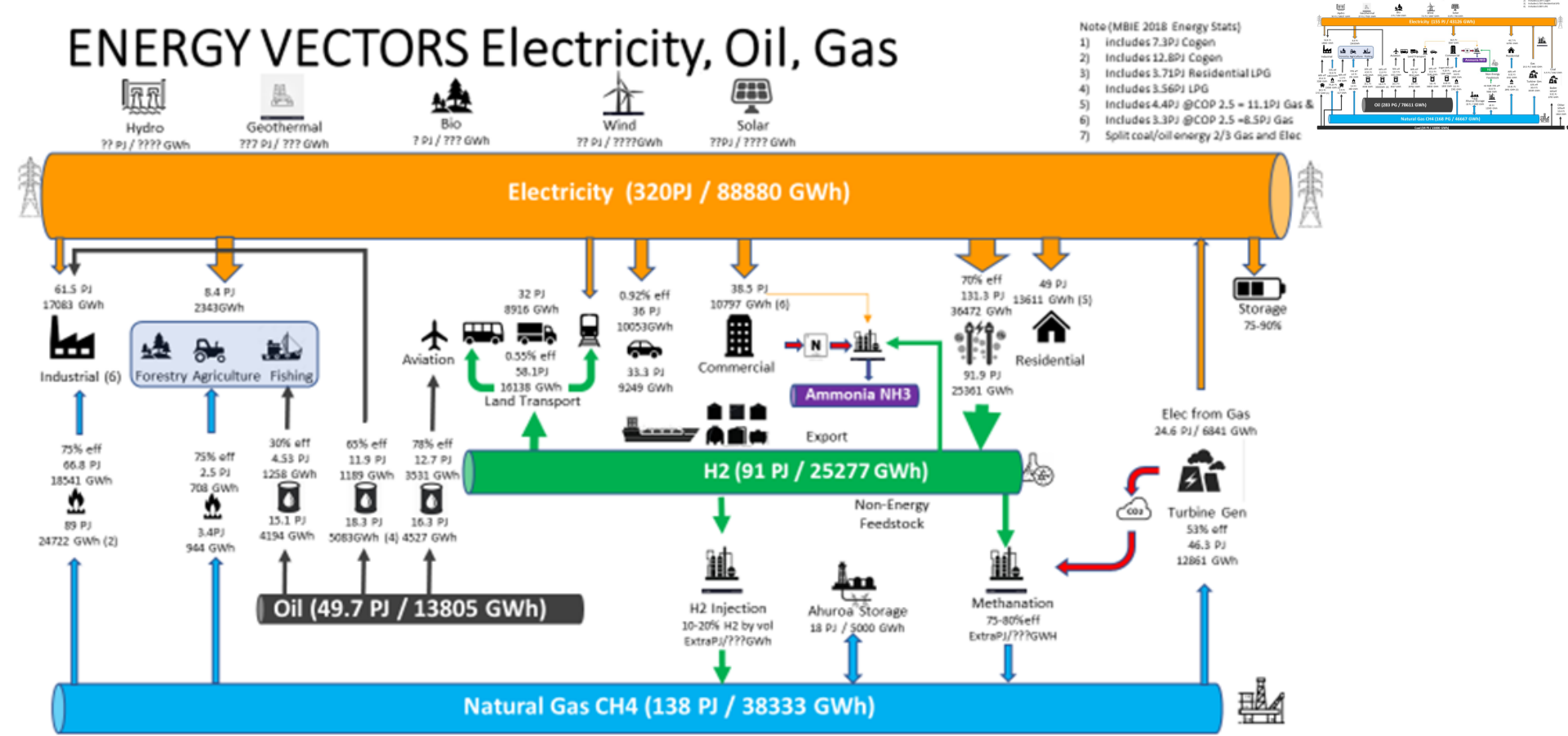

Note (MBIE 2018 Energy Stats)

1) Includes 7.3PJ Cogen
2) Includes 12.8PJ Cogen
3) Includes 3.71PJ Residential LPG
4) Includes 3.56PJ LPG
5) Includes 4.4PJ @COP 2.5 = 11.1PJ Gas &
6) Includes 3.3PJ @COP 2.5 =8.5PJ Gas
7) Split coal/oil energy 2/3 Gas and Elec

Options to meet the challenge

- Renewable overbuild

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54,824hec, NZ$7.9B, 1013 Turbines

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- Renewable overbuild
- Pumped hydro

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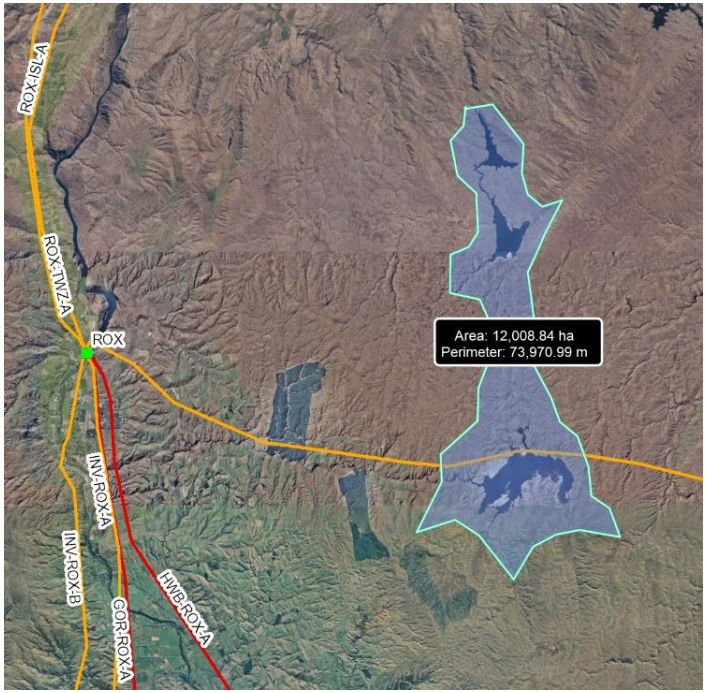

Options to meet the challenge

- Renewable overbuild

54,824hec, NZ$7.9B, 1013 Turbines

- Pumped hydro

12,000hec, NZ$3.5B, 1 Lake

Options to meet the challenge

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- Battery storage

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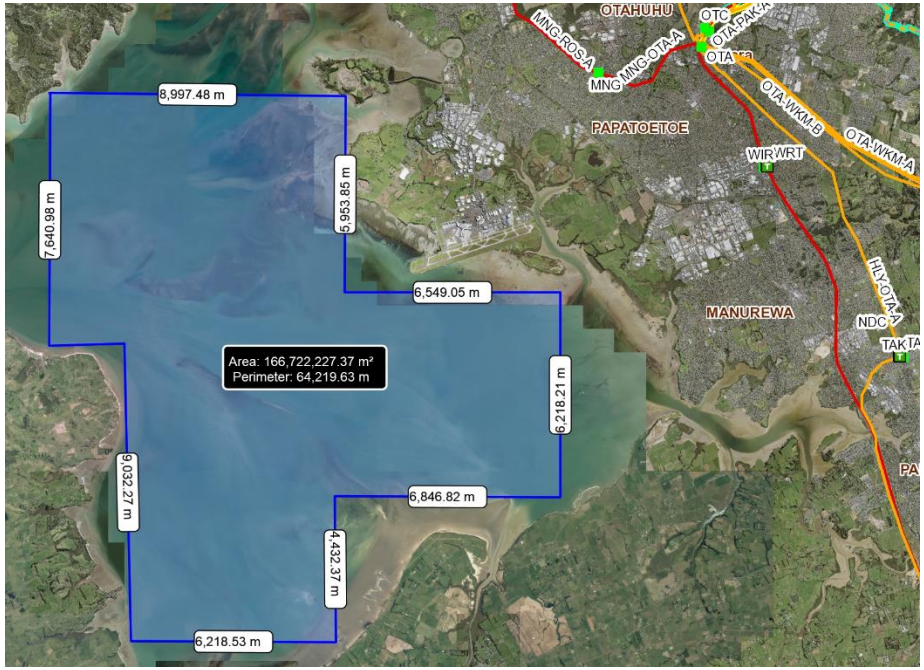


Options to meet the challenge

- Renewable overbuild
- Pumped hydro
- Battery storage

54,824hec, NZ$7.9B, 1013 Turbines

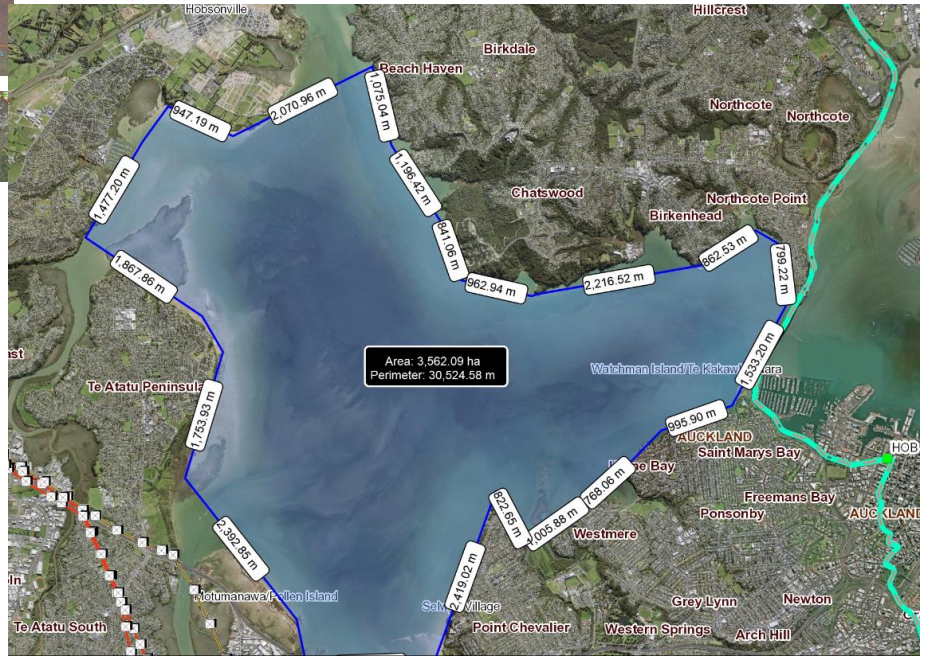
12,000hec, NZ$3.5B, 1 Lake

16,842hec, NZ$5.8T, 4.2M/2MW Packs

Options to meet the challenge

- Renewable overbuild
- Pumped hydro
- Battery storage
- H2 electrolysis H2 liquid

54,824hec, NZ$7.9B, 1013 Turbines



Options to meet the challenge

- Renewable overbuild  54,824hec, NZ$7.9B, 1013 Turbines
- Pumped hydro  12,000hec, NZ$3.5B, 1 Lake
- Battery storage  16,842hec, NZ$5.8T, 4.2M/2MW Packs
- H2 electrolysis H2 liquid  2,399hec, NZ$118B, 2,399/35k T tanks

Options to meet the challenge

- Renewable overbuild
- Pumped hydro
- Battery storage
- H2 electrolysis H2 liquid
- H2 electrolysis H2 CH4

54,824hec, NZ$7.9B, 1013 Turbines

12,000hec, NZ$3.5B, 1 Lake

Options to meet the challenge

- Renewable overbuild  54,824hec, NZ$7.9B, 1013 Turbines
- Pumped hydro  12,000hec, NZ$3.5B, 1 Lake
- Battery storage  16,842hec, NZ$5.8T, 4.2M/2MW Packs
- H2 electrolysis H2 liquid  2,399hec, NZ$118B, 2,399/35k T tanks
- H2 electrolysis H2 CH4  0hec, NZ$1.8B, 2.5 injection facilities

Options to meet the challenge

- Renewable overbuild
- Pumped hydro
- Battery storage
- H2 electrolysis H2 liquid
- H2 electrolysis H2 CH4
- H2 electrolysis H2 NH3

Options to meet the challenge

- Renewable overbuild  54,824hec, NZ$7.9B, 1013 Turbines
- Pumped hydro  12,000hec, NZ$3.5B, 1 Lake
- Battery storage  16,842hec, NZ$5.8T, 4.2M/2MW Packs
- H2 electrolysis H2 liquid  2,399hec, NZ$118B, 2,399/35k T tanks
- H2 electrolysis H2 CH4  0hec, NZ$1.8B, 6 injection facilities
- H2 electrolysis H2 NH3  190hec, NZ$7.3B, 190/35kT NH3 tanks

Options to meet the challenge

- Renewable overbuild
- Pumped hydro
- Battery storage
- H2 electrolysis H2 liquid
- H2 electrolysis H2 CH4
- H2 electrolysis H2 NH3
- H2 electrolysis H2 LOHC






Options to meet the challenge

- Renewable overbuild  54,824hec, NZ$7.9B, 1013 Turbines
- Pumped hydro  12,000hec, NZ$3.5B, 1 Lake
- Battery storage  16,842hec, NZ$5.8T, 4.2M/2MW Packs
- H2 electrolysis H2 liquid  2,399hec, NZ$118B, 2,399/35k T tanks
- H2 electrolysis H2 CH4  0hec, NZ$1.8B, 6 injection facilities
- H2 electrolysis H2 NH3  190hec, NZ$7.3B, 190/35kT NH3 tanks
- H2 electrolysis H2 LOHC  Nett 239hec, NZ$3.1B, 239/35k LOHC tanks

Focusing on the most promising

Option	NH3	CH4	LOHC	Pumped Hydro	Overbuild
Storage	NZ$7.3B	NZ$1.8B	NZ$3.1B	NZ$3.5B	-
Energy Carrier	NZ$1.3B	NZ$1.5B	NZ$0.8B	-	-
Extra Gen	NZ$3.8B	NZ$3.3B	NZ$3.8B	NZ$1.5B	NZ$8B
TOTAL	**NZ$12.B**	**NZ$6.7B**	**NZ$7.8B**	**NZ$5B**	**NZ$8B**

Option (NPV)	NH3	CH4	LOHC	Pumped Hydro	Overbuild
Storage	NZ$2.3B	NZ$0.18B	NZ$1.5B	NZ$2.2B	-
Energy Carrier	NZ$0.07B	NZ$0.08B	NZ$0.04B	-	-
Extra Gen	NZ$0.35B	NZ$0.31B	NZ$0.36B	NZ$0.14B	NZ$0.75B
TOTAL	**NZ$2.72B**	**NZ$0.57B**	**NZ$1.9B**	**NZ$2.3B**	**NZ$0.75B**

Focusing on the most promising

This is the value of using

- Modular and Scalable solutions matching build to need over time
- Repurposing existing “Sunk Cost” assets

Option (NPV)	NH3	CH4	LOHC	Pumped Hydro	Overbuild
Storage	NZ$2.3B	NZ$0.18B	NZ$1.5B	NZ$2.2B	-
Energy Carrier	NZ$0.07B	NZ$0.08B	NZ$0.04B	-	-
Extra Gen	NZ$0.35B	NZ$0.31B	NZ$0.36B	NZ$0.14B	NZ$0.75B
TOTAL	**NZ$2.72B**	**NZ$0.57B**	**NZ$1.9B**	**NZ$2.3B**	**NZ$0.75B**

NZ$5-8B is a lot over 20 years but so is annual…

- NZ exports NZ$80B
- Land transport fuel imports NZ$6B
- Roading spend NZ$1.8B
- Land transport air pollution NZ$1.4B
- Electricity consumption NZ$7.7B

Other factors to consider

	NH3	CH4	LOHC	Pumped Hydro	Overbuild
Positive	Moderate Known Tech Modular/Scalable	Minimal Known Tech Utilises Existing Modular/Scalable Repurposes existing assets	Moderate Std Petro chem Modular/Scalable Enables innovative finance and energy for export Repurposes existing assets	Large Scale Established Tech	Large Scale Business as Usual Can make sustainable pipeline of work Modular/Scalable
Negative	Known but not at this sclae		New Tech	Consents Environmental Implications 40m operating range Single large scale	Large

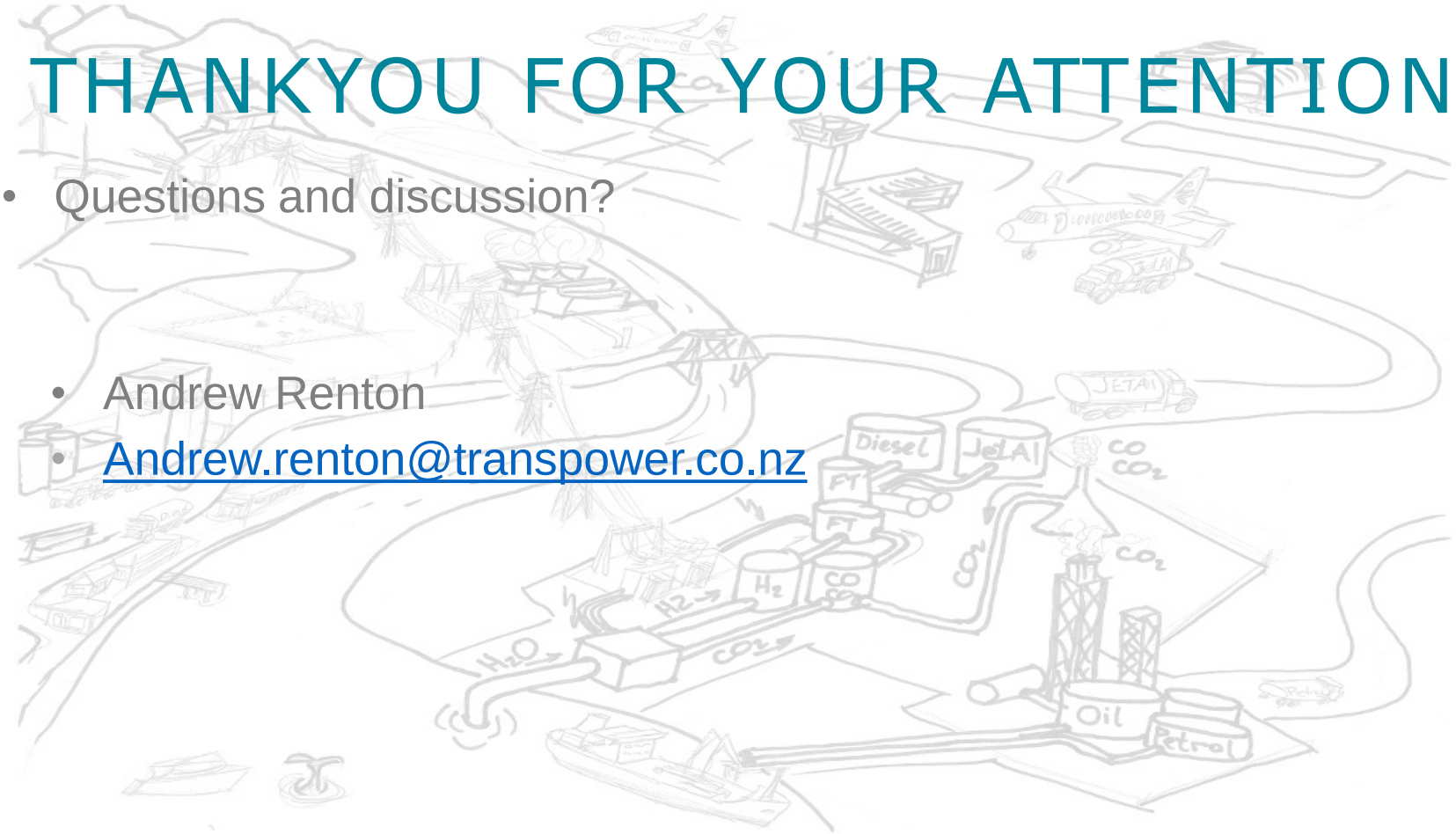
Is there a practical solution we can afford?

- YES, it will be a mix of
  - Energy efficiency
  - Demand response
  - Various Energy Vectors, storage options, type and scale
  - Modular and scalable
  - Repurposing existing assets required for H2 Vector economics
  - Falling storage costs improve dispatchability renewables
- Need for a wider systems view identifying all costs and benefits including wider community and intangibles

THANKYOU FOR YOUR ATTENTION

- Questions and discussion?

  - Andrew Renton
  - Andrew.renton@transpower.co.nz



We're for New Zealand.

Tū mai Aotearoa.