TIMES-NZ energy model and scenarios

- University of Auckland Energy Economics Summer School
- 21st February 2024
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ENERGY EFFICIENCY & CONSERVATION AUTHORITY

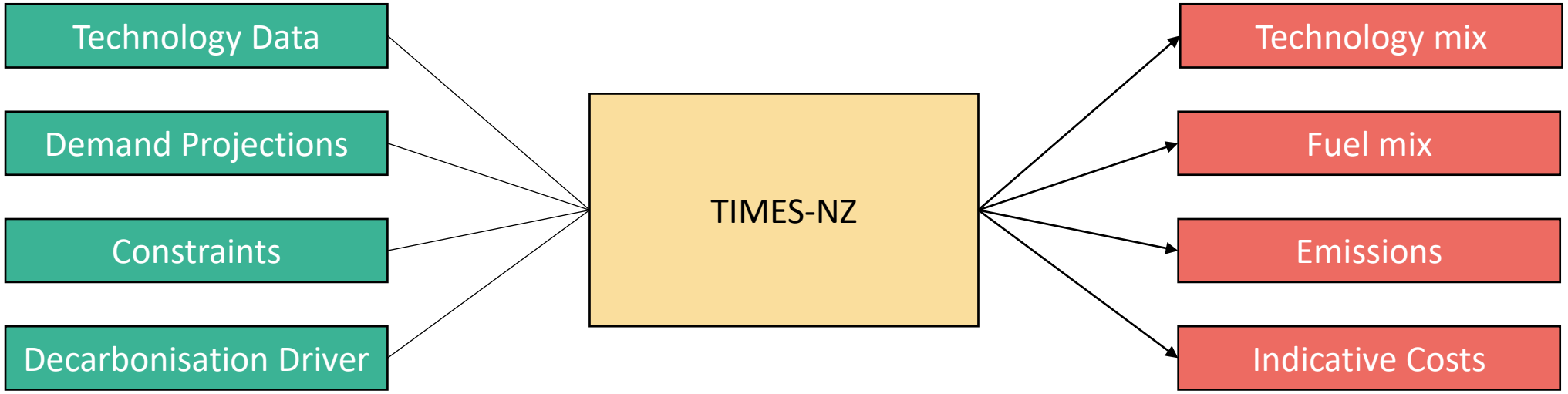
Contents

- The model (structure + start point)
- The scenarios (inputs)
- Outputs – Kea and Tūī
- Outputs – Sensitivity studies
- Current and future work

The model

The TIMES-NZ model

- **A least-cost optimisation model – meaning any constraint will add cost**
- **Perfect foresight**
- **Considers ‘energy service demand’ by sector and subsector – based on economic or population data**
- **Energy service demand can be met by various fuel and technology options going forwards**
- **Technology costs and primary fuel costs are inputs, but electricity cost is calculated in the model**



The TIMES-NZ model – Sectors and sub-sectors

Residential

Detached Dwellings
Joined Dwellings

Commercial

Education
Healthcare
Office blocks
Warehouses Supermarkets and Retail (WSR)
Other

Transport

Light road
Heavy road
Aviation
Shipping
Rail

Industry

Aluminium
Construction
Dairy Product Manufacturing
Food Processing
Iron/Steel Manufacturing
Meat Processing
Metal Product Manufacturing
Methanol Production
Mineral Production
Mining
Petroleum/Chemicals
Refining of petroleum products
Urea Production
Wood Product Manufacturing
Wood Pulp and Paper Processing

Agriculture, Forestry, and Fishing

Dairy Farming
Livestock Farming
Outdoor Horticulture & Arable Farming
Indoor Cropping
Forestry
Fishing

Time periods and time slices

- **Time periods**
  - 2018 (1 yr.), 2019-2022 (4 yr.), 2023-27 (5 yr.), … , 2058-2062 (5 yr.)
  - Everything is the same for each year in these periods
- **Time slices**
  - 4 seasons
  - 2 types of day (weekday and weekend)
  - 3 periods during the day (day, peak and night)
    - Day = 7am-6pm (11 hrs), peak = 6pm-7pm (1 hr), night = 7pm-7am (12 hrs)

Key inputs

- Fixed costs – CAPEX ($/kW), fixed O&M
- Variable costs – Fuel costs, variable O&M, carbon price
- Availability (capacity) factors
  - Annual, and by time slice
- Process efficiencies

The scenarios

The TIMES-NZ model - Scenarios

Kea

Kea represents a scenario where climate change is prioritised as the most pressing issue and New Zealand deliberately pursues cohesive ways to achieve a low-emissions economy.

Tūī

Tūī represents a scenario where climate change is an important issue to be addressed as one of many priorities, with most decisions being left up to individuals and market mechanisms.

The TIMES-NZ model - Scenarios

1. GDP growth, and sub-sector growth
2. Population
3. Discount rate for energy demand technologies
4. Wind cost projections
5. Solar cost projections
6. Solar development capacity
7. Hydro development capacity
8. Methanex, Urea, and Tiwai exit dates
9. Charging patterns of Electric Vehicles
10. Projected EV year of cost parity with internal combustion engine vehicles
11. Passenger transport demand
12. Freight transport demand
13. EV import limitations
14. Li-Ion battery cost
15. Electrolyser cost projections
16. Fuel cell cost projections
17. Carbon price

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1. GDP

- **An ‘default’ level of GDP growth (per scenario)**
- **Tailored values for sub-sectors (per scenario – only Kea shown here)**
- **A resulting ‘composite’ GDP (as per website)**

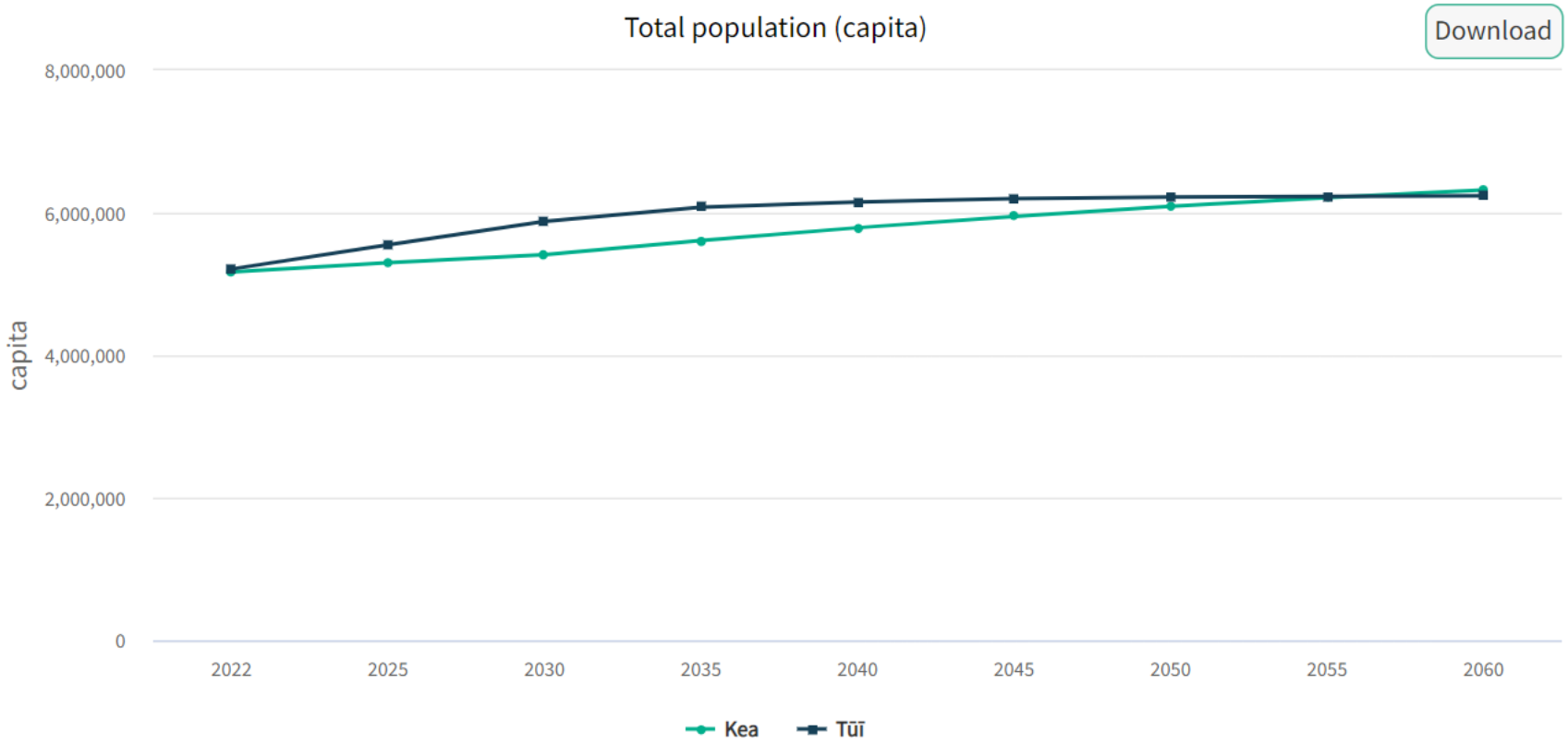
	2020	2025	2030	2035	2040	2045	2050	2055	2060
Kea	2.0%	2.0%	2.0%	2.5%	2.5%	3.0%	3.0%	3.0%	3.0%
Tūī	4.0%	4.0%	4.0%	2.5%	2.5%	1.0%	1.0%	1.0%	1.0%

Table 6: Industrial sub-sector growth assumptions, Kea

TIMES-NZ 2.0 industrial sub-sector	2020	2025	2030	2035	2040	2045	2050	2055	2060
National economy growth stage	Low growth			Transition		High growth			
Other Food Processing	2%	2%	2%	2.5%	2.5%	3%	3%	3%	3%
Wood Product Manufacturing	2.7%	2.7%	2.7%	2.5%	2.5%	3%	3%	3%	3%
Metal product Manufacturing	-1.2%	-1.2%	-1.2%	2.5%	2.5%	3%	3%	3%	3%
Petroleum/Chemical Product Manufacturing	-10%	-10%	-10%	0%	0%	0%	0%	0%	0%
Mineral, Mining, Construction, Other	0.6%	0.6%	0.6%	2.5%	2.5%	3%	3%	3%	3%

2. Population

- **Drives residential, some commercial, some transport**



2. Population

“How big and fast will New Zealand grow in the future? … It is worth pointing out that some of the growth projections have not been particularly accurate. In 2004, they were that New Zealand would reach a **population of 5 million in 2050**. As it has turned out, it has reached that mark 30 years earlier than originally expected, in March 2020. The growth in numbers as a result of very high net immigration gains during 2013-18 changed matters.”

Paul Spoonley, *The New New Zealand*, p. 46

3. Discount rates

- **Kea = 2.5%**
- **Tūī = 5% except biomass and hydrogen at 2.5%**

8. Methanex, Urea, and Tiwai exit dates

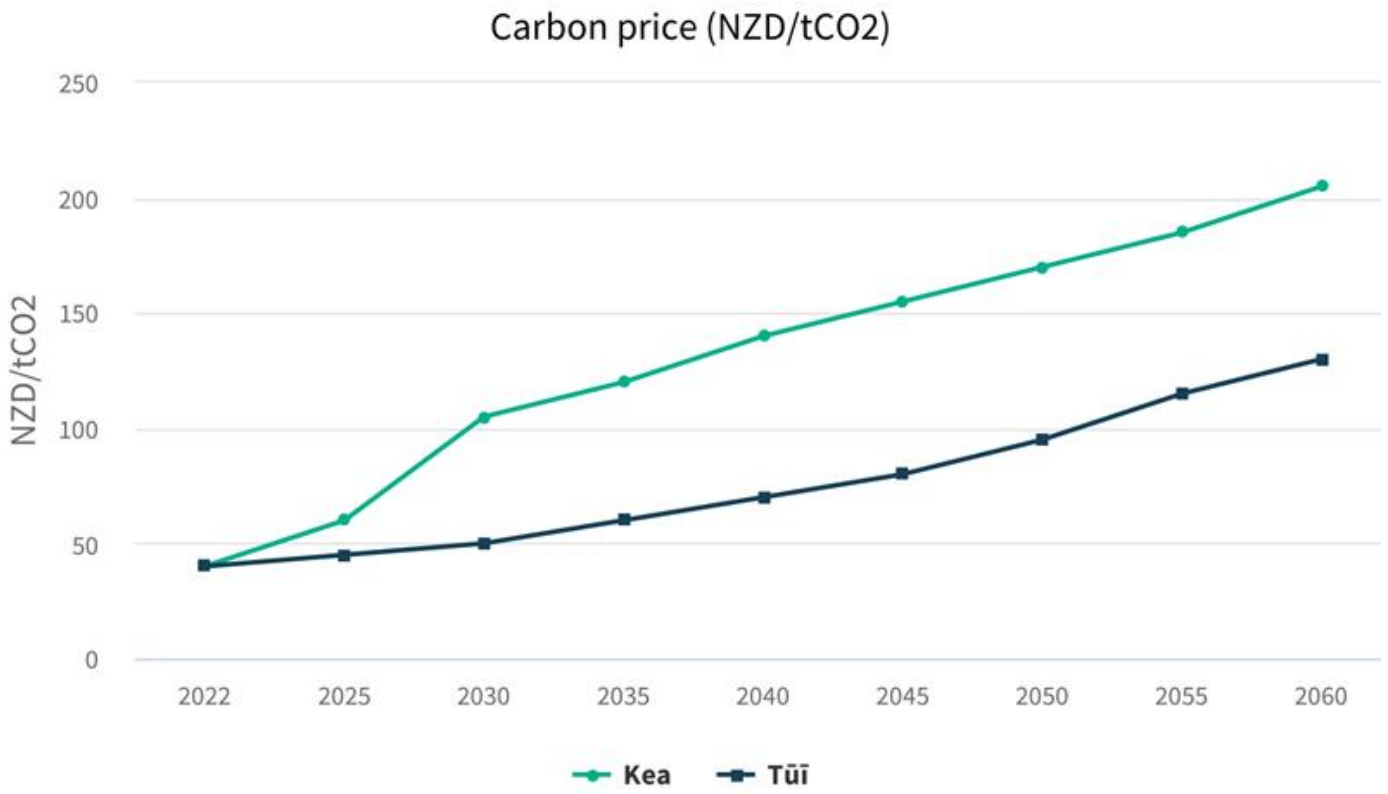
- Kea
  - Methanex exits in 2032
  - Urea exits in 2027
  - Tiwai exits in 2027
- Tūī
  - Methanex exits in 2047
  - Urea stays
  - Tiwai stays (or is replaced by an equivalent exogenous demand)
- Note 2032 Methanex exit has significant impact on gas for electricity (probably)

11. Passenger transport demand

- Kea based on “Staying Close to the Action”
- Tūī based on “Golden Triangle”
- VKT/capita calculated from MoT projections (which include population)
- VKT in Kea and Tūī based on population projections in those scenarios
- Note BEC “Energy Strategy Deep Dive” paper tested Tūī (Golden Triangle) VKT/capita in Kea. Significant impact.

- VKT = vehicle kilometres travelled

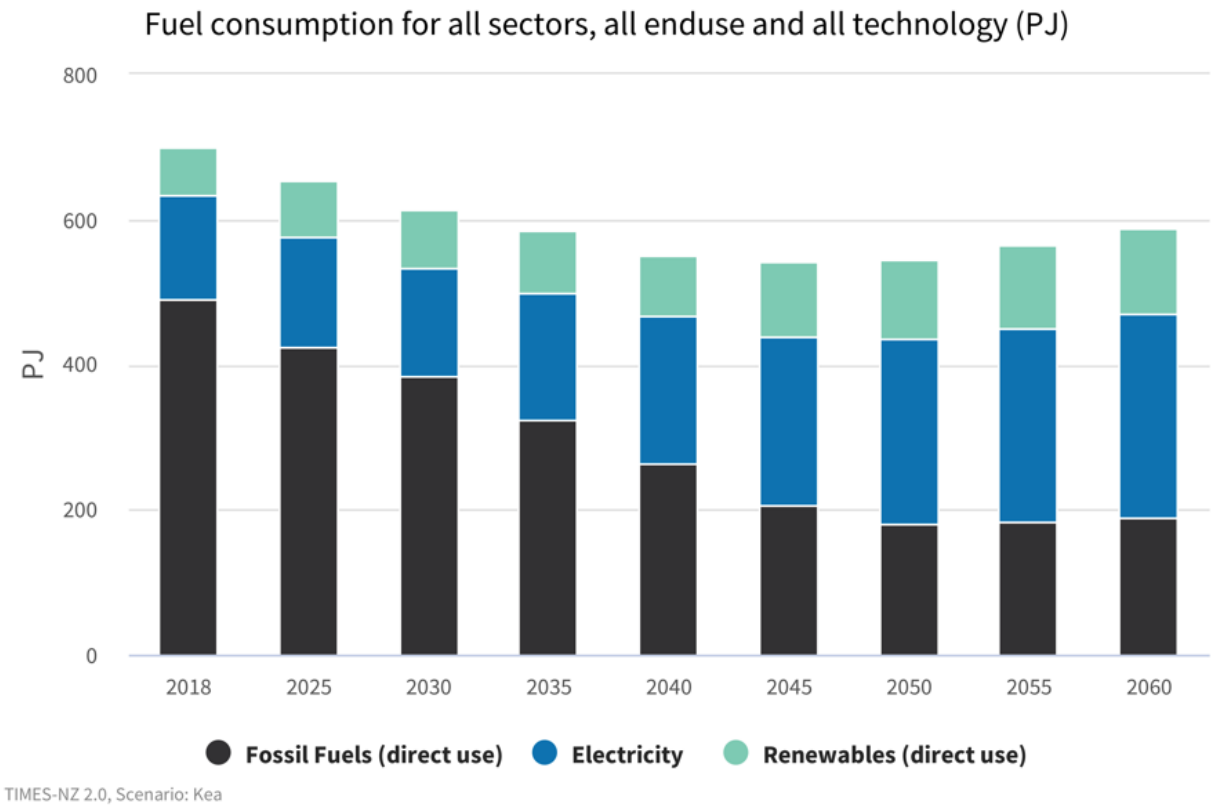
17. Carbon price



Outputs – Kea and Tūī

All sectors

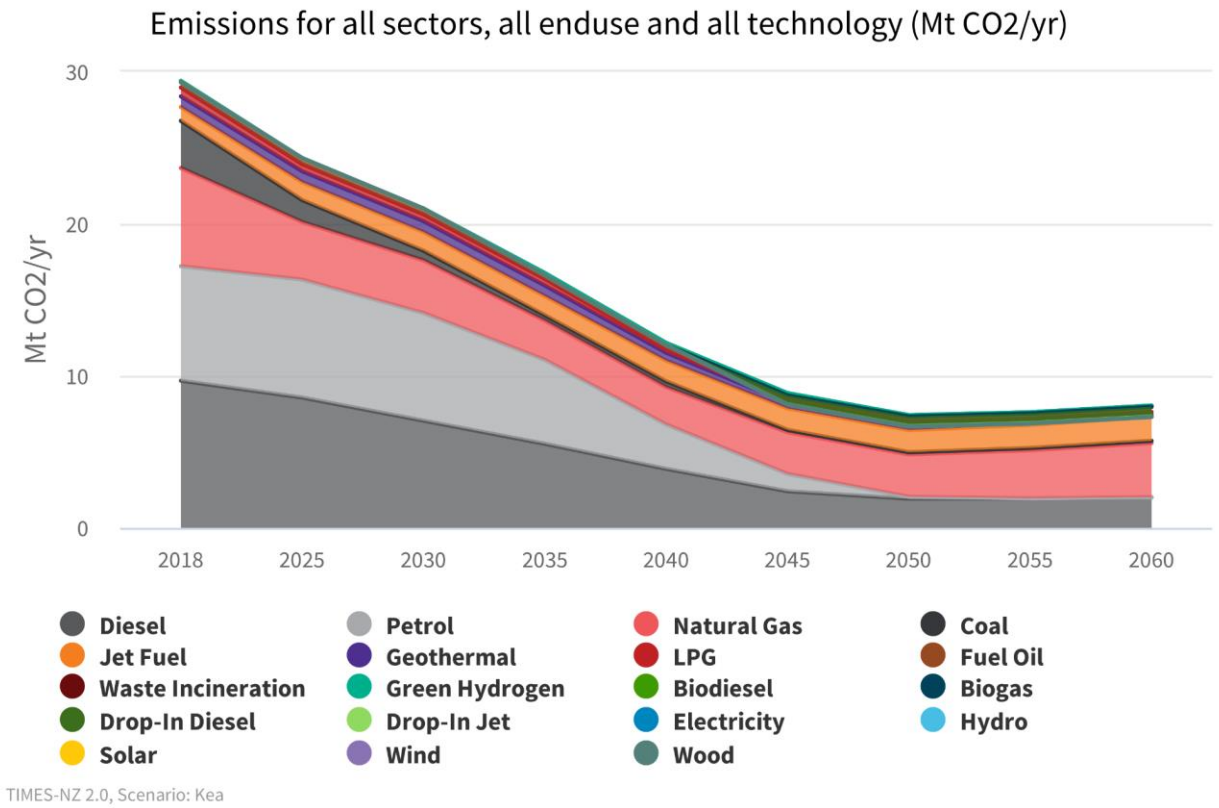
What and how much energy might we consume?



TIMES-NZ 2.0, Scenario: Kea

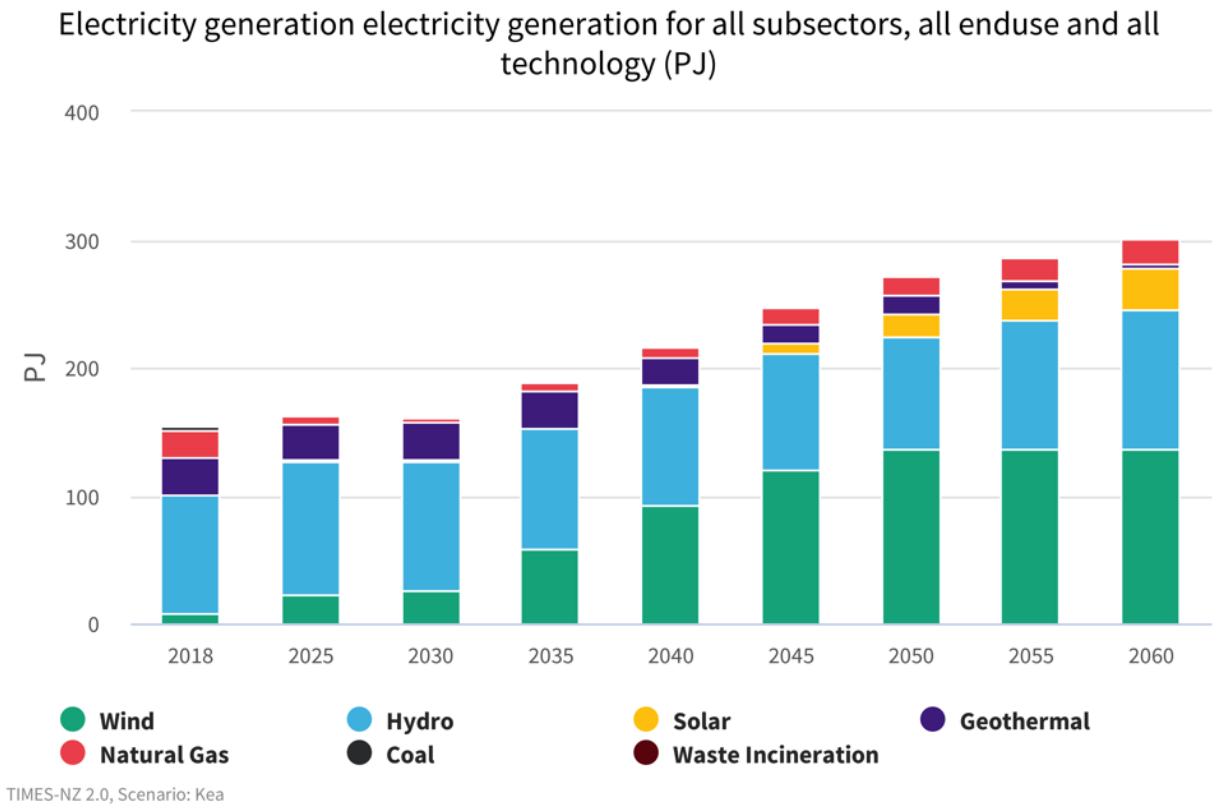
All sectors

What might our energy-related emissions profile look like?



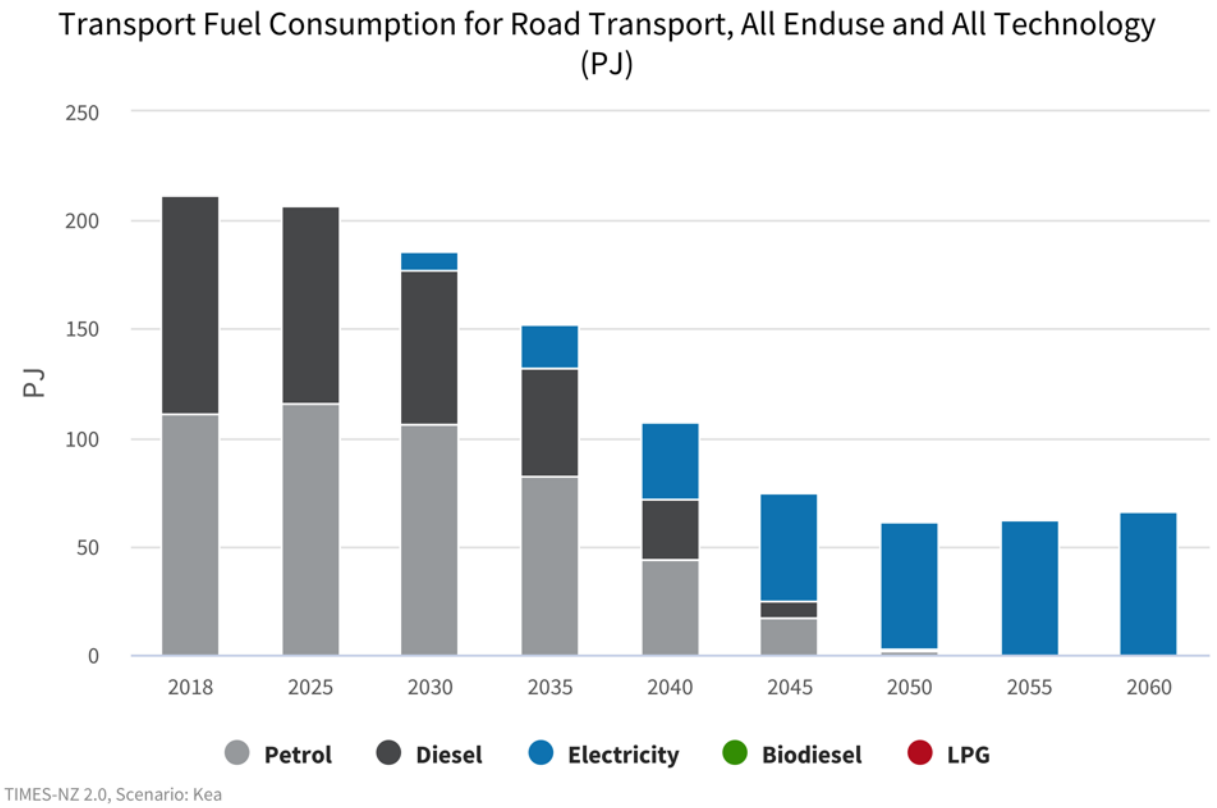
Electricity generation

What might electricity generation look like?



Transport

How might road transport look?



Transport

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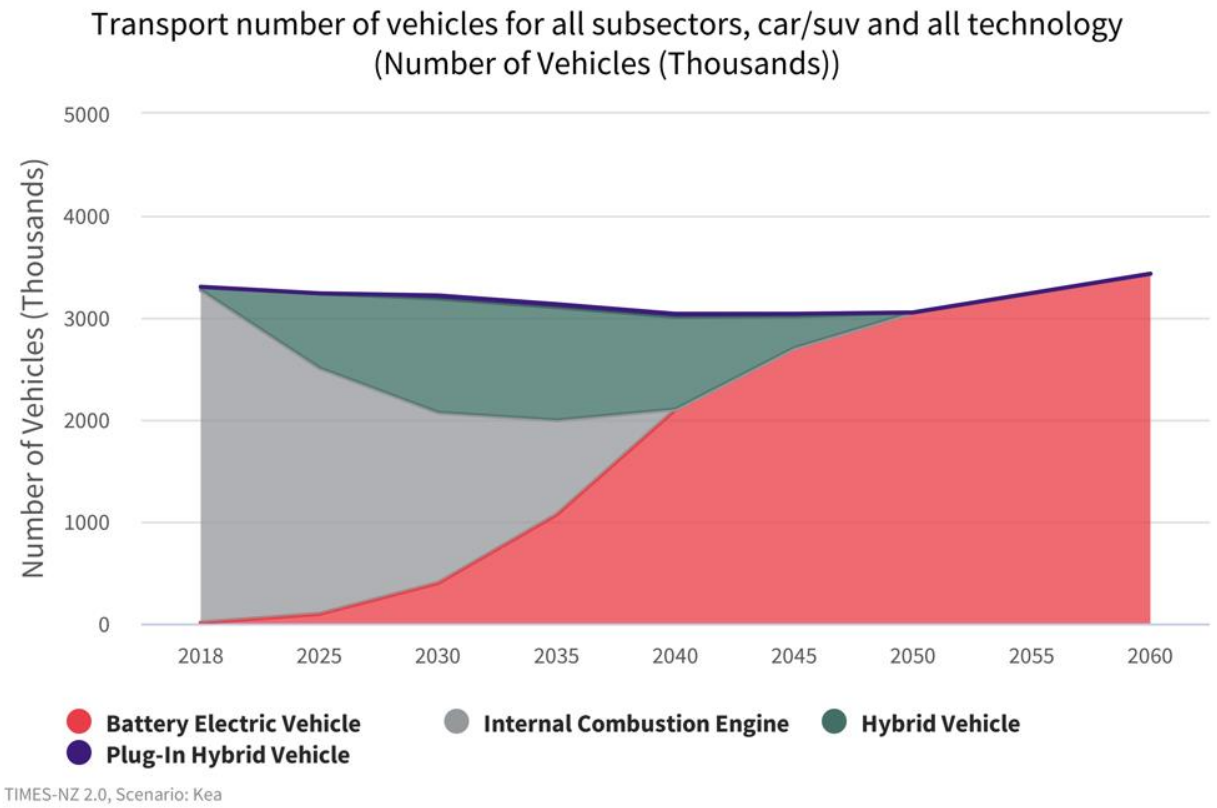
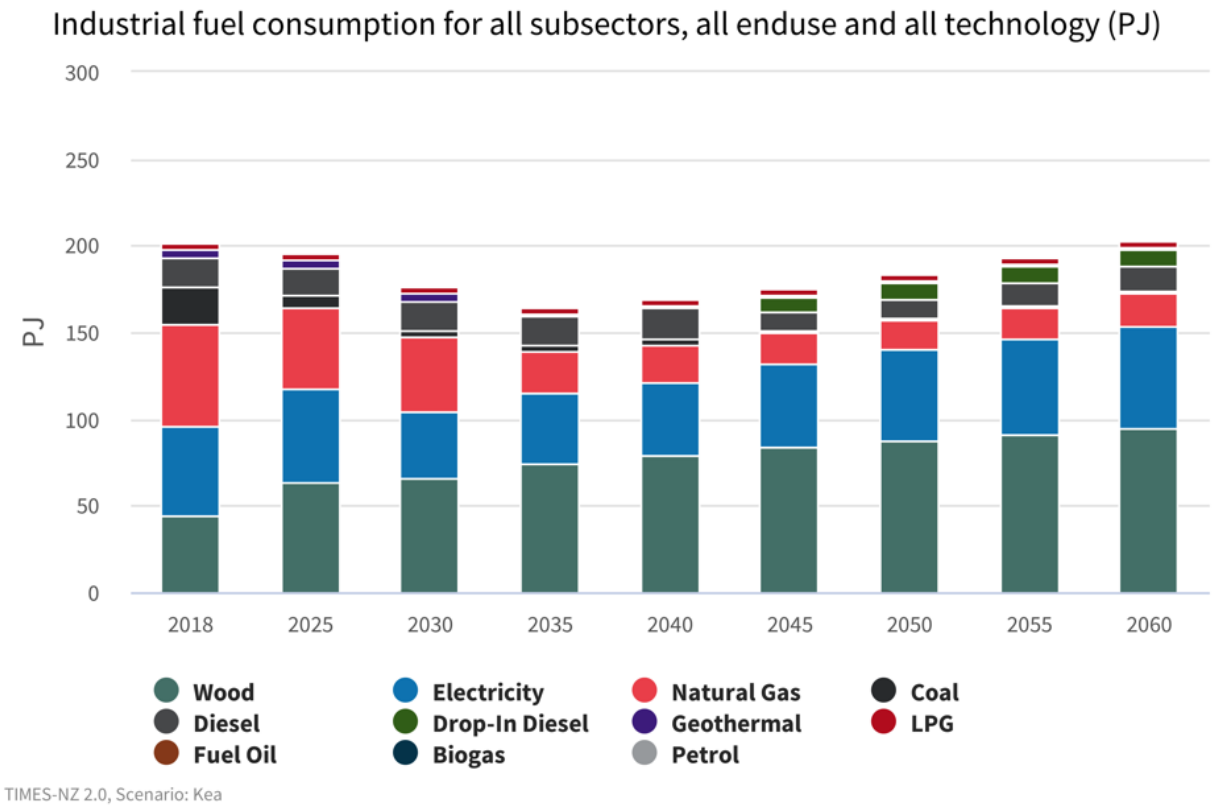


Industry

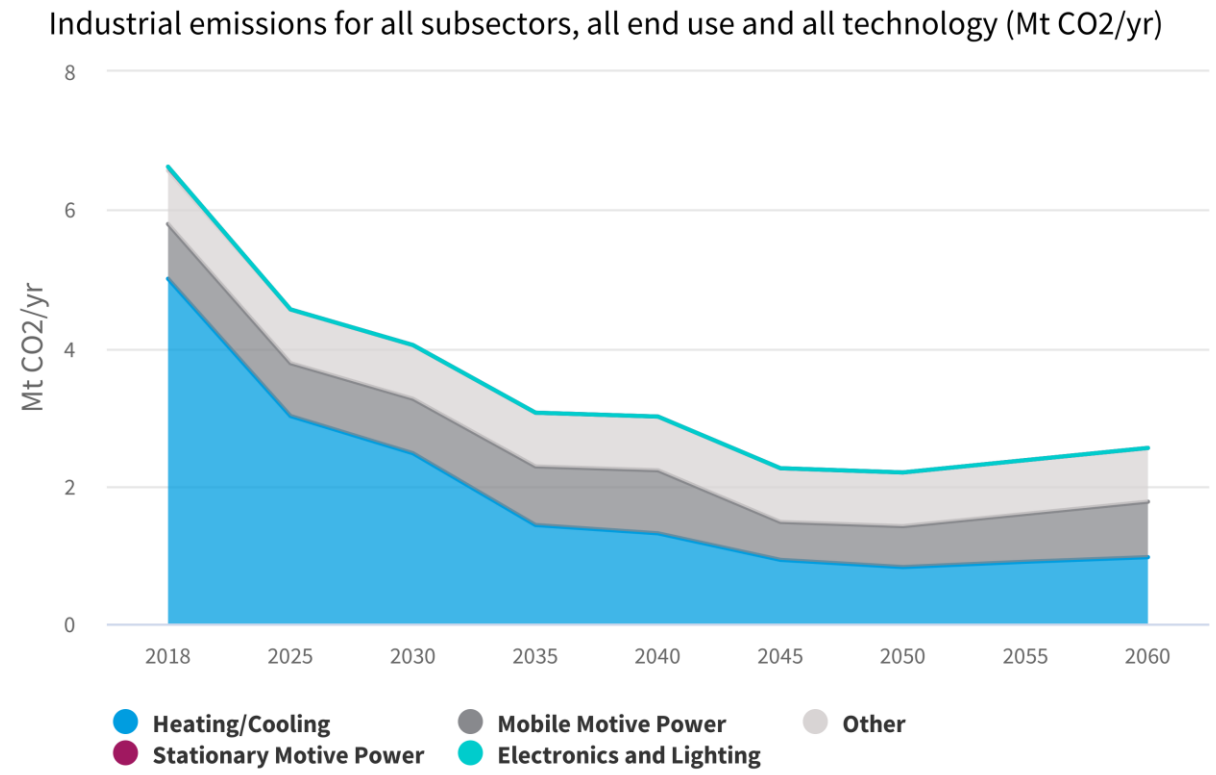
What fuels might industry use?



TIMES-NZ 2.0, Scenario: Kea

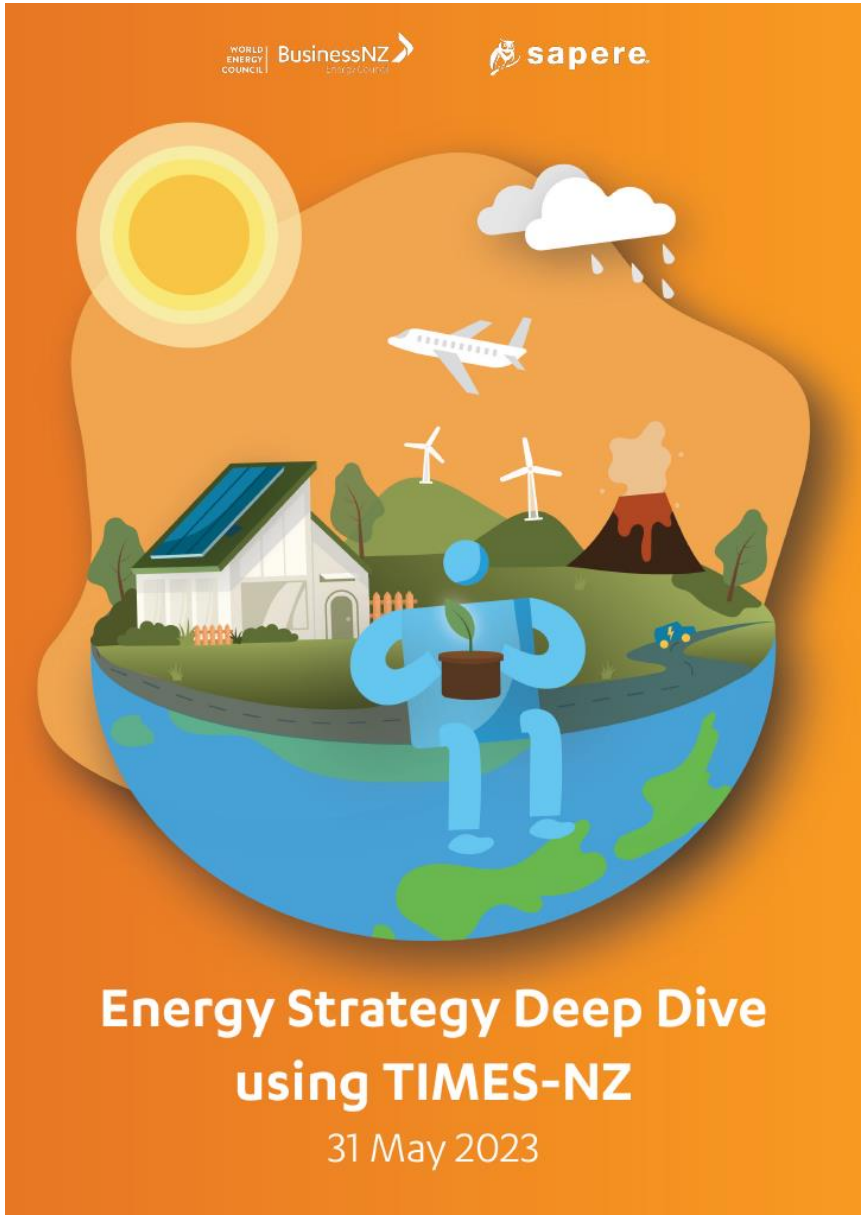
Industry

What technologies decarbonise more readily?



Outputs – Kea and Tūī sensitivity studies

Sensitivity studies (BEC ‘Deep Dive’)



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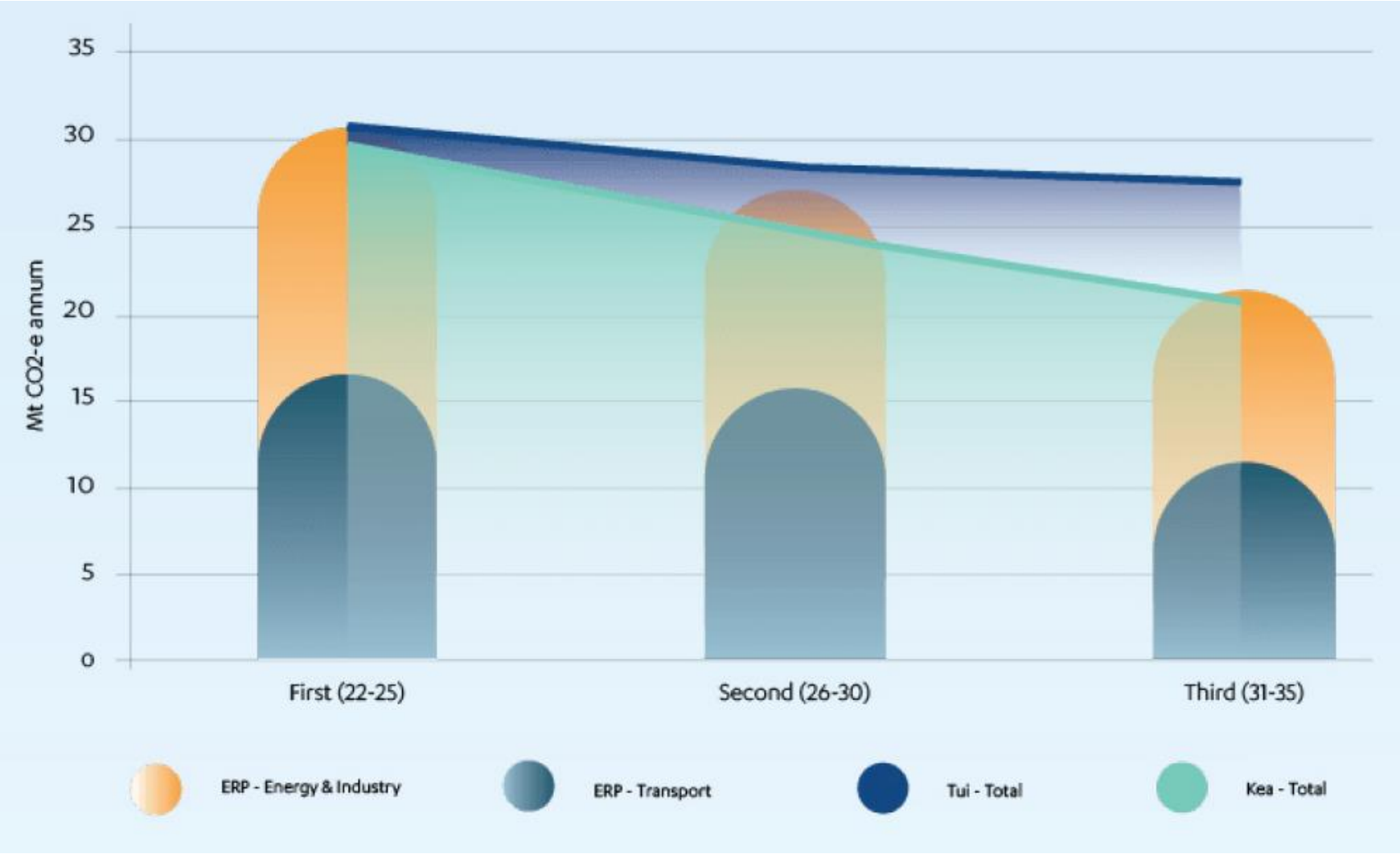
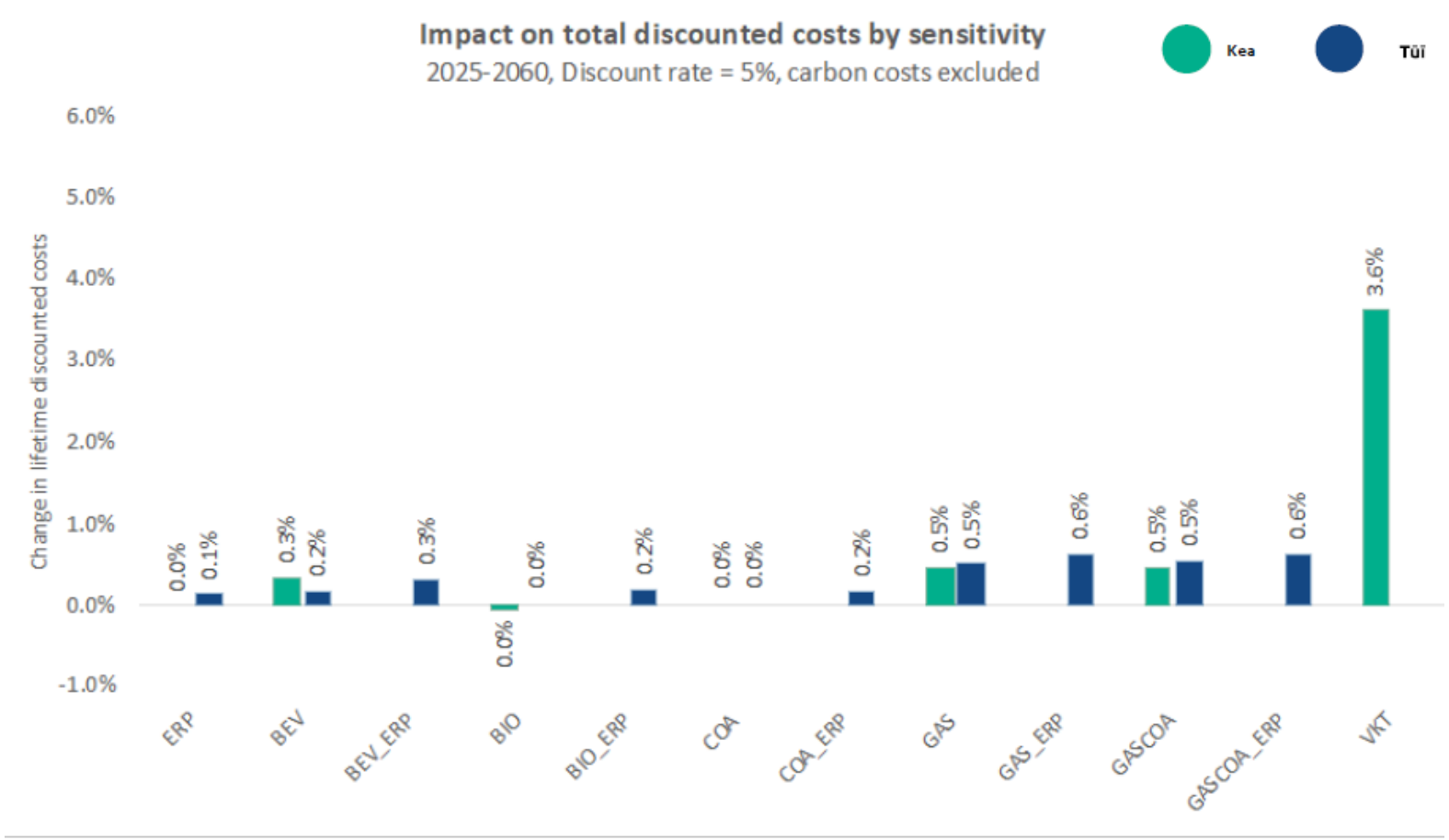


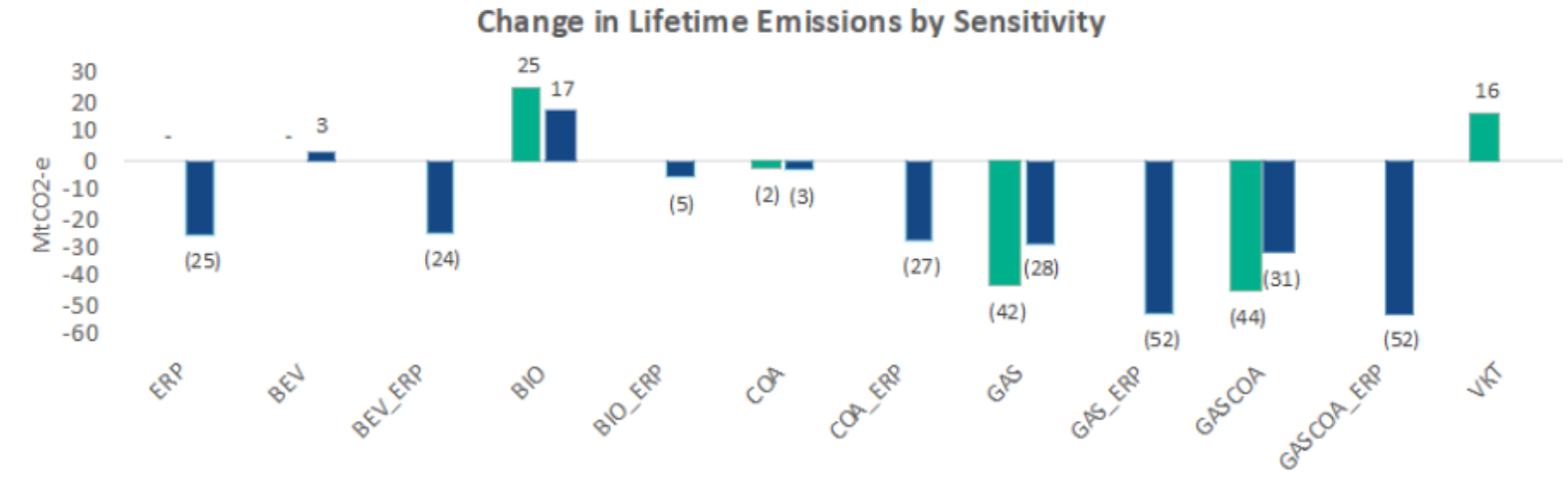
Sensitivity studies (BEC ‘Deep Dive’)

- ERP = Emissions budgets imposed
- BEV = Increase in BEV CAPEX of $10k per vehicle
- VKT = Tūī VKT/capita in Kea scenario
- BIO = Woody biomass at $20/GJ
- GAS = Post-Methanex gas price of $35/GJ + additional $4/GJ for storage
- COA = A ban on coal use in 2037 (cf. ND from GHG emissions from industrial process heat)
- GASCOA = GAS + COA

- Note: VKT sensitivity is only one that increases energy service demand. All other sensitivities impose constraints or increase fuel costs.

Sensitivity studies (BEC ‘Deep Dive’)





Current and future work

Current work

- TIMES-NZ 2.1.x update
  - Refinery now closed – limited impact on model, but does remove some natural gas use for refining
  - Some additional detail in transport sector – addition of ‘very heavy trucks’ to represent high utilisation linehaul trucking
  - Better representation of industrial sector load factors
  - Likely inclusion of committed projects e.g. NZ Steel

Future work

- Update ‘base year’ from 2018 to 2022
- Review assumptions – and ‘tag’ uncertainties
- More comprehensive documentation of model
- Additional functionality – shocks
- Release as open source, and support wider use

Future work – shocks

Scenario 1: Perfect foresight, Methanex stays throughout

Scenario 2: Perfect foresight, Methanex leaves in 2040

Scenario 3: Scenario 1 path until 2040, then ‘un-forecast’ departure of Methanex in 2040

2022 2040 2060

A final reflection …

- **Two ways to use TIMES-NZ:**
    1. **To generate plausible scenario outputs**
    2. **To generate quantitatively correct predictions of the impact of x *within* a scenario**
        - **E.g. If the carbon price increases by x, what is the impact?**

Q&A

Visualization tool demo

- Overview
  - Key insights / Assumptions
- Industrial
  - Fuels / Separated / Methanol / Feedstock / Feedstock / Feedstock
- Residential
  - Technologies / Separated / All / Space Heating / All / Fuel