The Climate PoLicy ANalysis (C-PLAN) Model

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AUT
TE WĀNANGA ARONUI
O TĀMAKI MAKAU RAU

Outline

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1. New Zealand Climate Policy

- The **Zero Carbon Act** provides a framework for New Zealand to develop and implement climate change policies

- The Act sets long-term targets for two baskets of greenhouse gases (GHGs)
  - Reduce biogenic methane by 24-47% below the 2017 level by 2050
  - Gross emissions equal removals by forestry (net zero) for other GHGs

- Established an independent Climate Change Commission (CCC)
  - Contracted development of tools for climate policy analysis

2. An overview of the Climate PoLicy ANalysis (C-PLAN) Model

- Inspired by the Economic Projection and Policy Analysis (EPPA) model at the Massachusetts Institute of Technology
- New Zealand-focused recursive-dynamic computable general equilibrium (CGE) model of economic activity and GHG emissions
- Economic activity linked to GHG emissions and interactions among sectors
- Represents two regions (NZ and RoW), 38 sector, all greenhouse gases (CO_2 CH_4, N_2O, F-gases) and new technologies
- Informed by/linked to sectoral models
- Built on economic theory, national statistics, and estimates of behavioural responses

CPLAN sectors

Agriculture	Transport
Dairy farming	Road Transport
Beef and sheep farming	Air transport
Other animal products	Water transport
Horticulture	Private transport
Forestry	
Fishing	**Energy-intensive manufacturing**
	Chemical, rubber & plastic products
	Cement manufacturing
Energy extraction & distribution	Non-ferrous metals (e.g., aluminium)
Crude oil extraction	Iron and steel
Refined oil products	
Coal extraction	**Other sectors**
Natural gas extraction and distribution	Mining of metal ores
Coal electricity	Dairy products
Gas electricity	Meat products
Hydroelectricity	Other food processing
Wind & solar electricity	Wood and paper products
Geothermal electricity	Textiles, clothing and footwear
Electricity transmission and distribution	Trade
	Construction
	Services

Emissions reduction options in C-PLAN

- Fuel switching
- Price-driven energy efficiency improvements
- Exogenous energy efficiency and emissions intensity improvements
- Reducing output/consumption changes
- Production from new, low-emissions technologies (e.g., electric vehicles)

New technologies

Technology	Substitute for	Available from
Electric road transport	Road transport	2015
Electric household transport	Household transport	2015
Dairy farming with reduced methane	Dairy farming	2030
Beef & sheep farming with reduced methane	Beef and sheep farming	2030
Geothermal electricity with CCS	Geothermal electricity	2028
Electric heat	Coal-gas in selected sectors	2020
Bioheat	Coal-gas in selected sectors	2020

3. Calibration

- Version 10 of the Global Trade Analysis Project (GTAP) Power Database (Chepeliev, 2020)
- New Zealand's GHG Inventory 1990–2017 (MfE, 2019)
- 2014 benchmark year

2014 emissions matrix, $MtCO_2e$

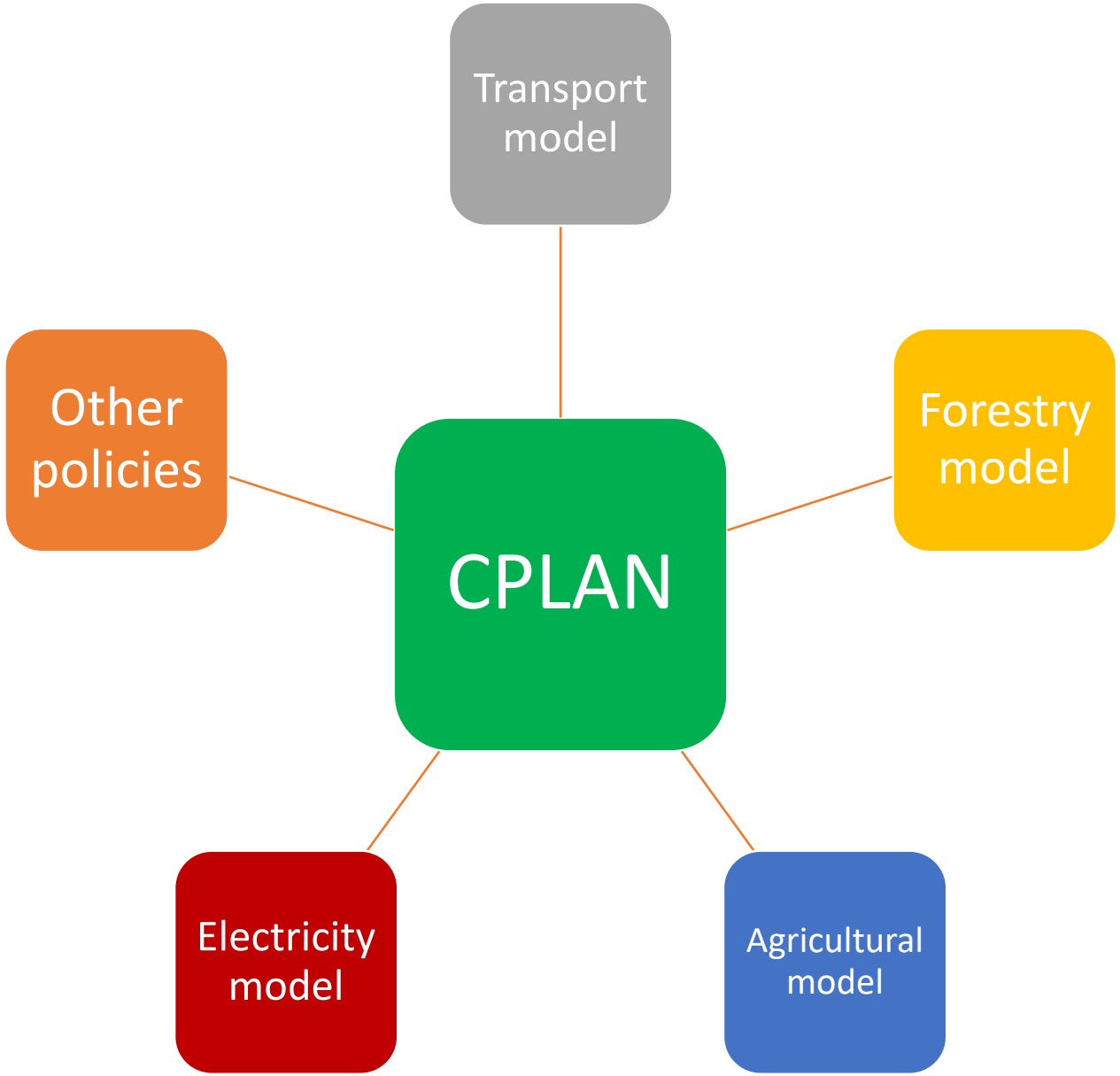
Major emissions sources:

- CH_4 emissions from dairy farming (19.2%) and sheep & beef farming (18.5%)
- CO_2 emissions from commercial road transport (8.5%) and household transport (8.1%)
- CH4 emissions from services (5.2%)
- N_2O emissions from dairy farming (4.0%) and beef & sheep farming (2.4%)
- CO_2 emissions from burning gas for electricity generation (3.9%)

Sector	CO_2-oil	CO_2-gas	CO_2-coal	Other CO_2	CH_4	N_20	f-gases
rmk	0.464	0.002	0.048	0.583	15.000	3.192	
b_s	0.336	0.004	0.059	0.401	14.403	1.892	
oap	0.062	0.001	0.010	0.018	0.666	0.019	
hor	0.222	0.003	0.004	0.097	0.022	1.858	
frs	0.144	0.035	0.020	0.004	0.014		
fsh	0.170	0.145	0.004		0.000	0.001	
col	0.000	0.000	0.118		0.225		
cru	0.000	0.064		0.308	0.005		
gas	0.000	0.638		0.298	0.402	0.000	
oxt	0.481	0.027	0.002		0.001	0.007	
oil	0.768	0.111			0.000	0.001	
ecoa			1.214			0.007	
egas		3.022			0.002		
eoth				0.646	0.166		
tnd	0.000						
crp	0.096	1.303	0.028	0.254	0.127	0.001	
nmm	0.044	0.067	0.337	0.830			
nfm	0.043	0.069	0.004	0.538	0.000	0.000	0.073
i_s	0.052	0.113	0.033	1.732	0.000	0.000	
fmp	0.020	0.017	0.005	0.320	0.000	0.001	
mil	0.099	0.554	1.209		0.003	0.005	
mtp	0.004	0.014	0.334		0.001	0.001	
ofd	0.013	0.263	0.115		0.001	0.002	
w_p	0.074	0.334	0.050		0.031	0.049	
mvh	0.005	0.000	0.001				
omf	0.093	0.037	0.021	0.041	0.000	0.058	1.320
rtp	6.656	0.044	0.001		0.007	0.055	
wtp	0.319	0.000	0.001		0.001	0.002	
atp	0.846	0.000			0.000	0.007	
cns	0.351	0.022	0.002		0.001	0.002	
afs	0.028	0.088	0.003				
ser	0.304	0.272	0.104		4.070	0.119	
c	0.064	0.276	0.026		0.075		
hht	6.349					0.092	

Baseline scenario

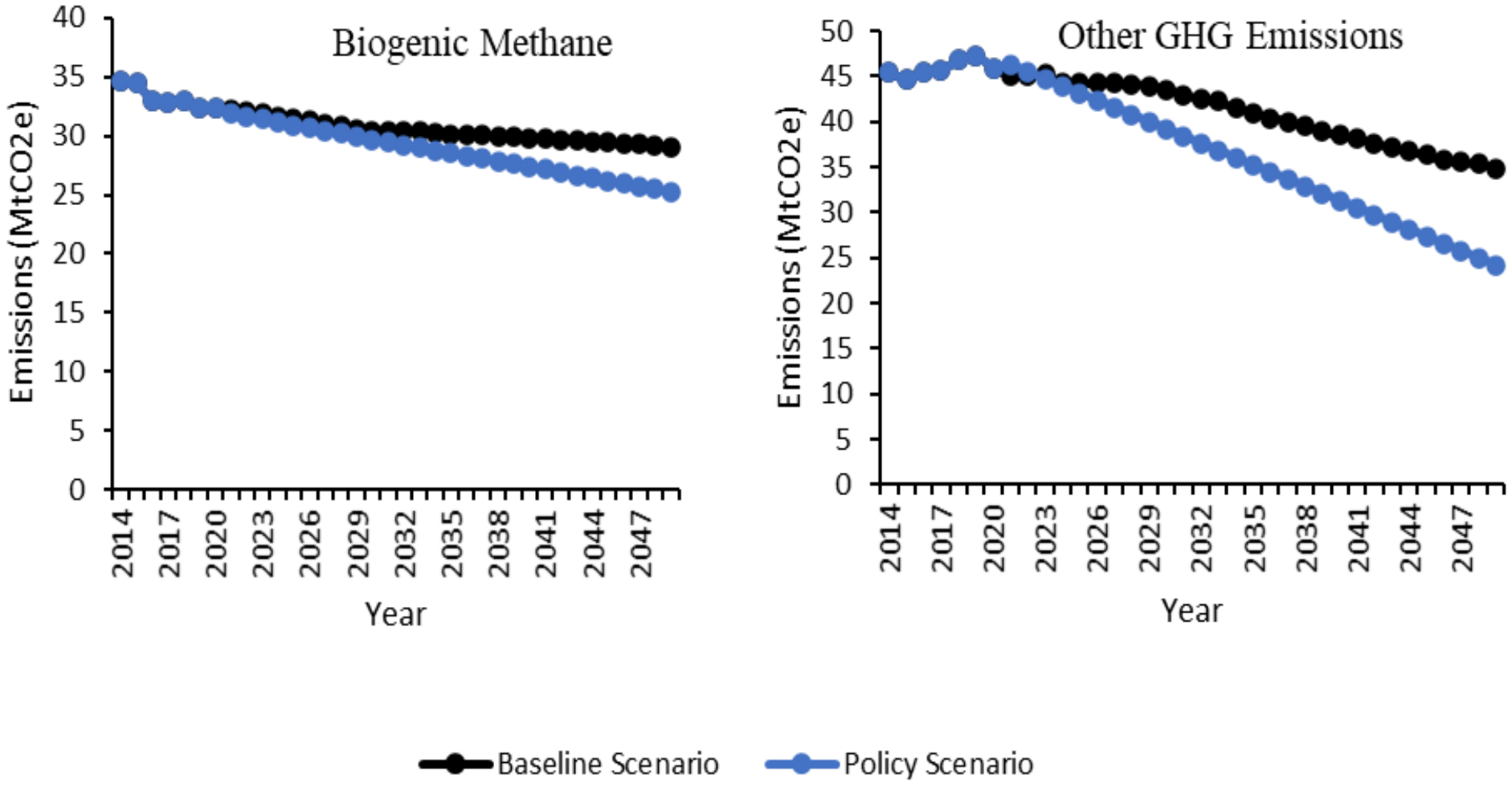
- A numerical projection consistent with future changes in socioeconomic drivers used as reference for evaluating the impacts of policies of interest
- Baseline drivers
  - Projections for GDP, the labour force, electricity generation, forestry, and oil prices
  - Expected technology developments (e.g., electric vehicles)
  - Resources constraints
  - Current climate policies
  - Other policies expected to have a significant impact on emissions (e.g., fresh water policies)


Transport model
Other policies
CPLAN
Forestry model
Electricity model
Agricultural model

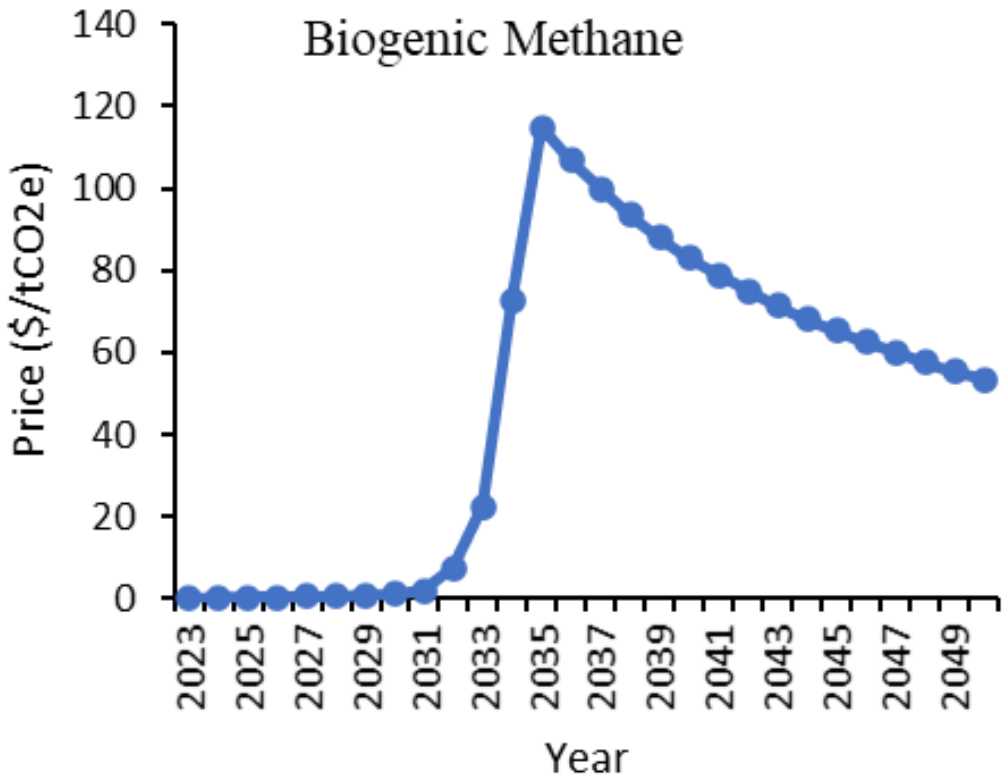
A policy scenario

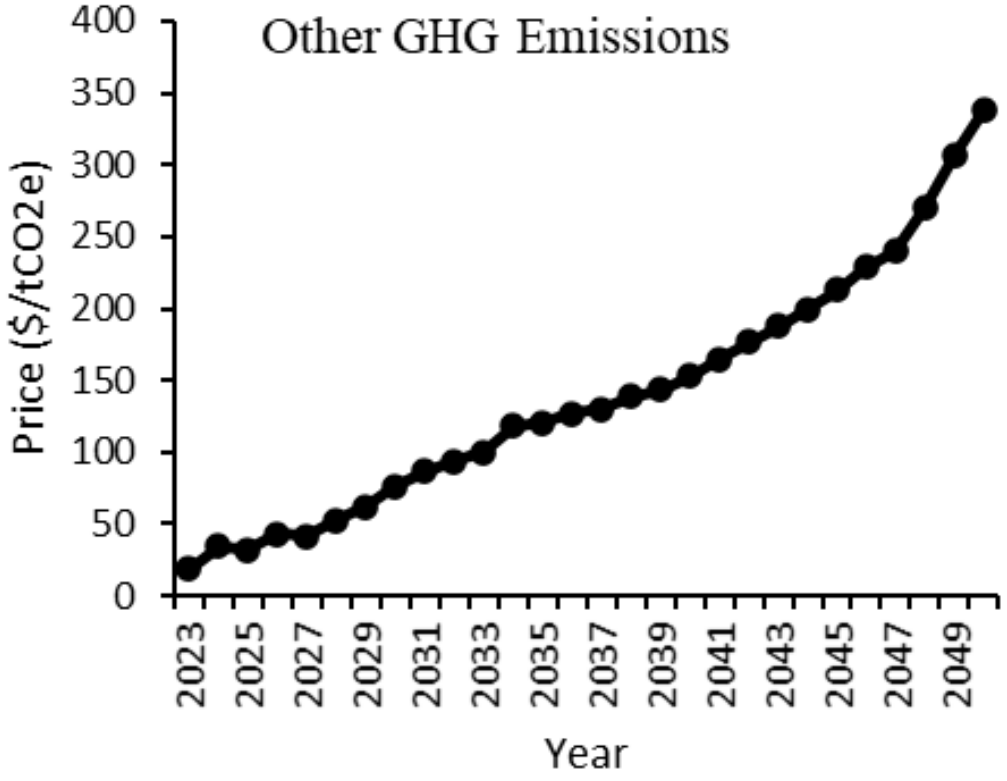
- Two Emission Trading Systems (ETSs)
  - Reduce emissions of biogenic methane to 24% below the 2017 level by 2050
  - Reduce net emissions of other GHGs to zero by 2050
- Free, output-based allocation of permits for some sectors
- All new technologies available
  - Electric vehicles are available in the baseline and policy scenarios

GHG emissions, $MtCO_2e$



Carbon prices, $/tCO$_2$e

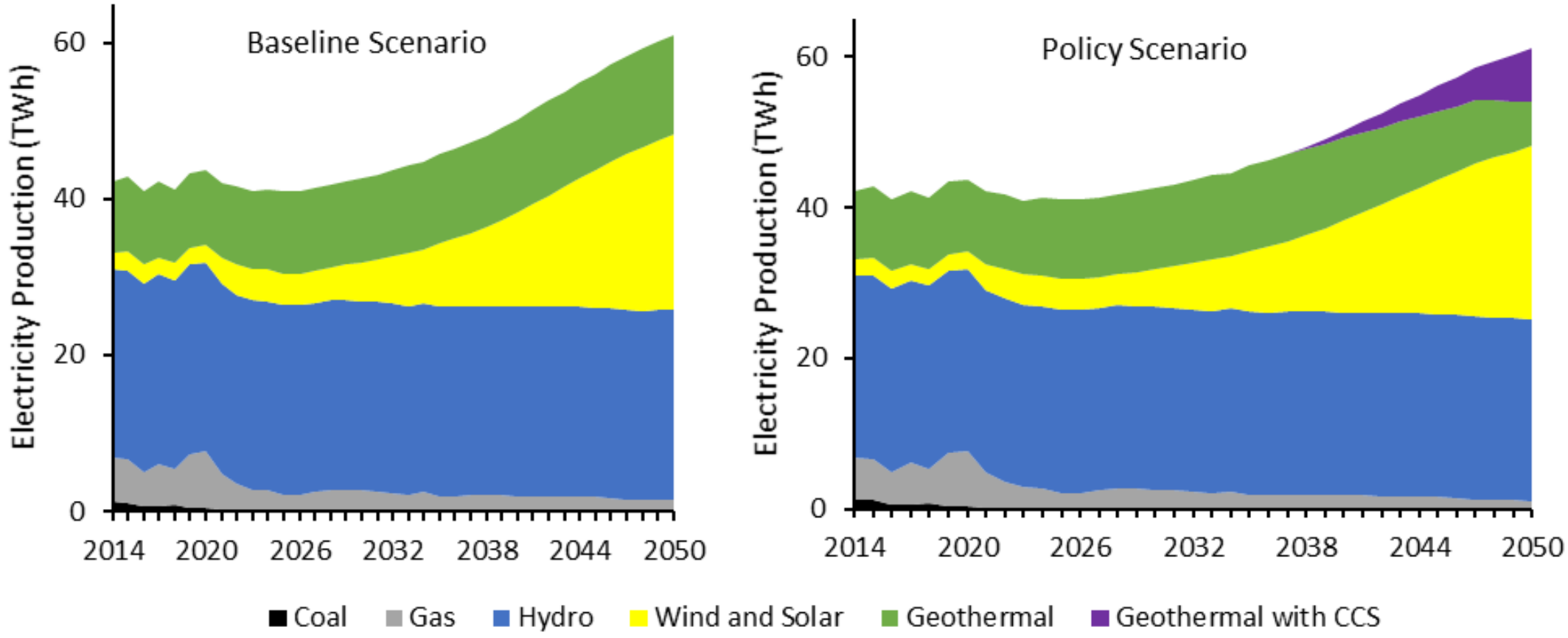




Results

	2035		2050	
	Baseline	Policy	Baseline	Policy
GDP, % change relative to baseline	-	-0.15	-	-0.34
Welfare, % change relative to baseline	-	-0.10	-	-0.26
GHG emissions, $MtCO_2e$				
Biogenic methane	30.21	28.77	29.06	25.27
Other GHGs, gross	41.50	36.06	34.83	24.25
Forestry removals	12.12	13.39	22.19	24.25
Other GHGs, net	29.38	22.67	12.64	0.00
% of travel from electric vehicles				
Road transport	12.6	13.5	54.7	64.4
Household transport	31.5	33.4	91.2	100.0

Electricity generation, TWh



Distributional Impacts

- The Distributional Impacts Module – Employment (DIM-E) downscales results from CPLAN to estimate employment impacts for subgroups
- Uses the Integrated Data Infrastructure

Conclusions

- C-PLAN is a global, recursive dynamic CGE model tailored to New Zealand for climate policy analysis
- Built to help shape the CCC's advice to the New Zealand government on GHG emission targets and climate policies
- Documented and open source, able to replicate results used for the CCC's draft advice to government
- Future developments:
  - Endogenous land-use change
  - Improved representation of the vehicle feet
  - Improved representation of electricity generation technologies
  - Examine the sensitivity of results to alternative baseline assumptions