20 YEARS Integrated Research and IRADe Action for Development

Decarbonising India's Power System: Technological options and costs

Integrated Research and Action for Development (IRADe)

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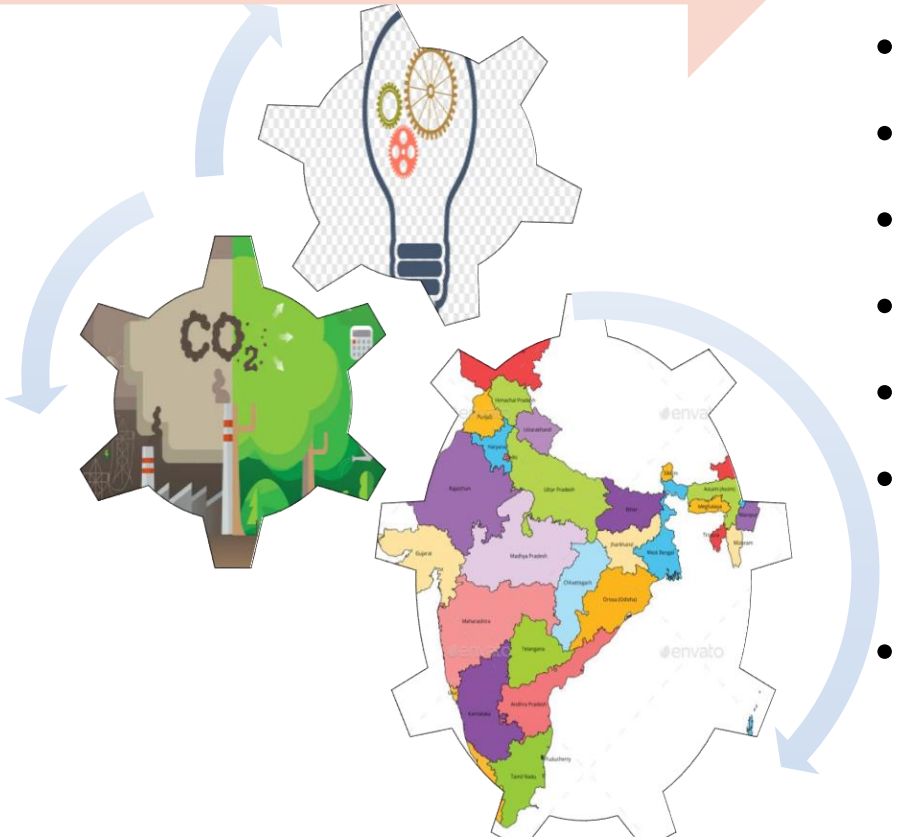
Objective & Research questions to be addressed

Objective: Assessing technology and cost implications of Net Zero of the Indian power sector by 2050 & 2060

Key Research Points



- Role of different technologies
  - Solar, Wind Onshore, Wind Offshore, Battery Storage, Hydro on river and off river, Nuclear and Coal CCS.
- Cost reduction rates of emerging technologies
- Potential of different RE sources
- Role of CCS and Nuclear?
- Implications of intermittency on storage
- Electricity demand growth
- Cost of reaching Net Zero by different dates
  - Climate finance needs
- Policy implications

Methodology

Indian power system is modelled using

IAEA-MESSAGE,

Least cost linear optimisation software

Time frame : 2015-2085,

with five years period

Exogenous annual electricity demand

Captures seasonal and daily variations of load and supply of wind, solar, hydro with 288 time slices (12 seasons and 24-hourly variations in an average day in each season)

Technologies-

Pump-storage hydro, Power plant with CCS, Battery Storage are some of the alternatives modelled

Assumptions

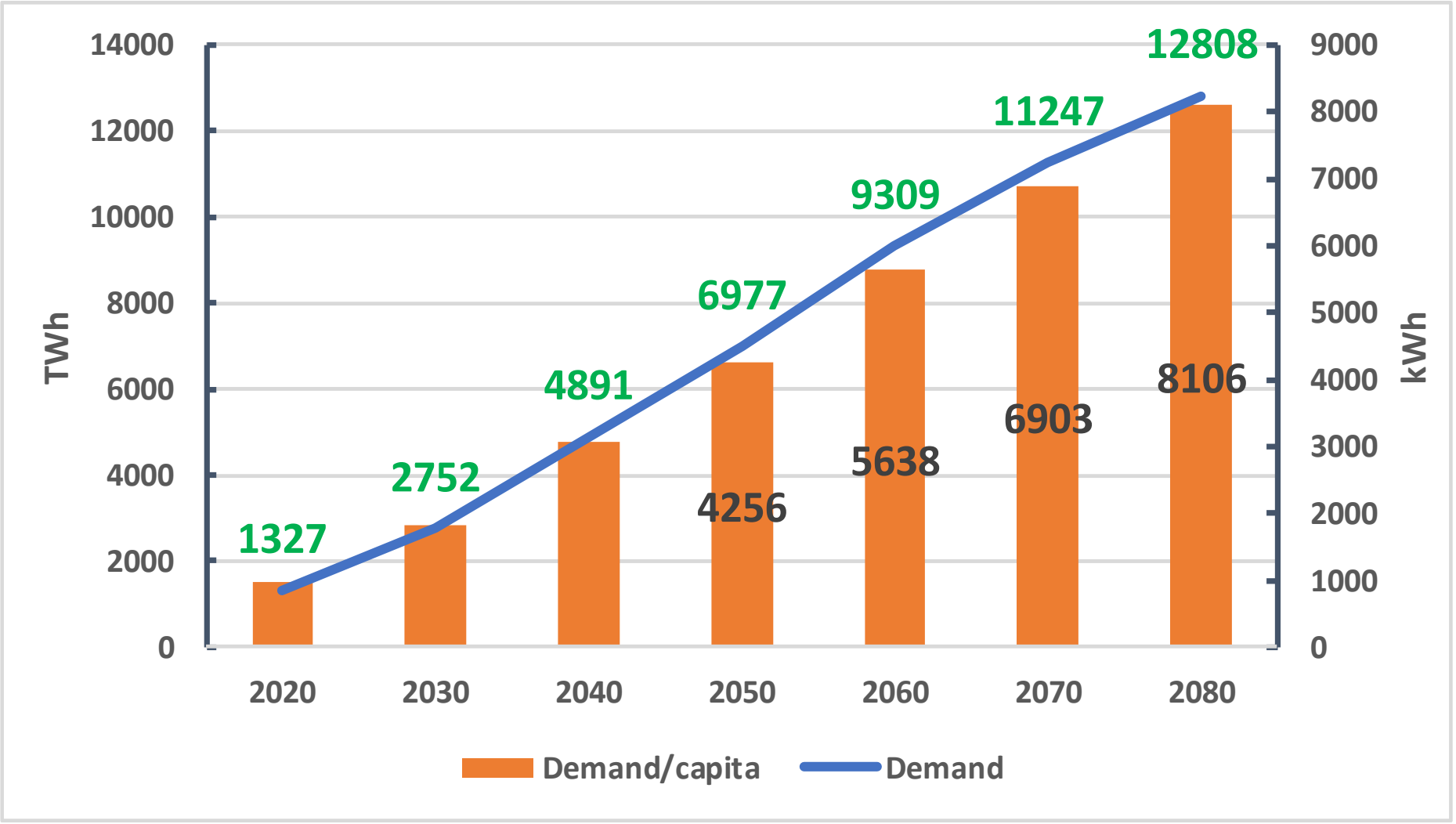
- ✓ All costs are in 2015 USD
- ✓ Real discount rate -4%
- ✓ Technologies are represented through technical and economic parameters

- ✓ Fast decline in capital costs of RE and storage technologies
- ✓ 25 Gt of Cumulative CO2 storage capacity
- ✓ CO2 transport and storage cost 15 USD/t from 2030

Table 1: Upper bound on capacity (GW)

Technology	2050	2060
Nuclear	60	80
Solar PV	2000	3000
Wind Offshore	300	600
Wind Onshore	450	750
Large Hydro	120	145
Pumped Storage	56	76

Electricity demand



Time period	GDP Growth Rate(%)	Electricity-GDP Elasticity	Electricity growth rate
2020-30	8	0.8	6.4
2030-40	8	0.7	5.6
2040-50	7	0.5	3.5
2050-60	7	0.3	2.7
2060-70	6	0.3	1.8
2070-80	6	0.2	1.2

Scenarios

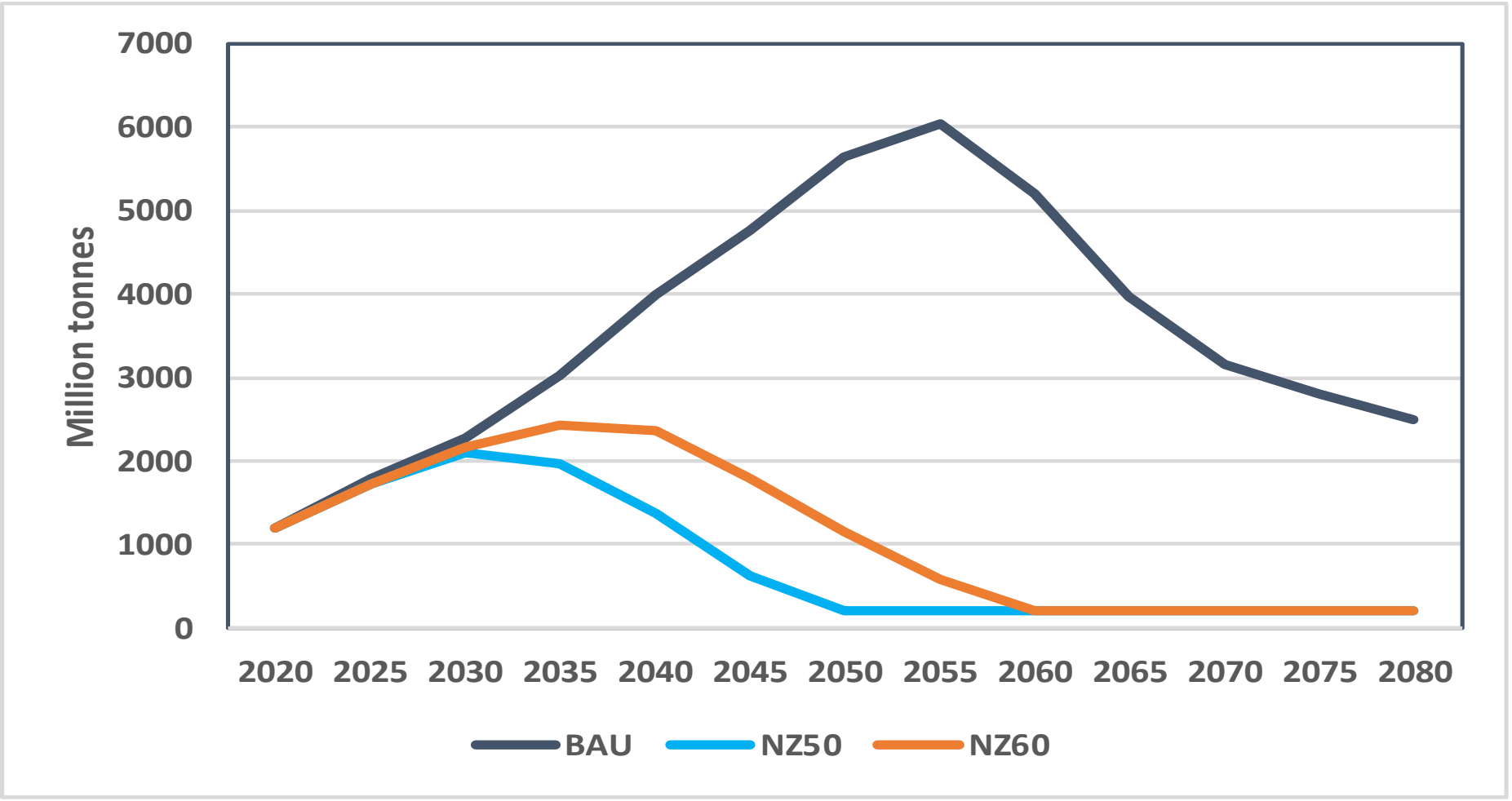
BAU Scenario: includes all policies that are in place as on 2020.

- ✓ Renewable targets- 175 GW by 2022
- ✓ 500 GW from non-fossil sources (Renewables + Large Hydro+ Nuclear) by 2030

NZ50: Power sector CO_2 emissions gradually stabilise at 0.2 GT from 2050 and onwards

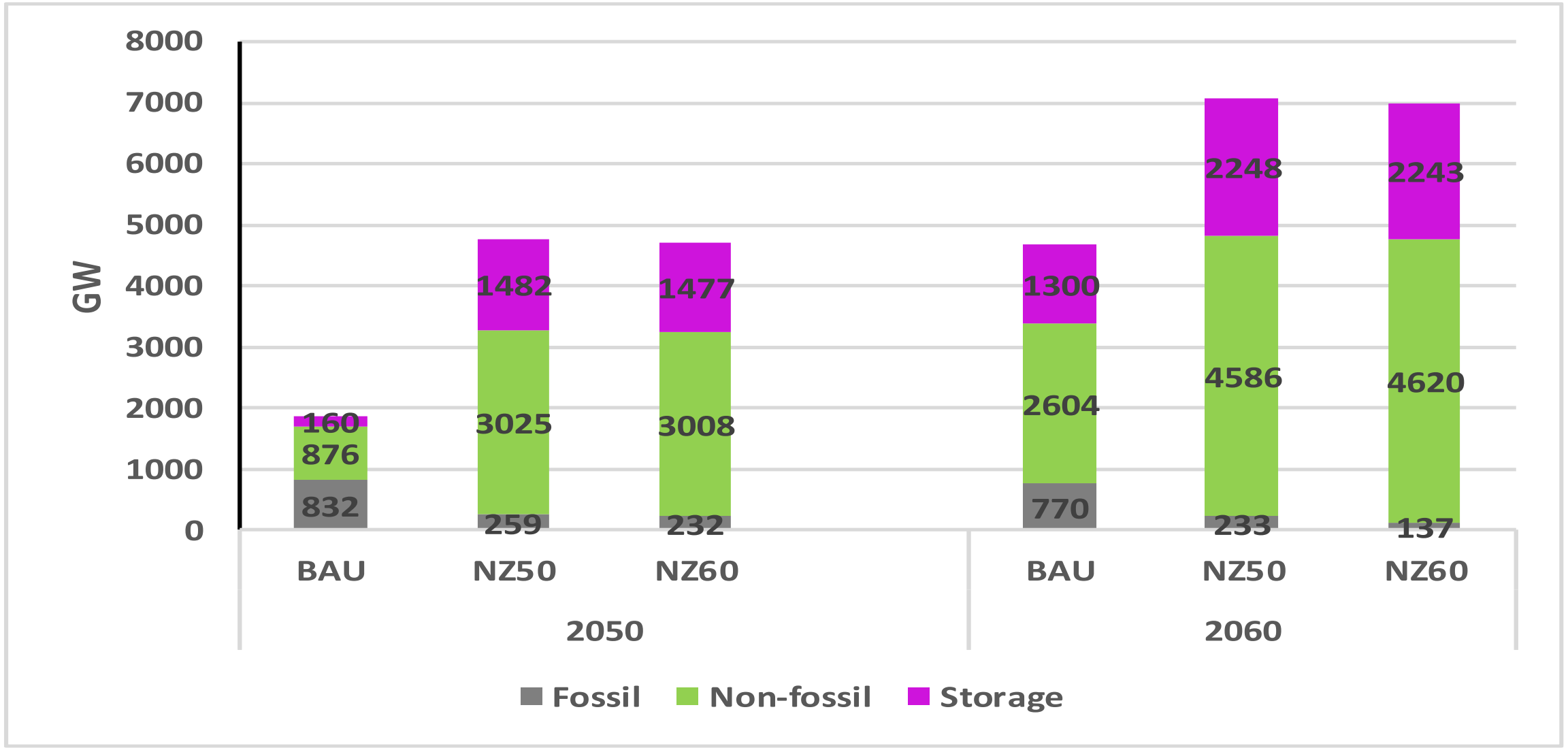
NZ60: Power sector CO_2 emissions gradually stabilise at 0.2 GT from 2060 and onwards

CO2 trajectories and Net zero scenarios

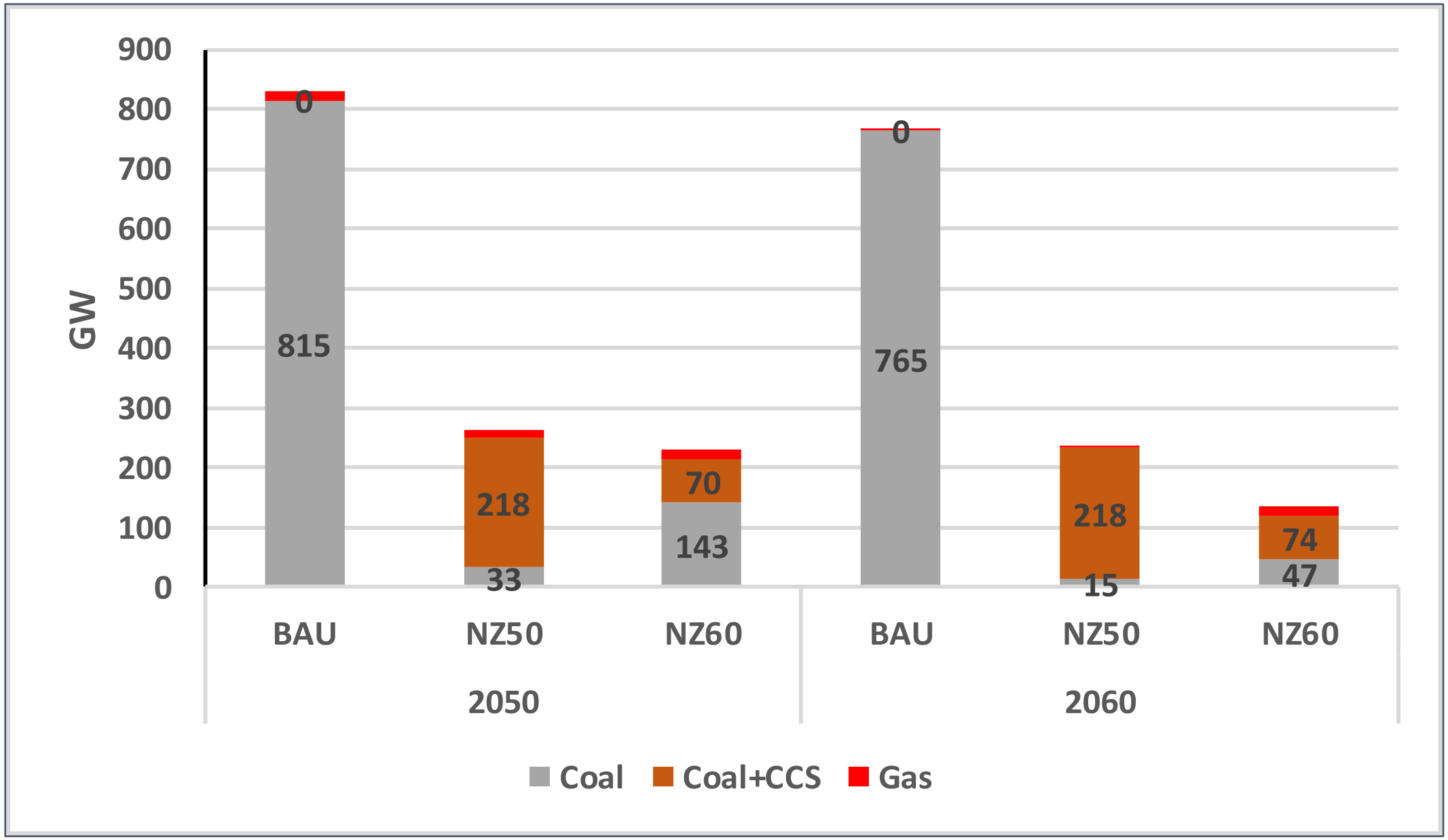


Power sector emissions			
	BAU	NZ50	NZ60
Peaking year	2055	2030	2035
Cumulative emissions (2020-60) in Gt	157	44	65

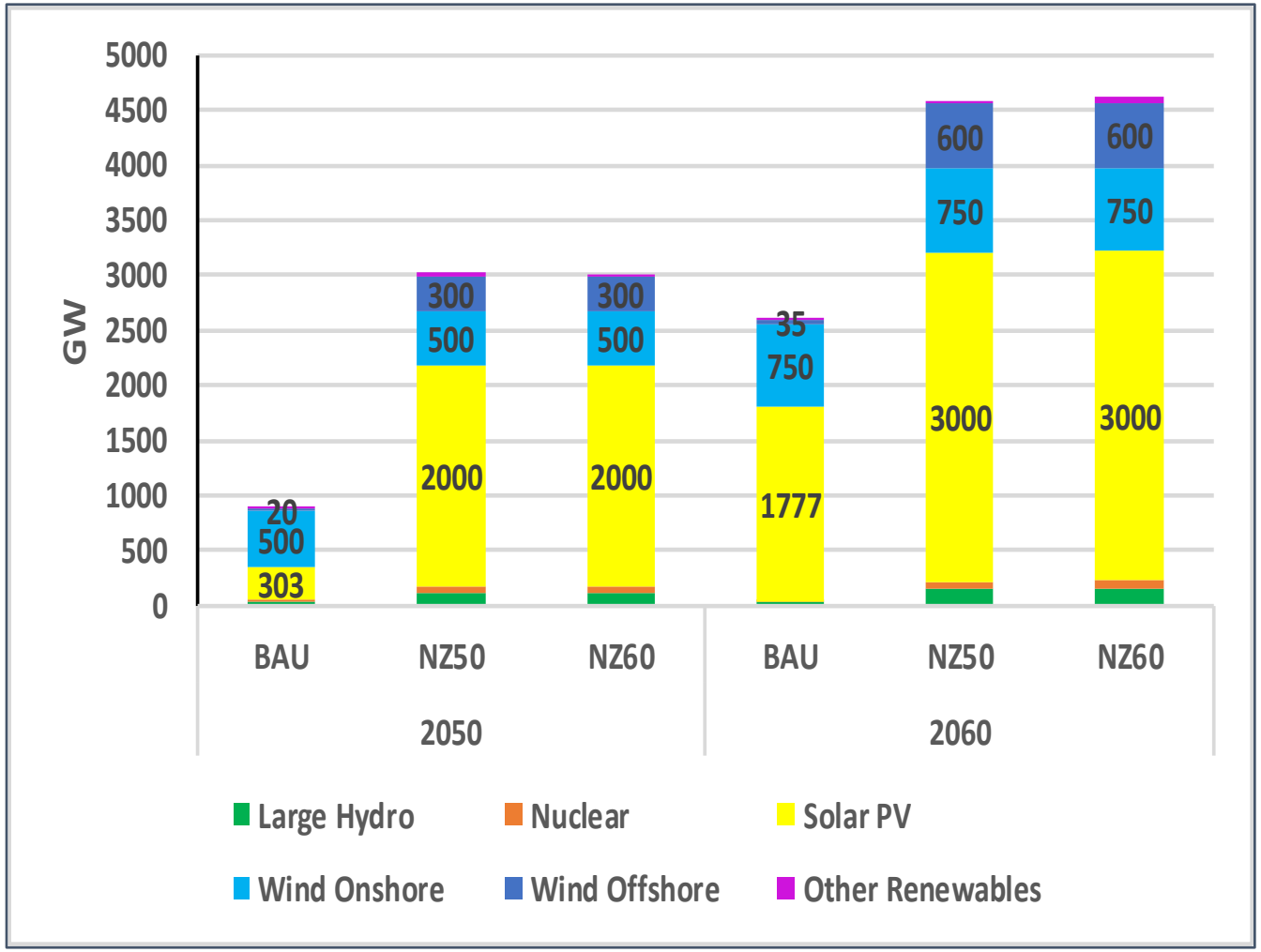
Total Power Generation Capacity

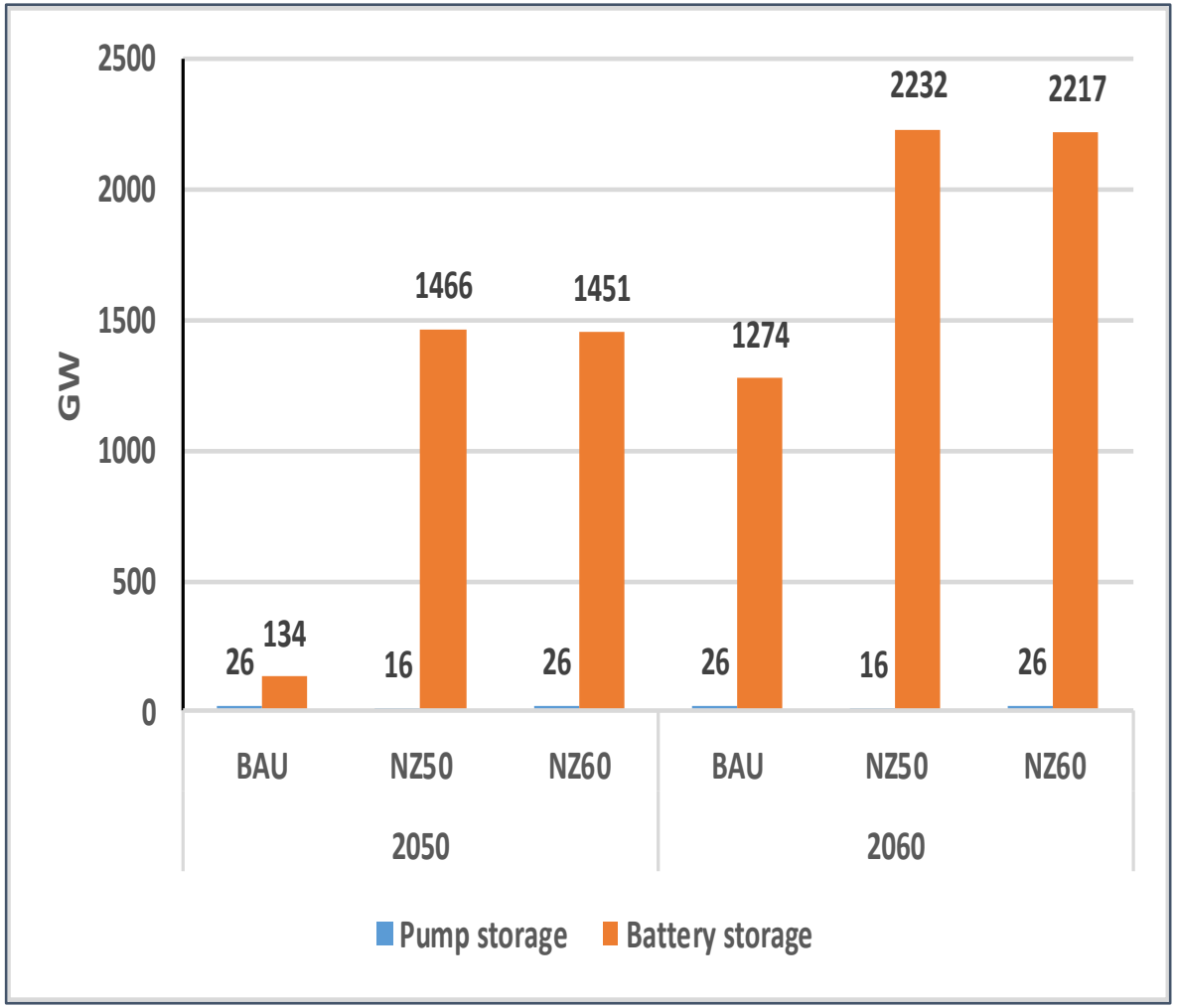


Fossil Capacity

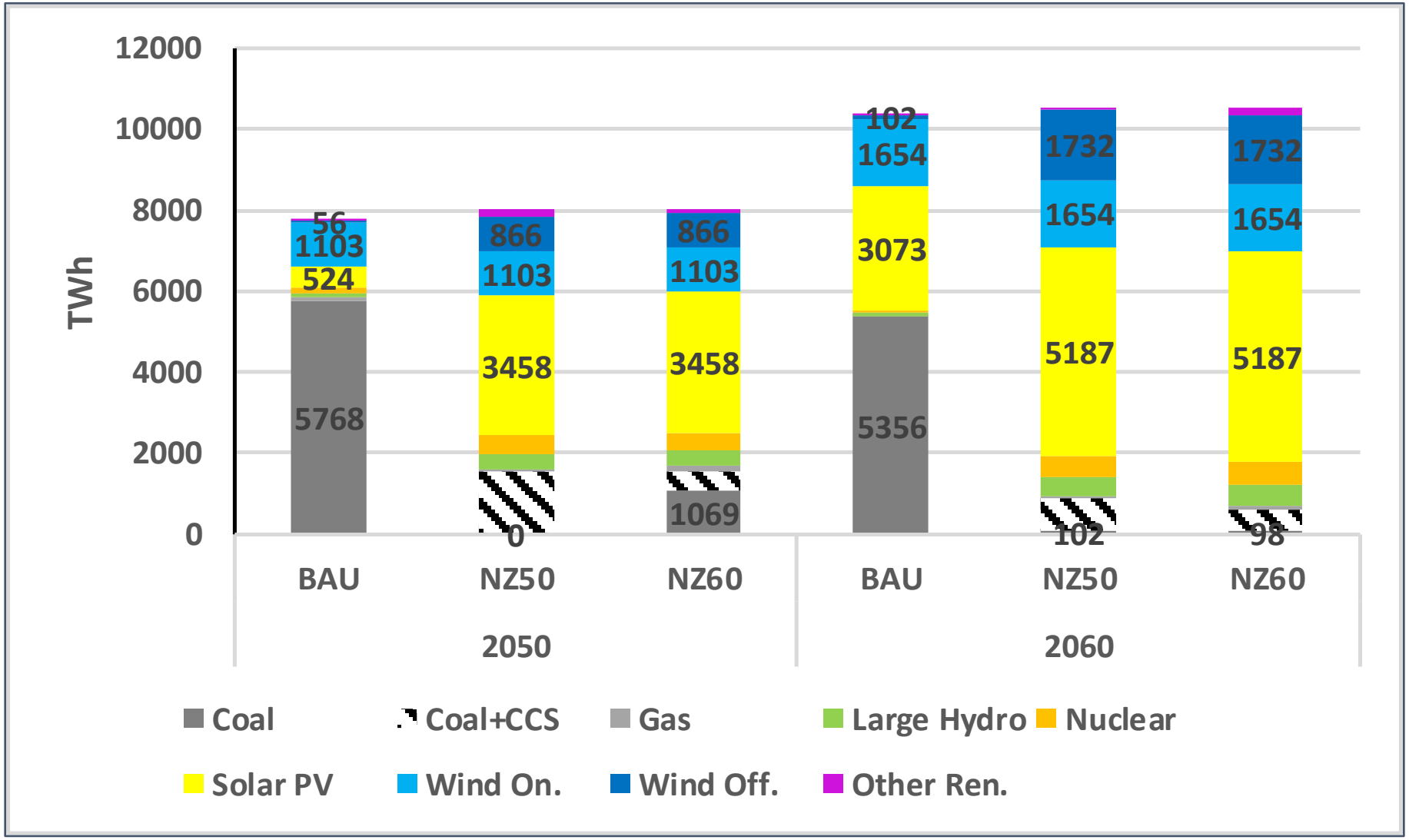


Non fossil and storage capacity





Generation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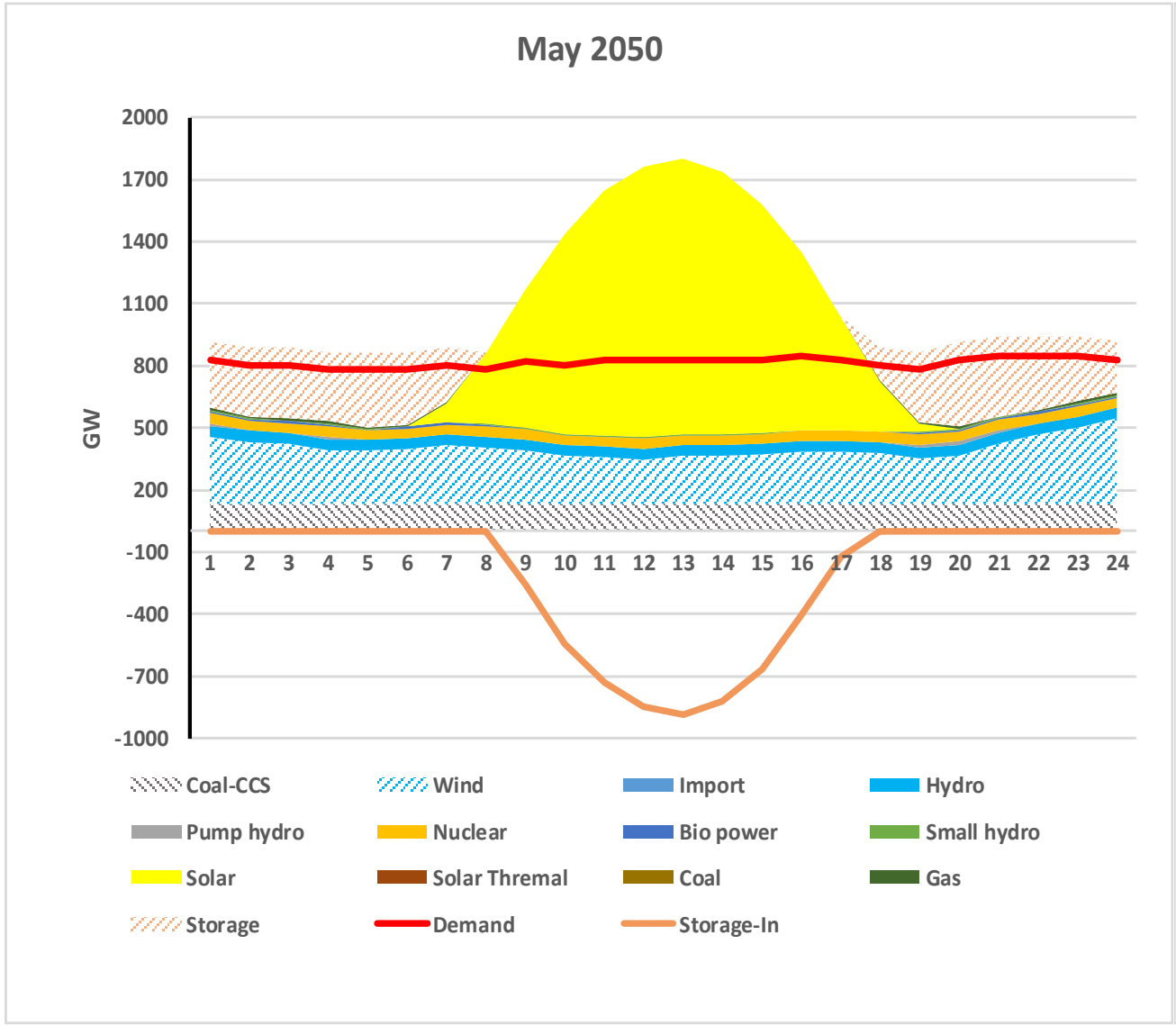
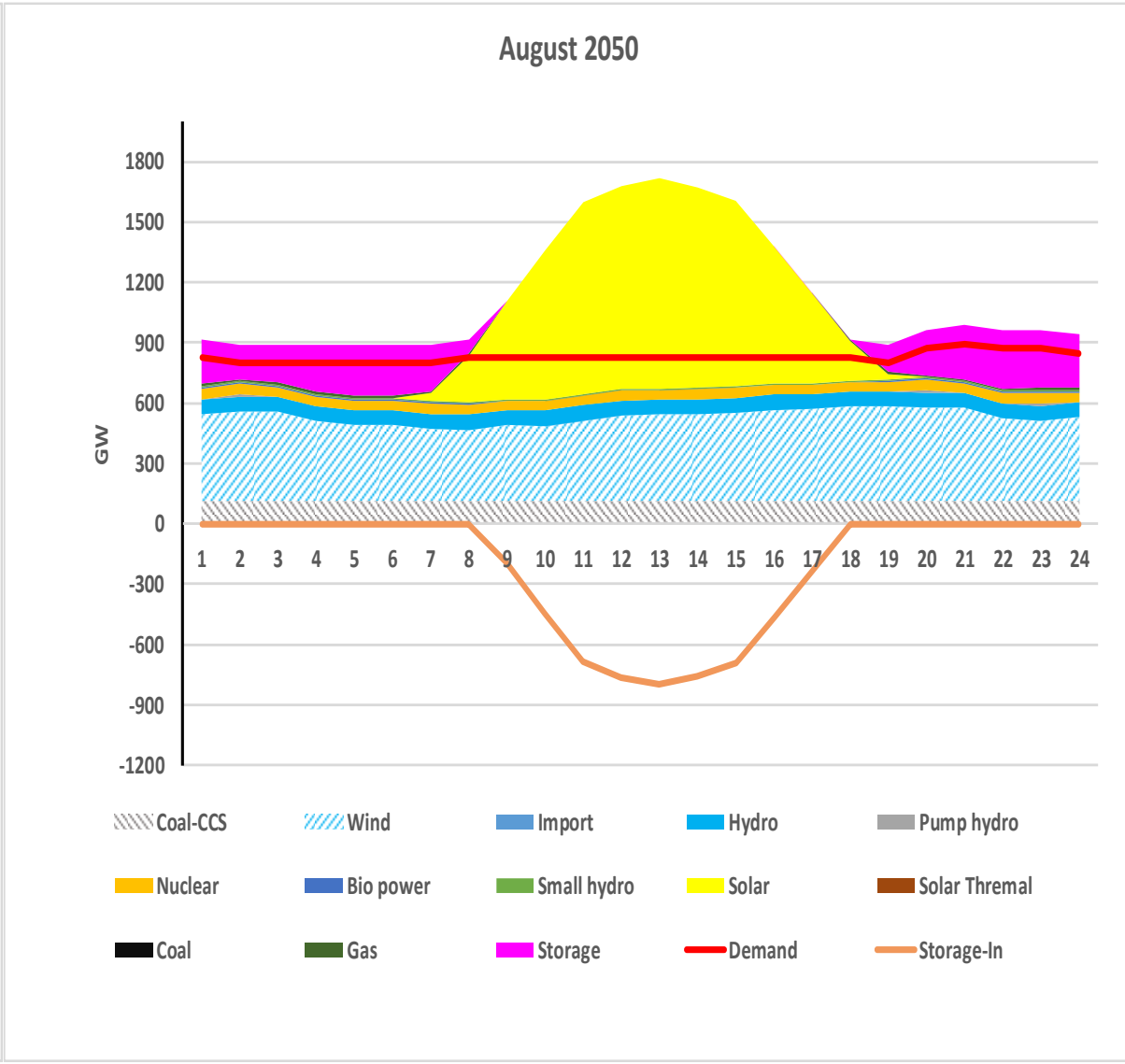
1654
3073
5356
1732
1654
5187
102
1732
1654
5187
98
BAU
NZ50
NZ60
BAU
NZ50
NZ60
2050
2060
Coal
Coal+CCS
Gas
Large Hydro
Nuclear
Solar PV
Wind On.
Wind Off.
Other Ren.

Merit-Order Dispatch





Additional (undiscounted) investment and total cost over BAU (2030-60) in billion USD (2015)

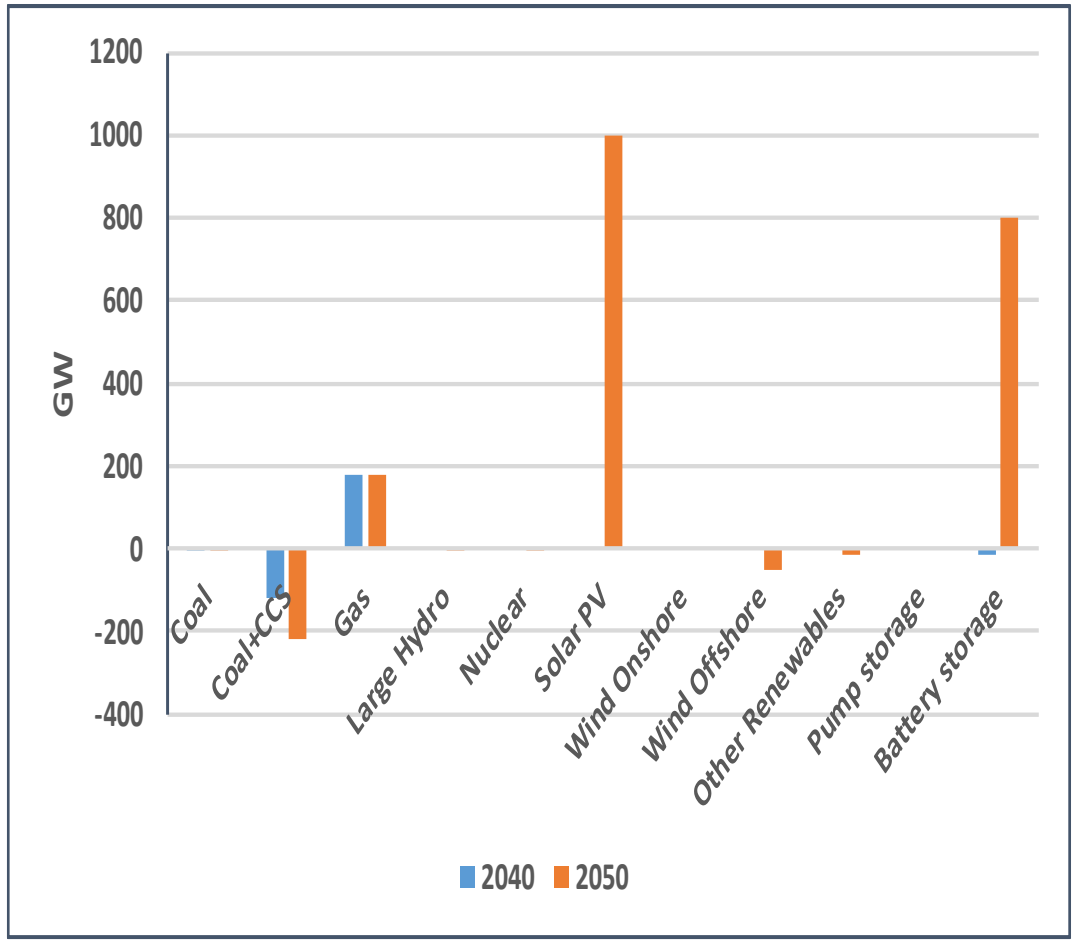
Indicator	NZ50	NZ60
Investment	1844	1684
Energy system costs	1642	967

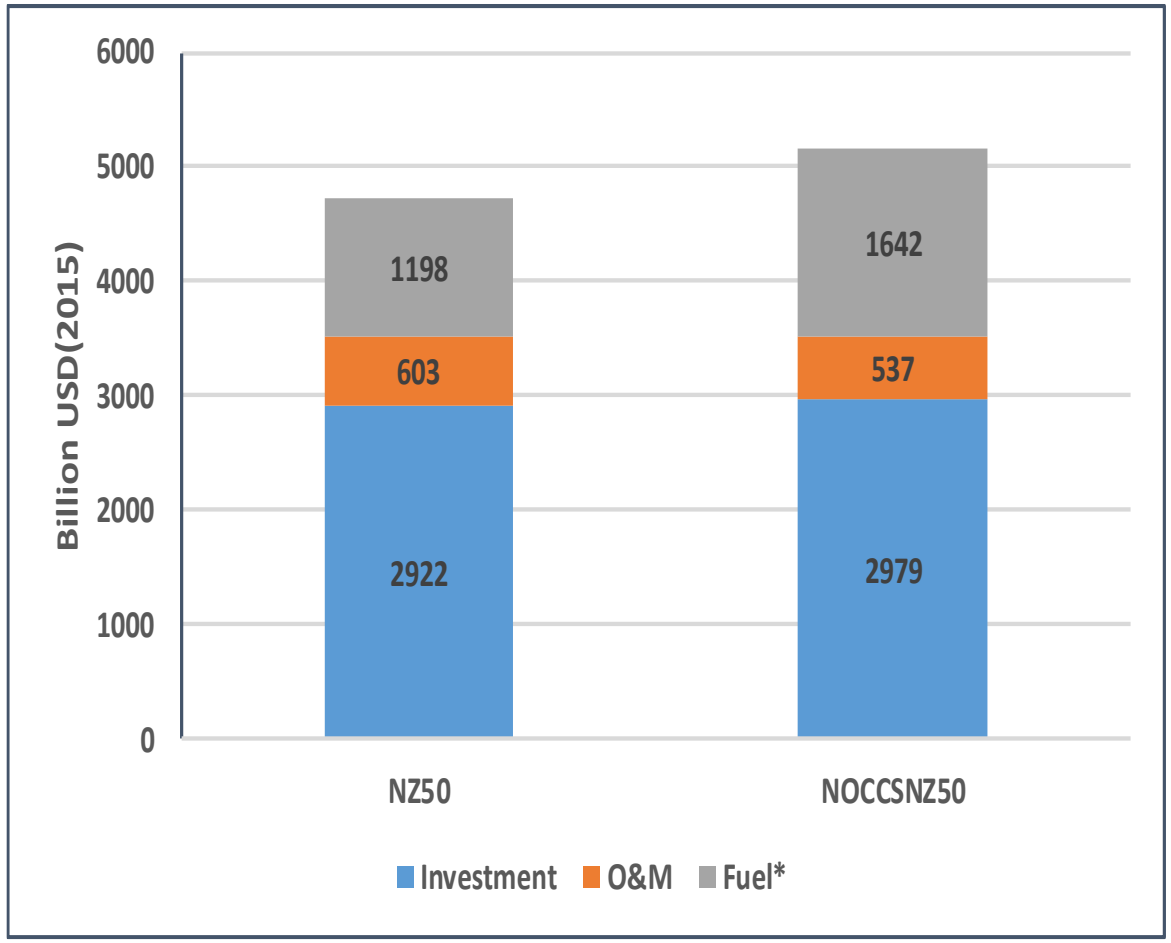
Indicates level of climate finance requirement

Achieving Net zero by 2050 is more investment intensive and expensive

Sensitivity analysis

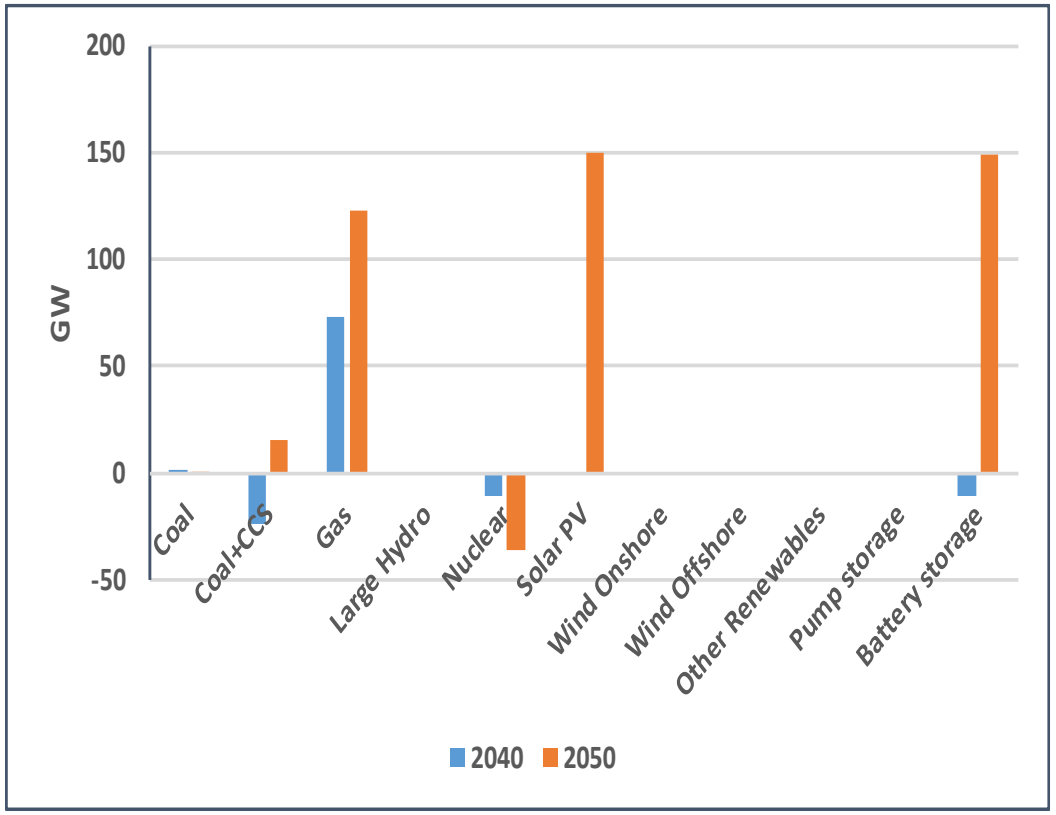
No CCS possibility

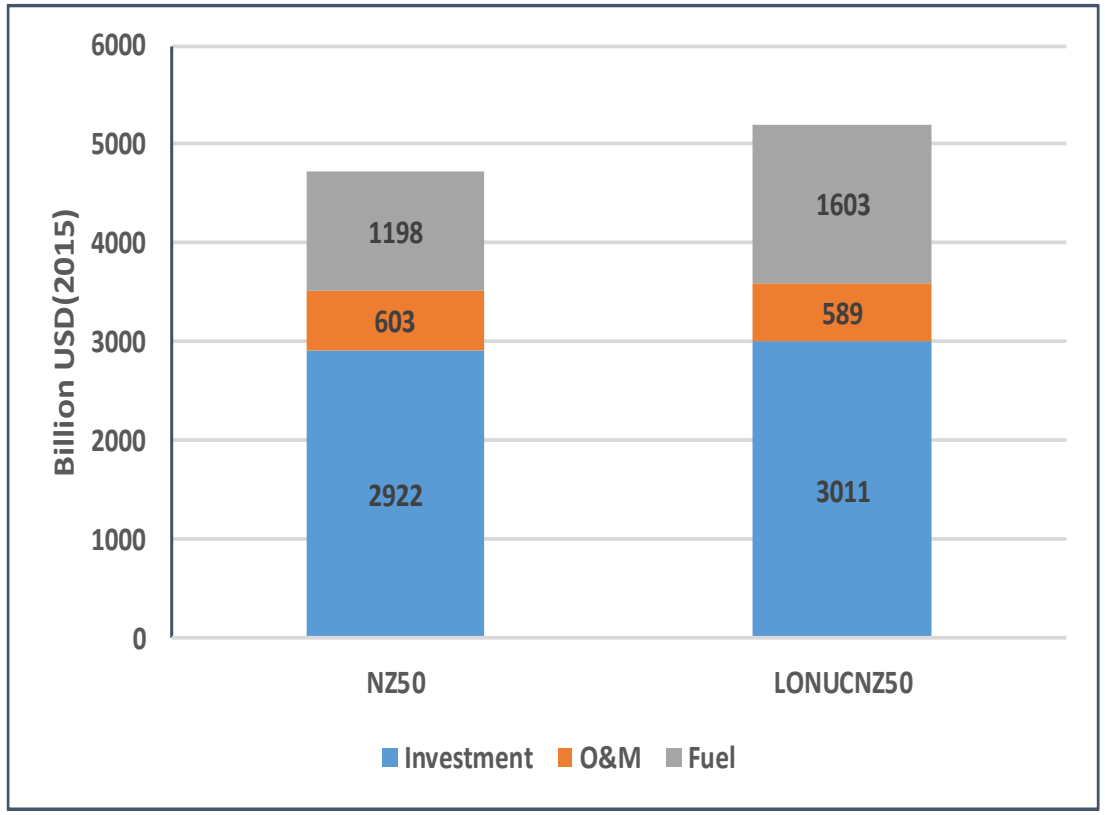




Low nuclear development

Nuclear capacity restricted to 30 GW

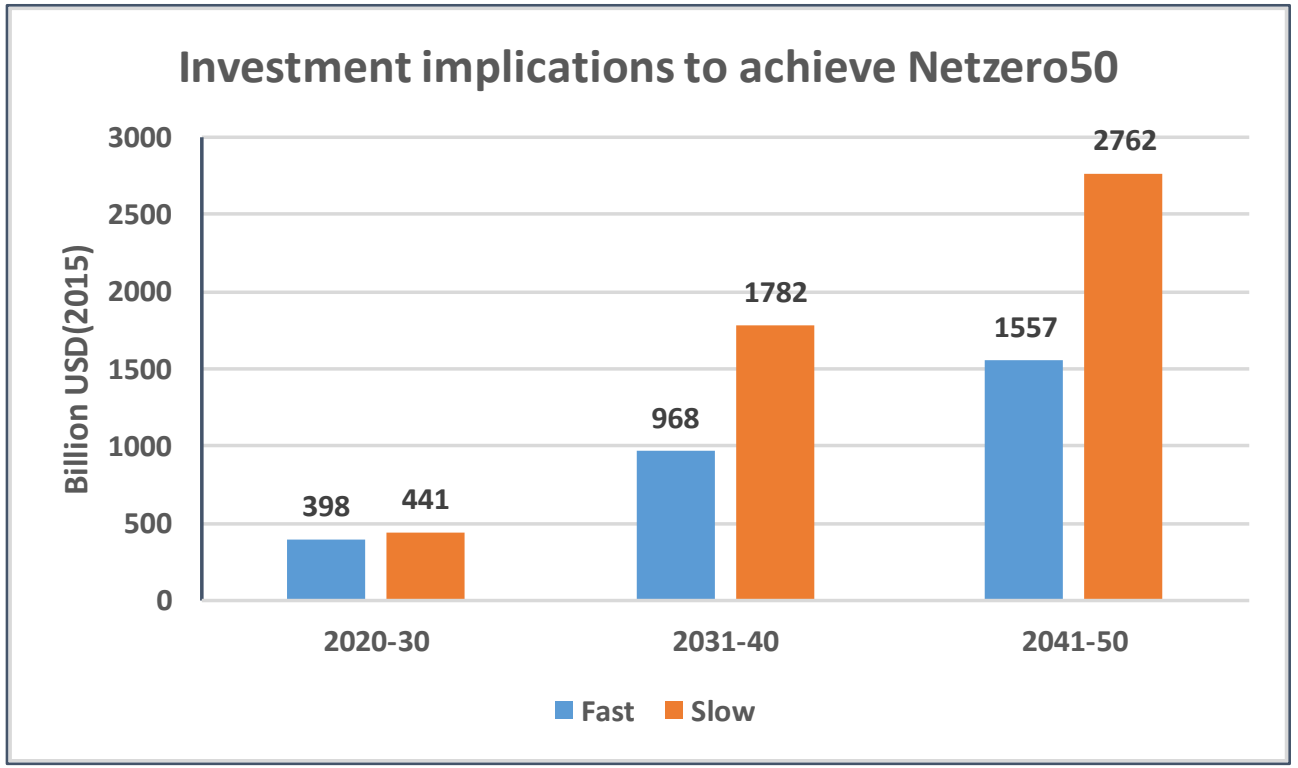




Slow cost decline in mitigation technologies

Table 6: Capital cost in 2050 as % of 2020 level

Technology	Fast	Slow
Solar PV	27%	47%
Solar CSP	43%	92%
Wind Onshore	54%	66%
Wind Offshore	38%	69%
Storage- 6Hours	24%	72%



Slow decline in capital cost development of renewable and storage technologies

Investment needs and costs will further go up

Concluding remarks

Decarbonisation strategy

- **Dominant technologies:** Solar, wind (offshore and onshore), large hydro, Battery storage, pump storage
- India needs to build 65 GW of solar PV, 20 GW of wind (offshore+ Onshore) every year starting from today till 2050, along with large amount of storage
- Non-intermittent technologies like Coal+CCS, nuclear would ease the decarbonisation process
- It has substantial additional investment and electricity costs, achieving Net zero in 2050 is more expensive than postponing to 2060
- Future cost development of key energy technologies would have strong impacts
- Energy demand reduction through accelerated efficiency improvement would reduce the decarbonistion challenges and cost (study does not include costs of efficiency improvement)

Policy Implications

- ✓ Assessments needed on
  - ✓ Potentials of solar, wind, CCS, nuclear etc.
  - ✓ Feasibility and implications of adding vast amount of solar, wind, battery storage etc. in next 30-40 years
  - ✓ Impacts on employment and skills
- ✓ International collaboration on technologies and potential climate finance needs to be explored