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Macroeconomic Effects of Clean Energy Transition for Net Zero Emissions in Nepal

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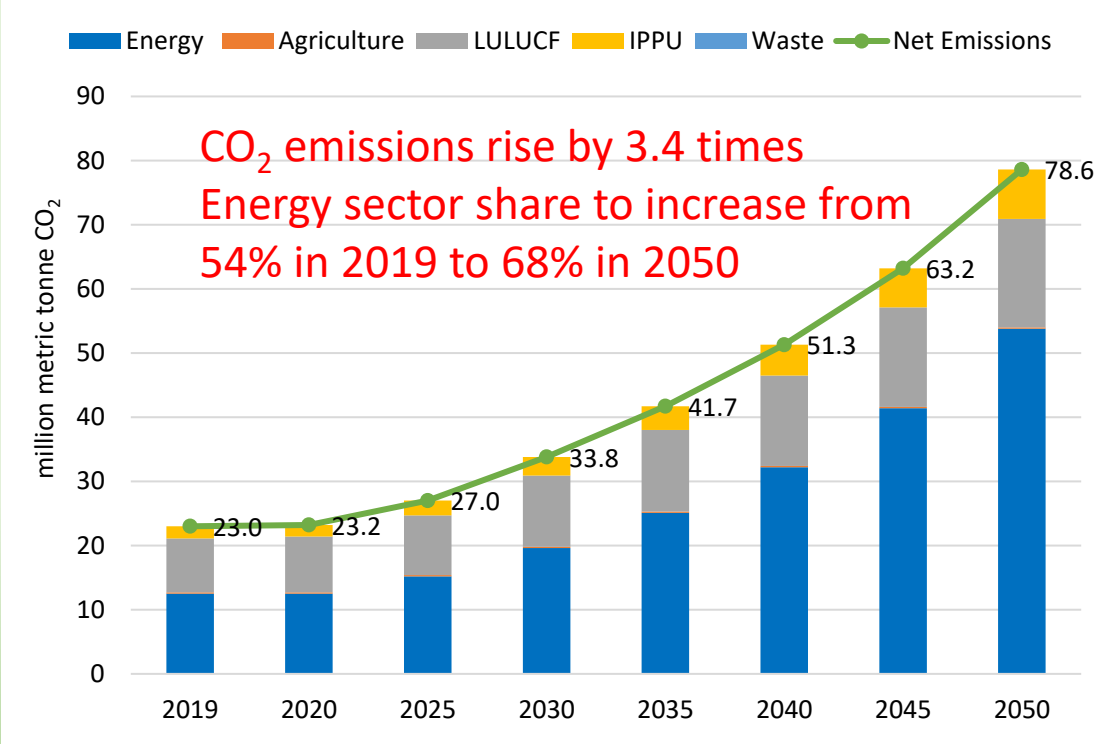
Outline

- Nepal's Long-term Strategy for Net Zero CO_2 Emissions
- Scenario Description
- Modeling Framework
- Mitigation Opportunities for Achieving Net Zero Emissions in Nepal
- Macroeconomics & Welfare Indicators
- Final Remarks
- Future Research

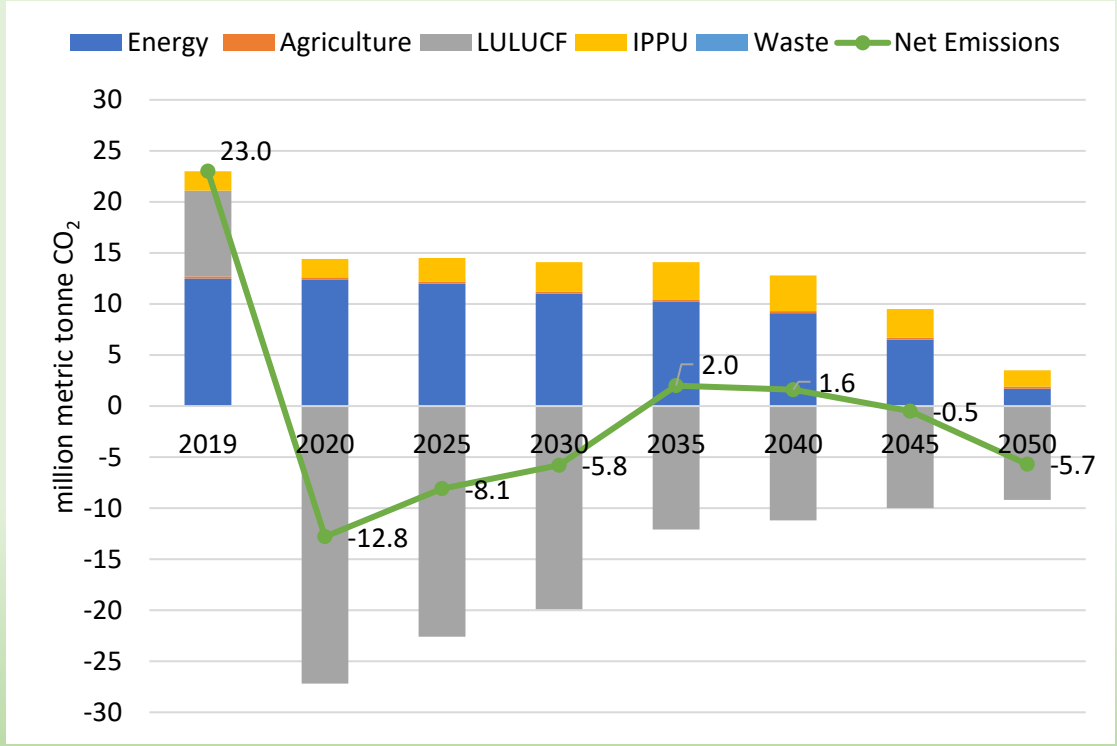
Nepal's Long-term Strategy for Net Zero CO_2 Emissions

"Nepal aspires to minimize emissions & sustainably achieve net-zero emissions by 2045"

Reference Scenario



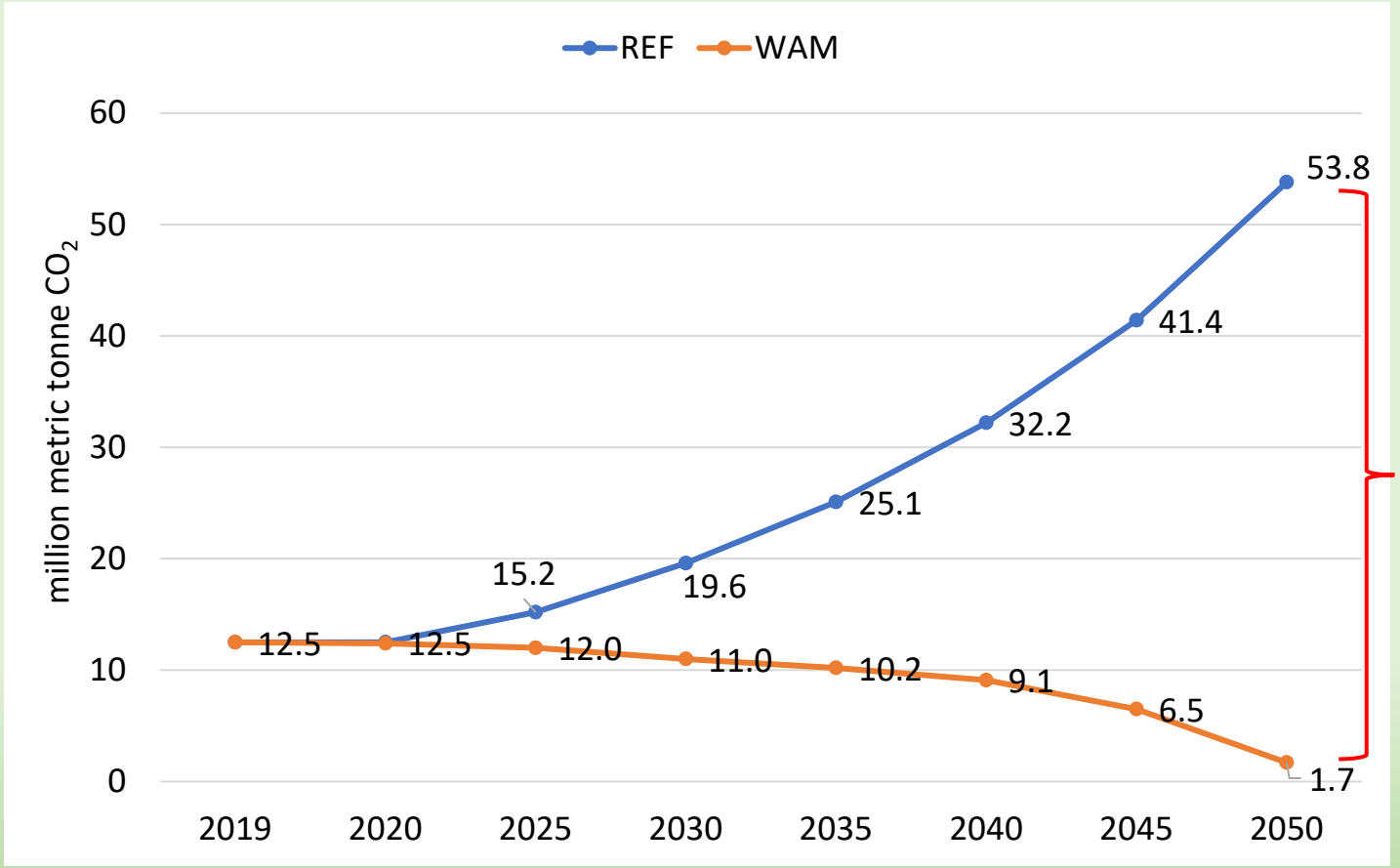
With Additional Measures (WAM) Scenario



Source: GoN (2021), Nepal's Long-term Strategy for Net-zero Emissions

Nepal's Long-Term Strategy

Energy related CO_2 Emissions in Additional Measures Scenario



A 97% CO_2 emissions reduction from energy sector in 2050

Source: GoN (2021), Nepal's Long-term Strategy for Net-zero Emissions

Second Nationally Determined Contribution of Nepal

1

Power

1. Expand clean energy generation from 1,400 MW to 15,000 MW, of which 5-10% generated from mini/micro hydro, solar, wind & bioenergy.
2. By 2030, ensure 15% of the total energy demand is supplied from clean energy sources.

2

Transport

1. By 2030, increase sales of e-vehicles to cover 90% of all private passenger vehicle sales, including two-wheelers and 60% of all four-wheeler public passenger vehicle sales.
2. By 2030, develop 200 km of the electric rail network to support public commuting & mass transportation of goods.

3

Residential

1. By 2030, ensure 25% of households use electric stoves as their primary mode of cooking.
2. By 2025, install 500,000 improved cookstoves, specifically in rural areas.
3. By 2025, install an additional 200,000 household biogas plants & 500 large scale biogas plants.

4

Agriculture, Forestry and Other Land Use (AFOLU)

1. By 2030, maintain 45% of the total area of the country under forest cover (including other wooded land limited to less than 4%).
2. By 2030, manage 50% of Terai and Inner Terai forests & 25% of middle hills & mountain forests sustainably.

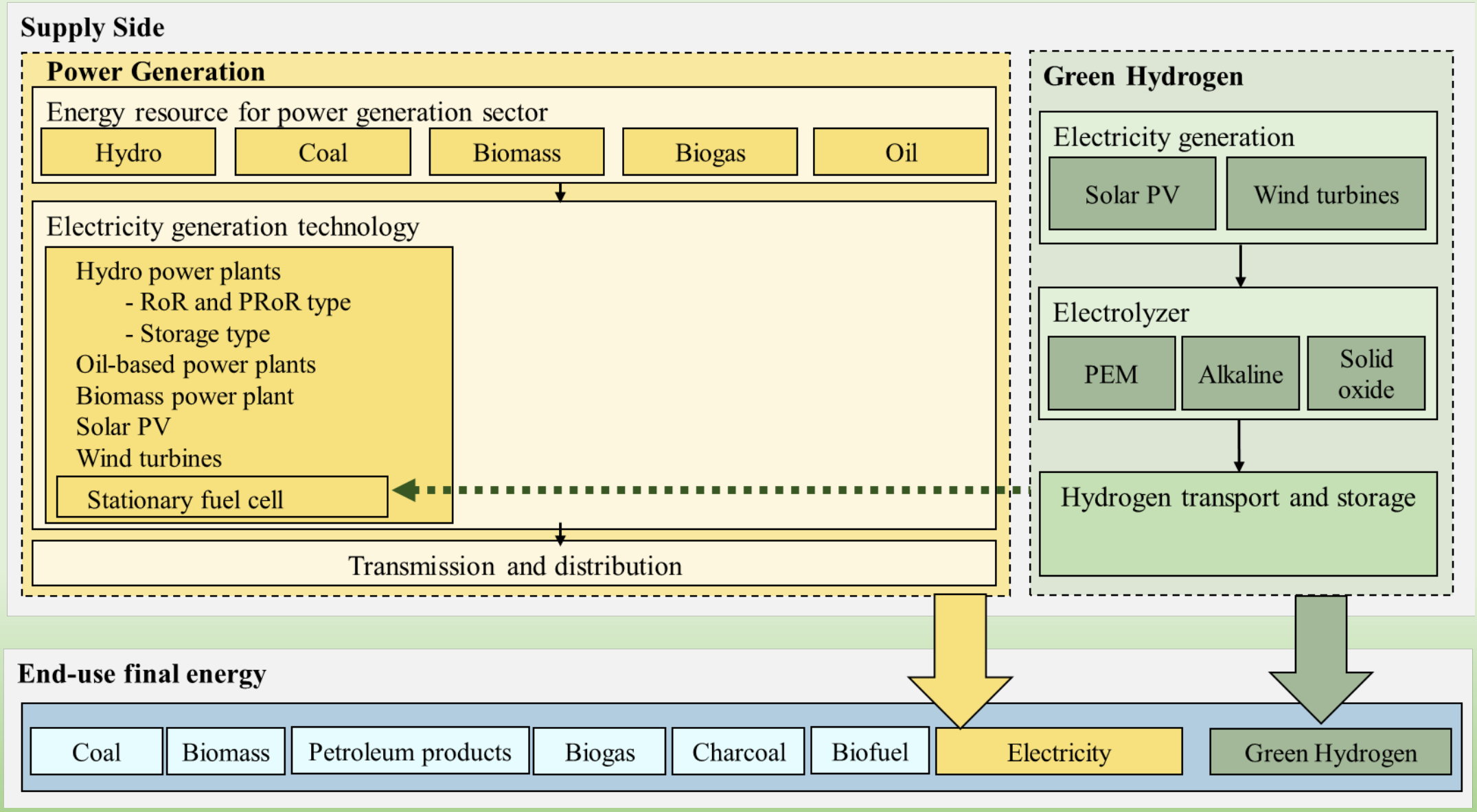
5

Waste

1. By 2025, 380 million litres/day of wastewater will be treated before being discharged, & 60,000 cubic meters/year of faecal sludge will be managed.

Source: GoN (2020)

Modeling of Green Hydrogen in Nepal's AIM/Enduse Model



Scenario Description

BAU

- Reference scenario that provides a perspective on energy system such that energy & technology use follows historical pattern
- No emission constraints

NZE_ELY

- CO_2 emissions in the energy sector follow LTS trend
- NDC targets are achieved
- Electrification in all the sectors
- No hydrogen-based technologies are considered

NZE_ELY+H2

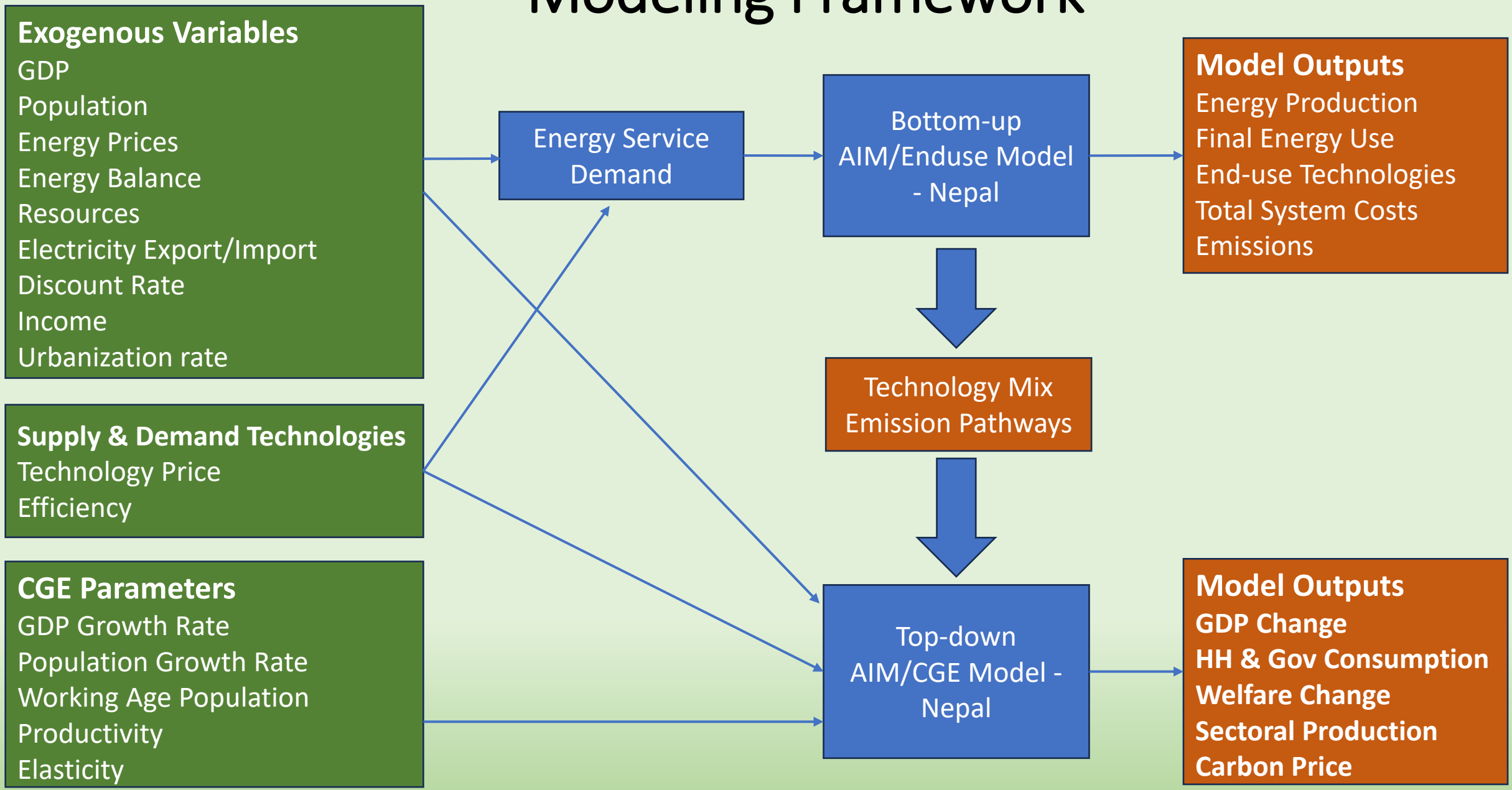
- CO_2 emissions in the energy sector follow LTS trend
- NDC targets are achieved
- Electrification in all the sectors
- Hydrogen-based technologies are available for further reduction of CO_2 from hard-to-abate sectors

Scenarios Assumptions

		NZE_ELY	NZE_ELY+H2
Electric-transport	LDVs	Full	Full
	HDVs	**Partial**	Full
Biofuels in transport	All	Full	Full
Hydrogen-based fuel and technologies in transport	LDVs	-	Full
	HDVs	-	Full
	Aviation	-	**Partial**
Electrification in industry	Cement	-	-
	Brick	Full	Full
	Paper and pulp	Full	Full
	Iron & steel		
	Others (Process heat)	Full	Full
Hydrogen-based fuel and technologies in industry	Cement	-	**Partial**
Electrification in residential and commercial	All heating applications	Full	Full

Note:
1. In NZE_ELY scenario not all HDVs are considered to be electric considering the country's mountainous terrain.
2. In NZE_ELY+H2 scenario, the H2 option is considered from 2035 onwards. However, in the cement and aviation H2 is only considered partially.

Modeling Framework

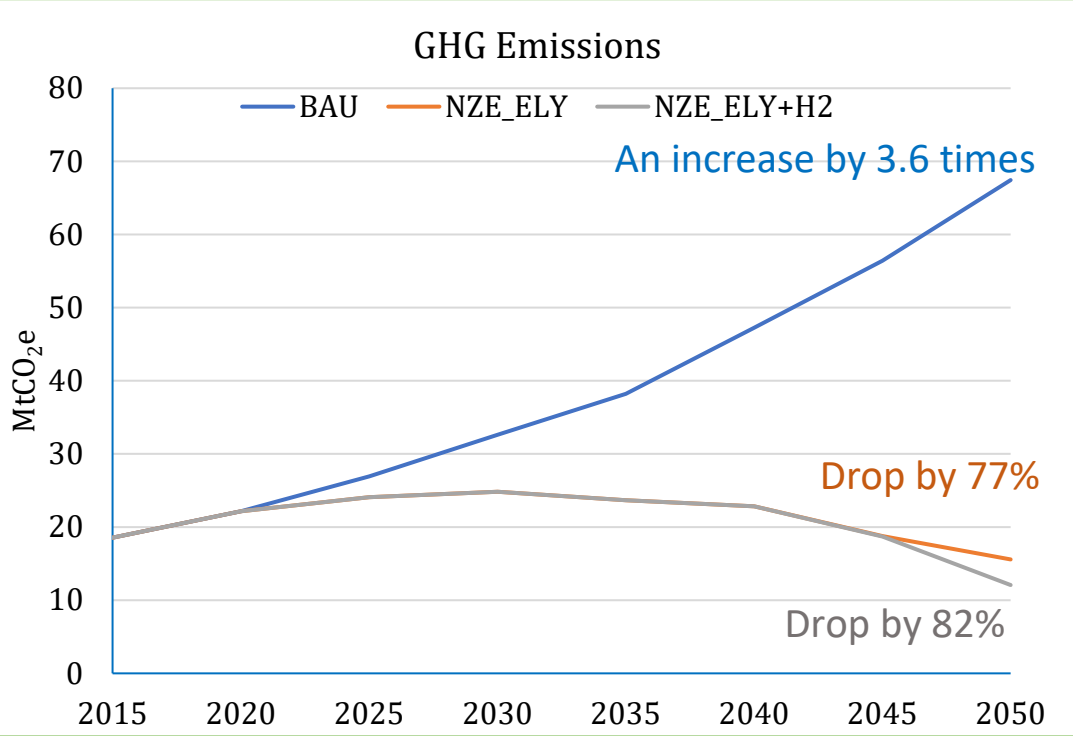


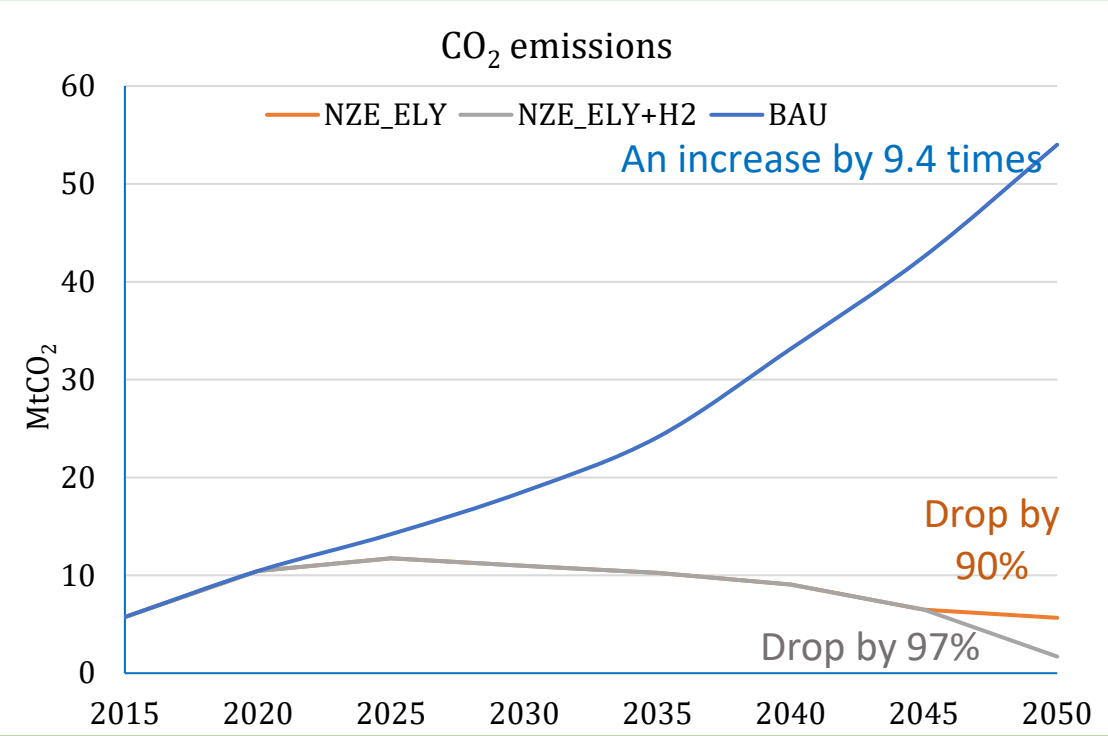
GHG & CO_2 Emissions from Energy Using Sectors in BAU & NZE Scenarios

Rising Emissions from Energy Using Sectors in the BAU Scenario

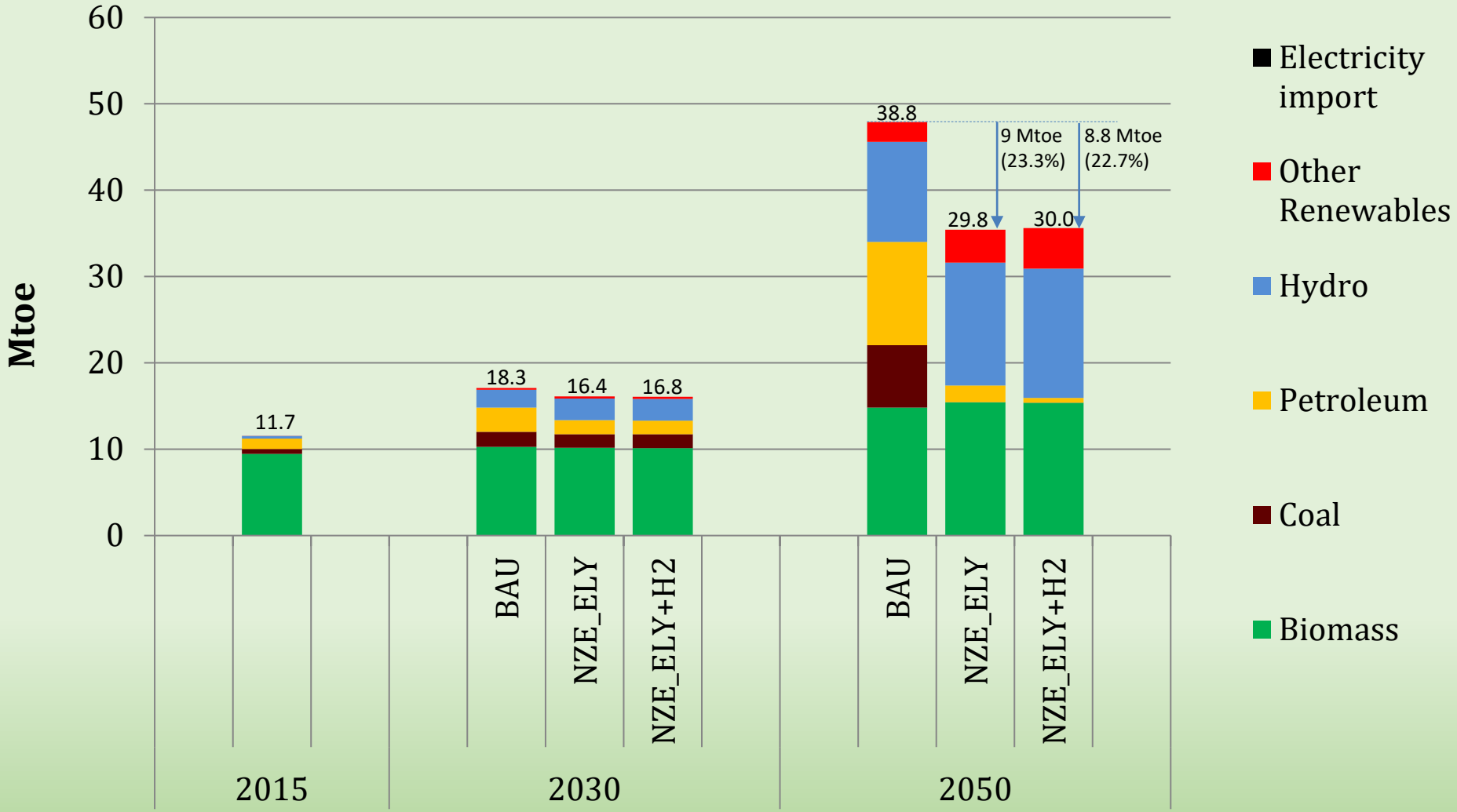
CO_2 emissions would undergo a significant increase

CO_2 emissions share increase from 31% to 80% during 2015-2050



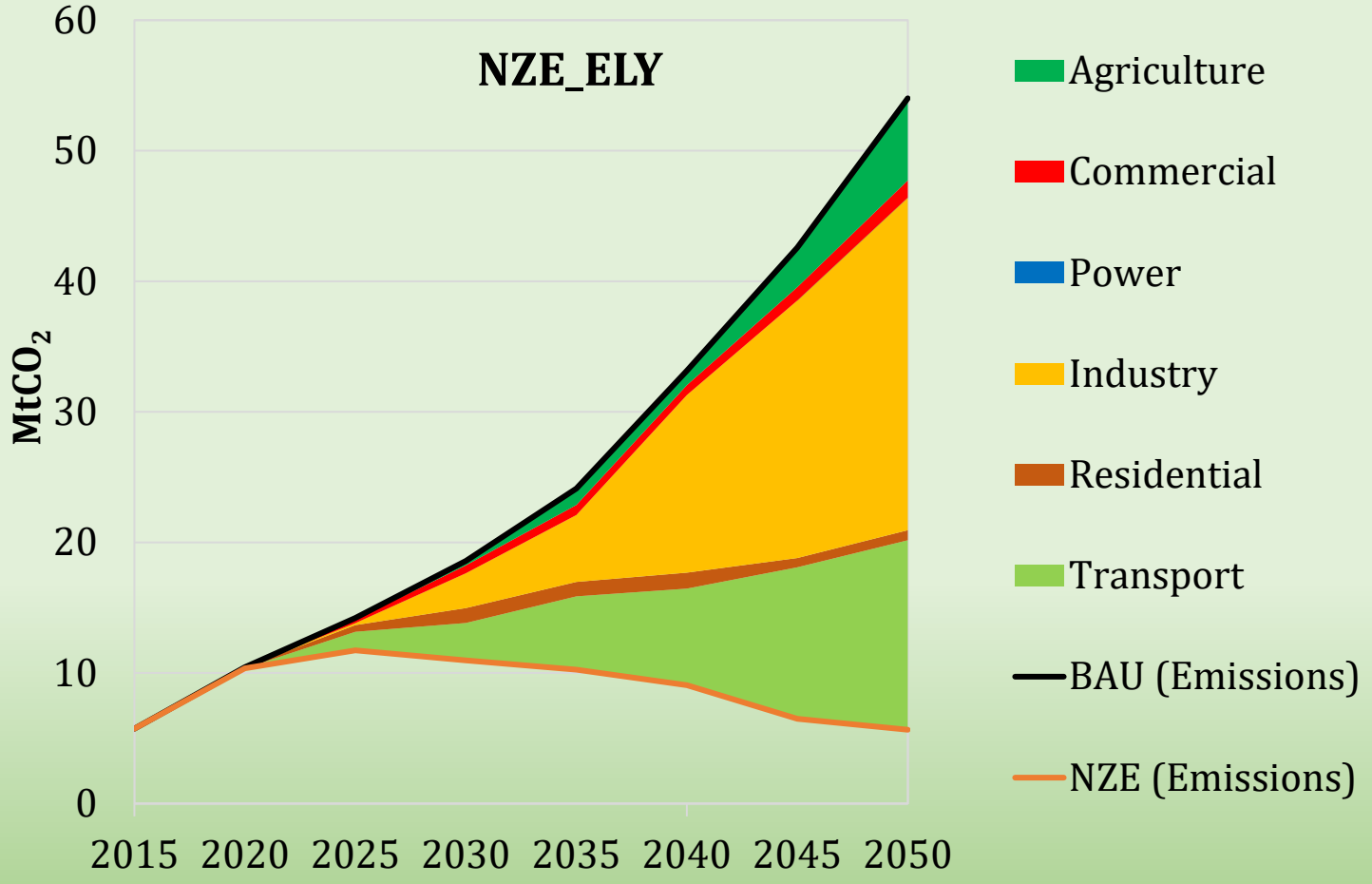


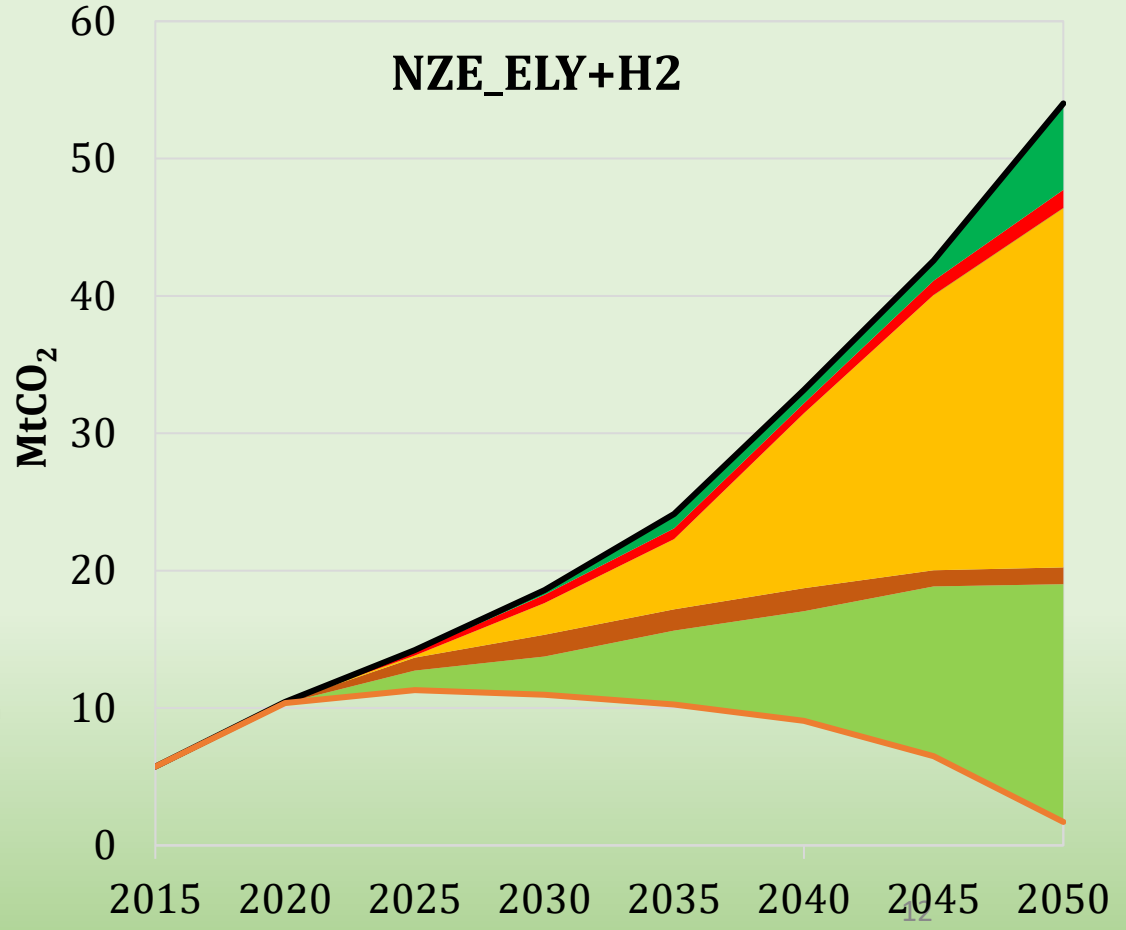
Primary Energy Consumptions



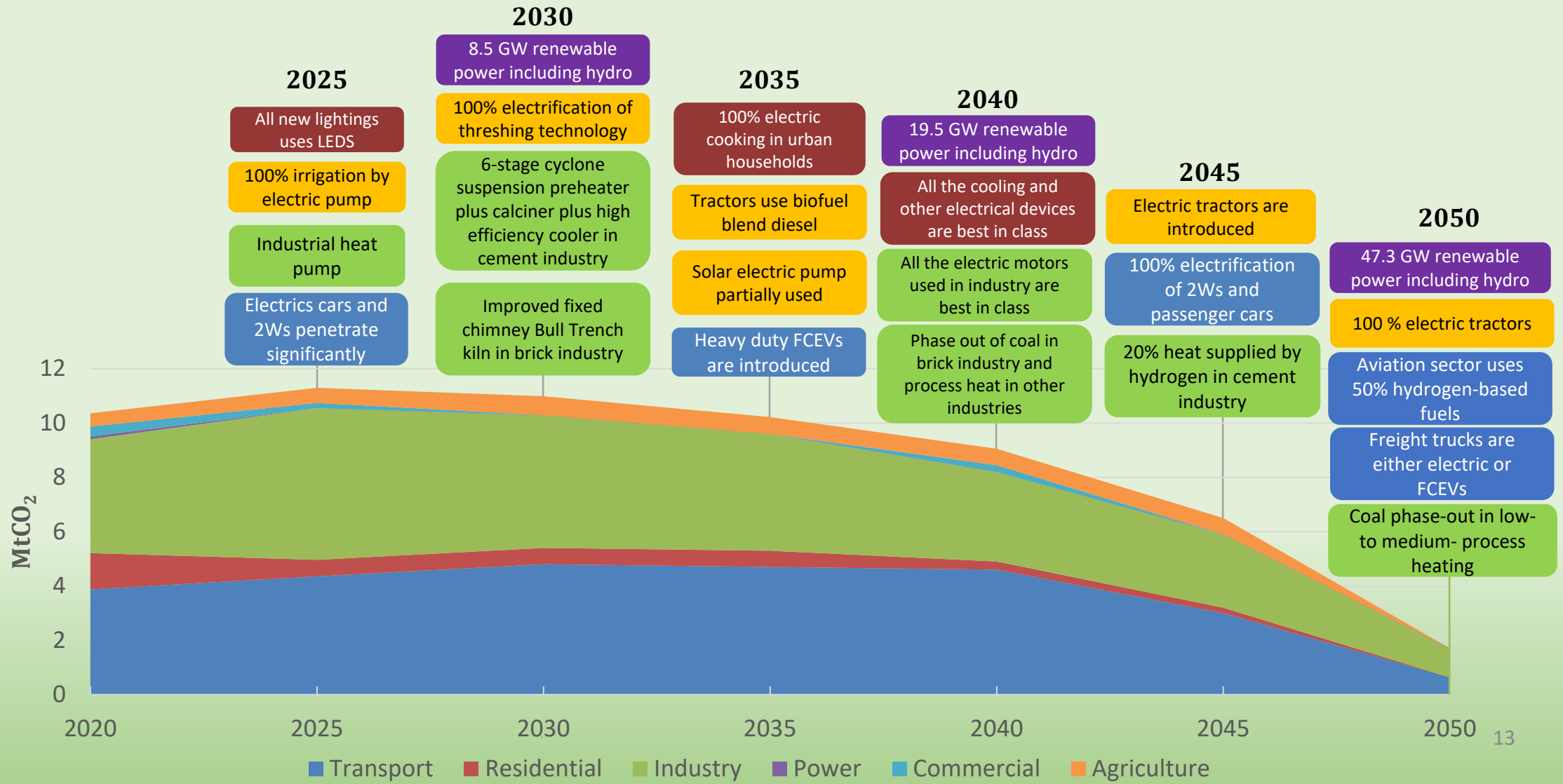
CO_2 Emissions Reduction by Sector

Electrification options can drop total emissions in 2050 at most to 5.7 $MtCO_2$, whereas with hydrogen-based technology options, additional 1.9 $MtCO_2$ emissions can be abated.

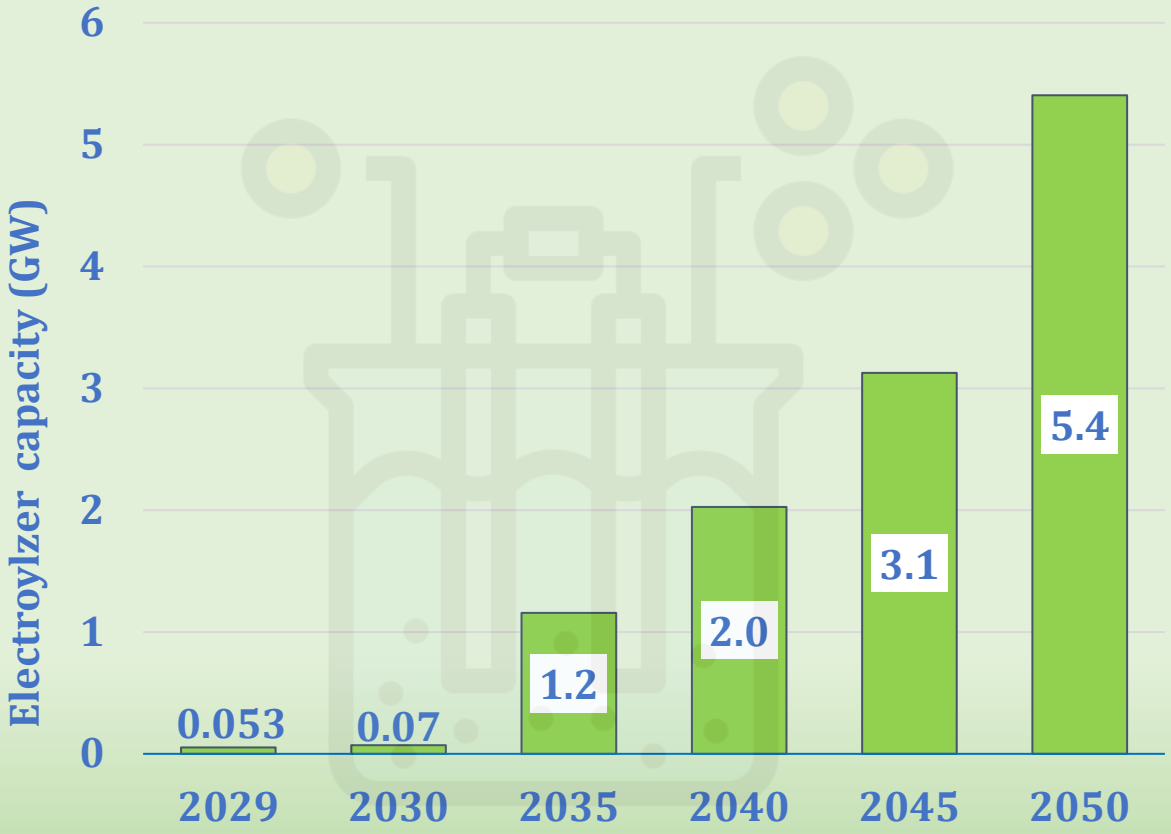


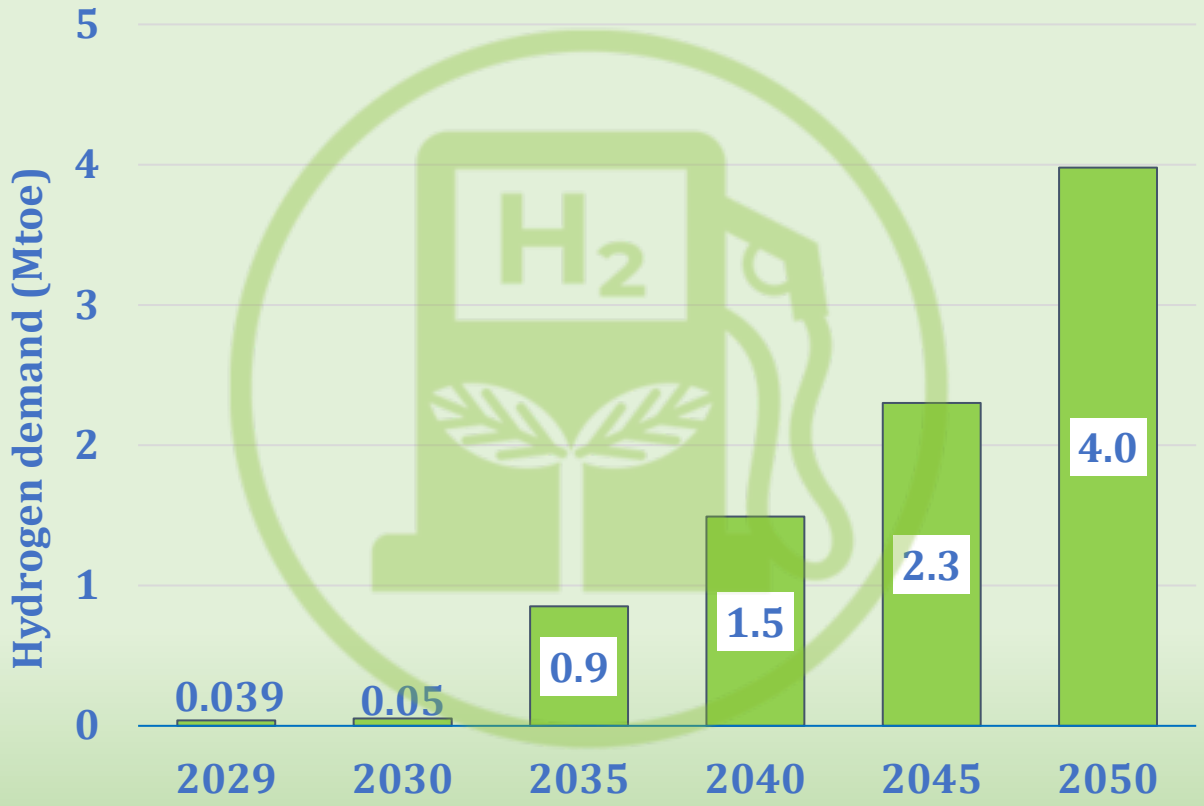


Milestones to Net Zero CO_2 Emission by 2045 in Energy Sector in NZE_ELY+H2 Scenario

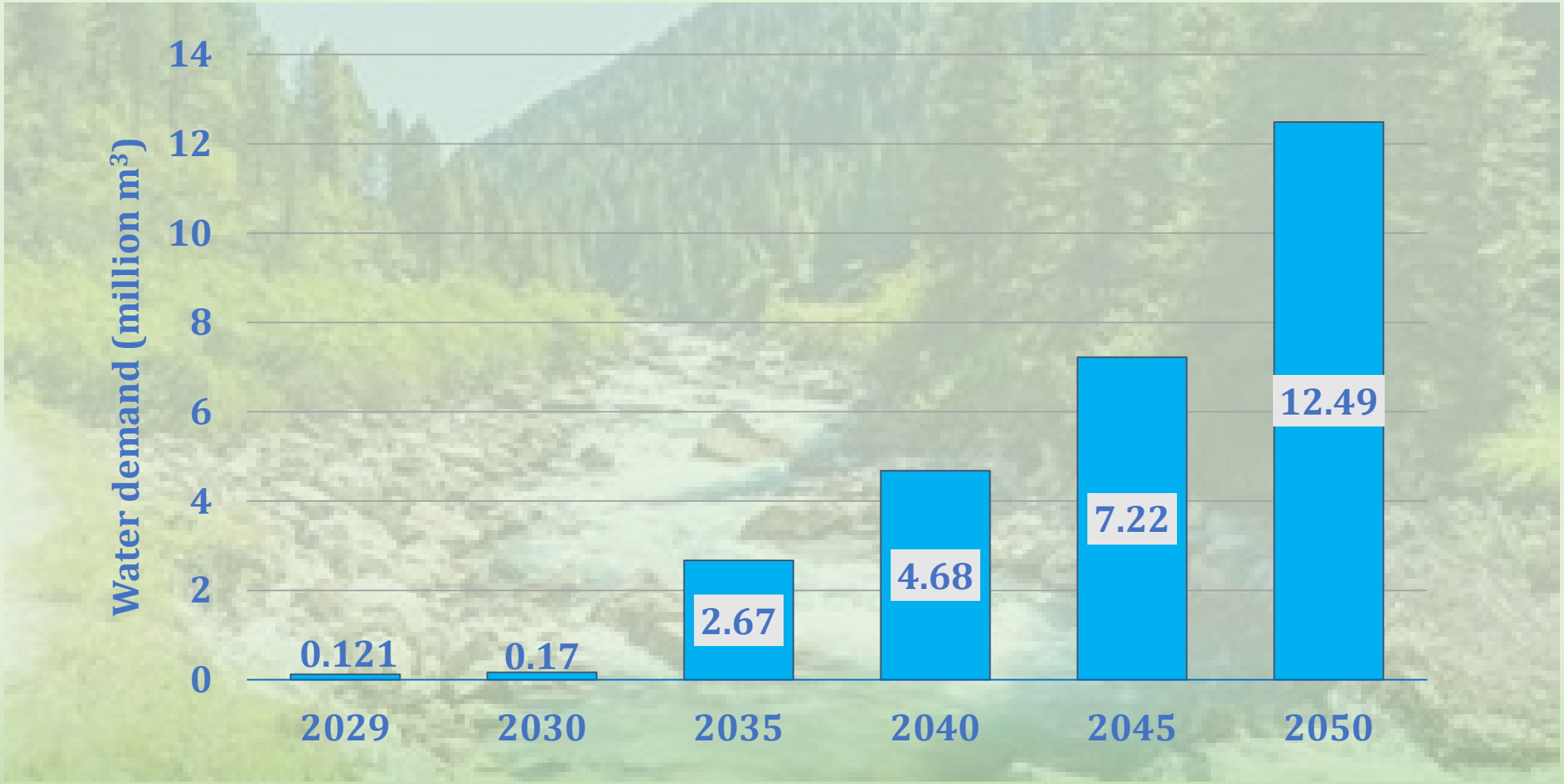


Hydrogen Requirement in NZE_ELY+H2



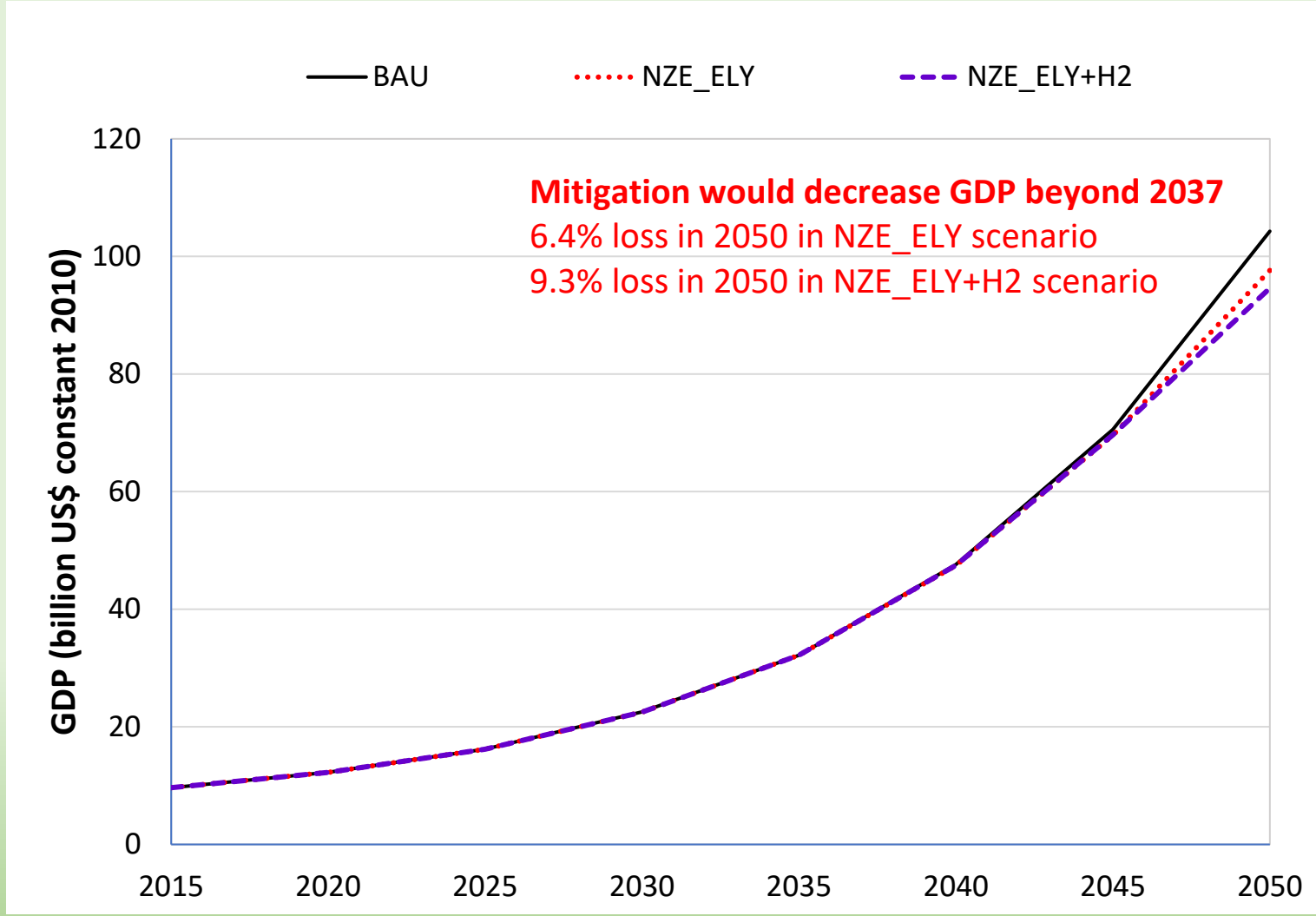


Fresh Water Demand in NZE_ELY+H2



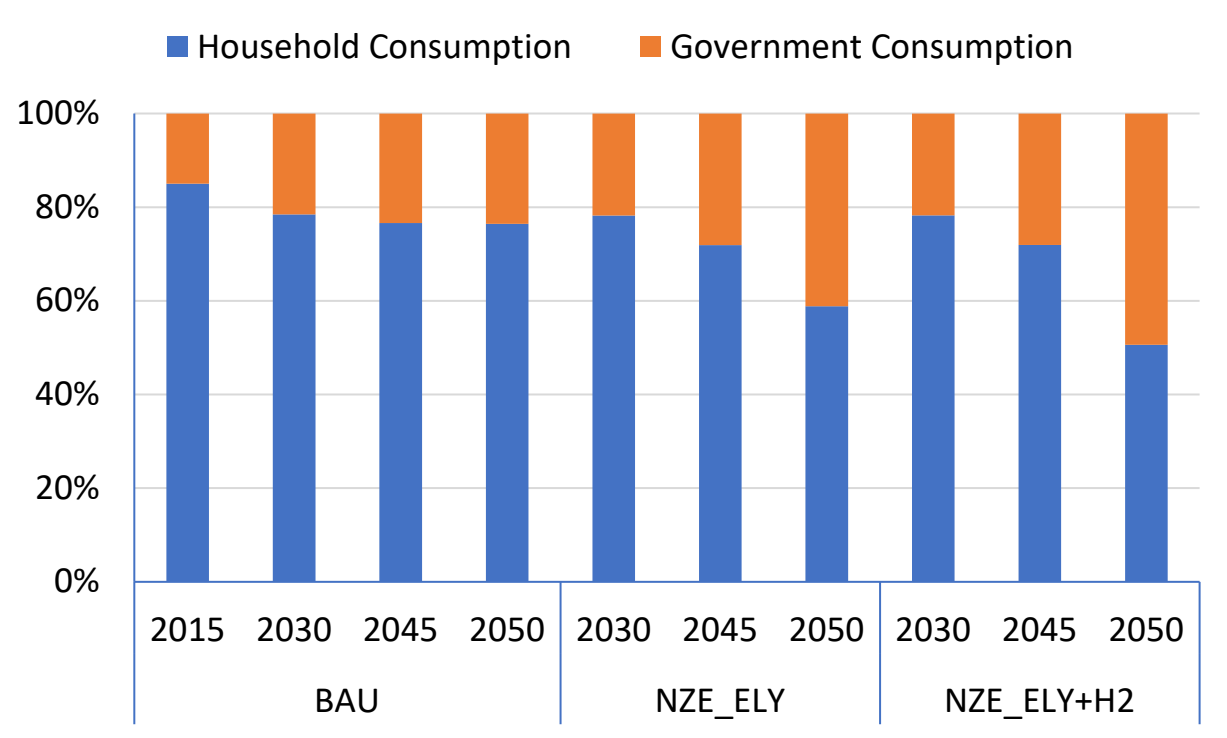
In 2021, the water demand in Kathmandu Valley was 171 million m^3. In 2050, water demand for H_2 production will account for 7% of valley's water demand in 2021. KV's water shortage in 2021 was 36 million m^3. The water demand in KV and all over the country is expected to increase significantly by 2050. The water for household versus green hydrogen should be carefully considered by the policy making and relevant government institutes to match the water demand in the future.

Macroeconomic & Welfare Indicators: GDP
(Preliminary results)

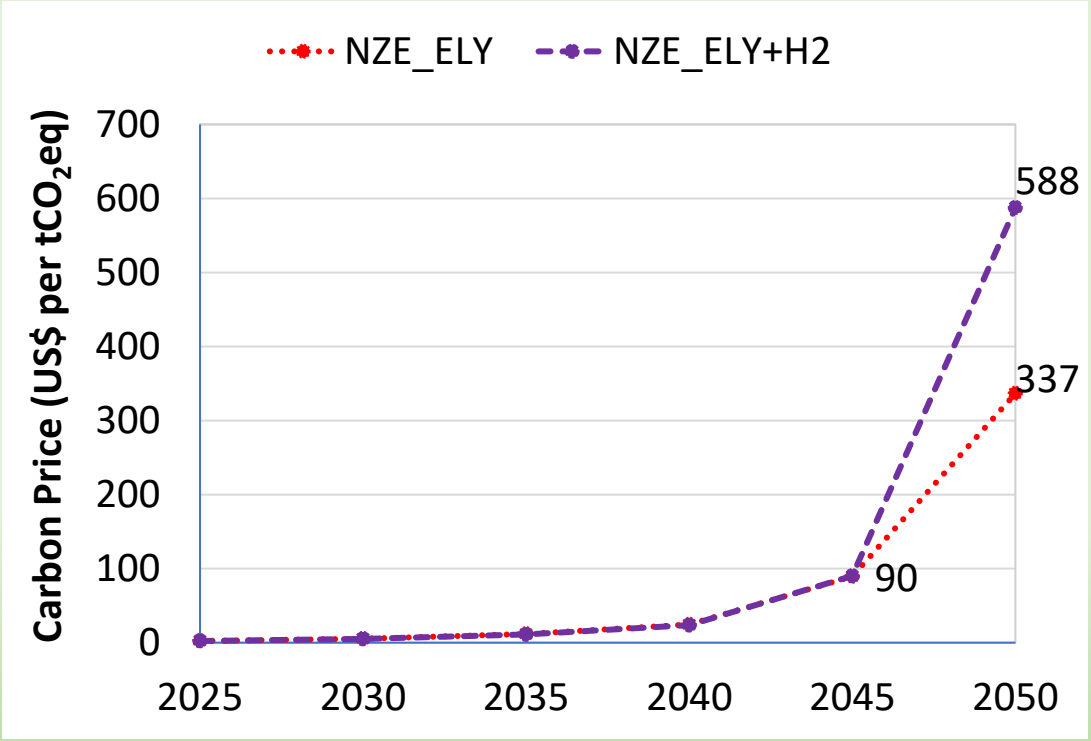


Macroeconomic & Welfare Indicators:
Consumption & Carbon Price (Preliminary results)

Higher Government consumption required in NZE scenarios



Higher carbon prices in NZE_ELY+H2 scenario during 2045-2050

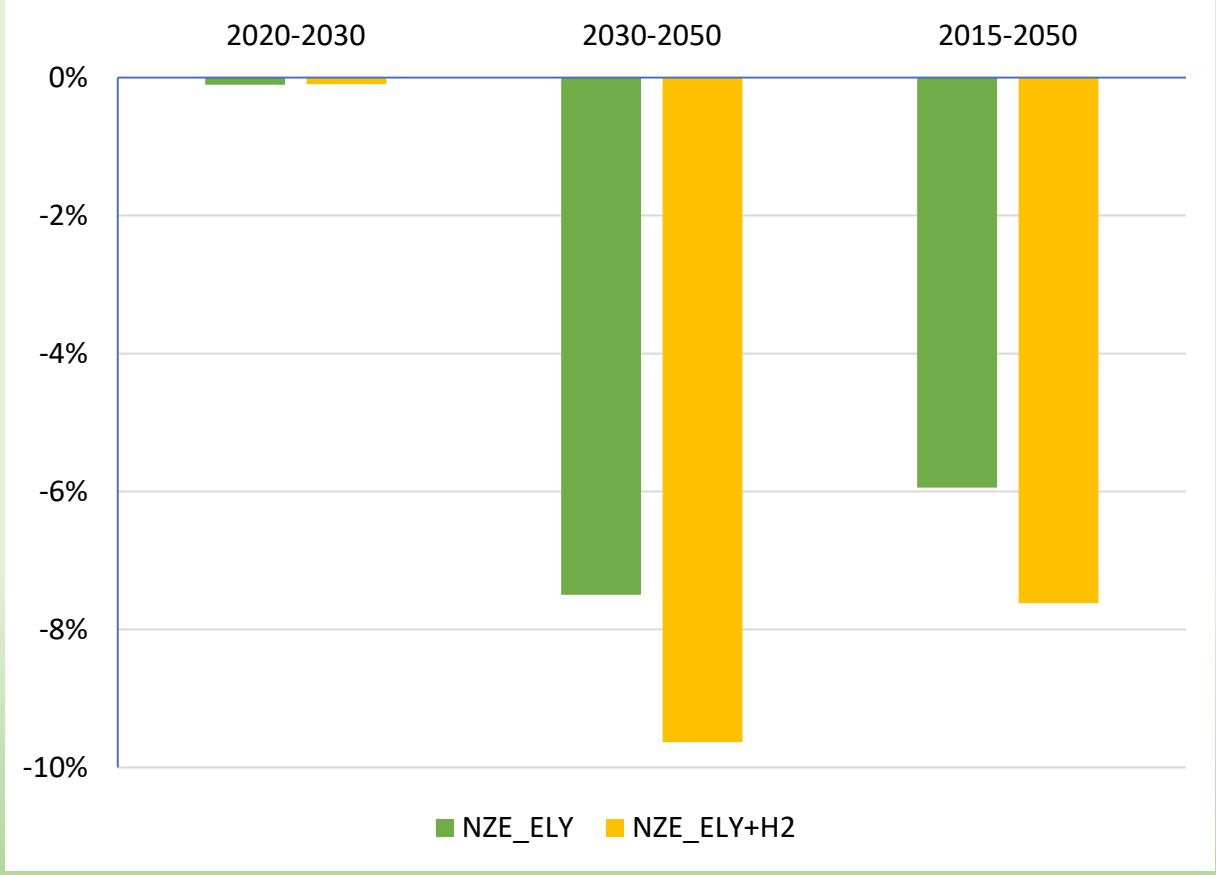


Government consumption increases by 18-59% in NZE-ELY & by 18-82% in NZE_ELY+H2 during 2045-2050

Welfare Losses

(Preliminary results)

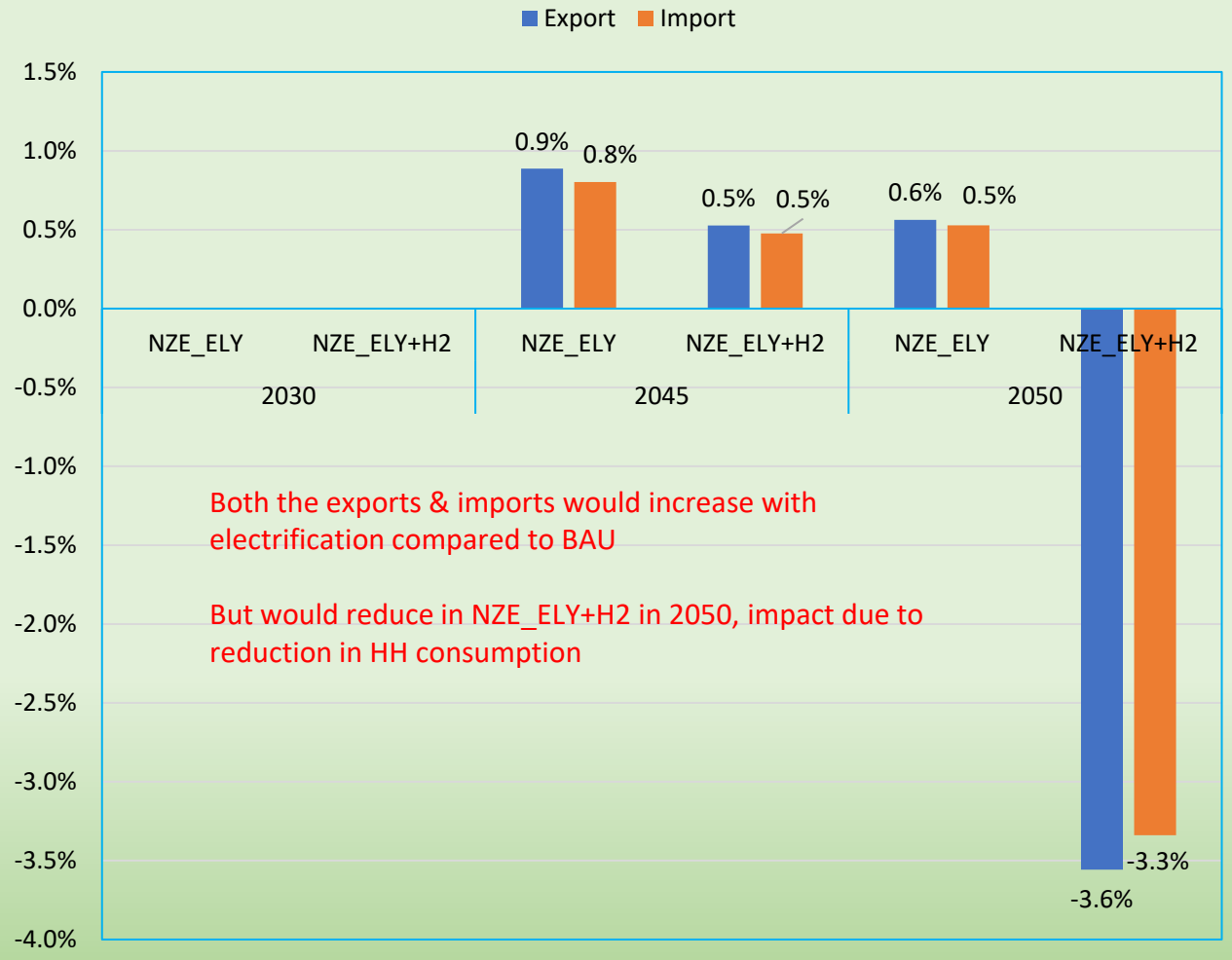
Achieving net-zero emissions has a large effect on economic welfare in Nepal



- Lower household consumption is the major cause of such welfare losses.
- During 2045-2050, household consumption gets lowered by 8-30% in NZE_ELY and 8-43% in NZE_ELY+H2.

Effects on Trade Balance (Preliminary results)

Nepal would continue to have a trade deficit future



Final Remarks

- Electrification options would mitigate about 77% of GHG emissions in 2050. With introduction of hydrogen-based technology options, additional 5% of GHG emissions could be abated in 2050.
- With decarbonization targets, the national GDP is likely to suffer towards 2050.
- Electrification & green hydrogen considered in this analysis are limited to only CO_2 emission mitigation from energy using sectors.
- Higher level of electrification & hydrogen use would be necessary if non-CO_2 mitigations are also considered.
- The sustainability of NZE beyond 2045 will also depend on the level of carbon sequestration from LULUCF. The level of future sequestration is uncertain.

Decarbonization Study of Nepal using AIM/CGE Model

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Transition to Deep Decarbonized Energy Systems in Nepal: The Macroeconomic Perspectives

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ABSTRACT

This study analyzed the macroeconomic impacts of the Nationally Determined Contribution (NDC) and the deep decarbonization pathways aligning with the 2°C and 1.5°C scenarios in Nepal using the computable general equilibrium (CGE) model. The analysis shows that the NDC, the 2°C and the 1.5°C scenarios would be achievable at the expense of national economic loss in Nepal. Results show that extending the NDC targets beyond 2030 without strengthening them would result in a greenhouse gas (GHG) emission reduction of 9.9% by 2050, which is far behind the level of reductions compared to that which could be required under the ideal mitigation pathways needed to confine the temperature rise to 2°C and 1.5°C compared to the pre-industrial levels. Results indicate that the NDC scenario of Nepal could be achievable at a carbon price of US$ 4.0 per tCO_2eq in 2050. However, the results of the CGE modelling analysis of Nepal showed that a much higher carbon price of US$ 21 per tCO_2eq and US$ 245 per tCO_2eq would be needed by 2050 to achieve the 2°C and the 1.5°C scenarios respectively.

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Decarbonization Studies of Nepal using AIM/Enduse Model

Attainability of Net Zero Carbon Emission Targets in Nepal under Different Effort-sharing Approaches

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Abstract

Nepal aims to achieve carbon neutrality by mid-century. This study aims to analyze the energy sector transformation needed to achieve the carbon neutrality target. The study employs the AIM/Enduse model as a modelling tool to analyze the energy system. A business-as-usual (BAU) scenario is developed in which energy and technological use follow historical trends. The carbon dioxide (CO_2) emissions in the energy sector in BAU would reach 66.3 $MtCO_2$ in 2050. The study also assesses the carbon budget and carbon dioxide emission allowance with various effort-sharing approaches. Based on the estimated emission allowances, the emission pathway in the energy sector is determined to develop an emission reduction (ER) scenario. The ER scenario also incorporates the Nationally Determined Contributions (NDC) targets of Nepal. In the ER scenario, CO_2 emissions from the energy sector in Nepal peak in 2036, then drop, reaching 6.4 $MtCO_2$ in 2050. The ER scenario would require energy efficiency improvement and electrification of the end-use technologies in all the sectors; and fuel-switching from coal and oil to biomass in addition to electrification in thermal applications in industries. The electricity consumption in the ER scenario would be higher by 70% compared to the BAU scenario in 2050. Hydro, solar and biomass would have crucial roles in the decarbonization of the energy sector. In the ER scenario, the combined power generation capacity of hydropower, solar and wind would reach 72 GW by 2050, which in the BAU scenario would be 37 GW. Policies and incentives that would promote the electrification of end-use technologies and renewable power generation need to be formulated to achieve the mitigations of the ER scenario.

Key words: AIM/Enduse, carbon neutrality, hydropower, Nepal, renewable energy

1. Introduction

Limiting the emissions of anthropogenic greenhouse gases (GHG) emissions to keep the global average temperature below 2ºC and efforts to keep it below 1.5ºC have been major concerns for the climate change community. Studies show that the combined mitigation efforts of countries' currently pledging NDCs would not be sufficient to meet the 2ºC and 1.5ºC targets. The IPCC's special report concludes that net carbon dioxide emissions should reach zero by mid-century to keep the temperature below 1.5°C above the pre-industrial level (IPCC, 2018). Researchers have tried to develop different ways to share GHG emissions using equity principles to keep the emissions below the limit. van den Berg et al. (2020) have presented various effort-sharing approaches to estimating carbon budgets and emission allowances. Nepal submitted its Long-term Strategy for Net-zero Emissions (hereafter referred as 'Nepal-LTS') to the United Nations Framework Convention on Climate Change (UNFCCC) in 2021 (GoN, 2021). The report states that Nepal can achieve carbon neutrality by 2045. Achieving carbon neutrality in Nepal implies decarbonization of the emitting sectors, mainly the energy sector, as well as utilizing carbon sinks, to offset emissions from hard-to-abate sectors. The Nepal-LTS also shows that in the land-use, land-use change and forestry (LULUCF) sector, there would be net CO_2 emissions in the reference scenario. More than 40% of the land area of Nepal is forested. Despite significant forest area coverage,

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RESEARCH ARTICLE

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Achieving the Paris Agreement's 2 degree target in Nepal: the potential role of a carbon tax

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ABSTRACT

The 2015 Paris Agreement aims to limit global temperature rise in this century to well below 2°C above the pre-industrial level, and pursue efforts to limit further the temperature rise below 1.5°C. All parties ratifying the Paris Agreement have submitted Nationally Determined Contributions (NDCs), many stating emission reduction targets. The international climate research community has designed five different Shared Socioeconomic pathways (SSPs) to characterize various possibilities in demographic and economic changes over the next century. These SSPs were implemented by six integrated assessment model (IAM) teams, which also determined the carbon price trajectory required to limit the temperature rise below 2°C in respective SSPs. In SSP5, also termed the fossil-fueled development scenario, only three IAMs identified that the 2°C target would be feasible, with carbon prices ranging from 220 to 518 US$/$tCO_2e$ in 2050. This study aims to analyse the effects of these carbon prices on energy and emissions during 2015–2050 in Nepal. It does so using a long-term energy system model using the framework of the Asia-Pacific Integrated Model/Enduse (AIM/Enduse) modelling tool. The base case scenario and three carbon price scenarios are developed. Primary energy supply, energy security, energy technology-mix (especially renewable energy usage and hydropower development), emissions of greenhouse gases (GHGs) and local pollutants, and local/regional environmental co-benefits are compared between the base case scenario and carbon price scenarios. The study finds that the implementation of a carbon tax would promote domestic hydropower, improve energy-efficiency and reduce imports of fossil fuels when compared to the base case. Hydropower-based electricity would have a major role in reducing emissions.

Key policy insights

- The carbon prices in SSP5 determined by IAMs to achieve the 2°C target would be sufficient to achieve Nepal's targets under its NDC in the energy sector.
- The industry and transport sectors would offer the highest GHG emission reduction.
- Hydropower and biomass would have major roles in decarbonizing the energy system.

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Decarbonization Studies of Nepal using AIM/Enduse Model

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Strategies to Achieve Net Zero Emissions in Nepal

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ABSTRACT

Countries adopted the Paris Agreement to pursue efforts towards limiting the global average temperature increase to 1.5 °C above pre-industrial levels. To achieve this target, the global emission level will have to be negative by the second half of the century. This study aims to analyse different GHG mitigation pathways to achieve net zero emissions by 2050 in Nepal. The study first assesses the energy use and emissions in the Business-as-usual (BAU) scenario during 2010-2050 using the Asia-Pacific Integrated Model/Enduse (AIM/Enduse). In addition to the BAU scenario, the study has assessed six scenarios: a No Climate Policy (NCP) scenario (without carbon tax) and five carbon tax scenarios. The carbon tax rate varies from $10 to $800 per tCO2e among the five carbon tax scenarios. According to the study, the GHG emissions in 2050 is estimated to be 32.9 MtCO2e in the BAU, 30.3 MtCO2e in the NCP and 5.1 MtCO2e at the highest carbon tax scenario (i.e. at $800/tCO2e). The study then analyses options to achieve net zero emissions by 2050. This can be achieved through carbon offset by hydropower export and carbon sequestration by forests. The analyses show that a carbon tax can be an effective instrument in reducing GHG emissions and that forests can act as a carbon sink to offset the remaining emissions to achieve carbon neutrality.

KEYWORDS
Carbon tax; net zero emission; AIM/Enduse; Nepal

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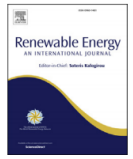

Implications of biogas and electric cooking technologies in residential sector in Nepal – A long term perspective using AIM/Enduse model

Check for updates

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ABSTRACT

This paper aims to analyze the effects of biogas and electricity based cooking on energy use and greenhouse gas (GHG) as well as local air pollutant emissions during 2010–2050 in the case of Nepal, which is highly dependent on traditional biomass (mainly fuelwood) for cooking. The country is rich in hydropower resources. A long-term bottom-up energy system model has been developed using Asia-Pacific Integrated Model/Enduse (AIM/Enduse) model for the analysis. The study developed a business as usual (BAU) scenario and three alternative cooking scenarios. Three alternative scenarios, named as "CL", "CM" and "CH" scenarios; consider low, medium and high level of penetrations of electric- and biogas-based cooking options, respectively. The changes in energy use and electricity generation in the BAU and alternative scenarios have been compared. Fuelwood consumption in the residential sector in 2050 when compared to the BAU would decrease by 12.5% in CL, 19.0% in CM and 24.2% in CH scenarios; and liquefied petroleum gas (LPG) consumption would decrease by 12.8% in CL, 16.3% in CM and 19.6% in CH scenarios. The electricity generation requirement in 2050 would increase by 9.4% in CL, 13.9% in CM and 17.0% in CH scenarios. Finally, the assessment of GHG and local pollutant emissions shows the decrease in all gases in CL, CM and CH scenarios when compared to the BAU.

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Future Research

Achieving Net Zero CO_2 Emissions in Nepal: The Role of Clean Energy Options

Macroeconomic Effects of Clean Energy Transition for Net Zero Emissions in Nepal

- Effects of technological innovation, mainly electrification & green hydrogen, in the economy
- Investment need for transition to electrification & green hydrogen
- Significant investment will be required to achieve ambitious GHG mitigation. How affordable would be such investment requirements of meeting the NZE 2045 targets for Nepal?
- How can developing countries achieve carbon neutrality & boost their resilience while pursuing economic growth & improved living standards?
- What are the benefits of the NZE strategy for Nepal?

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