Modeling Decarbonization Pathways in the Power Sector in Developing Countries: The case of Colombia

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Energy Modelling Platform Latin America and The Caribbean (EMP-LAC)
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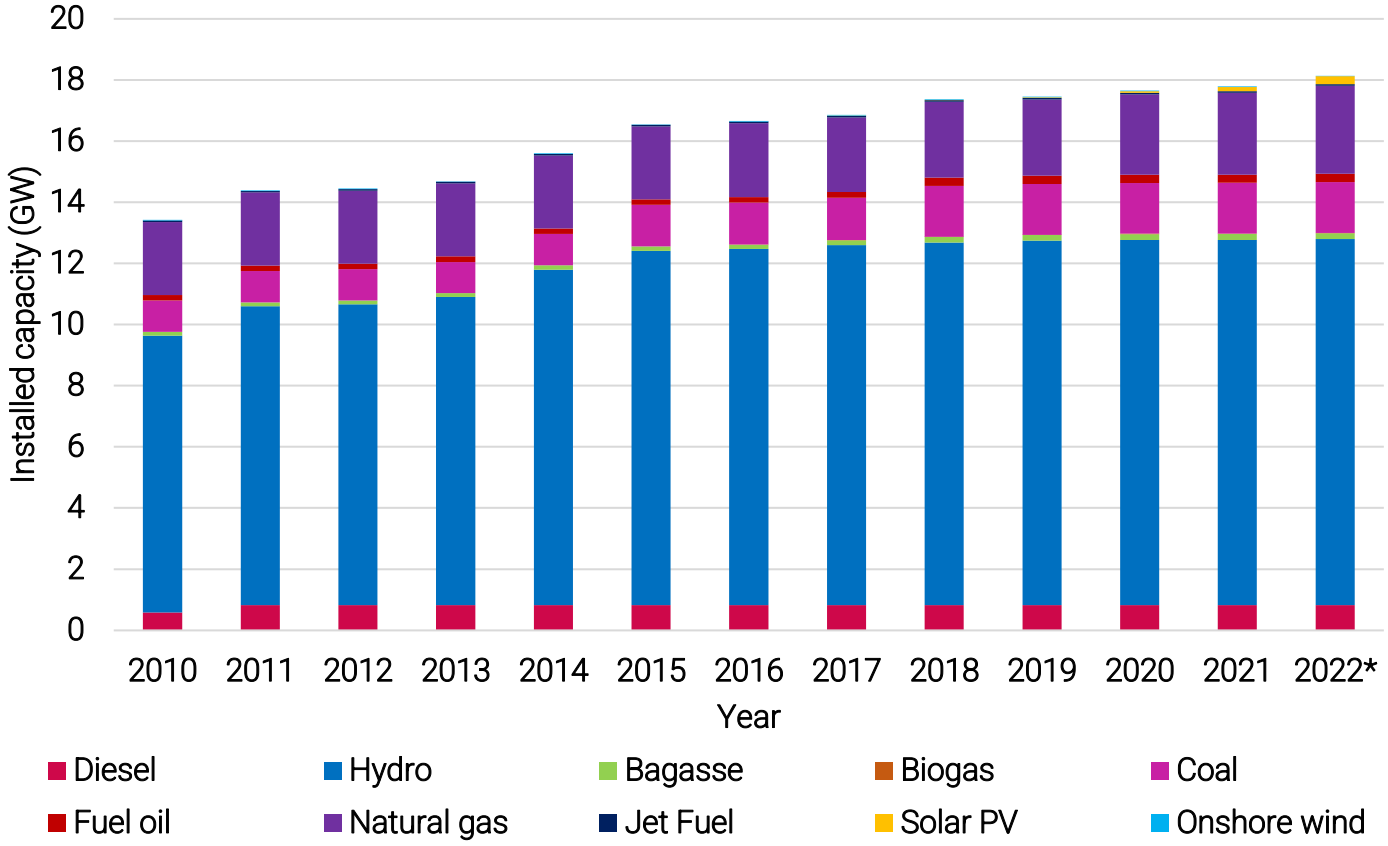
Context

- National Determined Contribution (Gobierno de Colombia, 2020): 51% GHG reduction by 2030 and carbon neutrality by 2050

- Electricity consumption should grow five times at the same time that the power system is decarbonized fully by 2050 (Plazas, 2022)

- Colombia is highly vulnerable to the effects of global warming and climate change (Gobierno de Colombia, 2021a; Portafolio, 2021; UNODC, 2008)

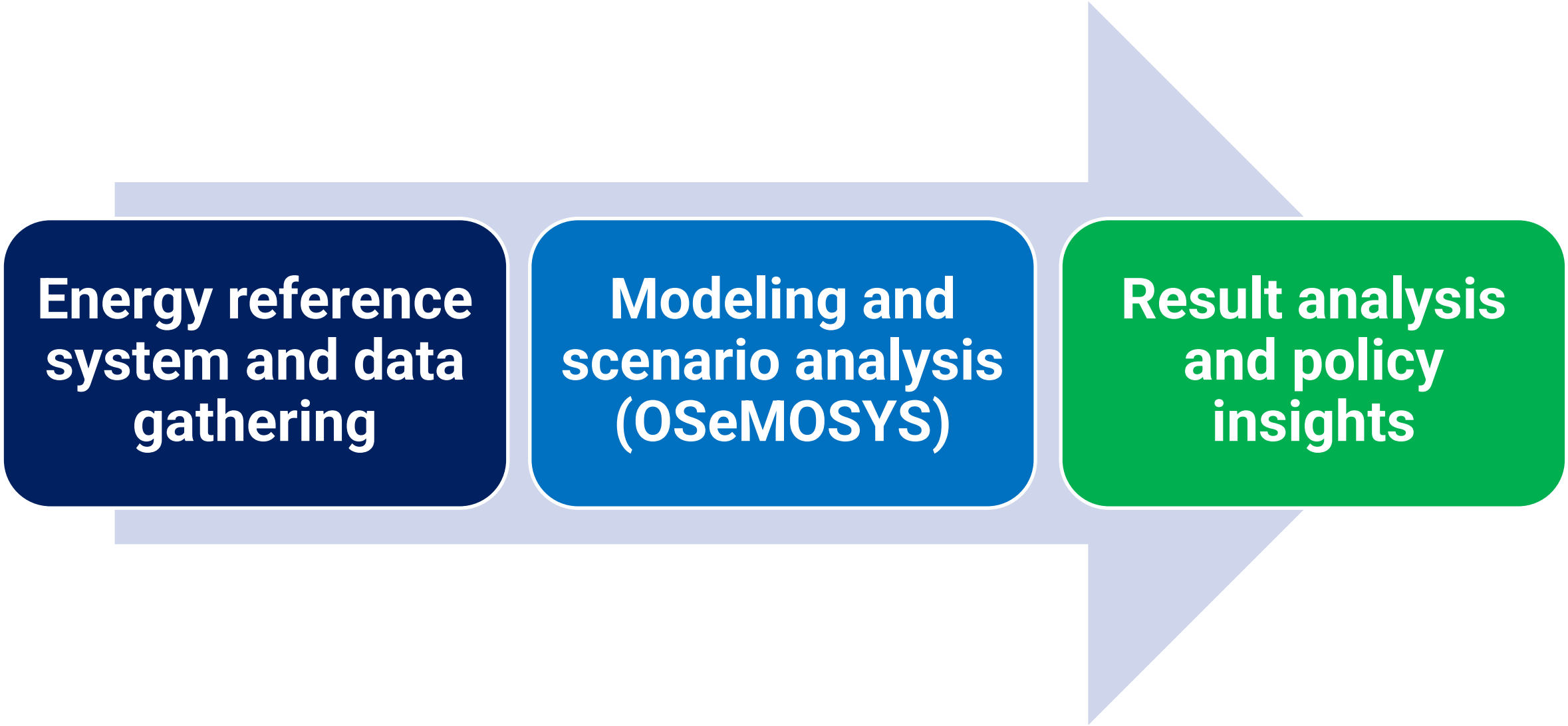


Source: XM, 2022

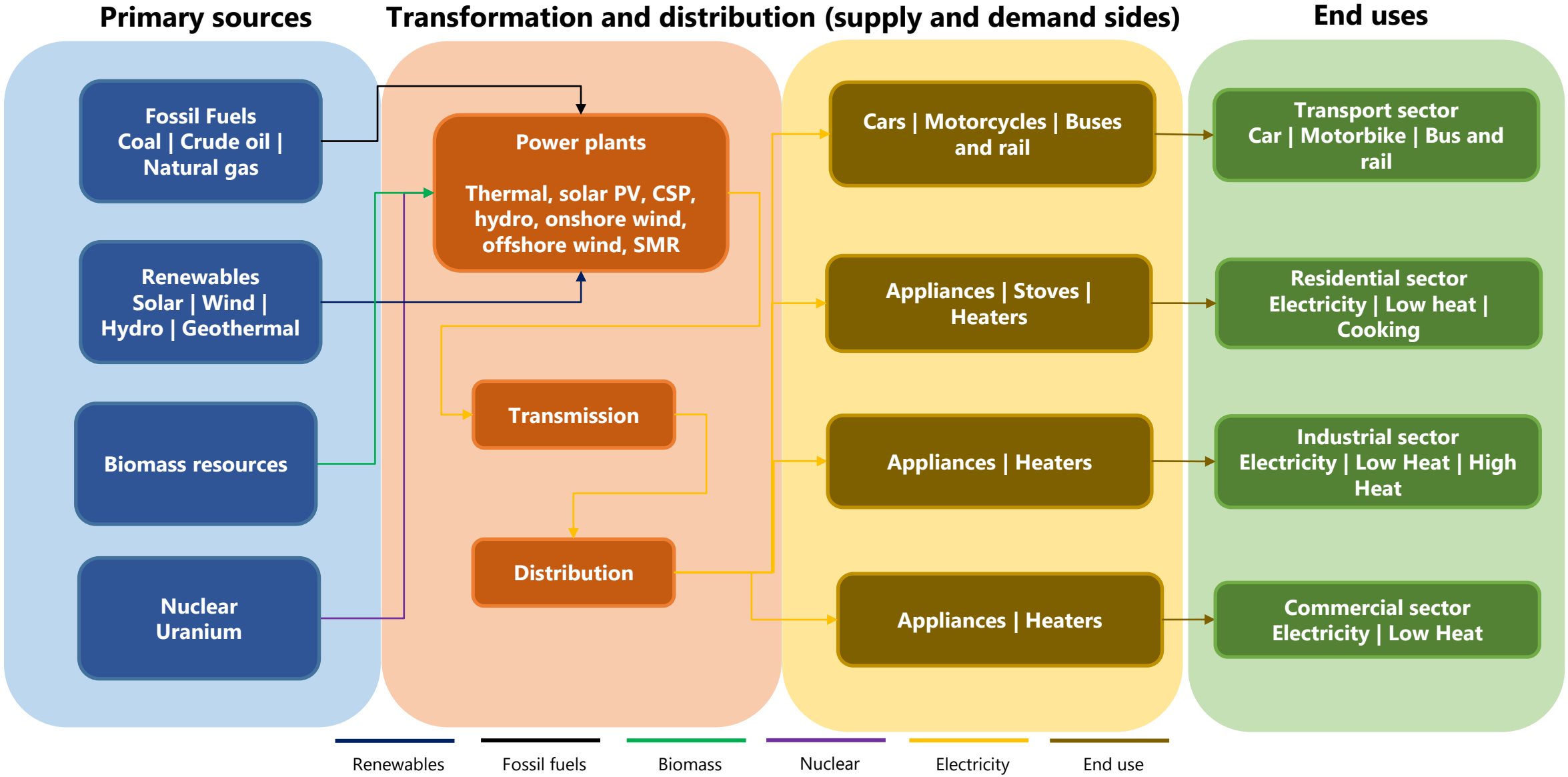
Research questions:

- **How will the Colombian power mix evolve under a full decarbonization target by 2050?**
- **What is the effect of a progressive drought regime in the performance of a decarbonized power system in Colombia?**

Methodology



Energy Reference System



Scenarios

Baseline (BAU)

- No carbon target
- Historical trends remain with limited penetration of non-conventional renewable technologies

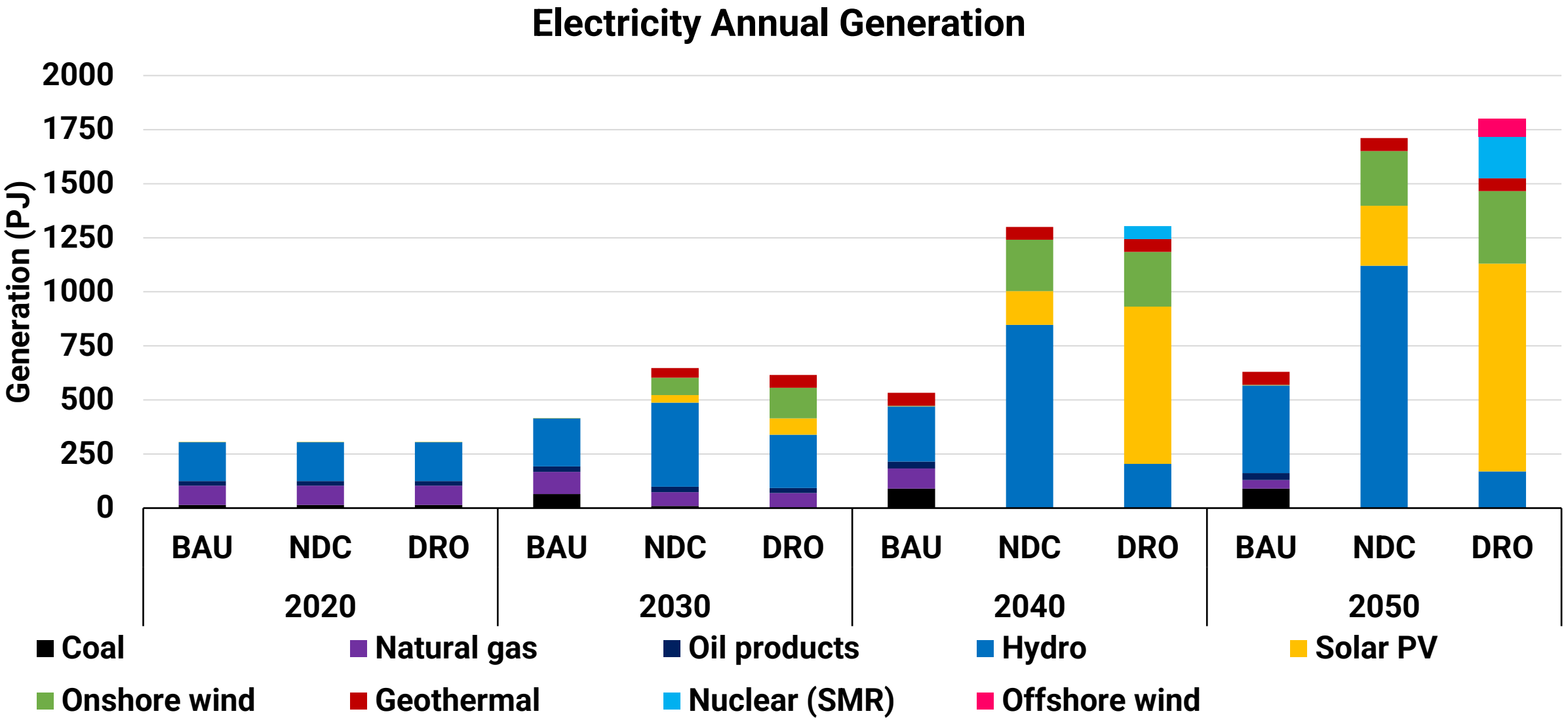
GHG Cap (NDC)

- Full decarbonization by 2050
- Renewable technologies are fully available (PV, wind, CSP, geothermal)

Drought (DRO)

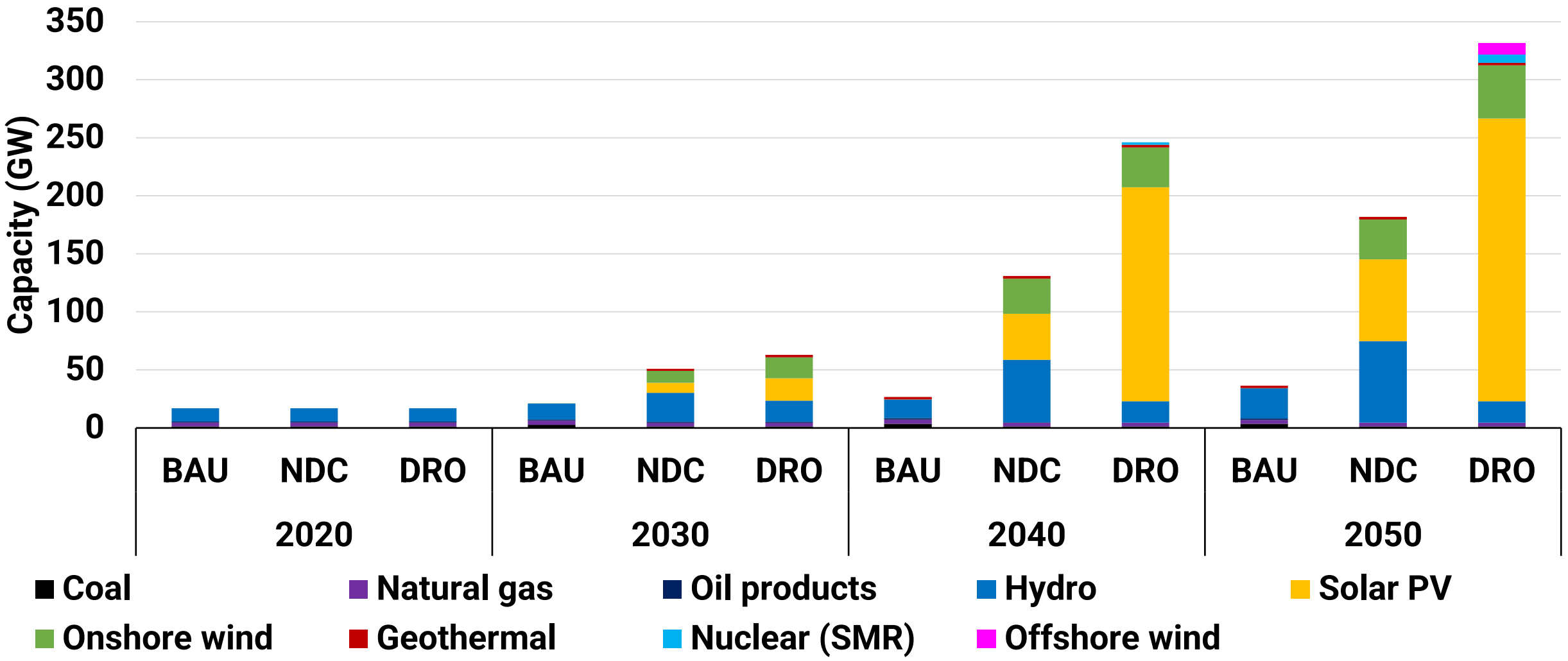
- Full decarbonization by 2050
- Reduction in 50% of capacity factor for hydro-based technologies (Mekonnen et al., 2022)

Results (1/4)


Electricity Annual Generation
Generation (PJ)
2000
1750
1500
1250
1000
750
500
250
0
BAU
NDC
DRO
2020
2030
2040
2050
Coal
Natural gas
Oil products
Hydro
Solar PV
Onshore wind
Geothermal
Nuclear (SMR)
Offshore wind

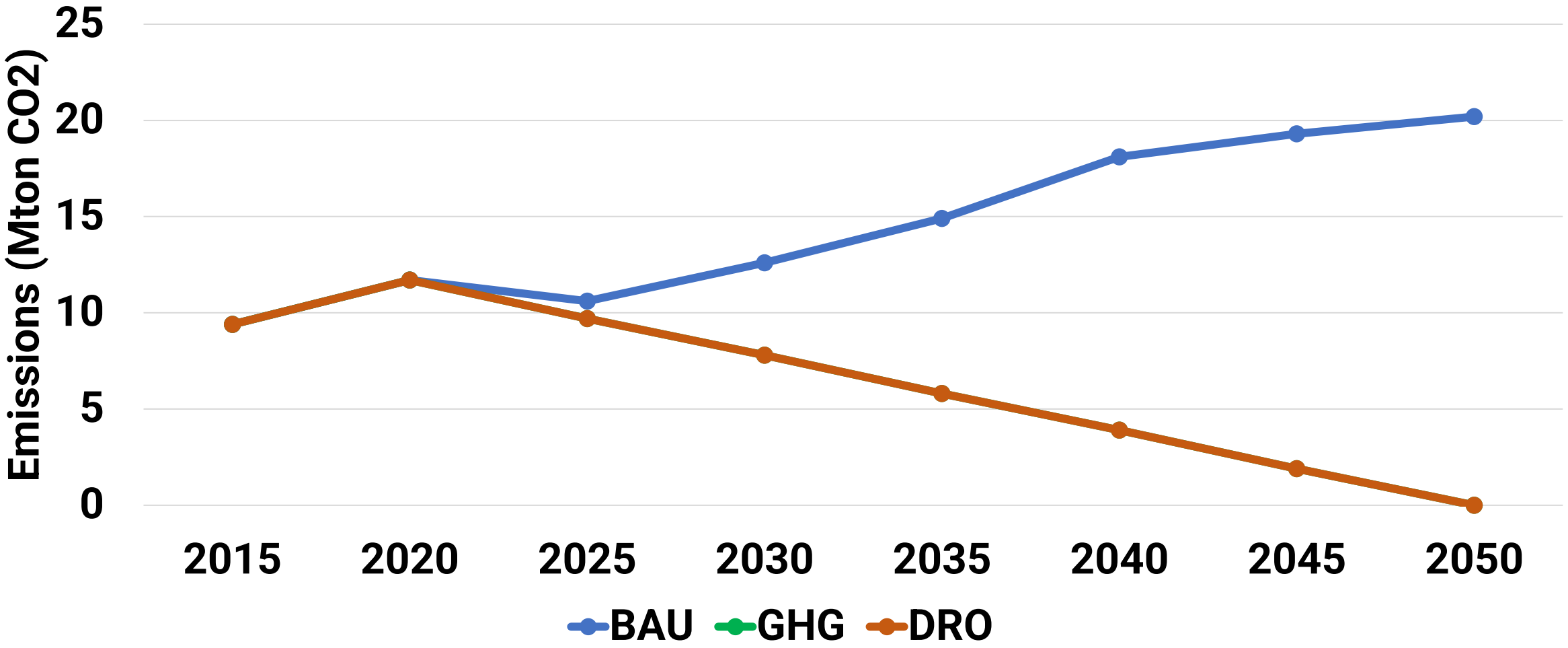
Results (2/4)

Total Installed Capacity

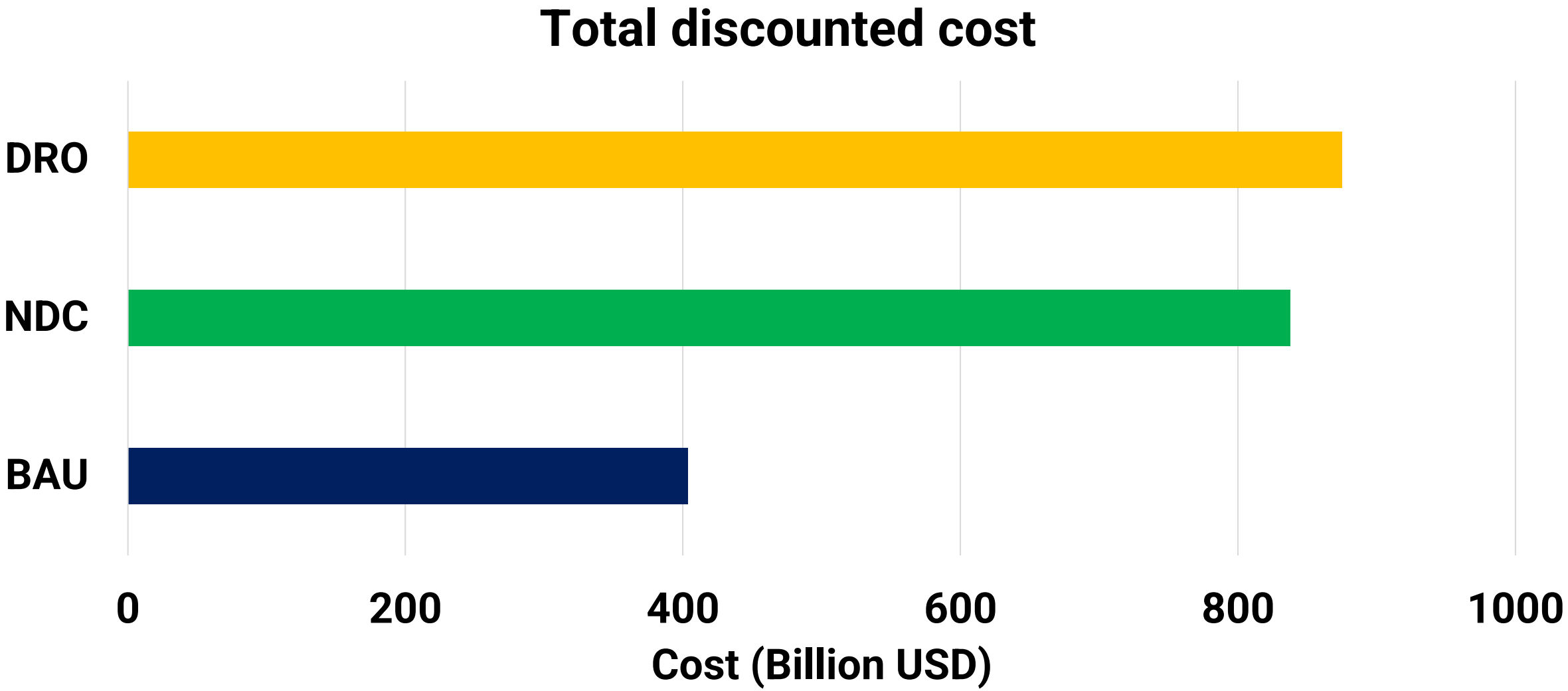


Results (3/4)

Annual emissions



Results (4/4)


Total discounted cost
DRO
NDC
BAU
0
200
400
600
800
1000
Cost (Billion USD)

Conclusion and Policy Insights

The current energy mix will not enable the accomplishment of the NDC and GHG emissions could double by 2050

Carbon neutrality requires the electrification of end-uses demanding between three and six more electricity, essentially hydro, solar PV and onshore wind

Under drought conditions, solar PV is required to replace hydro and a more diversified portfolio could work with the deployment of nuclear (SMR) and offshore wind

Future Work

- Flexibility assessment
- Data review and update
- Storage modeling implementation
- Robustness analysis

Acknowledgments

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Thank You!

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