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### I. Abstract | Objectives

The Energy Trilemma in international scale dates back to the 1987 Brundtland report on sustainable development. The report elucidated the interconnectivity of three components, which later evolved into what is now recognized as the Energy Trilemma. The World Energy Trilemma Index (ETI) assesses three key dimensions of a country's energy system: energy security, energy equity, and environmental sustainability.

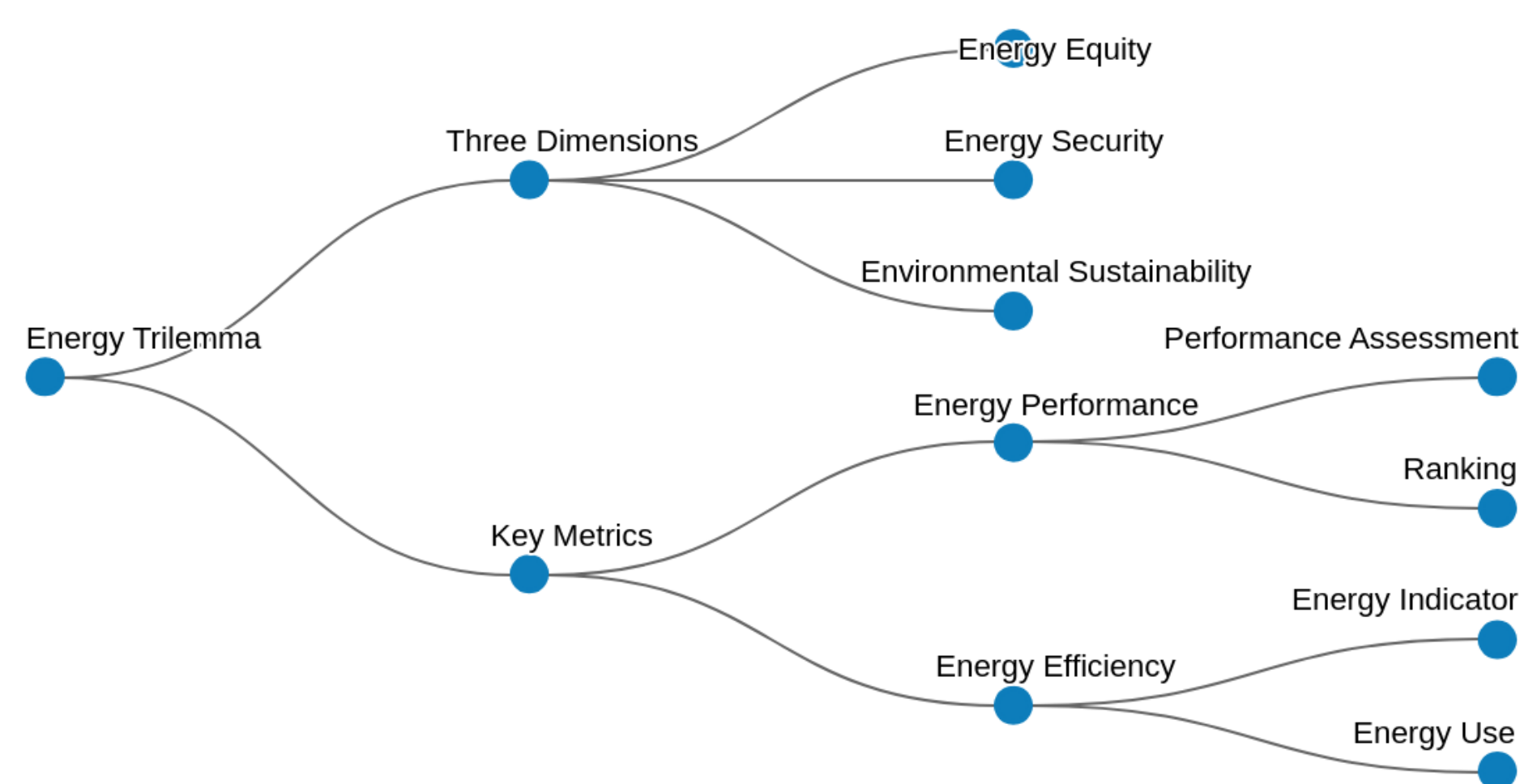


Figure 1. Energy Trilemma Key Metrics

### II. Introduction

The World Energy Trilemma Index (ETI) annually evaluates over 100 countries' energy systems based on three key dimensions: Energy Security, Energy Equity, and Environmental Sustainability. Turkey ranks 46th globally in the 2023 World Energy Trilemma Index, scoring 64.6 overall. While excelling in energy equity and environmental sustainability, its energy security score lags slightly behind. The country is intensifying efforts to enhance energy security by diversifying sources and supply chains, investing in renewables like wind and solar, and exploring domestic natural gas reserves. Despite progress, challenges persist, particularly in reducing CO<sub>2</sub> emissions, which primarily stem from the energy sector. To address this, Turkey aims to decrease fossil fuel dependency, improve energy efficiency, and boost innovation for a more sustainable energy landscape.

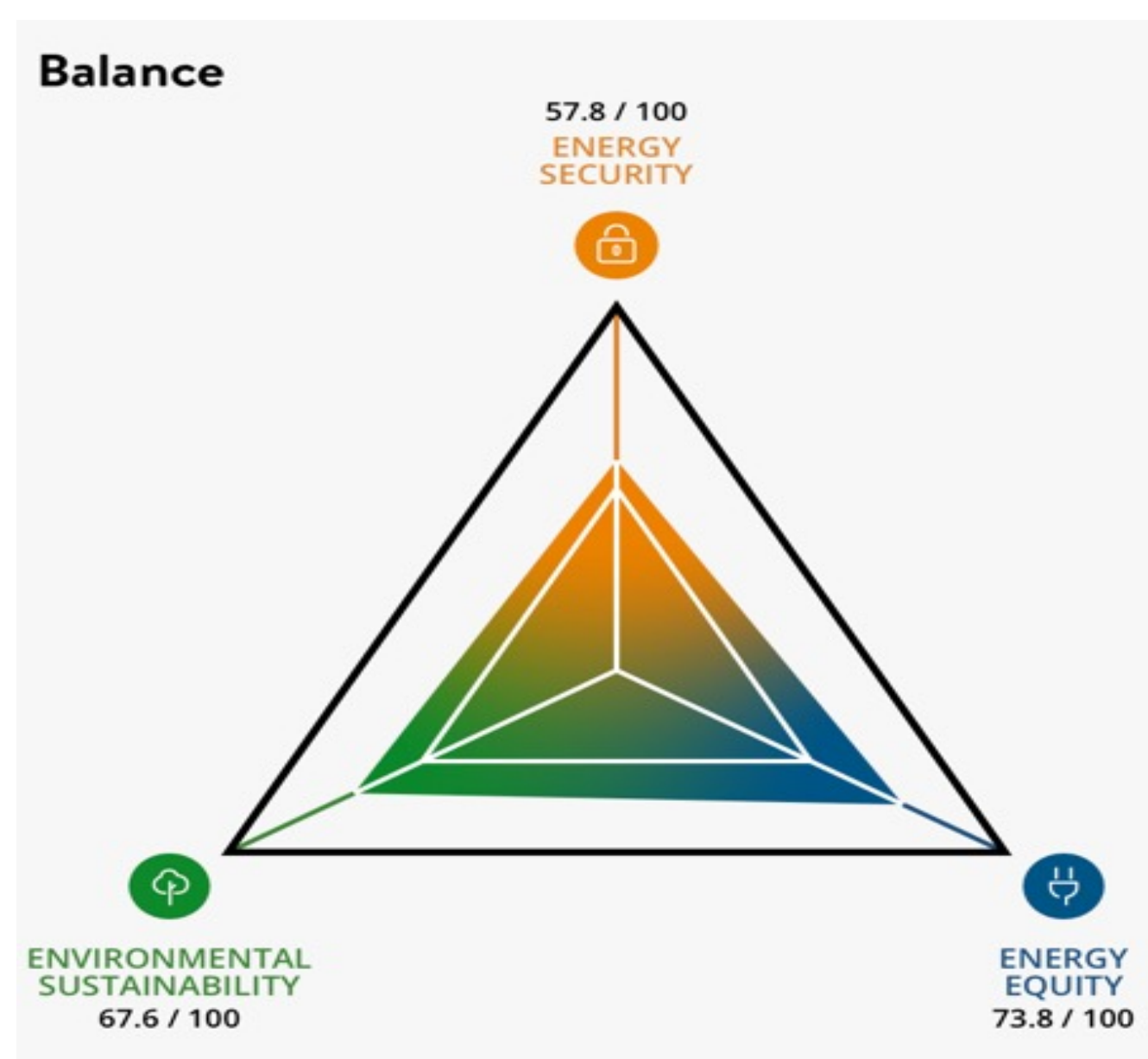


Figure 2. Turkey's Energy Trilemma Index (WEC, 2022)

### III. Procedure | Experimental Set-Up

Energy security focuses on mitigating supply-side shocks, ensuring access to scarce resources, and enhancing energy efficiency. Metrics like import independence, diversity of electricity generation, and energy storage gauge a country's resilience against demand-driven energy shocks and asymmetric threats.

Energy equity examines accessibility and affordability of energy supply across the population, considering metrics such as access to electricity and fuel prices. It also evaluates the societal and financial impacts of changes in energy service costs.

Environmental sustainability measures a country's response to rising greenhouse gas emissions, environmental concerns, and actions for emission reduction. Preference for renewable sources, circularity in energy systems, and metrics like final energy intensity and CO<sub>2</sub> emissions per capita are assessed to gauge environmental sustainability.

Overall, ETI provides a comprehensive framework for evaluating a country's energy system performance, addressing a wide range of factors including supply security, accessibility, affordability, and environmental impact. During the data collection phase involves gathering data on Turkey's hydrogen production capacity, electricity generation, energy consumption patterns, and emissions. A detailed analysis of Turkey's hydrogen technology strategy and roadmap follows, focusing on current actions, future goals, and key initiatives. These data are assessed within the Energy Trilemma Index framework, considering factors like security, equity, and sustainability. The evaluation highlights Turkey's import independence, energy diversity, accessibility, affordability, efficiency, low-carbon generation, CO<sub>2</sub> emissions, innovation, and policy effectiveness. Findings underscore Turkey's energy landscape, including hydrogen and electricity. Strengths and improvement areas are identified within the Energy Trilemma Index. Finally, impacts of hydrogen technologies are discussed, and Turkey's adaptation is evaluated within the Index's challenges and opportunities by G. Yilmaz et al., 2024.

### IV. Results

In summary, adopting the energy trilemma approach provides a holistic framework for evaluating Turkey's potential in hydrogen production. This assessment considers factors such as renewable energy sources, policy effectiveness, economic feasibility, and sustainability. It highlights the need to tackle challenges, capitalize on opportunities, and develop robust policies to position Turkey as a frontrunner in green hydrogen production.

The results indicate that Turkey possesses substantial potential for green hydrogen production utilizing diverse renewable sources, positioning itself as a prospective leader in the international hydrogen market. With strategic investments and policy adaptations, Turkey could feasibly scale its green hydrogen output to 3.4 million tons annually by 2050, offering considerable export opportunities by I. Hilali et al., 2023.

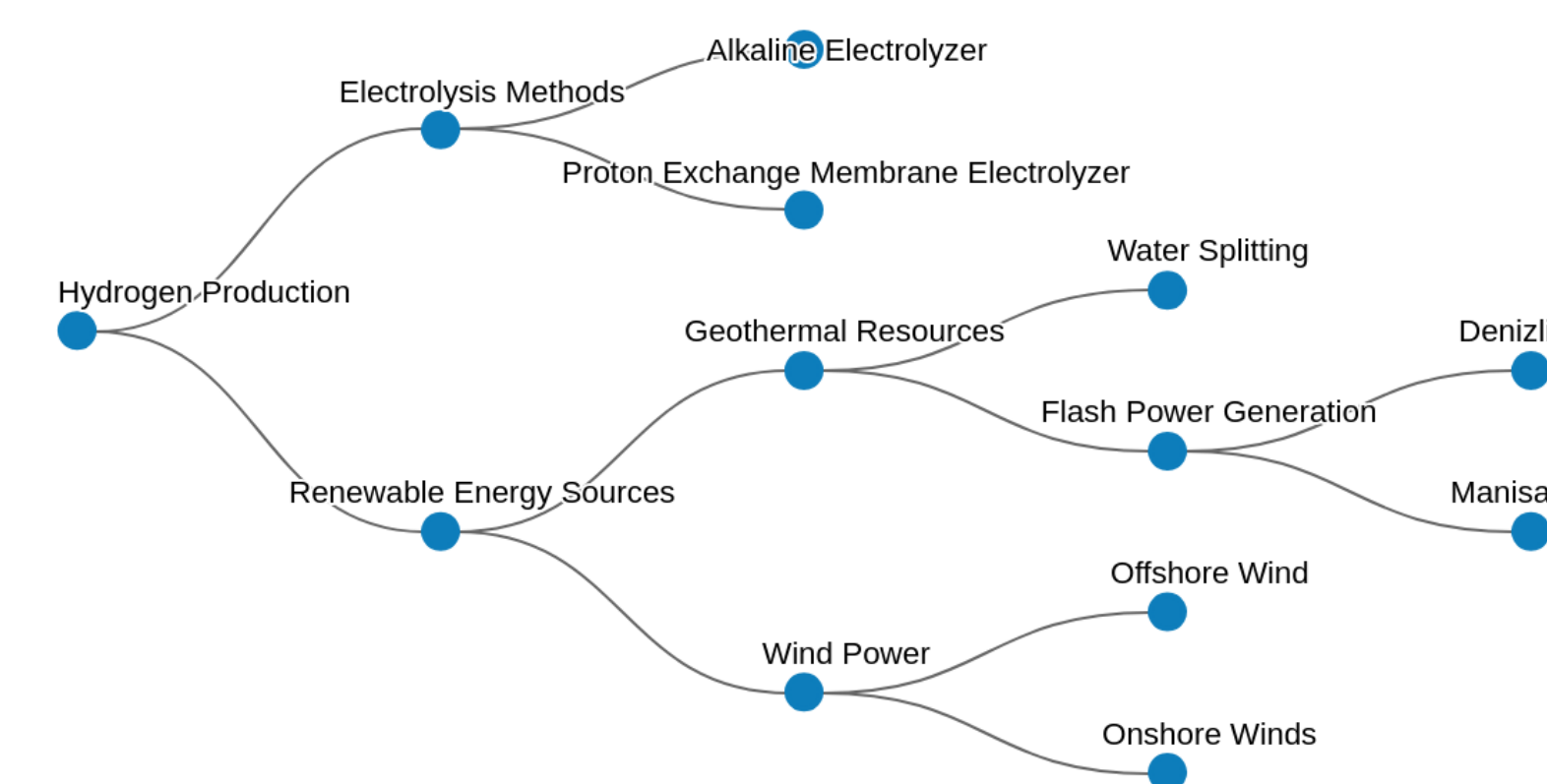


Figure 3. Turkey Potential of Hydrogen Production Framework

### V. Conclusion

The studies provide comprehensive insights into the diverse renewable energy sources and their potential for green hydrogen production in Turkey, aligning with the energy trilemma approach. However, the specific conclusion of the energy trilemma approach assessment must be directly addressed in the available abstracts.

### References

- Energy Trilemma Index. 2023. [www.trilemma.worldenergy.org](http://www.trilemma.worldenergy.org) (accessed March 31, 2024). MoEaNR. Türkiye Hydrogen Technologies Strategy and Roadmap. Ankara: Republic of Turkey Ministry of Energy and Natural Resources, 2023.
- TUIK. Turkish Greenhouse Gas Inventory 1990 - 2021. Ankara: Turkish Statistical Institute, 2023.
- World Energy Council. World Energy Trilemma 2024: Evolving with Resilience and Justice. London: World Energy Council, 2024.
- International Journal of Hydrogen Energy, The hydrogen perspective for Turkey, which is on the Asia-Europe energy transition route. Can Turkey become hydrogen hub? Hilali, İ. Işiker, Y. Ulker, N., 2024. <https://www.epdk.gov.tr/detay/icerik/3-0-23/elektrikaylik-sektor-raporlar> (accessed April 10, 2024).
- International Journal of Hydrogen Energy, Hydrogen energy development in Turkey: Challenges and opportunities S. I. Allakhverdiev, 2024

