

A Pathway Towards Sustainable Energy Transition

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Abstract

- Overdependence on fossil fuels like coal, oil, and gas has created a climate crisis.
- Greenhouse gas emissions (GHGs) are polluting our environment and driving climate change.
- Creating an unsustainable path that threatens public health, economic stability, and global energy security (IEA, 2021).
- This research explores a pathway for a global transition to sustainable energy, examining mechanisms, policies, and technologies that can create a cleaner, more secure future for all.

Background

- Transitioning to sustainable energy involves shifting to high-efficiency systems, emphasizing renewable sources to combat climate change.
- Bogdanov (2019) proposed an achievable carbon-neutral, renewable energy system by 2050 with targeted electricity costs of 52 €/MWh.
- Addressing challenges like systemic barriers and existing fossil fuel interests is crucial for energy industry progress (Cholewa et al., 2021).
- Solar, wind, and low-carbon technologies, alongside innovative designs in buildings for energy efficiency, represents key strategies (Kolokotsa et al., 2011).
- Lieu et al. (2020) examined the integration of gender perspectives in energy transitions for energy efficiency.

Methodology

This poster provides a thorough literature review of energy transition pathways and supports the findings using data from Our World and own analysis. It incorporates an IPAT analysis through the KAYA identity to predict global GHG drivers and CO₂ emissions, aligning with the Paris Agreement objectives.

The Kaya identity, a simple mathematical formula presented in Eq. (1) was used to measure and predict Global CO₂ emissions and GHG drivers.

$$C_t = P_t \times \frac{Y_t}{P_t} \times \frac{C_t}{E_t} \times \frac{E_t}{Y_t} \quad (1)$$

C_t is CO₂ emission rate (kt/year),

P_t is population in year (t),

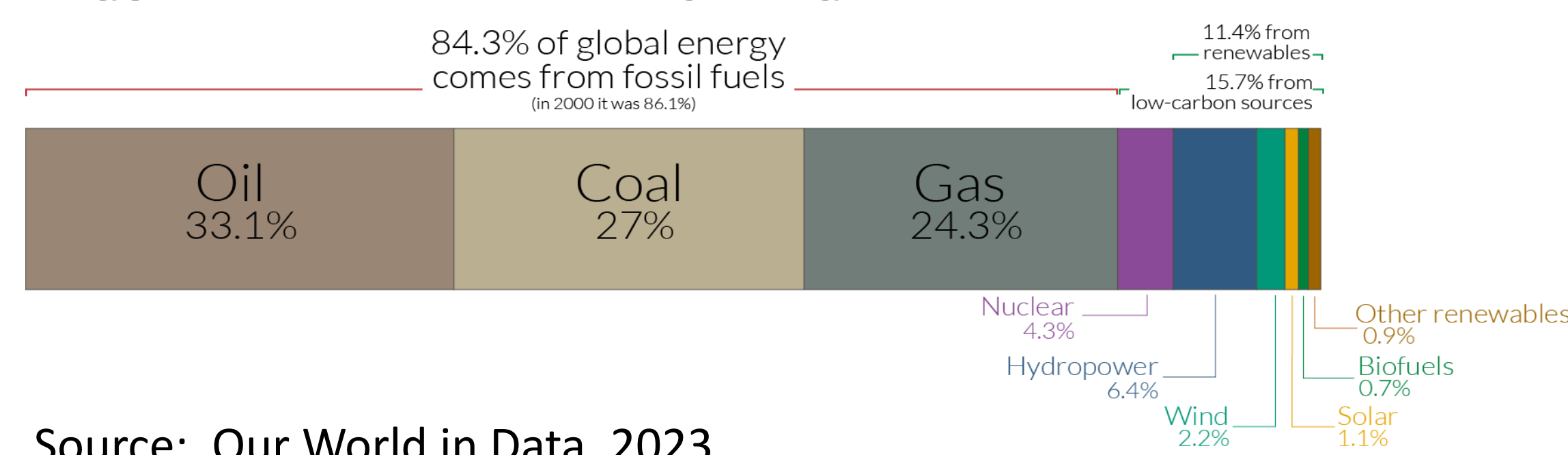
$\frac{Y_t}{P_t}$ is GDP/capita (\$/person),

$\frac{C_t}{E_t}$ is carbon intensity (kg/kilowatt-hour),

$\frac{E_t}{Y_t}$ is energy intensity (kilowatt-hour/\$)

Results

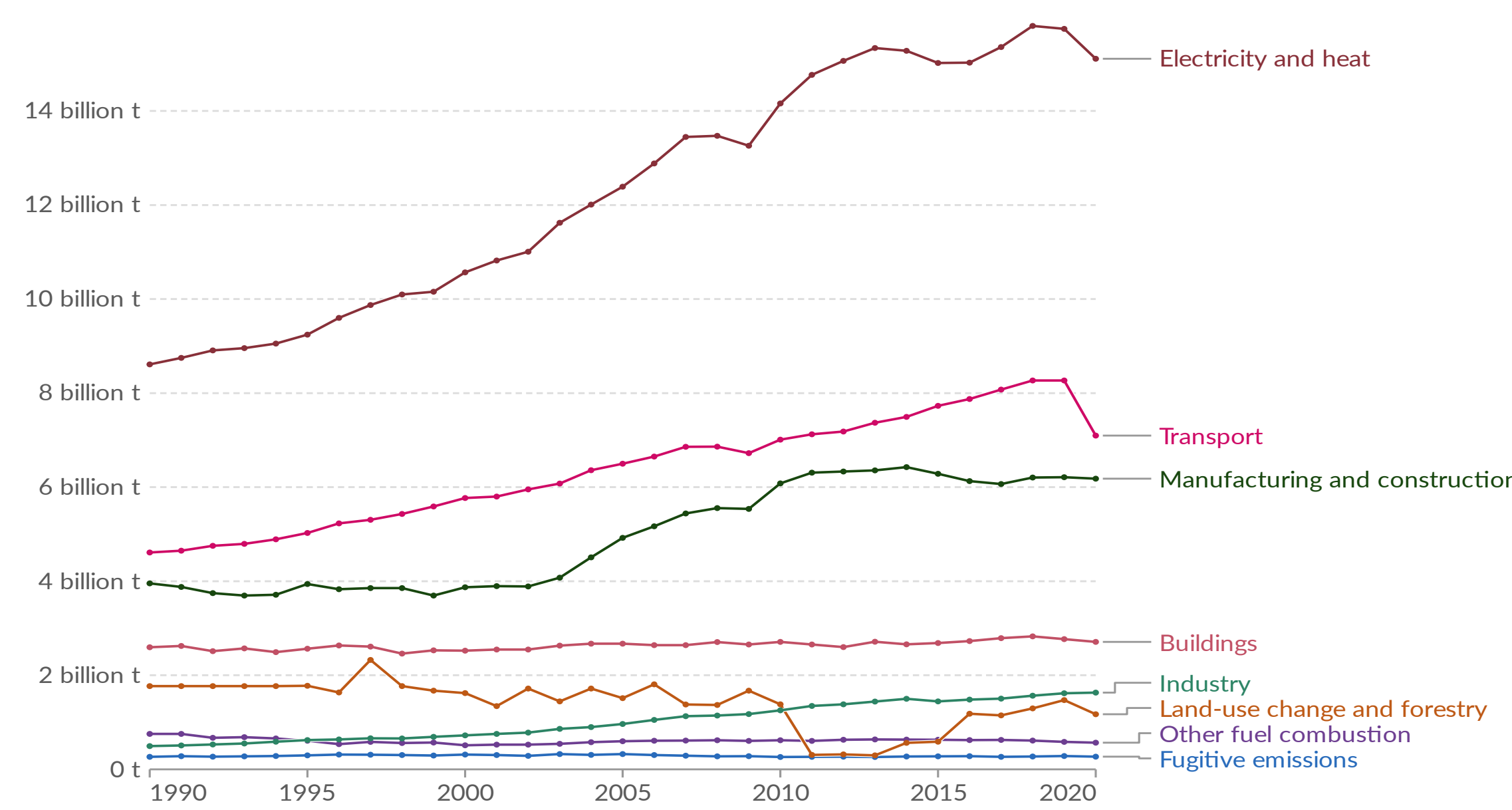
Global energy consumption is dominated by China, the USA, India, and Russia, with fossil fuels accounting for over 80% of this usage (Fig.1), leading to significant GHG emission(Our World in Data, 2022).



Source: Our World in Data, 2023

Fig. 1. Primary Energy Consumption by Source

Corroborated by Bogdanov et al. (2021), the sectors with the most emissions include Electricity & heat, Transportation and Manufacturing and construction.



Source: Our World in Data, 2023

Fig. 2. Emissions by Sector

The Kaya identity analysis (Fig. 3) shows that if current trends persist, global CO₂ emissions will hit 50 billion tons by 2030, three times higher than the Paris Agreement's target of reducing emissions to 16 billion tons, based on 2005 levels.

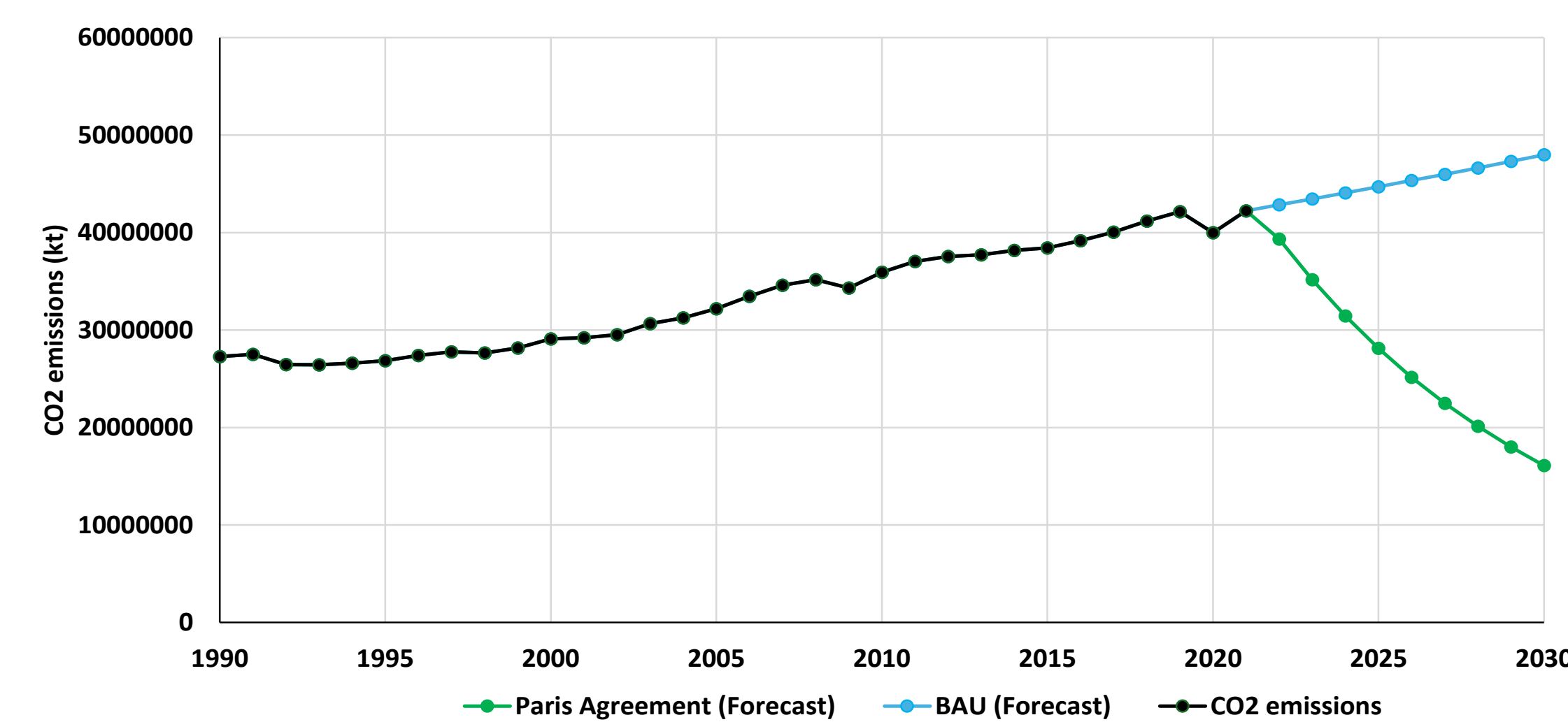
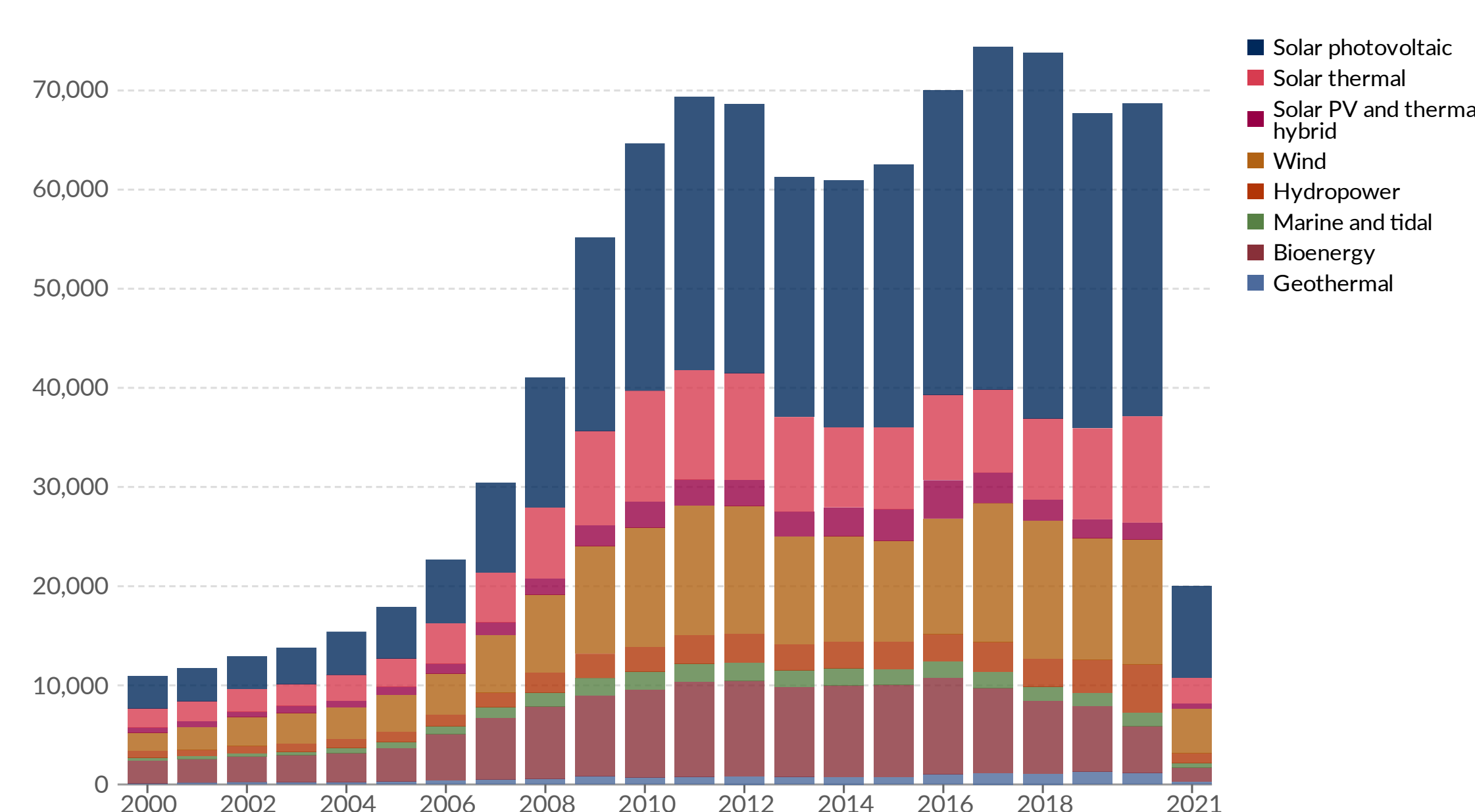


Fig.3. Kaya Identity Analysis

Given the potential role technology could play in leading the transition to sustainable energy, as theoretically outlined by the Kaya identity framework, a lot of investment is being made in the research and development of renewable energy sources (Fig. 4).



Source: Our World in Data, 2023

Fig. 4. Annual patents filed for renewable energy technologies

Table 1. Capital Costs (USD/kW)

United States	2022	2030	2050	% Change
Nuclear	5000	4800	4500	-10.00%
Coal	2100	2100	2100	0.00%
Gas CCGT	1000	1000	1000	0.00%
Solar PV	1120	660	460	-58.92%
Wind Onshore	1220	1150	1080	-11.48%
Wind Offshore	4060	2440	1720	-57.64%

Source: IEA analysis: IRENA (2023)

Table 1 shows that the USA is making notable advances in renewable energy, driving down costs for the future. Solar and offshore wind technologies are expected to see significant price drops of around 60%. This marks a key shift towards more accessible and sustainable energy solutions.

Besides investment in technology for renewable energy, as outlined by Kolokotsa et al. (2011) and Bistline et al. (2021), Lieu et al. (2022) emphasize the critical role of qualitative factors like gender.

Policy Recommendations

- Clean Energy Incentives:** Implement tax credits, subsidies, and feed-in tariffs for clean energy projects.
- Carbon Pricing:** Introduce carbon taxes or cap-and-trade systems to internalize the environmental cost of carbon emissions.
- Energy Efficiency Standards:** Set and enforce rigorous energy efficiency standards for buildings, appliances, and vehicles.
- Renewable Portfolio Standards (RPS):** Mandate that a specific percentage of electricity must come from renewable sources by certain dates, gradually increasing these targets over time.
- Research and Development:** Increase funding for R&D in renewable energy technologies, energy storage solutions, and energy efficiency.
- Education and Awareness:** Launch campaigns to educate the public and businesses about the benefits of renewable energy and energy efficiency.

Conclusion

- Transition to sustainable energy is necessary for the environment, economic opportunity, and societal requirements.
- Despite the enormous advancements of technologies in renewable energy sector, economic, technical, and policy barriers often hinder their adoption.
- Considering the social and gender aspects of energy policies ensures that the transition is inclusive and equitable, benefiting all segments of society.
- The shift to sustainable energy faces financial, technological, and social challenges but promises a healthier, more stable, and equitable world.
- Governments, corporations, and individuals must work together to expedite this shift by using innovation, technology, and policy to create a sustainable and prosperous future for all.

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