



EXPLORING CARBON TAXES AS CATALYSTS FOR FINANCING NUCLEAR POWER PROJECTS IN TURKEY

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Ahmet Gokhan Sahin¹, Guray Kucukkocaoglu²

¹Baskent University, Institute of Social Sciences, Ankara, Turkiye.

ben@ahmetgokhansahin.com, ORCID: 0000-0003-3291-4790

²Baskent University, Department of Business, Ankara, Turkiye.

gurayk@baskent.edu.tr, ORCID: 0000-0001-6170-3269

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ABSTRACT

Purpose- Climate change and the urgent need to transition to low-carbon energy systems have led nations worldwide to seek innovative financing mechanisms for sustainable energy sources. This article delves into the feasibility of leveraging carbon taxes as a potent financial instrument to promote nuclear power projects, with a particular focus on Small Modular Reactors (SMRs), in Turkey.

Methodology- This study outlines a methodology for designing a tailored carbon tax framework, addresses challenges, and highlights the strategic importance of this approach. Concurrently, an empirical case study has been conducted to introduce a carbon tax in Turkey to show the fundamentals of calculating carbon tax in Turkey.

Findings- By aligning carbon taxes with nuclear power initiatives, Turkey can reduce emissions, secure funding, enhance competitiveness, and contribute to global climate goals, paving the way for a sustainable energy future.

Conclusion- Implementing carbon pricing mechanisms could improve Turkey's investments in SMR power plants and reinforce its stance towards a more environmentally sustainable energy future.

Keywords: Green financing, nuclear power, sustainable investment, carbon taxes, financial

JEL Codes: Q30, Q40, H20

1. INTRODUCTION

In a world where it is increasingly urgent to transition to low-carbon energy systems, exploring innovative financing mechanisms to promote sustainable energy sources is vital. Although nuclear energy often provokes differing opinions, it offers significant opportunities for carbon-free energy production. The alarming rise in air pollution and its alarming role in exacerbating global warming underscore the urgent need for rapid and decisive global action. Forward-thinking countries, including the Netherlands, Sweden and Finland, have adopted the concept of a carbon tax as a way to control emissions and increase their commitment to energy initiatives to clean quantity.

However, it is increasingly evident that "pay as you pollute" alone is not enough to drive the deep, transformative change needed to usher in an era of widespread clean energy production. At this pivotal time when environmental sustainability requirements are higher than ever, innovative financing strategies must be explored to accelerate the transition to a low-carbon future.

The landscape of green finance is multifaceted, encompassing diverse interpretations. According to the United Nations Environment Program, green finance encompasses the augmentation of funds from both public and private sectors to bolster sustainable development projects (United Nations Environment Programme, 2023). Alternatively, Höhne (Höhne, Khosla, Fekete, & Gilbert, 2012) defines green finance as a broad concept encapsulating financial investments in sustainable development initiatives, environmental products, and policies fostering a sustainable economy. The Asia-Pacific Economic Cooperation (APEC) characterizes green finance as financial support aimed at propelling environmentally friendly growth (Asia-Pacific Economic Cooperation, 2011). Additionally, Zadek and Flynn (Zadek & Flynn, 2013) highlight that green finance entails covering operational costs, planning expenditures, land acquisition, and other financial aspects related to green projects. Soejachmoen (Soejachmoen, 2017) underscores the importance of sustainability in banking and investment decisions, wherein environmental screening and risk assessment guide choices to align with sustainability standards.

Conversely, a carbon tax is a levy imposed on carbon emissions stemming from the combustion of fossil fuels. The rates of carbon taxes are typically calibrated based on the carbon content of specific fossil fuels, with higher carbon content leading to higher tax rates. Carbon taxes serve as potent policy instruments in addressing global warming and mitigating climate change. Nonetheless, determining optimal tax rates necessitates meticulous consideration to achieve desired environmental outcomes while accounting for potential economic impacts.

The global landscape offers a mosaic of carbon tax implementations, with various countries adopting this approach for diverse reasons. Notable examples include Australia, Austria, Canada, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Japan, Mexico, Norway, Sweden, Switzerland, the United Kingdom, and Austria (Mengden, 2023). Some countries, like Turkey, have introduced similar taxes under different names, such as Motor Vehicle Tax or Private Consumption Tax.

Australia, for instance, introduced a comprehensive carbon tax in 2012, encompassing all greenhouse gas-emitting industries and major gas consumers, aiming for a 15% reduction in carbon emissions. Austria has recently integrated carbon taxes into broader reforms promoting renewable energy development and socio-ecological (CBC News, 2007) tax reforms (World Bank, 2014). Canada initiated its first carbon tax in Quebec in 2007, followed by a national carbon tax, which set a minimum price of \$20 per ton of CO₂ in 2019. Denmark has maintained a carbon tax since 1992, primarily levied on transport and non-district heating (Lenain, 2022). Estonia introduced a carbon tax in 2000, applying it to all CO₂ emissions from thermal energy producers, excluding biofuel emissions (Mengden, 2023).

This article delves into the feasibility of utilizing a carbon tax fund to finance nuclear power projects in Turkey, with a particular emphasis on Small Modular Reactor (SMR) projects. SMRs offer distinct advantages, such as lower initial costs, reduced construction periods, and decreased risk of project delays. In this study, we embark on a comprehensive exploration of the mechanisms involved in designing a carbon tax tool, establishing a carbon tax fund, deploying collected funds to support SMR projects, and adapting these frameworks to endorse nuclear energy initiatives in Turkey. The ensuing sections will address the nuances of green finance and carbon taxes, elucidating their global implementations, and subsequently, we will delve into the challenges and considerations associated with this innovative approach.

The study unfolds in four key sections. First, it elucidates the global landscape of green finance and carbon taxes, spotlighting diverse approaches adopted by countries to mitigate carbon emissions and drive clean energy transitions. This context sets the stage for the exploration of the intricacies of carbon tax design, target sectors, and fund allocation mechanisms specifically tailored to Turkey's unique circumstances. Second, the article outlines a meticulous methodology for crafting a robust carbon tax framework. It encompasses setting carbon tax rates calibrated to emission reduction targets, identifying priority sectors for taxation, and defining precise mechanisms for channeling carbon tax revenues into green energy projects, including nuclear power initiatives. Third, challenges and considerations associated with implementing this transformative strategy are addressed comprehensively. These encompass political will, public acceptance, regulatory complexities, international collaboration, economic viability, environmental impact, and security concerns. Navigating these challenges is essential for the successful implementation of carbon taxes and nuclear power projects in Turkey. Lastly, the article concludes by highlighting the significance of this innovative financing approach, positioning Turkey to secure funds for both emissions reduction and nuclear power expansion. It underscores how this strategic alignment can bolster Turkey's competitiveness on the global stage, foster economic growth, and contribute significantly to international climate goals.

In essence, this article serves as a call to action, inviting policymakers, researchers, and stakeholders to embark on a transformative journey towards a sustainable, resilient, and low-carbon energy future in Turkey. Through the fusion of carbon taxes, nuclear power projects, and strategic planning, Turkey stands poised to play a pivotal role in the global transition to a greener and more sustainable world. As our journey continues through this exploration of green finance, carbon taxes, and their global implications, we will also examine sectoral-based carbon emissions and regional-based carbon emissions, which will provide valuable insights into the broader context of the challenge at hand and the importance of innovative financing mechanisms to transition toward sustainable energy sources.

2. LITERATURE REVIEW

In this section of this article, we delve deeper into the realms of green finance and carbon taxes, elucidating their multifaceted nature and global implementations. Green finance, as previously defined, serves as a pivotal mechanism for channeling financial resources towards sustainable development projects and environmentally conscious initiatives. It represents a paradigm shift in financial decision-making, where sustainability criteria are integral in assessing investment viability.

Carbon taxes, on the other hand, have emerged as indispensable tools in addressing the pressing issue of carbon emissions. The case studies presented earlier, spanning countries from Australia to Sweden, showcase the diversity of approaches taken by nations worldwide to mitigate climate change through carbon taxation. These implementations vary in terms of tax rates, targeted sectors, and overarching objectives, yet collectively exemplify the global recognition of the need for effective policy measures to curb carbon emissions.

Green finance initiatives have made substantial contributions to sustainable development in various countries through several key mechanisms and impacts:

- i) Financing Renewable Energy Projects: Green finance channels capital into renewable energy projects such as solar, wind, and hydropower. By providing funding for these projects, countries can reduce their reliance on fossil fuels, decrease greenhouse gas emissions, and improve air quality, contributing to both environmental and public health benefits.
- ii) Supporting Energy Efficiency: Green finance encourages investments in energy-efficient technologies and infrastructure. This not only reduces energy consumption but also lowers operating costs for businesses and households, leading to economic savings and job creation.
- iii) Enhancing Infrastructure and Transportation: Funding sustainable infrastructure and transportation projects, such as public transit systems, bicycle lanes, and eco-friendly buildings, can improve urban planning and reduce carbon emissions, making cities more livable and sustainable.

iv) Promoting Sustainable Agriculture: Green finance can be directed toward sustainable agricultural practices, including organic farming, precision agriculture, and agroforestry. These initiatives reduce the environmental impact of agriculture, enhance soil health, and protect biodiversity.

v) Conservation and Biodiversity: Investments in conservation efforts, habitat restoration, and eco-tourism can help protect ecosystems and biodiversity. This not only preserves natural resources but also supports tourism-related industries and local communities.

vi) Climate Resilience: Green finance supports projects aimed at increasing resilience to climate change impacts. This includes infrastructure improvements to withstand extreme weather events, flood control measures, and reforestation efforts to reduce the risk of natural disasters.

vii) Access to Clean Water and Sanitation: Financing green initiatives in the water sector ensures access to clean water and sanitation for communities. This contributes to improved health outcomes, reduced waterborne diseases, and increased overall well-being.

viii) Social Inclusion and Job Creation: Green finance often emphasizes social inclusion by promoting investments in projects that benefit disadvantaged communities. Job creation in green sectors, such as renewable energy and sustainable agriculture, can provide economic opportunities to marginalized populations.

ix) Reduction of Environmental Degradation: Green finance discourages investments in environmentally harmful industries, reducing deforestation, air and water pollution, and habitat destruction. This helps preserve ecosystems and natural resources for future generations.

x) Alignment with Sustainable Development Goals (SDGs): Many green finance initiatives align with the United Nations Sustainable Development Goals (SDGs). By addressing climate change, promoting clean energy, and supporting sustainable practices, these initiatives contribute directly to the achievement of these global goals.

Overall, green finance initiatives play a crucial role in fostering a more sustainable and environmentally responsible approach to economic development. By directing capital toward projects and industries that prioritize environmental and social well-being, countries can make significant progress toward achieving their sustainable development objectives while mitigating the adverse impacts of climate change.

3. DATA AND METHODOLOGY

3.1. Designing a Carbon Tax Framework in Turkey

Developing a well-designed carbon tax strategy in Turkey is extremely important as it is an essential tool in the country's efforts to reduce carbon emissions and facilitate a transition to energy sources that are cleaner and more durable. This section presents an in-depth and systematic approach, summarizing three key stages, each of which plays an important role in implementing an effective carbon tax: establish an appropriate carbon tax, identify the target sectors to be taxed and establish a clear framework for allocating the funds generated by the mechanism.

3.1.2. Setting Carbon Tax Rates in Turkey

To determine appropriate carbon tax rates in Turkey, a meticulous analysis of several factors is imperative. These include:

i) Emission Targets: Turkey should establish clear and ambitious carbon emission reduction targets in line with its international climate commitments.

ii) Social and Economic Impacts: Assessing the potential repercussions of carbon taxes on various sectors, employment, and household incomes is vital to strike a balance between environmental goals and economic stability.

iii) Revenue Allocation: Decisions regarding the allocation of collected carbon tax revenues must be made, whether they are directed toward supporting green energy projects, compensating vulnerable populations, or financing energy-efficient programs.

iv) Tax Rate Progression: Consideration should be given to adopting a progressive tax rate system where higher emissions result in higher tax rates, incentivizing emissions reductions.

v) International Comparisons: Benchmarking Turkey's carbon tax rates against other countries with similar economic profiles and emissions profiles provides valuable insights for policy calibration.

3.1.3. Identifying Target Sectors in Turkey

Effectively reducing carbon emissions in Turkey necessitates the identification of priority sectors for carbon taxation. Potential target sectors include:

i) Energy Generation: Taxing emissions from power plants, with higher rates applied to fossil fuel-based generation.

ii) Transportation: Applying carbon taxes to gasoline and diesel fuels, thereby encouraging the adoption of electric and alternative-fuel vehicles.

iii) Industry: Implementing carbon taxes on emissions-intensive industries, such as cement, steel, and petrochemicals.

iv) Residential and Commercial Buildings: Exploring options for taxing carbon emissions stemming from heating and cooling systems.

v) Agriculture: Considering carbon taxes on agricultural activities with significant emissions, such as livestock farming.

3.1.4. Fund Allocation Mechanisms in Turkey

Once carbon tax revenues are collected, defining clear mechanisms for allocating these funds to support green energy projects is crucial. Potential approaches include:

- i) Green Energy Fund: Establishing a dedicated fund to finance renewable energy projects, including nuclear power.
- ii) Energy Efficiency Programs: Allocating a portion of carbon tax revenues to energy efficiency initiatives in residential and commercial sectors.
- iii) Compensation Mechanisms: Implementing mechanisms to compensate low-income households for potential energy cost increases resulting from carbon taxes.
- iv) Innovation and Research: Investing in research and development of clean energy technologies, including advanced nuclear reactors.

3.2. Adapting the Carbon Tax Framework for Nuclear Power Projects in Turkey

To channel carbon tax revenues into funding Small Modular Reactor (SMR) projects in Turkey, several strategic steps can be taken:

- i) Project Identification: Identifying specific SMR projects that align with Turkey's energy goals and emissions reduction targets is imperative. Furthermore, stringent adherence to safety and environmental standards is essential.
- ii) Cost Assessment: Conducting a comprehensive cost assessment for each SMR project is crucial. This assessment should consider factors such as construction, operation, maintenance, and decommissioning costs.
- iii) Revenue Allocation: Dedicating a portion of the carbon tax revenues to support SMR projects is vital. The determination of this amount should be based on the outcomes of the cost assessment and the desired timeline for project implementation.
- iv) Public and Private Partnerships: Exploring partnerships with private companies and international organizations can be instrumental in securing additional financing for SMR projects.
- v) Regulatory Framework: Establishing a clear and efficient regulatory framework for SMR development is necessary to avoid delays and uncertainties, fostering investor confidence.
- vi) Community Engagement: Engaging with local communities is crucial to address concerns and garner support for SMR projects. Transparency and open dialogue are key components of this engagement.
- vii) Monitoring and Reporting: Implementing a robust system to monitor the progress of SMR projects and report on their environmental and economic benefits is essential for accountability and informed decision-making.

3.3. A Suggestion on Carbon Tax Calculation Mechanism for Turkey

In this section, we designed a pricing method for the carbon tax under the projected green investment in Turkey. This method should be applied to all countries planning to invest in clean energy and looking for project financing. By providing a case study of our methodology in the next section, we aim to enhance our research's overall credibility and reproducibility, allowing readers to assess the soundness of our methods and the trustworthiness of our results.

In this method, the financing budget of green investment projects of the Turkish Government's plan for the following year is considered a year lacking financing. That lack of funds is planned to meet with the carbon tax to be collected in accordance with the emitted carbon for the previous year. The carbon tax is calculated as the total projected green investment in USD in Turkey for the following year divided by total carbon emission as tons in Turkey for the previous year.

The carbon taxes will be gathered in a carbon tax fund, and in case funds are needed for green investments, the fund will finance the green projects with fiscal incentives and direct financing.

$$CT = \sum_{n=1}^{\infty} \frac{GI(t+1)}{CE(t)}$$

Where;

GI: Total projected green investment in USD in Turkey for the following year

CE: Total carbon emission and carbon equivalent as ton in Turkey for the previous year

CT: Carbon tax for the current year

Case Study

We present a case study of our methodology in this section. Our objective is to bolster our research's overall credibility and replicability, enabling readers to evaluate the robustness of our approaches and the reliability of our findings. We benefited from empirical figures, which

are shown in Table 4. for two years sequentially. The empirical figures are parallel with the following news published on temizenerji.org. According to the news (Temiz Enerji Vakfi, 2022), the investment requirement for Turkey's energy transformation is estimated to be between 5.3-7 billion dollars annually by 2030.

Table 1: Turkey's Projected Green Investment Plan

Projects to be financed	2023	2024
Small Modular Reactor Project	3.476.686.000 USD	3.824.354.600 USD
Electric Vehicle	129.999.500 USD	110.499.575 USD
Wind Power Plant	245.400.000 USD	208.590.000 USD
Solar Power Plant	560.000.000 USD	476.000.000 USD
Decommissioning fund for existing fossil fuel power station	600.000.000 USD	510.000.000 USD
Energy Efficiency	1.213.000.000 USD	1.031.050.000 USD
Other	900.000.000 USD	765.000.000 USD
TOTAL	7.125.085.500 USD	6.925.494.175 USD

Table 2: Total Carbon Emission Breakdown in Turkey

	2022	2023
Energy	366.600.000 ton	402.500.000 ton
Industry	68.000.000 ton	75.100.000 ton
Agriculture	73.200.000 ton	72.100.000 ton
Waste	16.300.000 ton	14.700.000 ton
Total Emission	524.100.000 ton	564.400.000 ton

Carbon Tax Calculation for 2023:

$$7.125.085.500 \text{ USD} / 524.100.000 \text{ ton} = 13,59 \text{ USD Carbon Tax per ton}$$

In parallel with increasing existing green investments, fund needs for clean energy projects are expected to decrease gradually. Therefore, the following year's carbon tax is supposed to be lower than the current year, especially within the first years.

Carbon Tax Calculation for 2024:

$$6.925.494.175 \text{ USD} / 564.400.000 \text{ ton} = 12,27 \text{ USD Carbon Tax per ton}$$

By using the calculation method above, all green investments in Turkey should be financed and Turkey should reduce its carbon emission and reached the zero-carbon emission target.

4. FINDINGS

Implementing a carbon tax framework to finance nuclear power projects in Turkey presents several complex challenges and considerations:

- i) **Political Will:** The success of such an initiative hinges on sustained political support and a deep commitment to addressing climate change. Political stability is pivotal for long-term planning and implementation.
- ii) **Public Acceptance:** Convincing the public about the benefits and safety of nuclear power, particularly SMRs, is paramount. Robust public outreach and education efforts are required to foster understanding and trust.
- iii) **International Collaboration:** Turkey may benefit significantly from international collaboration and partnerships to access expertise, technology, and financing for SMR projects. Collaboration with established nuclear nations can facilitate knowledge transfer and capacity building.
- iv) **Regulatory Hurdles:** Establishing clear and efficient regulatory processes for SMR development is necessary to avoid delays and uncertainties, thereby ensuring a conducive investment environment.
- v) **Economic Viability:** SMR projects must demonstrate economic viability and competitiveness with other energy sources to attract investors and secure long-term financing.
- vi) **Environmental Impact:** Rigorous assessment and mitigation of the environmental impact of SMR projects, particularly in terms of nuclear waste management and the potential release of radioactive materials, are essential.
- vii) **Security Concerns:** Ensuring the security of SMR facilities and materials is imperative to prevent unauthorized access, theft, or malicious activities, safeguarding both the public and the environment.

This article serves as a comprehensive exploration of the intricate interplay between green finance, carbon taxes, and their potential application in Turkey's transition to sustainable energy sources, particularly nuclear power. It highlights the transformative potential of innovative financing mechanisms in the global effort to combat climate change, all while ensuring the energy needs and environmental

responsibilities of Turkey are met. The challenges are formidable, but with strategic planning, collaboration, and unwavering commitment, the vision of a low-carbon, sustainable energy future in Turkey can be realized.

As for nuclear power's financing issue, countries like Turkey do not have enough funds to finance large power plants due to high upfront capital. Conversely, SMRs' capital upfront is considered affordable rather than large plants. Locatelli (Boarin, M.E., Mancini, & Locatelli, 2015) indicated that the modular approach of SMRs has some excellent opportunities to replace large plants. Their modular structure feature can make them more affordable than large plants by reducing the capital upfront and construction duration.

Although there is an ongoing construction of a large reactor power plant to meet Turkey's electricity demand, which was started in 2015, to meet the growing energy demand, electricity generation still needs to be increased because of the insufficiency of generation. Therefore, investing in SMR plants should be an alternative to meet the energy demand in the long run. In fact, several studies mentioned that SMR could also provide positive contributions to nuclear energy. For example, Kessides and Kuznetsov (Kessides & Kuznetsov, 2012) indicated that SMRs could be attractive and affordable in many developing countries with limited financial resources.

According to Mian and Ramana (Ramana & Mian, 2014), investing in a nuclear power plant could have some minimum metrics like GDP or income per capita in a country. The countries that have such minimum metrics will be able to afford SMRs.

The results align with Lovering's (Lovering, 2020) research, which emphasized the significance of carbon pricing within a country in order to enhance the cost competitiveness of constructing nuclear power plants in comparison to natural gas.

5. CONCLUSION

The imperative to urgently address climate change and curtail carbon emissions compels us to explore innovative financing mechanisms. Among the array of options, carbon taxes have emerged as a promising avenue, already embraced by numerous countries, to mobilize funds for green energy initiatives, including the promising domain of nuclear power. This article has underscored the potential for designing a comprehensive carbon tax framework, meticulously tailored to the unique context of Turkey, as a pivotal strategy. This not only serves as a means to reduce emissions but also as a mechanism to secure vital financing for the realization of Small Modular Reactor (SMR) projects in the nation.

Central to this endeavor is the intricate calibration of carbon tax rates, the strategic identification of target sectors, and the formulation of astute fund allocation mechanisms. These elements collectively constitute the framework's bedrock, which, when fortified with sound policy and meticulous planning, promises to steer Turkey toward a sustainable and low-carbon energy future.

Intrinsically linked with the technical and economic aspects are the nuanced challenges on the horizon. These encompass the formidable terrain of political will, which, when fortified, can provide the steady ground for the long and arduous journey ahead. Overcoming the hurdles of regulatory intricacies, bolstering public acceptance, and nurturing international collaborations will undoubtedly prove to be instrumental.

Nevertheless, we stand at a juncture where Turkey's proactive engagement with carbon taxation and nuclear power offers not only the prospect of substantial reductions in emissions but also the opportunity to enhance its competitiveness on the global stage. This approach aligns Turkey's aspirations with broader international climate objectives, positioning the nation as a beacon of responsible energy transition.

In conclusion, this comprehensive exploration has illuminated a path forward. One that, when navigated with foresight, diligence, and unwavering commitment, can lead Turkey towards a sustainable, resilient, and low-carbon energy future. As we embark on this transformative journey, the fusion of innovative financing mechanisms, such as carbon taxes, with the burgeoning potential of nuclear power projects beckons a new era for Turkey—one that harmonizes economic prosperity with environmental stewardship, while making a profound impact on the global stage in our collective pursuit of a greener and more sustainable world. Introducing carbon pricing mechanisms holds the potential to enhance Turkey's SMR power plant investments and further solidify its position on the path to a cleaner energy future.

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