

RENEWABLE ELECTIRICTY ENERGY POLICIES: CASE OF TURKEY

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Overview

Turkey has declared a reduction of greenhouse gas emissions up to 21% from the business as usual by 2030 and signed Paris agreement as a developing country in COP21. In that manner, Turkey needs studies in consideration of climate change, yet no related academic study is can be found in the related literature. This study is the first model examines Turkish energy system using TIMES [1] modeling methodology to assess the future pathways of the system with a detailed representation of the electricity sector under policy options.

With increasing energy demand, due to industrialization and increase in population, Turkey's future energy supply should be cautiously planned with respect to national resources, energy security, and greenhouse gas emission rates and policies. The electricity sector is the key component of the energy system due to high dependence.

Fossil fuels that are the primary reason for greenhouse gas emissions have a dominant share of energy consumption in Turkey. Natural gas as the dominant fuel accounted for 37.0% of total power generation in 2015. Other primary energy resources were coal (29.1%), hydro (25.9%), geothermal and the wind (5.8%), liquid fuels (0.8%), and renewable and waste (0.7%).

To increase the renewable energy resource's share in power generation sector there are legal regulations in Turkey. The renewable energy law no: 5346 on the utilization of renewable energy sources for the purposes of generating electrical energy introduces incentives for domestic energy projects, providing feed-in tariffs for electricity from renewable energy sources. The aims of this law are increasing the share of electricity generated from renewable energy resources, reducing the import dependency on fuels and environment protection by producing clean energy. Other than this law, there are YEKA auctions announced in 2016 to promote renewable energy investments by allocating areas to the investors to producing clean and local energy aiming to reach 5 GW capacity.

The focus of this study is to assess the potential CO₂ abatement within the economy coupled with possible impacts on the whole national energy system. The economic efficiency of the law and several policies will be benchmarked with respect to the most widely accepted policy of CO₂ tax that generates the equivalent level of CO₂ reductions. Thus, the study will show the design issues of policies with respect to monetary measures as well as sectoral impacts.

Methods

Bottom-up models evaluate on a detailed representation of technological options and potentials for technical changes in the energy system. The connections represented as energy flows, a resources network and final users described in detail. Paths from the extraction of resources to final use are introduced and the technologies include technical and economic parameters. Bottom-up models represent demand as end-use demands such as lighting, cooling, and heating instead of energy types.

The TIMES as a bottom-up model generator aims to find the minimum cost energy system with balanced energy supply and demand by the linear programming approach based on user-defined constraints. To model the general energy system of Turkey, a TIMES database has been developed which covers the period 2015 through 2035 with five-year increments. In this study, electricity generation pattern has been adapted to 24-hour time slices concept within TIMES framework.

Characterization of existing and future technologies within the database is developed from public data sources and non-profit organizations.

Following the calibration and reference scenario formation based on expected economic growth and policies of Turkish economy and energy system, as a reflection of the renewable energy law no:5346, three government incentive scenario application has developed with feed-in-tariff for solar, wind and for both technologies. Additional

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two optimization scenarios are developed to restrict electricity sector carbon dioxide emissions by the level of electricity sector carbon dioxide emissions of solar and wind feed-in-tariff scenario and to restrict whole energy sector carbon dioxide emissions by the level of total carbon dioxide emissions of solar and wind feed-in-tariff scenario. Likewise, other scenarios for Renewable Energy Resource Areas (YEKA) and alternative renewable energy policies applied in other countries will be modeled for assessing the cost/mitigation effectiveness of the current policies.

Standard TIMES modeling framework does not inherit the random nature of intermittent renewable energy resources directly. Instead, this intermittency/stochasticity is reflected in the energy system investment/operation strategies through the peaking reserve calculations. While controllable resources' (natural gas, hydro) capacities are assumed to be 90% or above available for peaking demand consumption, intermittent resources capacities are accepted to be less than 50% according to technology type. Besides, intermittent renewable energy level reaches 26% level at maximum and declines to a steady-state after feed-in tariff expired in the wind and solar FIT scenario, this model still can be effectively used for penetration of renewables. However, a stochastic TIMES model is planned to be implemented for higher levels of intermittent renewable penetration levels for a more detailed analysis.

Results

In the reference scenario, as is shown in Figure 1, natural gas accounted for 37.7% share in 2015 and decrease to 25.6% in 2025 and hard coal becomes the dominant energy resource in 2025 with the share of 47.5% in the power generation mix. This changeover is preferable due to lower primary energy cost and electricity production costs of coal power plants comparing to the lignite and natural gas for the replacement of retired capacity within the system.

In the reference scenario, the total CO₂ emission is 349 Mton in 2015 and is almost doubled in 2023 and expected to reach 1,076 Mton which is three times of 2015 value in 2035. The highest share of the total CO₂ emission arises from the electricity sector. In 2015, power generation sector covers the 36.5% of total CO₂ emission with 128 Mton CO₂ and increased to 46% as 494 Mton CO₂ in 2035.

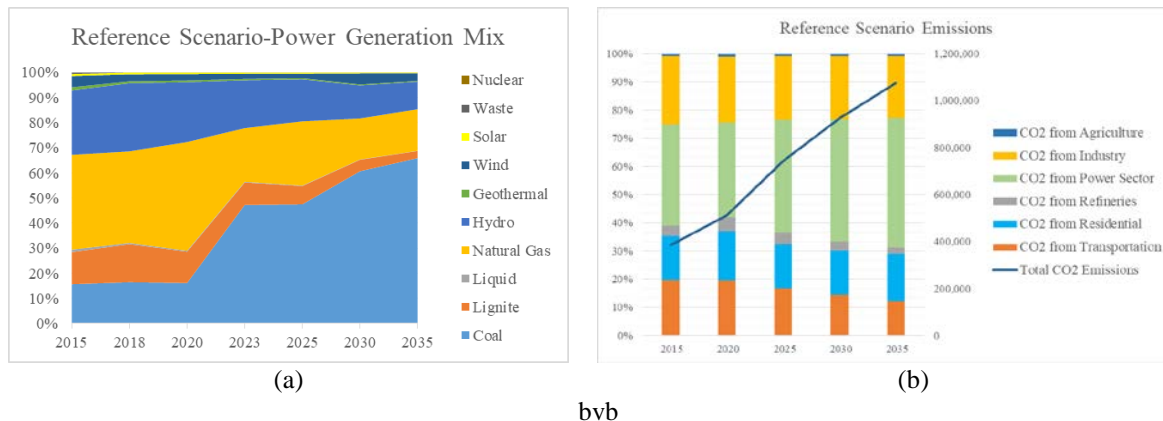


Figure 1: (a) Power generation primary energy mix (%), (b) Sectoral carbon dioxide emissions in reference scenario (KT)

The electricity production primary resource mix and its hourly distribution, technology capacities, electricity prices, carbon dioxide amounts, and unit CO₂ reduction costs are obtained for each scenario and results are analyzed and conclusions are drawn accordingly.

Conclusions

According to the YEKDEM law no: 5346 is analyzed currently, the wind and the solar incentive scenario has the highest system cost across all scenarios when compared to the total CO₂ restriction scenario that has the same emission levels, cost of abatement is less costly under the equivalent emission tax scenario. Unit CO₂ reduction cost is 4 times higher in the wind and solar incentive scenario than CO₂ tax scenarios in short-run and only wind incentive scenario converges to the CO₂ tax scenarios in the long-run. To conclude this scenario analysis, the current set of CO₂ abatement policy is found to be cost inefficient with respect to the taxation strategy. With respect to climate change, direct CO₂ pricing such as ETS or direct emission tax may be a better strategy.

References

- [1] IEA-ETSAP, «Overview of TIMES Modelling Tool,» [Online]. Available: <http://iea-etsap.org/index.php/etsap-tools/model-generators/times>.