

Low-Carbon Power Generation Scenarios for Türkiye and the Role of Advanced and Innovative Nuclear Power Reactors

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1. Introduction

The Ministry of Energy and Natural Resources Turkish National Energy Plan modeling horizon is 2035 and based on the net-zero target in 2053. The energy and climate scenarios included in the official reports are:

- Energy Security Scenario (MENR, 2022)
- Baseline and Net-Zero Scenarios (IPC, 2022), and
- The Net-Zero 2053 (NZ2053) scenario (SHURA, 2023)

The capacity projections in the Energy Security Scenario (MENR, 2022) are illustrated in Table 1 with data from Baseline and Net-Zero Scenarios (IPC, 2022) given in parentheses.

Installed capacity	unit	2030	2035	2055
Solar power	GW	52.9 (59.7)		
Wind power	GW	29.6 (50.1)		
Nuclear power	GW	7.2 (4.8)		
New installed capacity	GW	96.9		
Total installed capacity	GW	189.7 (202.1)		
Battery storage	GW	7.5		
Electrolyser	GW	1.9	5.0	70.0
Demand side management	GW	0.9	1.7	

Table 1: Capacity projections from Energy Security Scenario (MENR, 2022) and Baseline and Net-Zero Scenarios (IPC, 2022) (in parentheses)

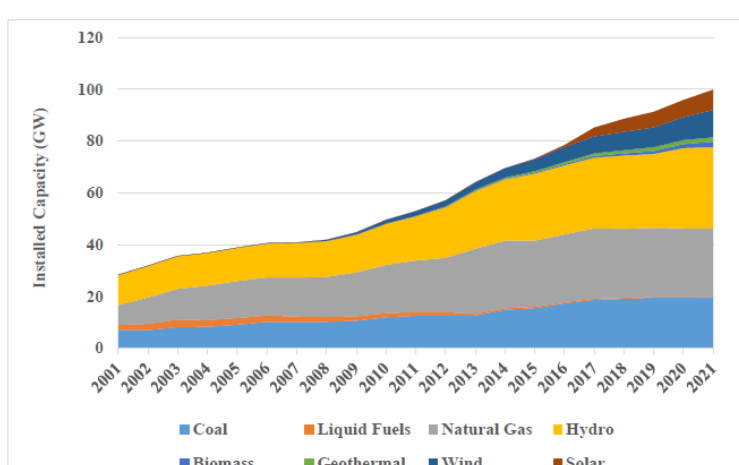


Figure 1. Installed power capacity by sources between 2001 and 2021 (TWh)

2. Carbon emissions

The Energy Security Scenario (MENR, 2022), illustrated in Figure 2, shows a peak fossil year of 2030 and a rapid expansion of renewable energy and nuclear power beyond 2050. MENR (2023) is related with the NDC of Turkey (MoEUCC, 2023).

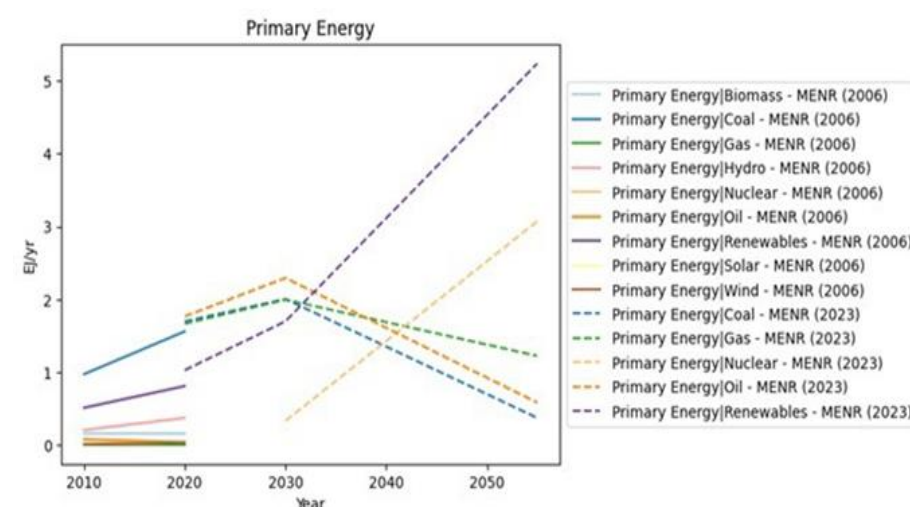


Figure 2: Primary energy supply projections from Turkish national plans

Once all four power units (4800 MW) are operational, Akkuyu NPP will avoid approximately 18 million tons of CO₂ equivalent per year as a result of substituting the volume of electricity generation from hydrocarbon production sources; This corresponds to approximately 3.2% of all annual greenhouse gas emissions in Türkiye (Akkuyu Nuclear Website, 2024).

Hydrogen (green or pink) required to achieve net-zero carbon emissions. The Türkiye National Energy Plan forecasts a battery storage capacity of 7.5 GW in 2035 to reach net-zero emission target (MENR, 2022).

Using Small Modular Reactors for hydrogen production can offer a clean and sustainable alternative. The high-temperature heat generated by SMRs can be harnessed to produce hydrogen through thermochemical processes, which produce no greenhouse gas emissions (Hagert, 2021).

3. Data Availability

The data and scripts are available at MESSAGE-ix Global Model no policy baseline.

4. Results

A reference scenario is created based on the year 2022. In the BAU (Business As Usual) reference scenario, the electricity



system is modeled without determining the policy and without any restrictions. The results of the study are shown on the Figure 3. This study is a work in progress.

years	Coal_P_P	Wind_PP	Solar_PP	Gas_PP	nuclear	Oil_PP	Hydro_Res	Bio_PP	Geotherm	Coal_imp	h2
2025	1228.73	2545.08	2105.15	13613.17	0	0	22533.87	1751.09	1260.29	3218.77	0
2030	1495.87	2633.84	2105.15	18079.97	0	216	22533.87	1751.09	1530.23	3965.91	0
2035	1495.87	2455.79	2553.88	26681.22	0	0	22533.87	2126.16	1530.23	2839.51	0
2040	1495.87	1536.18	24375.74	16085.75	0	0	22533.87	1751.09	1692.2	2342.11	0
2045	1495.87	201.12	42232.34	11102.56	0	0	22533.87	1751.09	1692.2	2241.71	0
2050	861.35	0	63460.28	6087.06	0	0	22533.87	1231.83	1474.8	861.13	0
2055	307.83	0	81601.63	5718.91	0	0	22533.87	782.57	630.6	306.47	0

Table 2: Producers of electricity on level secondary

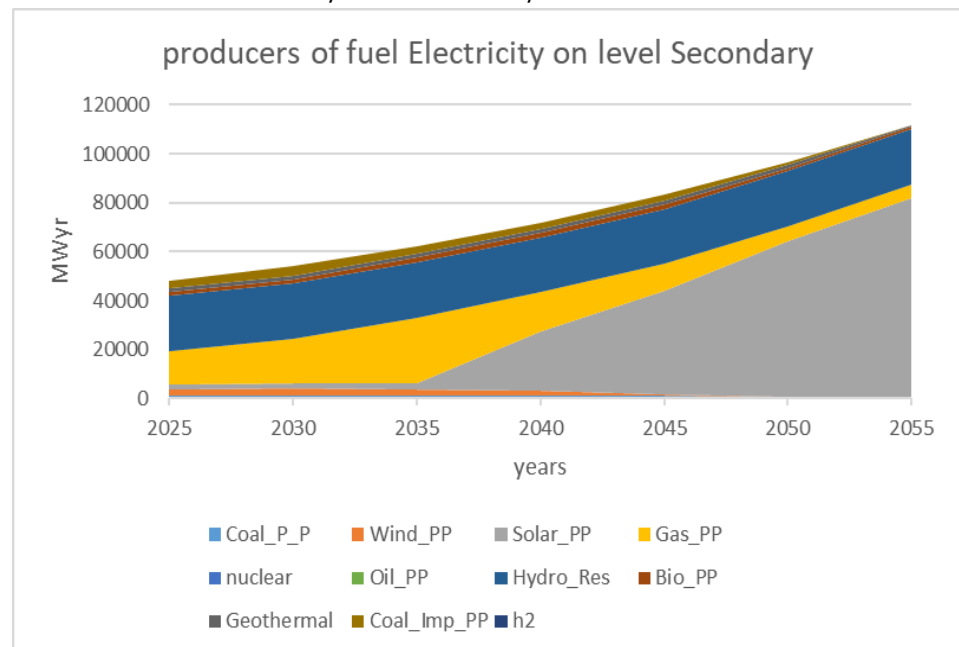


Figure 3: Producers of electricity on level secondary

In the future stages of the study, the carbon emission tax will be applied as a constraint and will be gradually increased, taking into account the world emission trading system data. After the carbon constraint is determined, the reduction in costs and greenhouse gas emissions will be determined by running NS1, NS2 and NS3 (net zero) scenarios for low, medium and high demand.

References

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