

Evaluation of the Reduction of Electricity Demand in Japan after the 2011 Tohoku Earthquake

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Abstract: It is believed that Japan's electricity demand shrank after the 2011 Tohoku earthquake because of consumers' electricity conservation behavior (Setsuden). We developed a state space model of monthly electricity demand, and estimated time variation of the electricity conservation effect (ECE). Our result clearly indicates that Setsuden after the earthquake became established as a habit. Between March 2011 and October 2015, the ECE on power demand ranged from 2.9% to 6.9%, and the ECE on light demand ranged from 2.6% to 9.0%. The ECE on the total electricity demand was 3.2%—7.5%. Setsuden also contributed to the reduction of CO₂ emissions, but it could not offset the emissions increase caused by the shutdown of nuclear power plants.

Introduction

- After the 2011 Tohoku earthquake, the Government of Japan asked companies and households to conserve electricity.
- We estimated time variation of the electricity conservation effects (ECEs) on power and light demands by removing irrelevant variations from the data (**Figure 1**).

Modeling

- The state space model (SSM) is a linear model with time-varying parameters, which is useful for analyzing nonstationary data.
$$Y_t = \theta_t^0 + \sum_{i=1}^m \theta_t^i X_t^i + v_t, \quad v_t \sim N(0, V)$$
$$\theta_{t+1}^j = \theta_t^j + w_t^j, \quad w_t^j \sim N(0, W^j), \quad j \in \{0, 1, \dots, m\}$$
- Irrelevant variations are removed by a seasonal component, a linear trend component, the degree-day indices, and economic variables.
- The impact of the earthquake on electricity demand is represented by the dummy variable which switches from 0 to 1 in March 2011.
- The ECE is measured by comparing the demand estimates from the models with and without the earthquake dummy.

Results

- We found that electricity conservation after the earthquake became established as a habit (**Figure 2**).
- Although households have no legal obligation, they aggressively contributed to the reduction of light demand.
- Electricity conservation slightly mitigated the CO₂ emissions increase caused by the shutdown of nuclear power plants (**Figure 3**).

Acknowledgement

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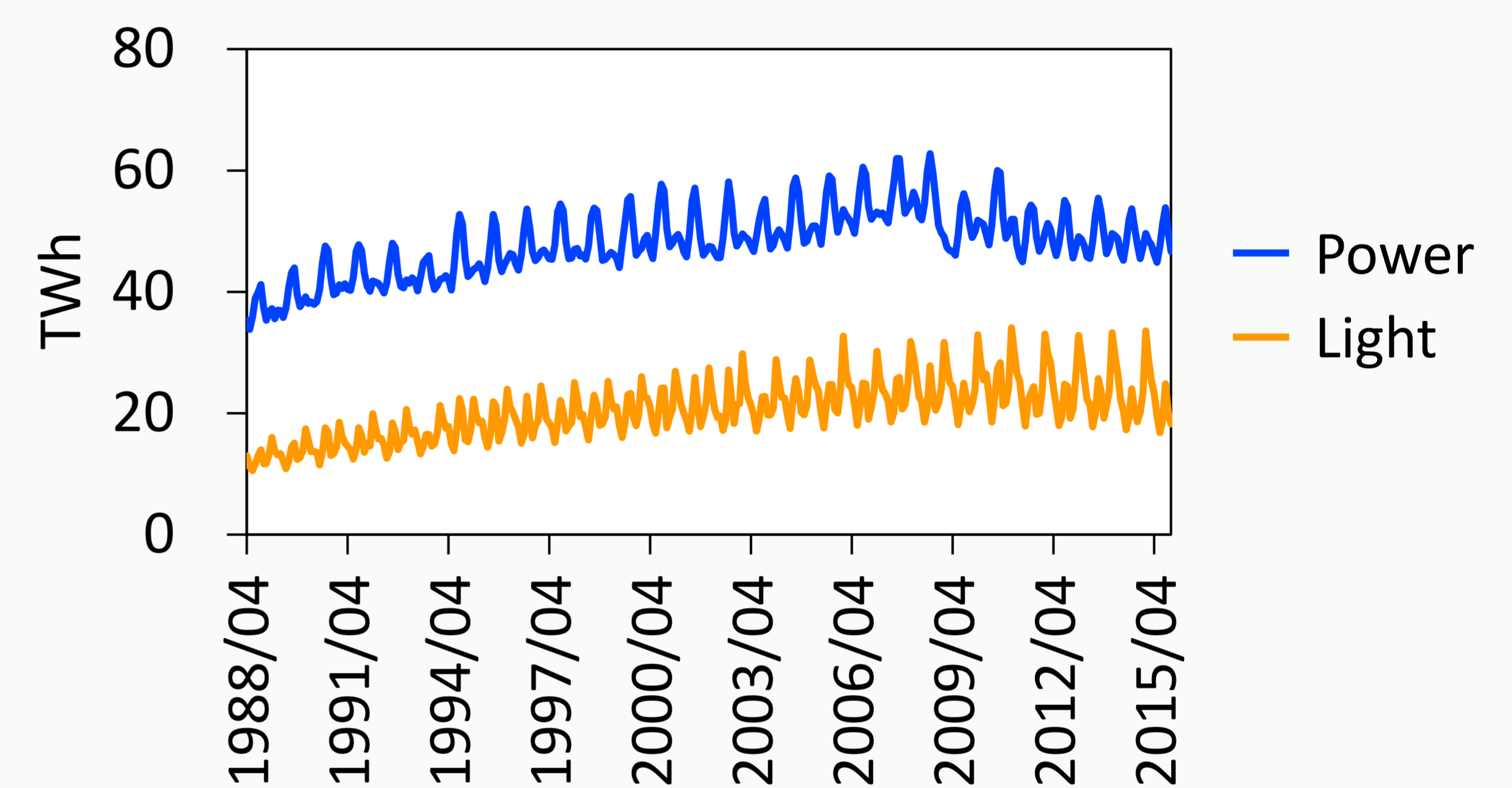


Figure 1: Power and light demands in Japan
Source: EDMC Databank (IEEJ)

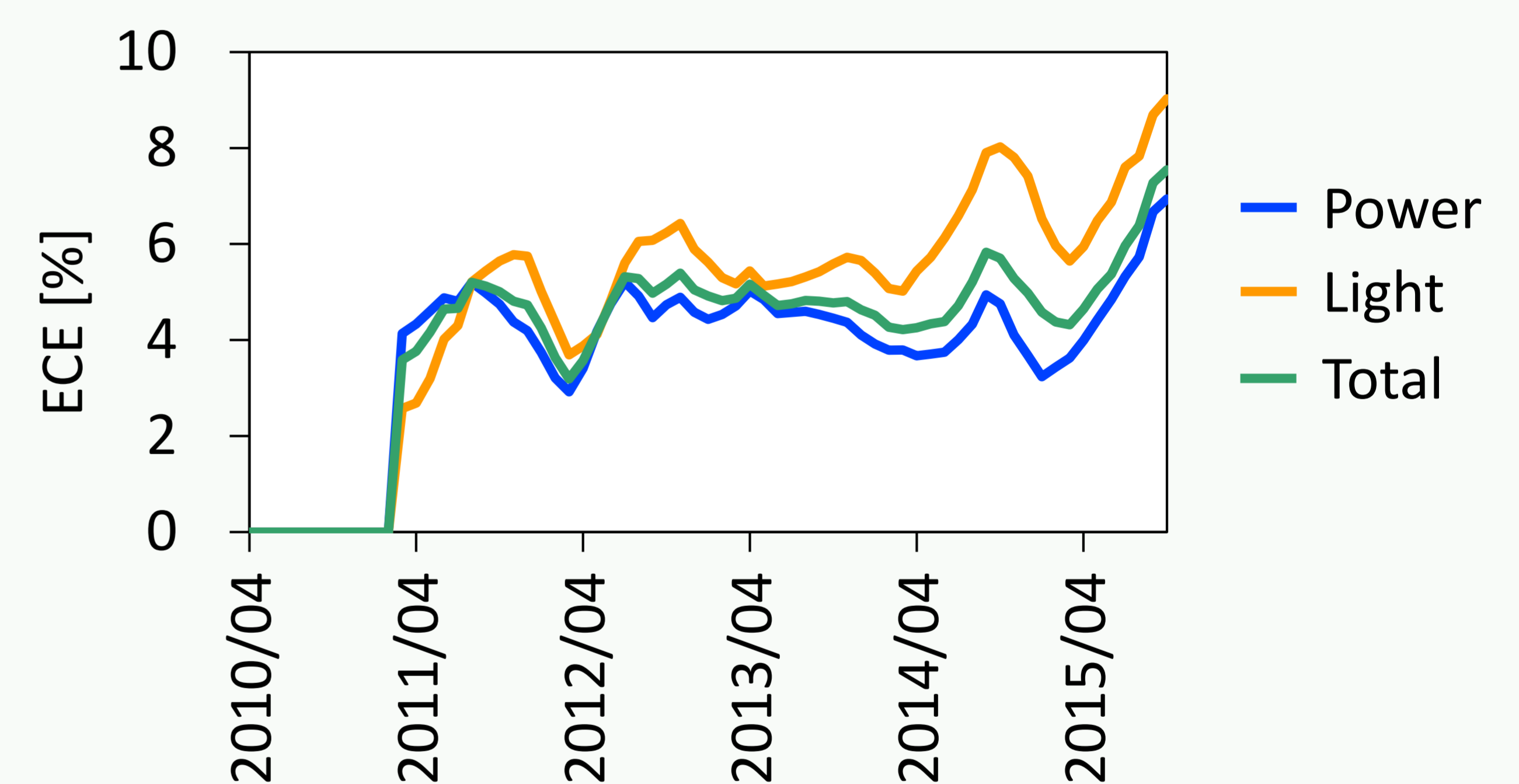


Figure 2: Time variation of the ECEs estimated by the models

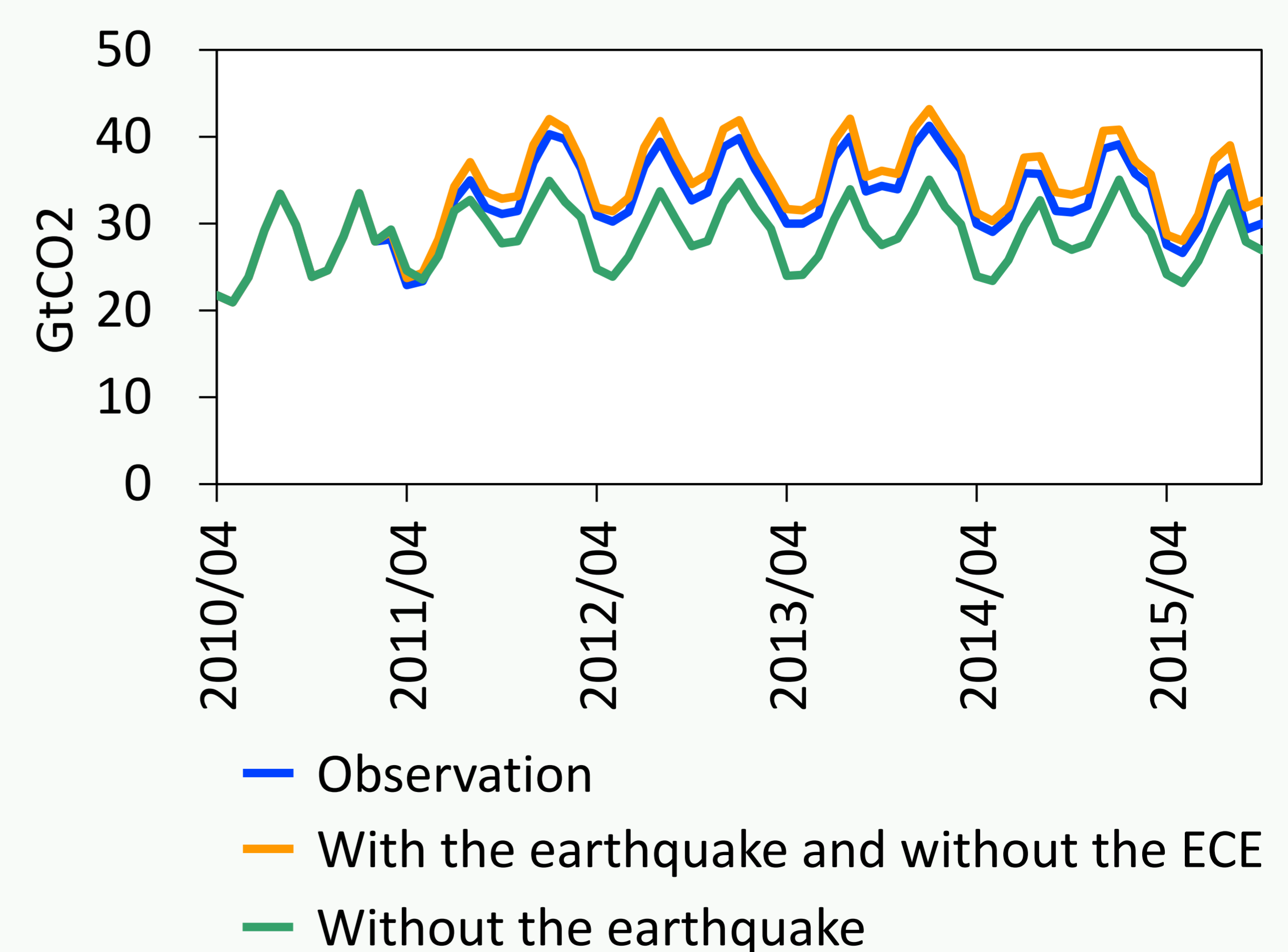


Figure 3: CO₂ emissions from electricity generation