CO$_2$ intensity of electricity is defined as

$$S = \frac{G}{E},$$

(1)

where $G$ is CO$_2$ emissions from power plants and $E$ is electricity demand. We classify energy into two types: fossil (type $\alpha$) and non-fossil (type $\beta$). Let $E'_i$ be the amount of energy $i \in \{\alpha, \beta\}$ input to power plants, and let $S'_i$ be CO$_2$ intensity of energy $i$. We assume that $S_\beta = 0$. Then

$$S = \frac{S'_\alpha E'_\alpha + S'_\beta E'_\beta}{E} = \frac{S'_\alpha E'_\alpha}{E}. \quad (2)$$

We define the input-output efficiency of power generation and transmission by $F_i = E_i/E'_i$. Following the system of General Energy Statistics developed by Agency for Natural Resources and Energy, we assume $F_\alpha = F_\beta$. The total input-output efficiency is

$$F = \frac{E_\alpha + E_\beta}{E'_\alpha + E'_\beta} = \frac{F_\alpha E'_\alpha + F_\beta E'_\beta}{E'_\alpha + E'_\beta} = F_\alpha. \quad (3)$$

From Eq (2), we obtain the target equation

$$S = \frac{S'_\alpha E_\alpha}{EF_\alpha} = \frac{R_\alpha S'_\alpha}{F}, \quad (4)$$

where $R_\alpha = E_\alpha/E$ is the rate of fossil fuel power generation.