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$$Atm_{t+1} = Atm_0 + (1-\delta_M)(Atm_t - Atm_0) + (1-\delta_E)(E_t + \bar{E}), \quad (12)$$

$$Temp_{t+1} = (1-\delta_T)Temp_t + \delta_T \log\left(\frac{Atm_{t+1}}{Atm_0}\right) \bar{T}, \quad (13)$$

where  $\delta_M$  is the atmospheric CO<sub>2</sub> depreciation rate,  $1-\delta_E$  the retention rate of emissions,  $\bar{E}$  are emissions linked to deforestation, agricultural production, and other non-energy greenhouse gas sources,  $\delta_T$  the temperature adjustment rate resulting from the atmospheric warmth capacity, and  $\bar{T}$  is the long-term equilibrium temperature change associated with a doubling of the atmospheric CO<sub>2</sub> concentration.

In various scenarios, energy is taxed at a fee  $\tau_t$  at the basis of its carbon content, and thus, the tax is expressed in \$/tC and it adds a constant markup to the energy system. In addition, the model includes subsidies for the renewable energy sources, so that market prices become

$p$

$$p_{n,t} = (1 - s_t)q_{n,t}. \quad (15)$$

The model has thus two instruments available, a carbon tax and a carbon-free energy subsidy, to enhance the transition from fossil fuel energy sources towards carbon-free energy sources.

Energy produced by both technologies has its own characteristics but they are substitutes. For convenience, we assume inelastic demand on the aggregate level,  $\hat{y}_t$ , which growth-rate is set equal to the population growth rate plus an assumed 1.5 per cent growth per year,  $g_{ypc}$ ,

$$\hat{y}_{t+1} = (Pop_{t+1}/Pop_t)(1+g_{ypc})\hat{y}_t \quad (16)$$

Population ( $Pop_t$ ) is assumed to grow logistically:



























































