Lecture 1B: Global Efforts for Decarbonization and Modeling History

=> Literature; Outline

- Basic model, Greiner et al 2014,
- Nyambuu /Semmler, paper 2020,
- Nyambuu /Semmler, book chs. 4-6
- Nyambuu /Semmler, book, ch 7

I. Global perils; Flattening –reversing- the emission curve?

GDP per capita increase from 1880: 10 times higher; Is there a Kuznets Environmental Curve? See IMF papers, with Loungani et al. (2018), Data Source: Owid-CO2

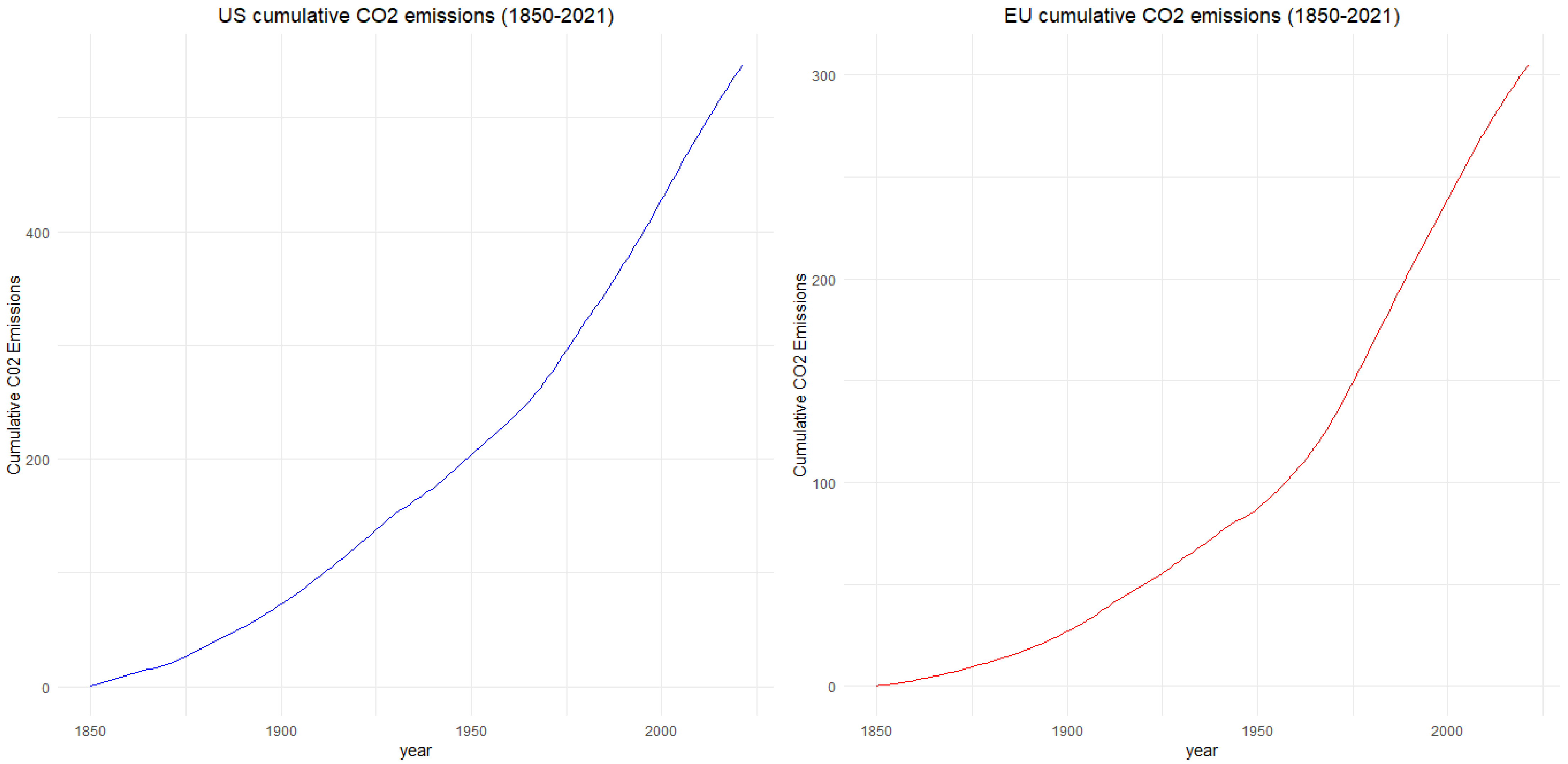
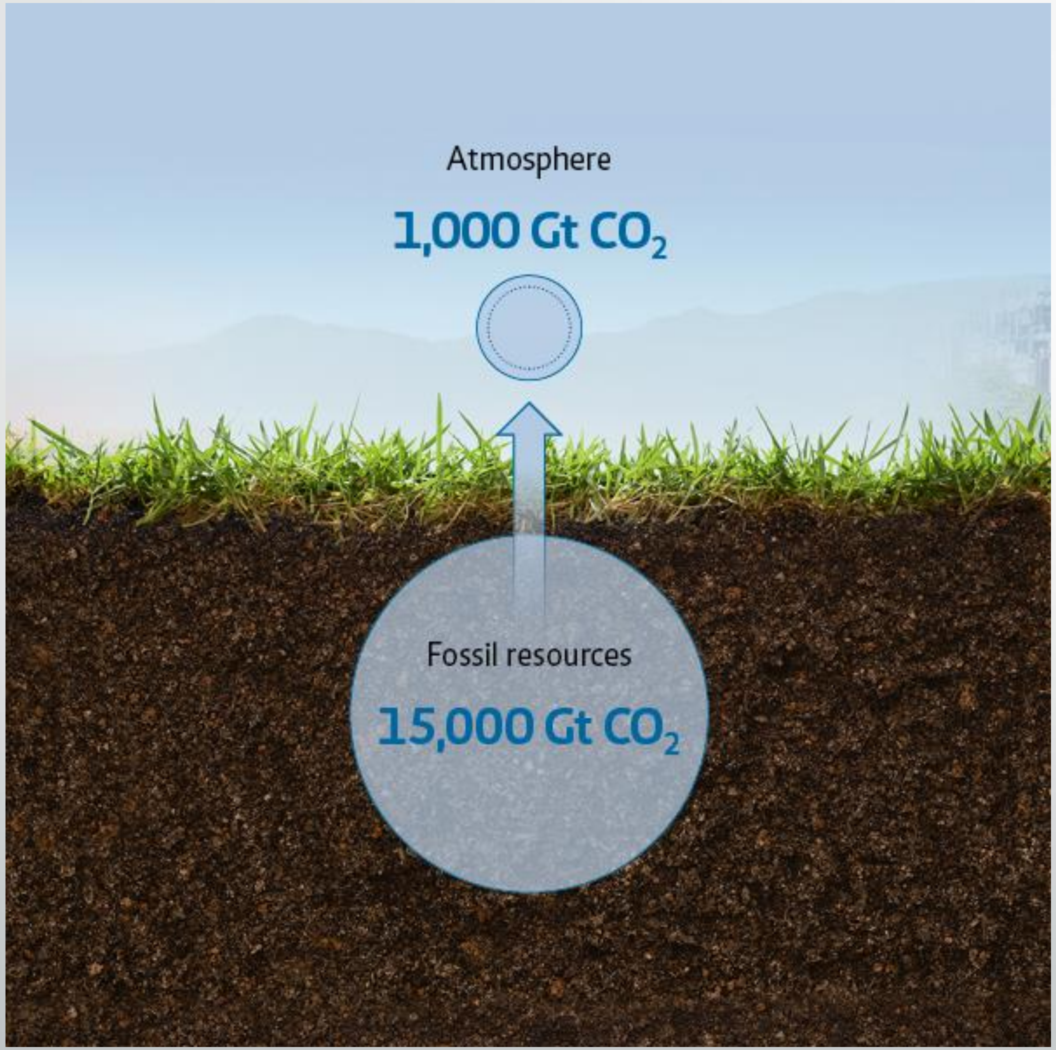


Figure 2: Cumulative Emissions in Giga Tones Plotted from 1850 to 2021, source: Owid-CO2

I. Global perils; Carbon budget?; Where are we now? At the upper constraint of 400 ppm Edenhofer et al. (2014), PIK research

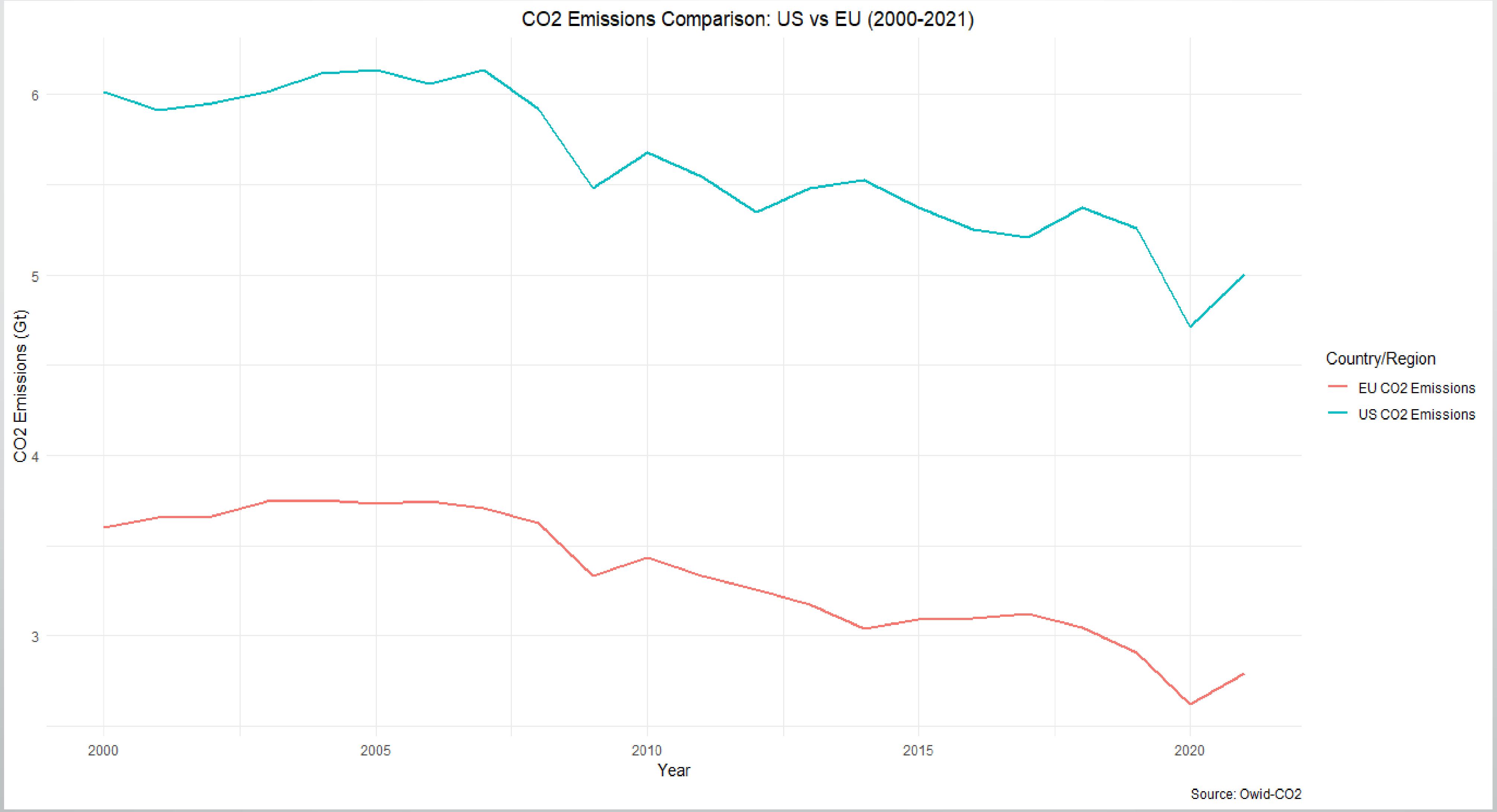


Until 2100	With CCS [%]	No CCS [%]
Coal	70	89
Oil	35	63
Gas	32	64

II. Global Efforts; Energy Transition? - Flattening (reversing) the emission curve?

Lower growth rates of emission

But: It requires lower and then near zero growth rates of net zero emission until 2050



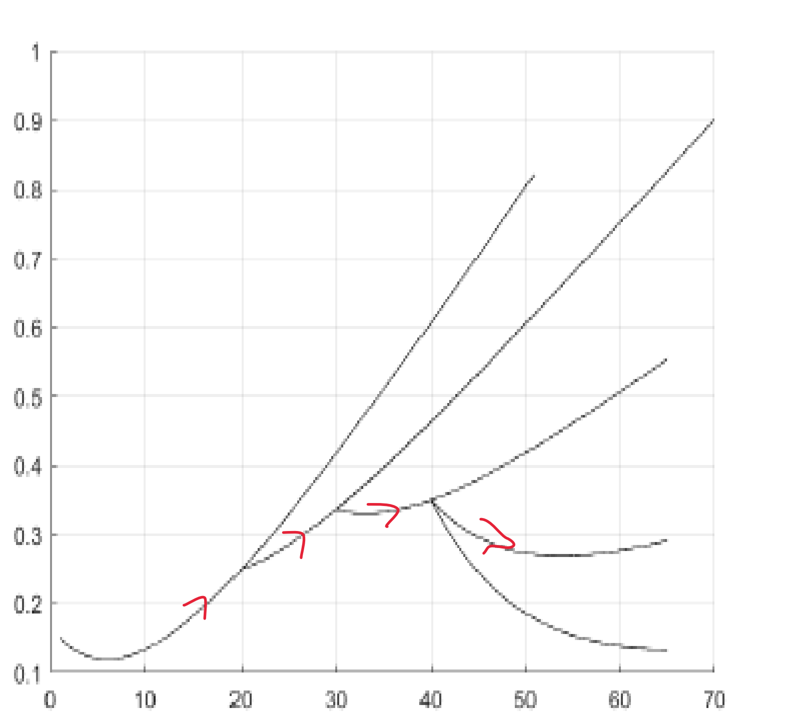
II. Global efforts: Energy Transition?– The tasks are how to flatten the curve

How to achieve lower growth rates and then net zero emissions for 2050

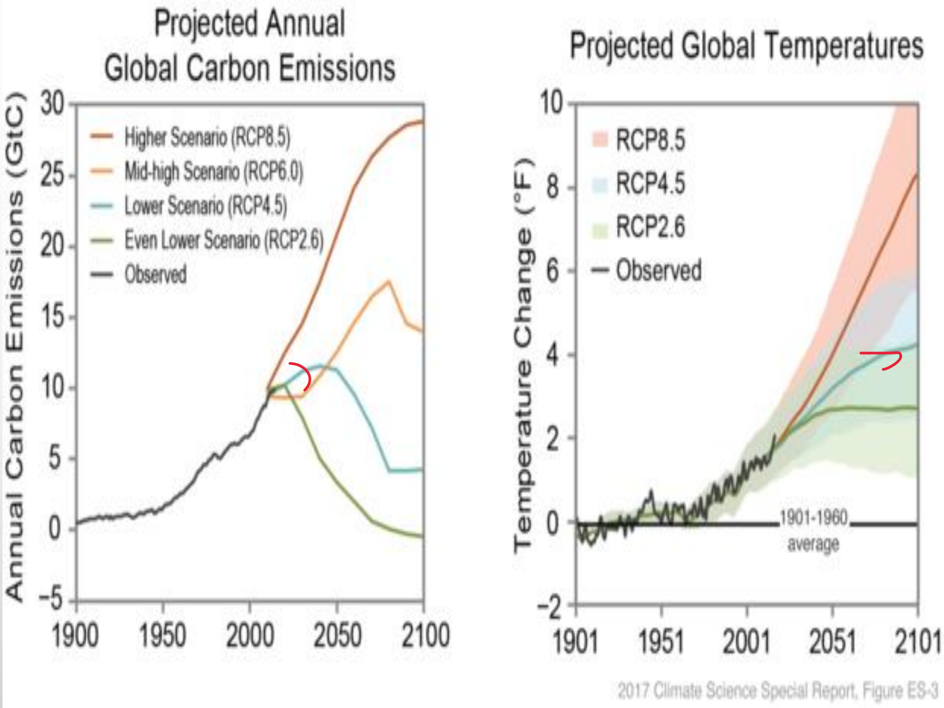
$$\dot{ce}(t) = -\alpha * ce(t) + log(e^{(g_{ce}t)})$$

=> mitigation measures

- Less output
- Standards, regulation
- Energy conservation
- Cap&trade
- Carbon tax-subsidies
- New energy technology
- Financial instruments
- Macro policies
- Sectoral policies



Non-stationary carbon emission simulated; starting from the upper curve: gce = 0.002, gce = 0.0015, gce = 0.001, gce = 0.0005,and gce =0.0001, only the lowest growth rate is not only flattening the curve but reversing it

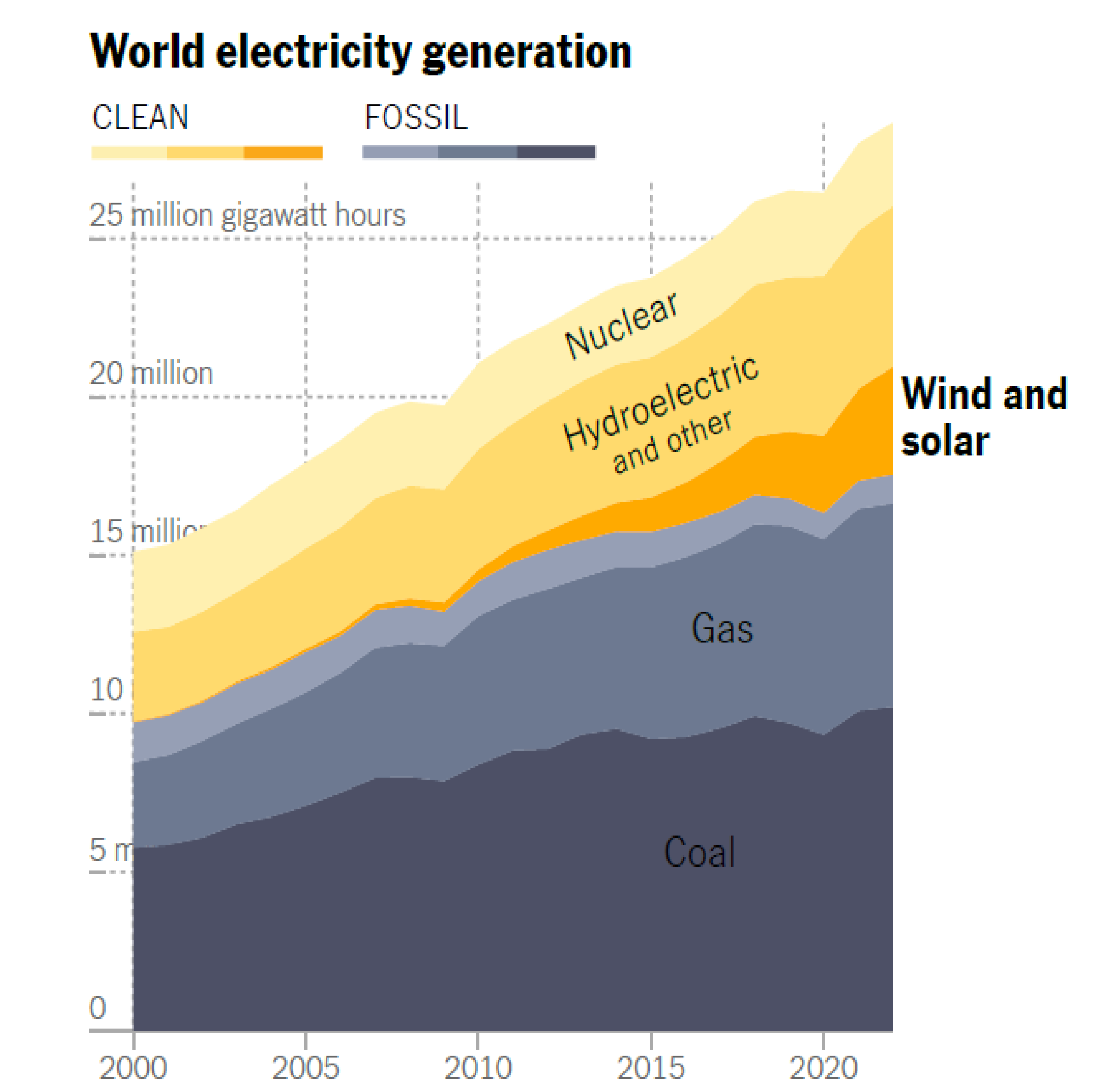


NOAA National Centers for environmental information, 2022

II. Global efforts: Energy transition – Increase of global green electricity generation

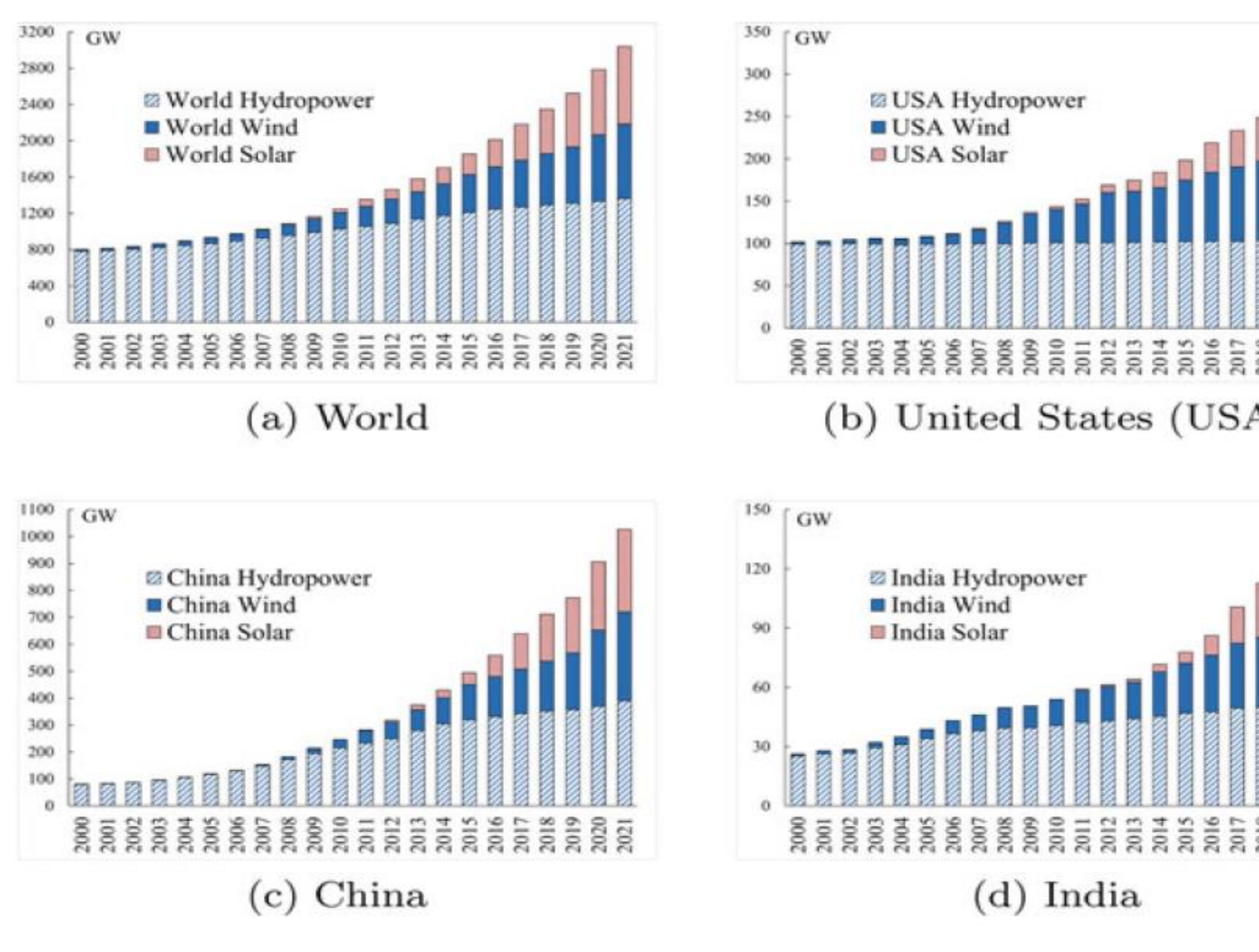
=> Global efforts:
International negotiations and Agreements, COP

=> Behavioral constraints:
There are global negotiations (COP) but there are also global irreversibilities, lock-ins, leakages, Non-participation, policy games, and resistance resistance in private, financial, public sectors
Ch. 10



II. Global Efforts; Global economy and energy transition – Increase of global green energy investments

- There are worldwide efforts of decarbonization
- Should all countries have the same targets and efforts for decarbonization?
- What should be the burden sharing; with financing flows to low-income and emerging market countries?



III. History of dynamic macro model types, see book chs

- **Hotelling (1931):** stock of exhaustible resource is given and optimally depleted, extraction rate monotonically decreasing, competitive pricing, and prices increase montonically with interest rate; see Greiner and Semmler „ A Model of Oil Extraction… „ with discoveries and U-shaped prices
- **Growth model** with **positive externalities**: Krautkraemer (1986) where the benefits natural resources appear in preferences, amenities
- **Growth model** with **negative externalities**: Hoel and Kverndokk (1996) of a non-renewable resource from carbon consumption, with damages in preferences
- **Growth model** with **resource extraction** and **resources use in production, with capital stock:** Chichilnisky and Heal (1993), Greiner et al
- **Heinzel et al (2011)**, refer to private and social discount rates when justifying tax and subsidies **Nordhaus canonical model** on growth and climate change, with negative externalities and damages in production, see Question of Balance (2008), and The Climate Casino (2013)
- **Van der Ploeg et al.** (2011, 2012) with externalitites, and two non-renweable energy sources (oil and coal) and renewable energy, no capital stock

III. History..extraction of non-renewable resource

- Hotelling (1931):non-renewable resources; Price rises with interest rate, but Greiner and Semmler (2012) and Pindyck, 1978: Price may first deline, before rising

Running down the stock ($x_0 > 0$)

$$
\begin{aligned}
\dot{x} &= -u(x) \\
& \quad x_0 - y \\
y &= \int_0^\infty u\,dt
\end{aligned}
$$

III History,,,. Models with positive externalities

Krautkraemer (1985): S= stock of non-renewables, C= consumption, R=extraction rate, S has amenity value

$$\int_0^\infty e^{-\delta t} U(C(t), S(t))\,dt$$

subject to:

$$\dot{S}(t) = -R(t)$$

$$C(t) = e^{\tau t} R(t)$$

$$S(0) = S_0$$

$$R(t) \geqq 0, \quad S(t) \geqq 0, \quad \text{all } t,$$

where C, R, and S denote the levels of consumption, resource extraction and resource stock respectively.

III. History…Models with negative externalities and damages

Hoel and Kverndokk (1996): S= atmosheric stock of carbon, x=extraction (consumption) of all fossil fuel, A=accumulated extraction of fossil fuel, c(A)x= total extraction cost, rises with cumulative extraction, D(S)= damages

$$\textit{maximize} \int_0^\infty e^{-rt} \cdot [u(x_t) - c(A_t)x_t - D(S_t)]\mathrm{d}t$$

$$\text{s.t.} \quad \dot{A}_t = x_t,$$

$$\dot{S}_t = x_t - \delta S_t,$$

$$x_t \geq 0$$

where $r > 0$ is a discount rate which is fixed throughout the analysis. we set $A_0 = 0$, and from the definition of S it follows that $S_0 > 0$.

III. History…Models with resources used in production, beside capital

Chichilnisky and Heal (1993)=> No externailities, but including capital; R=stock of resources, K=capital stock; u= extraction rate of non-renewable resources, see also Greiner and Semmler (2008)

$$Max_{(C,u)} \int_0^\infty e^{-\rho t} U(C_t) dt$$

$$\text{s.t.} \quad Y = F(K, u)$$

$$\dot{K} = Y - C - \delta K$$

$$\dot{R} = -u$$

IV. History…Models with resource use, externalities, and damages

Country group-specific targets (book, ch. 7), finite time

⟹A model of a gobally

Fair Transition:

- K=capital stock
- Y=output; $Y = Z(Z_K K + Z_S S)^{\omega}$
- C=consumption (or gap)
- R=Remaining fossil fuel resource
- S=extraction of fossil fuel
- m= stock of extracted fossil fuel
- E=emission
- λ = target relative to preindustrial emission (1880)

Solved with NMPC

$$\max_{C,S} \int_0^T e^{-\theta t} \left(ln(C) - \tau (E - E^*)^2 \right) dt$$

$$Y = Z(Z_K K + Z_S S)^{\omega}$$

$$\text{s.t.} \quad \dot{K} = Y - C - \delta K - \varrho (R^0 - m)^{-2} S$$

$$\dot{R} = \varphi (R^0 - m - R - R^b) - S$$

$$\dot{E} = \vartheta S - \varsigma (E - \lambda E^*)$$

$$\dot{m} = S$$

IV. History…Models to assess climate risks and fair energy transition => country-group specific targets? burden sharing?

Groups of countries:

=>Fair targets

λ = target relative to pre-industrial emission (1880)

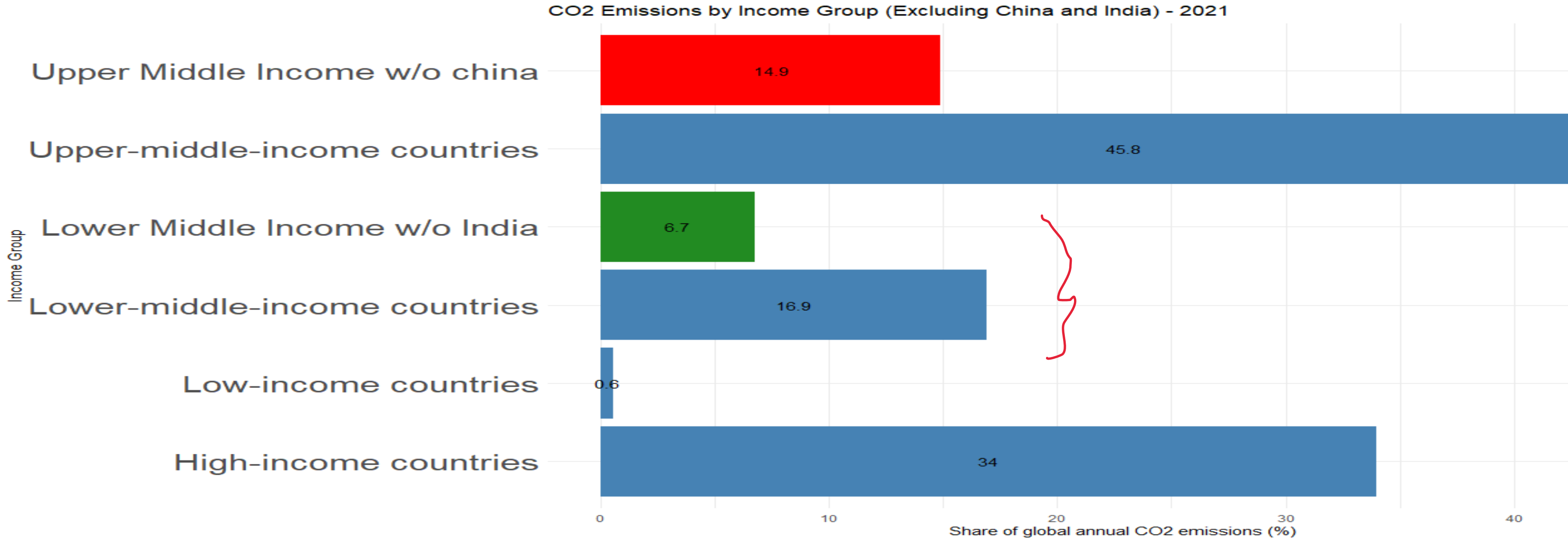
Higher carbon emission path of EMC, but a much lower share in world emission

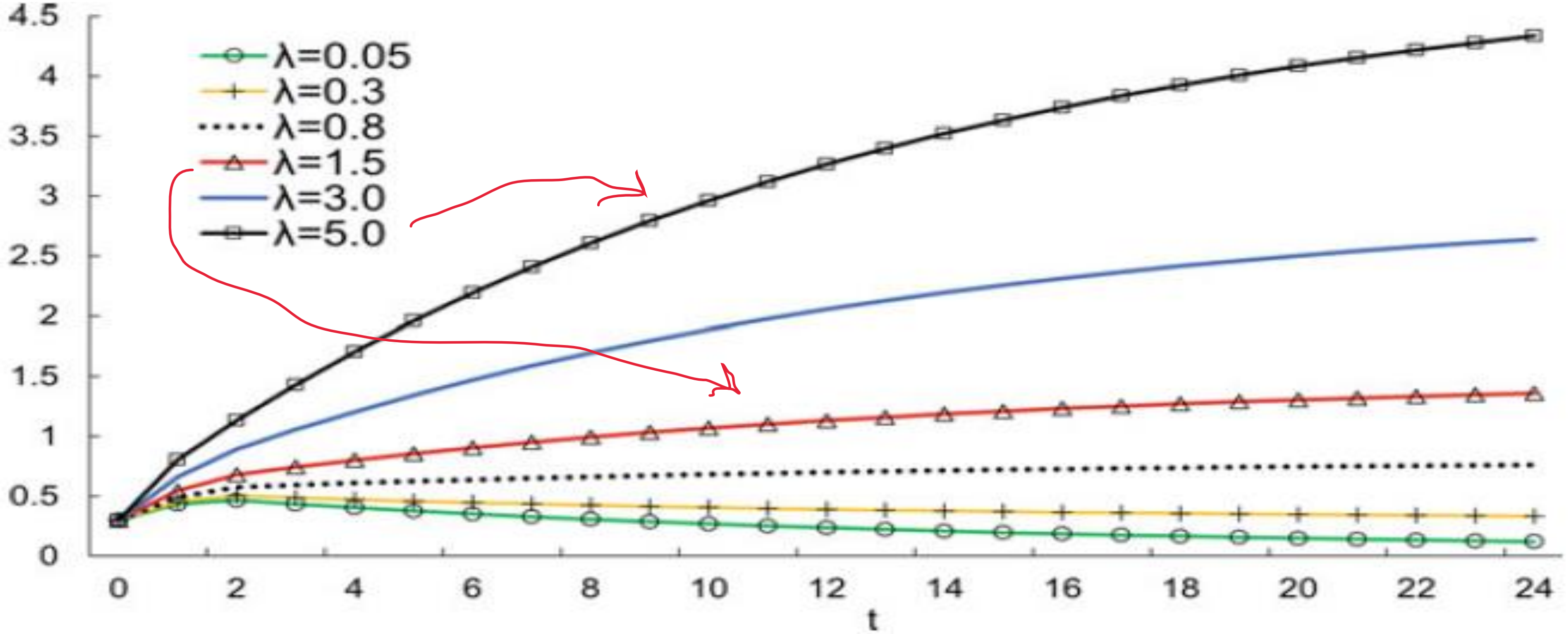
=> Fair transition:

giving higher weight to high and middle-income countries and less to low-income countries may accelerate the decrease in emission growth

Technology transfers?

Flow of finance needed





V. Conclusions—later
climate-macro models with comprehensive components

=> See our book chs. 8-11, and later letcures.

- Controversial views concerning burden, costs, and benefits?
- Fair transition – concerning the past and future?
- Financing the global efforts: Copenhagen ($100 bill) and beyond
- Sachs (2023): Grants and Loans
- Funds of oil-rich countries?