Climate Change, Growth and the Environment

From *Limits to Growth* to *Glasgow*

Economics of Climate Change

Prof. S. van Wijnbergen
S.J.G.vanwijnbergen@uva.nl

Sustainable energy: what are the key issues?

- Exhaustibility (natural) resources?
  - *Limits to Growth* report 1972, started the *circular economy* drive

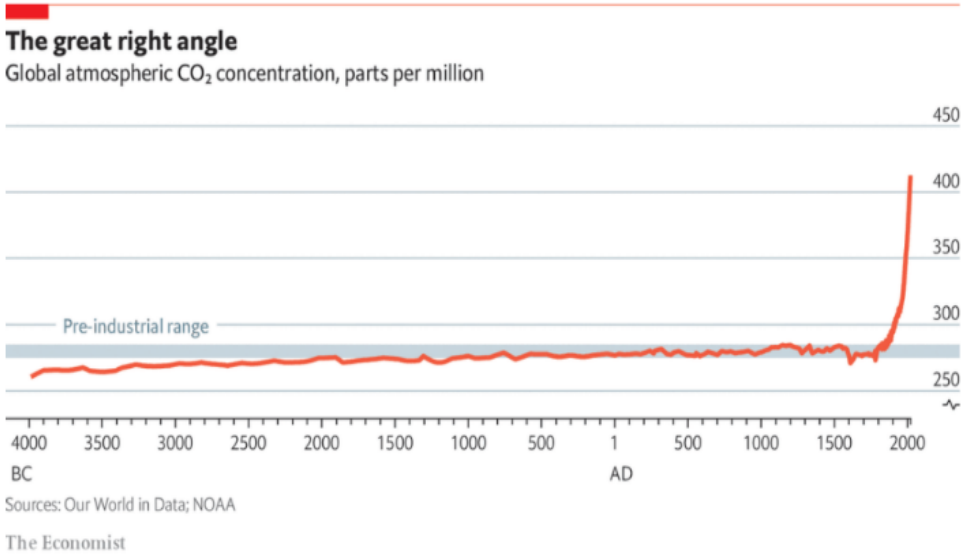
- But: innovation and technical change major are drivers in bringing down use of scarce resources
  - markets are good at allocating scarcity
  - prices will reflect scarcity => no external effects, so no need for policy intervention

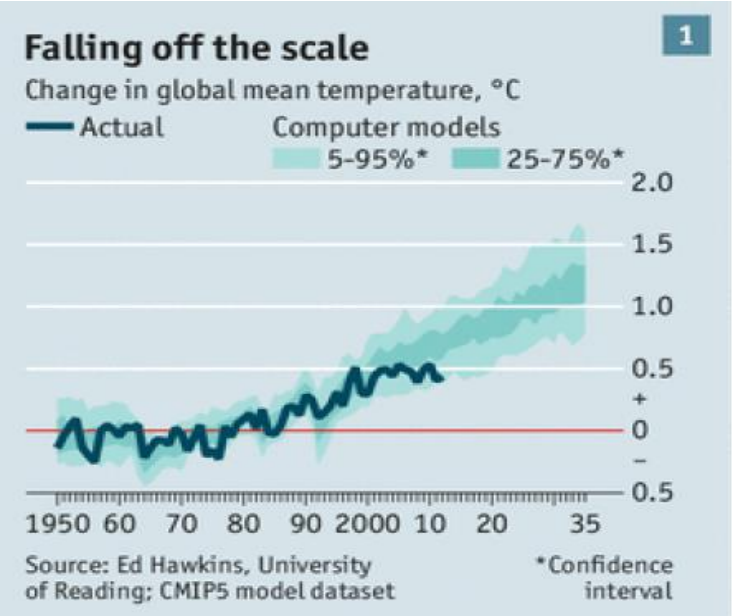
- Climate Change is different
  - CO_2 **is** a global issue caused by national players
  - => Nick Stern: Climate Change is *the mother of all externalities*

- Key challenges for the future
  - Carbon pricing/global Emission Rights Trading
  - Problems in forming and sustaining an international coalition to combat Climate Change

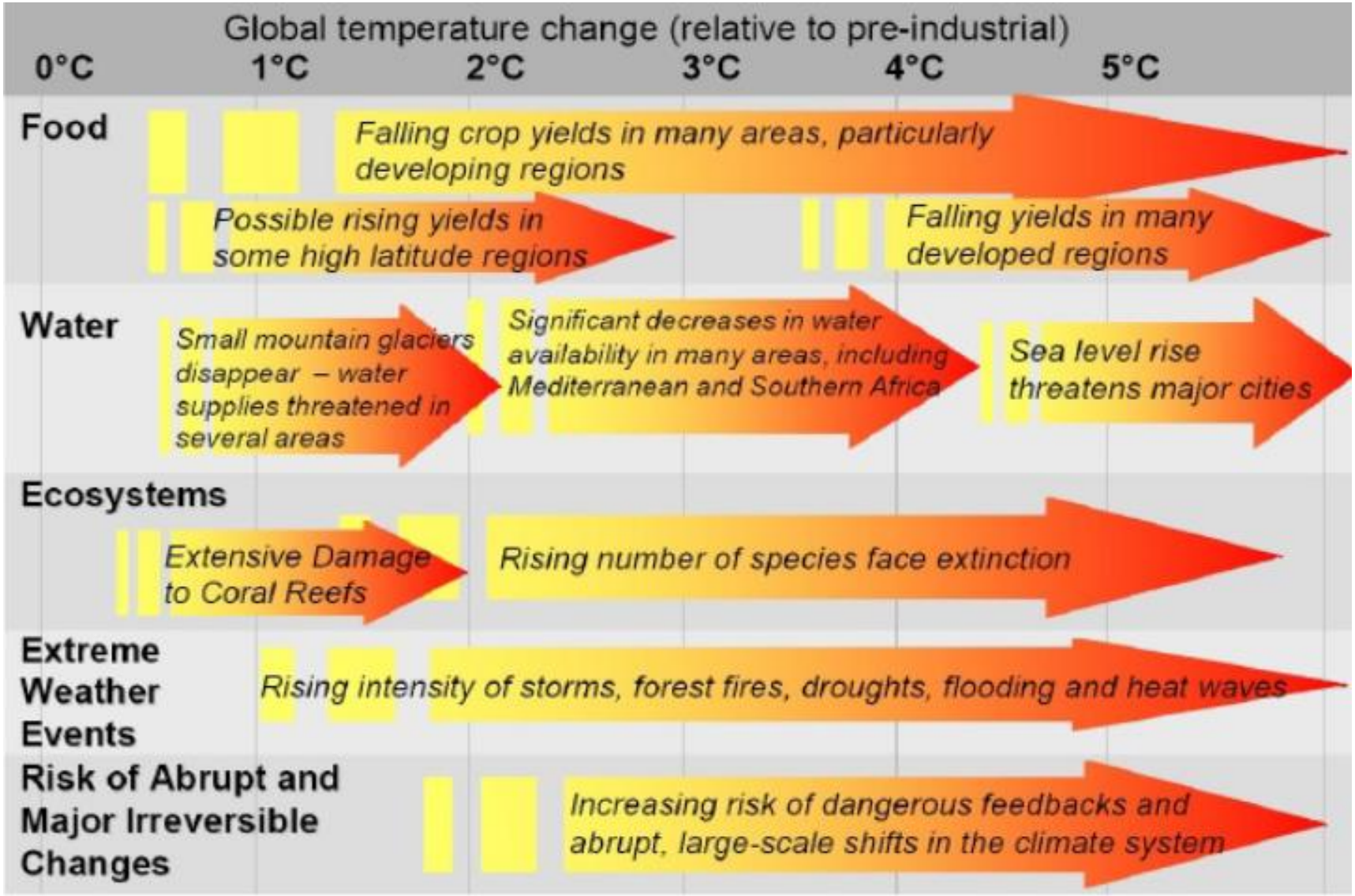
So the Real Issue is Climate Change

- Past 20 years, emissions of most pollutants have gone down in <u>absolute terms</u>
- Major exception: (man made) CO_2
- global rise in T accelerating
- higher T more than offsets the agricultural benefits of higher CO2 concentration in the atmosphere



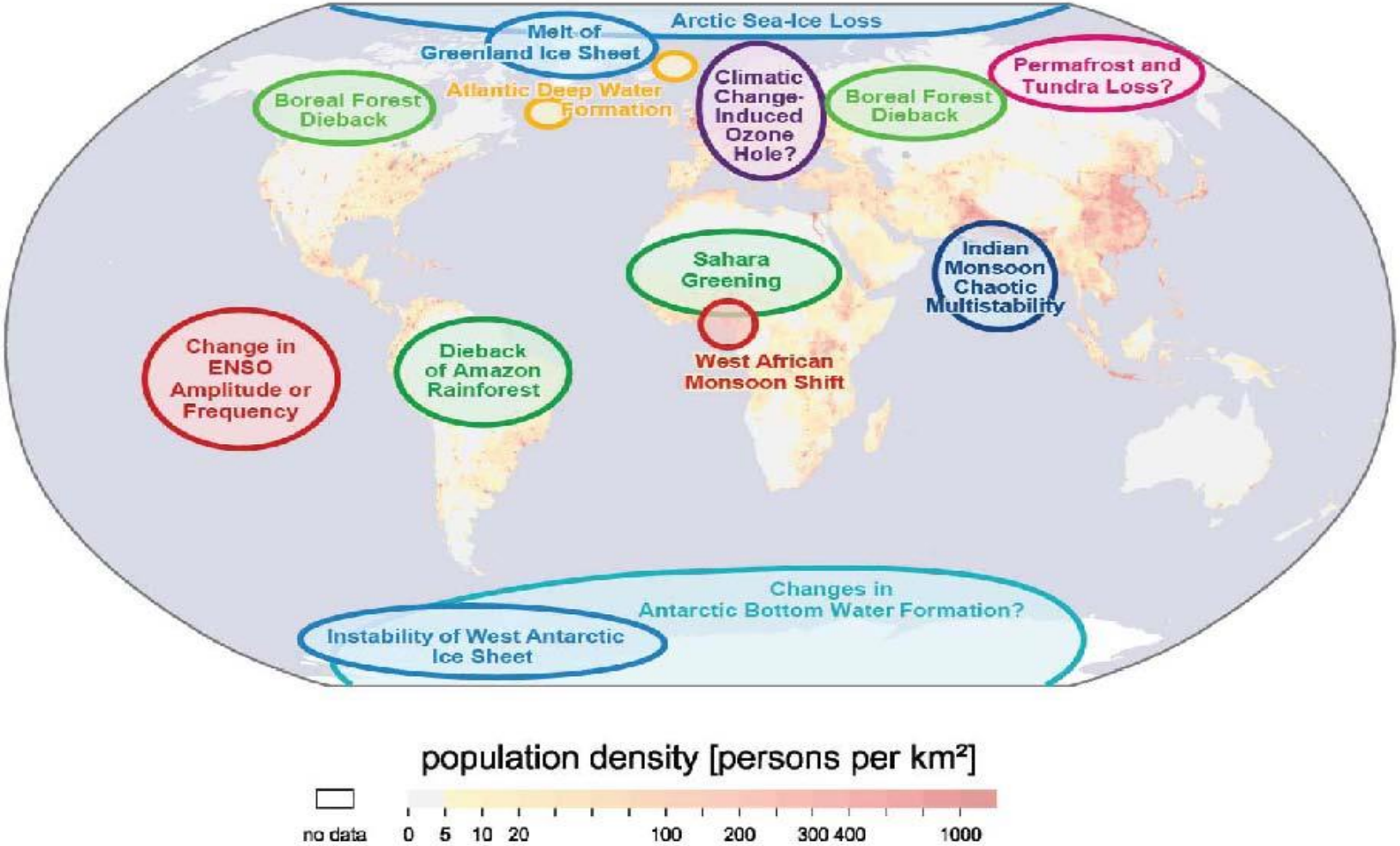


Impact of Climate Change



Source: Stern Review, adapted from IPCC

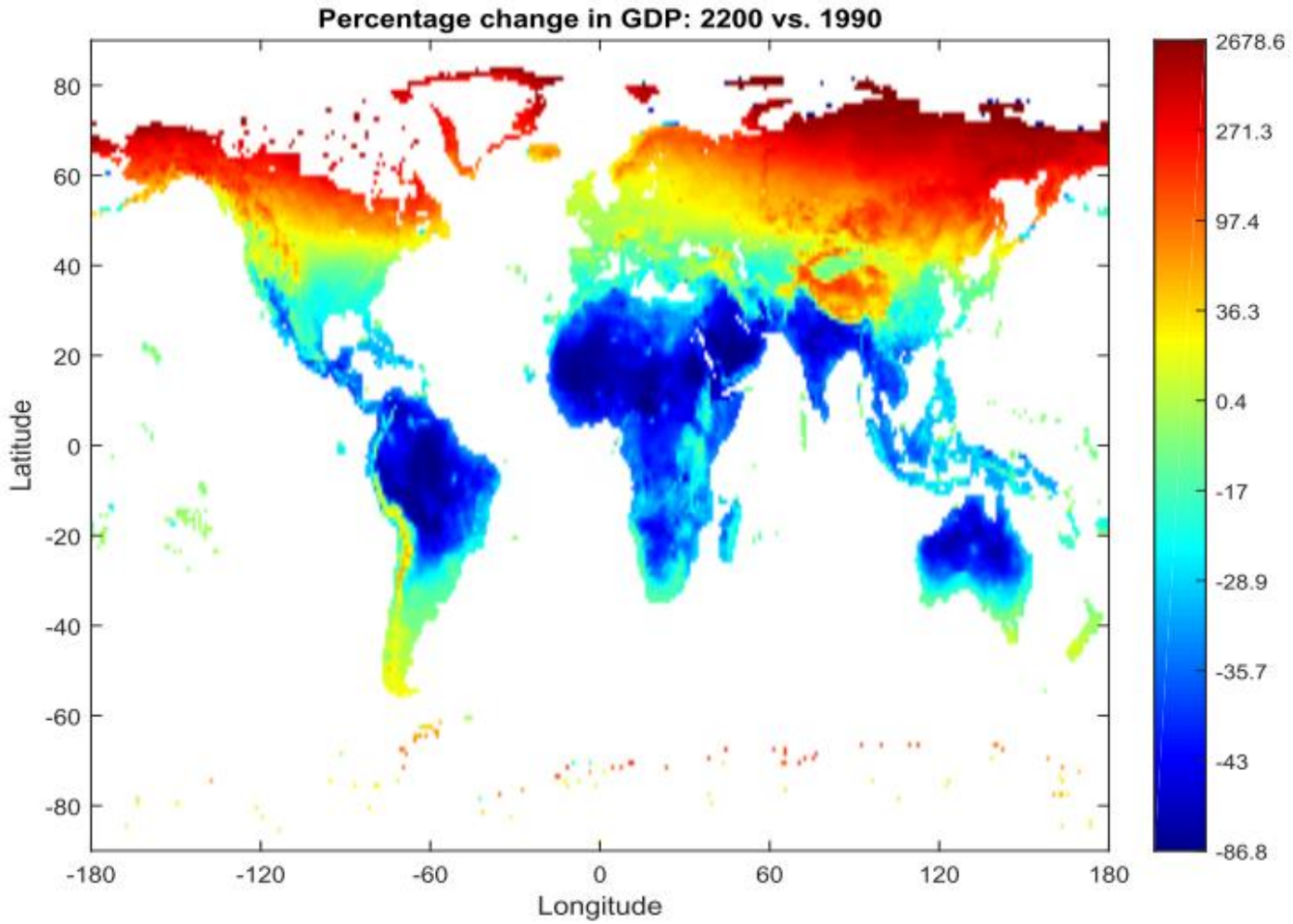
Tipping Points in the Earth System



Source: Lenton and Schnellnhuber (2007)

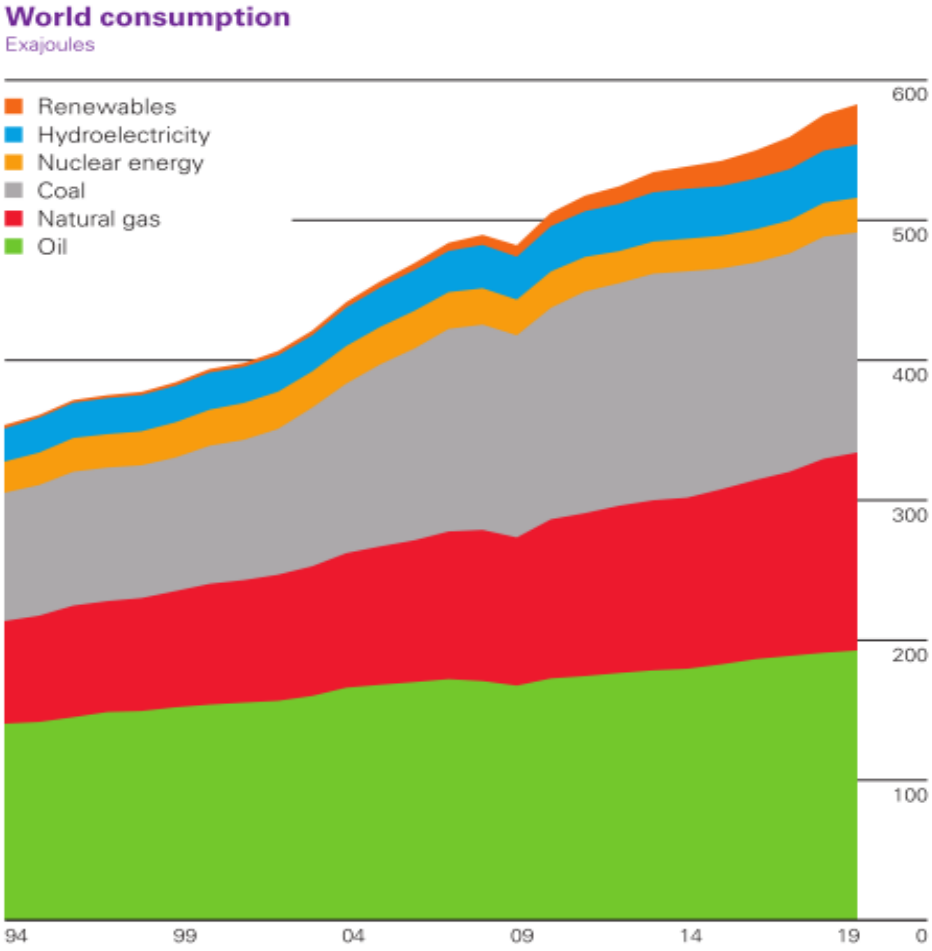
And climate change especially hits the poor

Source: Krusell et alii (2016)

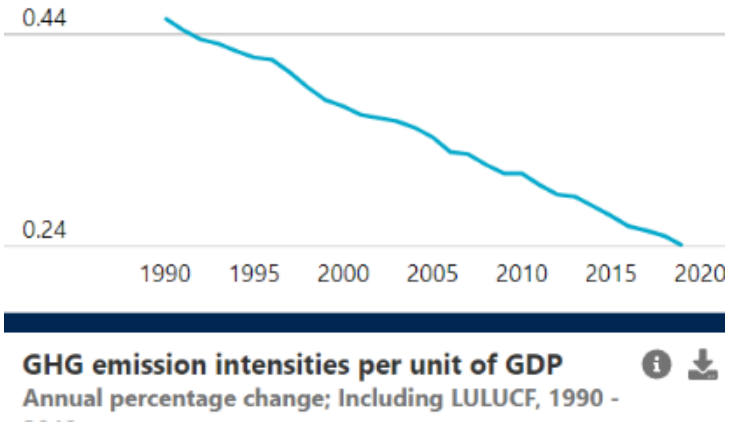


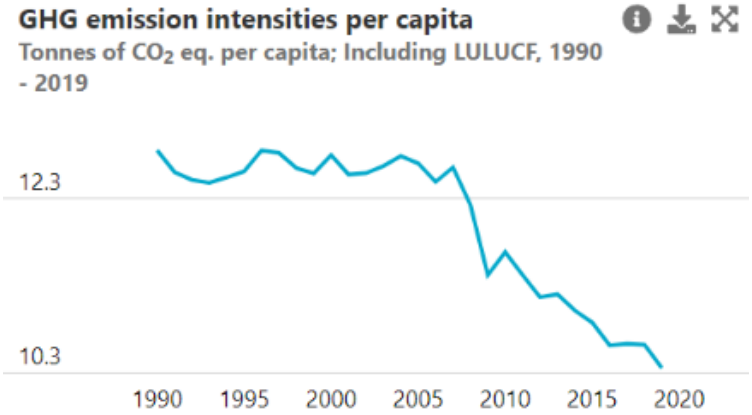
Global Use of Fossil Fuels is nowhere near decelerating...

Source: BP Energy Review 2020



GHG emissions are going down but nowhere near enough

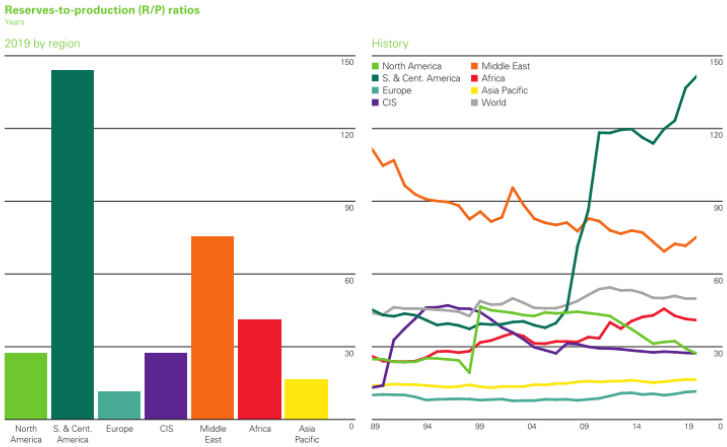




Source: OECD IPAC Dashboard

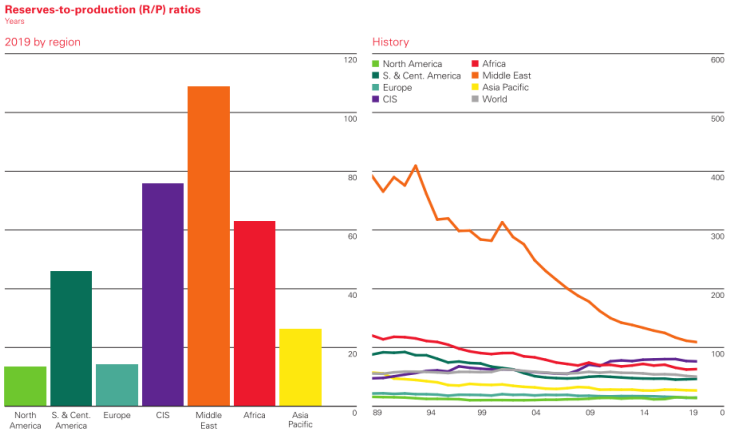
Stranded Assets Unavoidable...

Oil



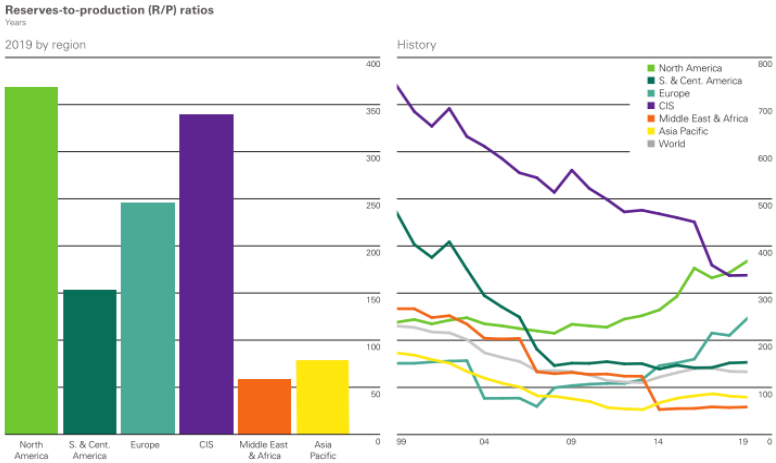
Global proved oil reserves were 1734 billion barrels at the end of 2019, down 2 billion barrels versus 2018. The global R/P ratio shows that oil reserves in 2019 accounted for 50 years of current production. Regionally, South & Central America has the highest R/P ratio (144 years) while Europe has the lowest (12 years). OPEC holds 70.1% of global reserves. The top countries in terms of reserves are Venezuela (17.5% of global reserves), closely followed by Saudi Arabia (17.2%) and Canada (9.8%).

Natural Gas



World proved gas reserves increased by 1.7 Tcm to 198.8 Tcm in 2019. China (2 Tcm) and Azerbaijan (0.7 Tcm) provided the largest increments, although this was partially offset by a 1.3 Tcm decline in Indonesian reserves. Russia (38 Tcm), Iran (32 Tcm) and Qatar (24.7 Tcm) are the countries with the largest reserves. The current global R/P ratio shows that gas reserves in 2019 accounted for 49.8 years of current production. The Middle East (108.7 years) and CIS (75.8 years) are the regions with the highest R/P ratio.

Coal

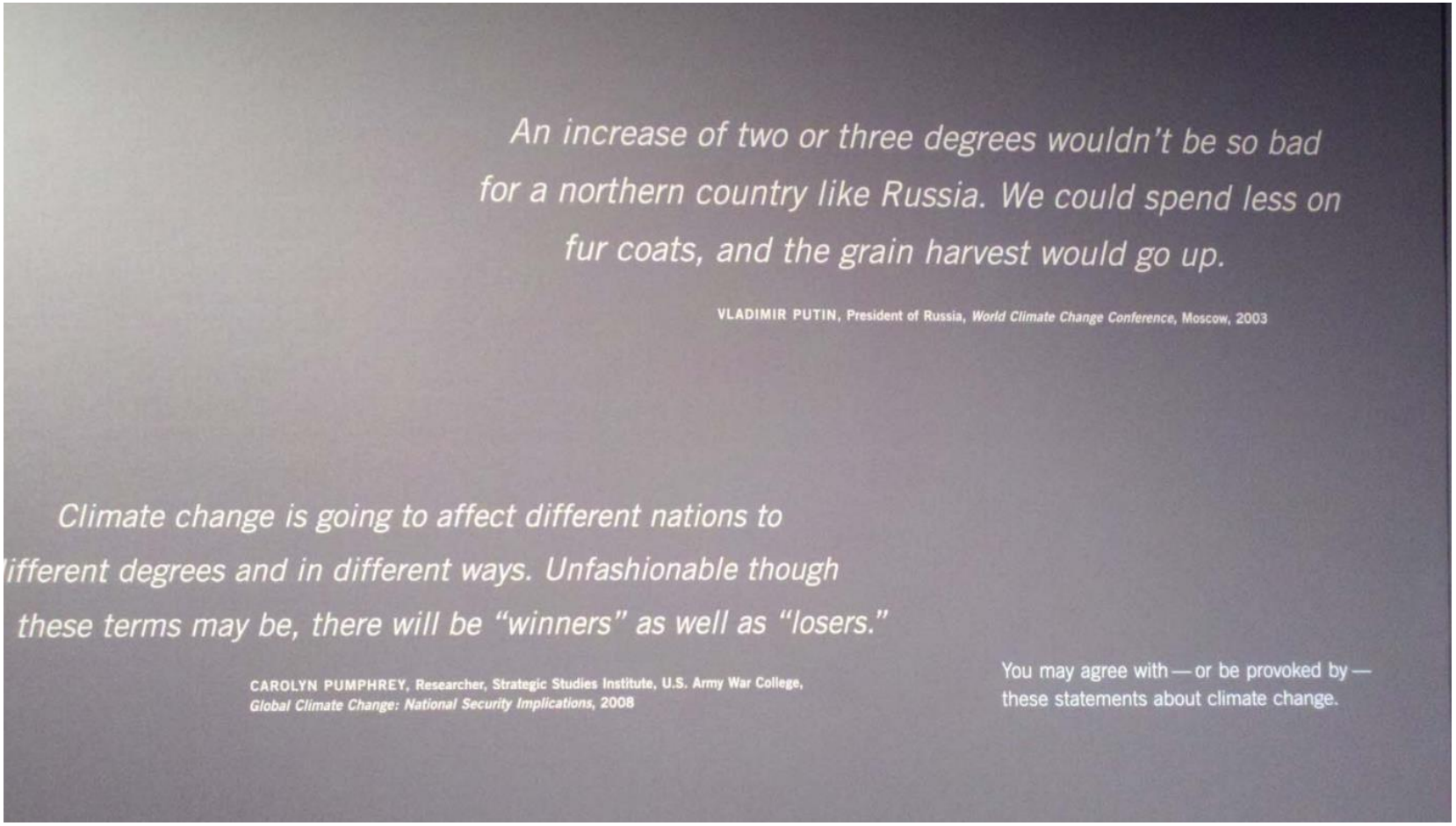


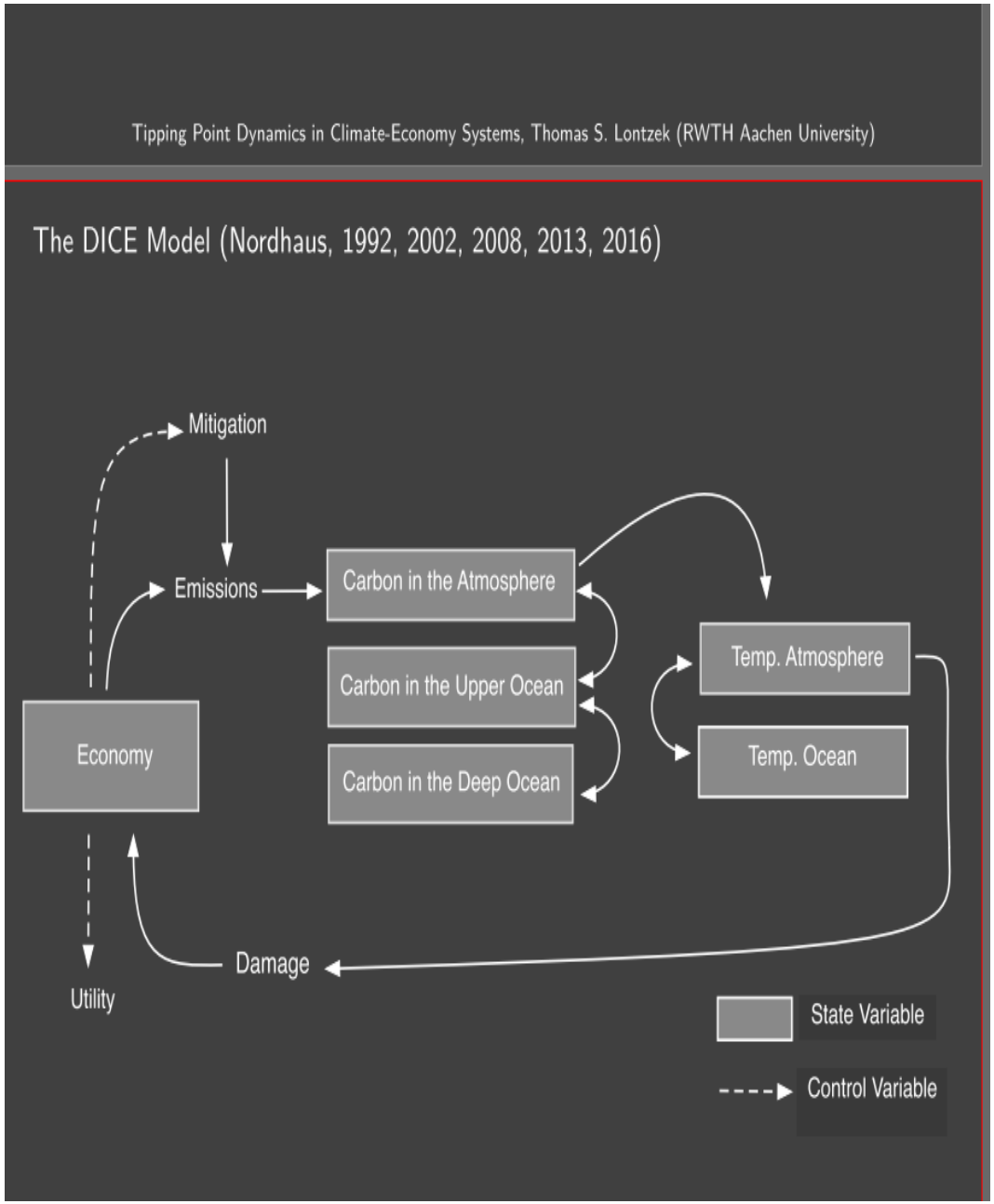
World coal reserves in 2019 stood at 1070 billion tonnes and are heavily concentrated in just a few countries: US (23%), Russia (15%), Australia (14%) and China (13%). Most of the reserves are anthracite and bituminous (70%). The current global R/P ratio shows that coal reserves in 2019 accounted for 132 years of current production with North America (367 years) and CIS (338 years) the regions with the highest ratios.

Global reserves/global output per year

- Oil : 50 years
- Natural gas : 49.8
- Coal : 132

Not everybody takes it seriously....





Source: Lontzek, Tipping Points Dynamics in a Climate-Economy Systems (2019)

The Natural Science Background

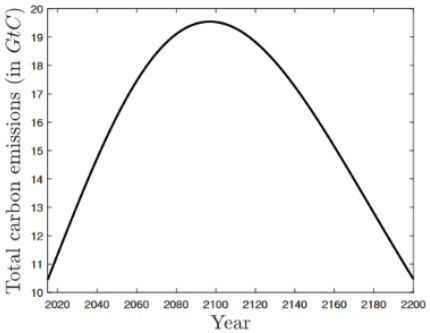
- Carbon cycle: how Carbon enters/exits the atmosphere
  - Emissions spread globally very quickly ("global externality issue")
  - Depreciation atmospheric CO_2 smooth, mostly very slow and partially absent altogether; averages out at a half-life time of several thousand years

- Emissions: 10 GtC/year; increase atmospheric CO_2 ~4,5 GtC/year

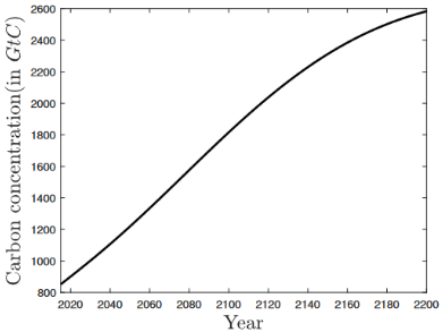
- Embedded CO_2: (a) Oil + Gas 300GtC, (b) Coal > 3000GtC/year
  - => Coal is the biggest problem

- Temperature follows from energy balance:
  - Inflow from the Sun: visible light, not blocked by higher CO_2
  - Outflow from the Earth: infrared light, partially blocked by higher CO_2
  - => Higher atmospheric CO2 concentration => less outflow => higher equilibrium temperature

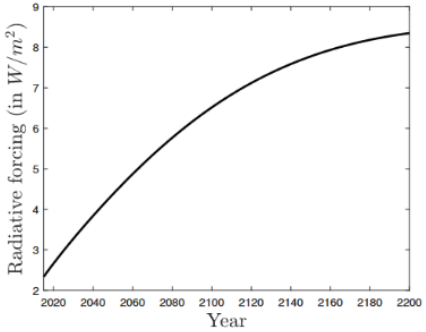
Evolution of climate state variables



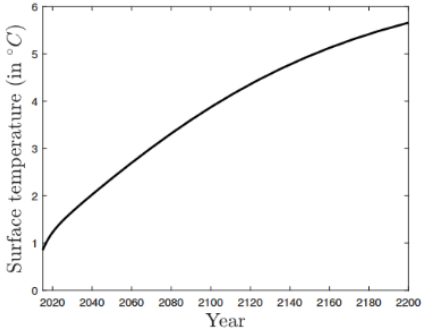
(a) Total emissions



(b) Carbon concentration



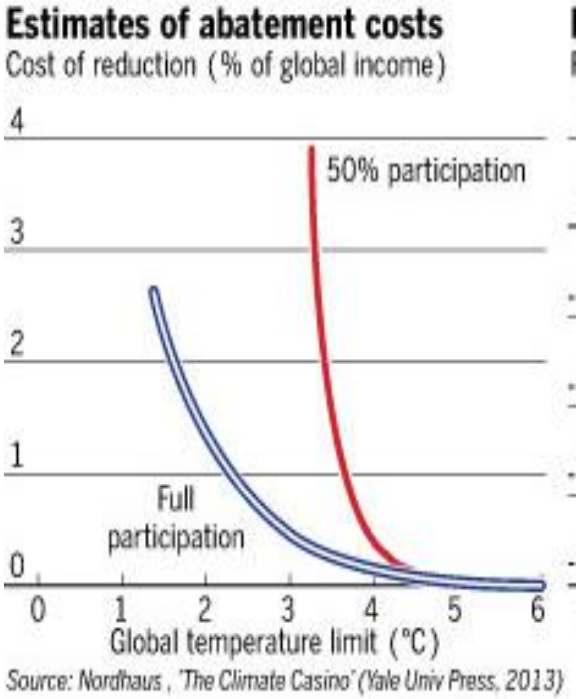
(c) Radiative forcing

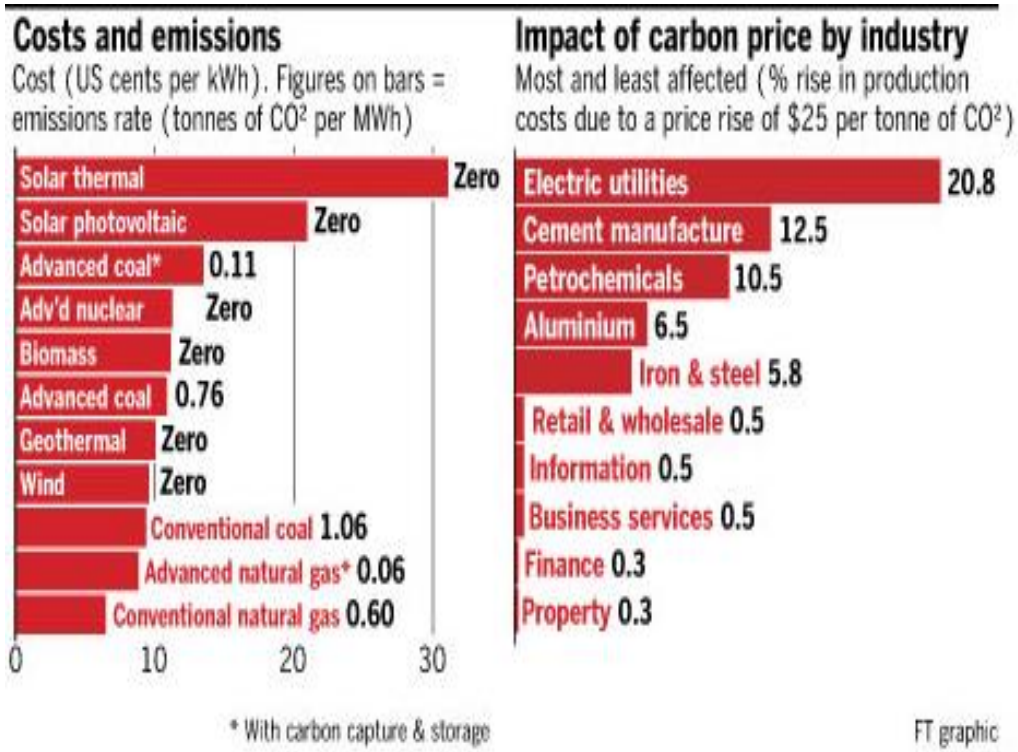


(d) Surface temperature

Source: Olijslagers & van Wijnbergen (2019)

Coöperation pays but inefficient policy is expensive





Intervention: subsidies, ERT or carbon taxes

- Advantage carbon taxes:
  - polluter pays, revenues can be recycled
  - neutral *vis a vis* alternative clean energy options
  - Predictable time path
- Disadvantages carbon taxes
  - requires international roll out
  - effect on emissions uncertain

- Advantages Emission Rights Trading (ERT)
  - Same as Carbon taxes, except prices maybe volatile BUT impact on carbon certain
- Disadvantages ERT
    - price volatility may hamper investment, but will derivative markets with sufficient maturity develop to allow hedging?
    - huge overhang unused CO2 emission rights
    - International roll out/tradability problematic (Glasgow "Article 6")

- China/India/Poland/… bring up legacy problems => UN's Legacy Fund

Are there technological limitations?

- Can Clean Fuels (CFs) be scaled up sufficiently?
  - not enough peak power (solar)
  - electricity infrastructure not ready for CFs like wind, solar
    - Mismatches between *location* sources and uses (windparks on sea, big users on land)
    - CFs introduce unmanageable volatility, conflicting with balancing needs
  - necessary infrastructure lacking (smart grid, large scale battery/hydrogen-based storage)

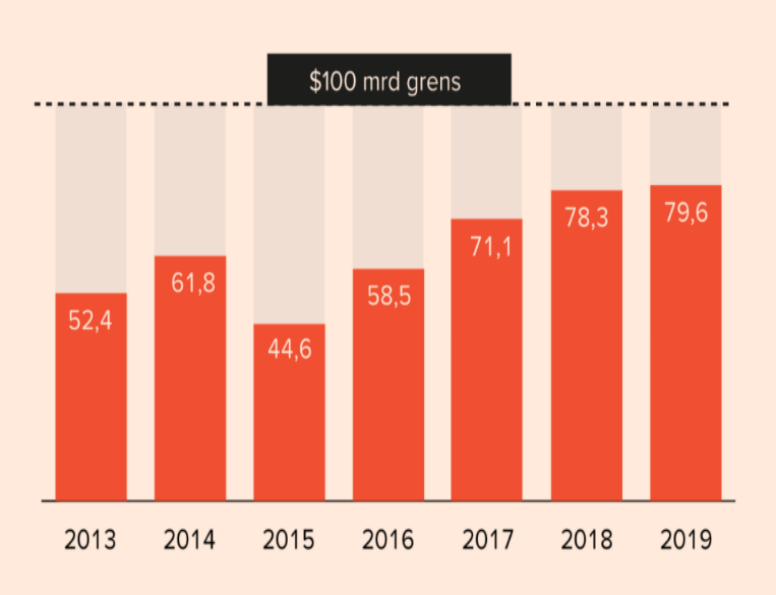
- Sometimes they trigger their own environmental problems
  - electric cars while we still use coal fired generation plants
  - waste problems nuclear energy
  - Bio fuels ("biomassa") actually increase CO_2 emissions…

- Nuclear needs some 50 years before it can be scaled up (time to build)
  - but new technology (modular molted salt reactors using Thorium?) promises to:
    - reduce the waste problem, end products have much shorter half life
    - help in annihilating long half-life waste of older technology reactors

And can we do all this while maintaining international equity?

- Legacy issue was addressed by establishing a legacy fund, the UN Green Climate Fund GCF (part of UNFCC), to be funded by the West and to be disbursed to finance adaptation/mitigation by poor countries

- But *GCF* is hugely underfunded
  - Target: $100 billion annual funding
  - US refuses to contribute fair share
  - Private Sector involvement controversial and unlikely to succeed anyhow
  - Additionality with respect to regular aid flows? (Dutch contribution from the regular foreign aid budget…)



- Will Glasgow rescue the GFC?

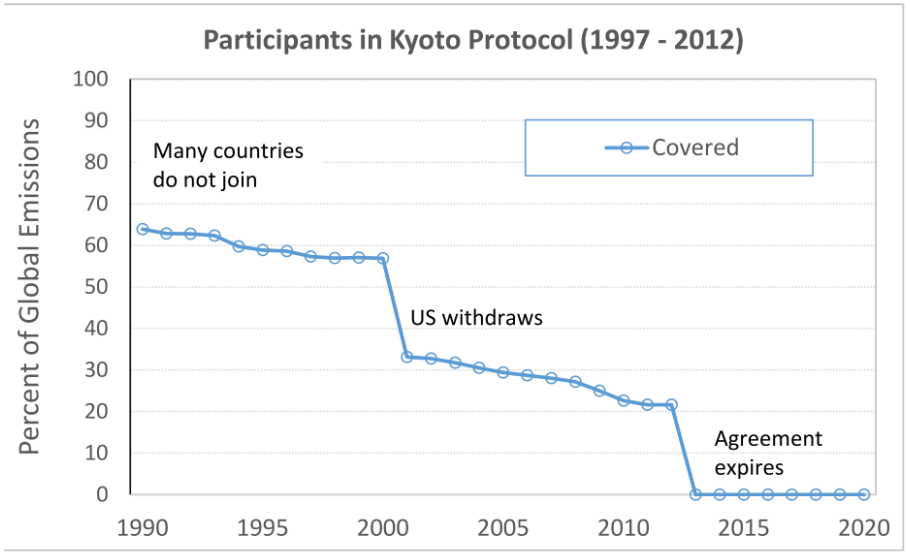
Towards International Coöperation-I: Rio (1994) and Kyoto (1997)

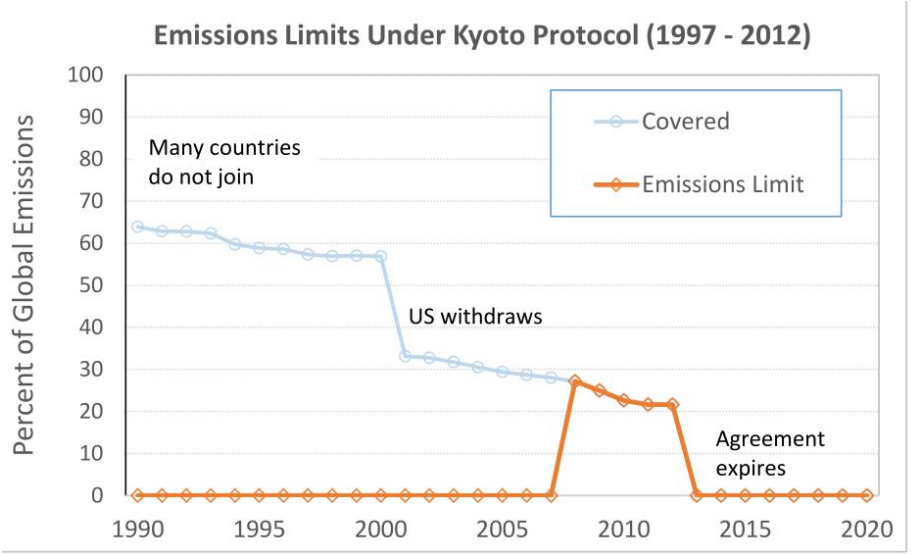
- Rio 1992: United Nations Framework on Climate Change (UNFCC) set up; establishes IPCC process

- Kyoto protocol (1997) attempts to establish an international architecture to harmonize policies of different countries
  - Participants committeed to reduce their emissions to 5% below 1990 levels
  - Established reporting requirements
  - Proposed an international cap-and-trade system

- Early problems:
  - Eastern Europe collapse in 1990/1991 made Kyoto an empty promise for EE & FSU
  - Emissions grew rapidly in non-participants (China!!!)
  - As first designed, Kyoto covered 2/3 of world's emissions
  - In its the final year it covered only 20%....

Towards International Coöperation – II: Kyoto protocol failed to get traction...





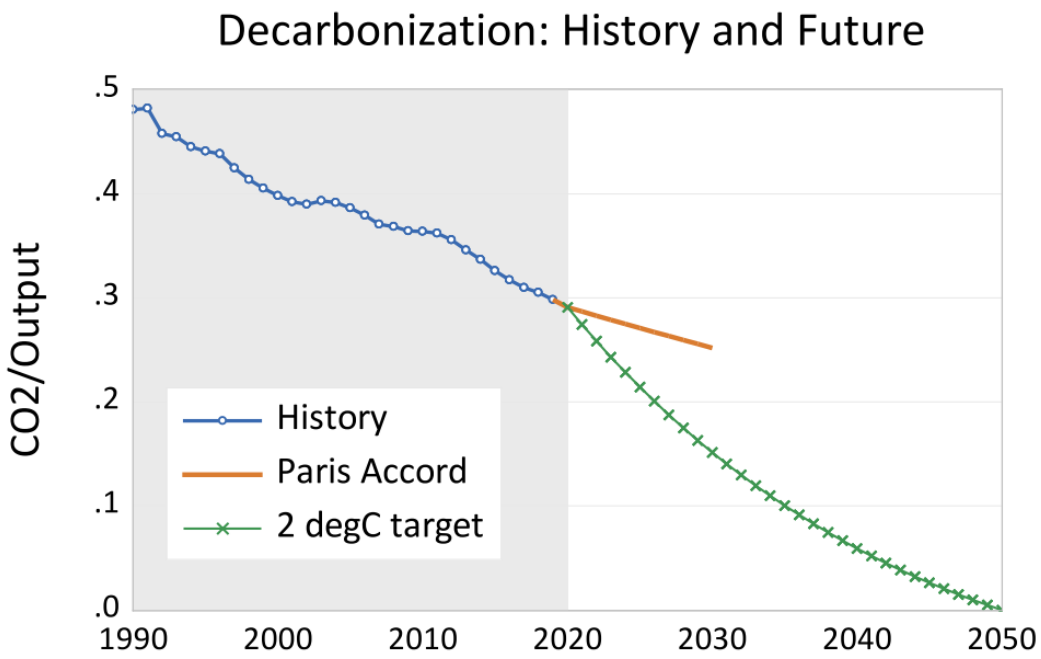
Source: Nordhaus Princeton Lectures, Nobel Prize lecture

Towards International Coöperation-III: Paris 2015

- Voluntary and uncoördinated
- established target of keeping T at "less than 2^0, preferably at $1{,}5^0$"
- hope was that being less ambitious would improve compliance

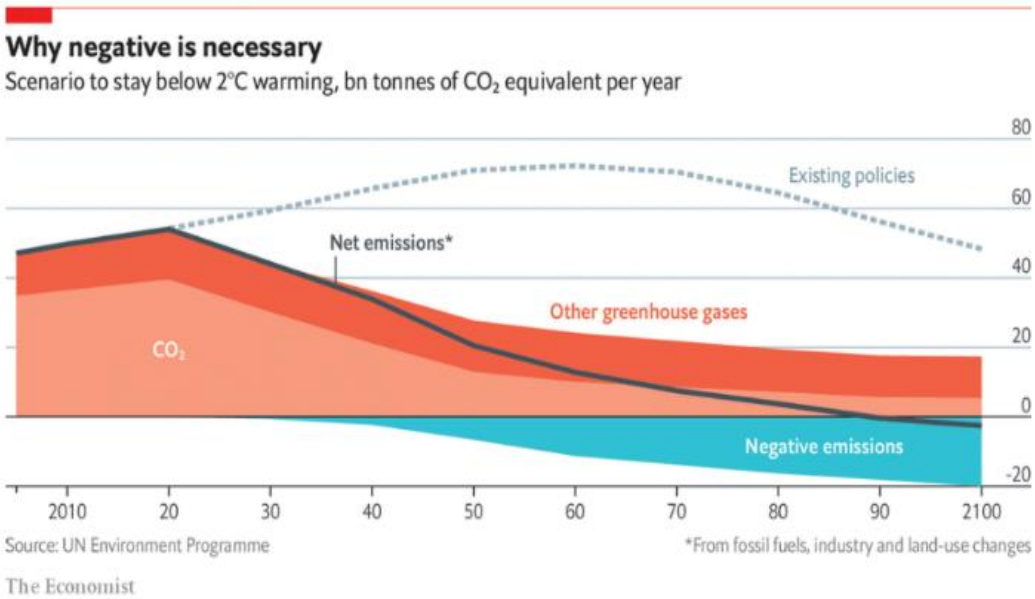
Source: Nordhaus
Princeton Lectures

- China and the US (under Obama) joined
- US under Trump quit the agreement, Trump claimed Climate Change was an anti-US Chinese hoax
- Biden rejoined…



Will leaders in Glasgow move from ambitious targets to actual measures?

- Paris not enough to even keep us below 2^0
- NDCs submitted in the run up to Glasgow may allow 2^0 but certainly not $1{,}5^0$
- CO_2 emissions stay > 0, so negative emissions necessary; CCS a way out?
- Large scale applications popular, but more than an excuse to postpone effective action?
  - Capture from the atmosphere (Climeworks, DAC) but… not scaleable, concentration is too low
  - Capture from powerplant exhaust possible but not implemented anywhere yet
  - Storage in gas fields runs into NIMBY problems on land
  - Storage in Icelandic rock possible but scale?
  - More trees?
- Subgroups are more ambitious
- China-US announcement???

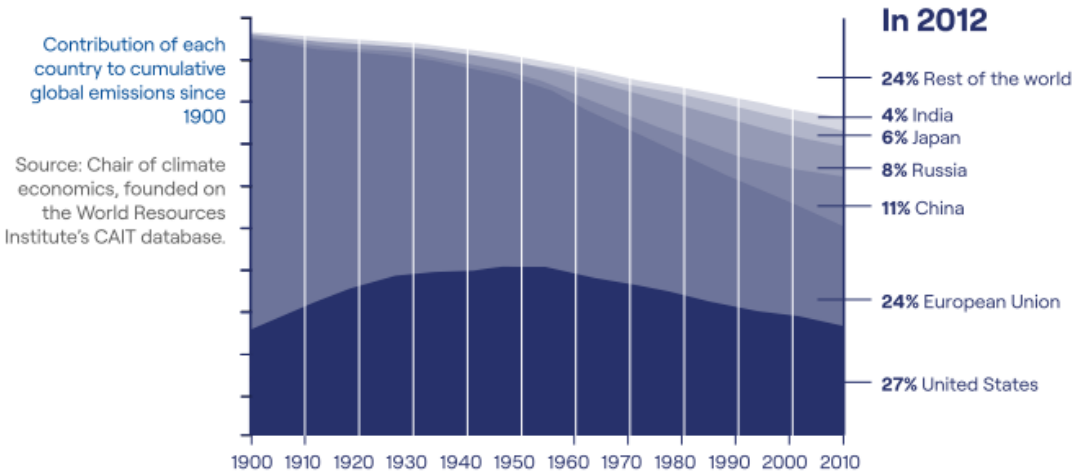


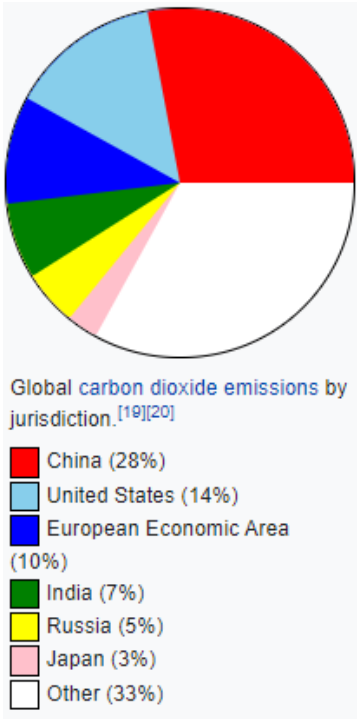
So where do we go next:

- Taking the Low Road:
  - Nordhaus' proposal of tariff clubs: nowhere near a serious proposal
    - Subgroups implement carbon pricing & raise external tariffs against non-participants
    - Retaliation, global efficiency losses, abuse for mercantilistic purposes
    - Would destroy WTO
    - Would result in a war of the rich against the poor

- Taking the high Road:
  - Tirole (2021) proposal: form a club of the 5 main polluters
    - carbon leakage, impact competitiveness
    - Timmermans' Green Deal: use CBAMs (Carbon Border Adjustment Mechanism)

Tirole Proposal: Staged approach





1. Climate Coalition of 5 or 6 largest polluters
2. Then work towards global CO_2 price
3. European Climate-ARPA for LARGE increase in green tech subsidies
4. This should induce others to join
5. Establish global enforcement mechanism

Wrapping Up

- Carbon pricing one way or another necessary
  - Fossil fuel reserves are way too high => stranded asset problem is unavoidable
  - Much investment, research in clean energy still necessary

- International agreements doubtlessly necessary
  - until now resulted in failure (Kyoto); Glasgow going on right now
  - cautious progress in Paris & Glasgow?
  - Tirole proposal (coalition of the big polluters take the lead) more likely: cf recent anouncement Biden-Xi, EU with Timmermans' Green Deal

- Population at large is starting to realize this is serious…..

- Dutch Government is all talk, no plans or vision
  - new cabinet minister rambles about becoming a climate leader but does not seem to have any idea what is necessary for that to happen