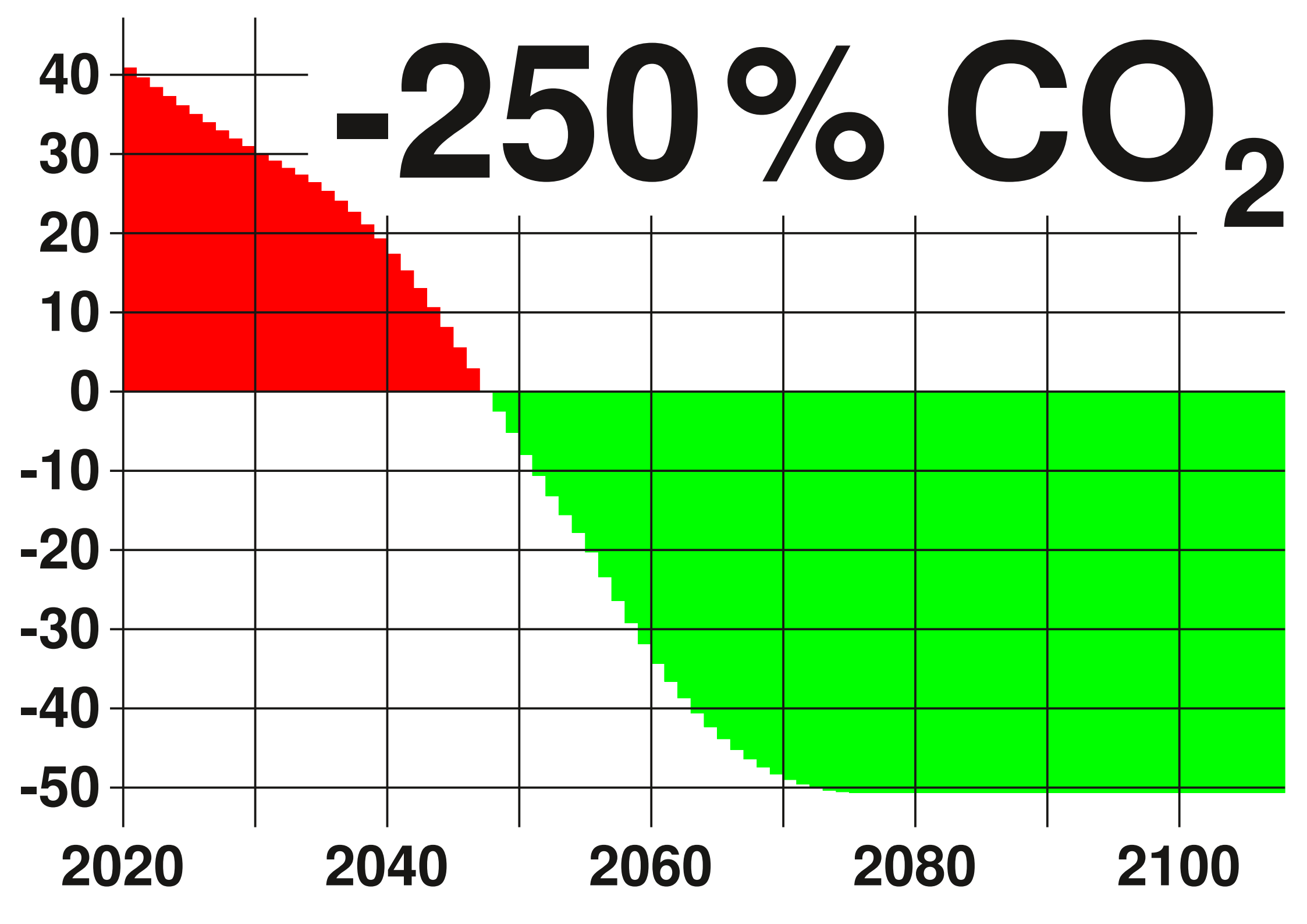

-250% CO2
40
30
20
10
0
-10
-20
-30
-40
-50
2020
2040
2060
2080
2100

CO2 Carbon dioxide reduction

It is not enough to reduce the increase of CO2 in the atmosphere. It is necessary to reduce the CO2 contained in the atmosphere to the amount in 1900.

With 20.-EUR, it's not possible to take 1 ton CO2 out of the atmosphere

Thr current price for CO2 emissions is by magnitudes to low. The prices are for a small reduction of the emissions, but not for a recuction of the CO2 quantity in the atmosphere.

1 ha forest takes out 10 t CO2 per year

But where to plant such a forest? Where just right now is no wood, where is no agriculture for food. When there remain only such dry areas, that 500mm irrigation per year is necessary, the reduction of 1t CO2 would cost around 400.-EUR

Let's view each kg CO2 emission as a credit. A credit which have to be paid back with an first time estimated range of 0.40 to 0,70 EUR.

It requires more exact studies, what areas are suitable at what irrigation costs and how much are the real costs. But here a first overview:

Cost per ton of CO2	400.--EUR	500.--EUR	600.--EUR	700.--EUR
1 litre gasoline 2366g CO2	0.95 EUR	1.18 EUR	1.42 EUR	1.66 EUR
1 liter diesel 2660g CO2	1.06 EUR	1.33 EUR	1.60 EUR	1.86 EUR
1 kg natural gas 2220g CO2	0.89 EUR	1.10 EUR	1.33 EUR	1.55 EUR
1 kWh electricity from lignite 1100g CO2	0.44 EUR	0.55 EUR	0.66 EUR	0.77 EUR
1 kWh electricity from coal 900g CO2	0.36 EUR	0.45 EUR	0.54 EUR	0.63 EUR
1 kWh German electricity mxi 514g CO2	0.20 EUR	0.26 EUR	0.31 EUR	0.36 EUR
1 kWh CC power plant 365g CO2	0.15 EUR	0.18 EUR	0.22 EUR	0.26 EUR

CO2 carbon dioxid interest

Who takes a credit has to pay back because of the interest much more. Also at the greenhouse gases, interest exists, the unfreezing permafrost grounds worsen the situation.

We have to see the fossil greenhouse gas emissions like a credit, which has to be paid back. Not only this, like at every credit, also with interest. Becaue of the interest, it has to be paid back more than the amount of the credit.

Slow realizing

Atound 1990, the idea was to take each year a little bit less new credits. Nothing else is it, at the reduction of the CO2 emission. Each CO2 emission is like taking a credit. Less CO2 emissions means less borrowing.

The next step is zero emission. Great! There goes somebody to the bank, tells I do not take any new credit, that's it, Good bye!

Revolutionary is the idea to take out all the fossil emission from the atmosphere. For this the first cost estimation from 2008

Pay back with much interest

According to new knowledge, the 350 billion tons CO2 from the fossil age could cause 1000 billion tons CO2 from unfreezing permafrost grounds could be freed. Even with the most radical counter measures, the fossil emission will rise to 400 billion tons. So we have to calculate 250% interest for our CO2 credit.

Instead of 400 to 700 by interest 1400 to 2450 EUR per ton CO2

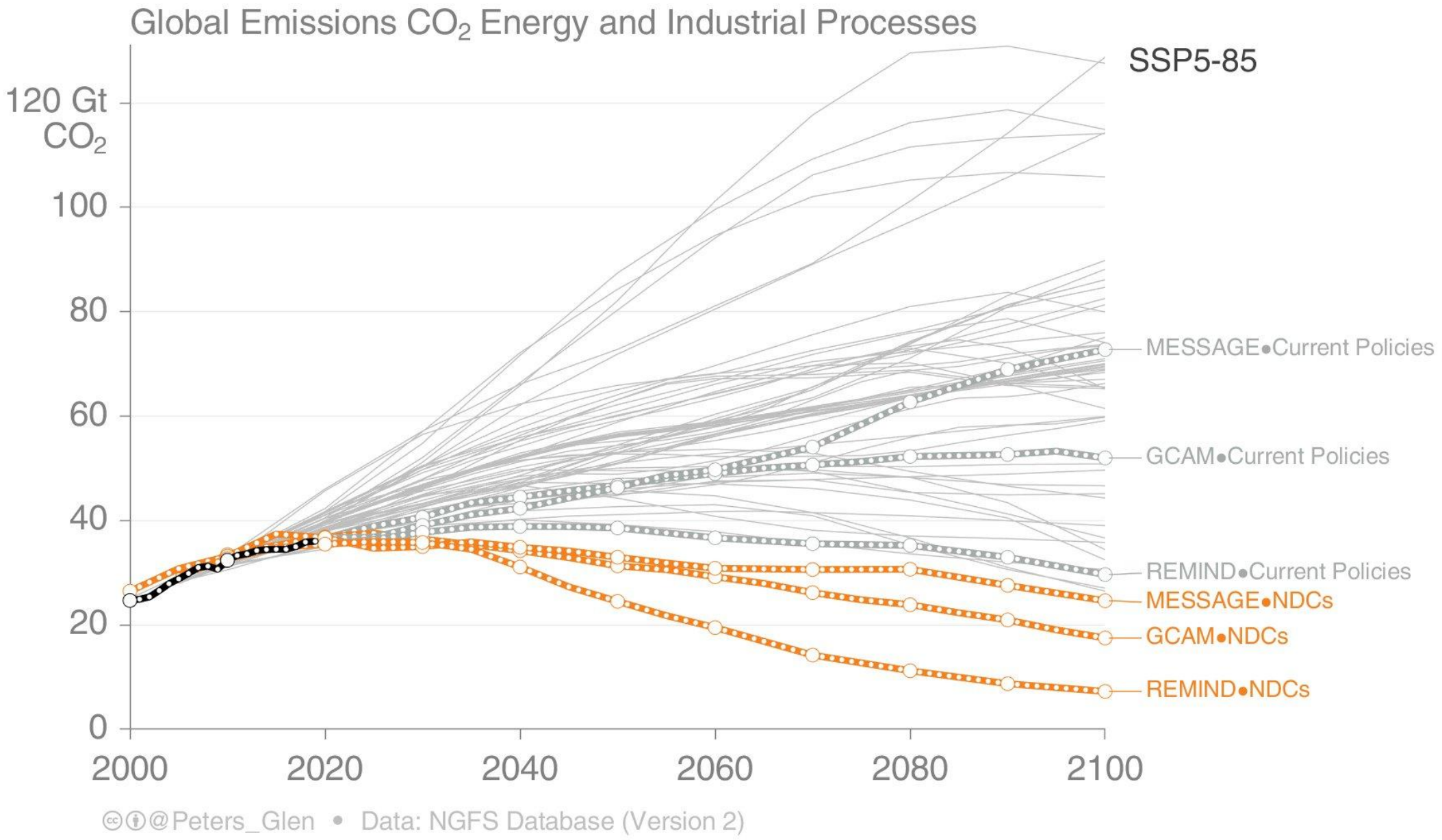
Ridiculous are the current 10.-EUR per ton CO2 certificates. A mockery of the following generations. We have tax laws to economize humans instead of CO2.

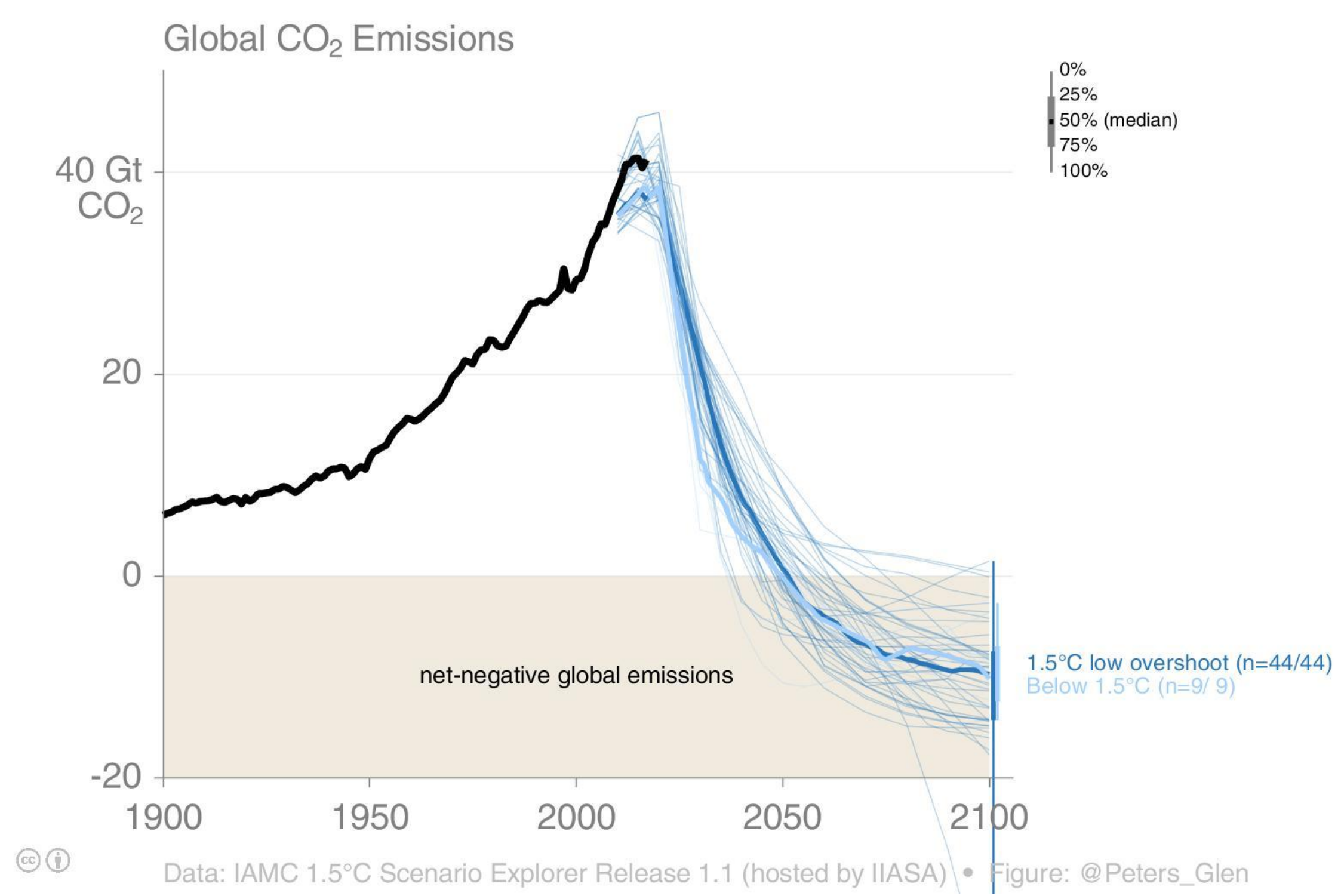
Ready for the climate MCA challenge

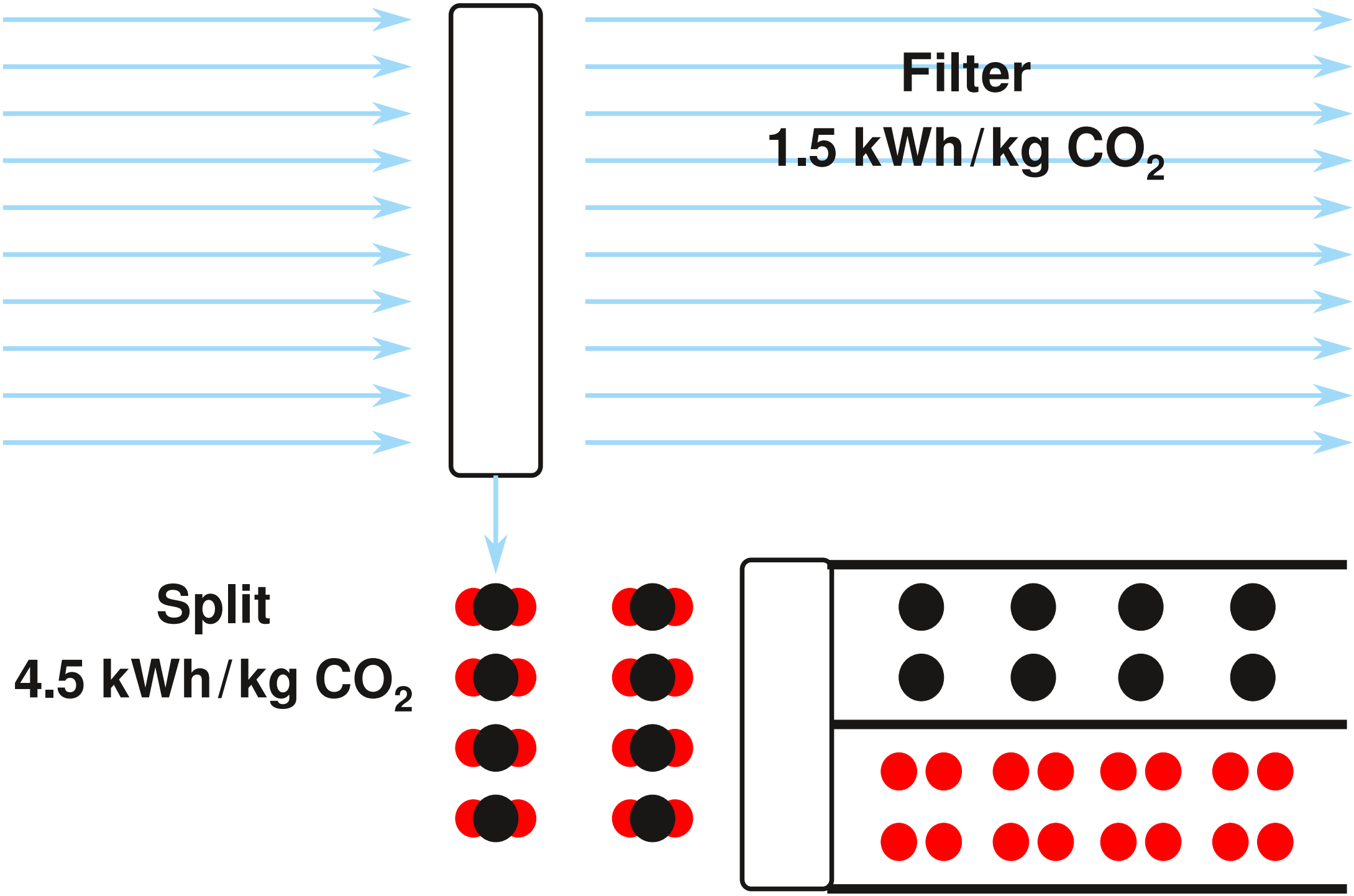
Civilization on planet Earth is not grown-up now; a further growth is necessary from a civilization helpless as a baby to a grown-up civilization able to deal with big challenges.

The first big challenge could be the climate MCA (Maximum Credible Accident). What happens when melting permafrost releases Green House Gases (GHG) in gigantic quantity? All the so called "climate conferences" talk only about GHG from human activities.

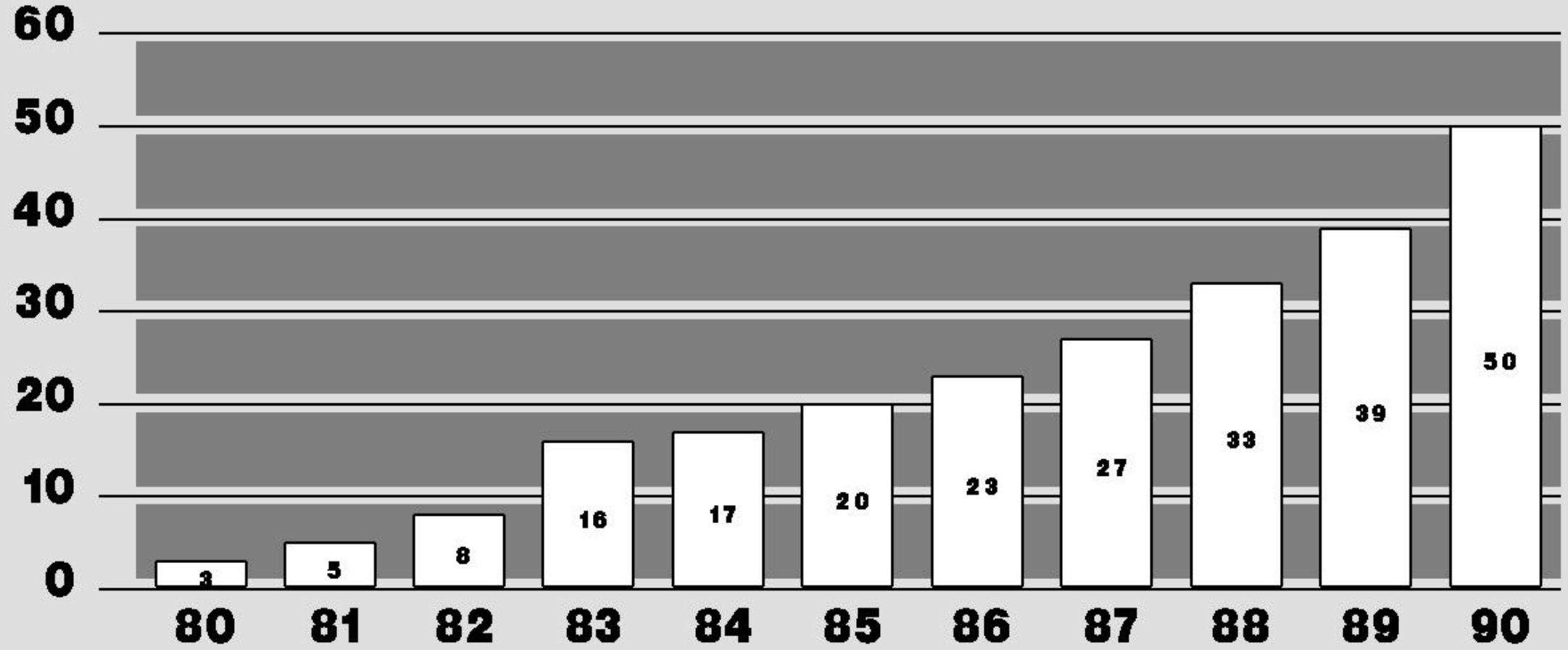
This is an almost non-researched problem. So let's assume a climate MCA makes it necessary to take 30 billion tons CO2 per year out of the atmosphere and to split this into C and O. To take out 30 billion


Global Emissions CO_2 Energy and Industrial Processes
SSP5-85
120 Gt CO_2
100
80
60
40
20
0
2000
2020
2040
2060
2080
2100
MESSAGE•Current Policies
GCAM•Current Policies
REMIND•Current Policies
MESSAGE•NDCs
GCAM•NDCs
REMIND•NDCs
@Peters_Glen • Data: NGFS Database (Version 2)

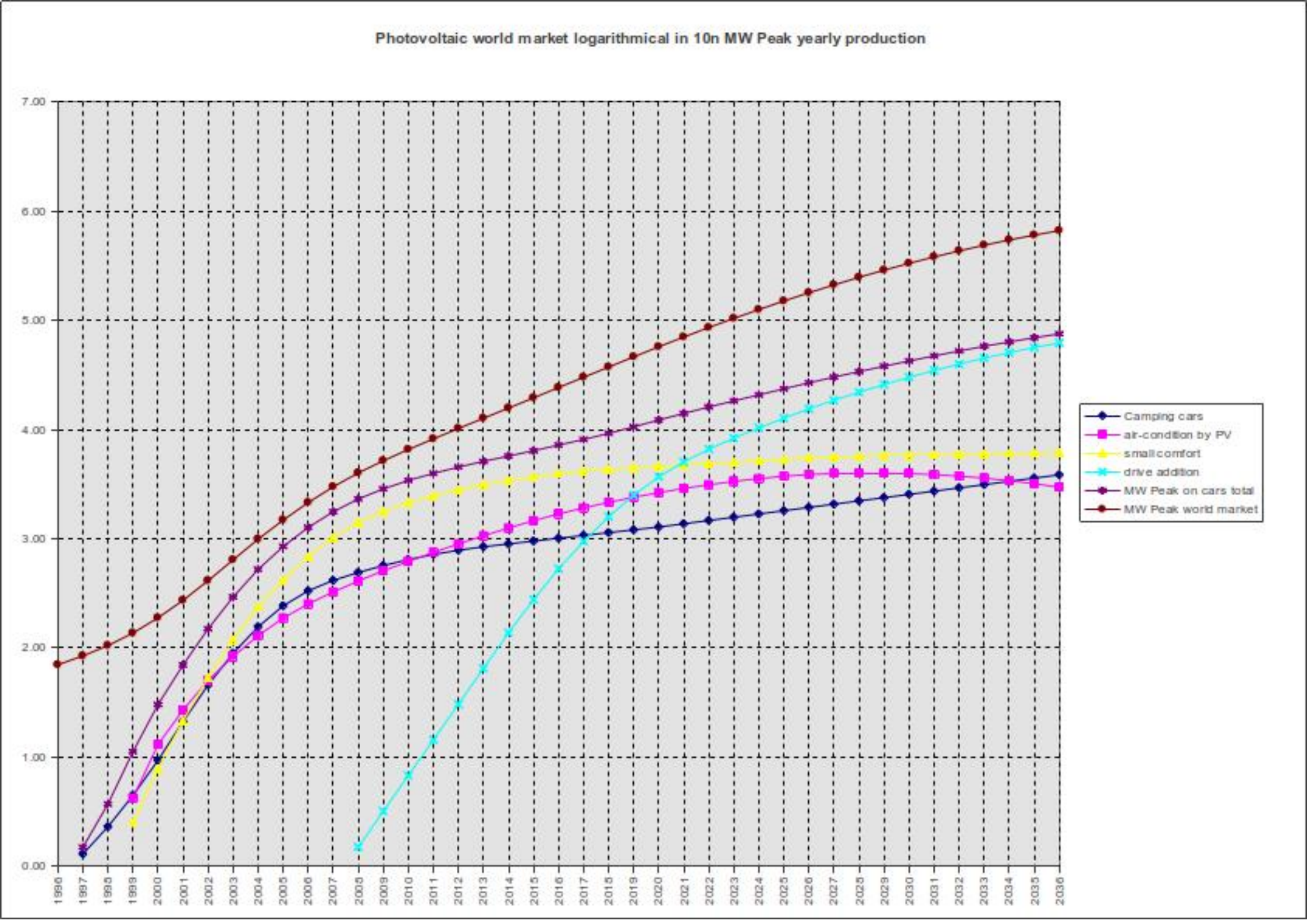

Global CO_2 Emissions
0%
25%
50% (median)
75%
100%
40 Gt CO_2
20
0
-20
net-negative global emissions
1.5°C low overshoot (n=44/44)
Below 1.5°C (n=9/ 9)
1900
1950
2000
2050
2100
Data: IAMC 1.5°C Scenario Explorer Release 1.1 (hosted by IIASA) • Figure: @Peters_Glen

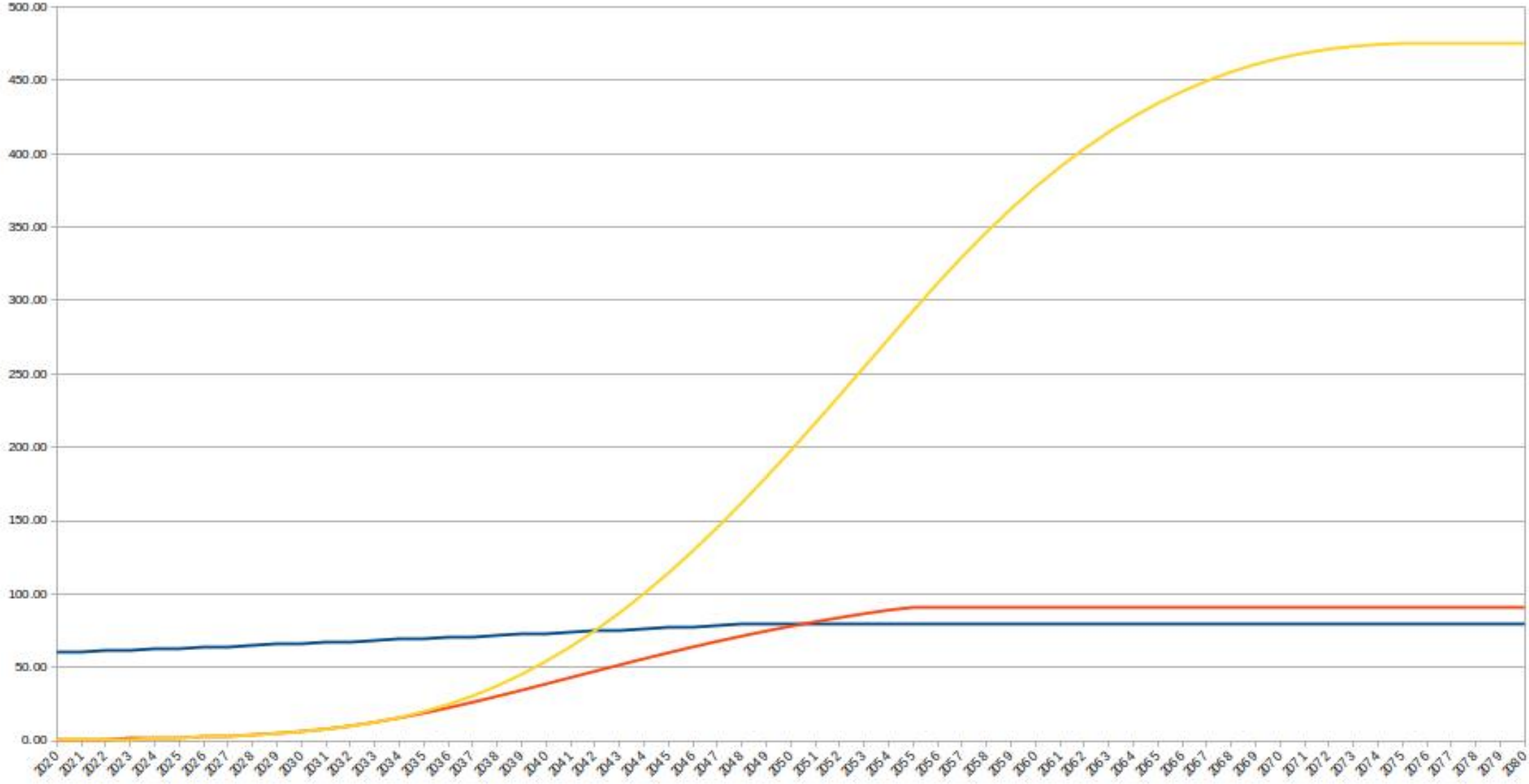

Filter
1.5 kWh/kg CO_2
Split
4.5 kWh/kg CO_2

Photovoltaik - Marktentwicklung (weltweit)



Quelle: Dr. Räuber

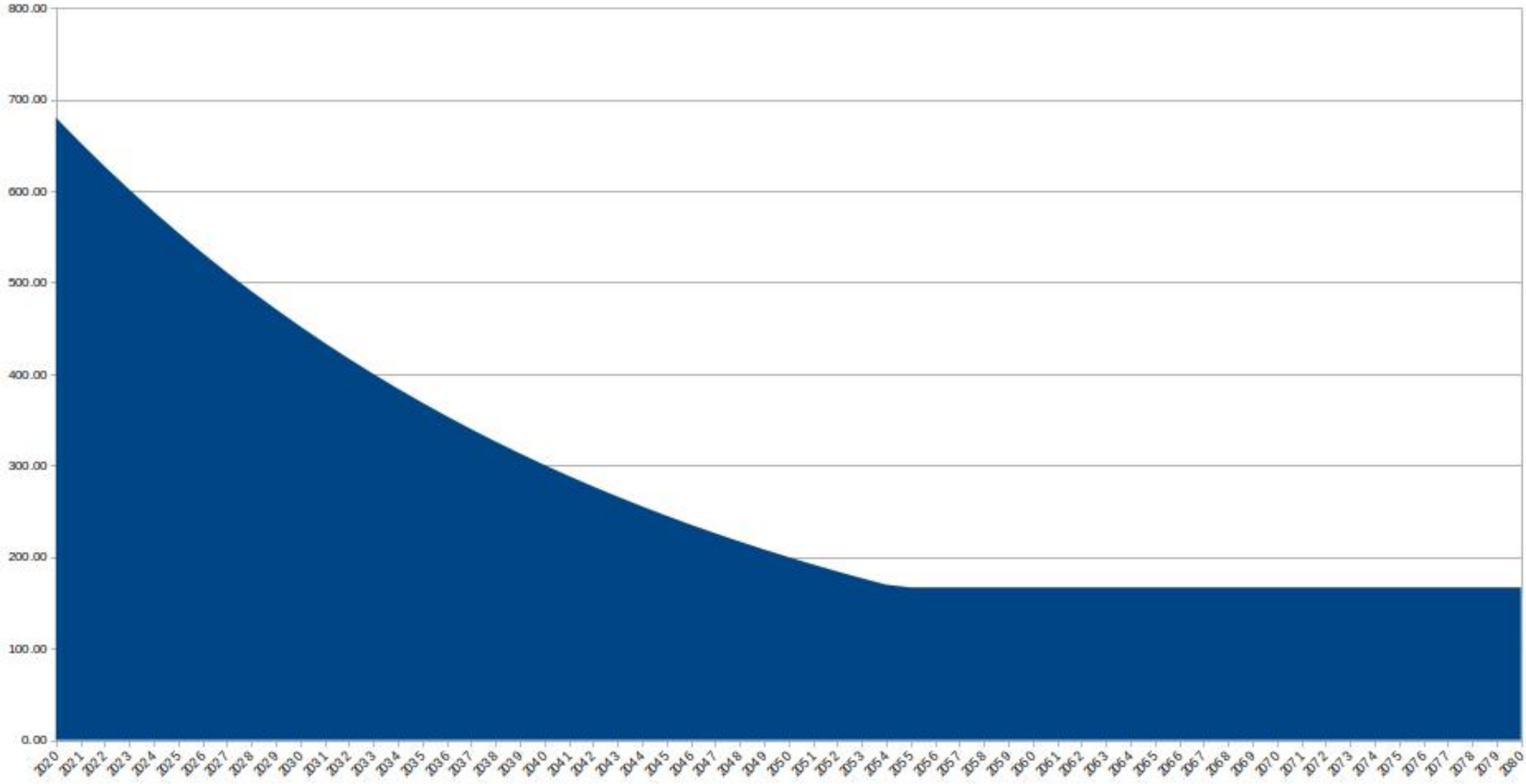

Photovoltaic world market logarithmical in 10n MW Peak yearly production
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
Camping cars
air-condition by PV
small comfort
drive addition
MW Peak on cars total
MW Peak world market



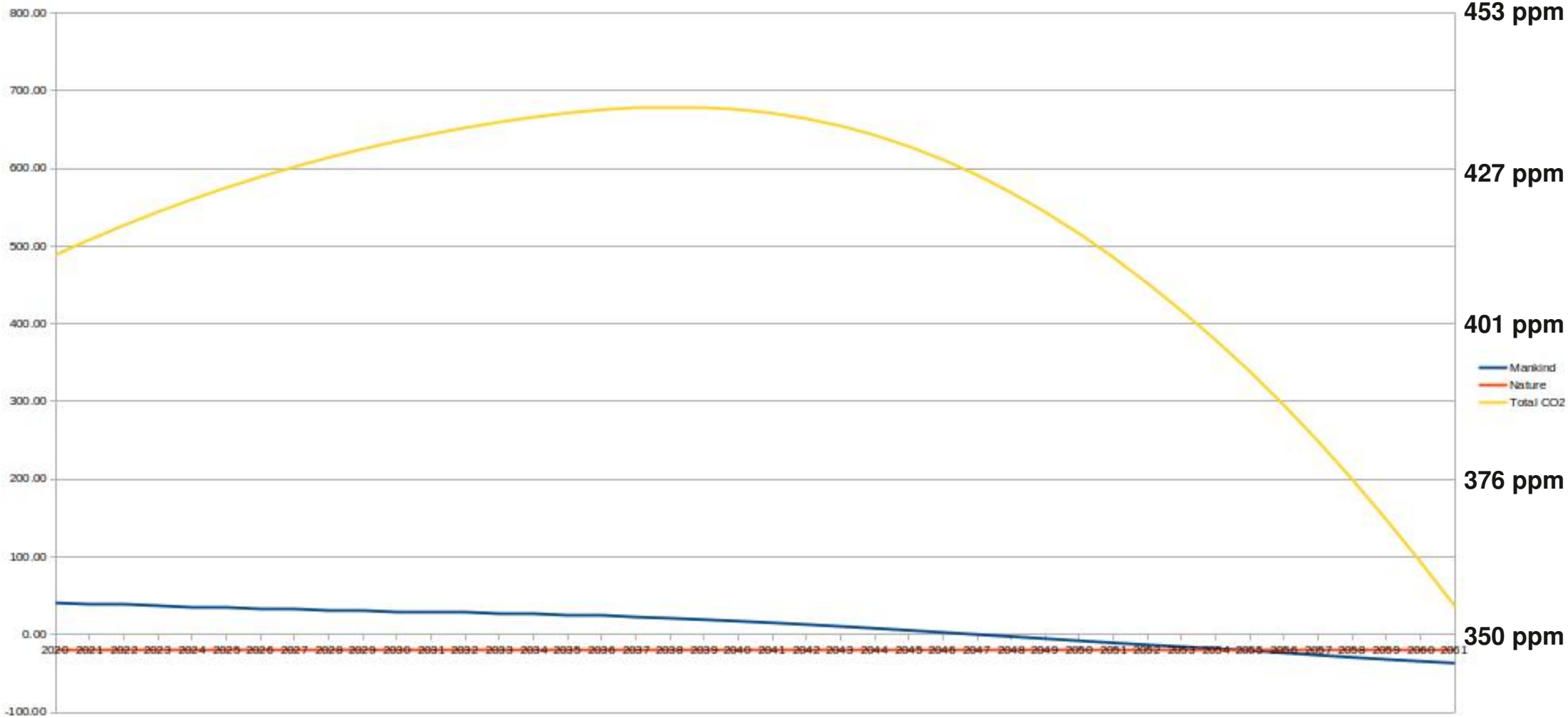
PWh/a for civilization without

PWh/a Production of photovoltaics, batteries, DAC CO2 and splitting plants

Electricity production through photovoltaics



CO2 reduction per kWh solar electricity

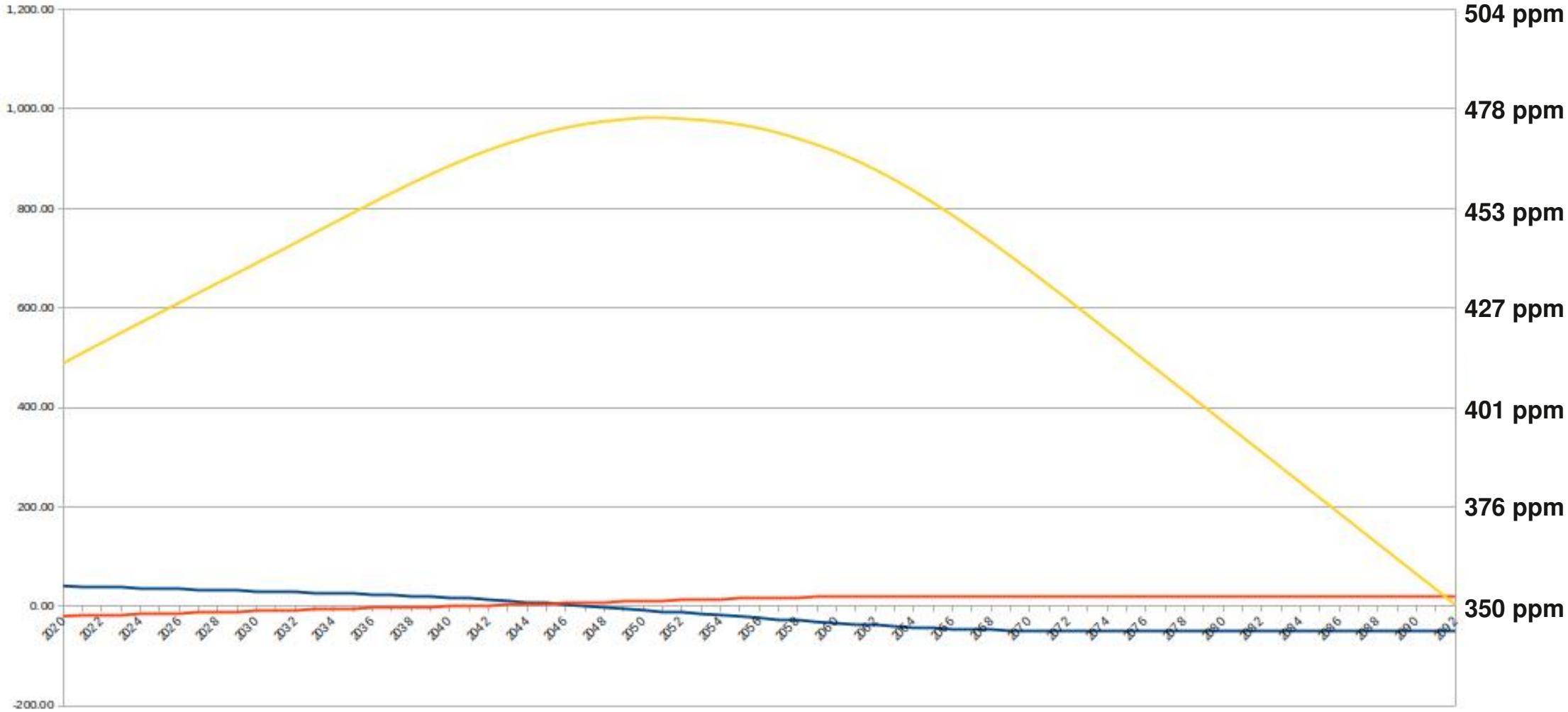


Naïve scenario until 2061: nature continues to absorb 20 Gt CO2 per year

Gt CO2 emission of civilization

Gt CO2 emission of nature

Gt CO2 more in the atmosphere than at 350 ppm

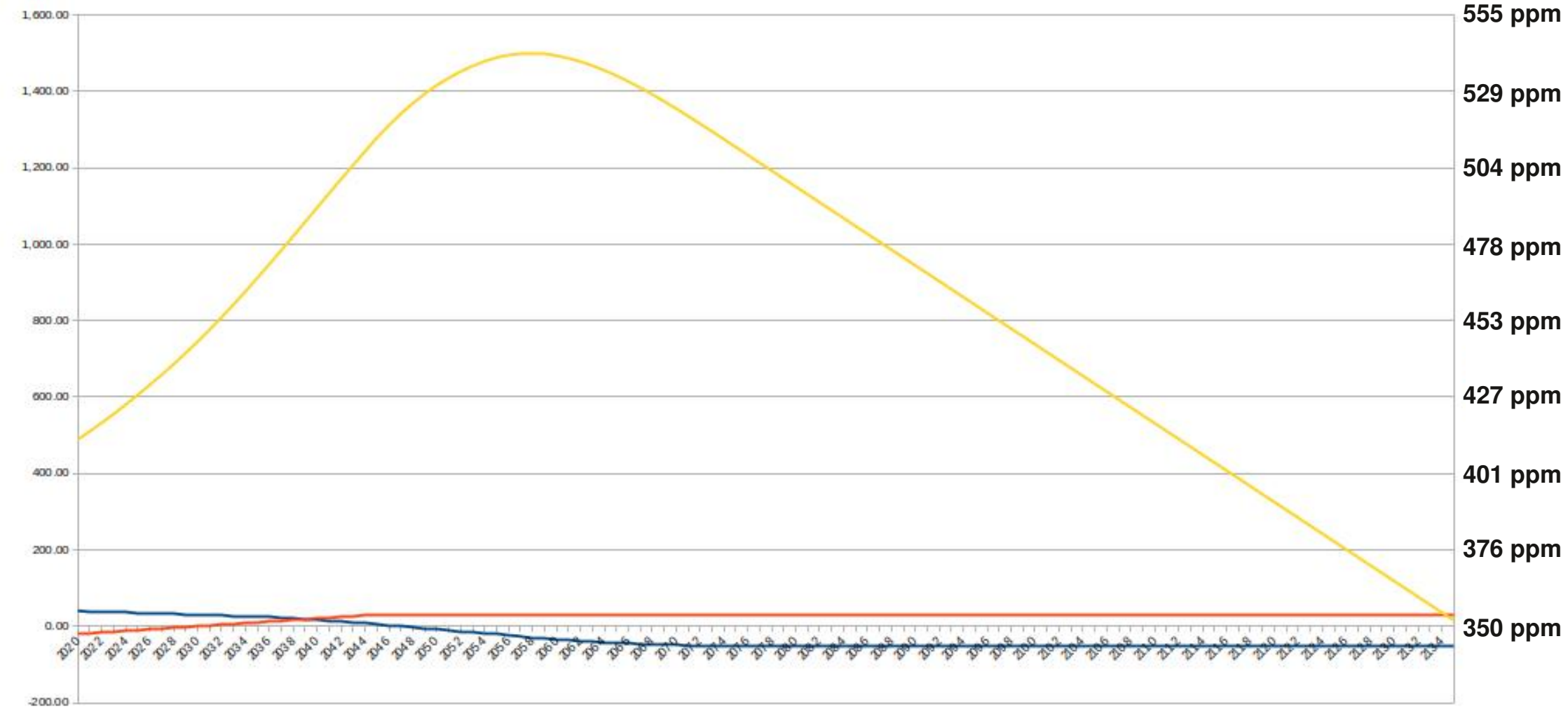


Change from -20 Gt to +20 Gt CO2 emission of nature with 1 Gt/a until 2092

Gt CO2 emission of civilization

Gt CO2 emission of nature

Gt CO2 more in the atmosphere than at 350 ppm

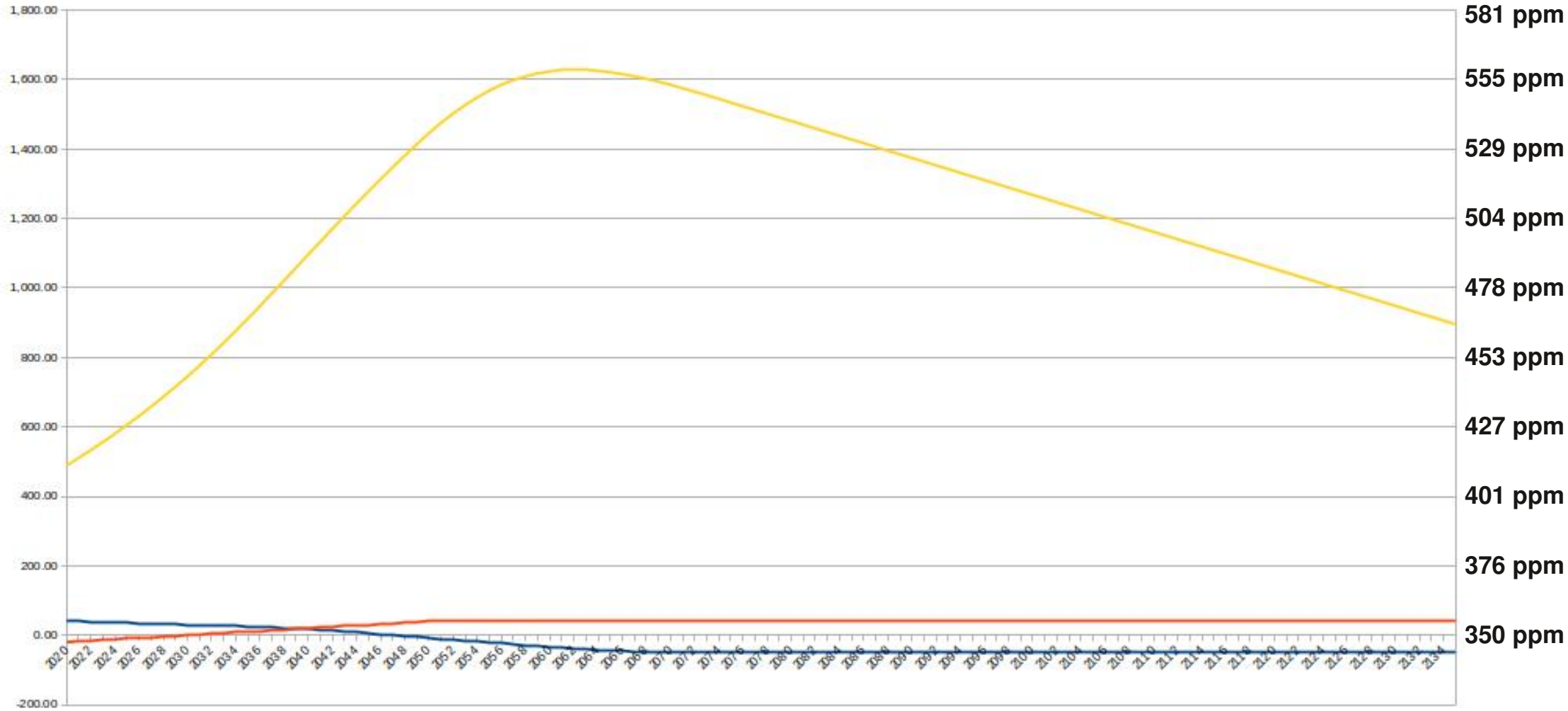


Change from -20 Gt to +30 Gt CO2 emission of nature with 2 Gt/a until 2135

Gt CO2 emission of civilization

Gt CO2 emission of nature

Gt CO2 more in the atmosphere than at 350 ppm



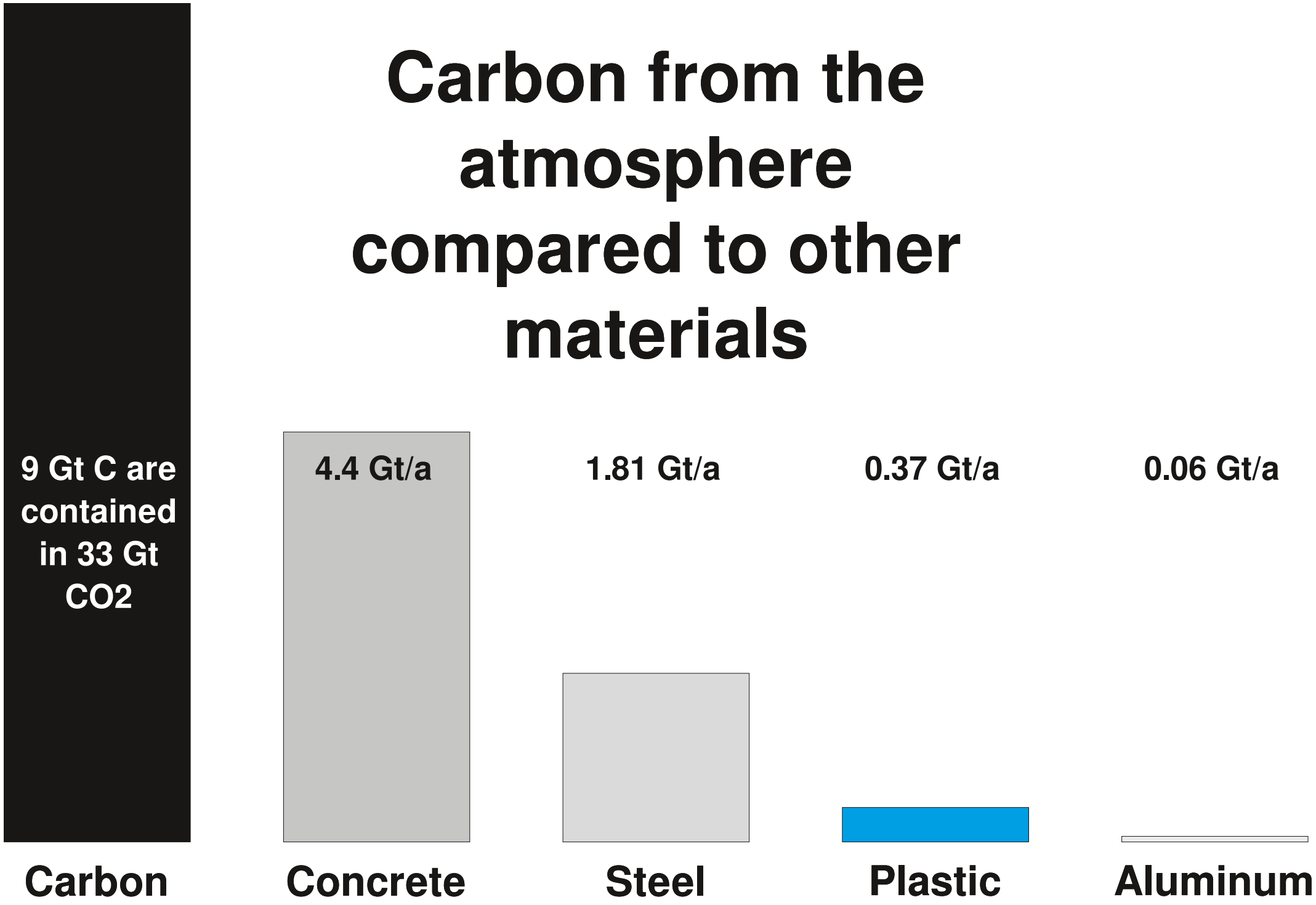
Change from -20 Gt to +40 Gt CO2 emission of nature with 2 Gt/a until 2135

Gt CO2 emission of civilization

Gt CO2 emission of nature

Gt CO2 more in the atmosphere than at 350 ppm

Carbon from the atmosphere compared to other materials



Berlin InnoTrans September 2018

50 Gt CO_2/y for Power to Carbon

300 PWh/year

5 Gt CO_2/y for Power to Liquid

30 PWh/year

40 Gt CO_2/y for plants

60 PWh/year

50 Gt CO_2/y for Power to Carbon

300 PWh/year

5 Gt CO_2/y for Power to Liquid

30 PWh/year

40 Gt CO_2/y for plants

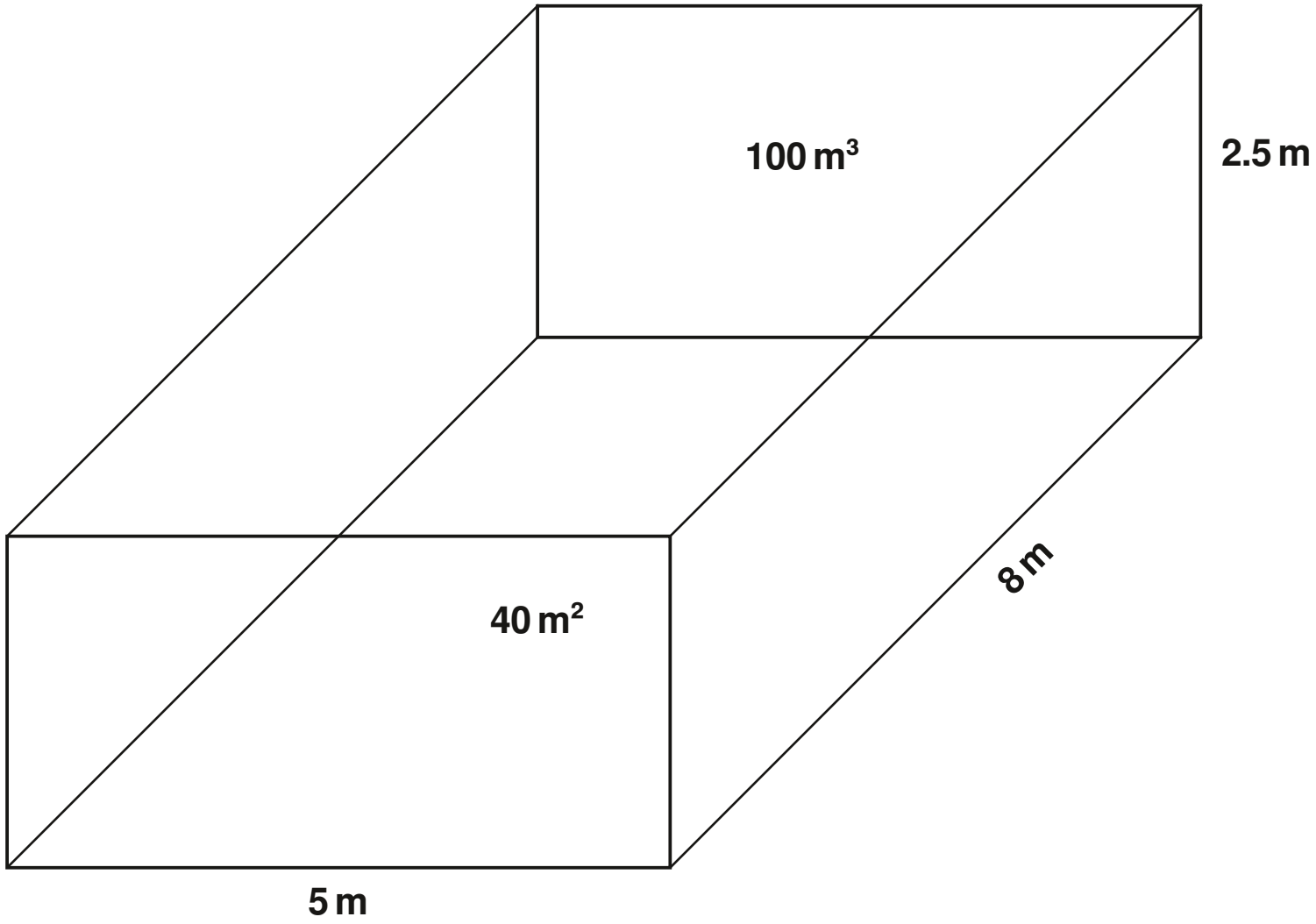
60 PWh/year

?!?


Champion

Example 100 m^3 glass house

This 100 m^3 greenhouse contains 120 kg of air, but with 416 ppm CO_2 this is only 76 g CO_2. However, an annual harvest of 3 tons of vegetables in a sunny country like Jordan requires 5 tons of CO_2. The problems this creates and why CO_2 DAC from ClimeWorks could be a solution.

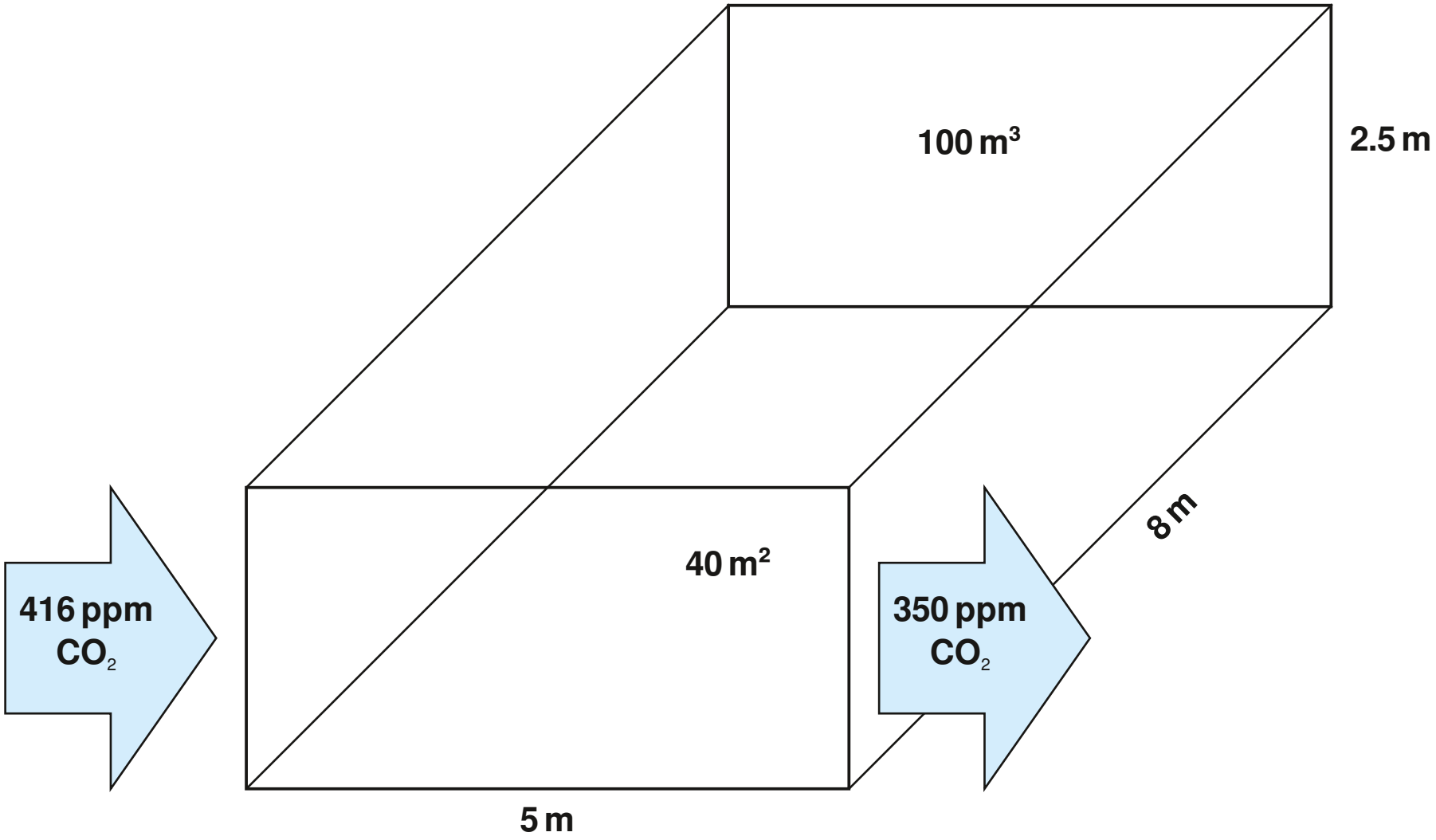


Bring 5 t CO2 into the greenhouse

66 thousand times the volume of the greenhouse contains the amount of CO_2 required to produce 3 tons of biomass. When air passes through the greenhouse, the plants take CO_2 from the air. The lower the CO_2 content, the more inefficient this process becomes.

If the CO_2 content of the air when passing through the greenhouse is to be reduced to only 350 ppm, then 416 thousand air changes per year would already be necessary.

That is one hundred times more air changes than is usual for living spaces.



Water loss during air exchange

At 35° a cubic meter of air contains 7.92 g of water at 20% humidity, but 27.72 g of water at 70% humidity. About 2 litres per air exchange.

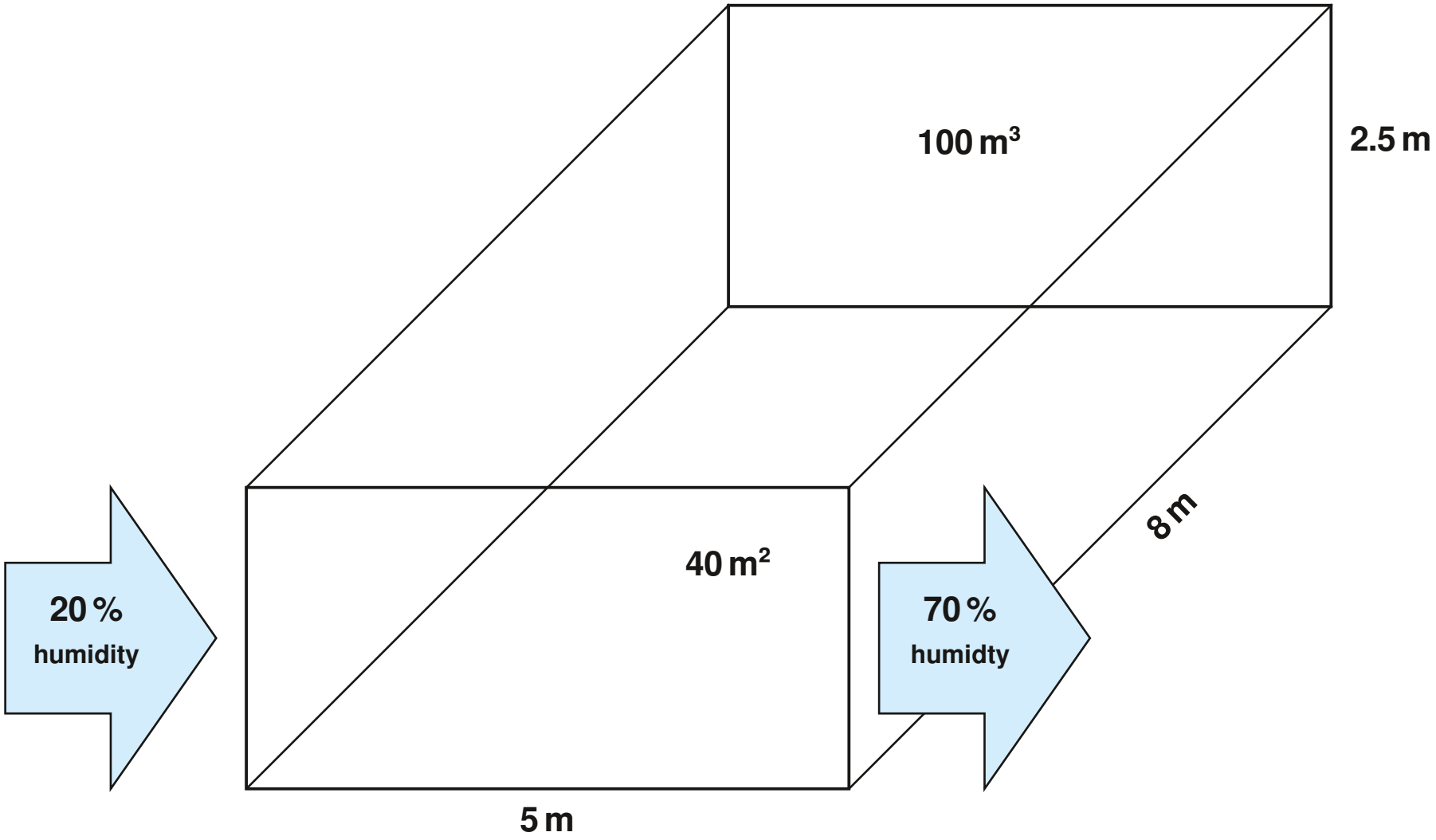
Not all 416 thousand air changes will take place with such extreme values, but this calculation shows how the enormously high water consumption of agricultural products is caused.

There are 3 ways to solve this problem:

1.) To supply the glasshouse with 500 m^3 of water per year

2) recover 500 m^3 of water from the exhaust air

3) Filter 5 t CO_2 from the air and feed it into the mostly closed glasshouse.



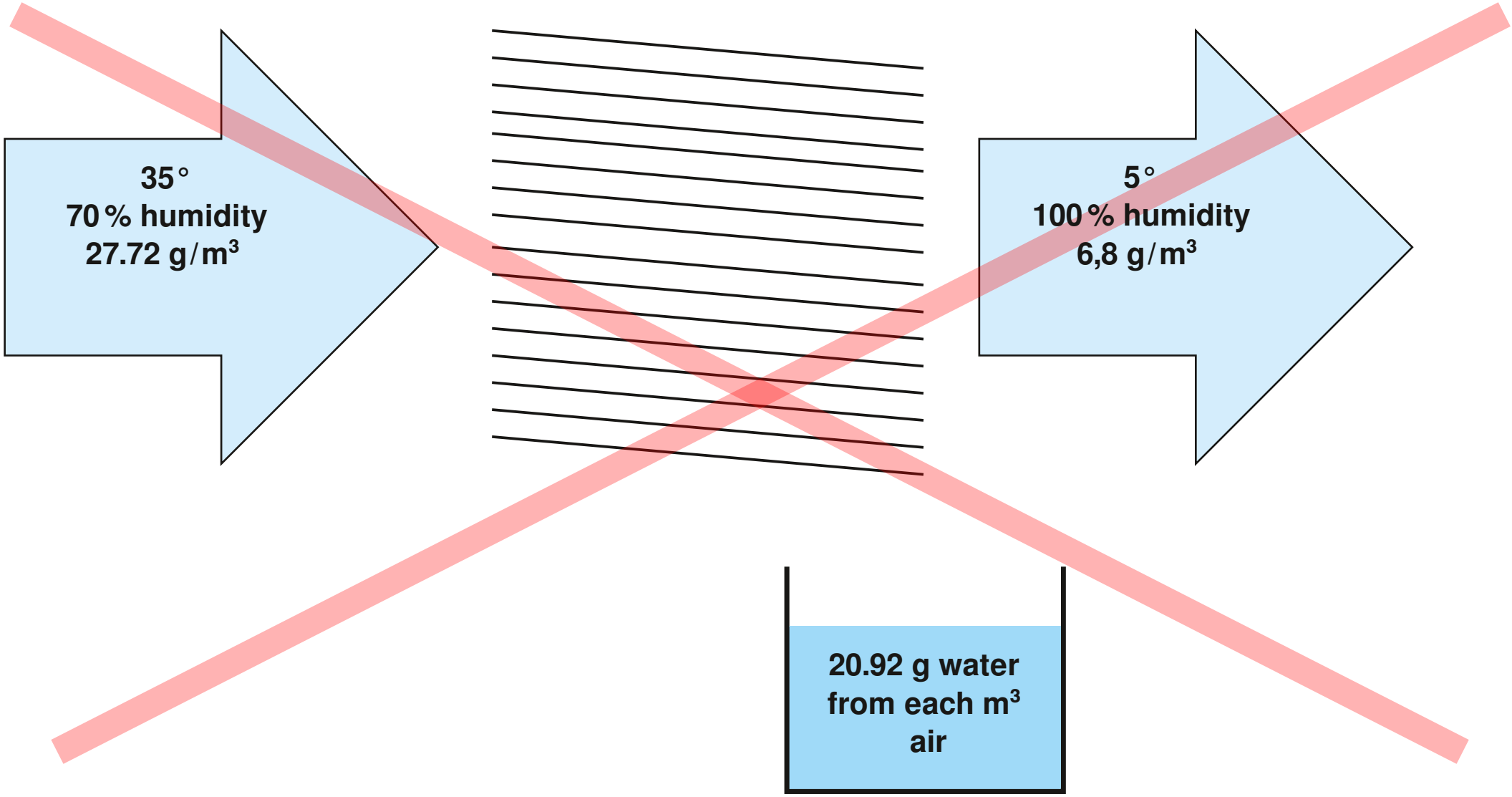
Moisture recovery from exhaust air

Fogged windows, the dew drops on the meadow. When air cools on a cold surface, that part of the air humidity which would have resulted in over 100 % relative humidity condenses.

But 10 Wh of cold to extract 20.92 g of water from one cubic meter of air in this example makes this process too costly.

The 10 Wh cold could be produced with 4 Wh electricity. But that would be about 200 kWh electricity per m^3 water, 100.000 kWh for a recovery of 500 m^3 water.

With 3 t of vegetables about twice as much electricity per kg as with aluminium production.

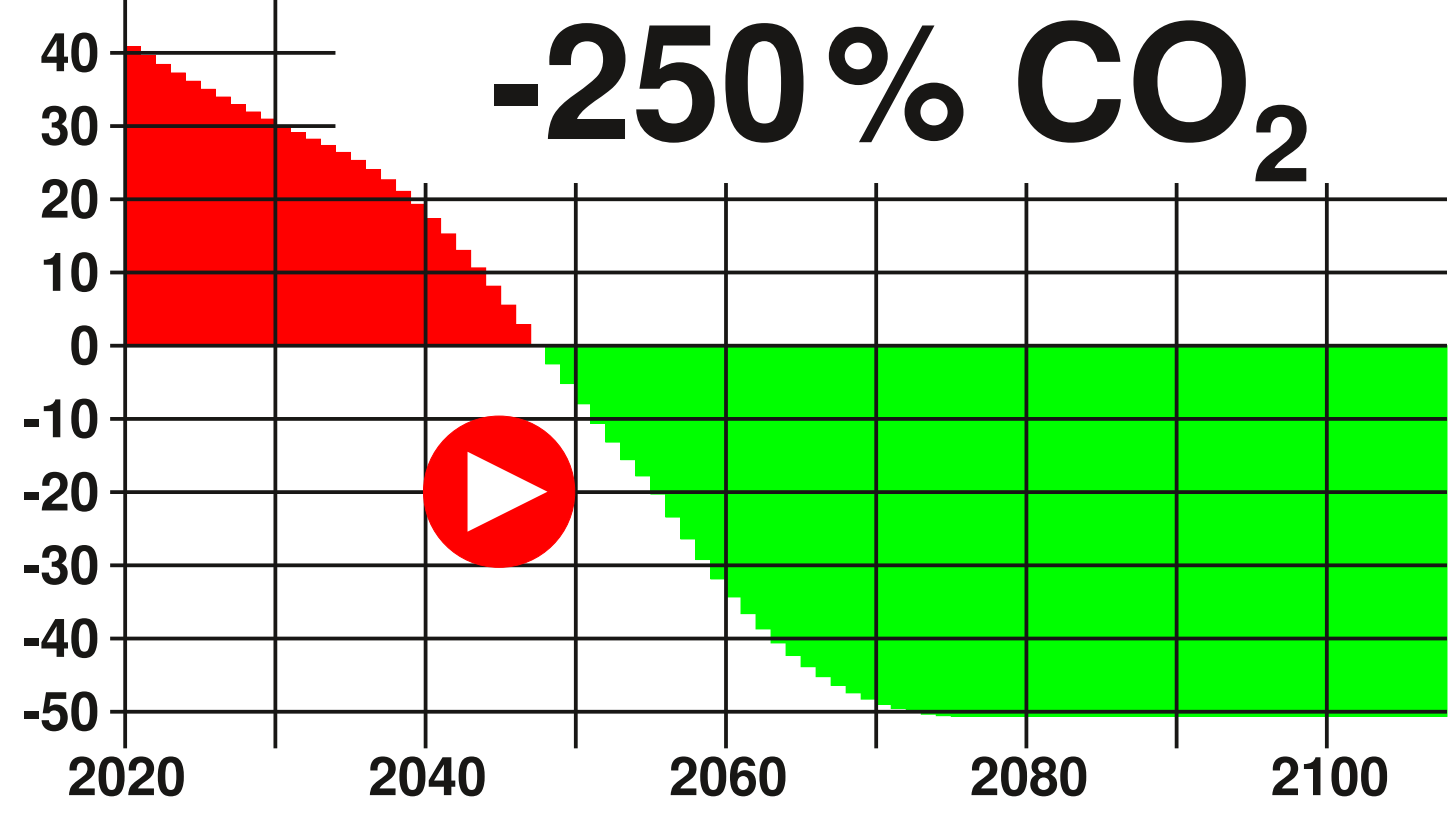


Current world production of electricity

100 % renewable energy simple

CO2 DAC for various applications

Suitable for the require-ments of planetary renovation


-250% CO_2
40
30
20
10
0
-10
-20
-30
-40
-50
2020
2040
2060
2080
2100