
DTU

Plastik i et absolut bæredygtigt perspektiv

Hvordan kan vi i fremtiden producere plastik, der holder sig inden for de planetære grænser.

Møbelseminar 2023 – 08.11.2023

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MOLGARD APS

Honoreret Professor, HFG i Karlsruhe

Indhold

Bæredygtighed - historie

Absolut bæredygtighed

Plastik i et absolut bæredygtigt perspektiv

Opfølgning

https://sustainability.dtu.dk/

https://molgard.com/sustainability/

Omfang: 26 slides

Bæredygtighed - historie

1713 – 1968 Bæredygtighedens historie

Nachhaltigkeit

Hans Carl von Carlowitz

1713

Thomas Malthus

David Ricardo

An Essay on the Principle of Population

1798

Alexander von Humboldt

Views of Nature

1802

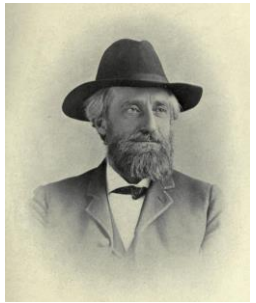
George Perkins Marsh

Man and Nature

1864

Nathaniel Southgate Shaler

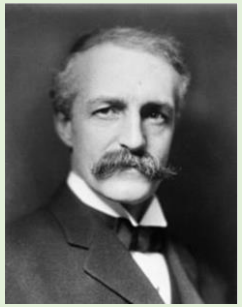
Nature and Man in America



1891

Gifford Pinchot

The Fight for Conservation



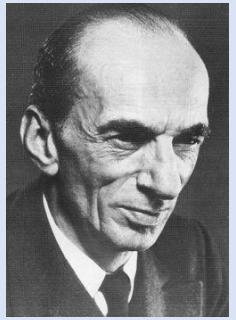
1910

William Vogt

Road to Survival

Henry Fairfield Osborn Jr.

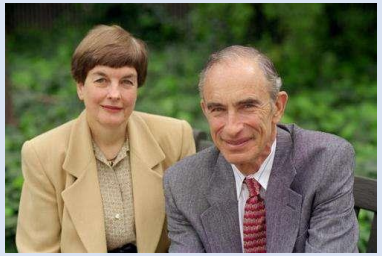
Our Plundered Planet



1948

Anne and Paul Ehrlich

The Population Bomb



1968

1971 – The IPAT model

Paul Ehrlich, John Holdren og Barry Commoner enes om IPAT formlen:

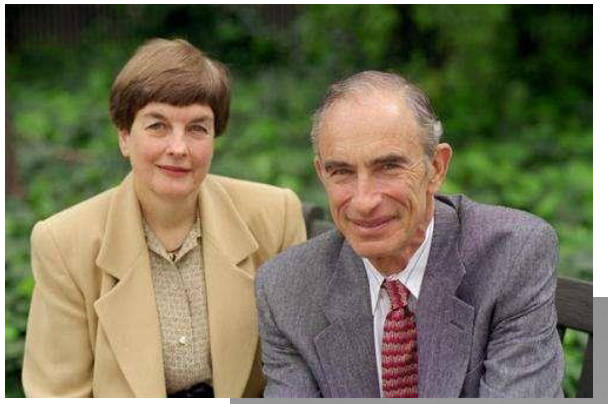
$$I = P \cdot A \cdot T$$

I: Miljøbelastning

P: Befolkningsstørrelse

A: Forbruget

T: Teknologi



1972 - FN's Stockholm-konference

Aren't poverty and need the most important pollutions? How can we talk to villagers and slum-dwellers of the need to protect the air, the ocean and rivers when their own life is contaminated?

The environment cannot be improved in conditions of poverty.

Er fattigdom og behov ikke de vigtigste forureninger? Hvordan kan vi tale med landsbyboere og slum-beboere om behovet for at beskytte luften, havet og floderne, når deres eget liv er forurenet?

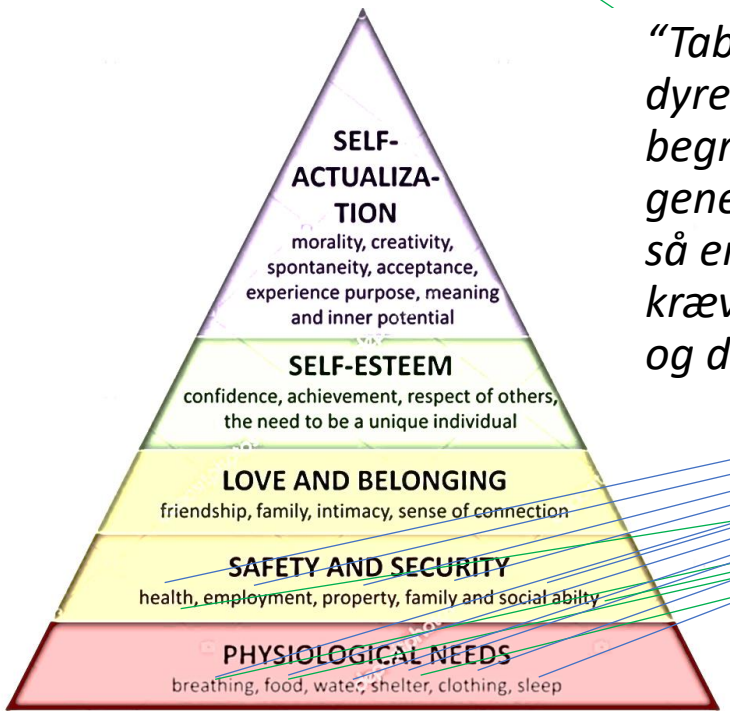
Miljøet kan ikke forbedres under fattige forhold.

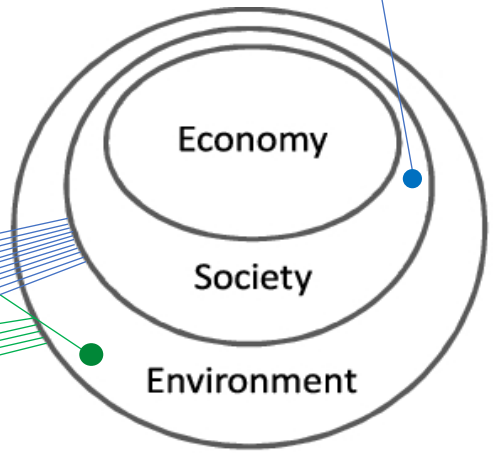
Indira Gandhi

1987 – Brundtlandrapporten og de 3 søjler

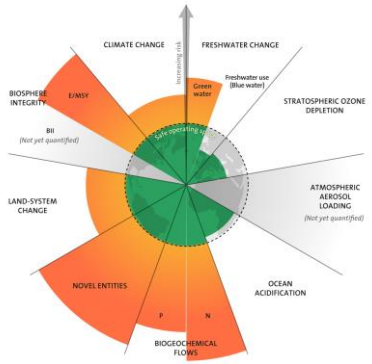
”En bæredygtig udvikling er en udvikling, som opfylder de nuværende behov, uden at bringe fremtidige generationers muligheder for at opfylde deres behov i fare.”

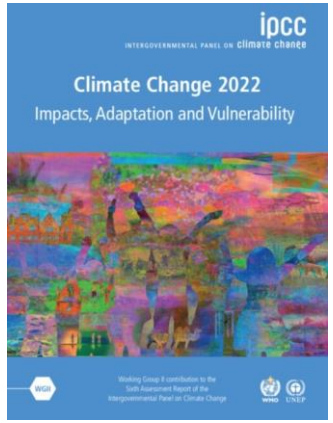
“Tabet af plante- og dyrearter kan i høj grad begrænse fremtidige generationers muligheder; så en bæredygtig udvikling kræver bevarelse af plante– og dyrearter.”

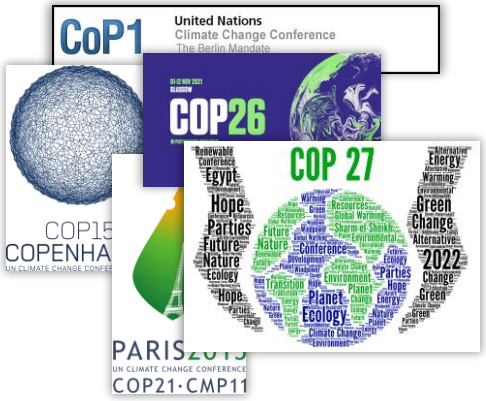




1992 – 2022 - Bæredygtighedens historie



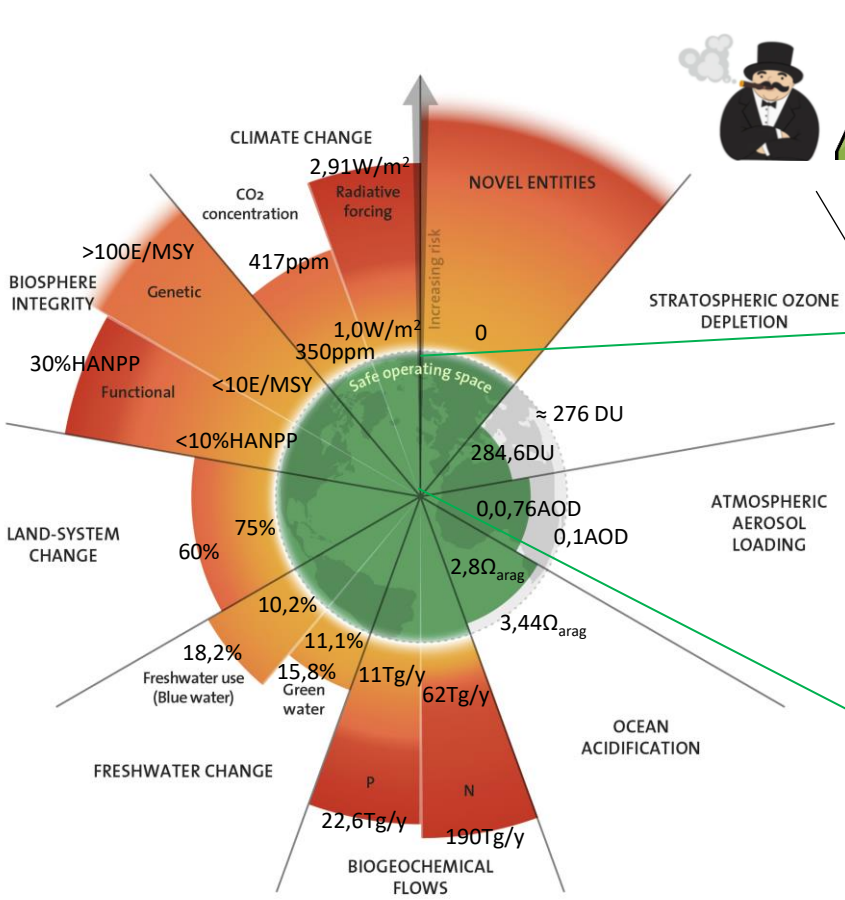




1992 1995 1996 2000 2002 2009 2010 2015 2016 2017 2018 2020 2022

Absolut bæredygtighed

Absolut Bæredygtighed



Safe Operating Space (SOS)

Impact category	World	Europe	Unit
			(per person year)
Climate change	985	985	kg CO_2-eq
	522	522	kg CO_2-eq
Ozone depletion	0.078	0.078	kg CFC-11-eq
Photochemical ozone formation	3.8	2.5	kg NMVOC-eq
Terrestrial acidification	2.3×10^3	1.4×10^3	mole H^+ eq
Terrestrial eutrophication	2.8×10^3	1.8×10^3	mole N eq
Freshwater eutrophication	0.84	0.46	kg P eq
Marine eutrophication	29	31	kg N eq
Freshwater ecotoxicity	1.9×10^4	1.0×10^4	[PAF]×m³×day
Land use, soil erosion	1.8	1.2	tons eroded soil
Land use, biodiversity	1.5×10^4	9.5×10^3	m²×year
Water depletion	306	490	m³

Source: Anders Bjørn og Michael Hauschild, 2015

Absolut Bæredygtighed

Fortid

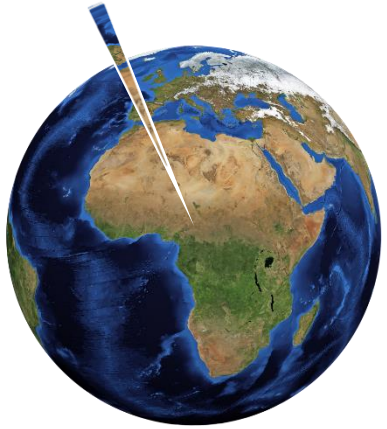
VS

Hvilken er bedst?

Lav miljøbelastning — Høj miljøbelastning

Fremtid

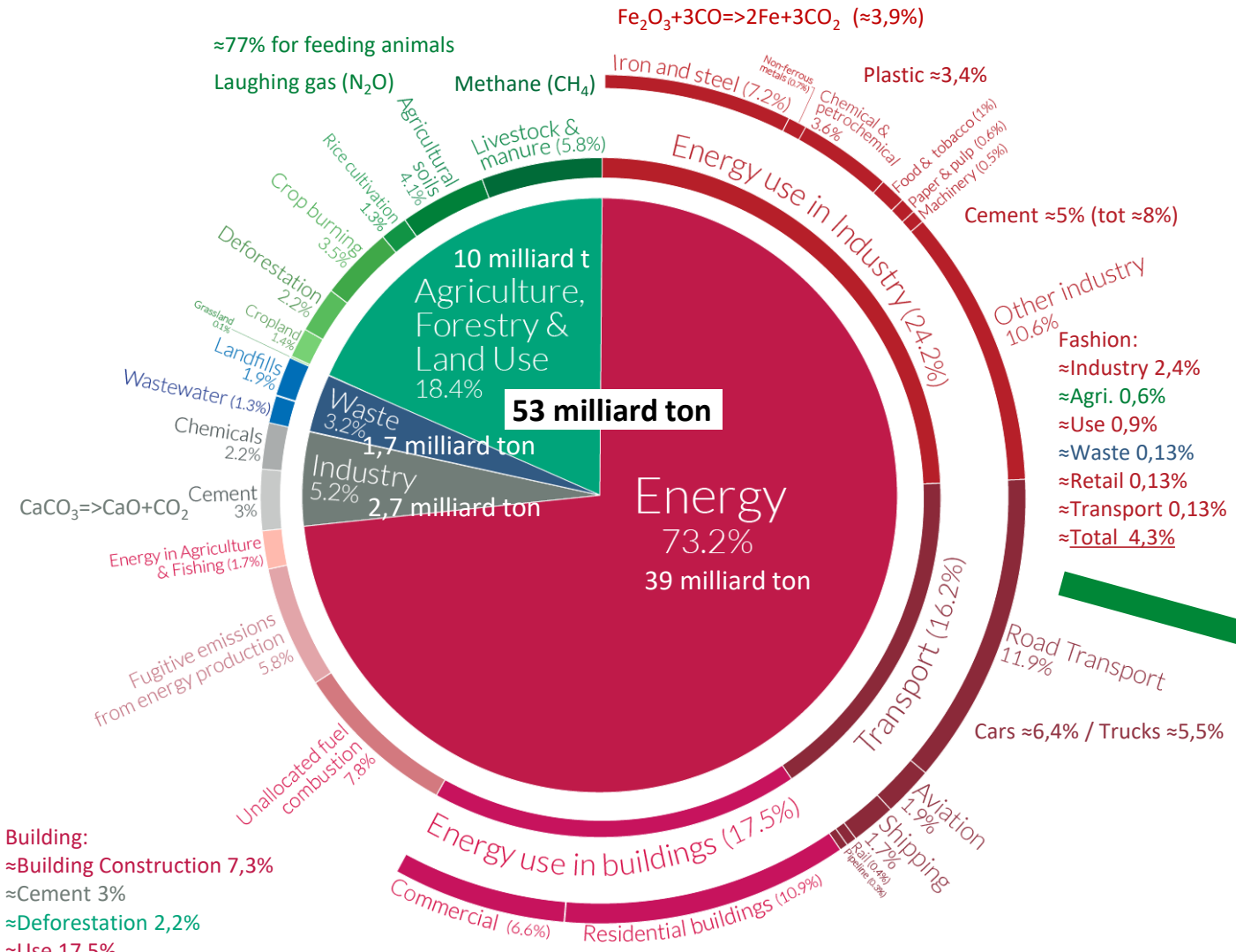
VS



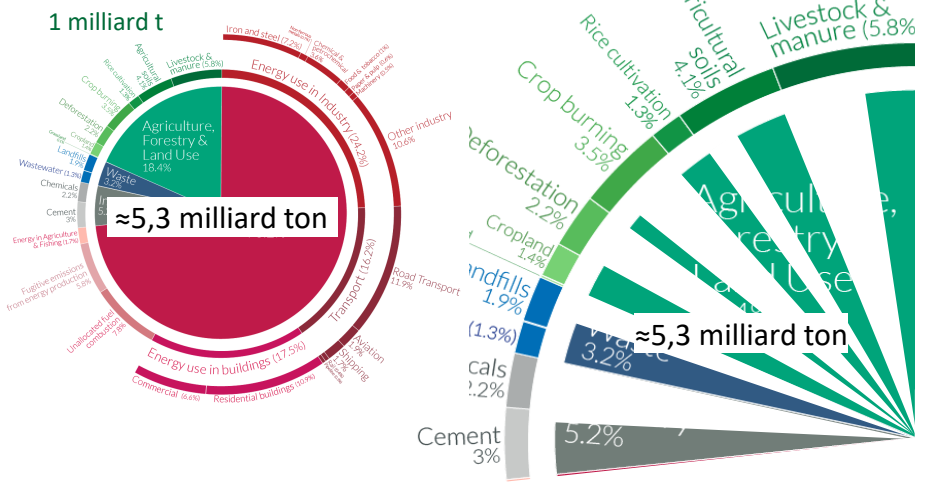
Er det godt nok?

Bæredygtig — Ikke bæredygtigt

Drivhusgasser (CO_2-e) for sektorer (2016)

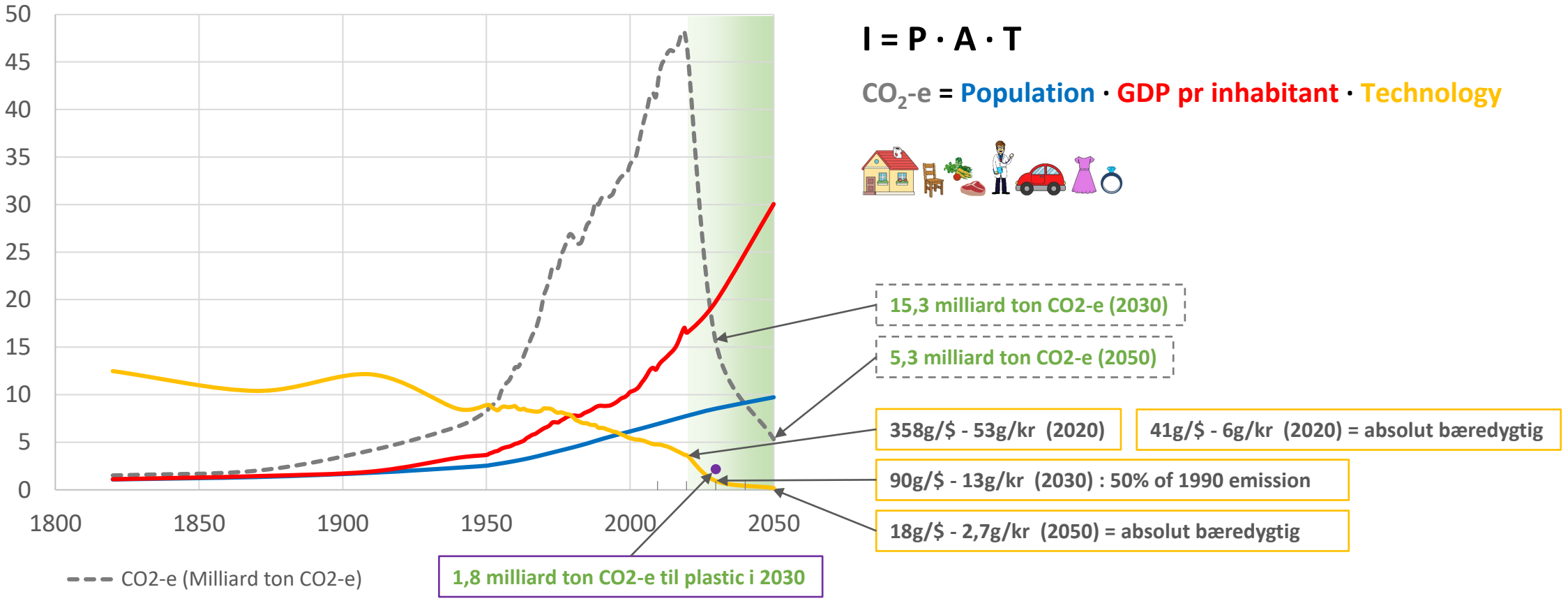


Absolut bæredygtighed - faktor ≈ 10



Sources:
Our World in Data

CO_2-e = Befolkning · Velstanden · Teknologi

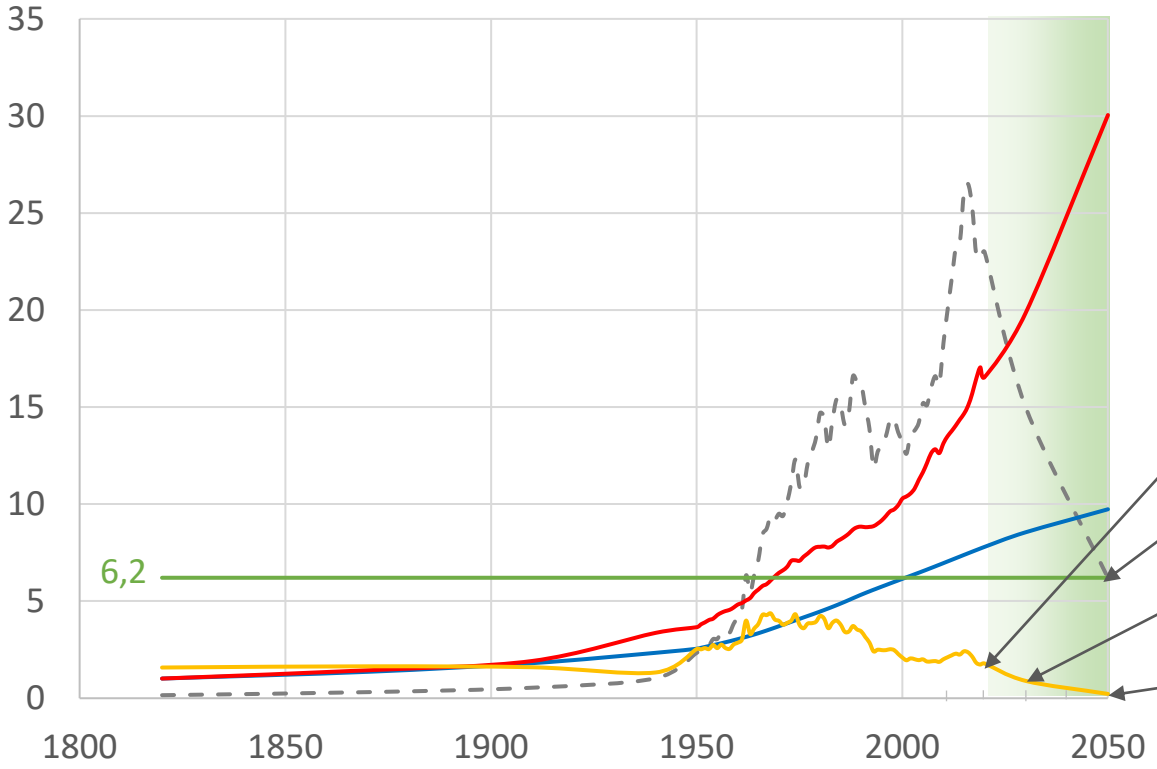


I = P · A · T

CO_2-e = Population · GDP pr inhabitant · Technology

Sources:
The World Bank: Population, CO2 emissions, GHG emission, GDP.
PWC: The World in 2050.
Bjørn & Hauschild: Introducing carrying capacity-based normalisation in LCA.

Fosfat = Befolkning · Velstanden · Teknologi



I = P · A · T

Phosphate = Population · GDP pr inhabitant · Technology

178mg/$ - 26mg/kr (2020)

48mg/$ - 7mg/kr (2020) = absolut bæredygtig

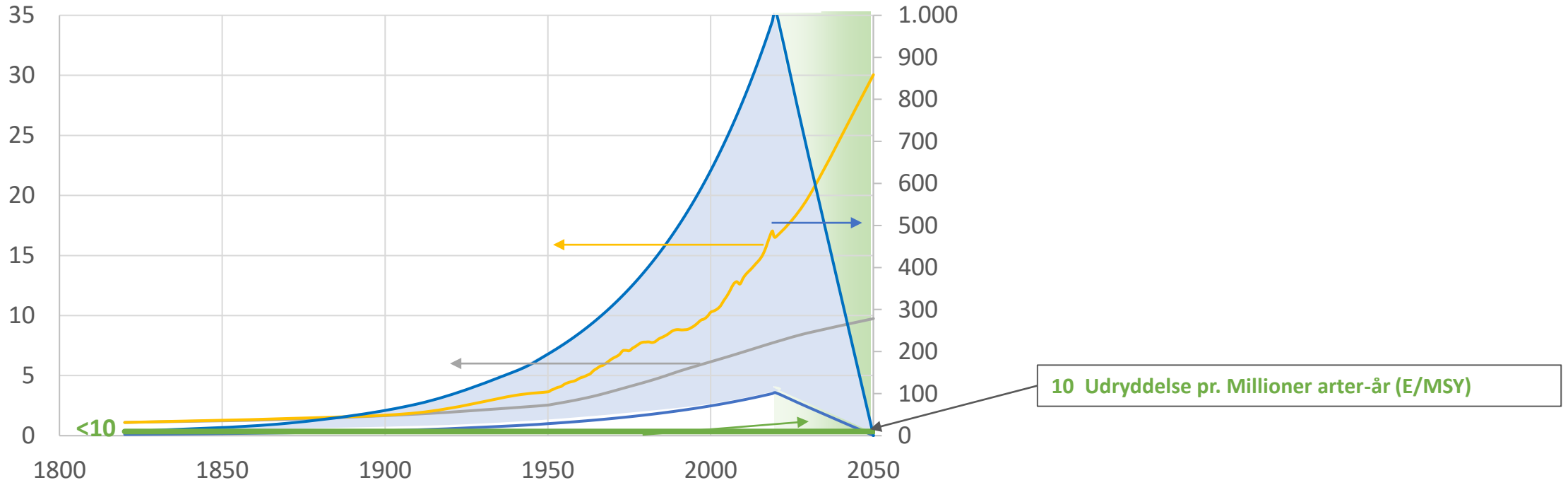
6,2 Million ton

88mg/$ - 13mg/kr (2030)

21,2mg/$ - 3,1mg/kr (2050) = absolut bæredygtig

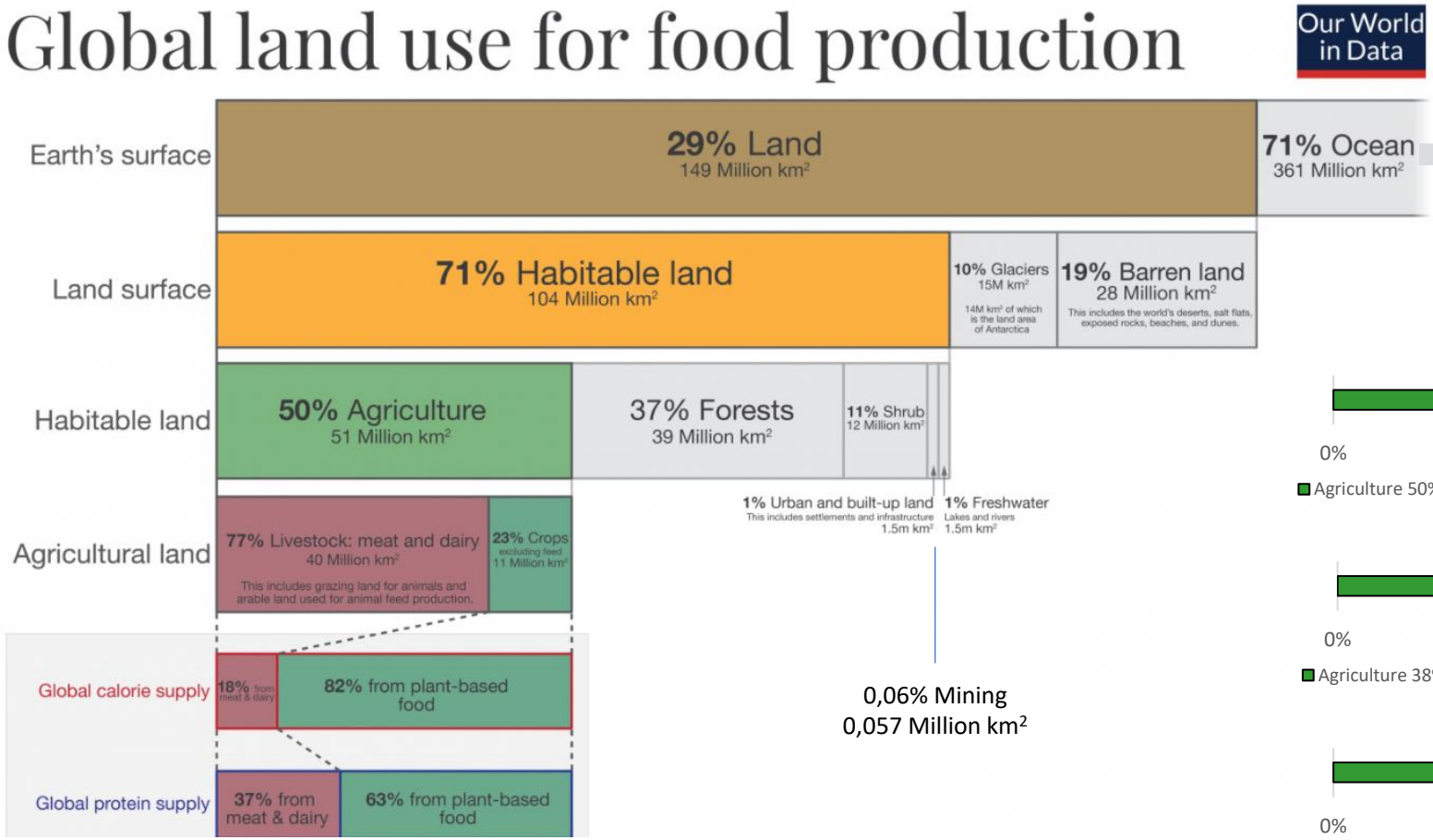
Sources:
The World Bank: Population, GDP.
USGS: Phosphate Rock - Historical Statistics.
PWC: The World in 2050.
Bjørn & Hauschild: Introducing carrying capacity-based normalisation in LCA.
Steffen et al: Planetary boundaries: Guiding human development on a changing planet.

Udryddelse af arter

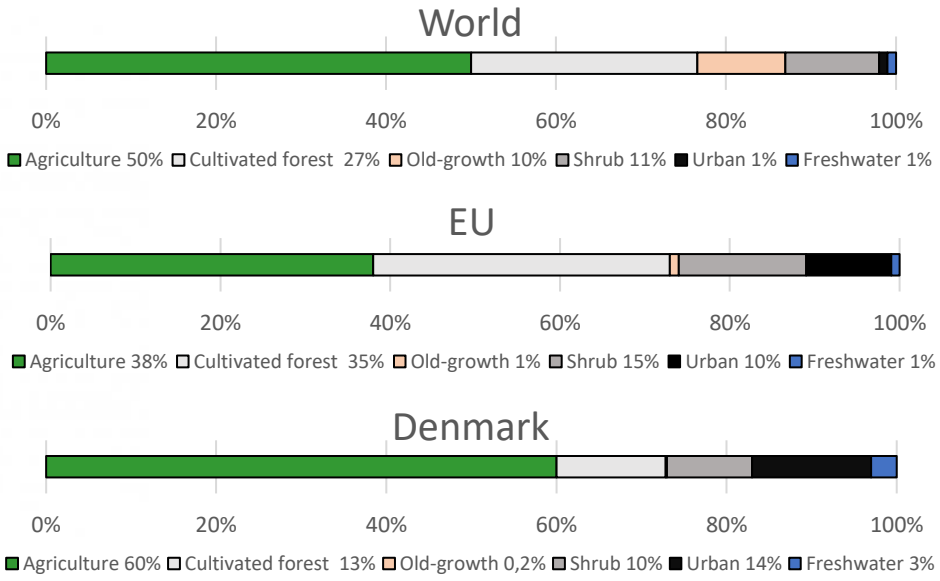


Sources:
The World Bank: Population, GDP.
PWC: The World in 2050.
The Biodiversity Crisis
Steffen et al: Planetary boundaries: Guiding human development on a changing planet.

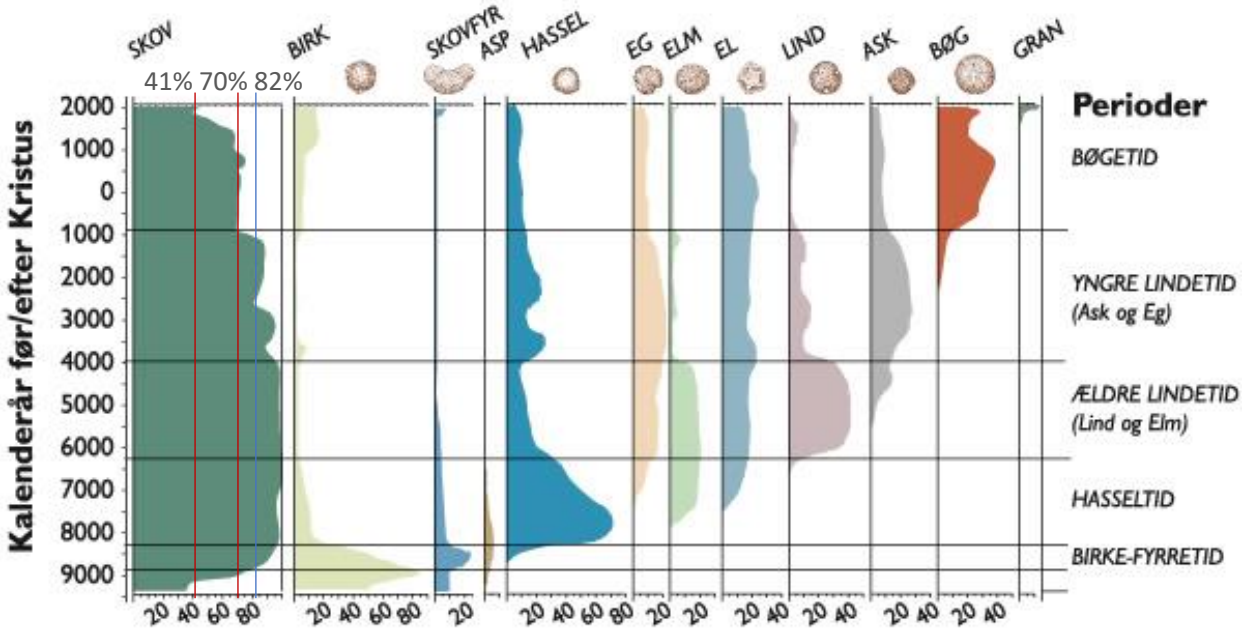
Hvad bruges jordens areal til? (2019)



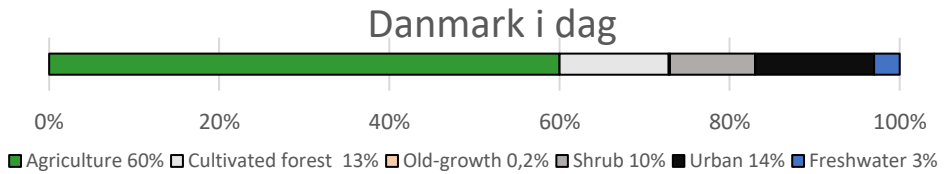
0,06% Mining
0,057 Million km²

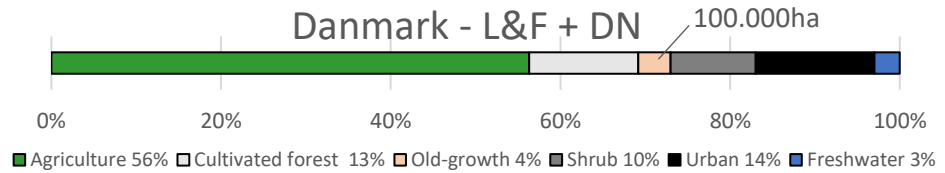


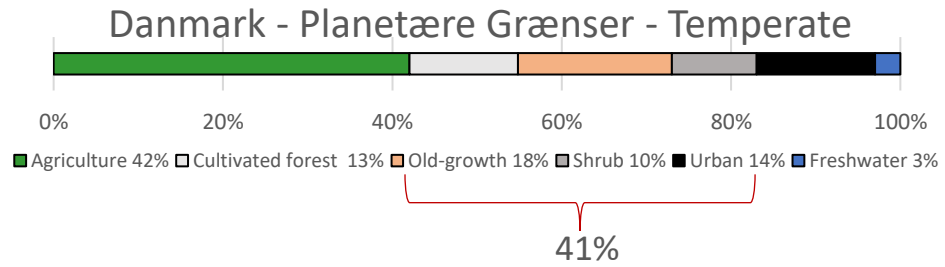
Hvordan skal den Danske jord bruges?

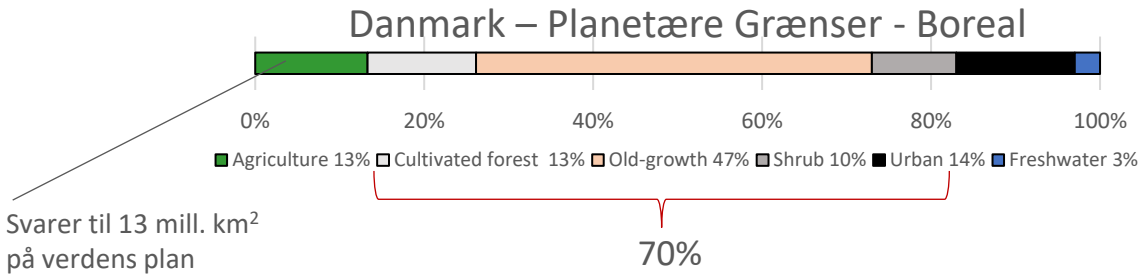


Land system change	*Global*: area of forested land as the percentage of original forest cover; *biome*: area of forested land as the percentage of potential forest (% area remaining)	*Global: 75%* values are a weighted average of the three individual biome boundaries; *biomes*: tropical, 85%; temperate, 50%; boreal: 85%





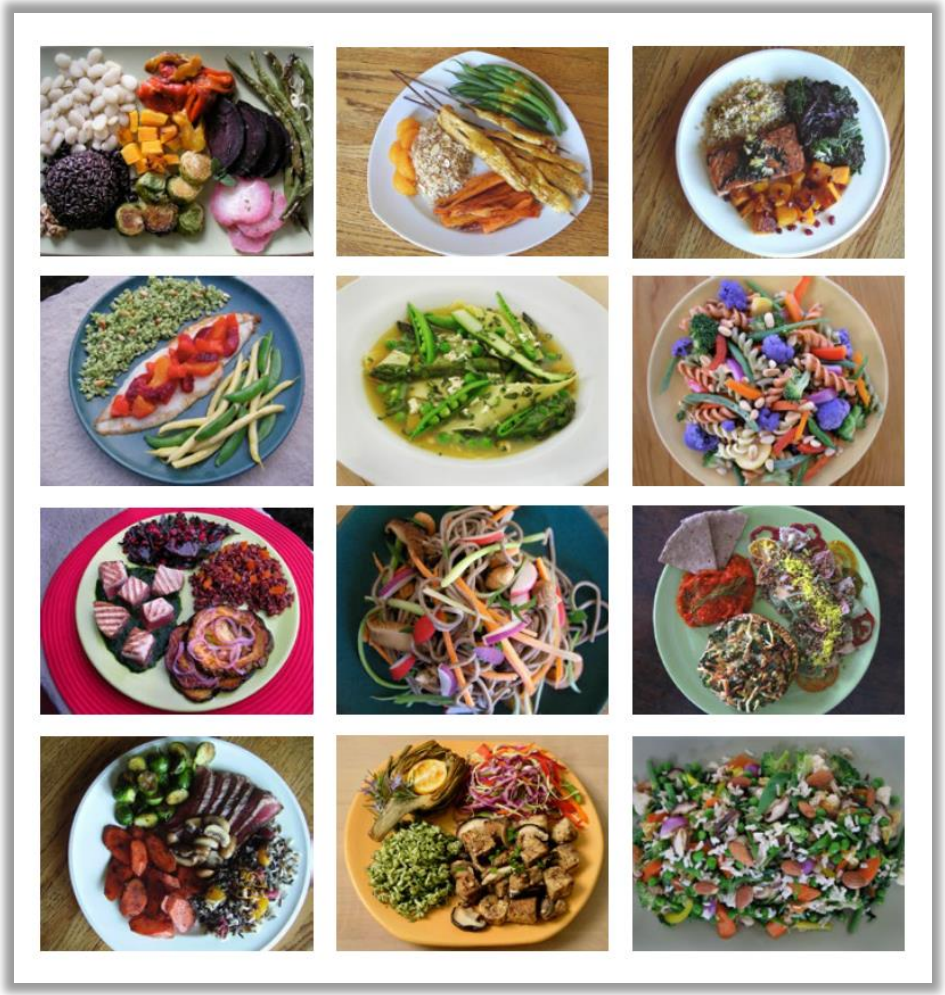




Source: TRÆ.DK, 2020

Sund kost fra bæredygtige fødevaresystemer

	Macronutrient intake grams per day (possible range)	Caloric intake kcal per day
Whole grains		
Rice, wheat, corn and other	232	811
Tubers or starchy vegetables		
Potatoes and cassava	50 (0–100)	39
Vegetables		
All vegetables	300 (200–600)	78
Fruits		
All fruits	200 (100–300)	126
Dairy foods		
Whole milk or equivalents	250 (0–500)	153
Protein sources		
Beef, lamb and pork	14 (0–28)	30
Chicken and other poultry	29 (0–58)	62
Eggs	13 (0–25)	19
Fish	28 (0–100)	40
Legumes	75 (0–100)	284
Nuts	50 (0–75)	291
Added fats		
Unsaturated oils	40 (20–80)	354
Saturated oils	11.8 (0-11.8)	96
Added sugars		
All sugars	31 (0–31)	120



Source: The EAT-*Lancet* Commission, 2019

Sund kost fra bæredygtige fødevaresystemer

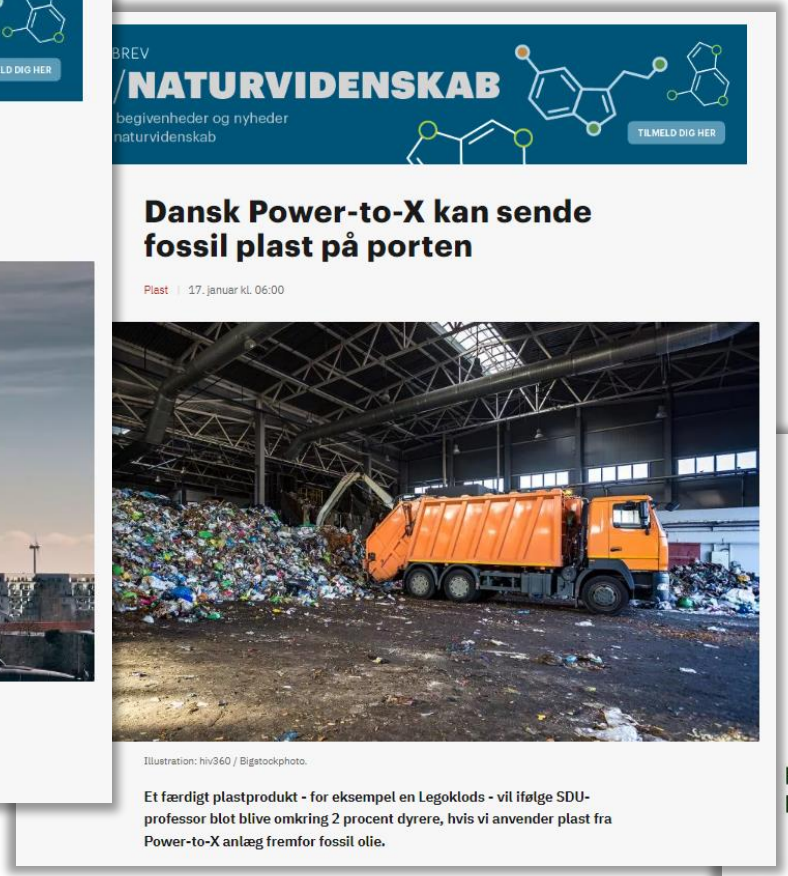
			GHG emissions	Cropland use	Water use	Nitrogen application	Phosphorus application	Biodiversity loss
Food production boundary			5.0 (4.7–5.4)	13 (11.0–15.0)	2.5 (1.0–4.0)	90 (65.0–140.0)	8 (6.0–16.0)	10 (1–80)
Baseline in 2010			5.2	12.6	1.8	131.8	17.9	100–1000
Production (2050)	Waste (2050)	Diet (2050)						
Busin. as usual	Full waste	**Busin. as usual**	9.8	21.1	3.0	199.5	27.5	1,043
Busin. as usual	Full waste	Dietary shift	5.0	21.1	3.0	191.4	25.5	1,270
Busin. as usual	Halve waste	**Busin. as usual**	9.2	18.2	2.6	171.0	23.2	684
Busin. as usual	Halve waste	Dietary shift	4.5	18.1	2.6	162.6	21.2	885
Impro. produc	Full waste	**Busin. as usual**	8.9	14.8	2.2	187.3	25.5	206
Impro. produc	Full waste	Dietary shift	4.5	14.8	2.2	179.5	24.1	351
Impro. produc	Halve waste	**Busin. as usual**	8.3	12.7	1.9	160.1	21.5	50
Impro. produc	Halve waste	Dietary shift	4.1	12.7	1.9	151.7	20.0	102
+Impro. produc	Full waste	**Busin. as usual**	8.7	13.1	2.2	147.6	16.5	37
+Impro. produc	Full waste	Dietary shift	4.4	12.8	2.1	140.8	15.4	34
+Impro. produc	Halve waste	**Busin. as usual**	8.1	11.3	1.9	128.2	14.2	21
+Impro. produc	Halve waste	Dietary shift	4.0	11.0	1.9	121.3	13.1	19

Control variable	Boundary (Uncertainty range)
GHG emissions	5 Gt CO_2-eq yr^{-1} (4.7 – 5.4 Gt CO2-eq yr^{-1})
Cropland use	13 M km^2 (11–15 M km^2)
Water use	2,500 km^3 yr^{-1} (1000–4000 km^3 yr^{-1})
N application	90 Tg N yr^{-1} (65–90 Tg N yr^{-1}) * (90–130 Tg N yr^{-1})**
P application	8 Tg P yr^{-1} (6–12 Tg P yr^{-1}) * (8–16 Tg P yr^{-1})**
Extinction rate	10 E/MSY (1–80 E/MSY)

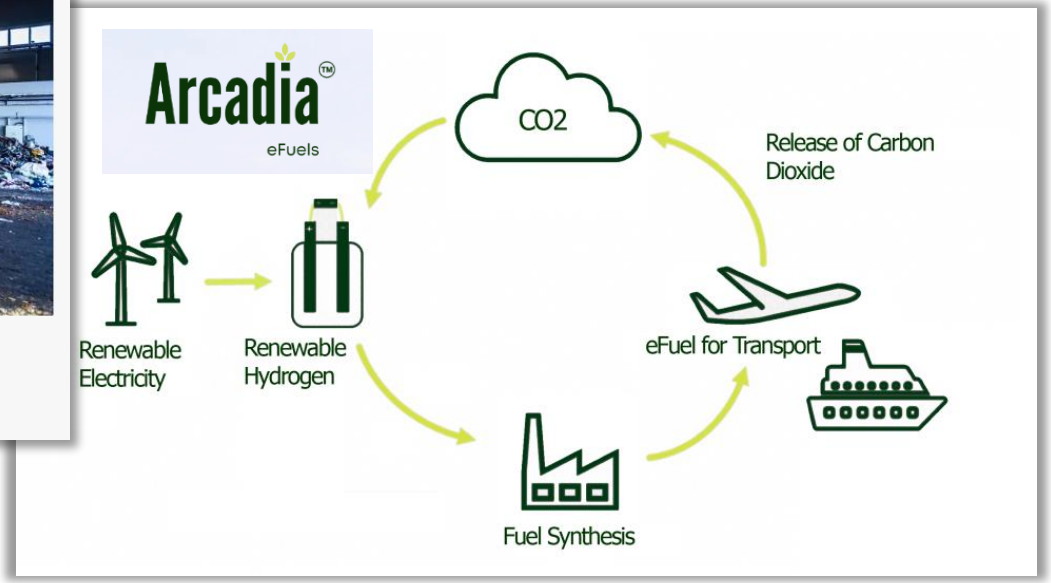
Source: The EAT-*Lancet* Commission, 2019

Plastik i et absolut bæredygtigt perspektiv

Plastic inden for de Planetære Grænser



Henrik Wenzel, 2021 + 2023



Plastic inden for de Planetære Grænser

nature sustainability

Analysis

https://doi.org/10.1038/s41893-022-01054-9

Towards circular plastics within planetary boundaries

Received: 23 June 2022

Accepted: 13 December 2022

Published online: 06 March 2023

Check for updates

Marvin Bachmann[1,5], Christian Zibunas[1,5], Jan Hartmann[1], Victor Tulus[2], Sangwon Suh[3], Gonzalo Guillén-Gosálbez[2] & André Bardow[4]

The rapid growth of plastics production exacerbated the triple planetary crisis of habitat loss, plastic pollution and greenhouse gas (GHG) emissions. Circular strategies have been proposed for plastics to achieve net-zero GHG emissions. However, the implications of such circular strategies on absolute sustainability have not been examined on a planetary scale. This study links a bottom-up model covering both the production and end-of-life treatment of 90% of global plastics to the planetary boundaries framework. Here we show that even a circular, climate-optimal plastics industry combining current recycling technologies with biomass utilization transgresses sustainability thresholds by up to four times. However, improving recycling technologies and recycling rates up to at least 75% in combination with biomass and CO_2 utilization in plastics production can lead to a scenario in which plastics comply with their assigned safe operating space in 2030. Although being the key to sustainability and in improving the unquantified effect of novel entities on the biosphere, even enhanced recycling cannot cope with the growth in plastics demand predicted until 2050. Therefore, achieving absolute sustainability of plastics requires a fundamental change in our methods of both producing and using plastics.

Plastics are versatile, durable, and cheap, and therefore ubiquitous in our modern life. Accordingly, plastics demand has doubled in the past 20 years and is expected to double again before 2050 (refs. [1,2]). Unfortunately, the increasing demand will also intensify the global challenge of plastic pollution[3–5]. Therefore, the United Nations Environment Programme recently pledged to tackle the triple planetary crisis recycling, bio-based production, and carbon capture and utilization (CCU)[8–10]. For example, recently, bio- and CCU-based processes have been shown to achieve net-zero GHG emission plastics when combined with recycling rates of 94%[10]. Thus, the global recycling rates need to substantially increase from their current values, which are estimated to be around 23%[11] but might actually be even lower[12]. Furthermore,

Marvin Bachmann. et.al, 2022

News & views

Environmental impact assessment

https://doi.org/10.1038/s41893-023-01069-w

Pathways to sustainable plastics

Michael Zwicky Hauschild & Anders Bjørn

Check for updates

Our current use of plastics is the epitome of an unsustainable lifestyle with their reliance on fossil resources and their widespread application through single use products that, after use, end up in the natural environment. A study now analyses what it would take for plastics to become a sustainable material.

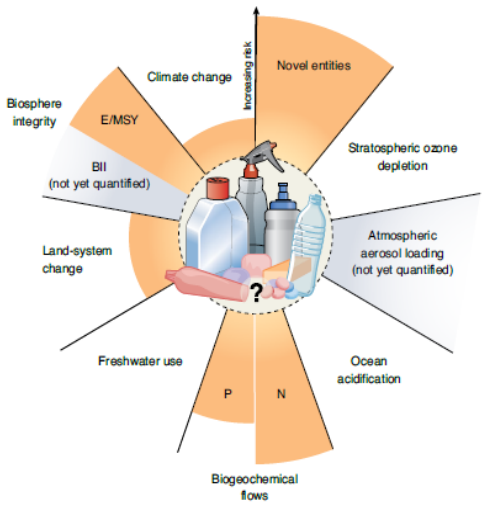


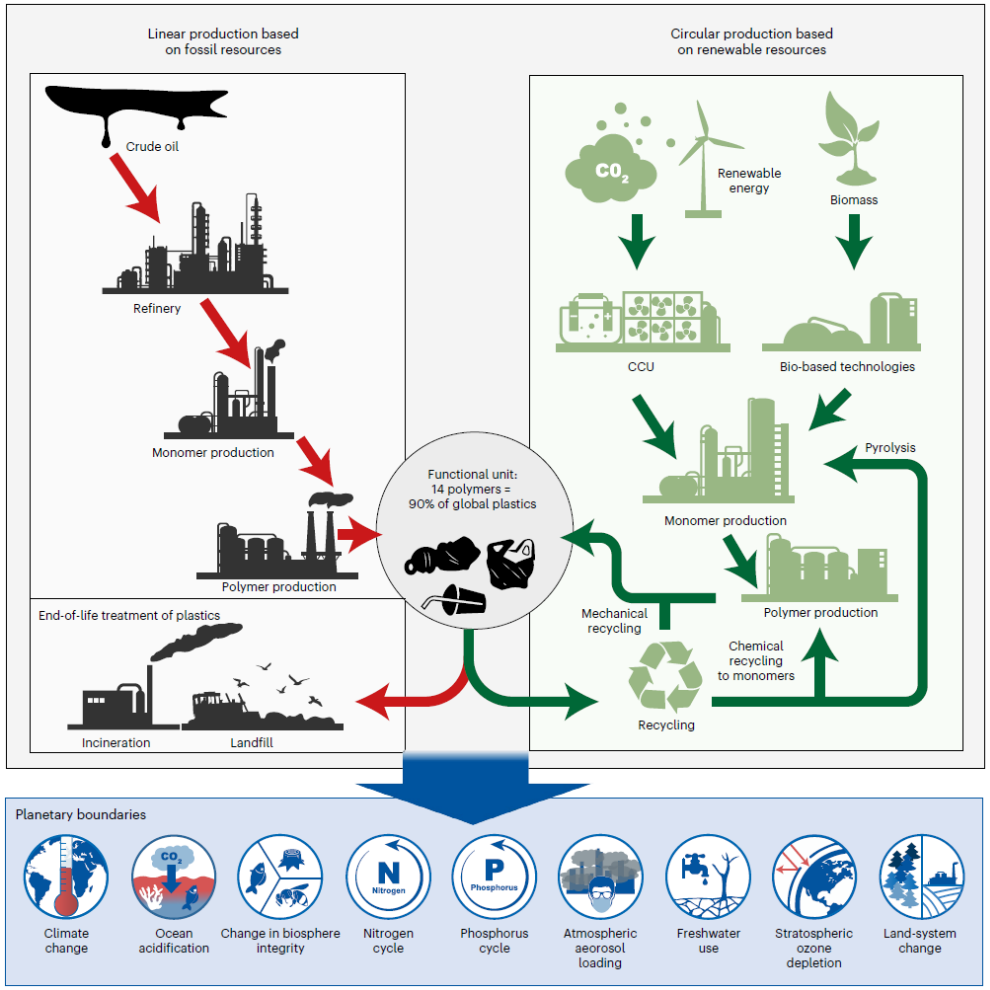
Fig. 1 | A sustainable future production and use of plastics must respect the planetary boundaries. The subcategories of biosphere integrity concern functional biodiversity (BII) and genetic biodiversity (E/MSY), and the subcategories of biogeochemical flows concern nitrogen and phosphorus flows.

Plastic is a cheap material suitable for many applications. This explains why our demand for plastics has doubled over the past few decades and is expected to continue to grow in the future[1]. Plastic is largely produced from fossil resources, with less than 1% originating in biological resources; with typical applications in short-lived, single-use products like packaging, plastics contribute an increasing share of global CO_2 emissions. In addition to the impacts on climate change, our reliance on plastics has created an accelerating waste problem, leading to growing concerns particularly about marine plastics pollution[2]. Bio-based plastics, circular economy strategies and a change in consumption patterns are all ways to reduce the environmental impacts of plastics. Writing in *Nature Sustainability*, Marvin Bachmann and colleagues[3] analyse how combining those available strategies could turn the future use of plastics sustainable.

With their seminal 2009 paper, Johan Rockström and colleagues[4] introduced the concept of planetary boundaries. The boundaries are based on biophysical limits that socioeconomic systems must respect if they want to protect the critical functions of natural processes that sustain human life (Fig. 1). In other words, the boundaries define a safe operating space for humanity. The concept of planetary boundaries has

Michael Hauschild & Anders Bjørn, 2023

Plastic inden for de Planetære Grænser i 2030



<u>2030</u> Share of Safe Operating Space

- 1,1% - økonomisk skaleringsprincip (0,7% i 2019)
- 0,17 milliard ton CO_2-e (1,8 milliard ton CO_2-e i 2019)

Produktions scenarier

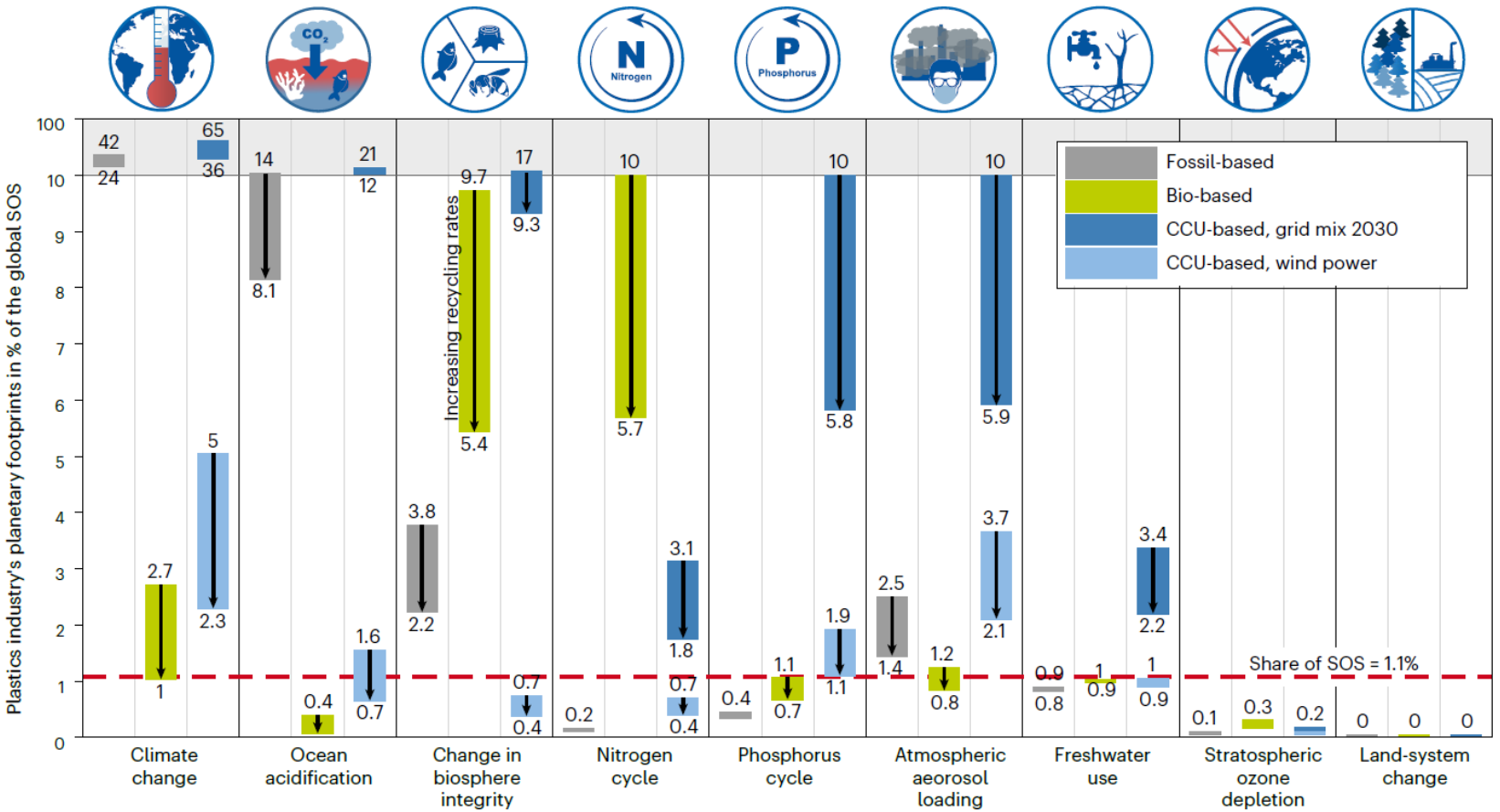
- Fossil-baseret
- Biomasse
- Carbon Capture and Utilization (CCU) + mix*
- Carbon Capture and Utilization (CCU) + wind

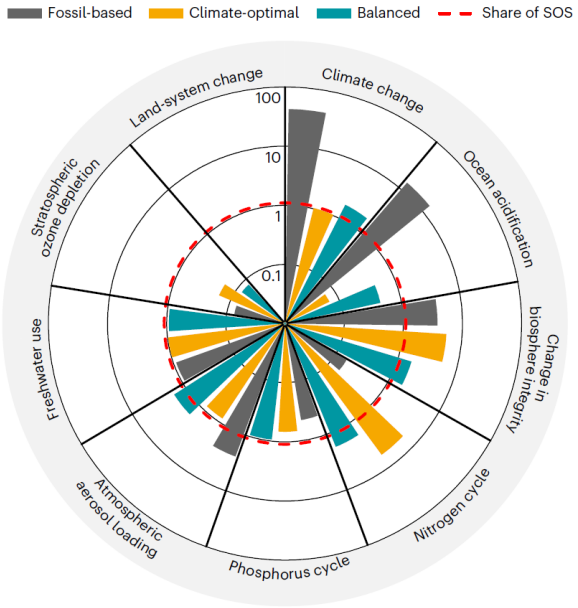
Recyklings scenarier

- Nuværende recykling rate 23%
- Høj recykling rate 94%
  - Mekanisk recykling af ren plastic 39%
  - Kemisk recykling af mixet plastic 55% (pyrolyse)

*Energy Agency Net Zero by 2050 scenario

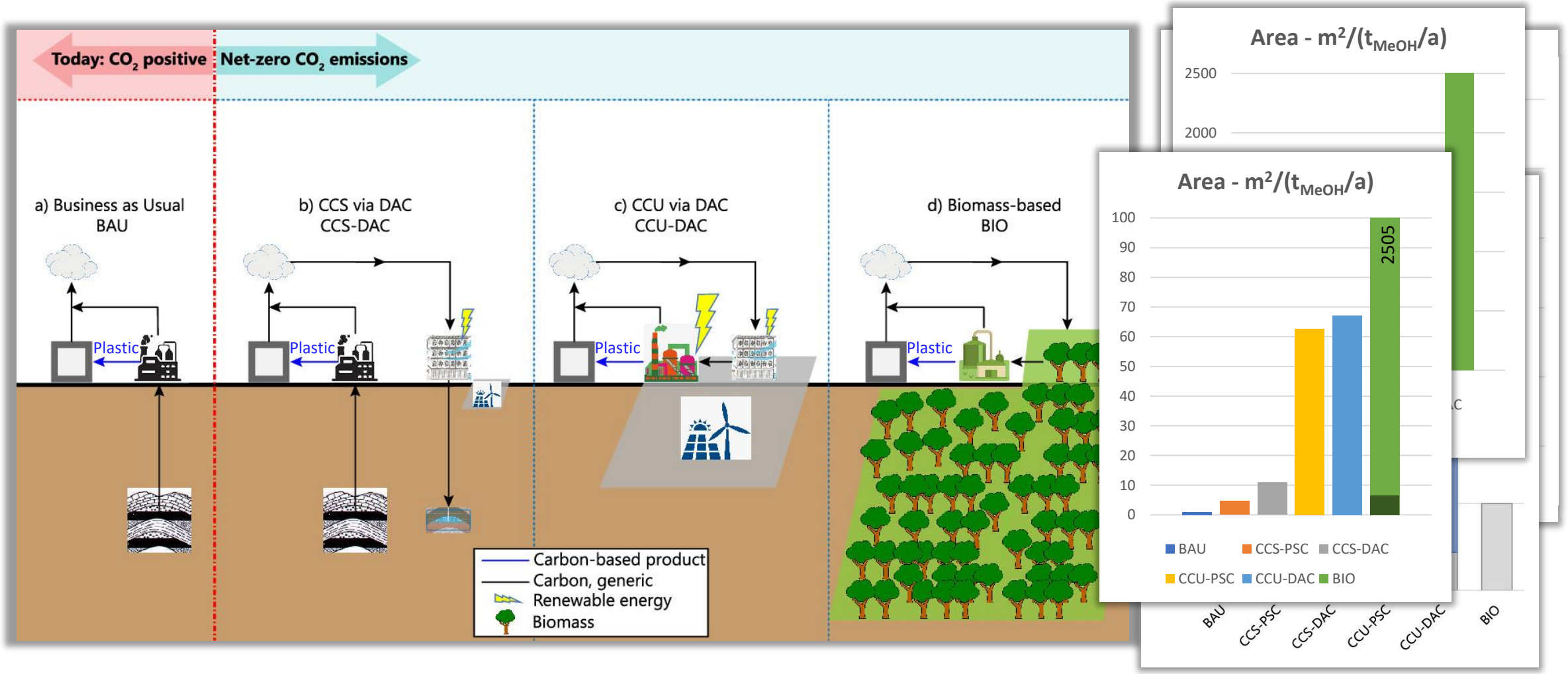
Plastic inden for de Planetære Grænser i 2030





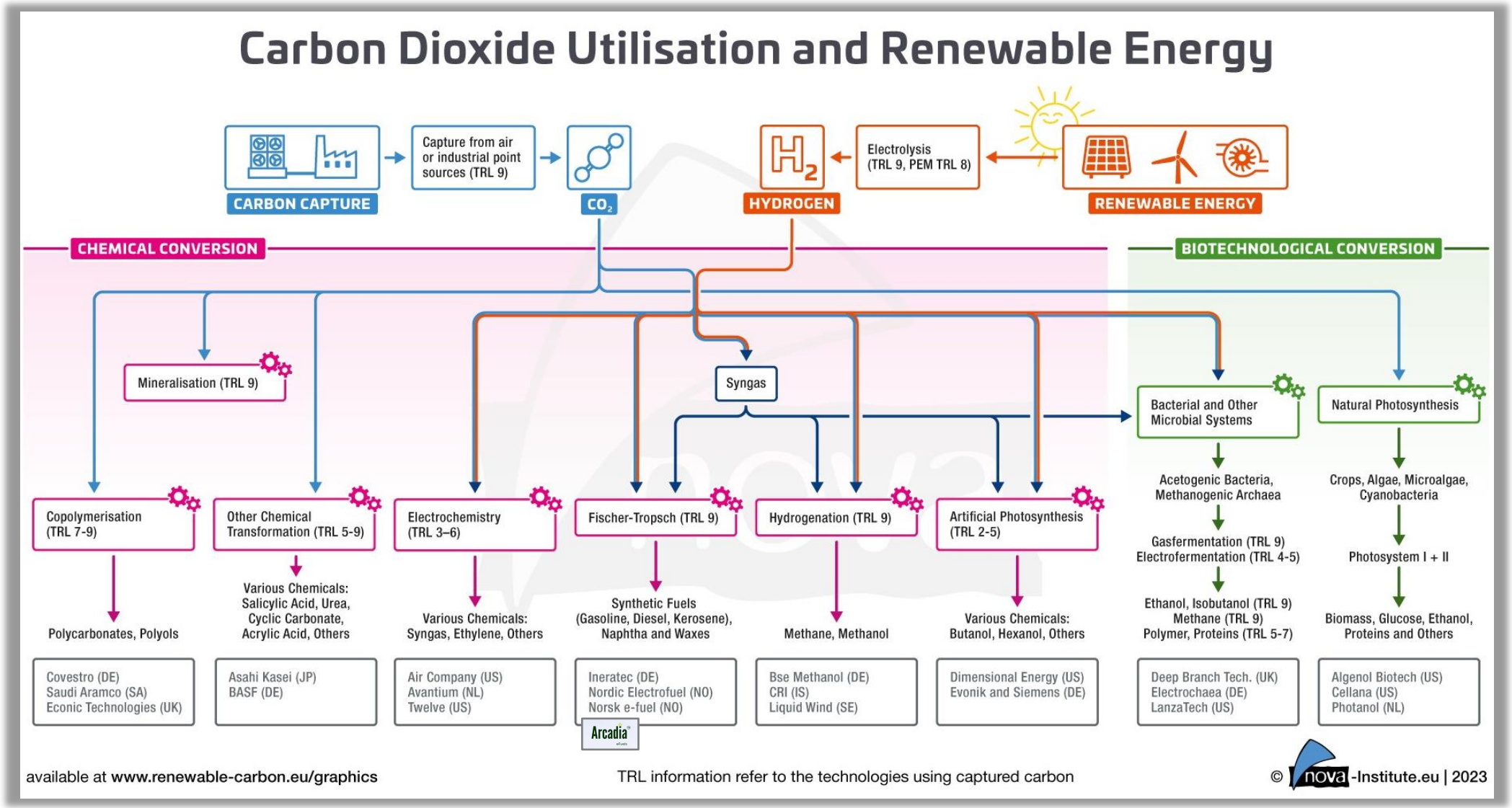
Source: Marvin Bachmann. et.al, 2022

Plastic inden for de Planetære Grænser



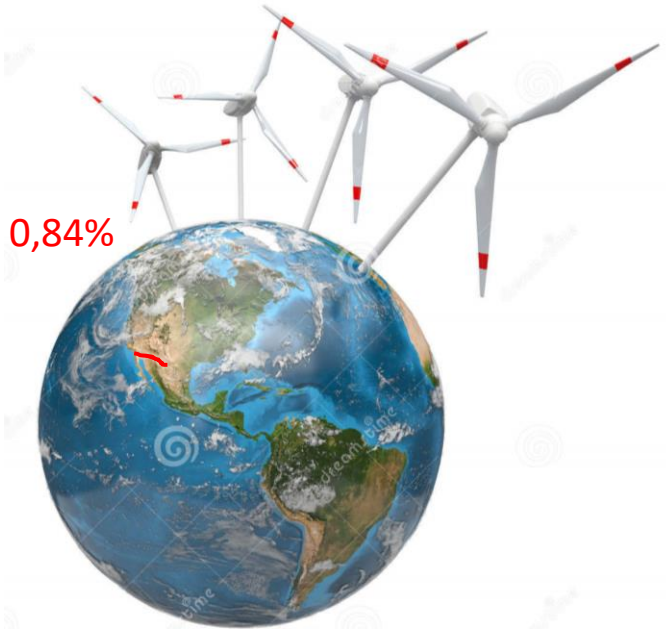
Source: Paolo Gabrielli,

Plastic inden for de Planetære Grænser



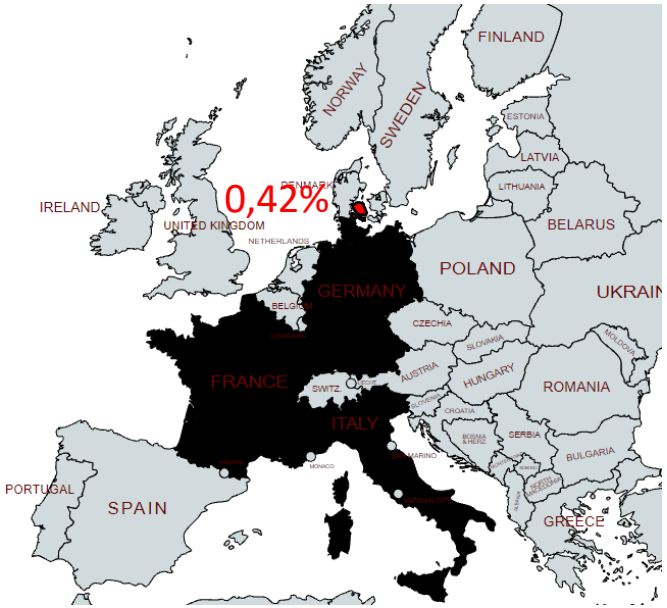
Renewable energy - 604 EJ (Exajoule) i 2019

4,6 mill. havvindmøller



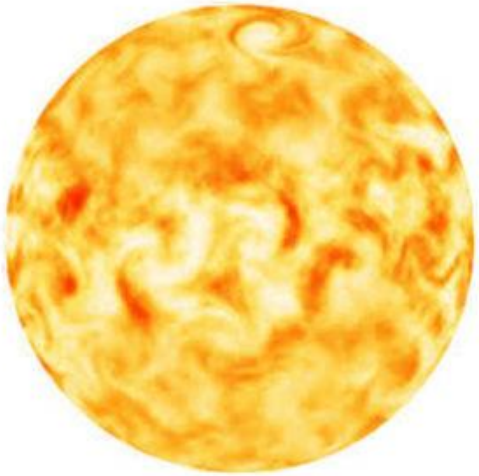
19 x rundt om jorden

1,1 mill. km^2 solceller



0,87% af jorden overflade

Indstrømning af solenergi



5.000 x vores forbrug

Opfølgning

Skab enorme mængder af renewable energy

Genopret den naturlige natur - ”nedlæg” halvdelen af landbruget

Værd omhyggelig med forbruget – minimer, cirkuler, etc.

Smid ikke ting hvor de ikke skal være – plast i havet, etc.

https://sustainability.dtu.dk/

https://molgard.com/sustainability/


DTU