Sustainability and Beyond
A Challenge for
Health Care

PG Luscuere, March 24th 2023

TU Delft

Introduction

Photos: Philips

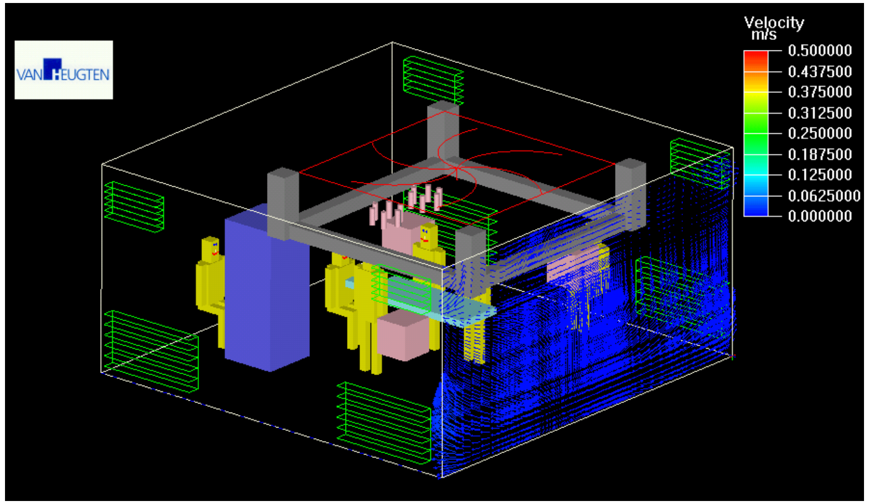

Photo: TNO Bouw, Animation: RTB Van Heugten, Bing Yu

Photo: RTB van Heugten

Photo: EGM Architecten

Photos: RTB van Heugten

0. Content of Presentation

1. Experiences from Building Practice

2. The need for a Renewable Energy Transition

3. From Sustainability to Cradle to Cradle and Beyond

4. From Beyond Sustainability to Circularity

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1. Experiences from Building Practice

Energy

Water

Materials

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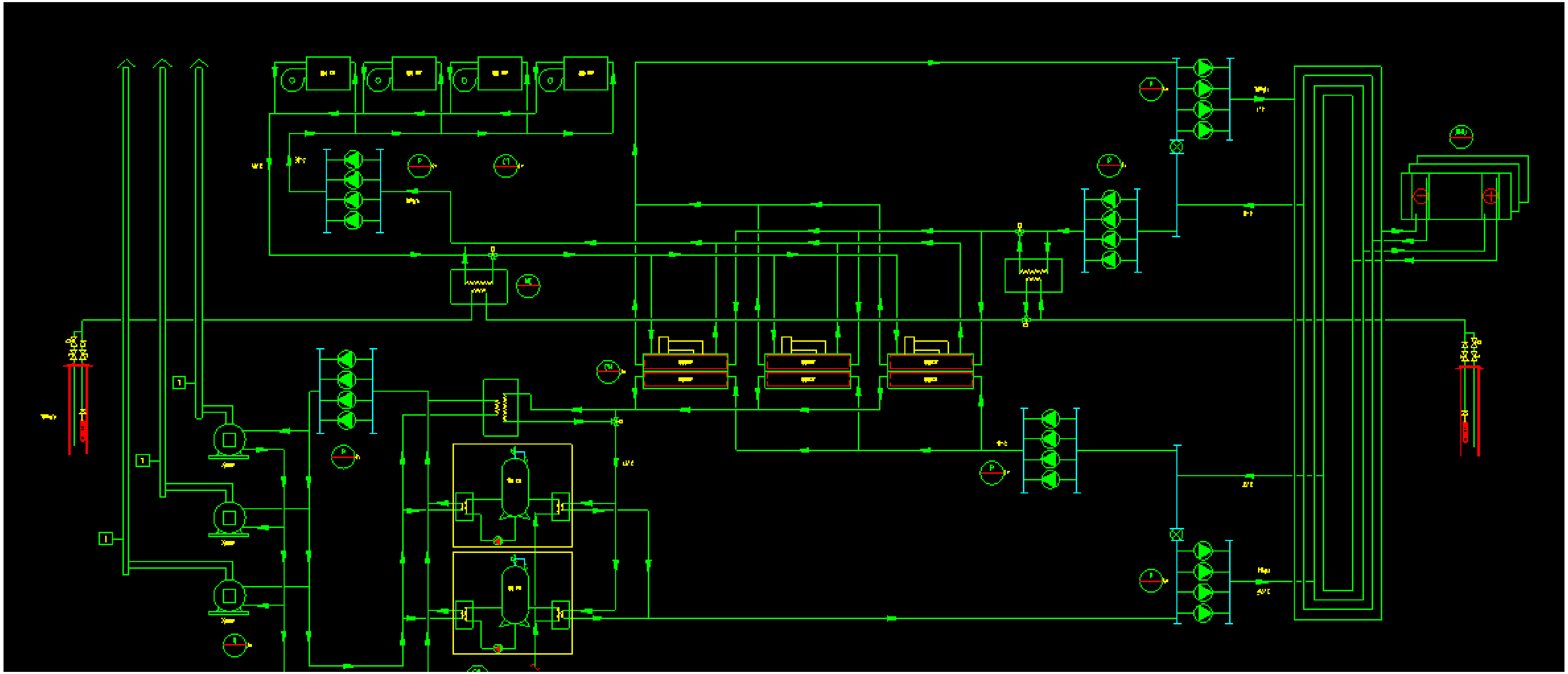
Energy in Building Projects

Source: Philips

Energy in Building Projects



Photos: RTB van Heugten

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Energy in Building Projects

	Maatregel	Toepassing/situering op:	Indicatie omvang t.o.v. totale energiegebruik van het Erasmus MC	Financieel [a]) (Meer)investering [a]) [€ 1.000,--]	Voordeel [€ 1.000,-- / jaar]	Terugverdientijd (SPOT) [b]) [jaar]	Terugverdientijd bij max. subsidies [jaar]	Milieu: Besparing CO_2 [ton/jaar]	Besparing CO2 t.o.v. totaal uitstoot	Totaal: Financieel	Milieu	PR	Relaties met andere aspecten van de nieuwbouw
Referentie	Conventioneel	in gebouwdelen	100% (cv+elektr.+stoom+koude)	referentie			n.v.t.	n.v.t.	n.v.t.	O	O	O	Geen
Referentie	Stadsverwarming [1])	onder de grond	100% c.v.	"niet meer (en ook niet minder) dan anders"			n.v.t.	628	1%	O	+	O	Geen
Duurzaam	Zonne-energie thermisch [2])	1240 m² dak	2% c.v.	465	20	23	21	182	0,3%	-	+	+	Techniek en groen op daken
Duurzaam	Zonne-energie elektrisch [3])	250 m² zonwering, 2.500 m² dak, 500 m² gevel	1% elektriciteit	1.550	39	40	20	177	0,3%	-	+	++	Achitectuur Techniek en groen op daken
Duurzaam	Windenergie [3])	O.b.v. 100 x vermogen Turby-windmolen op dak	1% elektriciteit	653	26	25	13	176	0,3%	-	+	++	Achitectuur Techniek en groen op daken
Duurzaam	Warmtepompen [3])	in gebouwdelen	8% c.v.	1.200	91	13	12	736	1,2%	-	+	+	Geen
Duurzaam	Bodemopslag (met warmtepompen) [1])	onder de grond, in gebouwdelen	41% c.v. 67% koude	3.200	453	7	4	3.679	6%	+	+	++	Locatie bronnen en leidingen
Duurzaam	Brandstofcel [4])	in gebouwdeel	3% c.v. 3% elektriciteit	2.256	54	41	17	241	0,7%	-	++	++	Geen
Efficiënt	Afkoelen rookgassen stoomketel [1])	in gebouwdelen	4% c.v. (= netto besparing)	260	36	7	7	396	0,7%	+	+	O	Geen
Efficiënt	Warmte/kracht-koppeling [1])	hoogbouw Faculteit, spin off zone	28% c.v. 35% koeling 56% stoom 86% elektriciteit	6.400	1.066	6	4	5.058	8%	+	+	O	Locatie

[1]) Globale omvang in relatie tot totale energiebehoefte Erasmus MC
[2]) Globale omvang op basis van potentie nieuwbouw
[3]) Globale omvang op basis van potentie tranche 1 van de nieuwbouw
[4]) Demonstratieproject met omvang op basis van één eenheid
[a]) De genoemde investeringsbedragen zijn exclusief staartkosten (circa 20%). Tevens is er geen rekening gehouden met een eventuele bijdrage van subsidies.
[b]) SPOT = simple pay out time = (meer)investering t.o.v. Referentie / Jaarlijkse kostenbesparing t.o.v. Referentie (=terugverdientijd)
[c]) m³ aardgas equivalent: het aardgasverbruik van de ketels + het aardgasverbruik in de elektriciteitscentrale om de benodigde elektriciteit op te wekken
[d]) PR-functie op basis van geschatte nieuwswaarde, niet zichtbaar voor publiek
[e]) Bij het indienen van definitieve subsidieaanvragen dient rekening te worden gehouden met maximale cumulaties tussen subsidieregelingen en Europese wetgeving ten aanzien van maximale subsidies per project. Naast subsidiemogelijkheden voor de investeringen bestaat in een aantal gevallen de mogelijkheid subsidie te verkrijgen voor de uitvoering van haalbaarheidsstudies.

$kWh/m^2.y$	1991 *)	2009 **)
Heat	95	115
Cold	69	55
Steam	59	57
Electricity	128	134
Total	**351**	**361**

Energy data for academic hospitals in the Netherlands (RTB Van Heugten)
1991 *) Operational data academic hospital (228.000 m^2)
2009 **) Design values for renewed academic hospital (409.840 m^2)
2016 Total still ≈ 278 $kWh/m^2.y$

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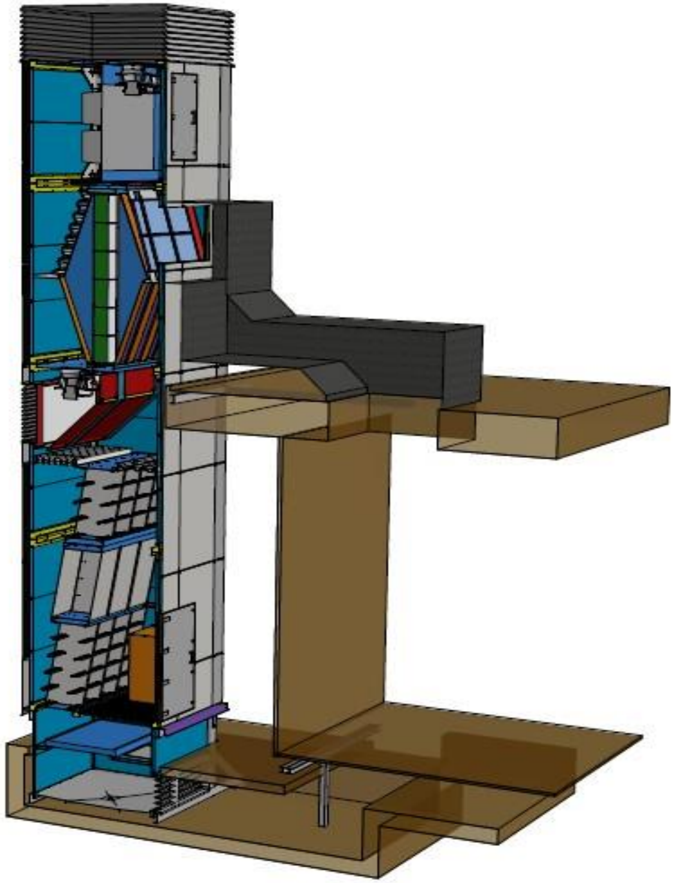
Energy in Building Projects, Converge

Photo: Tim Jonathan



Source: Van Dorp Installaties

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Energieverbruik gebouwen op TU Delft campus

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Source: Tim Jonathan

Water in Building Projects

Photo: Pharmafilter

From sewer system to near drinking water quality

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Materials in Building Projects

Photo: Philips

Photo: Flip Franssen

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Photo and movie: Maria Koijck

Experiences from building practice

Indoor Air Quality:

High Energy Consumption @ Micro electronics, Hospitals and Museums versus Converge

Water quality hospitals:

Sewer to drinking quality is possible

Material consumption health care:

Excessive

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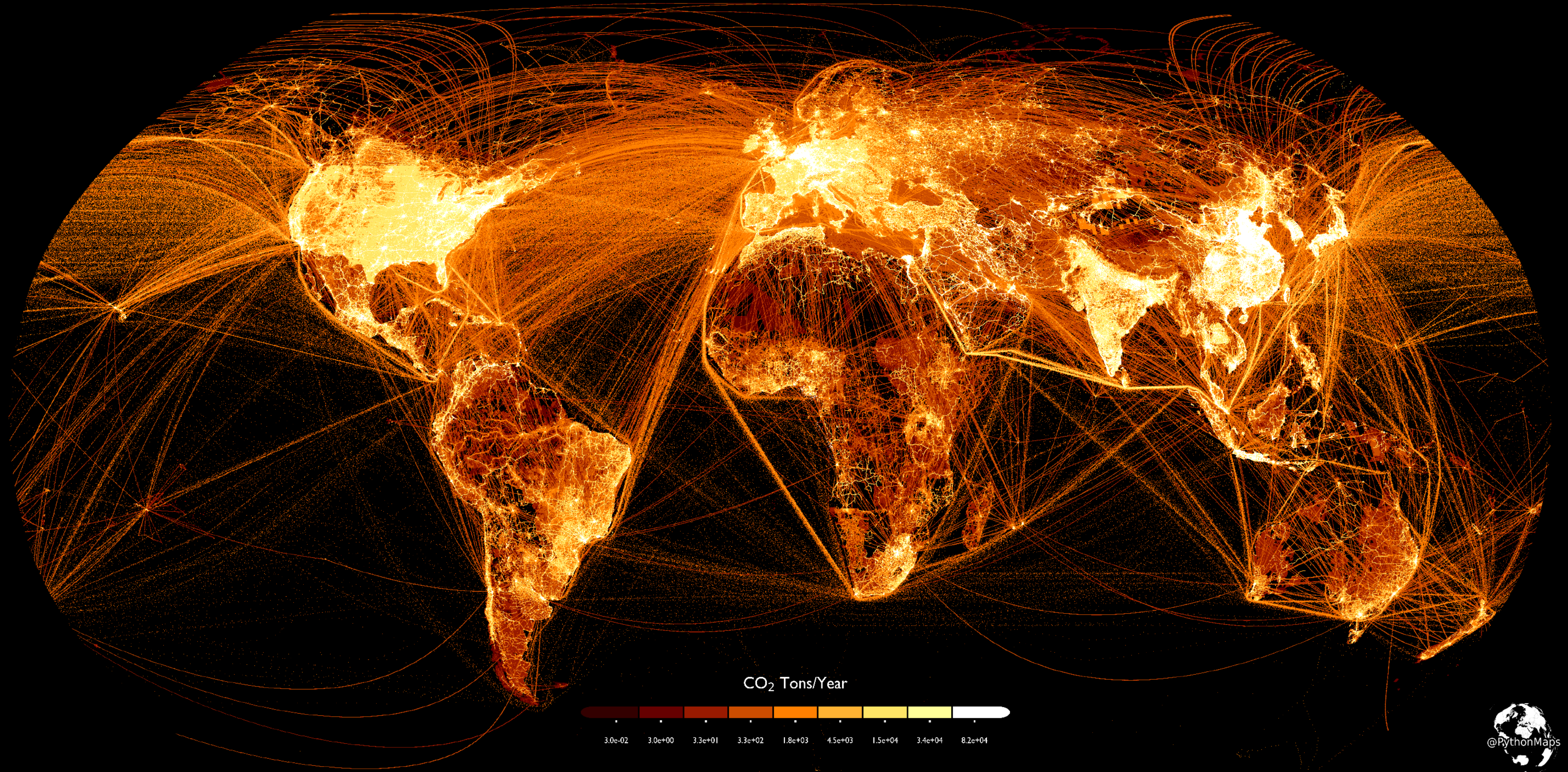
2. The need for a Renewable Energy Transition

Climate Change

Temperature Anomalies

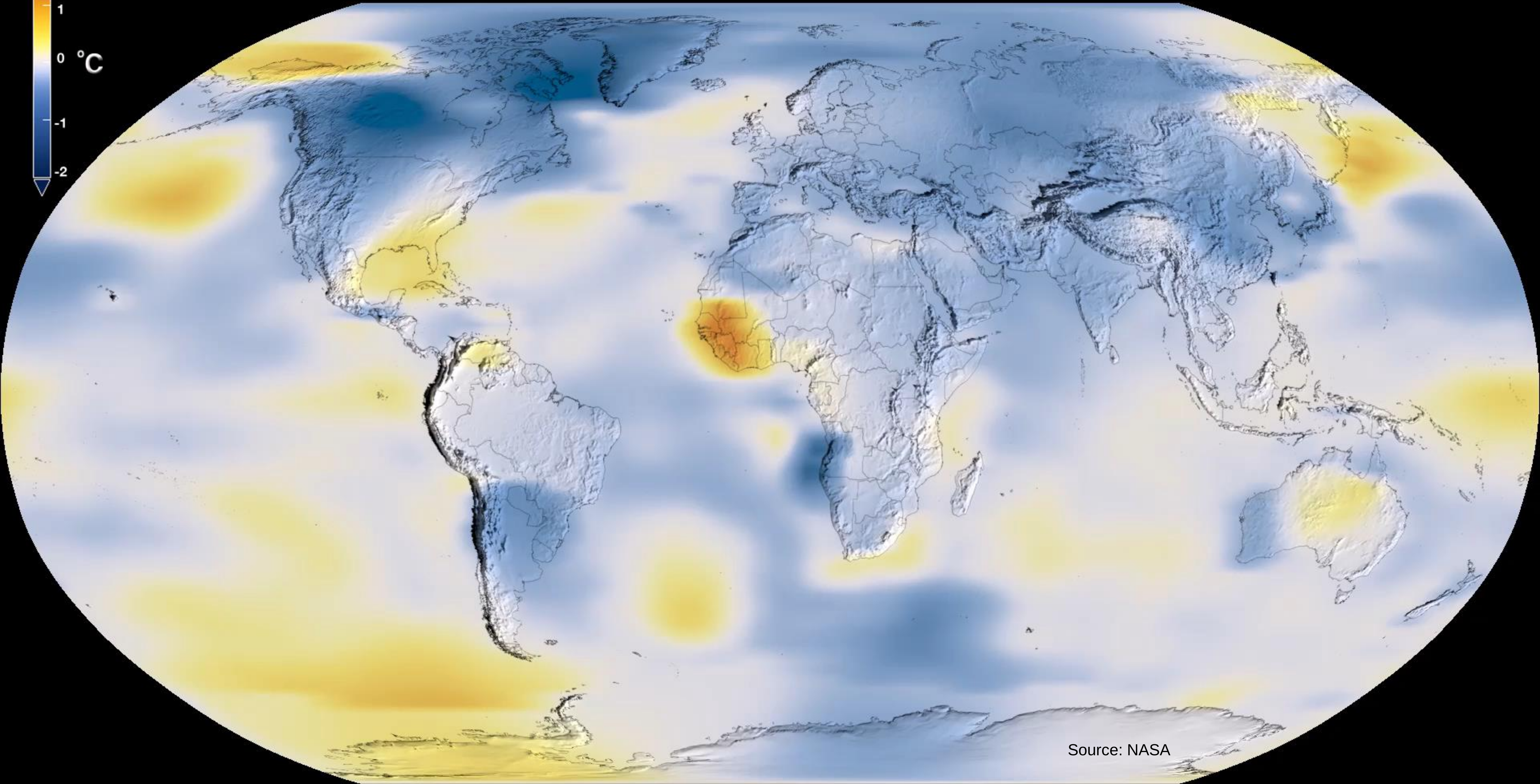
Artic Melt



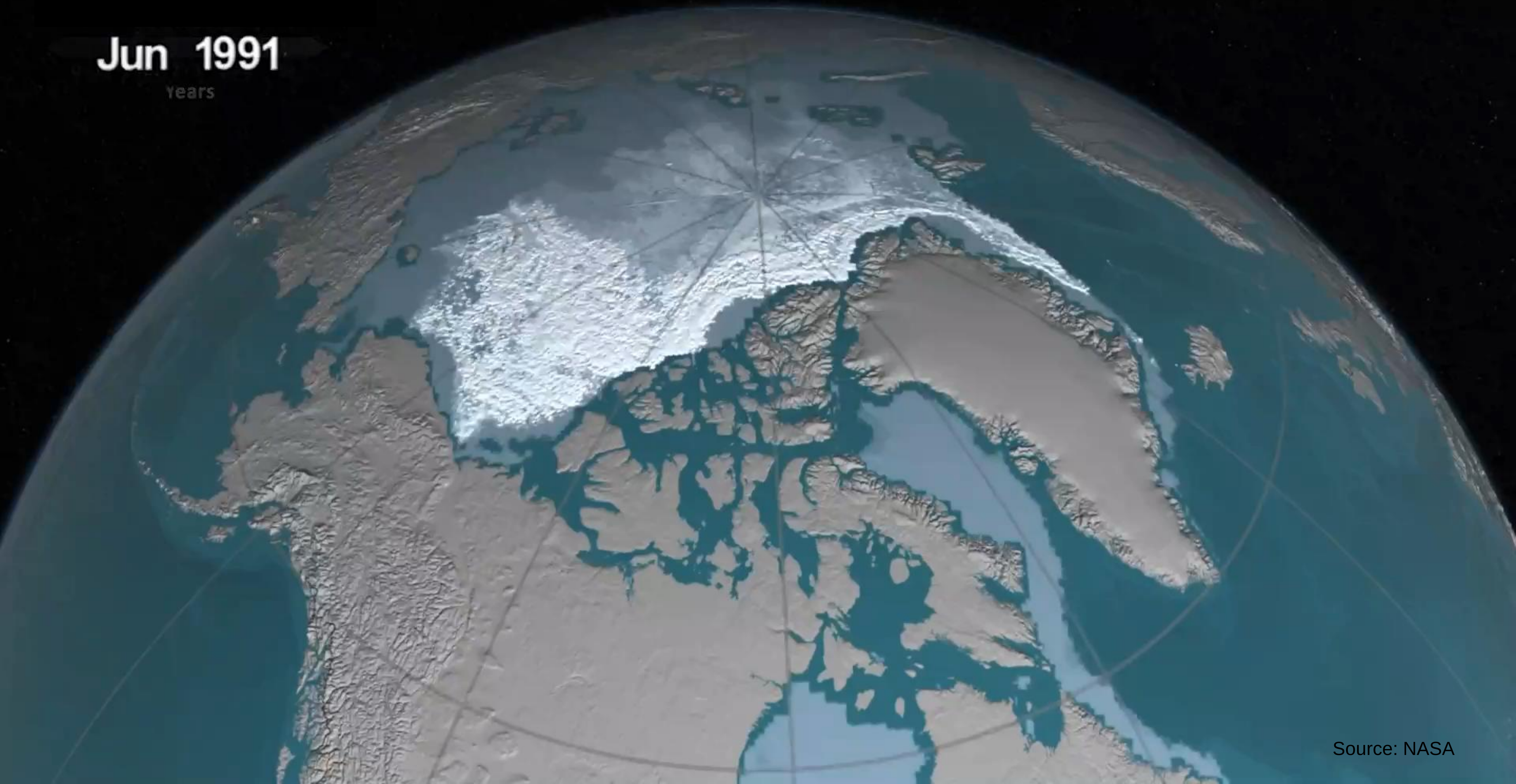
CO_2 Emissions. @PythonMaps
This map shows the world's CO_2 emissions and shows tonnes of CO_2 within 0.1x0.1 degree grid tiles in 2018.
Data source - https://edgar.jrc.ec.europa.eu/dataset_ghg60

Source: Adam Symington

1880 - 1884



Artic Melt, 1991 – 2016



Source: NASA

Failing to agree on climate action would [‘not only be immoral’ but ‘suicidal’], UN chief António Guteris tells COP24N

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3. From Sustainability to Cradle to Cradle and Beyond

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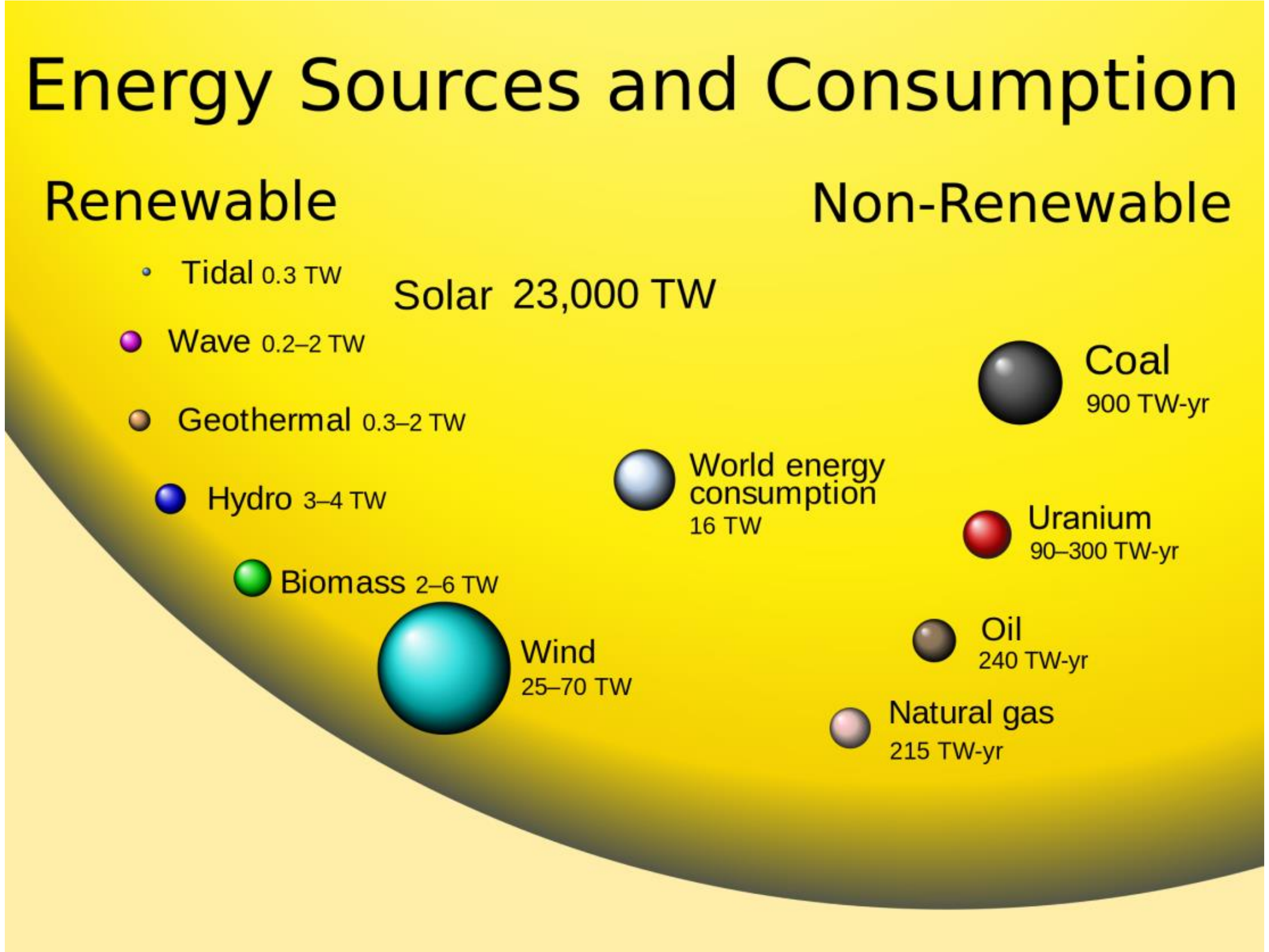
Sustainability, natural resources

Cradle to Cradle

Positive Footprint

Co-Benefits

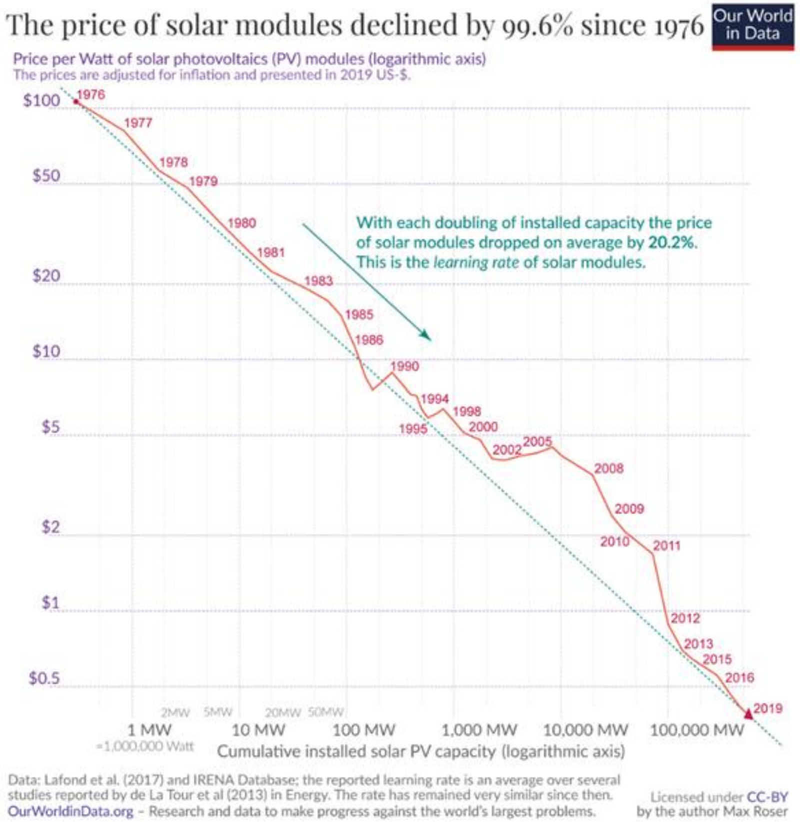
Sustainability, Energy

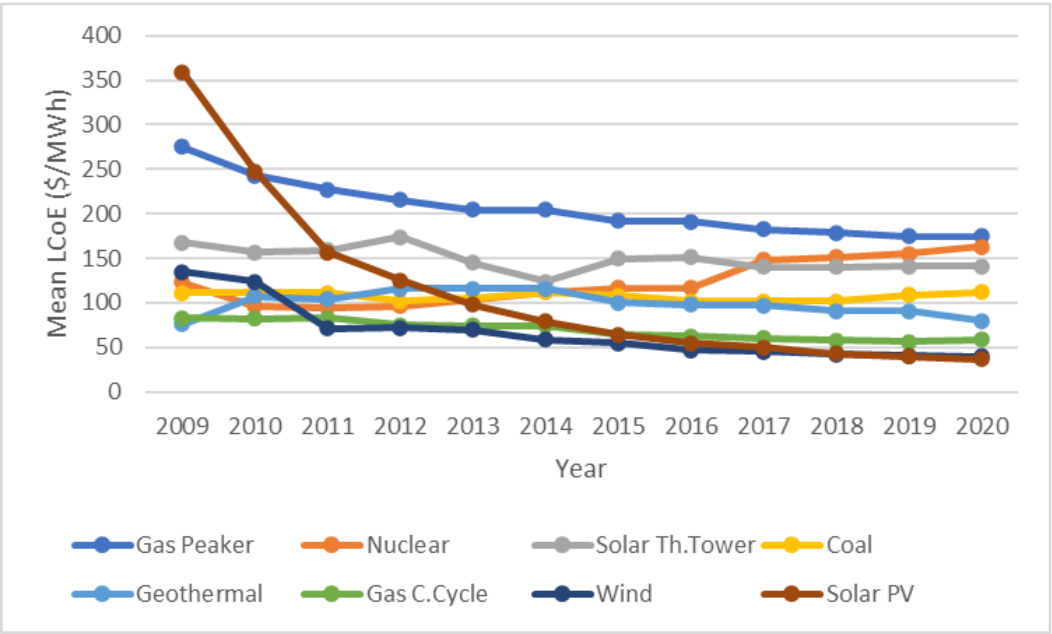


Source: Richard Perez* & Marc Perez, A FUNDAMENTAL LOOK AT ENERGY RESERVES FOR THE PLANET (2009)

Sun and wind can power the whole world many times over

Sustainability, Energy and costs





Source: Lazard (2020)

Bids for energy from sun- and wind parks nears 0.01 $/kWh
At this level **renewables will outcompete Fossils!**

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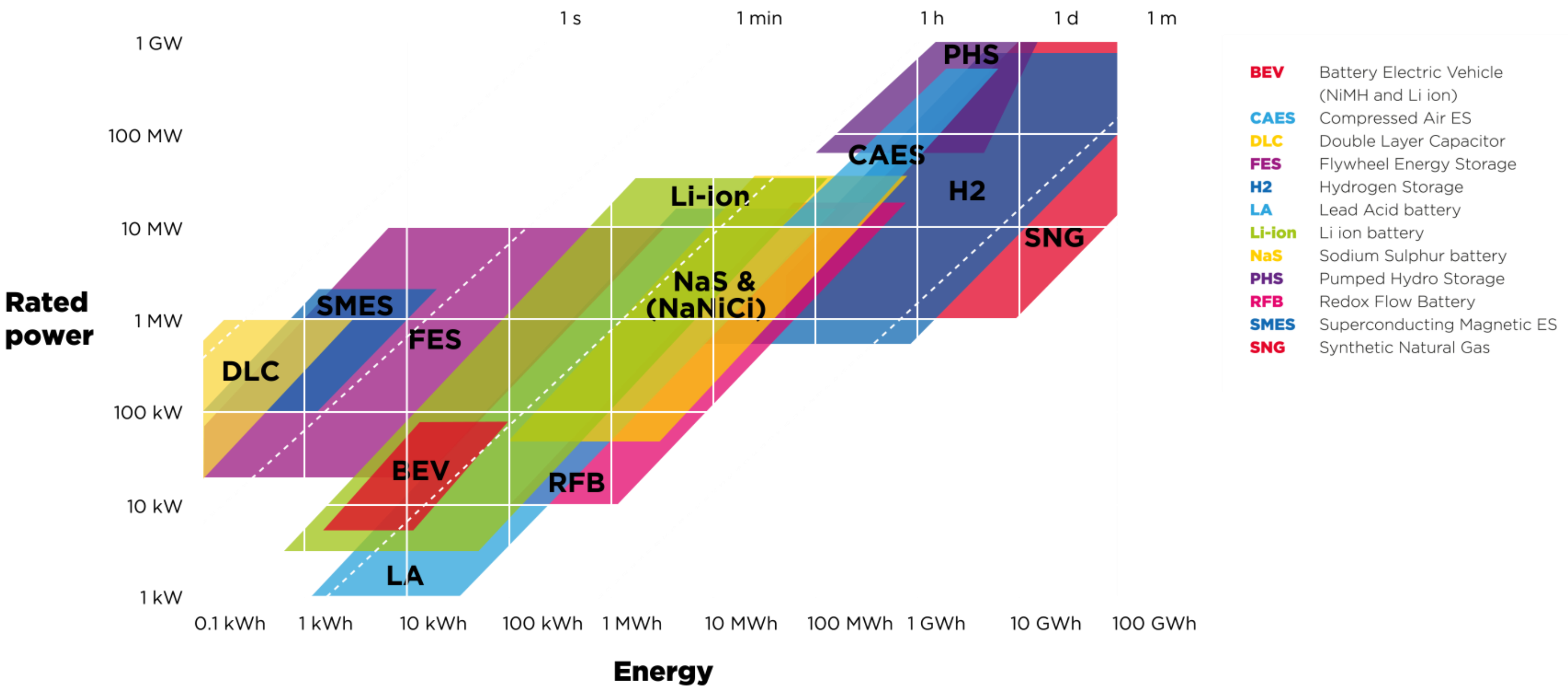
Sustainability, Energy and Storage



Source: Marco Bijkerk

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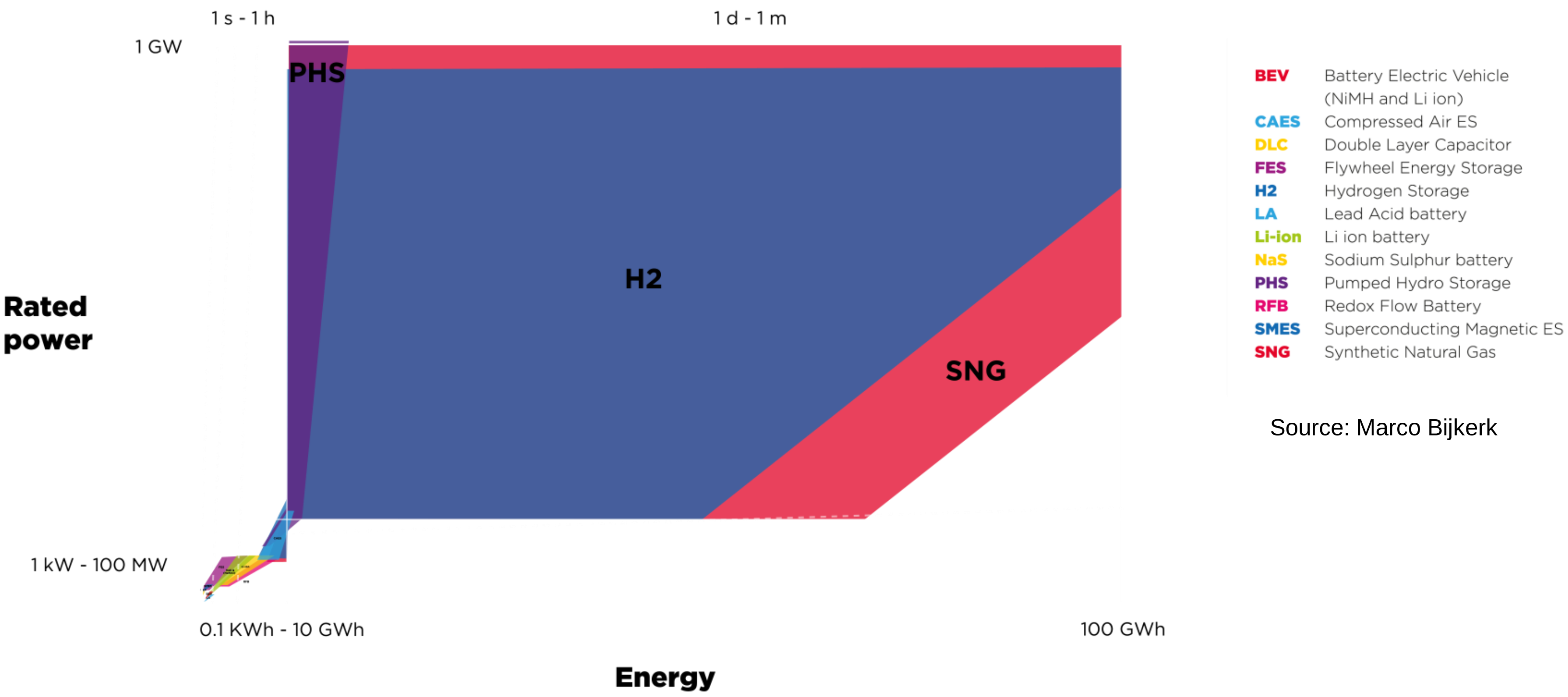
Sustainability, Energy and Storage



Source: Marco Bijkerk

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Hydrogen based energy storage is the most promising, **if not the only possibility**, for decarbonized energy storage over longer time periods

Sustainability, Water, Global average water footprint

	Serving	Water (l)
	250 ml	27
	250 ml	74
	125 ml	109
	125 ml	132

	Serving	Water (l)
	250 g	50
	150 g	80
	150 g	125
	200 g	160

	Serving	Water (l)
	60 g	200
	100 g	433
	100 g	599
	100 g	1.540

Source pictures and data: https://waterfootprint.org/en/resources/interactive-tools/product-gallery/

Sustainability, Air

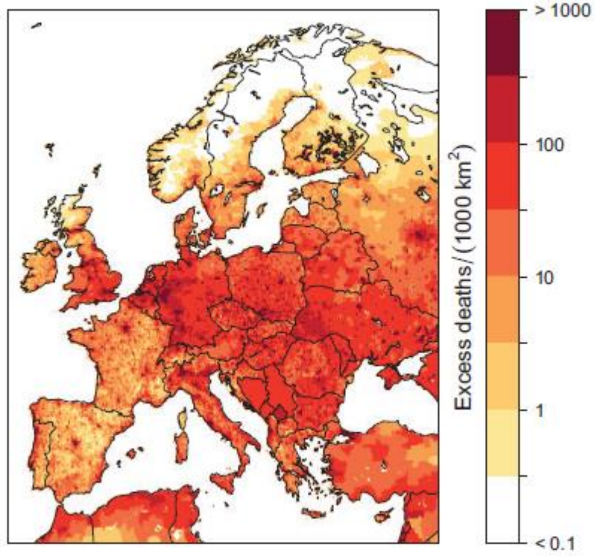

Figure 2 Regional distribution of estimated annual excess mortality rates from cardiovascular diseases (CVD = IHD + CEV) attributed to air pollution. These rates are lower limits as other non-communicable diseases are not included.

Source: European Heart Journal (2019) 40, 1590–1596

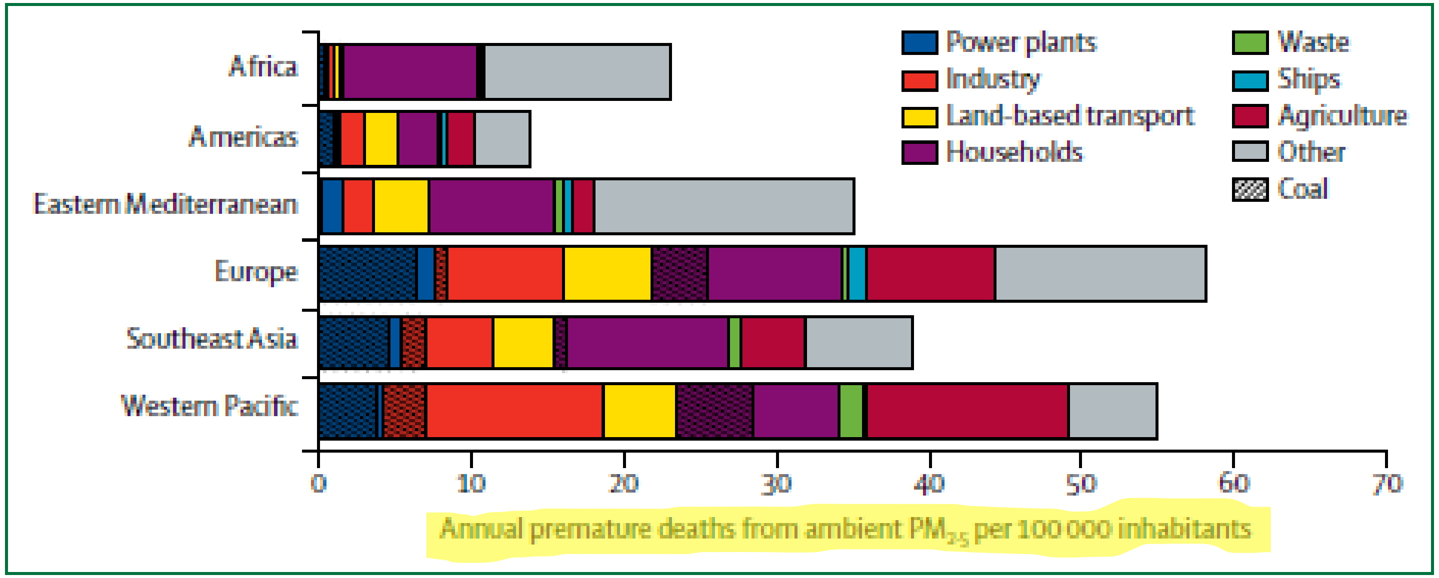

Figure 18: Health impacts of exposure to ambient fine particulate matter ($PM_{2.5}$) in 2015, by key sources of pollution by WHO region

Coal as a fuel is highlighted by hatching. Country aggregations correspond largely to WHO regions, except for small exceptions (appendix). $PM_{2.5}$=atmospheric particulate matter with a diameter of less than 2·5 μm.

Source: Lancet 2018; 392: 2479–514

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Sustainability, Topsoil

- 50% is lost in the last 150 years (WWF)
  - "Half of the topsoil on the planet has been lost in the last 150 years. In addition to erosion, soil quality is affected by other aspects of agriculture. These impacts include compaction, loss of soil structure, nutrient degradation, and soil salinity. These are very real and at times severe issues."

Desertification

Deforestation

'Blowing in the Wind'

Source: https://www.worldwildlife.org/threats/soil-erosion-and-degradation

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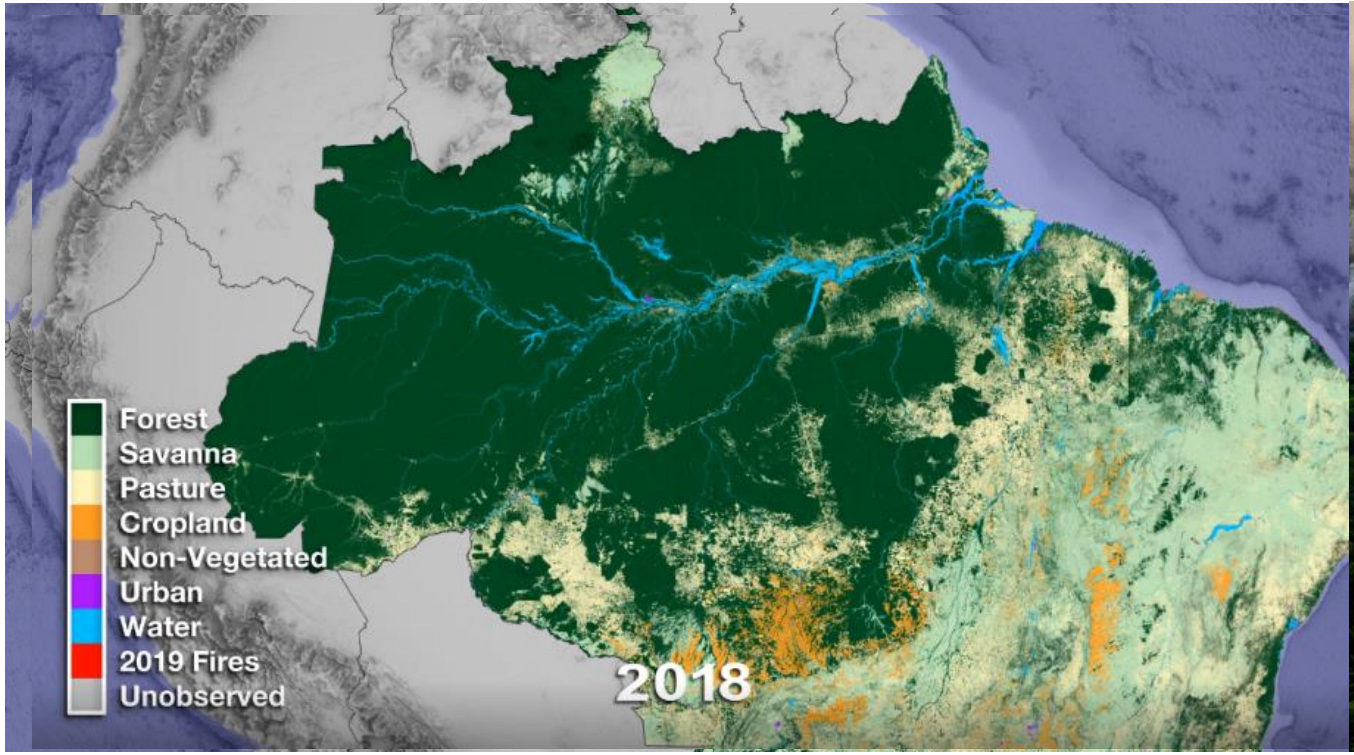
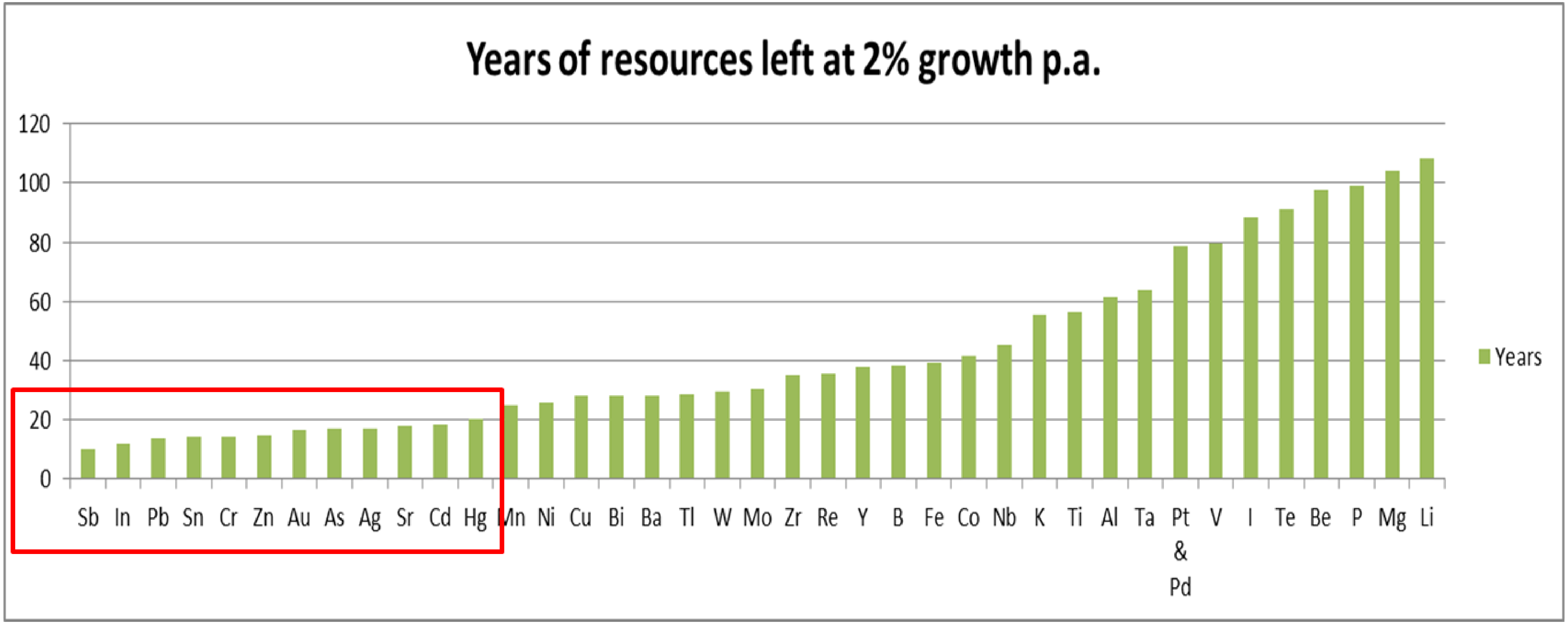
Sustainability, Biological materials



Amazone 1985-2018

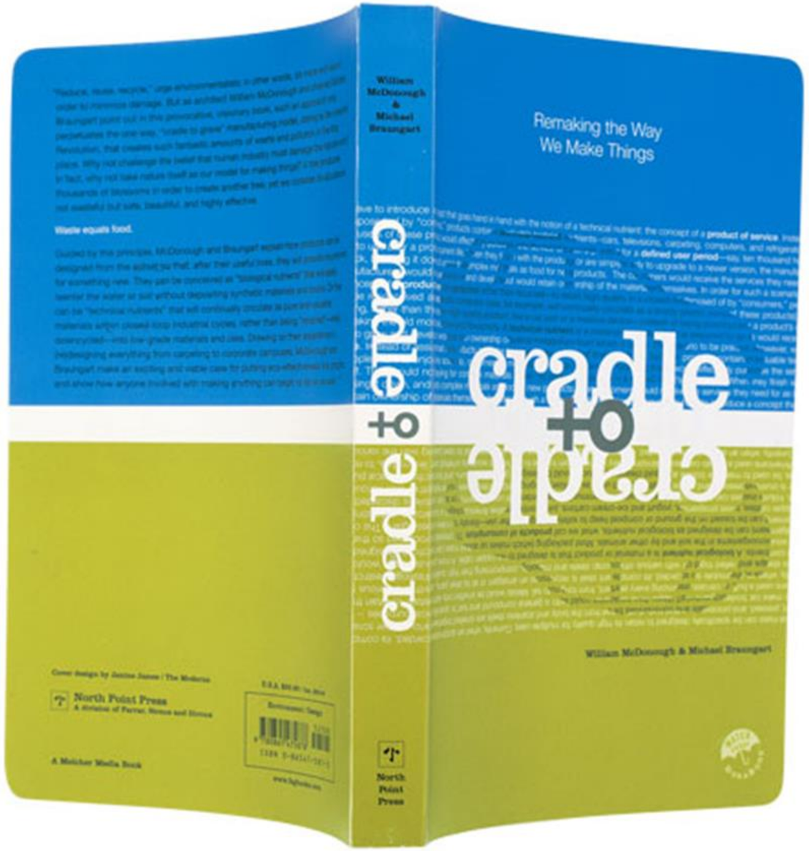
Wildfire

Sustainability, Technical Materials



Source: PG Luscuere after AM Diederen

Sustainability, Cradle to Cradle



Three Doctrines
Waste equals food
Use current solar income
Celebrate diversity

Michael Braungart @
Cradle to Cradle lab @ Bk

Sustainability, Environmental Challenges / Solutions model

Beyond Sustainability

Values / Re-sources	Ecology			Economy			Equity		
	Biodiversity	Health Effects	Climate Change	Scarcity	Cost / Benefits	PR Metaphor	Social Responsibility	Fairness	
Energy	SO_2 NO_x Acid Rain	NO_x $PM_{2.5}$	CO_2 CH_4	Fossil fuels	Pay Back Time *********** Life Cycle Analysis *********** Total Cost of Ownership *********** Life Cycle Costing *********** Hard & Soft Costs and Benefits *********** Co-Benefits	'Net Positive'	Energy Positive Buildings	Climate Change Consequences	Coal Powered Electricity ************ Child Labor ************ Increasing Inequality ************ non-Inclusivity ************ Resource Depletion ************ 'Externalised' Costs ************ Rampant Environmental Pollution ************ Flooding of lands ************ Burning Tropical Forest
	Solar, Wind, Hydro, Geothermal, Wave & Tidal Energy and (High Productive) Biofuels (eg Algae)								
Air	SO_2	SO_2 NO_x O_3 CO $PM_{2.5}$ PM_{10}	CO_2 CH_4	Clean Air		'Every Breath We Take'	Actively Cleaning Buildings	Global burden of disease / DALY's	
	Limit fossil emissions of transport and energy systems. Apply filtration in buildings, metabolize particles by vegetation, use TiO2 coatings								
Water	Contaminated Water	Hormones & Medicines	Rising Sea Level	Fresh Water		'Clean'	Cleaner Discharge as Intake	Geo-Political Governance (lack of)	
	Local Cleaning (Reed filters), use of Algae, Nutrition Regeneration								
Materials	Waste *)	Hazardous Emissions	Chlorofluoro-carbons	Virgin Materials		'Healthy'	Waste as Resource & Endless Recycling	'Securing' Resources	
	Non-hazerdous Substances, From Down- to Re- and UpCycling								
Topsoil	Loss, Degradation & Compaction **)	Contamination	CH4 - Emissions	Phosphate		'Fertile'	Positive Contribution to Top Soil Quality	Displacing Arable Land by BioFuels	
	Apply Green Roofs & Walls, Close Continuous Cycles, Recover Nutrients, Apply local solutions & Large Scale Eco-Rehabilitation								
Space	Expulsion of wild life	Proximity heavy industry	Energy/Food Production	Scarcity in densly used areas		'Available'	Responsible multiple use of space	'Supergrid' or 'Soft Diplomacy'	
	Multiple use of space; Fair, economic and ecologically sound consideration of alternatives where conflicts arise								

*) Toxic-, Carcinogenic-, Mutagenic, etc. **) Specific for The Netherlands

Environmental Challenges / Solutions / model v15.7, PG Luscuere & WM Luscuere & SC Jansen, May 2021

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Cradle to Cradle, Positive Footprint

Source: Douglas Mulhall

Forget about saving/reducing to ‘nearly zero’, but make a **net positive** contribution!

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BUILDINGS LIKE TREES

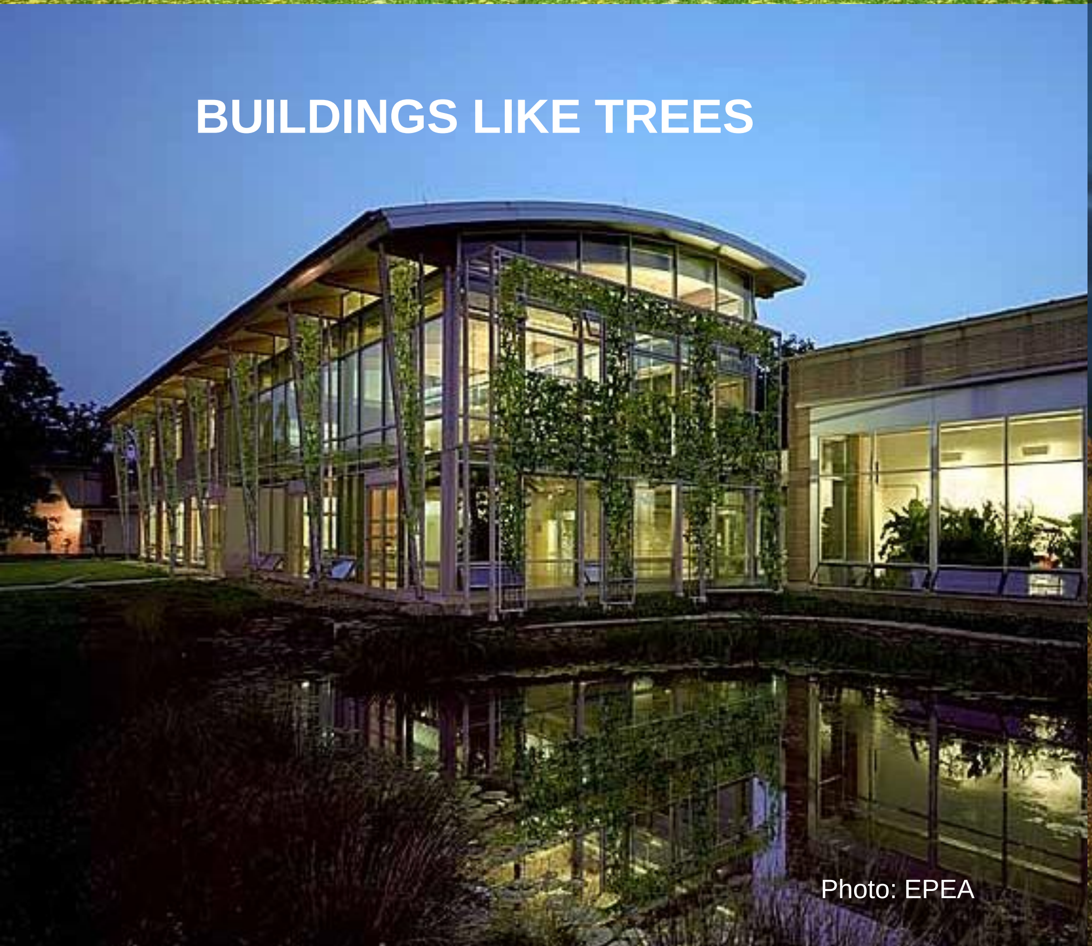

Photo: EPEA

CITIES LIKE FORESTS

Source: Lateral Thinking Factory

Sustainability, Co-Benefits

Photos: EPEA

Sustainability, Co-Benefits

By widening the view on interventions in the built environment often other shareholders can be identified with **monetizable interests**.

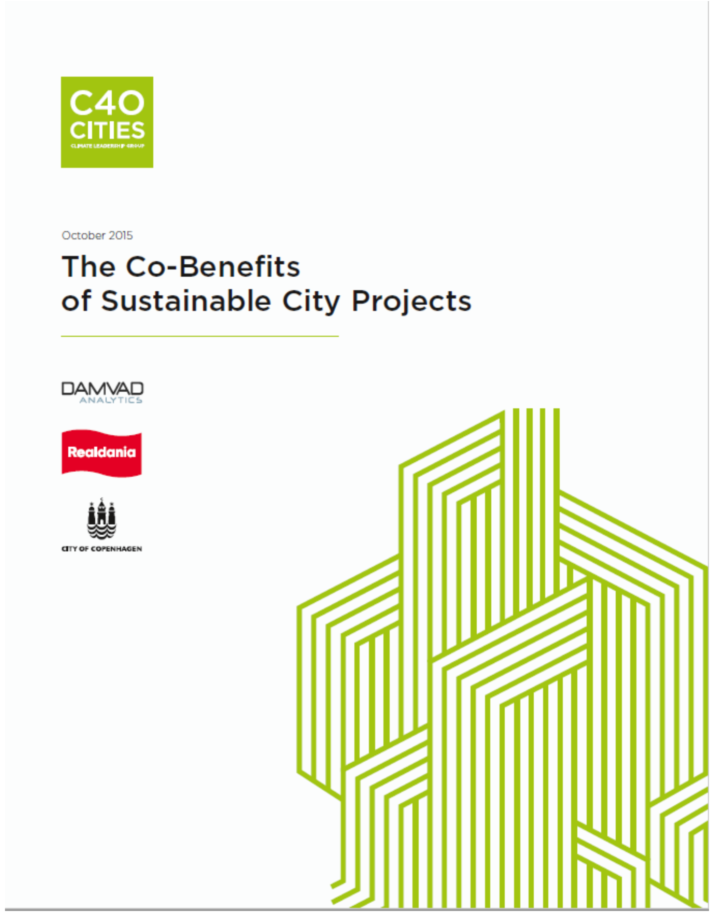

TABLE 5.1 NET BENEFITS, CONGESTION IN LONDON

Source of benefit	Loss/gain (million USD per year)
Private benefits	64
Travel time and reliability (charge payers)	473
Car operating savings (charge payers)	51
User charge and compliance costs (charge payers)	-464
Reduced crowding (bus passengers)	78
Deterred trips	-56
Private parking revenues	-18
Society benefits	31
Accidents	25
CO_2 emissions	4
NOx and PM (Particulate Matter)	2
Government benefits	85
Charging	231
Fuel duty	-49
VAT	-25
Additional buses	2
Infrastructure	-45
Parking revenues	-27
TOTAL	**180**

Source: Evans 2007

Note: Average currency exchange rate for 2005 has been used between British Pounds and US Dollars. The exchange rate was 0.55 GBP for 1 USD.

Source: Realdania

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4. From Beyond Sustainability to Circularity

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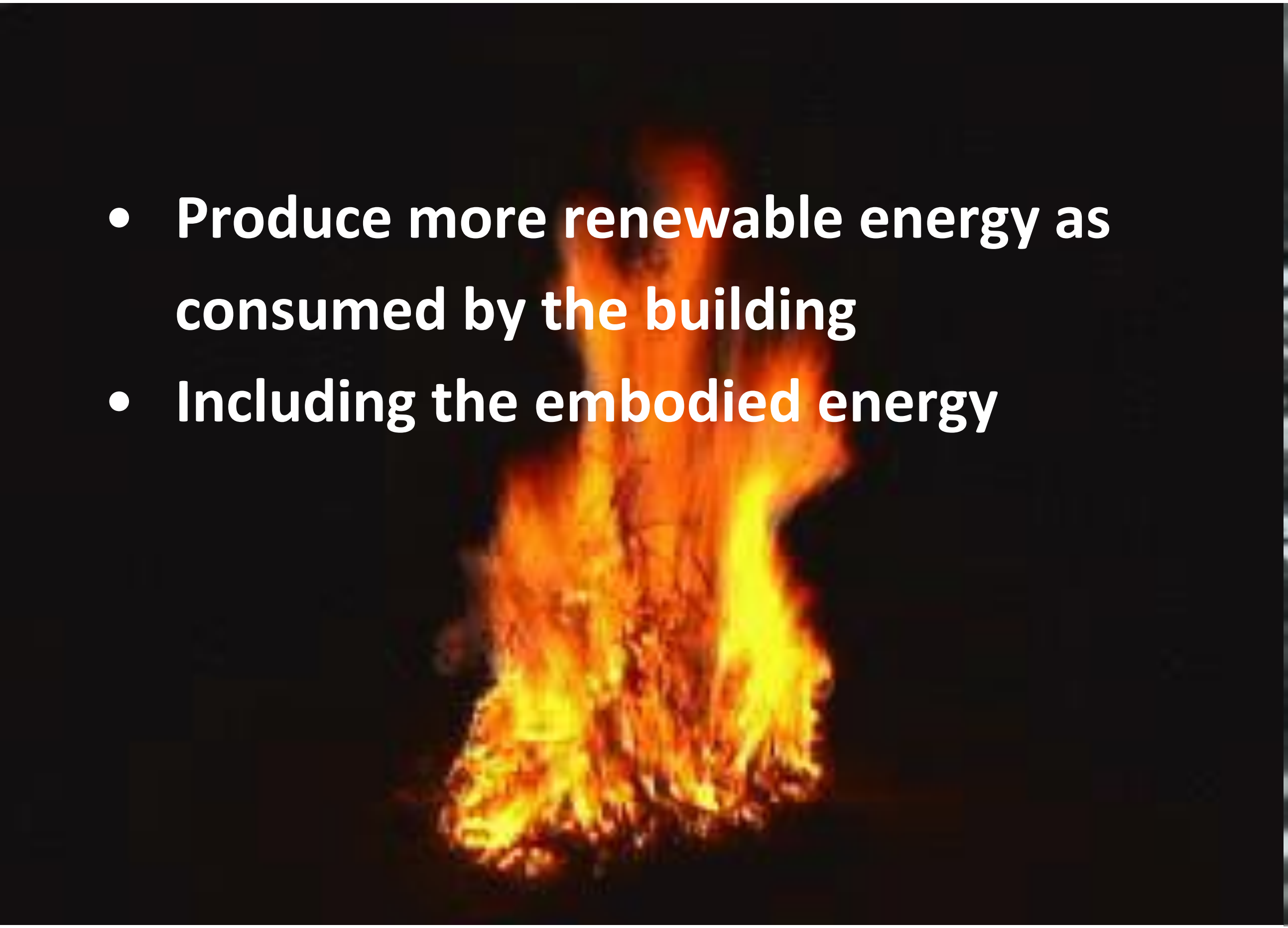
Beyond Sustainability

Circularity

Sustainable Abundance?

Limits to a Renewable Energy Transition

Beyond Sustainability, Energy and Water



- Produce more renewable energy as consumed by the building
- Including the embodied energy

- Produce locally a better water quality out as in

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Beyond Sustainability, Air and Topsoil

- **Produce locally a better air quality out as in**

- **Improve Topsoil quality, based on local threats: erosion, compaction and organic matter content (Dutch scale)**

- **Eco-systems rehabilitation (world-scale)**

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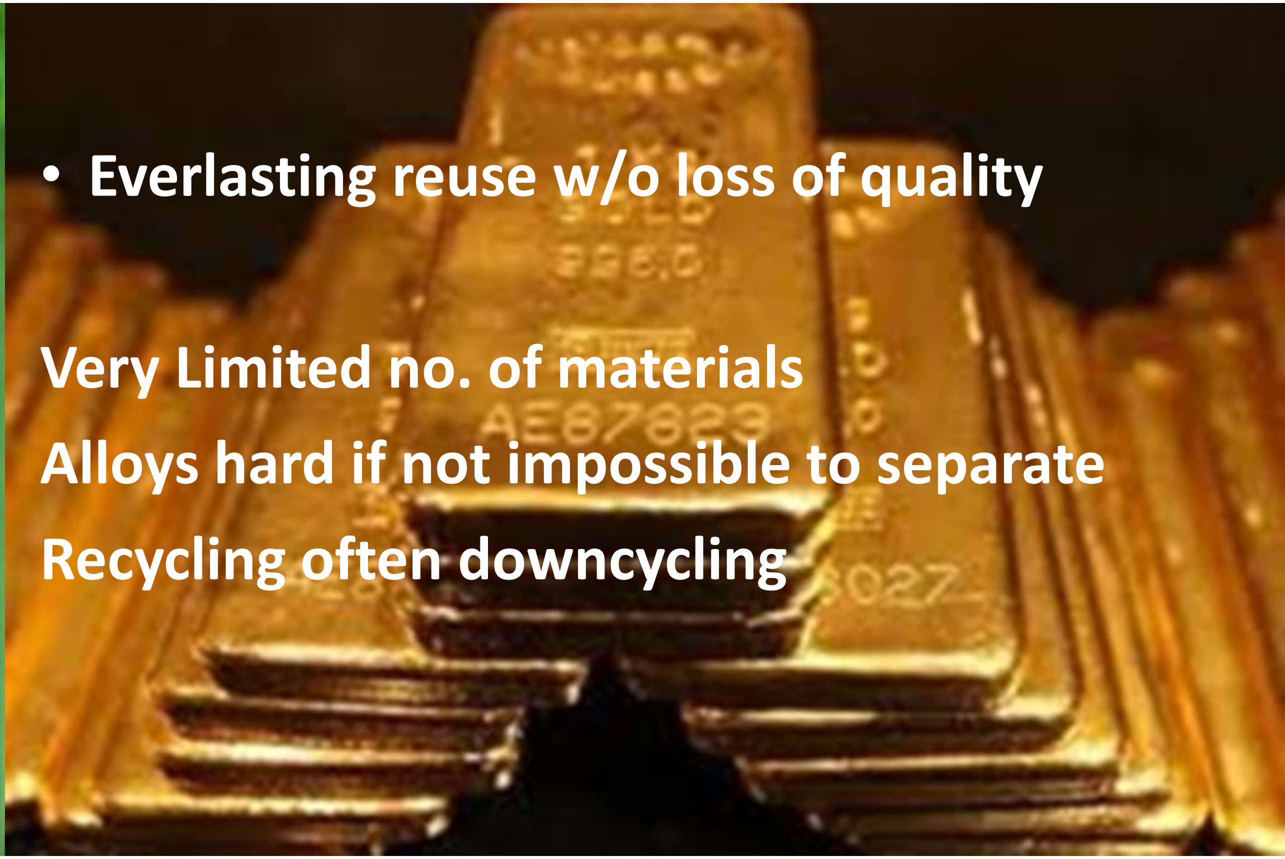
Beyond Sustainability, Biological and Technical Materials

- See Waste as Resource:

e.g. CO_2 as a resource, food: Urea, Bevarages, Decaffeinate, Greenhouses

CO2 as a resource, industry: Polycarbonates, CO2 to CH4 , Thermodynamic cycles, Biofuel / Biomass



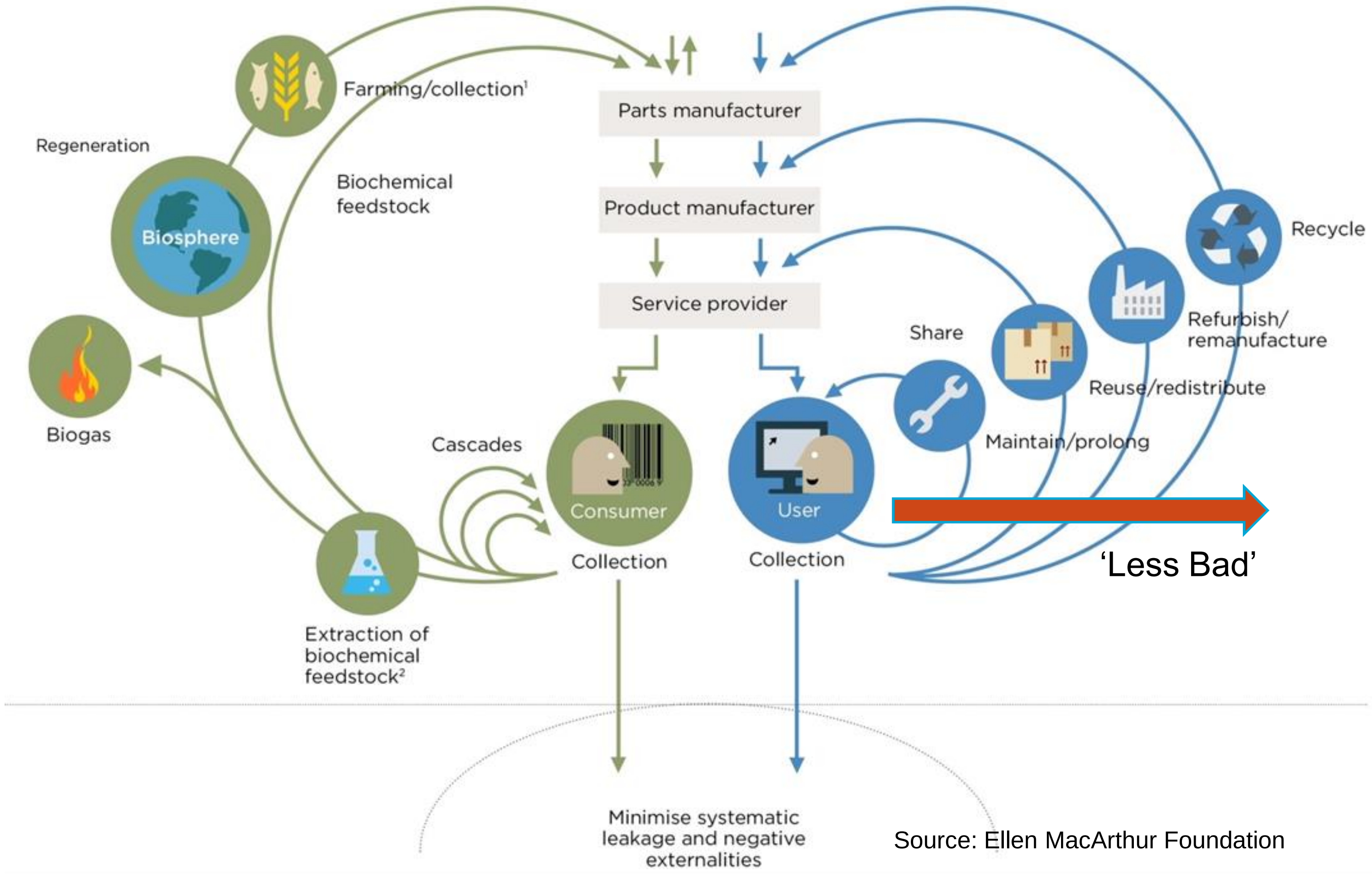
- Everlasting reuse w/o loss of quality

Very Limited no. of materials

Alloys hard if not impossible to separate

Recycling often downcycling

Circularity



Source: Ellen MacArthur Foundation

In nearly all cases:

Recycling = Downcycling

Circularity = Renewability

For All Resources

Circularity

- **Energy should come from a renewable source**
- **Air, water, and fertile ground must be cleanable to start quality**
- **Biological materials may be used only to the point that nature can grow them back**
- **Technical materials should be everlasting recyclable**
- **Space should be reusable without loss of quality or quantity**

Lessons for Health Care

- **Be inspired Beyond Sustainability!**
- **Energy: Reduce, Renew, and be Positive!**
- **Air and water: Reduce and Produce cleaner out as in!**
- **Technical materials: Reduce, Recycle and consider Biological materials**

Technical Materials and Building Services Industry

- Building Services in Utility Buildings: 30-50% investment costs
- Mainly composed of high-quality technical materials
- Life-span of these systems: 10-15 years

- Building Services Industry carry great responsibility to deliver on circularity!
- Integrated approach over whole industry is essential!

Technical Materials are not the only Limiting Factor

- From today in 2022 to

  2030: 2.089 workdays (50% Circular)

  2050: 7.309 workdays (100% Circular)

“The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom.“

Isaac Asimov

Sustainability and Beyond
A Challenge for
Health Care

PG Luscuere, March 24th 2023

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