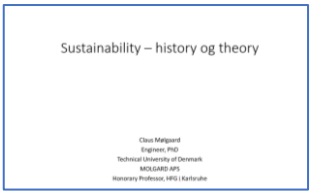
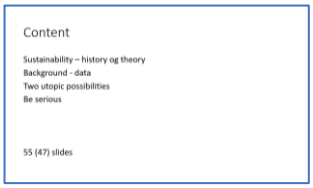
Notes

Sustainability – history and theory

Slide 1 

My name is Claus Molgaard am a mechanical engineer and hold a PhD in environmental science. I am working at DTU's Centre for Absolute Sustainability, and also an honorary professor at HFG in Karlsruhe. Besides that, I have a consulting company named MOLGARD APS.

Slide 2 

Content

First, we will talk about history and theory.

Then we will talk a lot about background and data.

We will look into two utopic possibilities.

Slide 3 

Three hundred years: 1700 – 2022

From philosophy to business

Philosophy – research – institutionalize - business.

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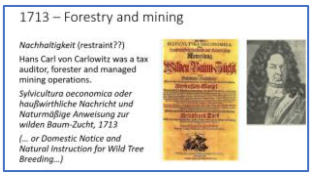
The idea of sustainability is first written 1713 with the German word “Nachhatigkeit”. Hans Carl von Calowitz was both responsible for a forest and a mine. Von Carlowitz figured out that if he were running the mine too hard, he could not grow enough wood in his forest and sooner or later he would not be possible to run the mine.

In 1798 Malthus and Ricardo argued that the problem was about the growth in population, which was some of the same argument we saw in the middle of the last century.

The German Alexander von Humboldt argued that we are all connected as nature.

Gifford Pinchot did have similar thoughts as Carlowitz and came up with a sentence, which is very similar to the later definition by Brundtland.

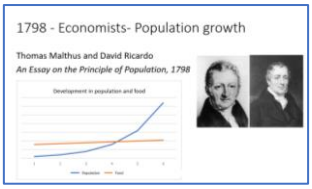
George Perkins Marsh and Nathaniel Southgate Shaler argued that people were influencing nature.

Slide 5 

Hans Carl von Carlowitz was a tax auditor, forester and managed aa mine.

In 1713 he was the first person to use the German word **“*Nachhaltigkeit*”** as an expression for sustainability in the article *Sylvicultura oeconomica oder haußwirthliche Nachricht und Naturmäßige Anweisung zur wilden Baum-Zucht. (… or Domestic Notice and Natural Instruction for Wild Tree Breeding…)*

Von Carlowitz had the problem that if he were running his mine too hard, he could not produce enough wood in his forest, and they would both collapse.

Slide 6 

In 1798 the economist Thomas Malthus published his essay on the principle of Population. He argued that the growth of the population was exponential, and the growth of food production was linear – which means one day it would not be possible to produce enough food. Malthus did not think we should try to help the poor and weak as it would only make the problem bigger as the population would increase.

David Ricardo had similar thoughts. Not only for food production, but for all kinds of production. Ricardo is known for his **comparative advantage theory**, which shows how nations can gain by international trade advantage, when they focus on producing goods, which are produced at the lowest opportunity costs as compared to other nations.

Ricardo is also known for his “Iron law of wages”, where the wages is always pressed to a minimum.

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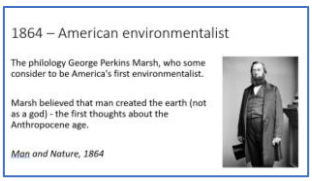
The German Alexander von Humboldt, who by some is considered to be the "inventor" of the nature, was a German scientist, explorer and, not least, a romantic.

Humboldt describes nature as a net where everything is connected, including humans.

He was supposed to have predicted climate change in the 19th century.

His work is published Views of Nature, 1808

Slide 8 

The philology George Perkins Marsh, who by some is considered to be the first American environmentalist.

Marsh believed that “man” created the earth (not as a god) - the first thoughts about the Anthropocene age.

Man and Nature, 1864

Slide 9 

The paleontologist and geologist Nathaniel Southgate Shaler.

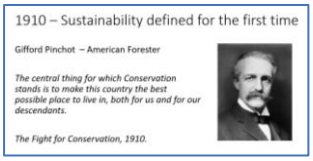
Flooded areas in the eastern part of United States and dry areas in the western part of United States led to his thoughts about human influence on the earth.

Nature and Man in America, 1891.

Shales was maybe not the nicest person in history. In the beginning of Shalers academic career he didn't believe in Darwins Theory, as also his professor on Harvard didn't.

When he later became professor at Harvard, he changed his mind.

Furthermore, Shaler was an apologist for slavery and an outspoken believer in the superiority of the Anglo-Saxon race.

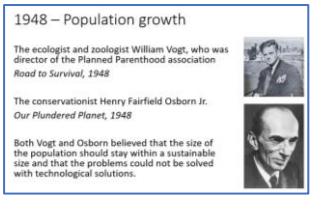
Slide 10 

Gifford Pinchot was American Forester and politician. He was a member of the Republican Party for most of his life, though he joined the Progressive Party for a brief period.

The central thing for which Conservation stands is to make this country the best possible place to live in, both for us and for our descendants.

Something very similar to the Brundtland definition.

The Fight for Conservation, 1910.

Slide 11 

In the middle of the last century population growth was very much on the agenda.

The ecologist and zoologist William Vogt, who was director of the Planned Parenthood association wrote *Road to Survival* in 1948

And the conservationist Henry Fairfield Osborn Jr wrote *Our Plundered Planet* in 1948.

Both Vogt and Osborn believed that the size of the population should stay within a sustainable size and that the problems could not be solved with technological solutions.

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The married couple Anne and Poul Erhlich wrote in 1968 the famous book – the population bomb.

Pual was professor on Stanford and his wife Anne (maybe the most intelligent) was a senior scientist at Stanford.

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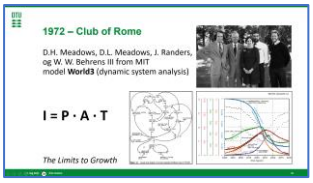
In 1971 Erhlich, Holdren and Commoner agreed about the IPAT model.

Erhlich and Holdren thought the population and consumption were the main problem where Commoner thought that the technology was the main problem.

Later Holdren served as the senior advisor for President Barack Obama on science and technology.

The I environmental impact is the multiplication of the P population, the A Affluence or consumption and the T technology (**environmental intensity of technology)**

We will look much more into the IPAT model later.

Slide 14 

In 1972 computer scientist from MIT used the IPAT model to simulate and forecast the **population**, **consumption of non-renewable resources**, **food production**, **industrial output**, **and pollution.**

They use dynamic system analysis to generate the model known as World3.

The work was communicated in the book "The Limits to Growth" and published by the Club of Rome.

The Club of Rome is a nonprofit, informal organization of intellectuals and business leaders, whose goal is a critical discussion of some pressing global issues.

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In 1972 the world was ready to discuss environmental issues at the UN Stockholm Conference.

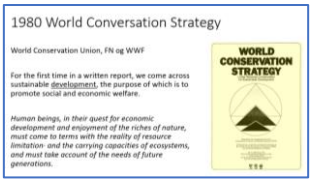
Until now all Sustainable discussions have more or less only been about the environment.

But then Indira Gandhi made a speak where she said:

"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."

And somehow, she blows up the discussion.

Slide 16 

For the first time in a written report, we come across sustainable development, the purpose of which is to promote social and economic welfare.

Human beings, in their quest for economic development and enjoyment of the riches of nature, must come to terms with the reality of resource limitation· and the carrying capacities of ecosystems, and must take account of the needs of future generations.

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15 years after the UN Stockholm conference the social dimension of sustainability was incorporated in the famous definition of sustainability from the Brundtland report which say "Sustainable …"

Another important sentence in the report is "The loss of ….", which tell us that the future generation is highly depending on the environment.

At that time, we thought that the environment, the social and economic dimensions were equally important.

We can argue that the present needs are mainly related to the social aspect and the future needs are mainly related to the environment.

But with our new knowledge we believe that the Environment is more important than the social and economic dimension. Without a good environment there is no society and thus no economy.

And we can see the needs are mainly related to the bottom of the Maslow pyramid of needs.

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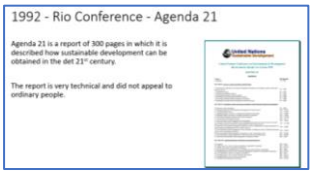
The next 30 years a lot of things happens.

The Rio Conference, Cop meetings, The SDG's, Donought Economy, Gretha Thunberg, IPCC reports.

The Planetary boundaries, that we will talk a lot more about later.

And in 2022 the launch of the Center for Absolute Sustainability at DTU.

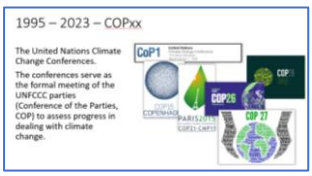
The light blue area indicates actions where the social dimension is a part of sustainability.

Slide 19 

In 1992 we had the Rio Conference, where the outcome was the Agenda 21, a non-binding action plan for sustainable development.

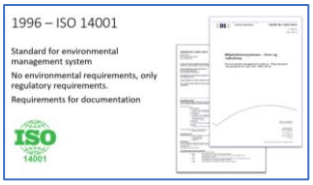
300 pages in which it is described how sustainable development can be obtained in the det 21st century.

The report is very technical and did not appeal to a lot of ordinary people.

Slide 20 

The first COP 1 (Conference of the Partis) were held in Berlin in 1995, and there have been many conferences since. We are now on number 28 in Dubai.

Most famous is probably COP 21 in Paris – The Paris Agreement – 1,5°C.

Slide 21 

In 1996 the ISO 14001 – the international standard for Environmental management system was released.

The standard regulates the environmental management of companies.

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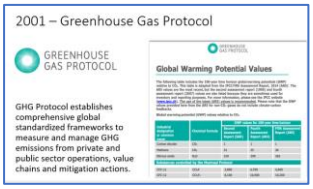
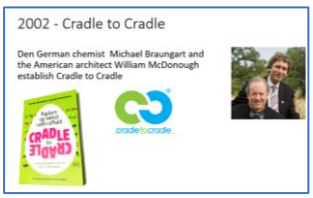
Maybe not very well known, but in 2000 UN launched their UN 2015 goals, which were later updated to the SDG's.

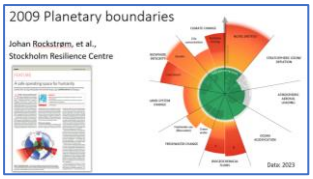
Slide 23 

The Greenhouse Gas Protocol (GHG) was launched in 2001. The GHG Protocol is a framework for measuring and managing GHG emissions in the private and public sector.

Among other things we can find the Global warming potential for different gasses. It is seen that methane has a potential of about 28 times higher than CO2 and laughing gas (N2O) has potential of about 265 times higher than CO2.

Slide 24 

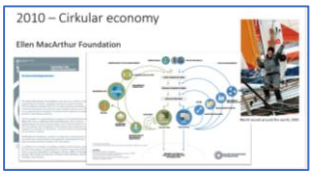
In 2002 the German chemist Michael Braungart and the American architect William McDonough establish Cradle to Cradle. The idea is to copy (inspire) the material flow from biological world in to technical (human) world. That means no waste. The book also includes a lot about toxic chemicals but very little about the climate (about one sentence).

Slide 25 

In 2009 Johan Rockstrøm from Stockholm Resilience Centre published the first article about the planetary boundaries.

They identified and quantified the 9 boundaries that must not be exceeded to prevent human activities from causing unacceptable environmental changes.

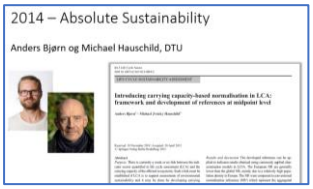
It is seen that today 6 of the boundaries of are already exceeded.

Slide 26 

In 2010 Ellen MacArthur Foundation was launched.

Ellen MacArthur herself is a former world record holder in single hand sailing around the world.

It is about circular economy, and the first reports were written by McKinsey and Company and were very much based on the idea from Cradle to Cradle.

Slide 28 

In 2014 my colleagues from DTU Anders Bjørn and Michael Hauschild published their first article about carrying capacity – which is LCA work based on the planetary boundaries.

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Science Based Target – SBTi was launched in 2015. SBTi is a system where companies can commit to reduce their carbon footprint according to the Paris agreement.

The companies sent their plan for reducing the carbon footprint. The plan is evaluated by SBTi, and the result can be seen on their website.

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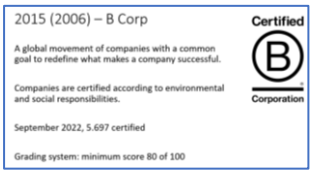
In 2015 all 193 leaders of the world agreed about the 17 Sustainable Development Goals and their 169 targets and 231 indicators.

Remember the SDGs are developed for countries in a global partnership, not for companies.

Slide 31 

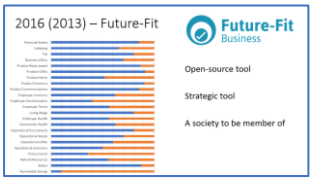
In 2015 B Corp was launched - a global movement of companies with a common goal to redefine what makes a company successful.

The B Corp work was actually started already in 2006.

Companies are certified according to environmental and social responsibilities.

In September 2022, 5.697 companies were certified.

Grading system from 0 to 100. The minimum score to be certified is 80 points.

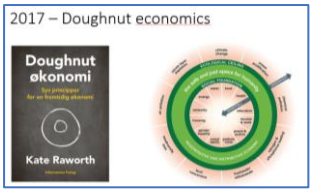
Slide 32 

In 2016 Future Fit was launched. It is an organization a little comparable to B-Corp

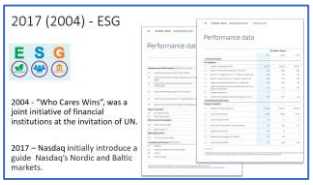
Future Fit is an Open-source tool and a Strategic tool.

They also have a member society.

With future Fit you can measure more or less scientific whatever you are sustainable in a future context – absolute sustainable?

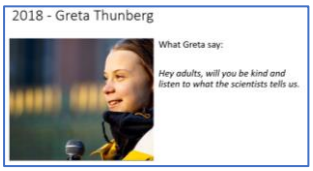
Slide 33 

In 2017 Kate Raworth published her book Doughnut Economy. The first many pages are a harsh description of the current economic system and at the end of the book we find some pages where she describes an economy in principle based on the planetary boundaries and the SDG's – the environment and the social.

Slide 34 

The ESG system was launched in 2017. The work actually stated already in 2004 with "Who Cares Wins."

ESG is the system companies use for reporting their environmental, social, and governance performances. Mainly in an annual report.

Slide 35 

In 2018 Greta Thunberg started her school strike for climate. What Greta more or less said was: Hey adults, will you be kind and listen to what the scientists tell us.

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In 2019 the EAT-Lancet commission published a report about food and absolute sustainability.

To Achieve Planetary Health Diets for nearly 10 billion people by 2050.

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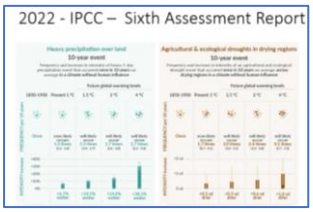
In 2020 we had the EU taxonomy. It is a part of the Green Deal and a classification system to clarify which investments are environmentally sustainable.

The aim of the taxonomy is to prevent greenwashing and to help investors make greener choices.

Slide 38 

In 2022 the sixth (6.) IPCC report was published, and it made it clear for almost all people that the climate change is man made and a huge problem.

We see that the **frequency** and **level** of extreme hot temperatures will increase dramatically depending on the future global warming level.

We can also see that **frequency** and **level** of heavy rain and drought will increase dramatically depending on the future global warming level.

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Larger companies take responsibility.

Ørsted which business model is more or less based on sustainability of cause report heavily about their sustainable goals.

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Maybe more interesting is that the old conservative company Maersk reports heavily on their sustainable goals.

In the sustainability report it is seen that in 2023 they will have the world's first container ship operating on green methanol, which happened some weeks ago.

Concerning methanol, I think they will change from bio-methanol to e-methanol, probably due to biodiversity.

In 2040 they should be carbon neutral.

In 2025 more than 40% of the management team should be female.

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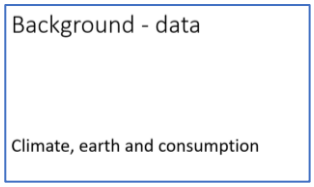
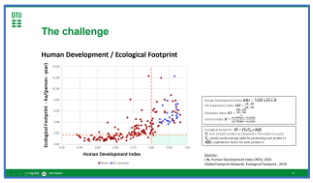
The Centre for Absolute Sustainability was launched in 2022.

Slide 42 

Side 43 

The Challenge – to move all people and countries into the green box.

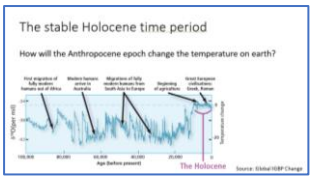
On the X-axis we have the Human development index, calculated by the UN, which includes the lifetime, the education and the income.

On the Y-axis we have the Ecological footprint which tells us something about one person's use of the earth for food production, CO2 emission etc.

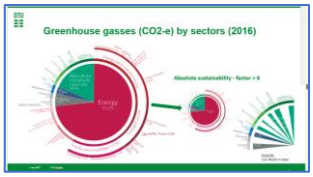
Ecological footprint is comparable to the "over shutting day" and is based on the same data.

Let's look into where some interesting countries located in the diagram.

No single country is in the green box, but Bahamas is close.

Slide 44 

It is worth to notice that the climate on earth has been very stable over the last 10.000 years – the Holocene time period – looking at the temperatures on the right axis. I think it will be a good idea staying with int the Holocene epoch.

Side 45 

Let's take a look at the total amount of greenhouse gases in 2016 in the world.

We can see that 73,2% is related to the production of energy, electrical power, engines, etc.

5,2% is from industry – not related to energy but for example the chemical process of producing cement.

3,2% is related to Waste –

18,4% is related to Agricultura and forest. Where 5,5% is the methane from cows, 4,1% is the laughing gas from production of vegetables but remember that about 70% is used to feed animals.

1,3% is from the methane related to Rice production.

2,2% is related to deforestation.

It is worth noticing that no sector is responsible for a major impact. Transportation from China is about 1,7% and aviation is about 1,9% – but remember only rich people is flying.

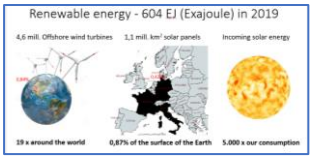
We know that the total amount of greenhouse gases should be reduced with more than a factor 8 (probably 10).

If it is done equally, there will not be a lot back to our food production.

Another strategy could be to base all the energy production on renewable resources and half the impact from industry, landfill and agriculture.

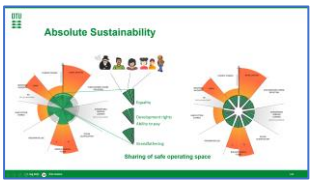
And still, we have to be aware of burdens shifting – using biomaterial for making energy can be problematic both because of laughing gas from agriculture, the lack of land and biodiversity.

Fortæl om numrene

Slide 46 

In 2019 the total consumption of energy was 604 Exajoule. At that time, I estimated we need wind turbines 19 times around the world to produce all energy only by wind or we need to cover 0,87% of the surface of the Earth with solar panels – an area with size of Germany, France and Italy. Today we only produce 0,84% of the energy with wind, which is comparable to half of the border between USA and Mexico and 0,42% with solar panels, which is comparable to the size of the Island Als.

Don't worry the incoming energy from the sun is about 5000 times our consumption – we have to find a way.

Slide 47 

Absolute sustainability is based in the Planetary Boundaries that we know from Johan Rocstrøms Stockholm Resilience center.

A lot of research has been done to estimate the safe operating space (SOS) for the 9 boundaries defined by Johan Rockstrøm, and the research still takes place and data is constantly updated.

Climate Change: which can be measured either by the concentration of CO2 in the atmosphere or radiation that cannot be emitted back to space.

Novel Entities which are toxic, plastic in ocean, etc.

Stratospheric Ozone depletion – that we know from CFC gases in the 80'es.

Atmospheric Aerosol loading is solid and/or liquid particles in the air that, we breathe, as dust, smoke and haze

Ocean Acidification is acid in the ocean mainly from CO2.

Biogeochemical flows are nitrate and phosphate mainly from agriculture.

Freshwater change –

'Blue water' is water in rivers and lakes, groundwater and the water frozen in glaciers and the polar ice caps.

'Green water' is found in plants, soil and rain.

Fortsætter på næste side

Land System change is mainly transformation of forest to agricultural fields.

Biosphere integrity is biodiversity.

Functional: is the ecosystem's capacity to contribute to biosphere processes

Genetics: is loss of species.

Next step is to share the safe operating space between people (“share the cake”) – poor to rich – to people over the world.

The cake can be shared equally between all a people.

Or people that had less in the past should maybe be allowed to have more in a period of time in the future.

Or we could all reduce our impact whit the same ratio – this is called grandfathering, as it depends on our impacts in the past. This is the way Science Based Target (SBTi) works.

Share of operating space has to be done for all boundaries.

Then the shared safe operating space has to be shared between different products and services (the cake has to be cut into even smaller slides).

It could be shared according to the economic value of the product or service - Utilitarian.

Or maybe some products or services are more important than other and should have bigger slice of the cake – more a Duty based sharing.

It is all about ethic.

When we at DTU are working with absolute sustainability, we do it from an LCA perspective. That means the safe operating space (SOS) have to be converted to the LCA impacts. Some are the same: Climate, Stratospheric ozone formation and Eutrophication.

Side 48 

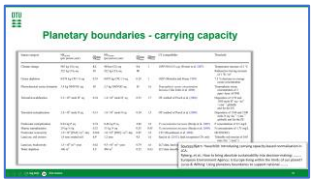
Many research groups are working on transferring the planetary boundaries to carrying capacity – converting the PB world to the LCA world.

Articles in red are written at the center for Absolute Sustainability at DTU

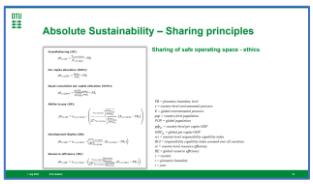
In PB the climate boundary is given in ppm CO2 in the atmosphere or W/m^2 reflected radiation in the atmosphere.

They both have to be converted to kg CO2-ekvivalent per person per year.

Work by Anders Bjørn and Michael Hauschild DTU

Side 48b 

Work by Anders Bjørn and Michael Hauschild DTU - Læs noget af listen.

Side 49 

Sharing principles – on country level – it could also be on company level or personal level.

Grandfathering – the country's impact divided by the global impact multiplied by the PB – if the country had a high impact in the past, the country would have the right, in a time period, to has higher impact compared to other countries.

Per capita allocation - population of the country divided by the world population multiplied by the PB.

Equal cumulative per capita allocation – almost the as the one above, but it takes into account the development of the population in the future.

Ability to pay – here is the country's GDP related to world GDP taken into account.

Development Rights – here is the country-level responsibility index – from the Climate Equity Reference Project taken into account.

Resource efficiency – here is the country's level of resource efficiency taken into account.

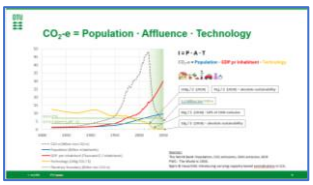
Slide 50 

In old classical LCA work, we compared products or services and found the most environmentally sound products, without knowing whatever it was good enough.

Comparing a wooden chair with steel frame and a plastic chair indicates that the wooden chair is more environmental sound.

Now we compare products and services to a "slide" of the world and can see if it is good enough.

We can see that the wooden chair with wooden frame is within the share of safe operating space (SOSOS).

Slide 50 

Let's take a look into the future and use the IPAT model.

I: is the CO2-ekvivalent impact.

P: is the world population

A: the affluence is the average world GDP per inhabitant in dollars

T: The technology is the CO2-ekvivalent per dollar

We can see that we have nearly always developed more efficient technology, as the T has almost always decreased.

But at the same time the population and the consumption are increased coursing a dramatical increased in CO2 emission.

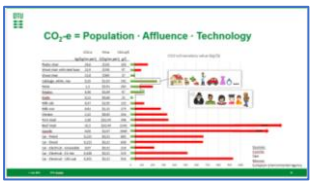
But more effective production and products have decreased the price per part but increased the overall consumption – this is called "rebound effects", which can be avoided be decoupling.

Fortsættes på næste side

As a result of the Paris agreement, we have to decrease the total amount of CO2-ekvivant per year to about 5,3-billion-ton CO2 in 2050, depending on which method used for calculating the safe operating space.

At the same time, we know that the number of inhabitants will increase to 10 billion and PWC estimates the GDP will increase too.

That means the efficiency of technology has to be increased dramatically – we have to come down from 358g/$ to 18g/$. Actually, if we have to behave absolute sustainable today, we have to be at 41g/$

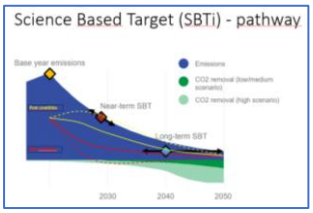
Slide 51 

Let's try evaluating some products with our new knowledge. First, we base our evaluation on utilitarian sharing principles – pure money.

It is seen that Mulle (Mussels) and a wooden chair is absolute sustainable as the prices are high compared to the carbon footprint.

We can also see that an electrical car is not absolute sustainable even when driving on renewable energy. It might help in the future if we manage to produce all our energy from renewable resources.

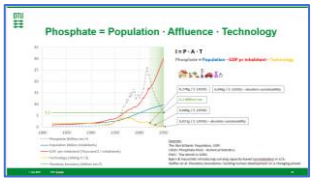
For a lot of reasons, it can be necessary to adjust the share of safe operating space. For example, food might be more important than other products.

Slide 52 

According to Science Based Target (SBTi) the companies must set a near-term target and a long-term target, which are in line with the Paris Agreement.

But is it fair? It is Grandfathering when companies are reducing with same percentage.

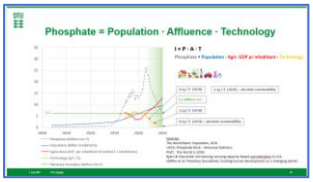
Should companies in rich countries reduce more over a time period to allow companies in poor countries to reduce less or even increase the impact over a time period.

Side 53 

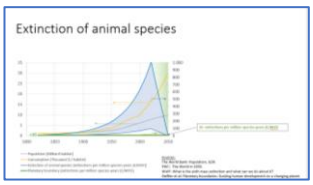
As for the CO2-ekvivalent it is also possible to use IPAT model to calculate the phosphate impact in relation to economy and population growth. It is seen that we are about a factor 4 over the absolute sustainable level and with the growth in population and GDP it will be even worser – only 0,021g/$

It is assumed there is a correlation between phosphate emission and phosphate consumption.

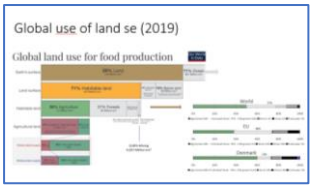
It might not be fair to allocate the impact to all products and services as the impact is mainly related to agriculture.

Slide 54 

If the impact only is related to the economy of the agriculture the is allowed to have 0,5g/$ instead of 0,021g/$. That means all impact from phosphate is allocated to the production of food.

Slide 55 

The figure shows the increase in population, consumption and the extinction of species which today is between 100 and 1.000 species per million species per year. According to planetary boundaries the extinction should be 10. Before human activities the extinction was only about 1 species per million species per year.

Slide 56 

It is seen that 29% of the surface of the earth is land.

Of this 29% - it is possible to live on 71%, the rest is glaciers and desserts, etc.

50% of the habitable land is agriculture, 37% is forest and only 1% is for infrastructure, (houses, roads airports etc.), and about 0,06% is for mining.

77% of the agricultural and is used for animals either as food production or grazing.

23% is used for production of Human food.

18% of our calories are related to the animals,

37% of the proteins are related to animals.

In EU 10% is for infrastructure and in Denmark 14% is for infrastructure

In Denmark 60% is for agriculture

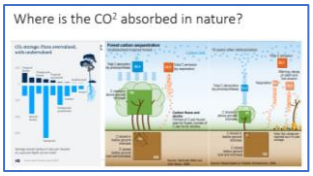
We have to remember that the biodiversity crisis is mainly related to the use of land – also monoculture – growing only one crop in the field.

Slide 57 

What about the nature?

What is best for our environment – the old growth forest or the cultivated forest?

The old growth forest is for sure best for biodiversity but what about the climate?

Slide 58 

I am absolute not a specialist in forest and the research is still quite young.

But it is important to notice that more CO2 are stored in the soil than in the trees and other vegetation.

Especially in wetlands, a lot of CO2 are stored in the soil.

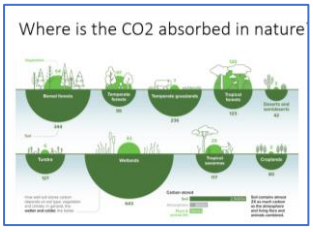
But also, in the Boreal Forest that we have in Denmark a lot of CO2 is stored in the soil.

On the figure to right we see some interesting aspects of deforestation.

For the tropical forest we can see that 10 years after deforestation, only about ¼ (25%) of the carbon is stored in the trees and 2/3 (66%) is stored in the soil, compared to undisturbed forest.

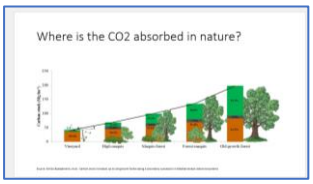
But we have to remember that a part of the CO2 from the deforest wood are now stored in wooden objects.

Difficult calculations

Slide 59 

More of the same

It is worth noticing that in the soil are stored about 2 times more carbon than in the atmosphere, plants and animals.

Slide 60 

Just more of the same

Slide 61 

Let's take a look at the EAT-Lancet Commission report from 2019.

The study is about Healthy Diets from Sustainable Food Systems.

EAT-Lancet Commission suggests a diet where the main calorie intake comes from: whole grains, oil, legumes and nuts.

You are only allowed to eat 14g of beef a day – that means you can have a small 100g beef every Saturday.

On the right side you see some examples of meals based on the table to the left – I think it looks great!

Slide 62 

And how will this look in an absolute sustainable scenario?

On the right side we see the boundaries. It is seen that 5,0 Gt CO2 per year is allocated to the food production, which means there is no CO2 left for other sectors!

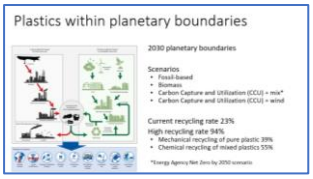
The top line is the baseline for 2010. We have already passed some of the boundaries.

Busin. as usual: production is carried out as today and the same diet as we eat today.

Impro. Produc: Improved production practices - *Standard level of ambition* – ex. closing of yield gaps to about 75%; (udbyttegab), lancing nitrogen and phosphorus fertilizer between regions.

+Impro. Produc: Improved production practices - *High level of ambition* - ex. closing of yield gaps to about 90%;(udbyttegab), 30% increase in nitrogen use efficiency, and 50% recycling rates of phosphorus.

All in all, that means we have to be very good and very efficient to be absolute sustainable.

Slide 63 

Plastic within planetary boundaries

Will it be possible to make plastic within the planetary boundaries in the future?

This has been analyzed by Marvin Bachmann. et.al, and the studied is reviewed by Anders Bjørn and Michael Hauschild from DTU Centre for Absolute Sustainability.

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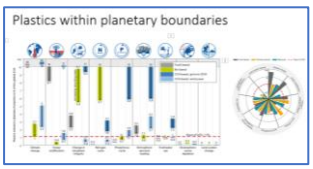
4 plastic production scenarios were analyzed in combination with 2 different recycling rates:

Fossil-based, Biomass, Carbon Capture and Utilization (CCU) + mix*, Carbon Capture and Utilization (CCU) + wind

Current recycling rate 23%,

High recycling rate 94% (Mechanical recycling of pure plastic 39% / Chemical recycling of mixed plastics 55%)

The analysis is based on 2030 Share of Operating Space (not 2050).

Slide 64 

The lower end of the bars represents the High recycling rate, and the upper end represents the current recycling rate.

The Share of Safe Operating Space is set to 1,1%, which is the percentage of GDP that plastic is expected to constitute in 2030 (today it is about 0,6%)

With the Biomass scenario we see that we are just OK for climate change (with the high recycling scenario) but really bad with the Biodiversity and Nitrogen cycle, as a lot of land has to be used for growing the biomass.

It is also seen that it is important that the CCU is based on wind turbines.

But it is still too high for climate change and the aerosol loading.

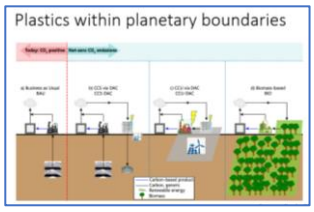
This is because the wind turbines are made of steel here the steel production emit CO2.

I am not 100% sure whatever this is only due to the chemical reaction by producing steel, that we saw on the previous slide, or if it is also because of the production of wind turbines is based on the 2030 electrical power mix.

Fortsættes på næste side

In the future it will be possible to solve the problem by producing steel with the process named Direct Reduced Iron. Where Hydrogen is used to reduce the steel ore.

Diskuter siden

Slide 65 

In the figure, 4 different scenarios for making plastic are represented.

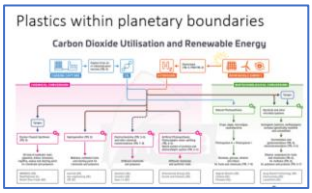
Traditional fossil-based, Carbon Capture Storage (CCS), Carbon Capture Utilization (CCU), and Biomass.

By CCS are the same amount of carbon, which are drilled out of the underground, stored in the underground.

CCS requires less energy than CCU. It is because the energy is already stored in the oil and gas from the photosynthetic, that have taken place many years ago.

By CCU energy is used to convert CO2 into plastic – we will see that a little more in detail on the next slide.

Biomass requires a lot of space as we saw in the last slide.

Slide 66 

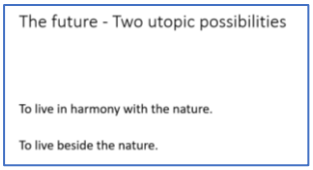
CO2 captured from the atmosphere can be converted into synthesis gas by reacting the CO2 with H (hydrogen). Producing hydrogen requires a lot of renewable energy.

The Natural Photosynthesis is of cause also a pathway, but as we saw in the last slide it requires a lot of space.

It has to be remembered that photosynthesis only has an efficiency of about 1-2%, algae is about 5-8% and solar panels about 20%.

Synthesis gas can be used for all kinds of chemical production also plastic.

But remember a lot of renewable energy is needed for the process and also needed for producing the steel for the wind turbines.

Slide 67 

Until now it all has been very scientific – the rest are more personal reflections – take it as an inspiration.

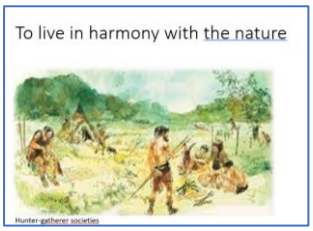
The future - Two utopic possibilities

To live in harmony with the nature.

To live beside the nature.

Slide 68 

Tak a look at the exhibition Planetary Boundaries (note that boundaires are written in plural). See if you can find burden shifting in the exhibited projects?

Slide 69 

In the past we were living in harmony with the nature as hunter gatherers.

Hunter gatherers were normally nomads. That means they were living in one area for a season and then moved to another area when there were no more to hunt and gather.

After some years they will come back to a previous area when it is regenerated

It was a tough life with an average lifespan of around 35 years.

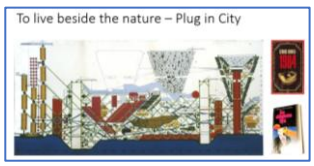
Slide 70 

Maybe Hunter gatherer is a little too much – we could also all live in smaller houses close to the nature.

Living local

What about, Transportation, energy, sharing, etc.

Do we have space enough for that?

Slide 71 

Or will it be smarter to live **beside** the nature as Peter Cook suggested in Archigram in 1963 in the concept Plug in City, where we would live very close together and share buildings and rooms. If you have a baby, you will automatically have a new bedroom connected to your apartment and it will be removed when the child is grown up.

Less transportation

But what about the surveillance of the society?

Some Archigram architects were thinking about one long city from Liverpool to Manchester, to London to Paris to Berlin

Slide 72 

Is that what happens now with the **Line** in Dubai? – no cars and everything within 5 minutes' walking distance!

But what about the original or local people?

Slide 73 

What about the food, if we want to live beside the nature and not interact with the nature.

An estimate by Professor Dickson Despommier indicates that by vertical farming is it possible to produce food for 50.000 person in one New York block (about 80x274m og 30 floors)

It is exactly the area of the old canning factory in my old hometown where 50.000 people are living.

But maybe too risky and vulnerable – where will an enemy place the first bomb?

Slide 74 

We must be very serious about this, there is a huge difference between the wild nature and the small activities humans do, trying to “fix” the problem.

This small bee hotel will not make a big difference in the big picture of wild nature.

Is the bee hotel just an indulgence?

Alide 75 

Be serious – it is needed – thanks!