



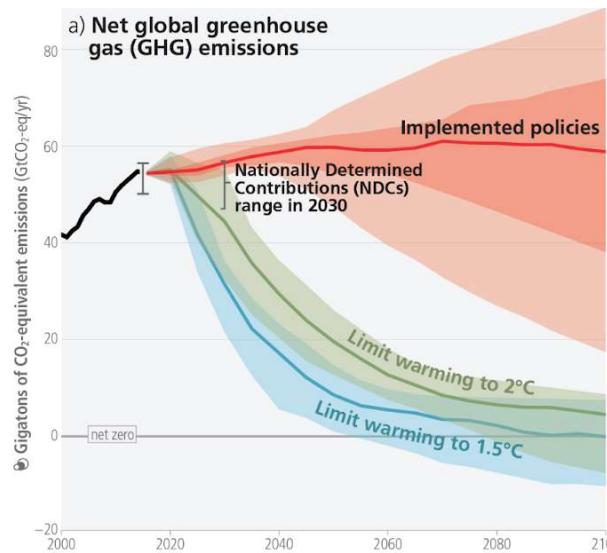
# *IAMs and long-term scenarios to support the IPCC Climate Change assessment*

Detlef van Vuuren

 @IMAGE\_PBL



# Quick introduction

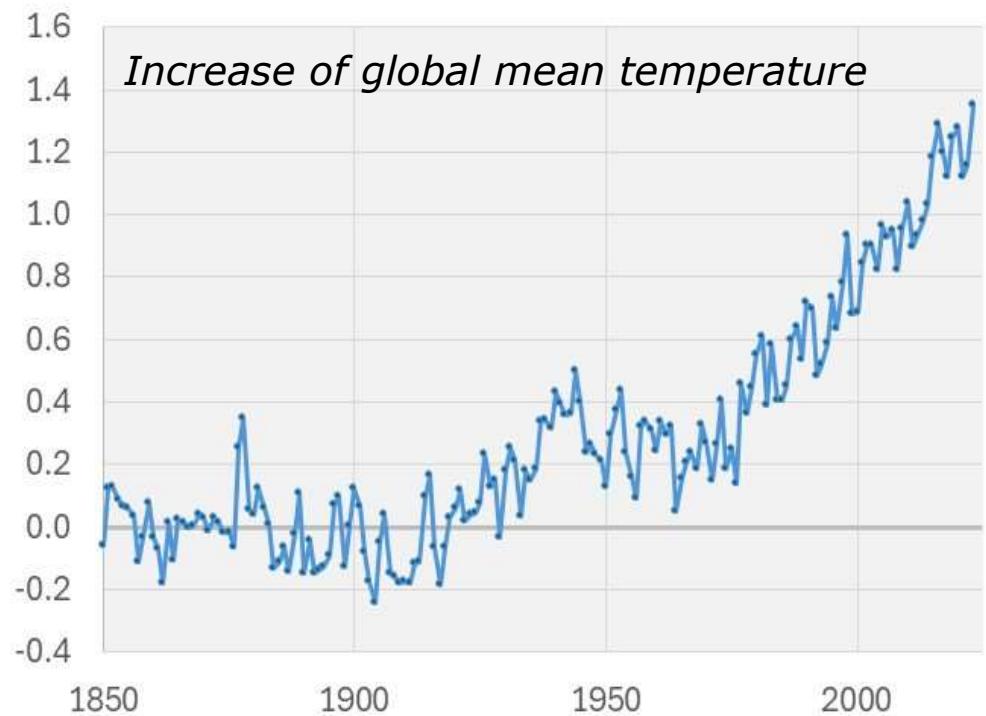


**Detlef van Vuuren**  
Senior researcher PBL  
Professor Universiteit Utrecht  
Lead Author IPCC reports

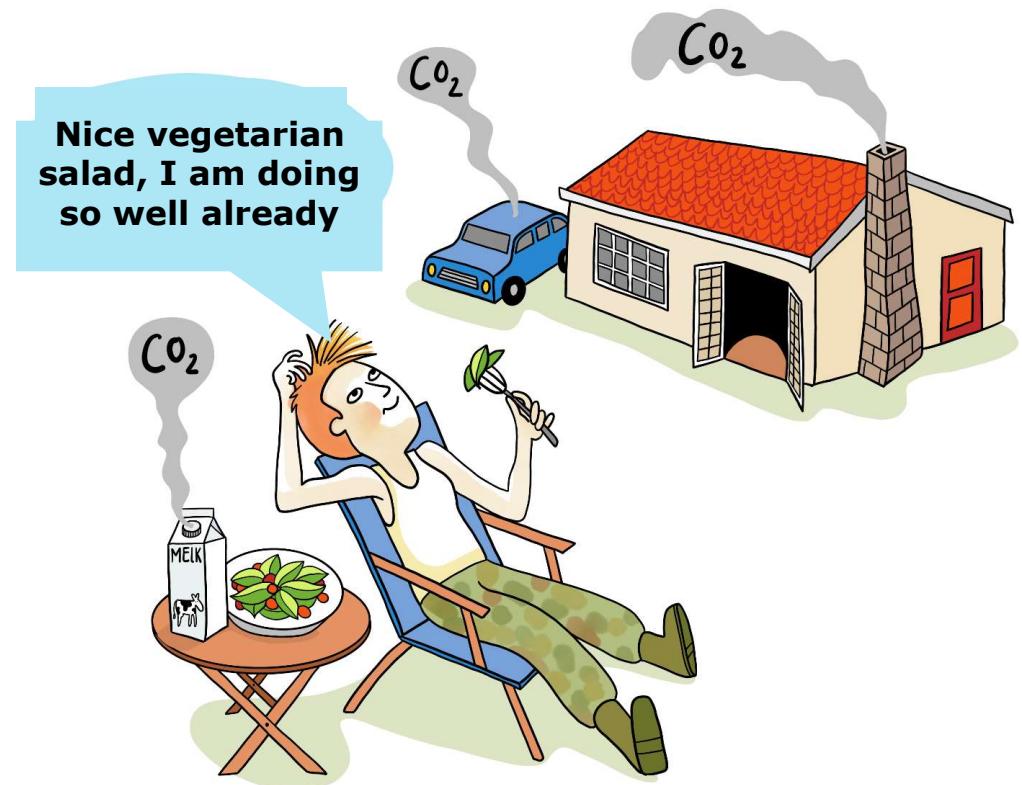
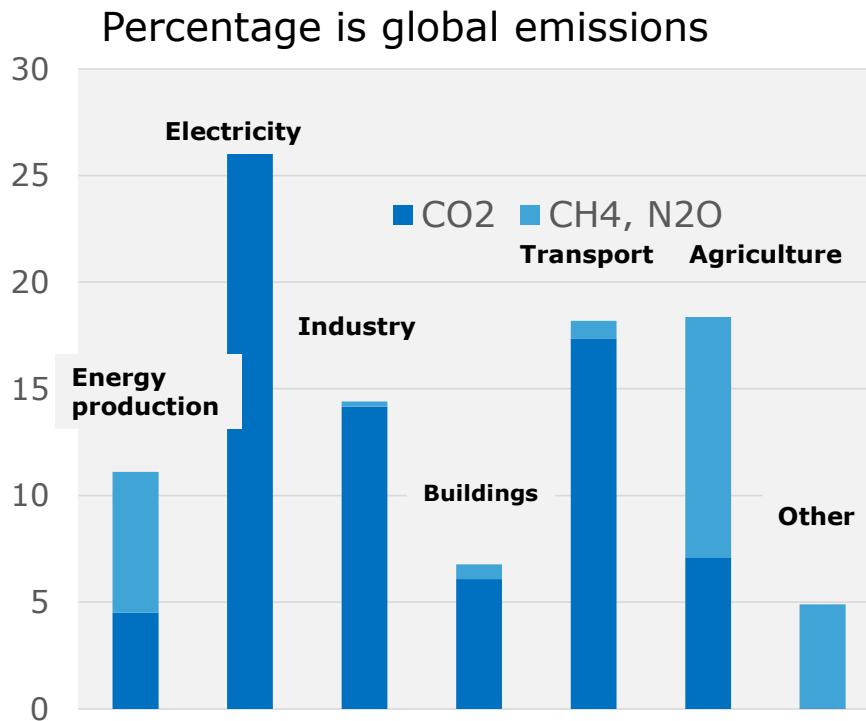
News: Climate researchers : 1.5-target is getting rapidly out of reach, rapid – deep and immediate action necessary.

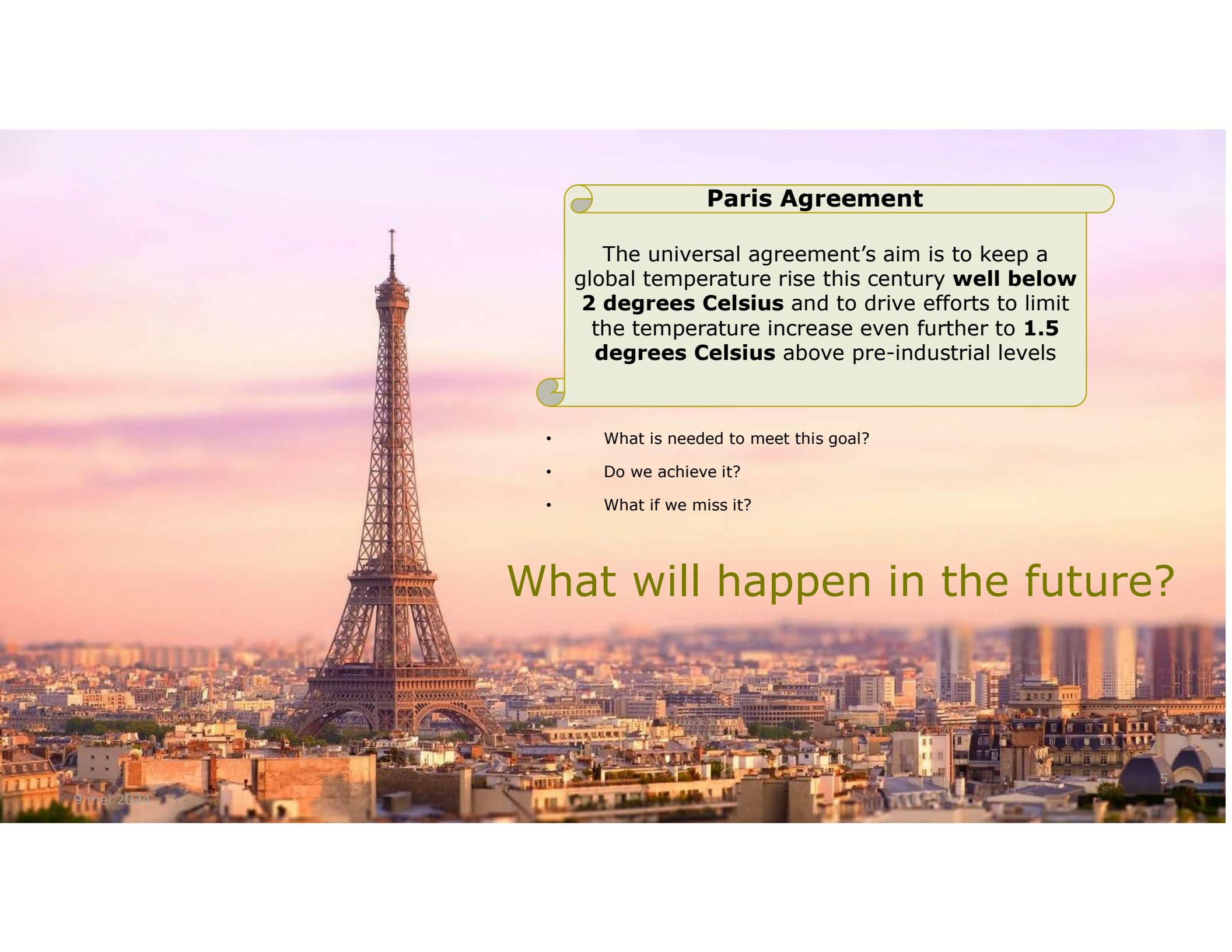


# Climate change is clearly visible



# *And emissions are related to everything we do*





## Paris Agreement

The universal agreement's aim is to keep a global temperature rise this century **well below 2 degrees Celsius** and to drive efforts to limit the temperature increase even further to **1.5 degrees Celsius** above pre-industrial levels

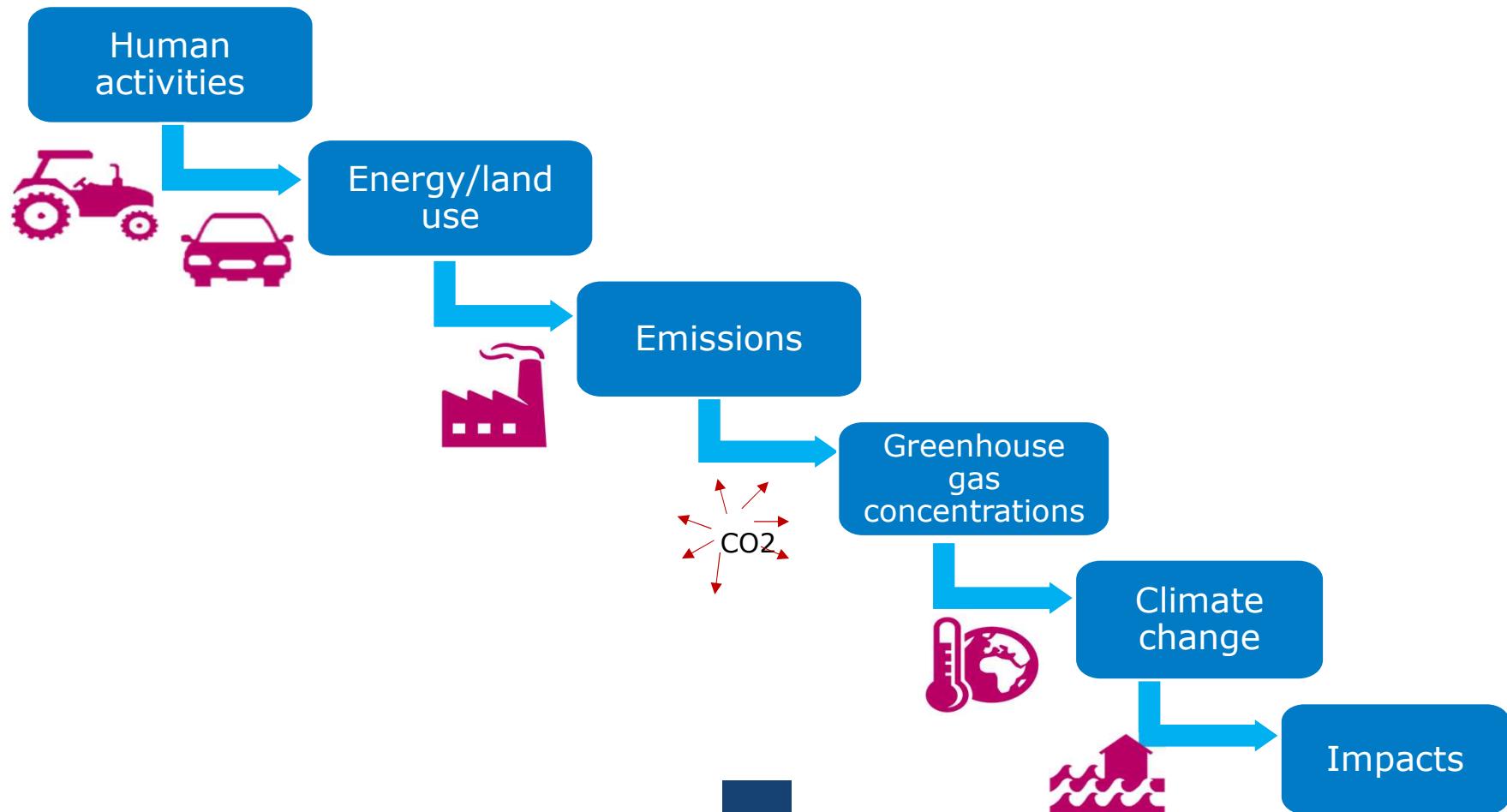
- What is needed to meet this goal?
- Do we achieve it?
- What if we miss it?

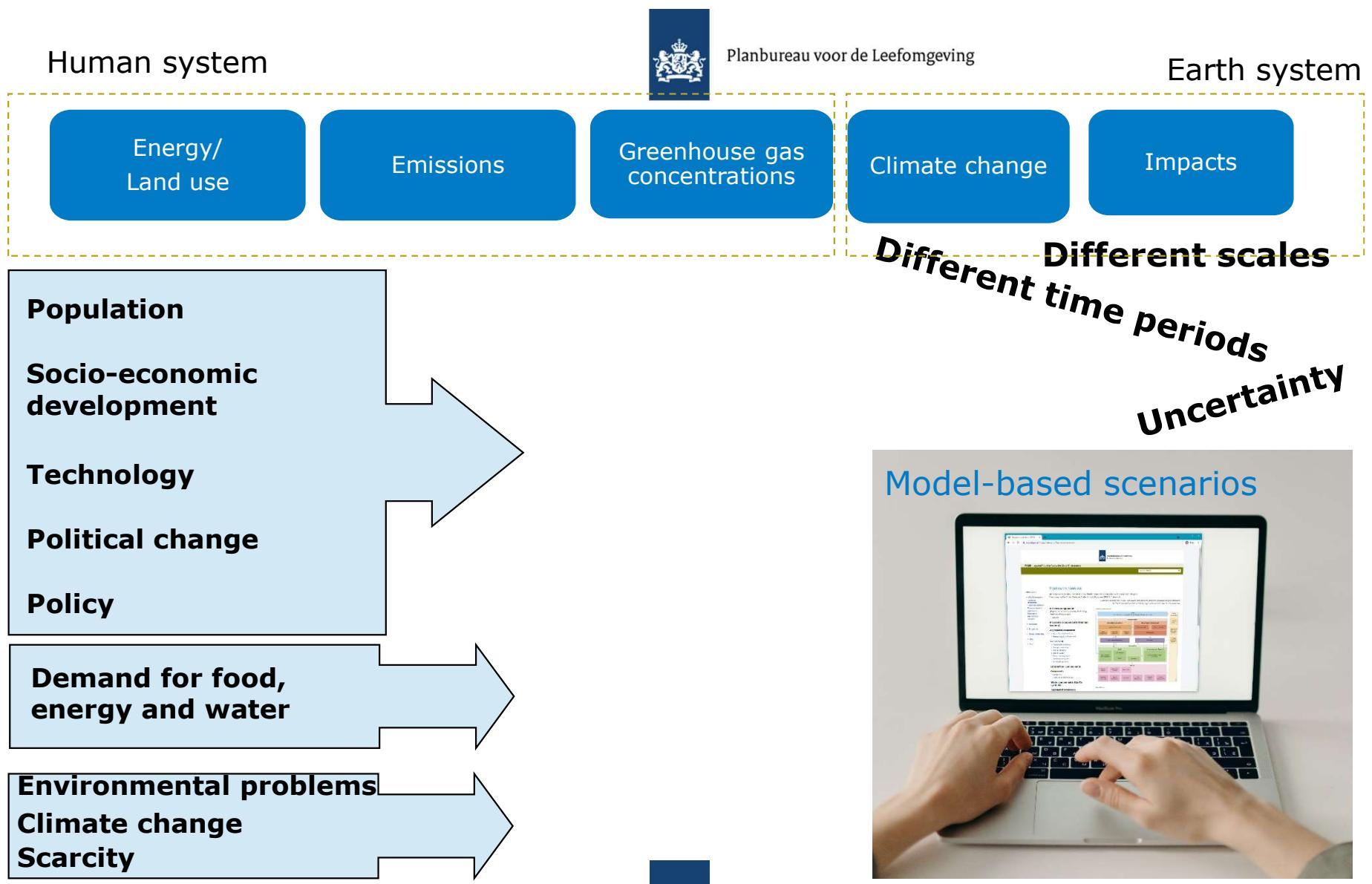
## What will happen in the future?



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## What will happen in the future?





## Model-based scenarios



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Energy/  
Land use

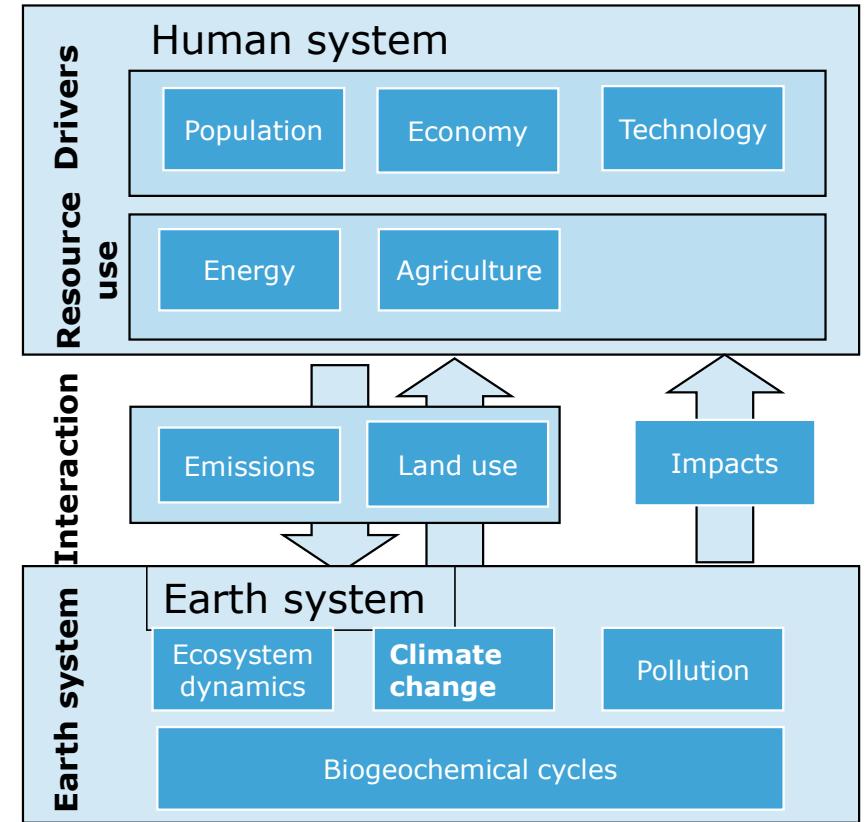
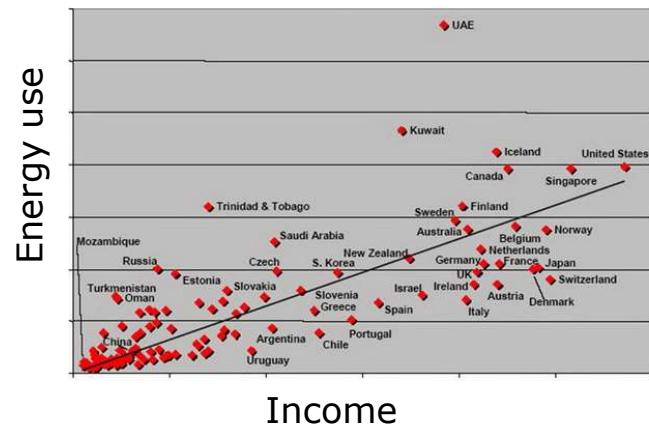
Emissions

Greenhouse gas  
concentrations

Climate change

Impacts

- Interaction of **human system** and **environmental system**
- Integration across different issues
- Focused on decisions processes (**assessment**)



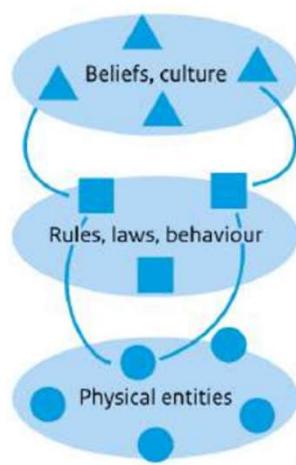
# Model-based scenarios



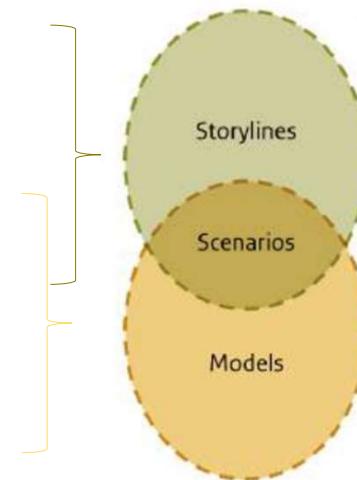
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Describe  
evolution of  
future systems



Available tools



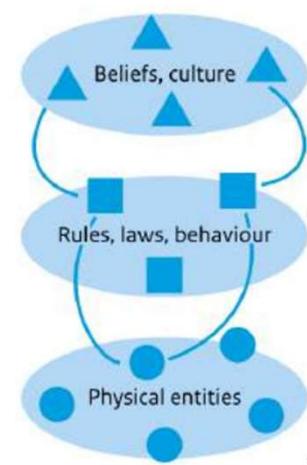


# Model-based scenarios

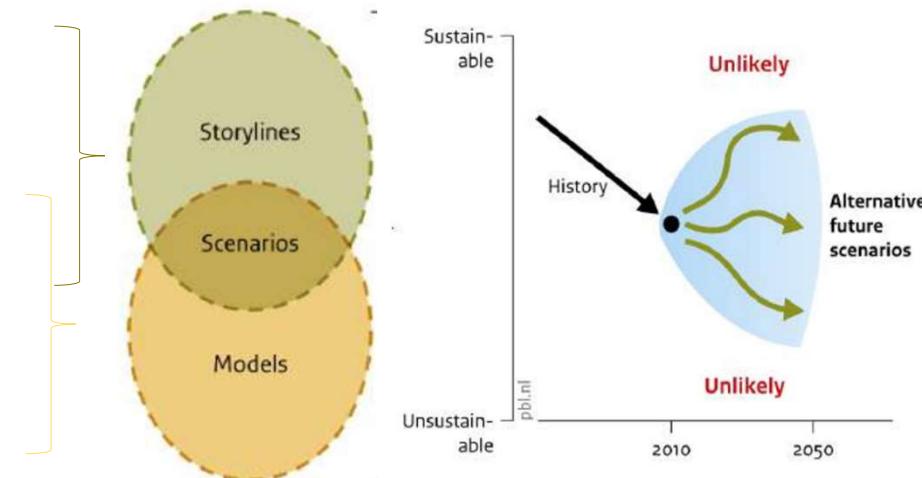
## Scenarios:

- Combination of narratives and modelling
- Modelling where there is enough knowledge to define quantitative relationships
- Narratives where there is need for complexity and flexibility

Describe evolution of future systems



Available tools



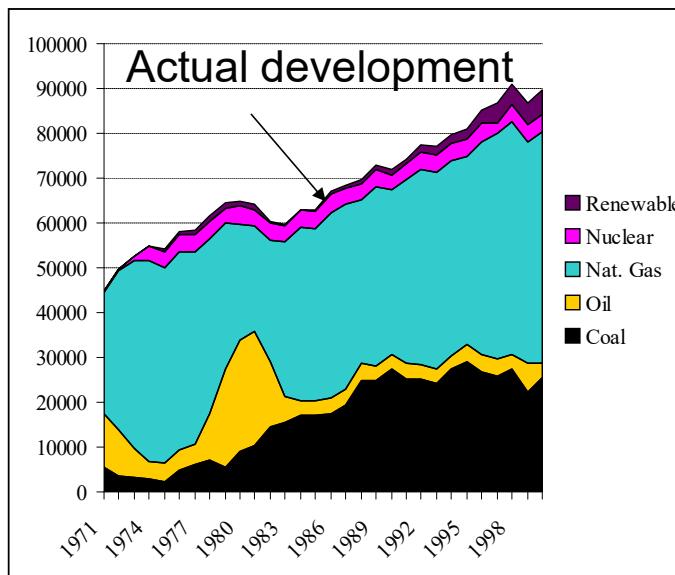


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# Model-based scenarios

31 Maart 1972

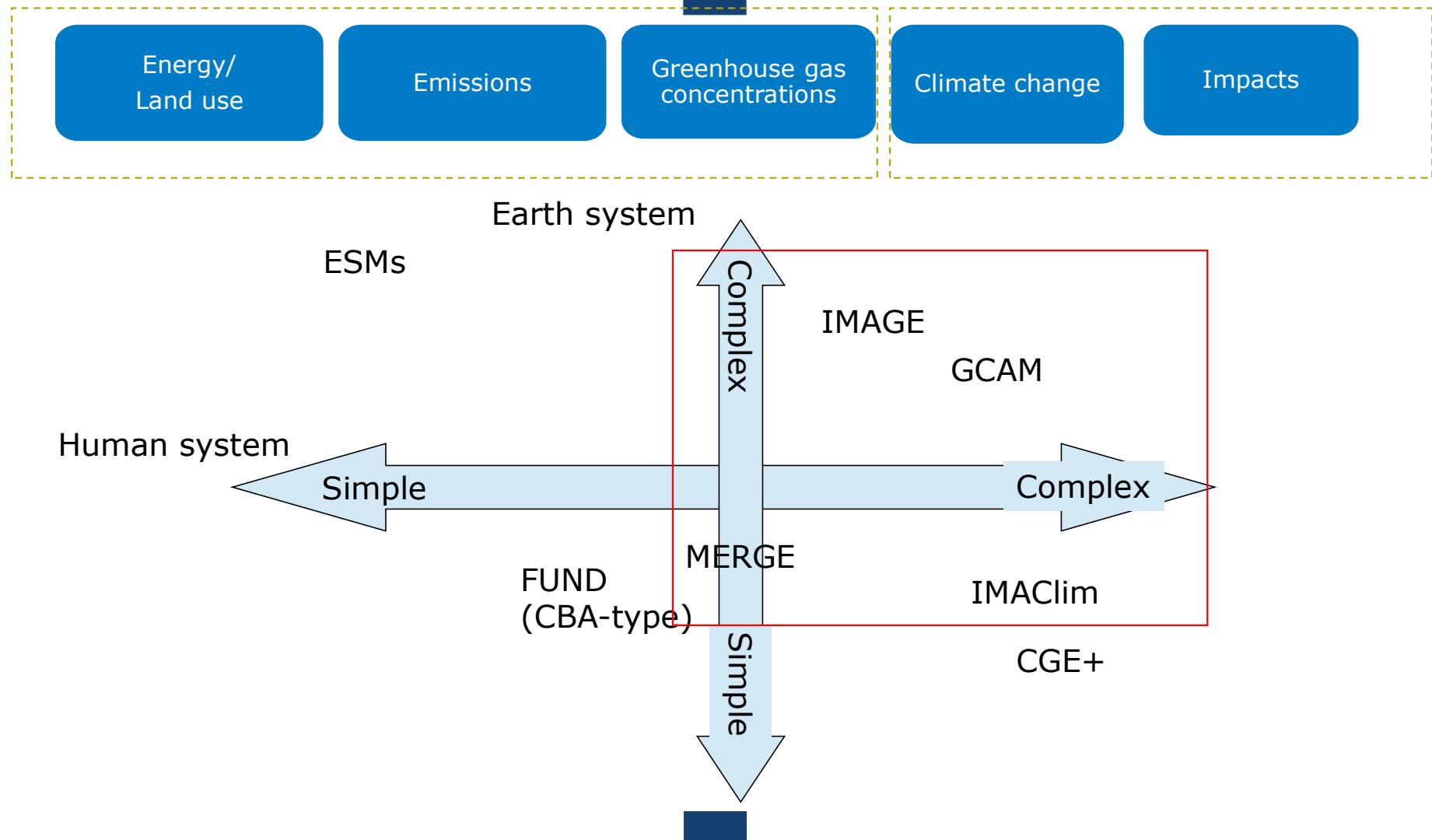


This wrong prediction influenced energy policy in the Netherlands to try to sell out natural gas in avoid getting stuck with it in the ground.

## Model-based scenarios

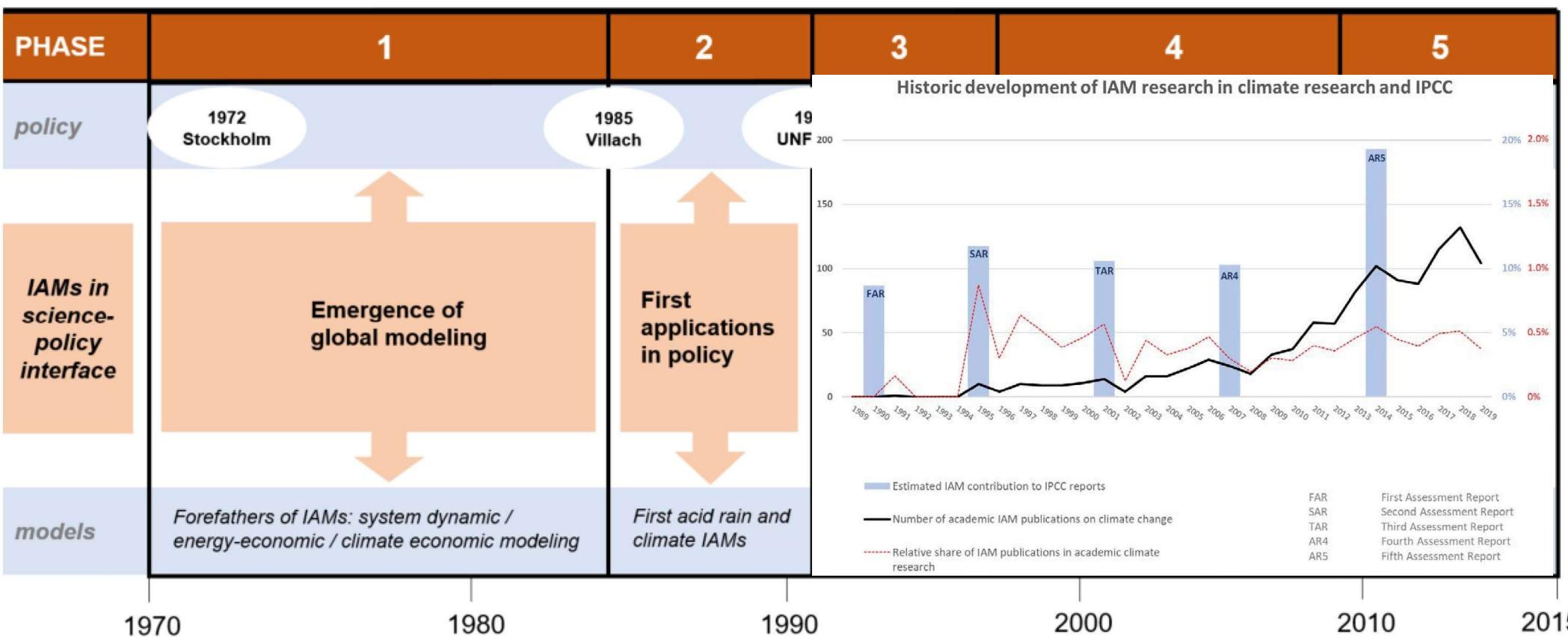


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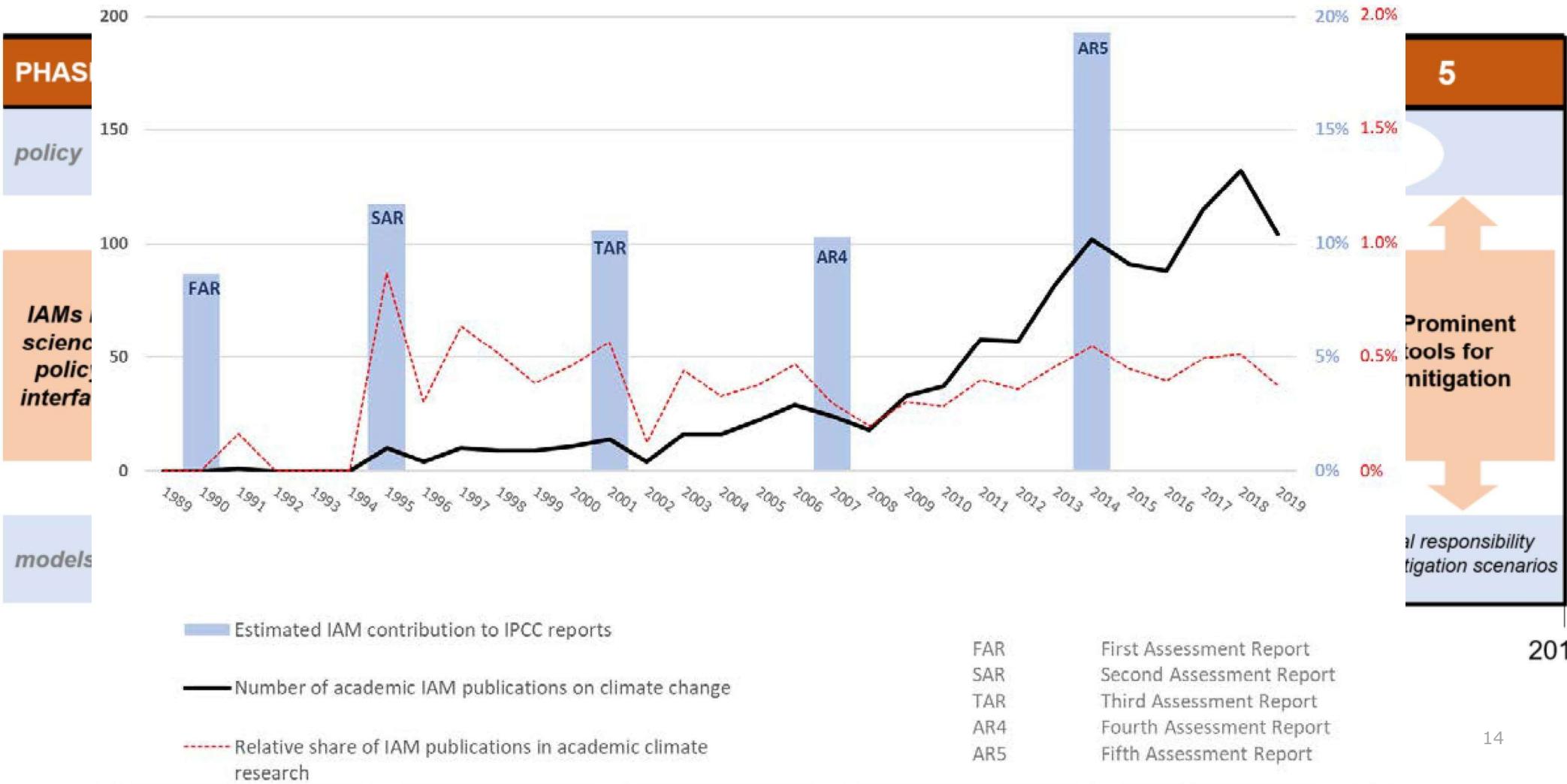




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## Historic development of IAM research in climate research and IPCC





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## Model-based scenarios

Meadows – 1972: If the present growth trends continue unchanged, the limits to growth on this planet will be reached sometime within the **next one hundred years**.

Meadows – 2005: In 1972 the model showed a time of crises 50-70 years into the future; now the crises appear **10-30 years** in the future.



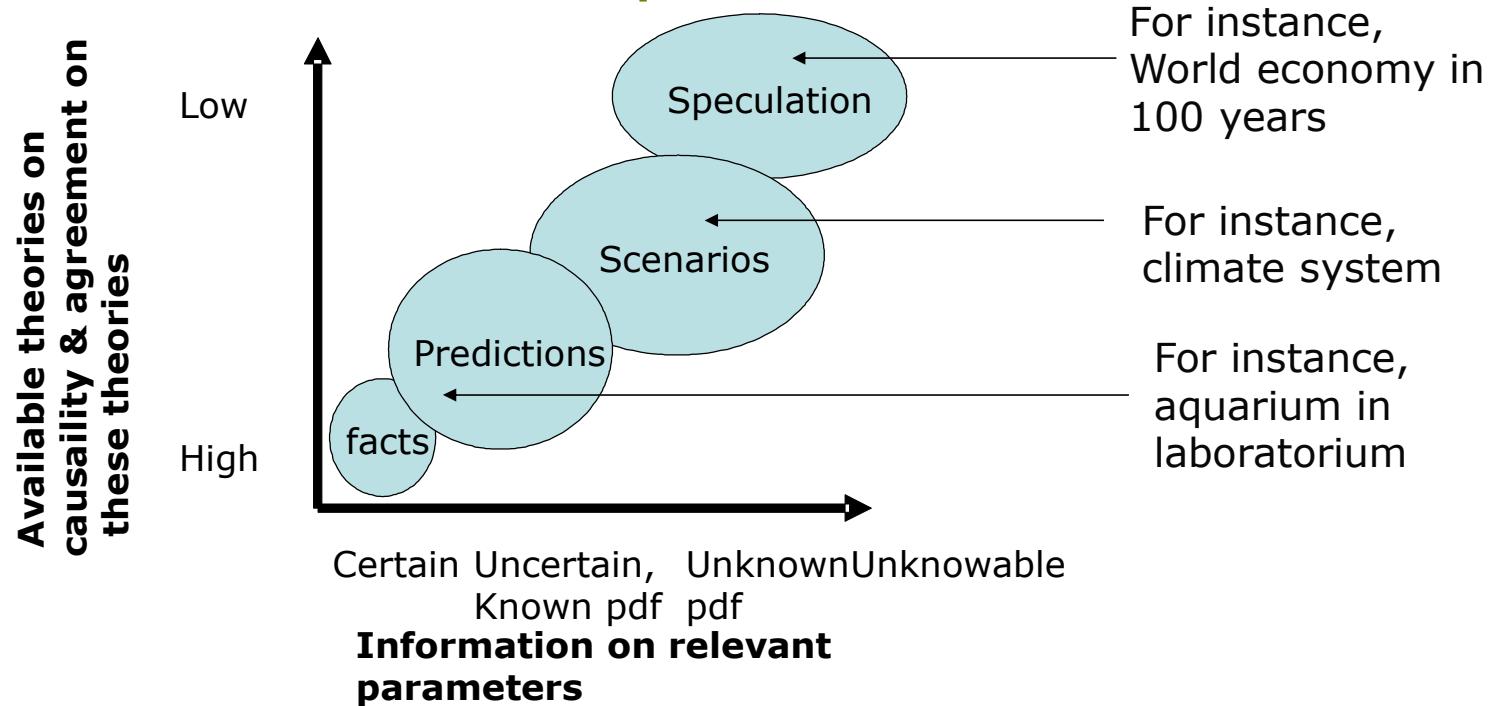
There are no limits to the growth of energy consumption, although present systems are clearly finite. I do not fear a lack of sources to complete this journey unscathed

(Willems  
– Shell Oil)





# Different tools to explore the future



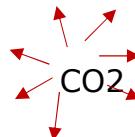


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## What will happen in the future?



Emissions



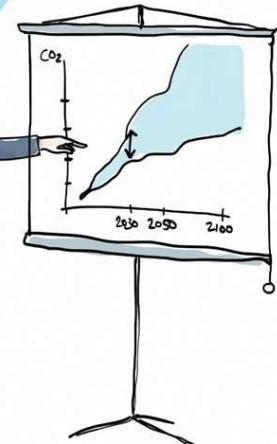
Greenhouse gas concentrations



The future is uncertain

Tell him the prediction

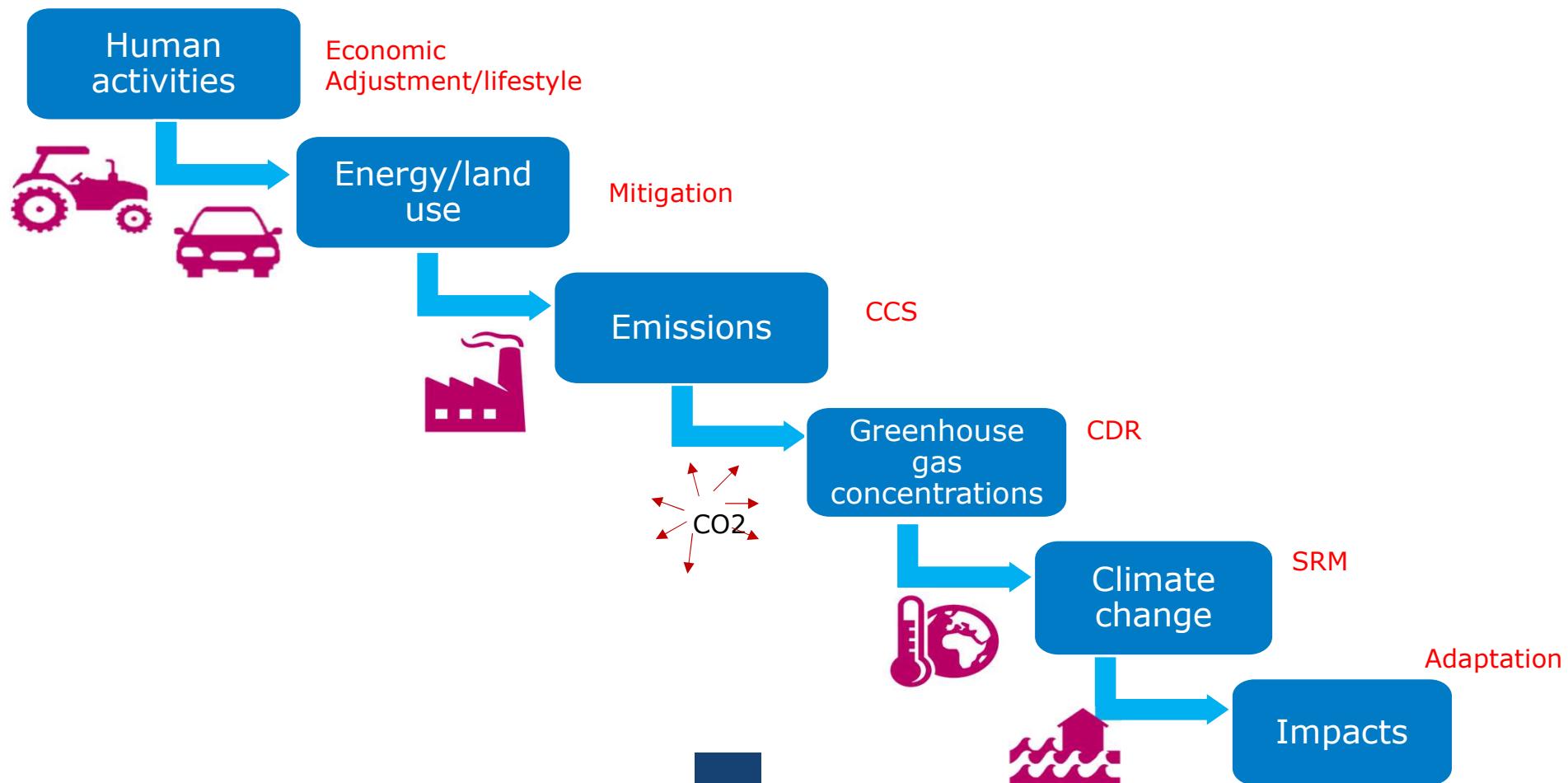
Uh... models only explore various possibilities





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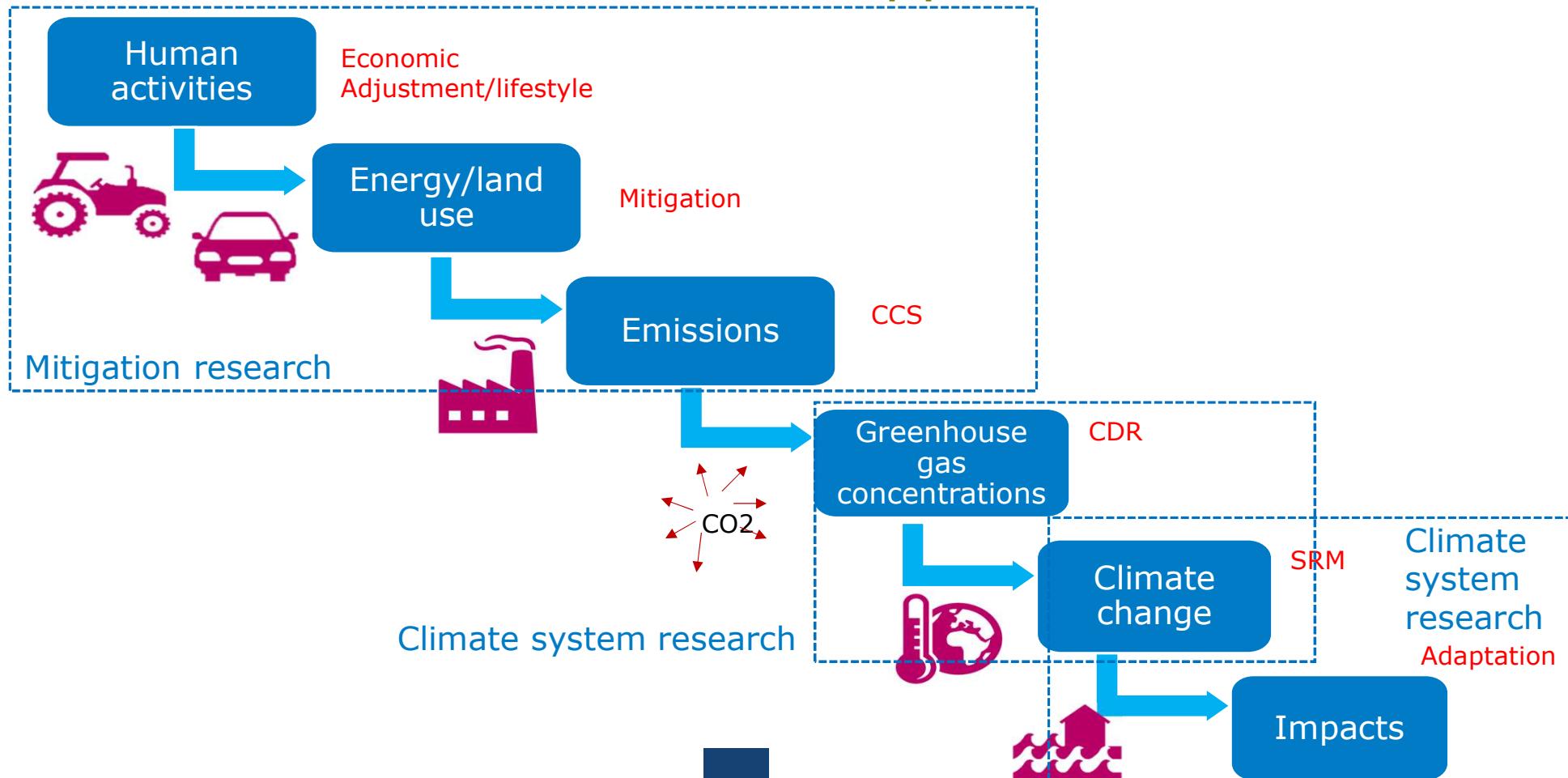
## What will happen in the future?





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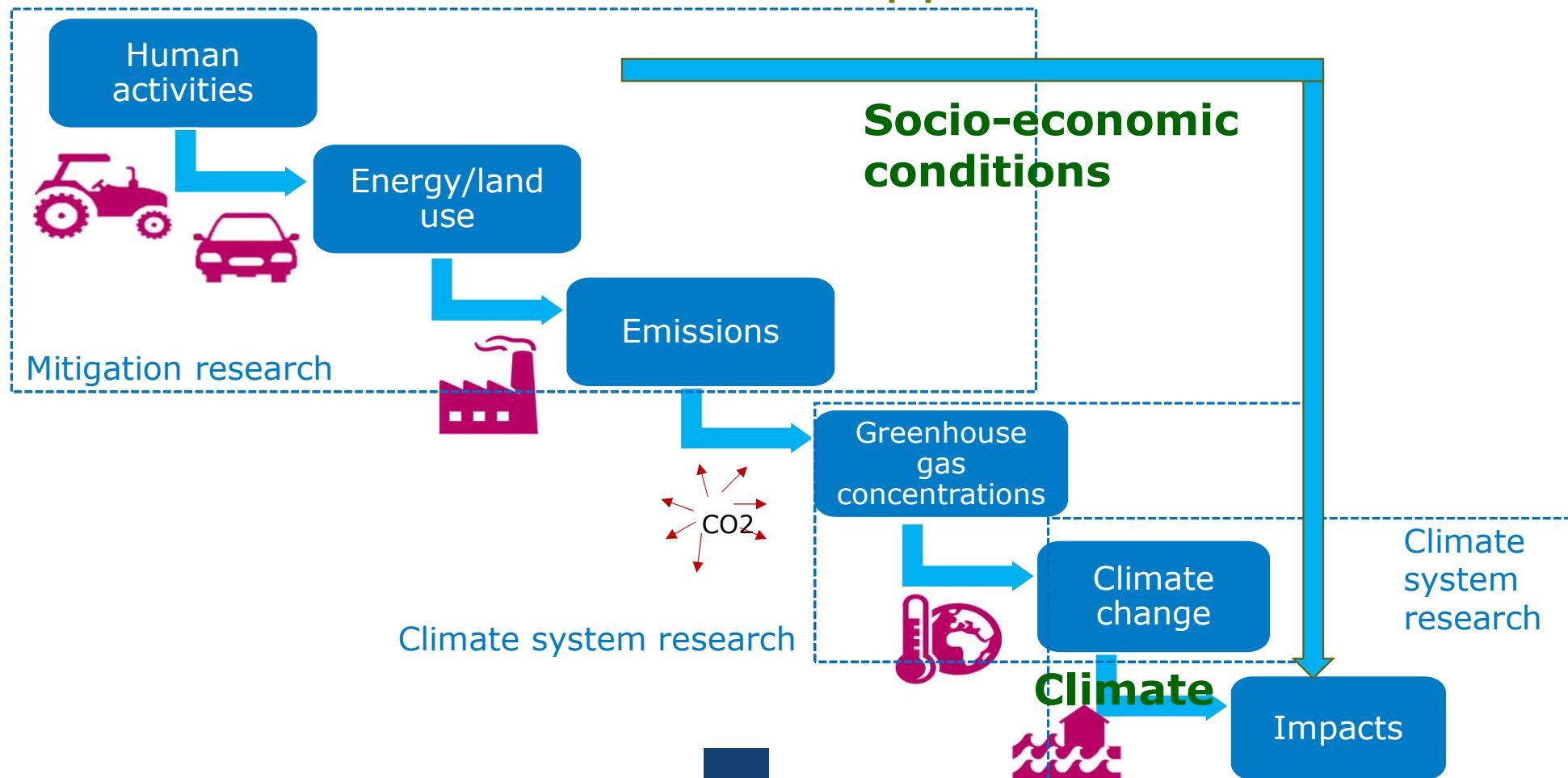
## What will happen in the future?





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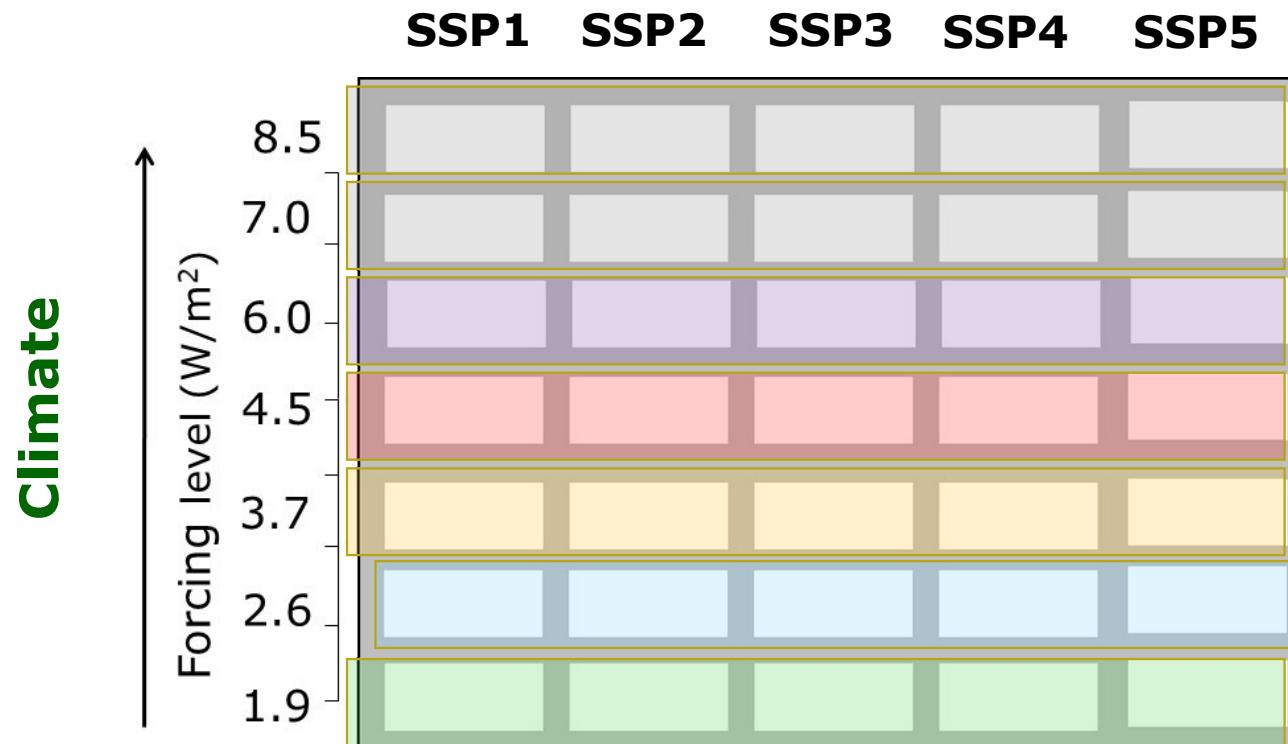
## What will happen in the future?





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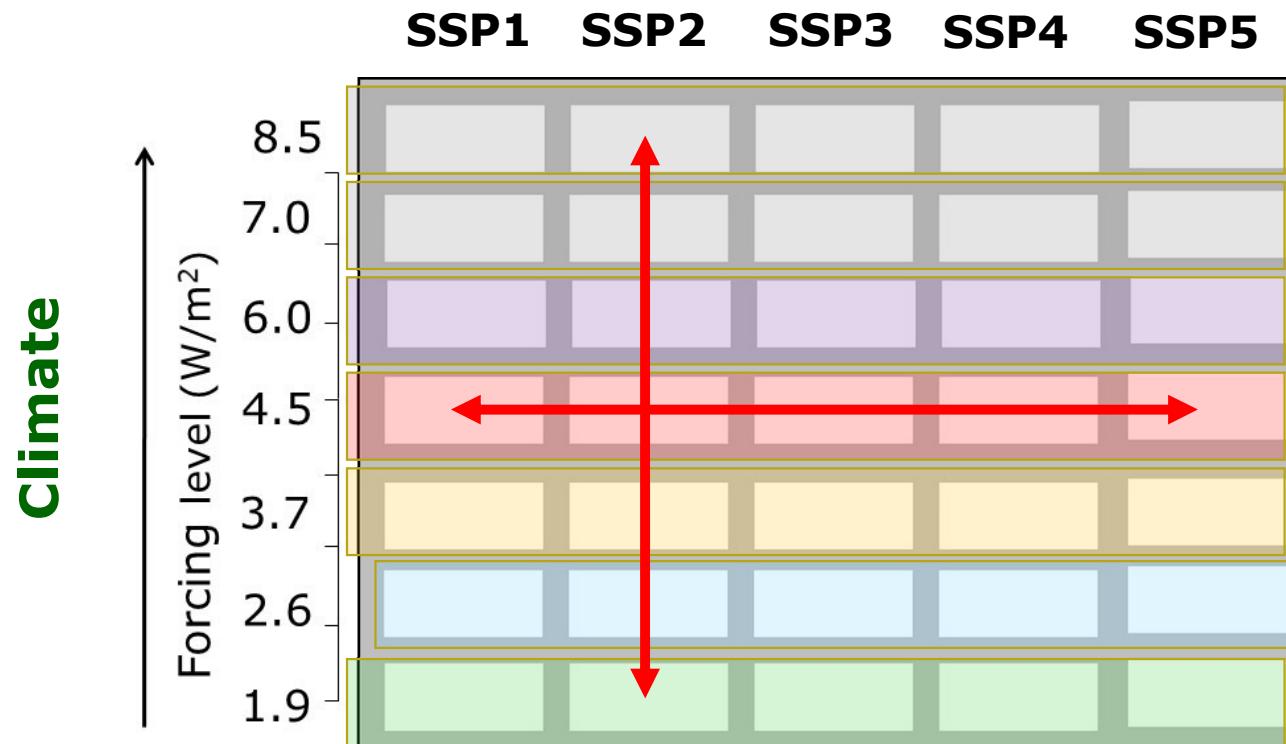
## Socio-economic conditions





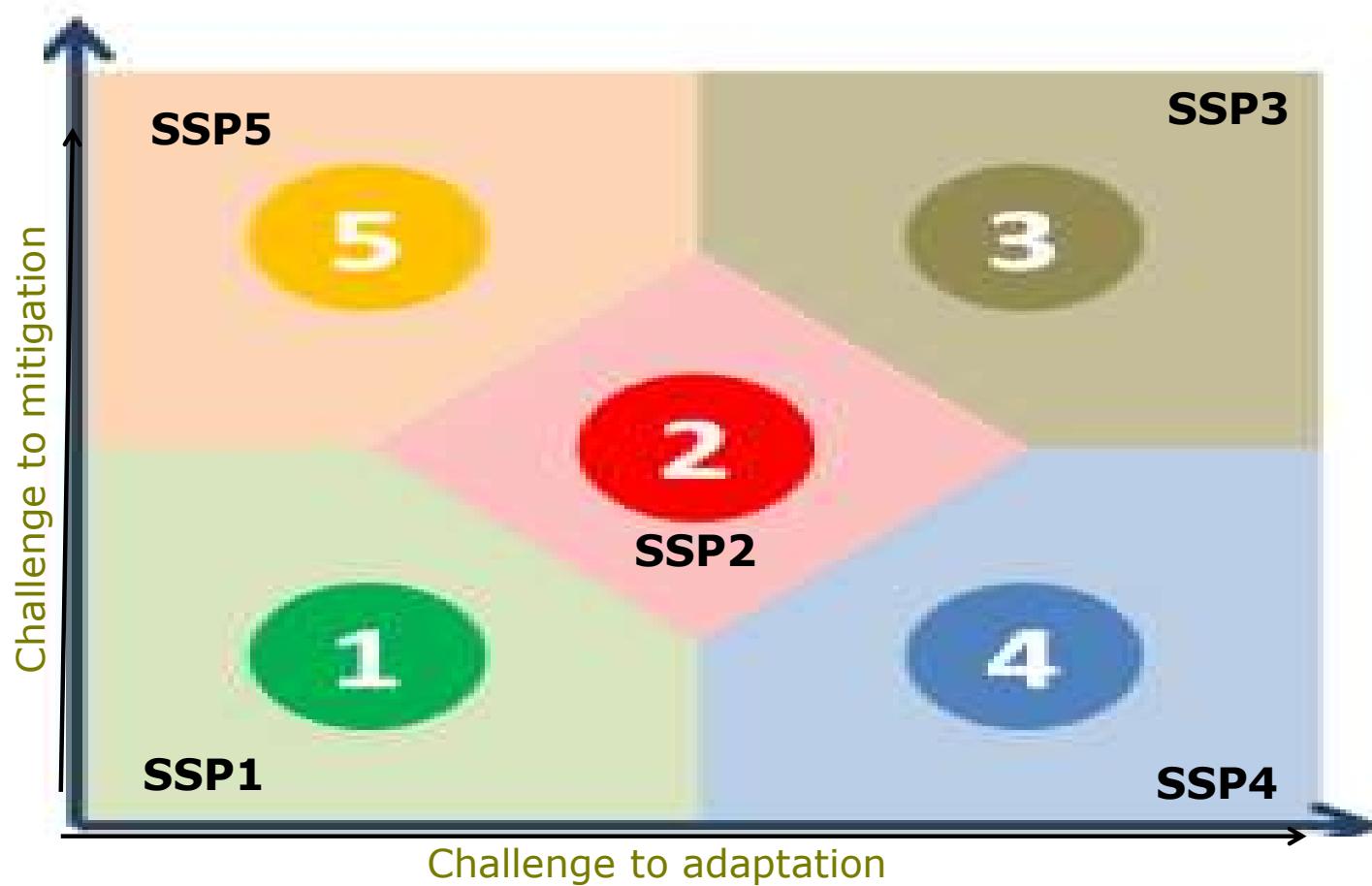
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## Socio-economic conditions





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# Shared Socio-economic Pathways: 5 possible stories about the future

## ↑ SSP5: Fossil fuel-ed development

- Rapid growth, free trade
- High technology development,
- Environment and social goals not a priority: adaptive, technology-fix
- Focus on economic growth



Clash of civilisations

## SSP1: Green growth

- Global cooperation
- Rapid technology dev.
- Strong env. policy
- Low population growth
- Low inequity
- Focus on renewables and efficiency
- Dietary shifts
- Forest protection



UN world

## SSP2: Middle of the Road



Have's and have not's

## SSP3: Regional rivalry

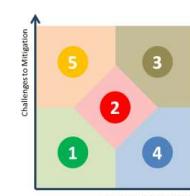
- Competition among regions
- Low technology development
- Environment and social goals not a priority
- Focus on domestic resources
- High population growth
- Slow economic growth dev. countries

## SSP4: Inequality

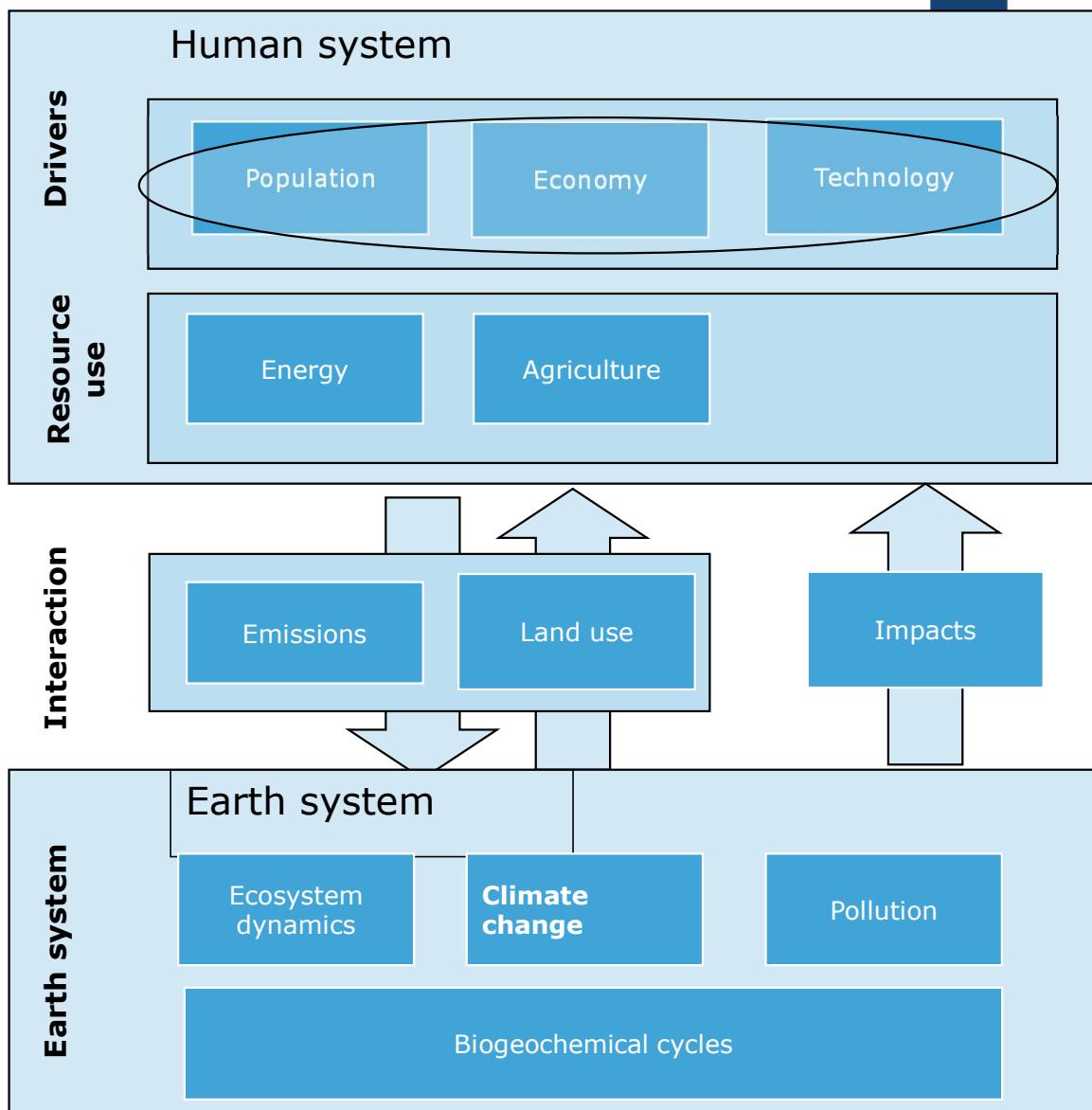
- Inequality across and within regions
- Low technology development
- Environment priority for those that can afford
- Limited trade



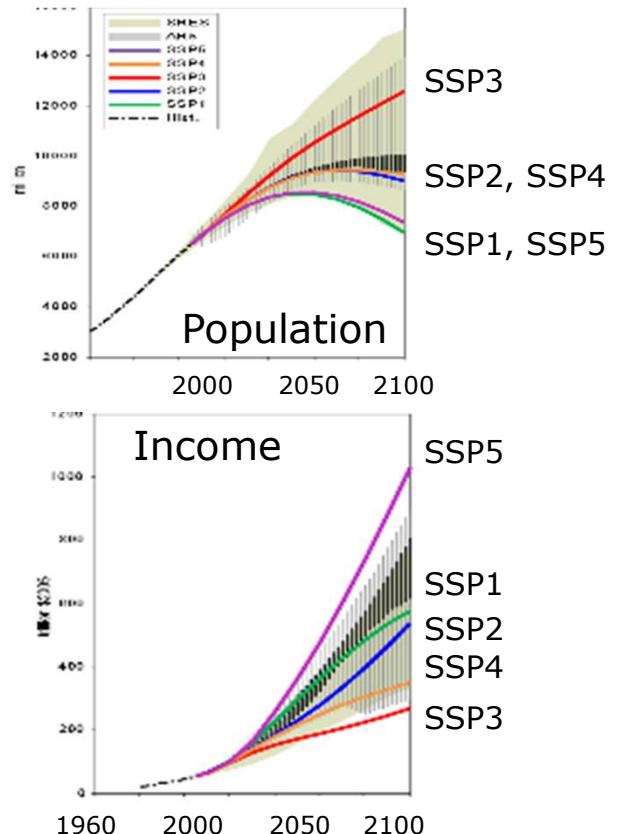
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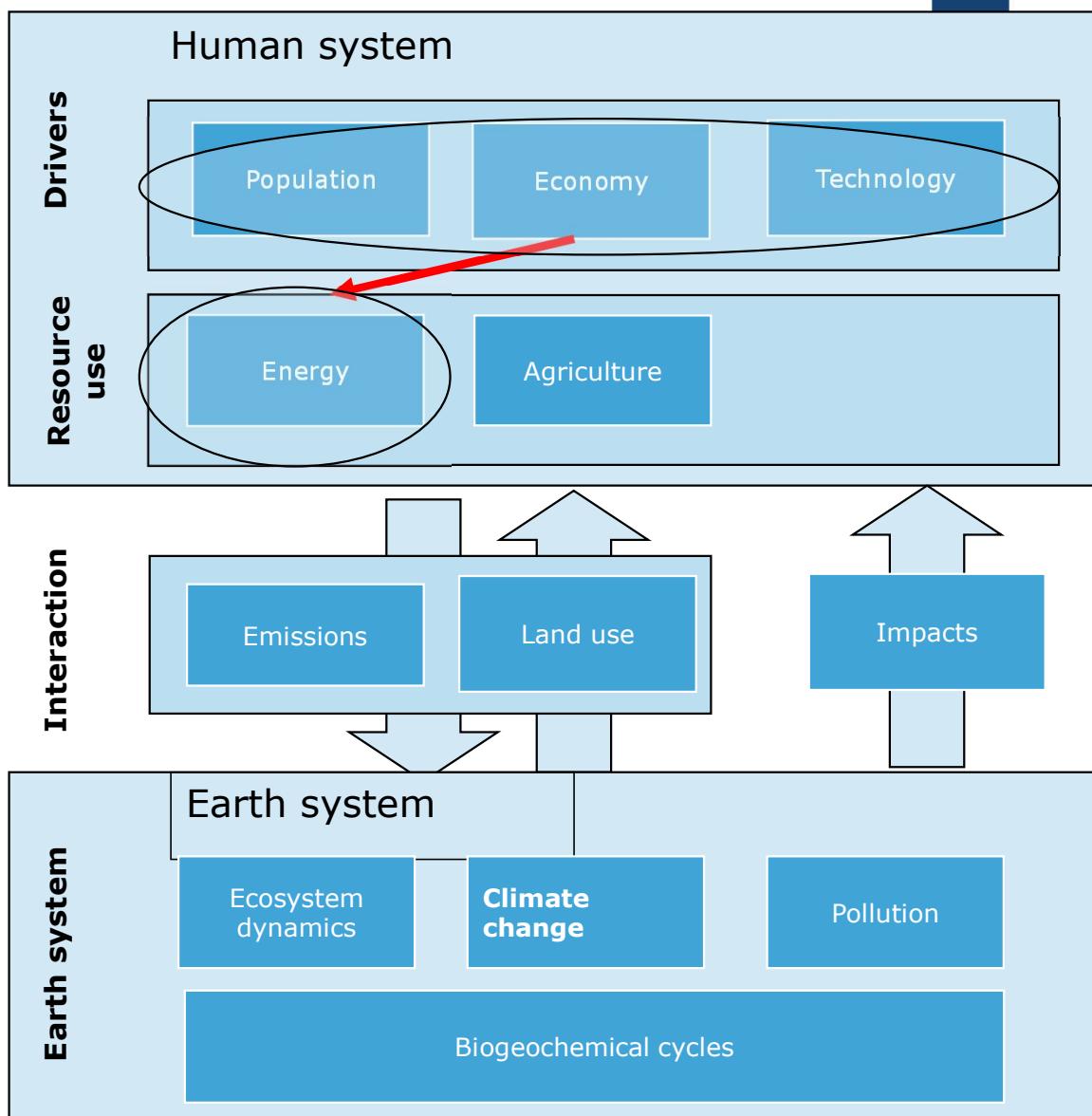
	<b>SSP1 Sustainability</b>	<b>SSP2 Middle of the Road</b>	<b>SSP3 Fragmentation</b>	<b>SSP4 Inequality</b>	<b>SSP5 Development First</b>
<b>2100 Population [billion] (IIASA)</b>	Low (5 <sup>th</sup> )	Middle (3 <sup>rd</sup> )	High (1 <sup>st</sup> )	Middle (2 <sup>nd</sup> )	Low (4 <sup>th</sup> )
<b>2100 GDP [trillion 2005 USD, PPP] (OECD)</b>	High (2 <sup>nd</sup> )	Middle (3 <sup>rd</sup> )	Low (5 <sup>th</sup> )	Low/middle (4 <sup>th</sup> )	Very high (1 <sup>st</sup> )
<b>Energy Service Demands</b>	Low	Medium	High	Medium	High
<b>End-Use Technology</b>	High	Medium	Low	Low / High	Medium
<b>Nuclear / CCS</b>	Low	Medium	Medium	Mixed	Medium
<b>Renewable Technology</b>	High	Medium	Low	High	Medium
<b>Fossil Fuel Extraction</b>	Low	Medium	High	Medium	High
<b>Crop Yield Improvement</b>	High	Medium	Low	Low / Medium	High
<b>Accession to Carbon Market</b>	All Instantaneous	Delayed	Delayed	Delayed	Delayed
<b>Coverage of Carbon Tax</b>	Universal	Universal	Fragmented	Fragmented	Universal



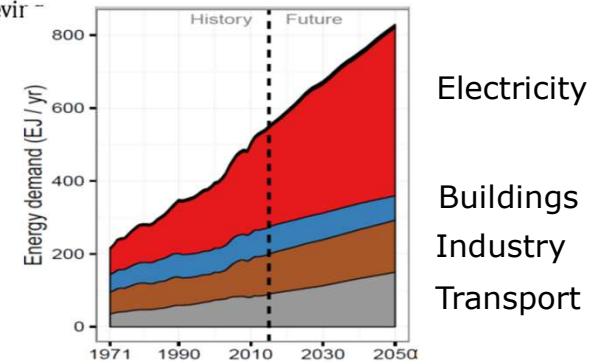
Stuurlijn voor de Leefomgev.



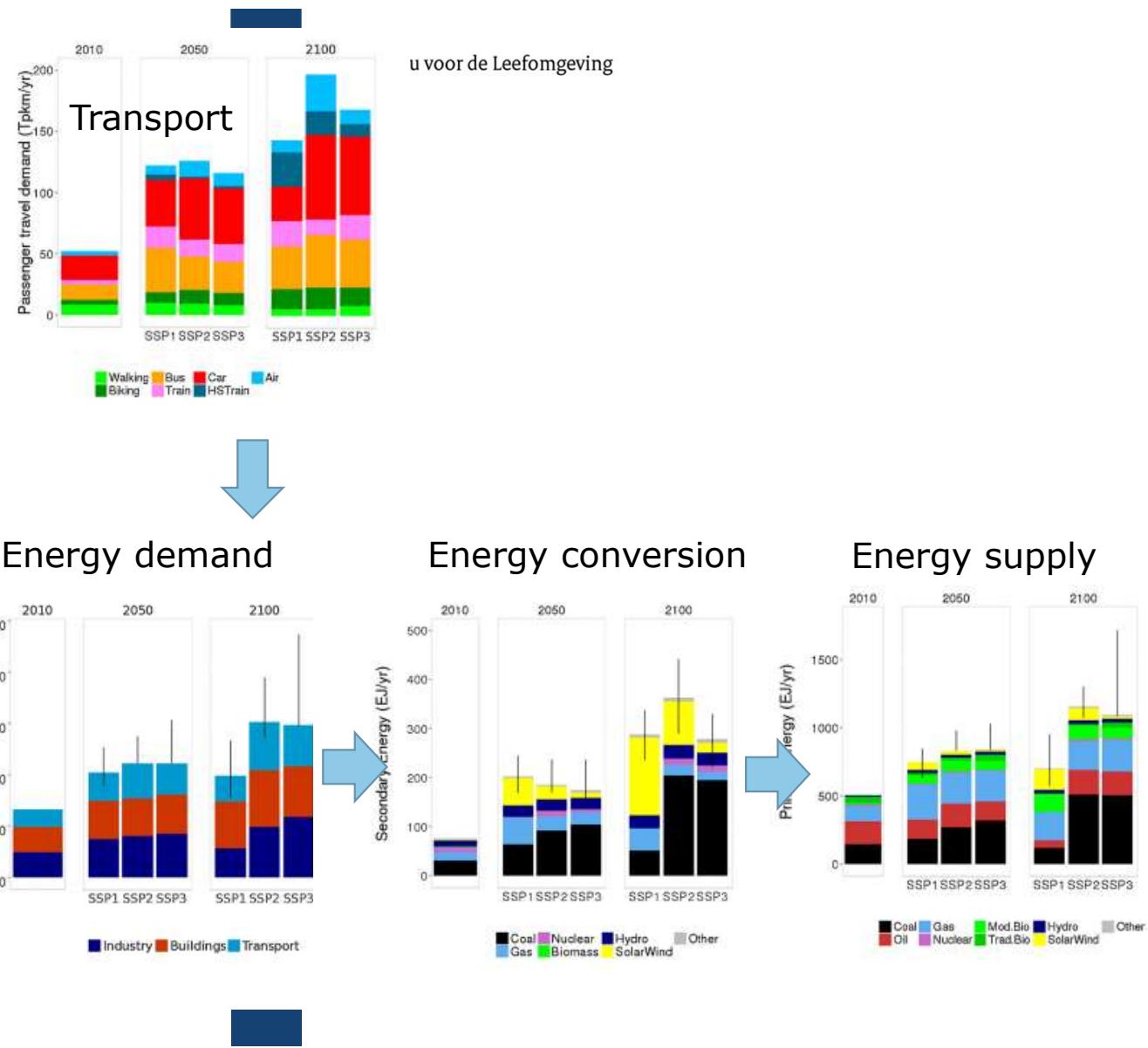
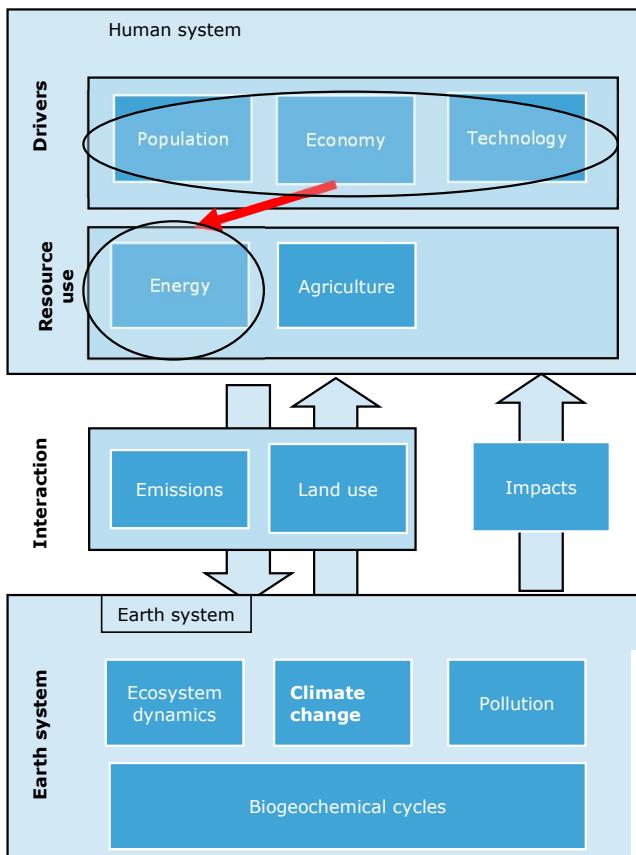
- SSP1: Sustainable development
- SSP2: Middle of the road
- SSP3: Increasing competition
- SSP4: Divided world
- SSP5: Rapid growth

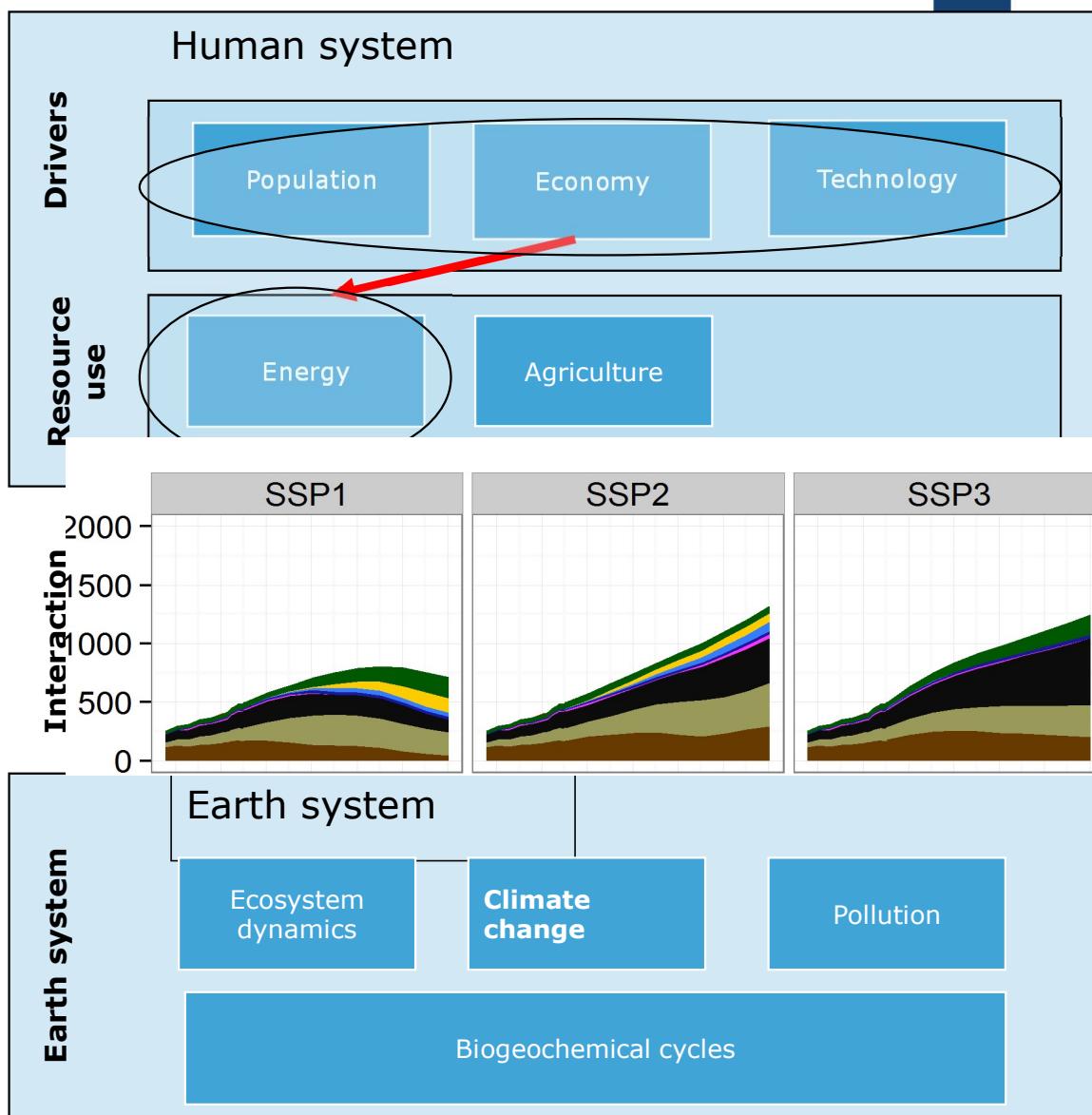


Leefomgevingsrapportage voor de Leefomgeving

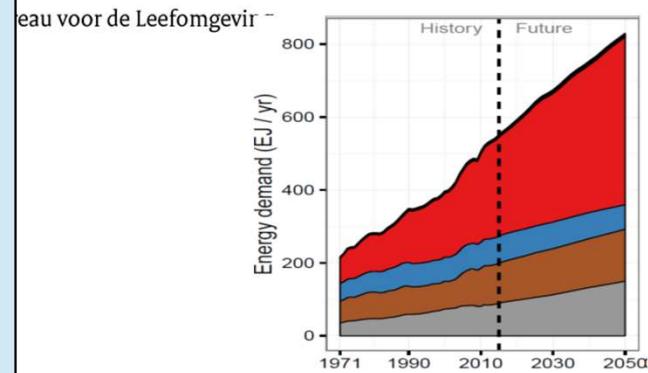


Electricity  
Buildings  
Industry  
Transport

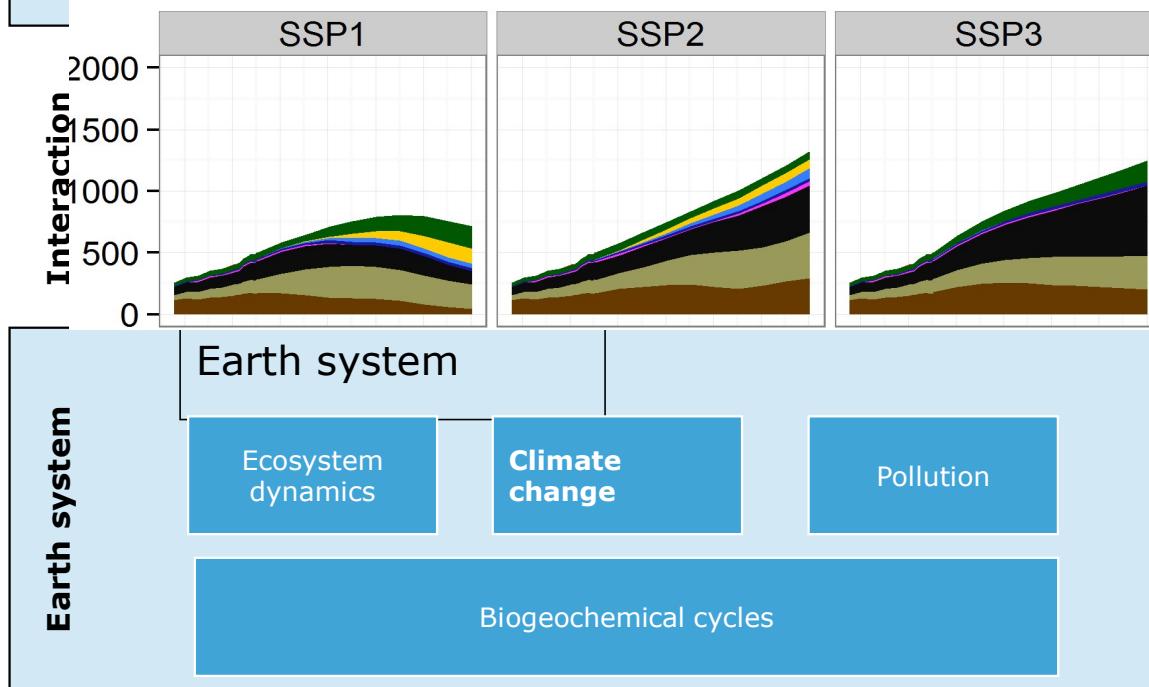




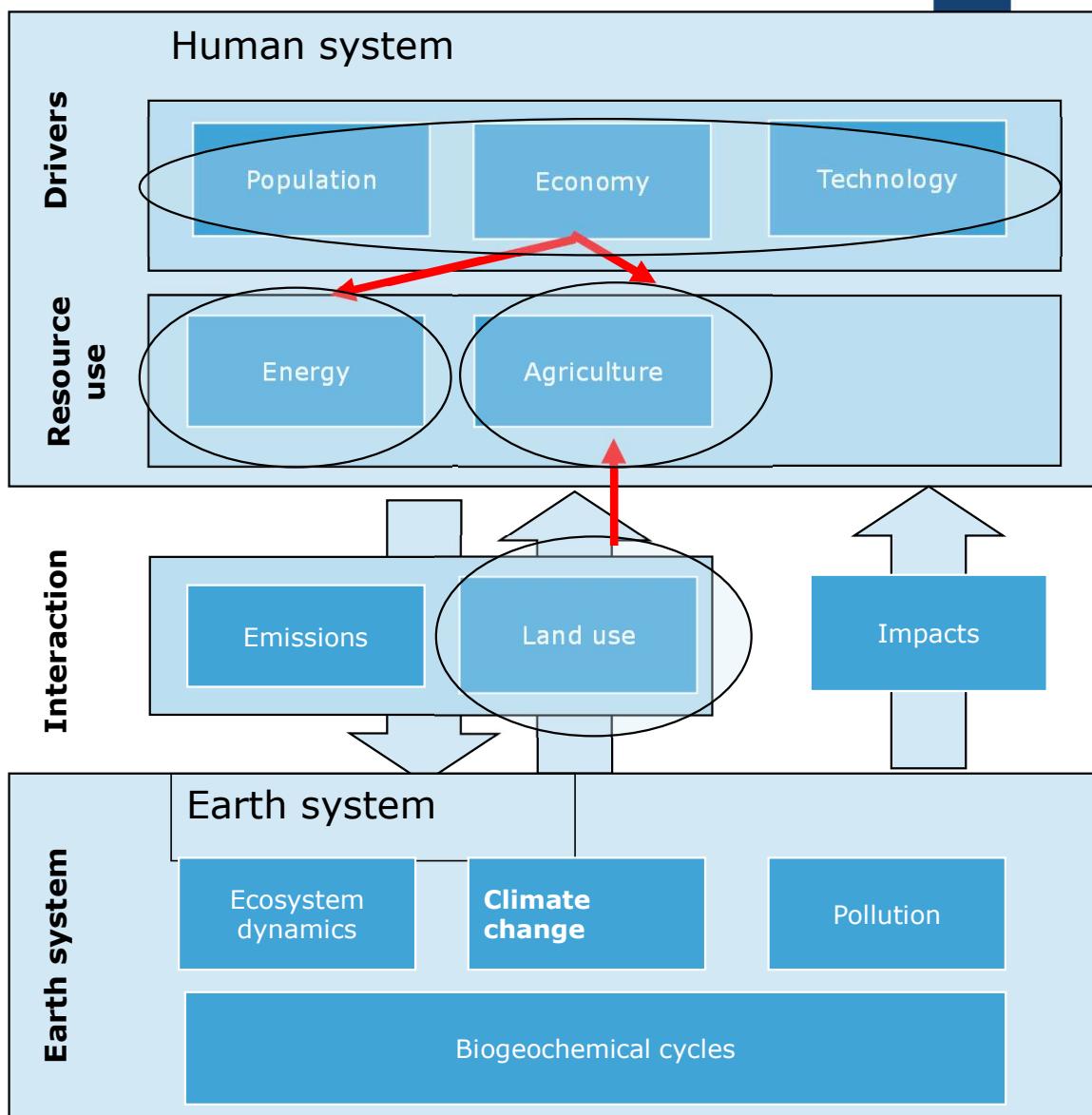
Leefomgevingsrapportage voor de Leefomgeving



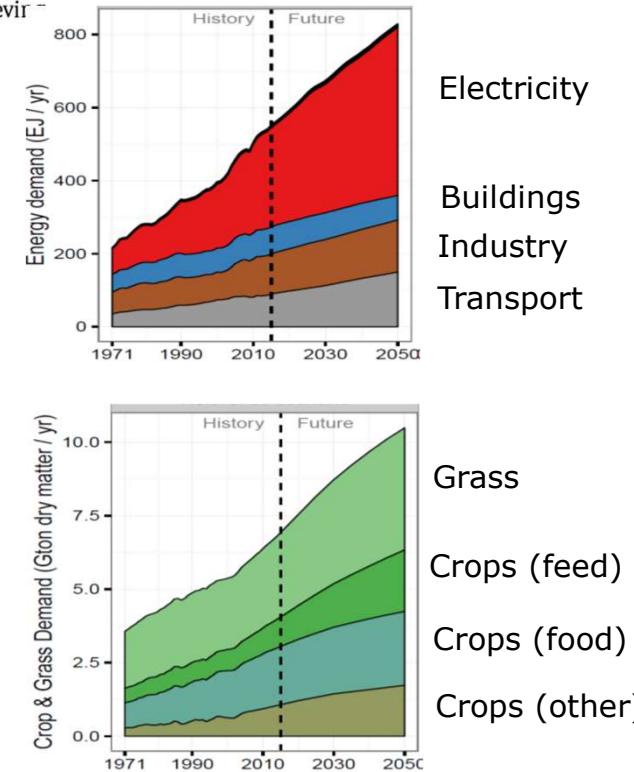
Electricity  
Buildings  
Industry  
Transport



- As a result, in all 5 stories without stringent climate policy:
  - further increase in global energy use
  - Fossil fuels continue to be important
  - Thus increasing greenhouse gas emissions



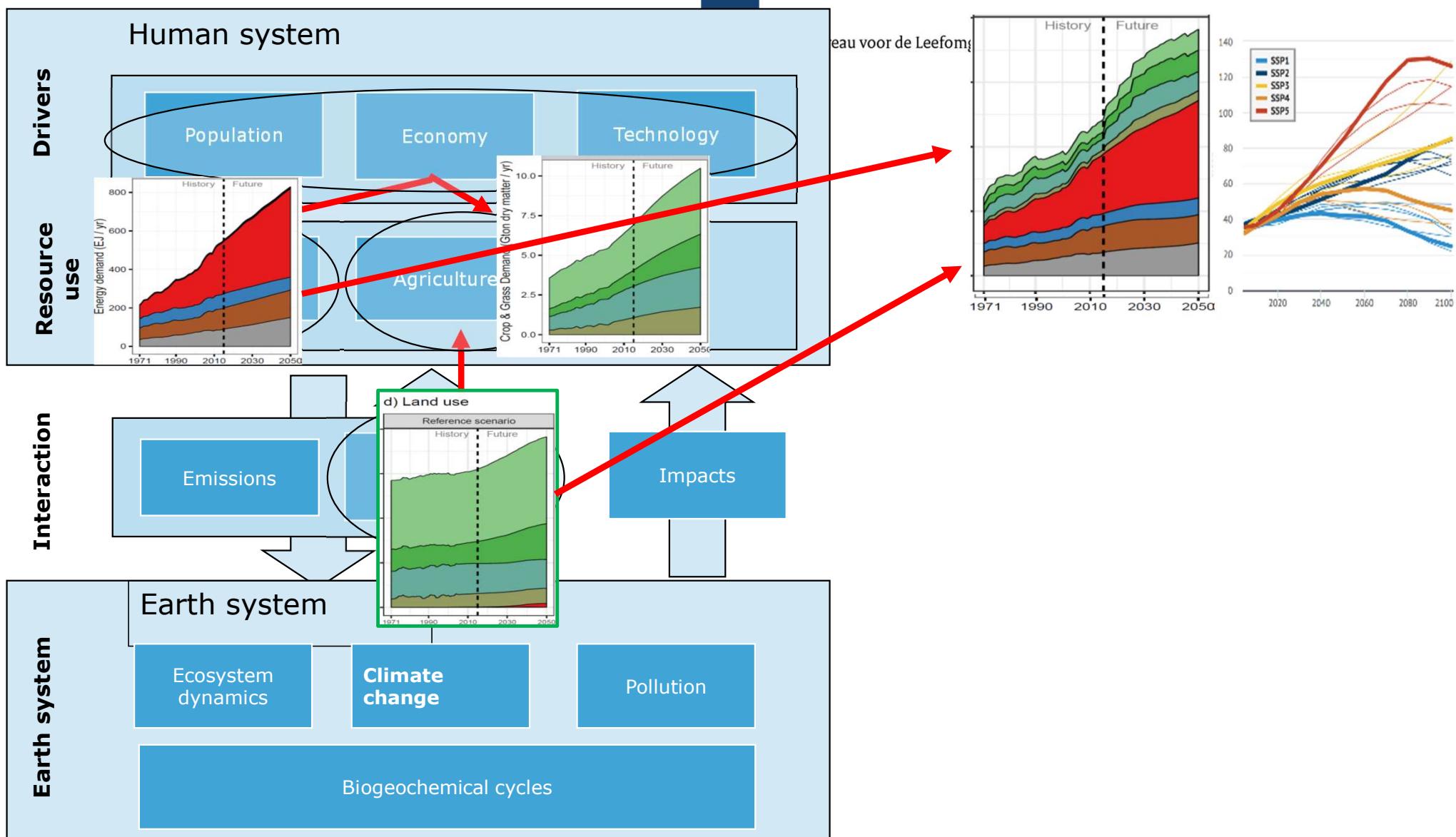
Leeu voor de Leefomgevind



Interaction demand / supply

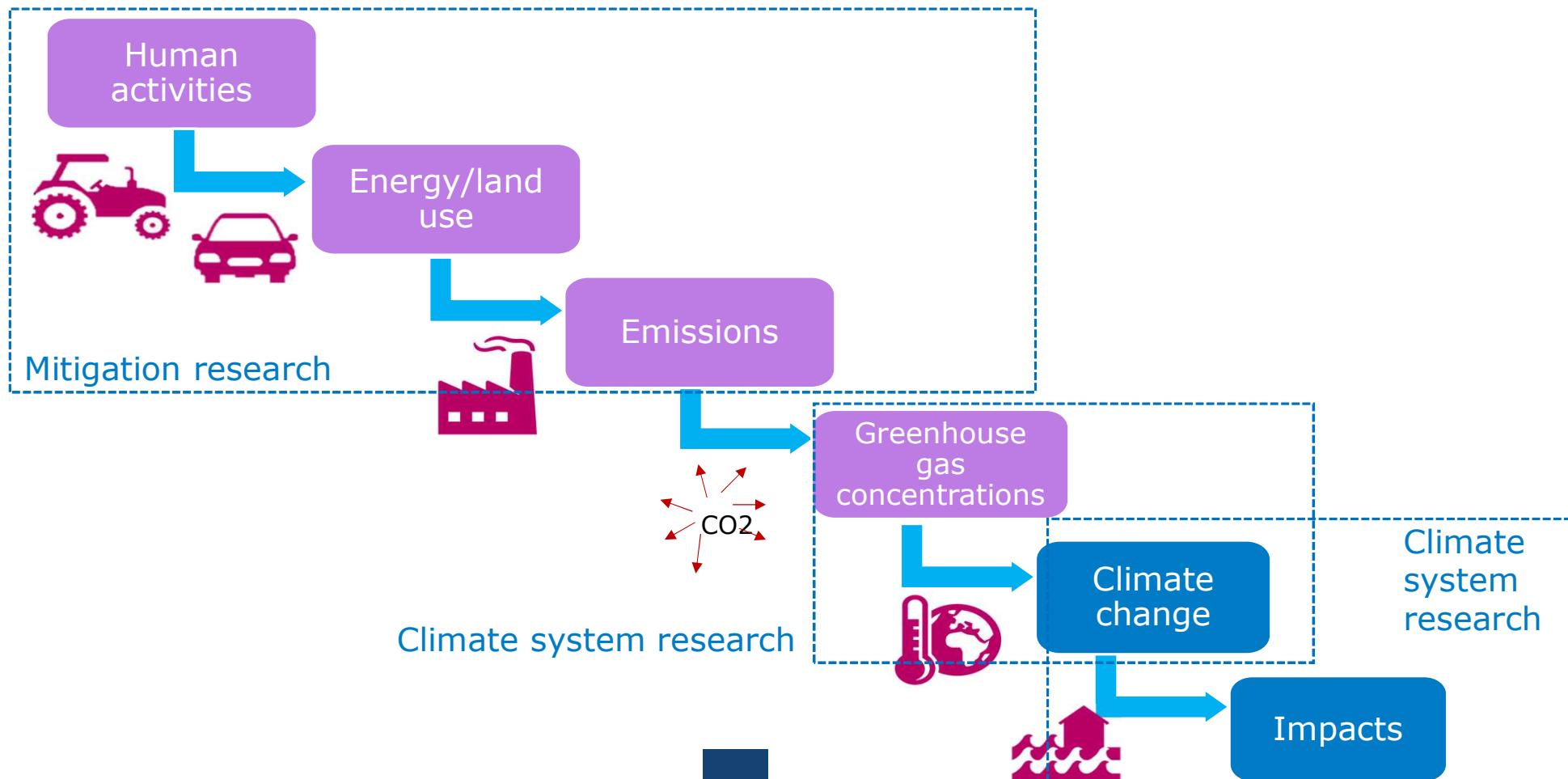
Allocation based on prices and preferences

Detailed representation of processes (technology development, depletion) and sectors (e.g. transport)

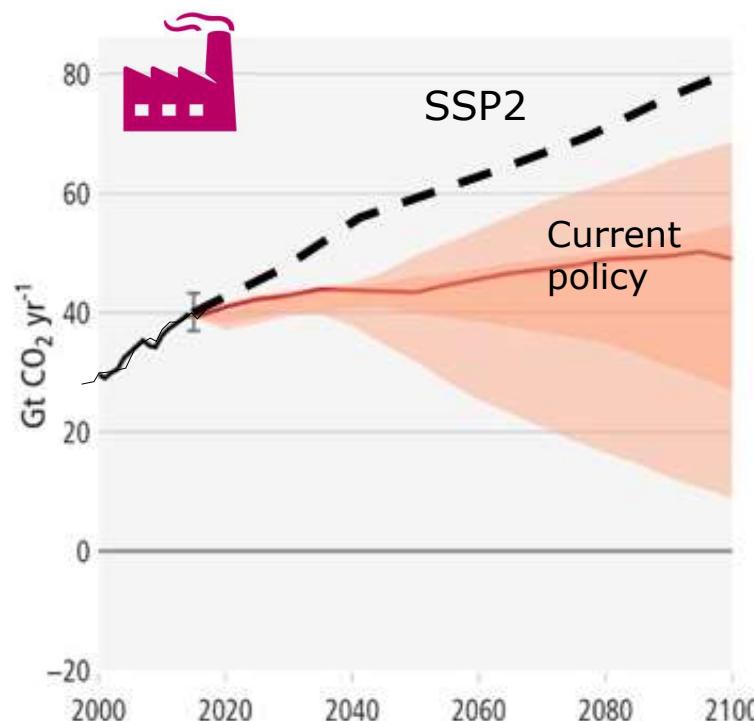




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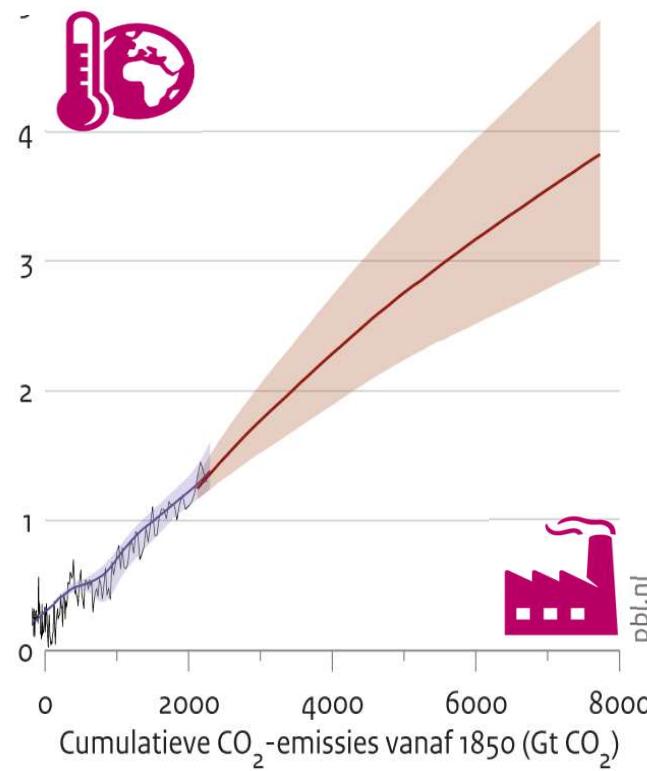
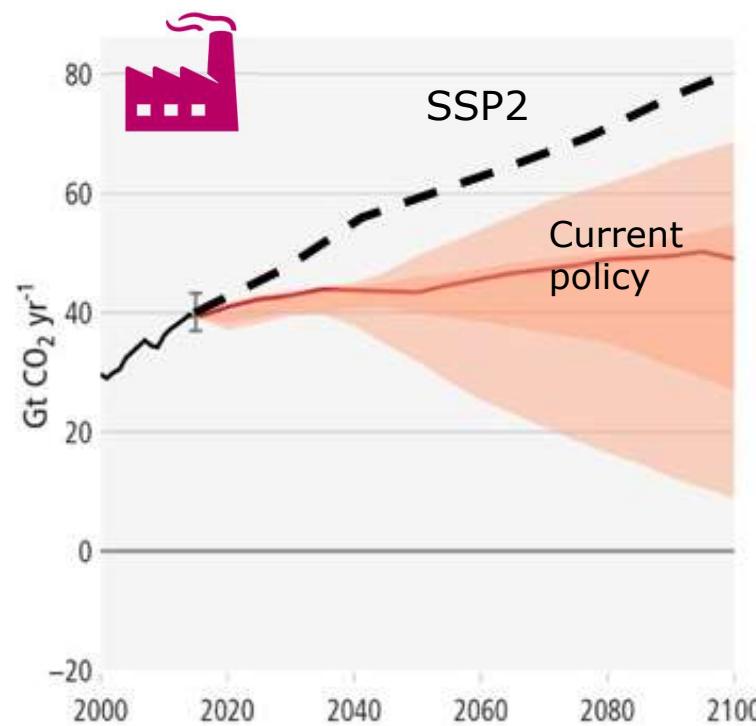


IPCC-2023: IAMs show that current policies could slow down emission growth, but won't lead to fundamental transition

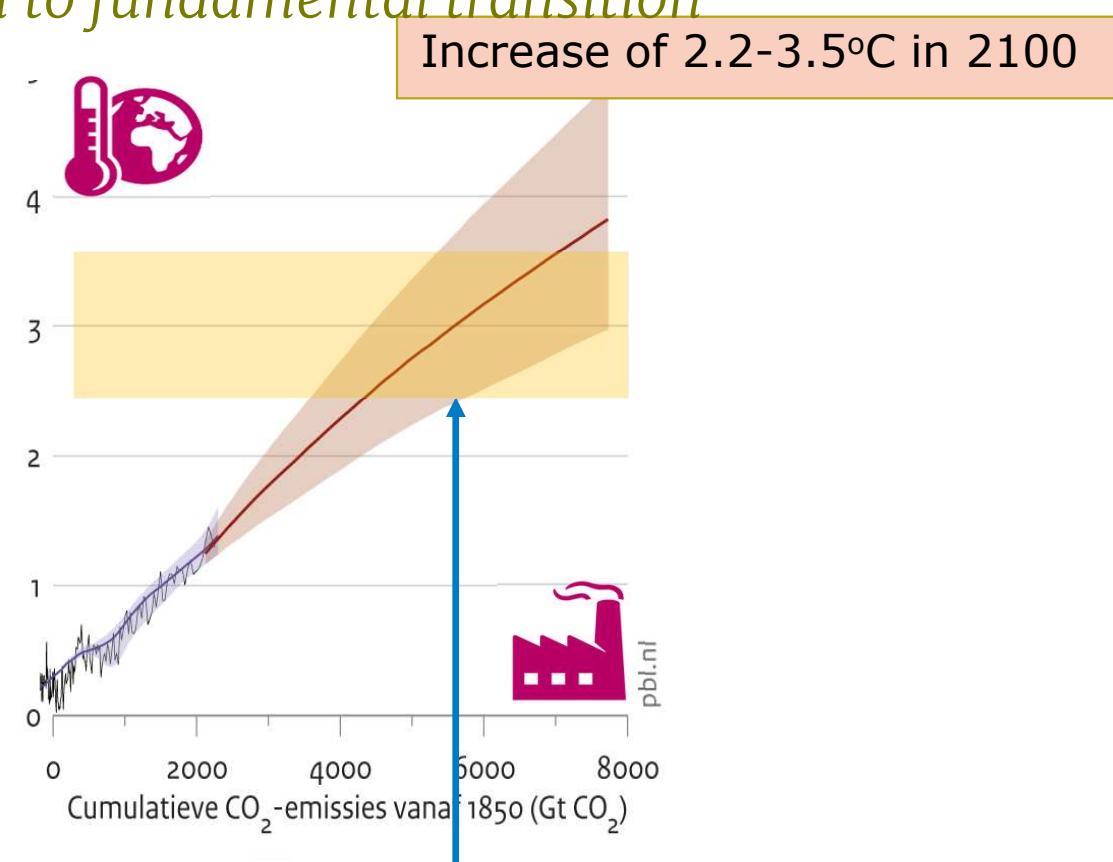
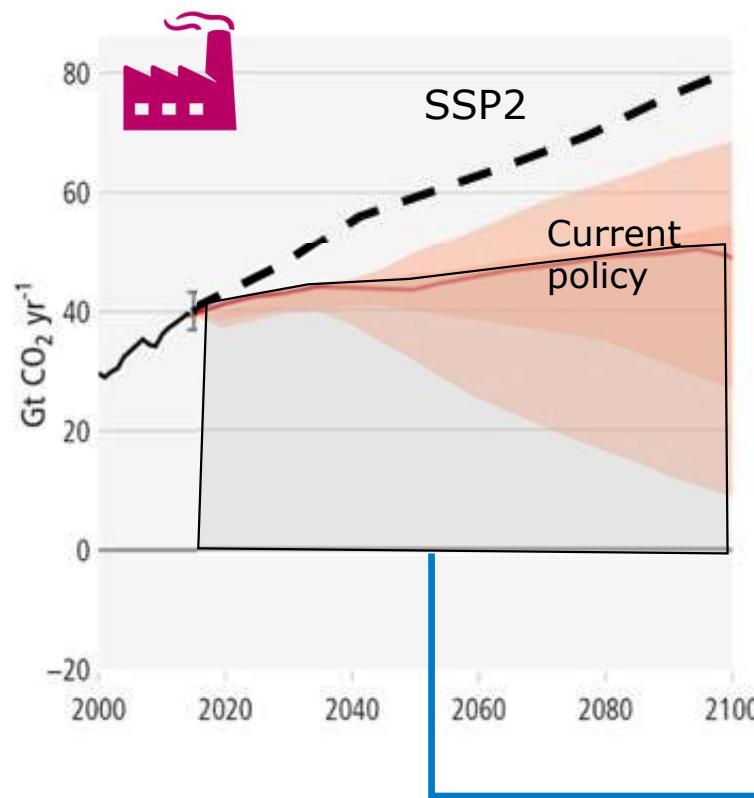




IPCC-2023: IAMs show that current policies could slow down emission growth, but won't lead to fundamental transition



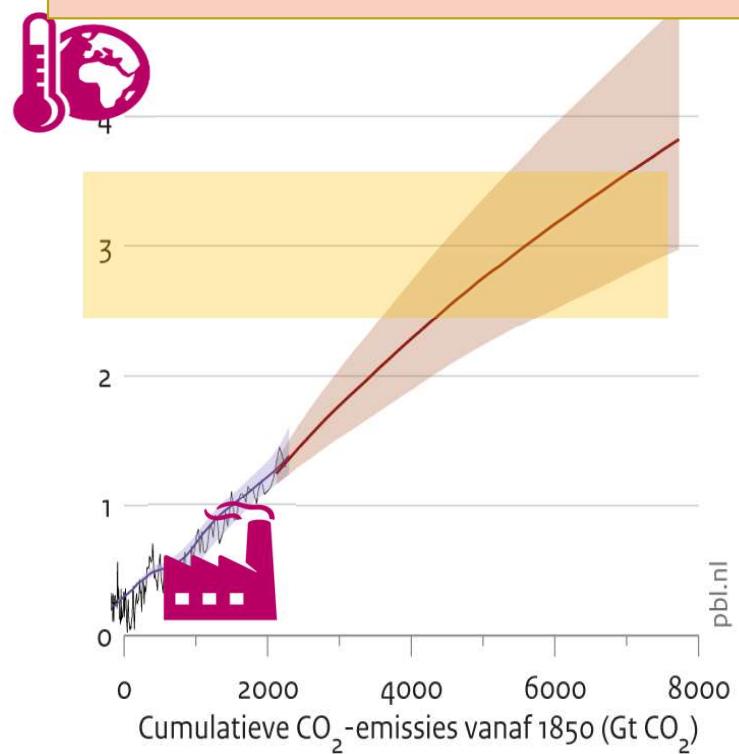
*IPCC-2023: IAMs show that current policies could slow down emission growth, but won't lead to fundamental transition*



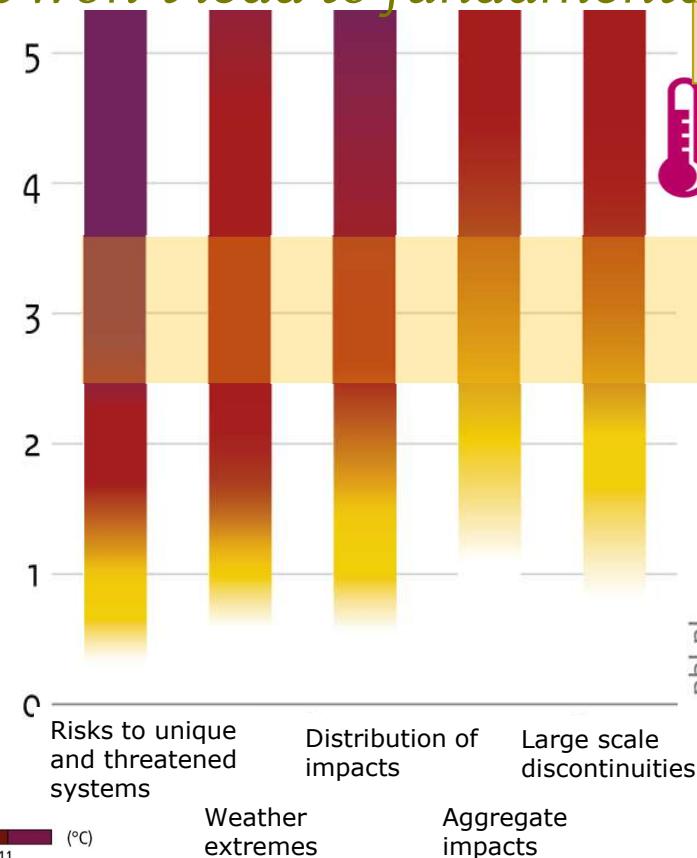
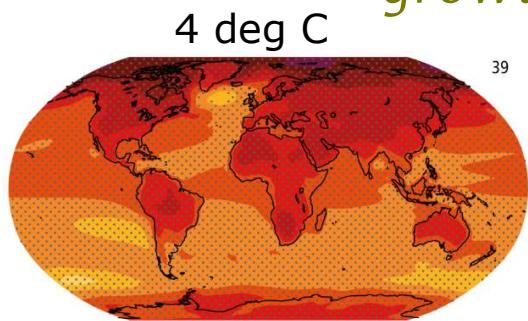
*IPCC-2023: IAMs show that current policies could slow down emission growth, but won't lead to fundamental transition*

4 deg C

Increase of 2.2-3.5°C in 2100



*IPCC-2023: IAMs show that current policies could slow down emission growth, but won't lead to fundamental transition*



Increase of 2.2-3.5°C in 2100



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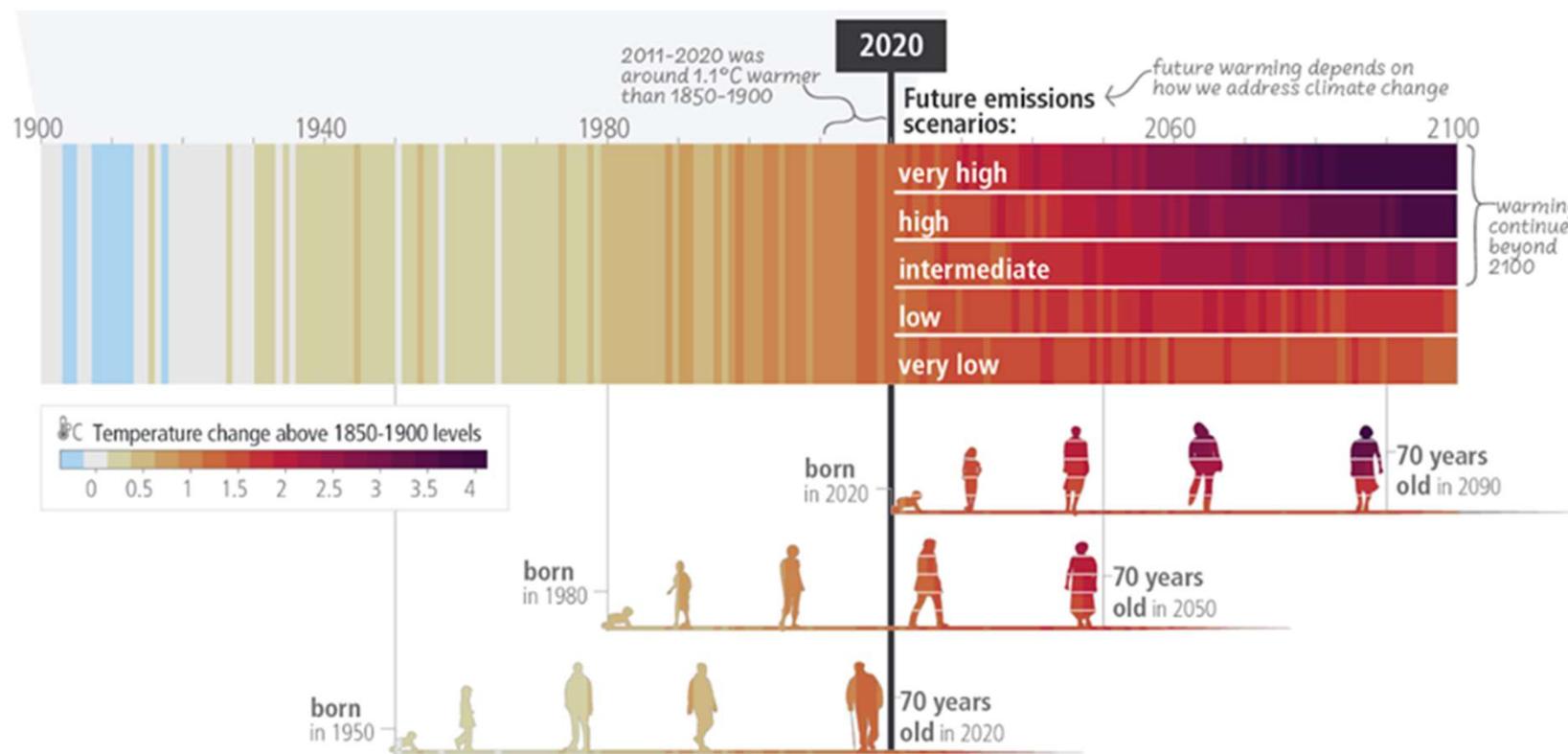
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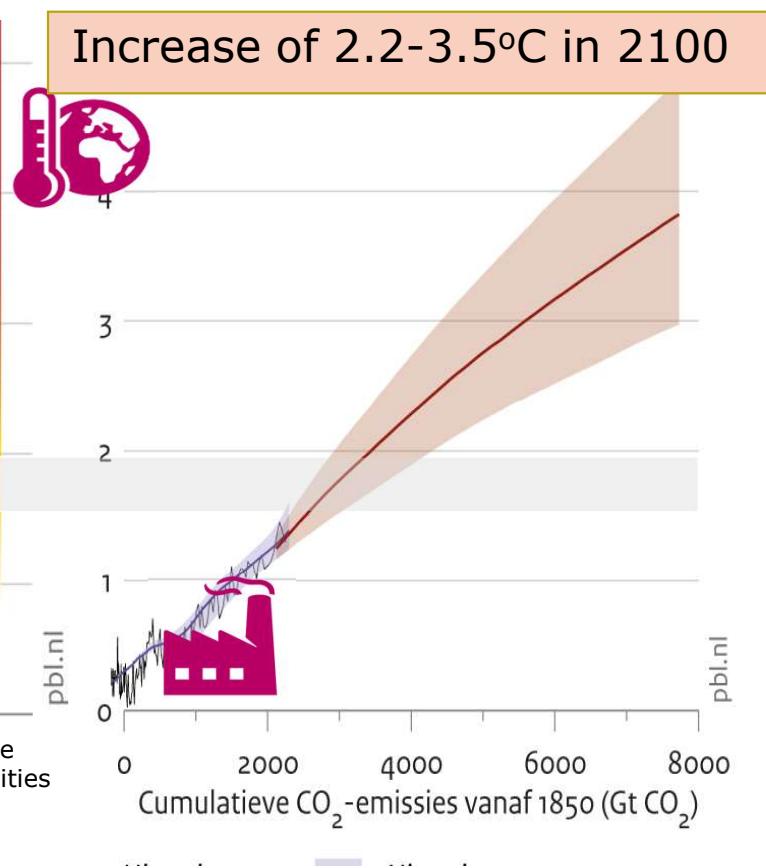
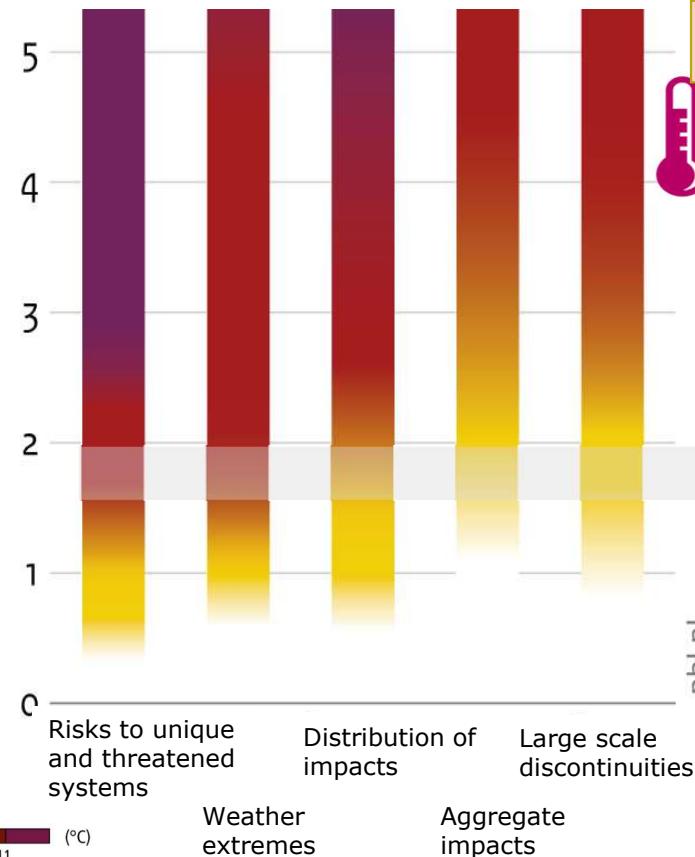
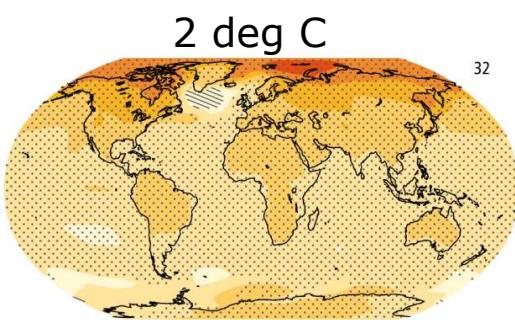
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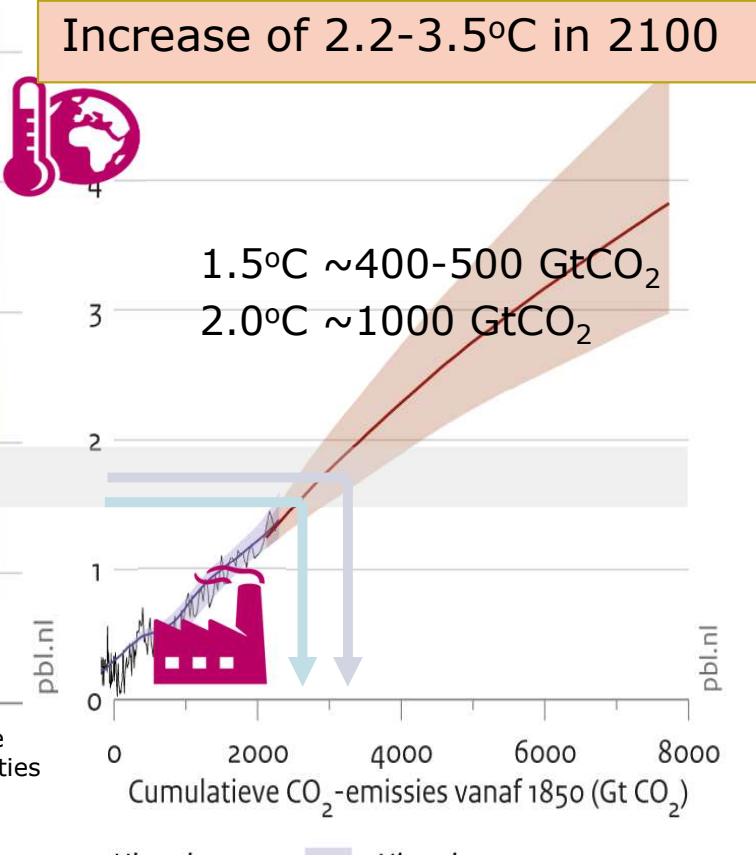
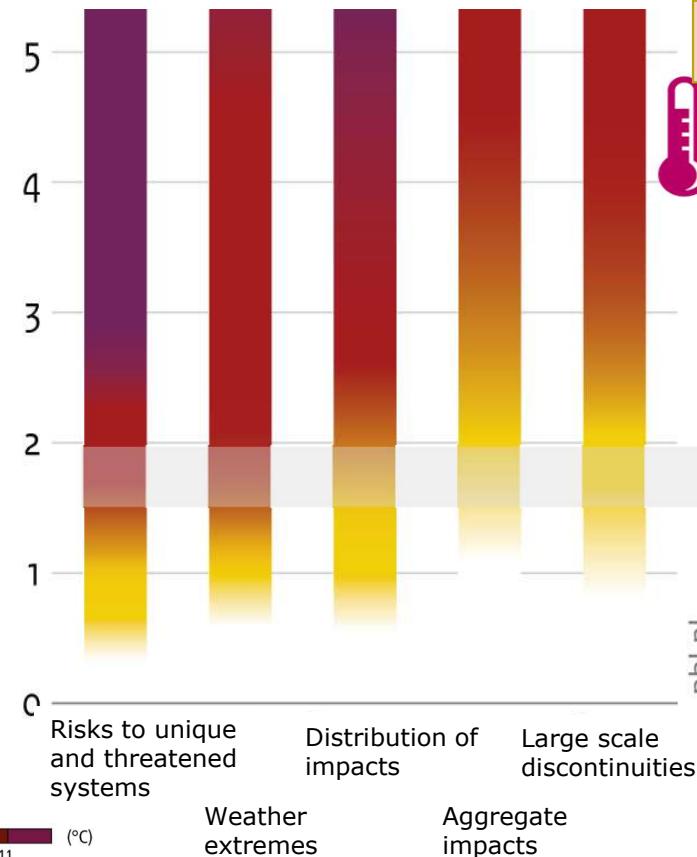
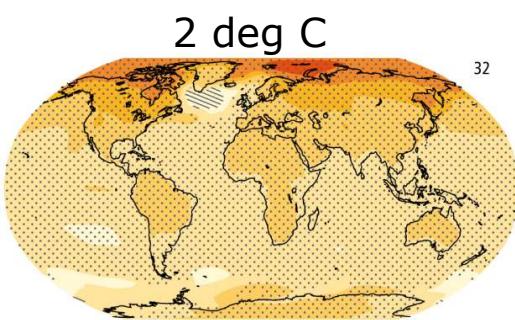
# Our choices determine the climate future



## Paris-agreement



## Paris-agreement

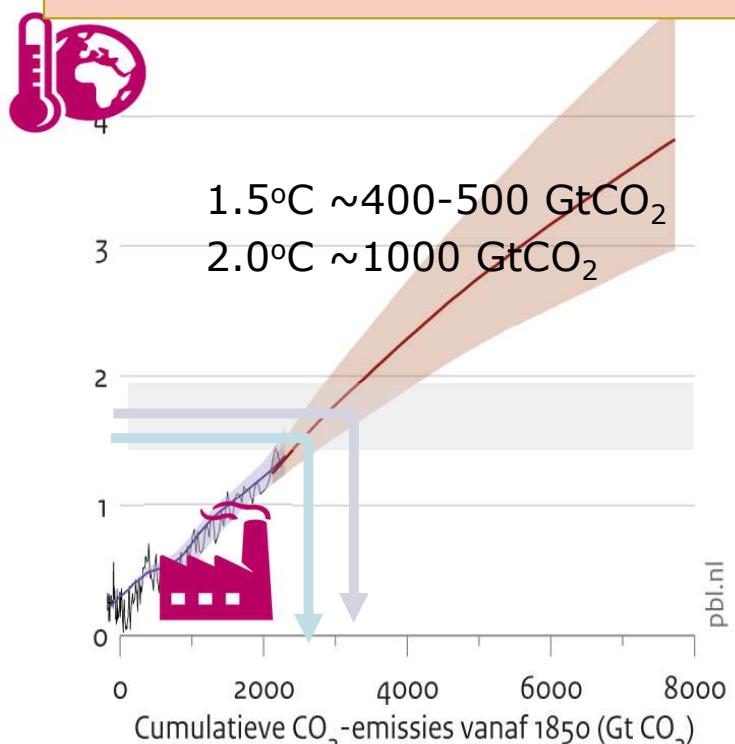




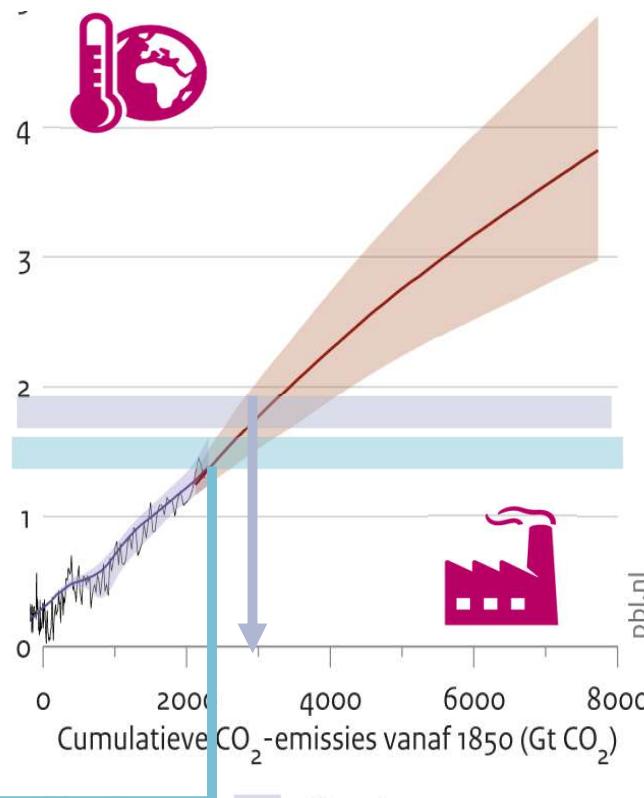
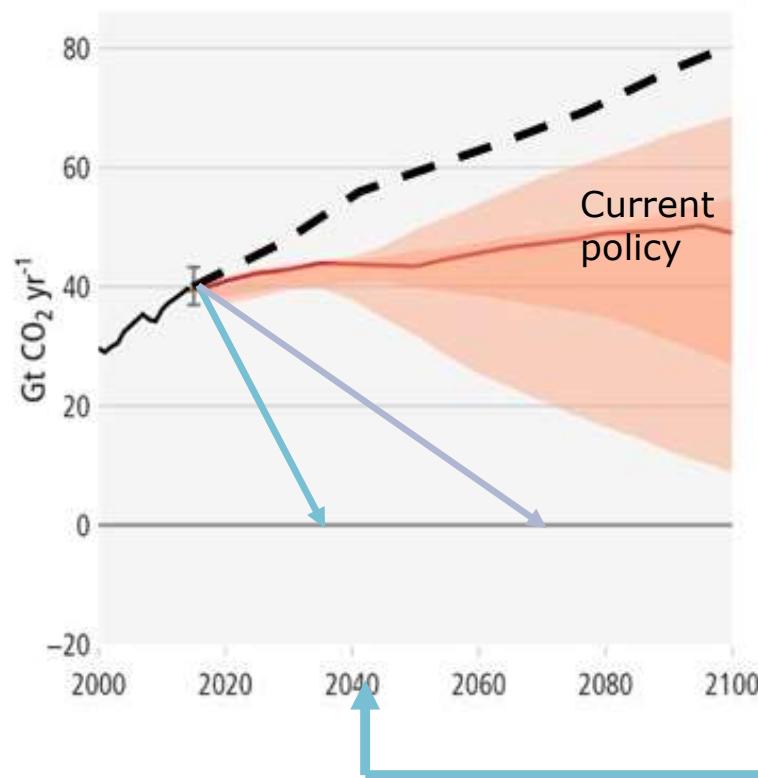
## Paris-agreement



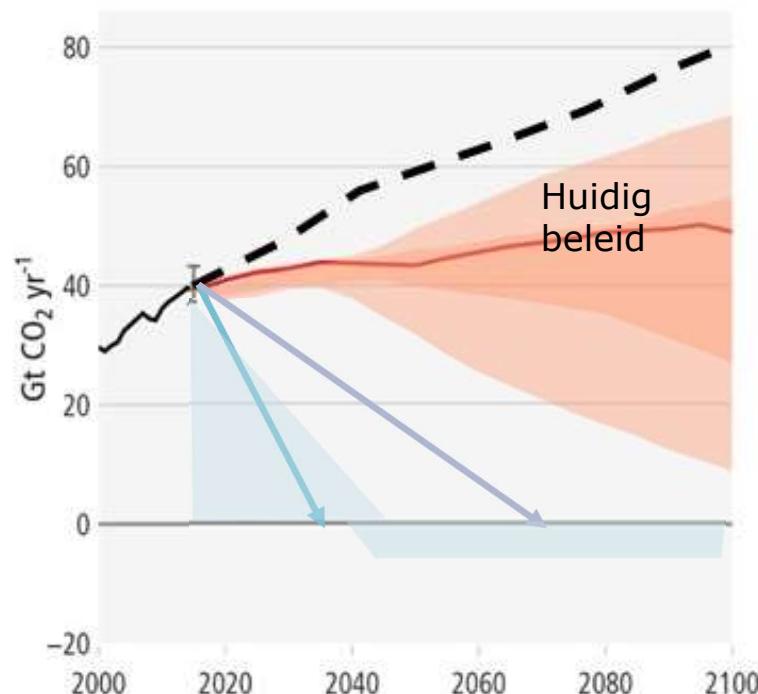
Increase of 2.2-3.5°C in 2100



## Paris-agreement



## Paris-agreement



### Negative emissions:

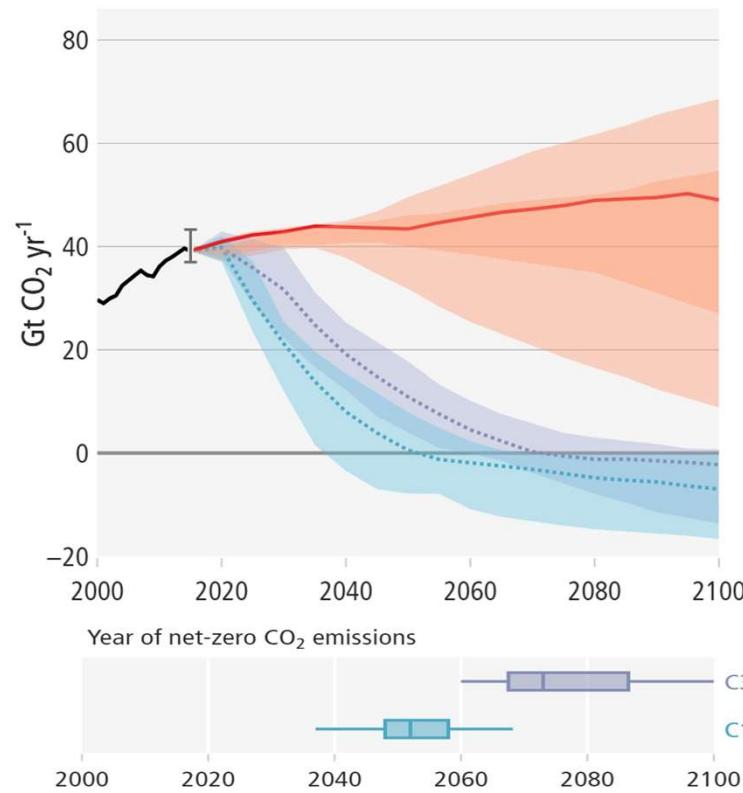
- Reforestation
- Bio-energy with CCS
- Direct air capture
- Nature-based solution (e.g. soil carbon)
- ...

Could help, but

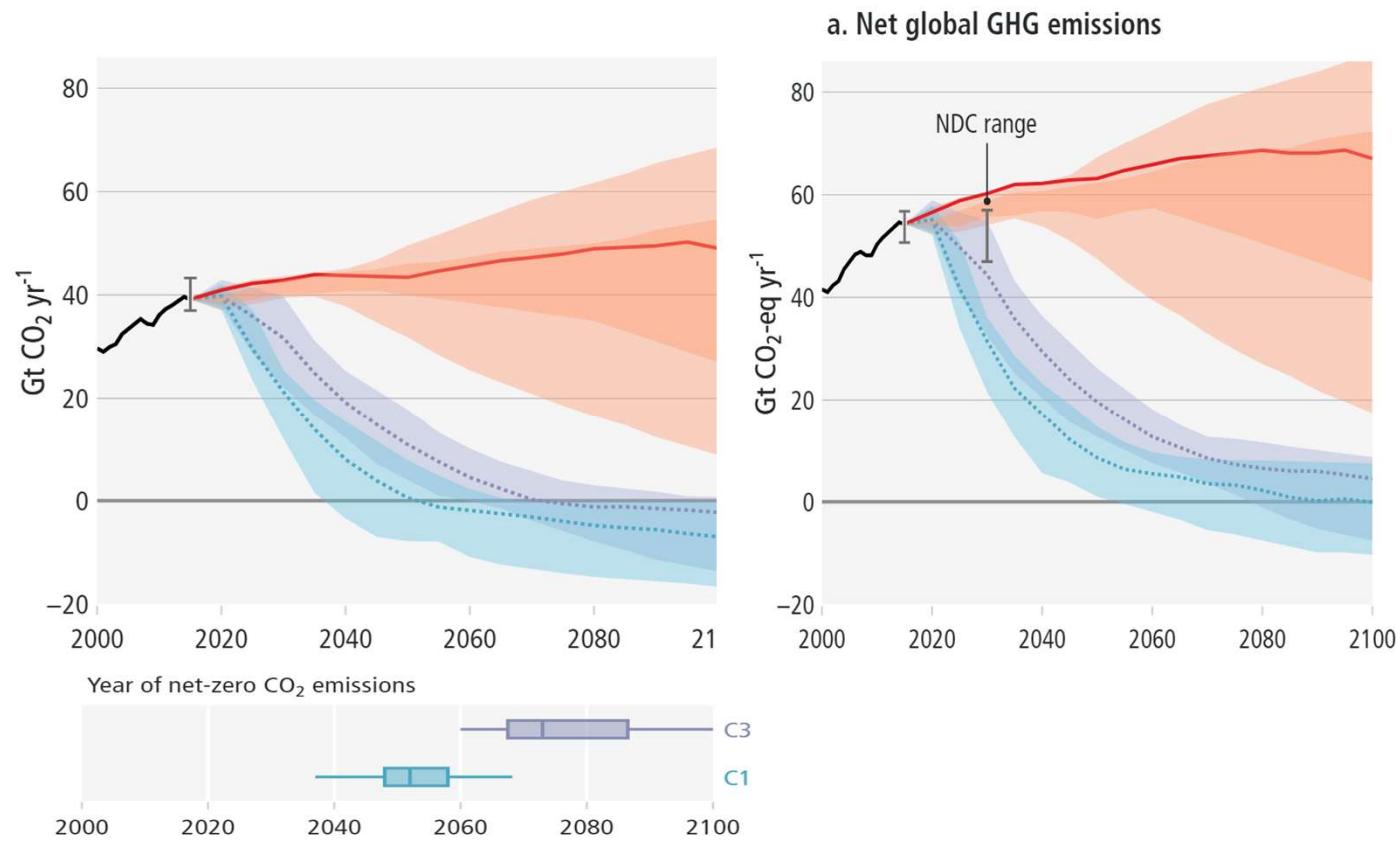
- Temporary overshoot temperature target
- Possible negative impacts on land use
- Limit potential



## Paris-agreement

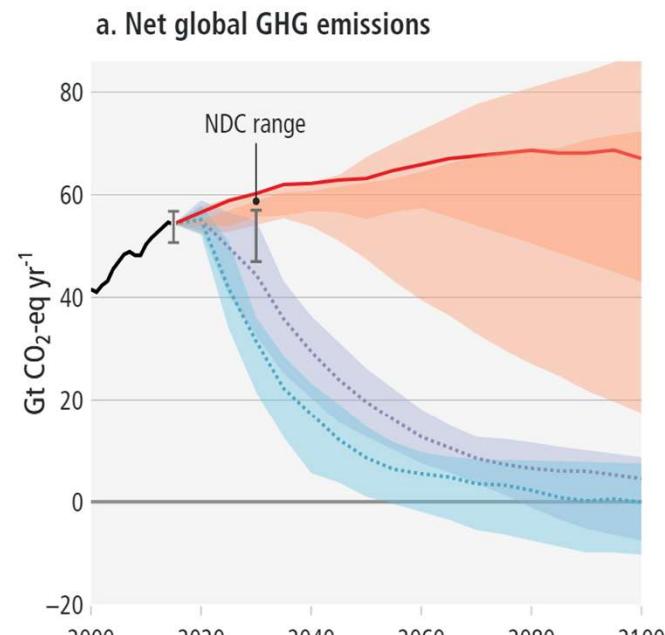
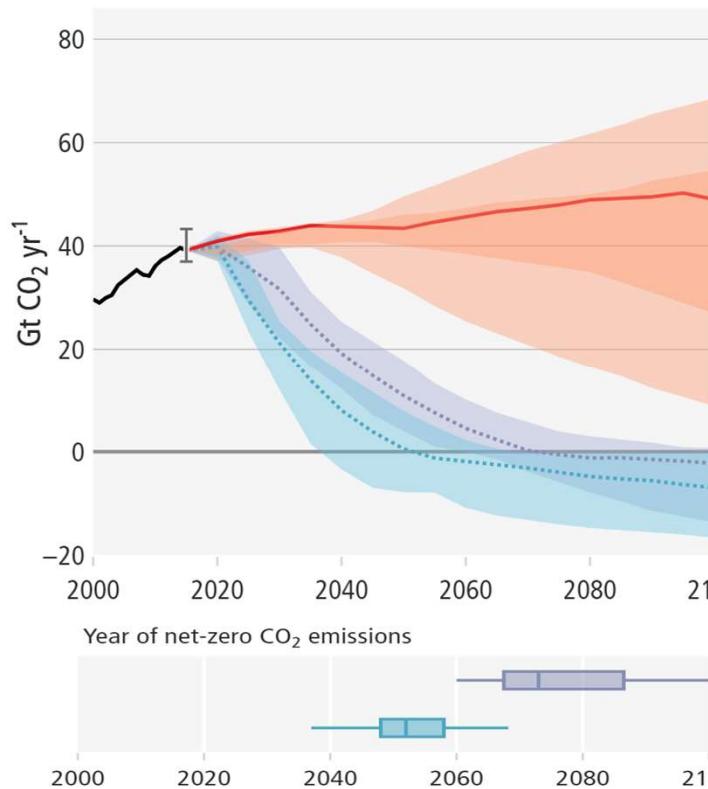


## Paris-agreement

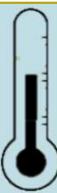




## Paris-agreement

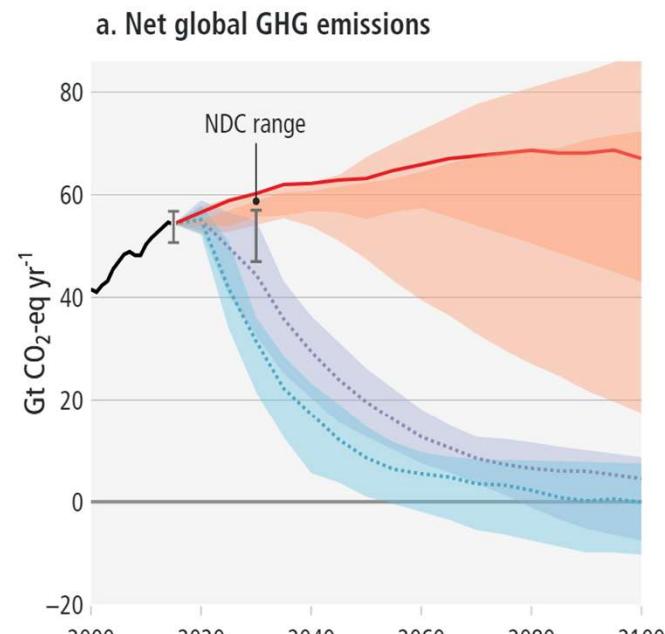
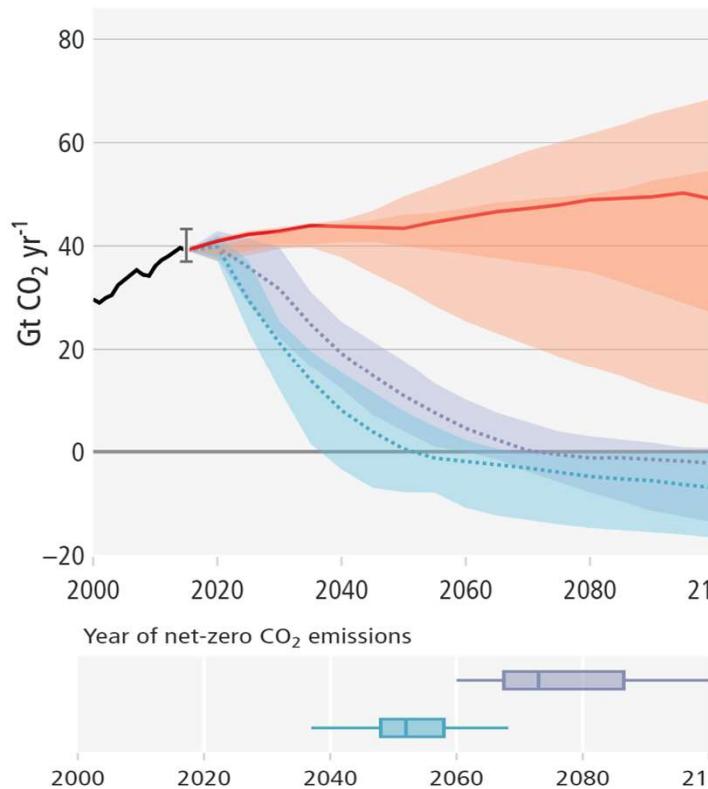


- 1.5 degrees target:
- Emissions peak before 2025
  - 43% reduction in 2030
  - Net zero around 2050





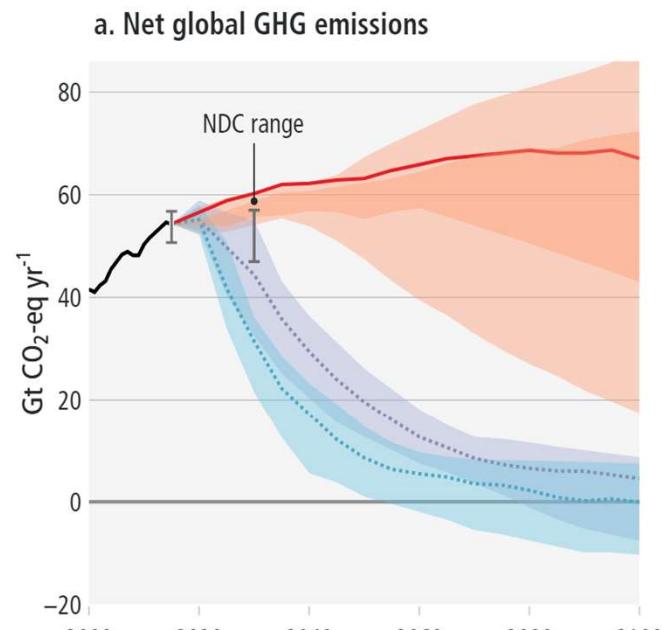
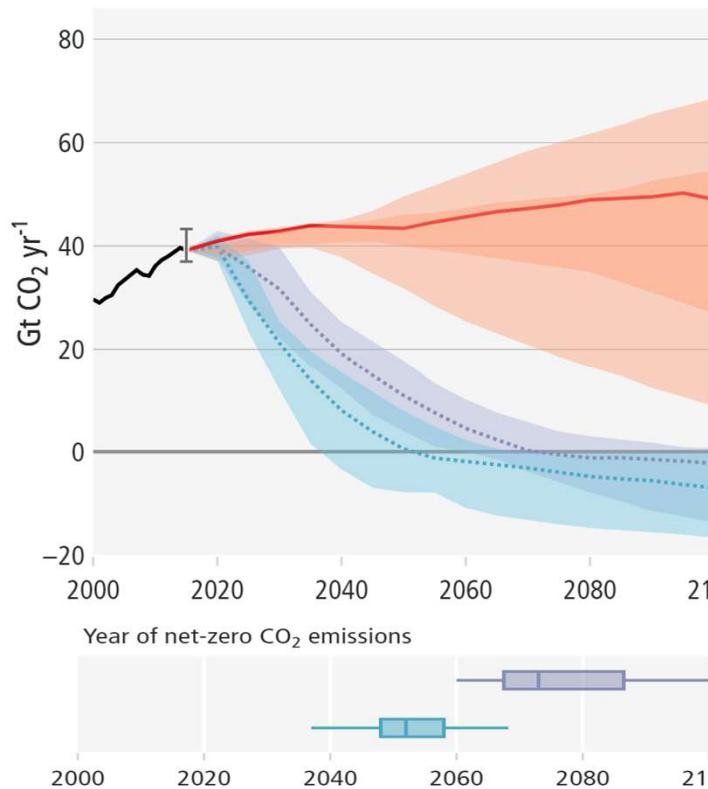
## Paris-agreement



- 1.5 degrees target:**
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  - Net zero around 2050
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- 2 degrees target:**
- 2070 net zero... but only if emissions are reduced in short-term
- 

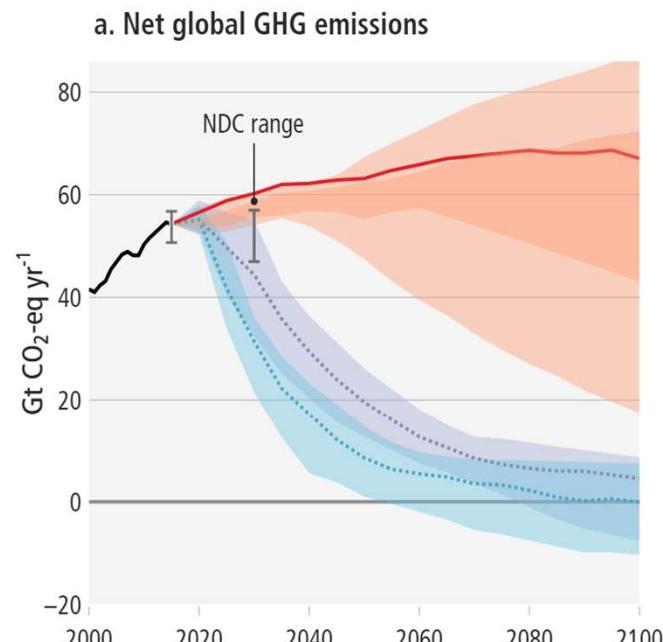
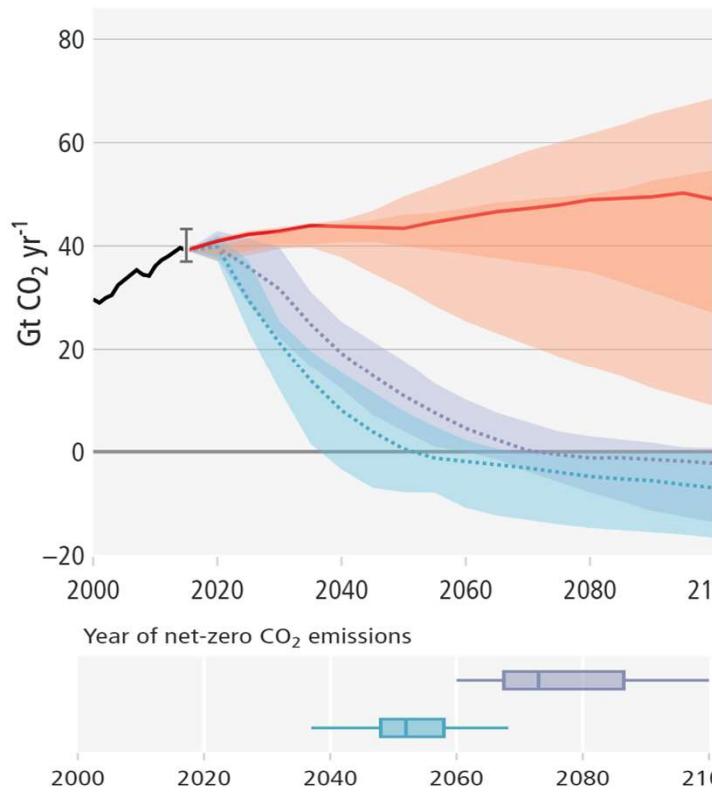


## Paris-agreement



- 1.5 degrees target:**
- Emissions peak before 2025
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- Net-zero year slightly later (consequence of less net negative emission scenarios)
  - Not all 1.5°C reach net-zero GHG

## Paris-agreement

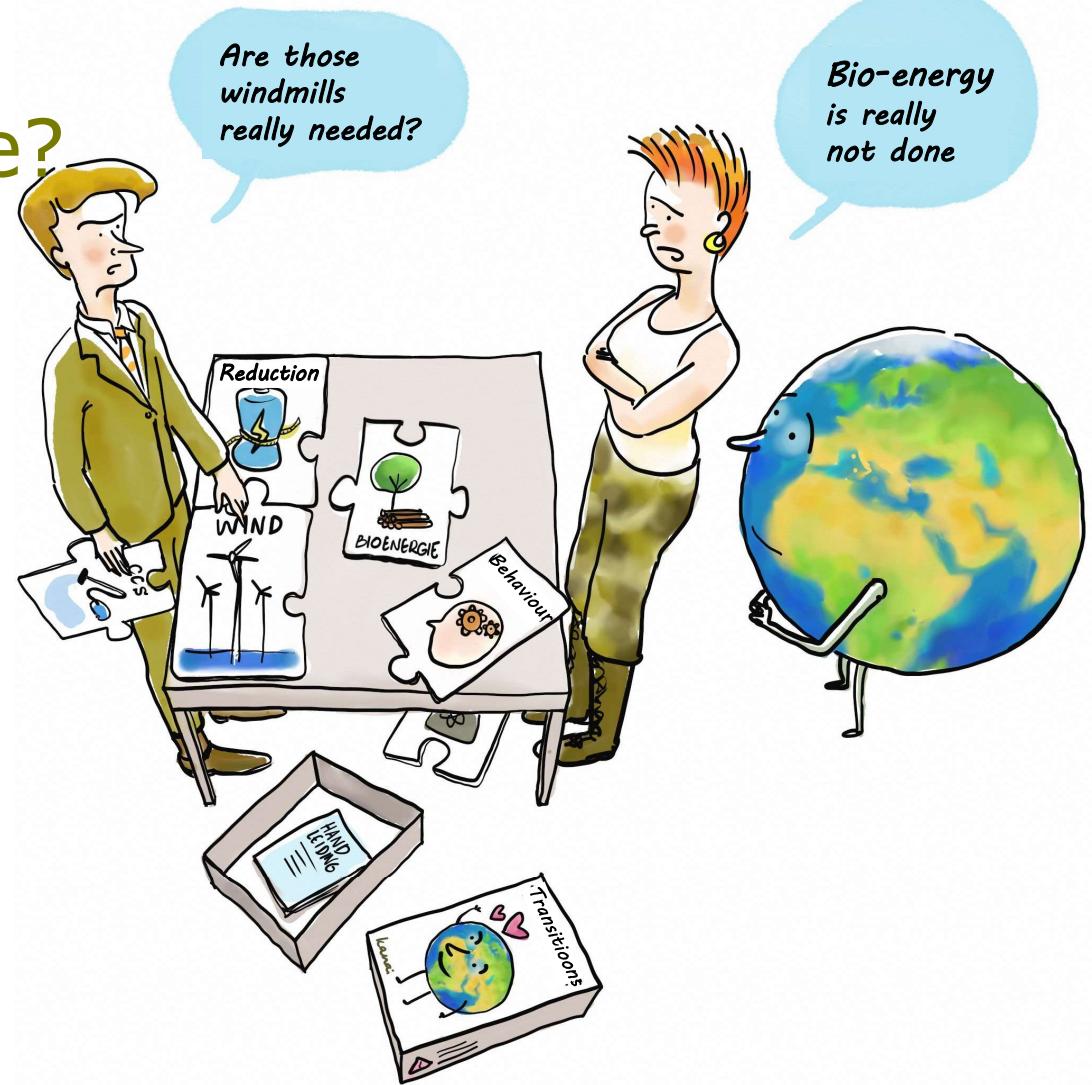
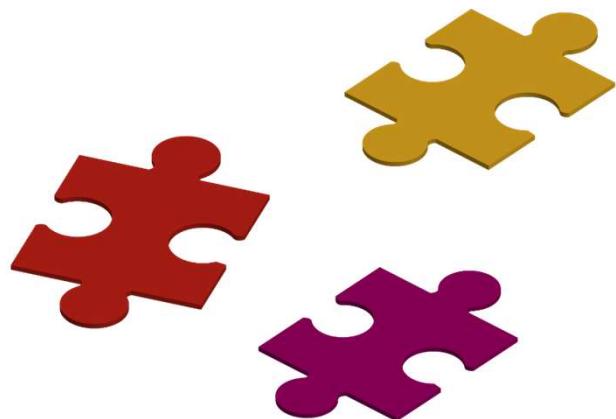


- 1.5 degrees target:**
- Emissions peak before 2025
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- 2 degrees target:**
- 2070 net zero... but only if emissions are reduced in short-term
- 
- Net-zero year slightly later (consequence of less net negative emission scenarios)
  - Not all 1.5°C reach net-zero GHG
- Gap from NDCs:**
- <<2°C ~ 10-13 Gt $\text{CO}_2$
- <1.5°C ~ 20-23 Gt $\text{CO}_2$
- +Gap implemented policy to NDC:  
~5 Gt $\text{CO}_2$



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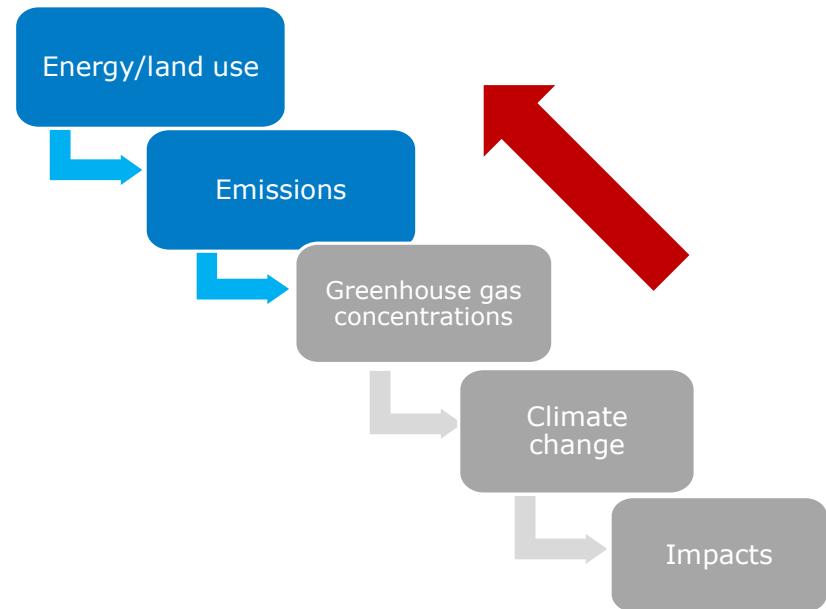
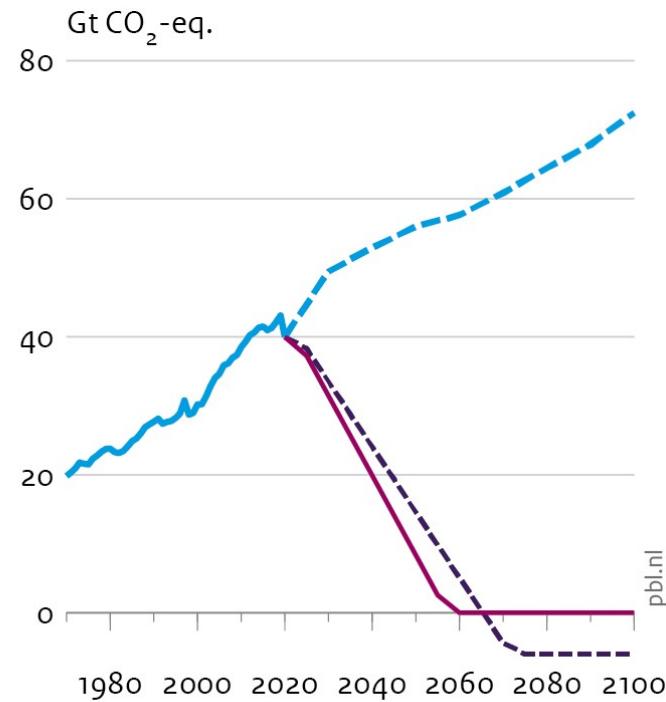
# How do we get there?





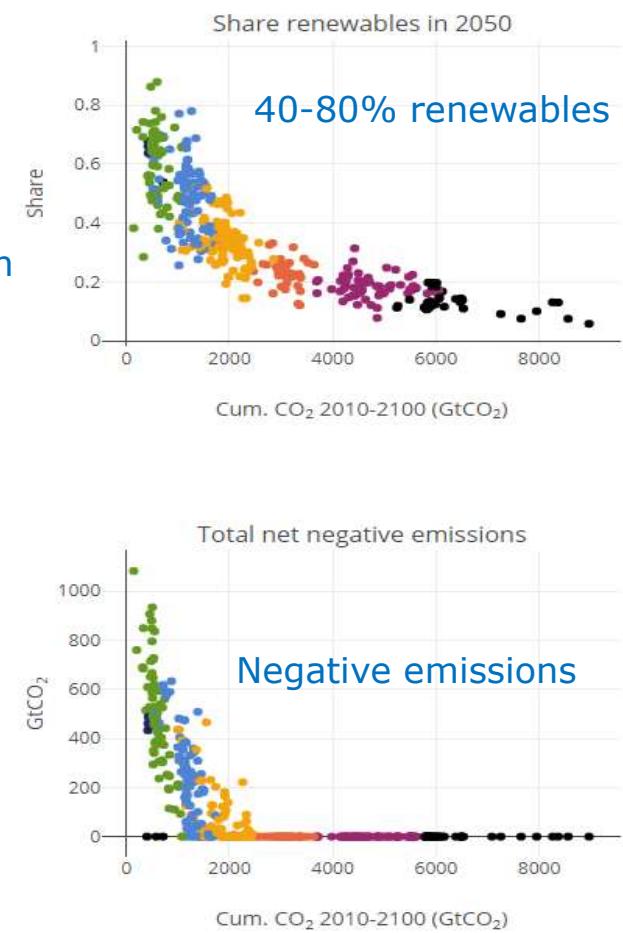
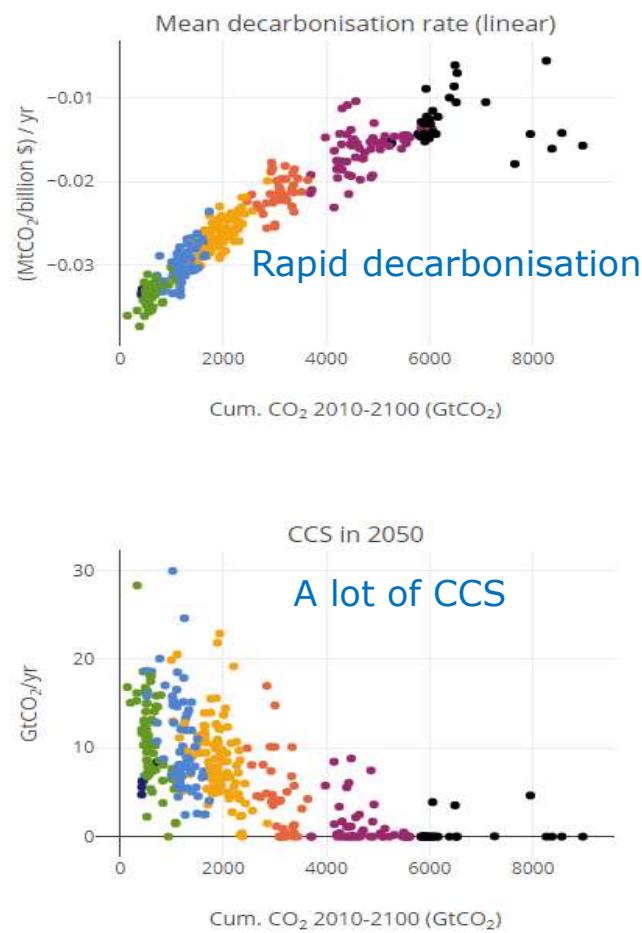
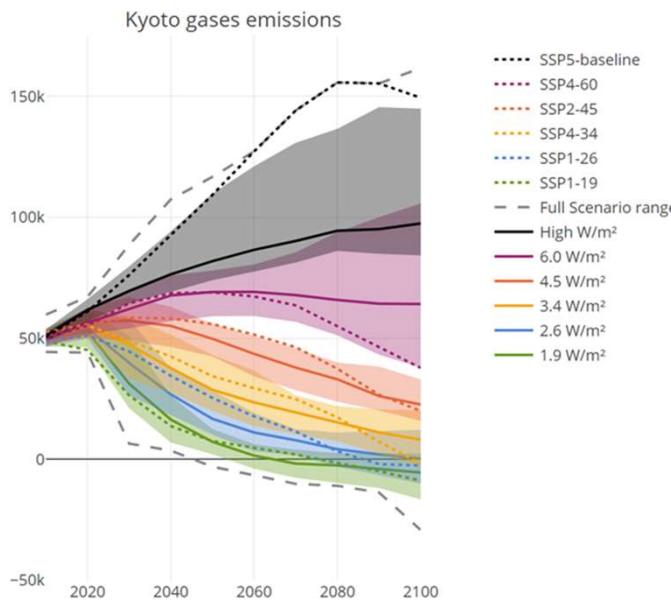
Planbureau voor de Leefomgeving

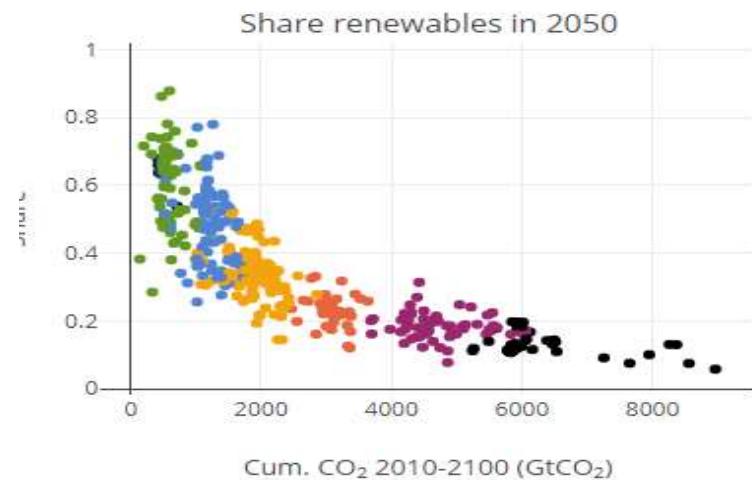
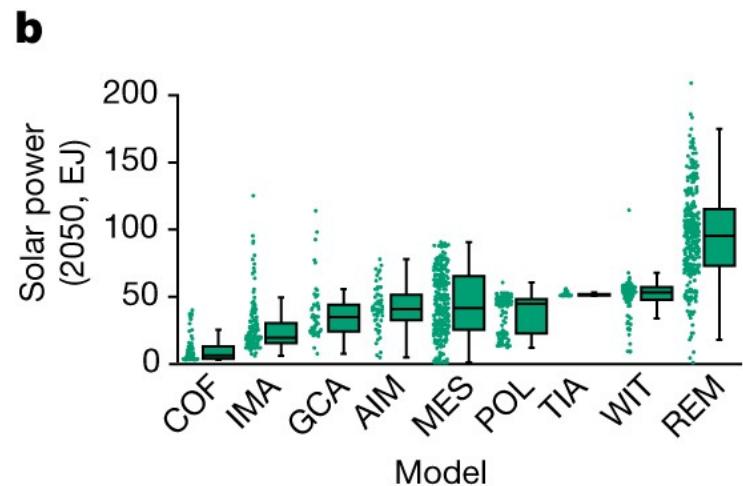
# How do we get there?

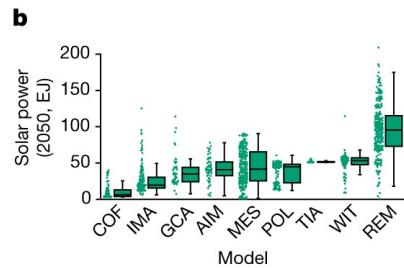




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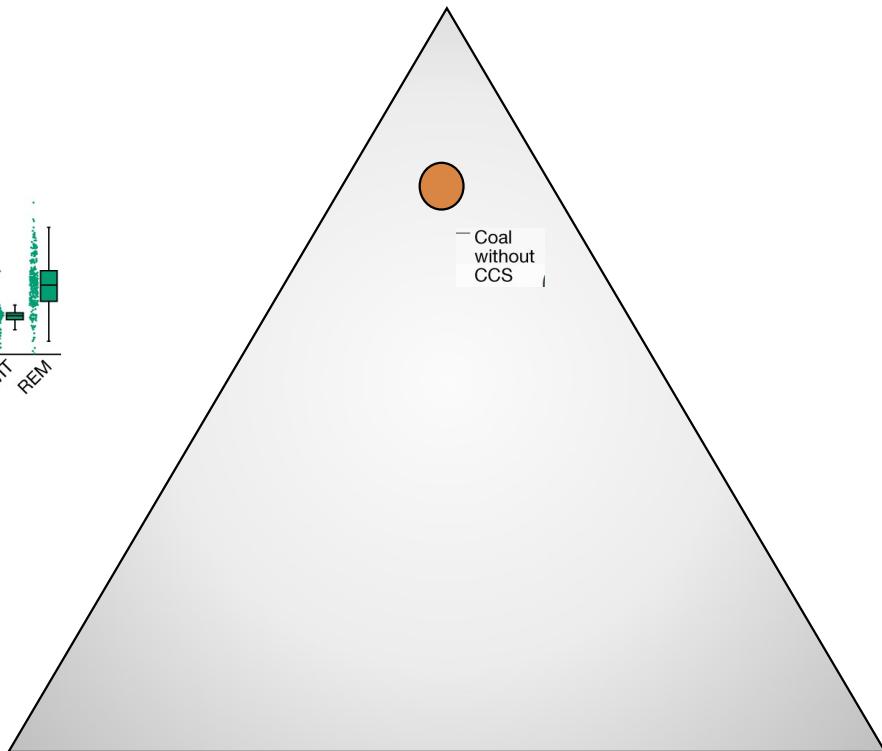


Model differences  
main driver

Climate target  
main driver

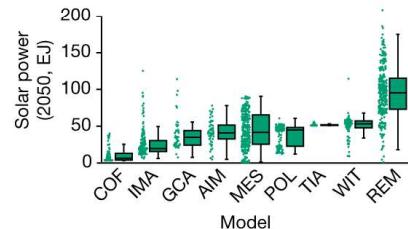
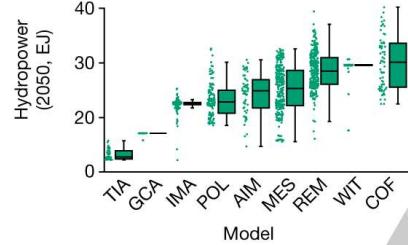
Coal  
without  
CCS

Other scenario assumptions  
main driver

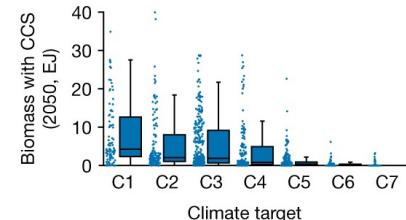


**a**

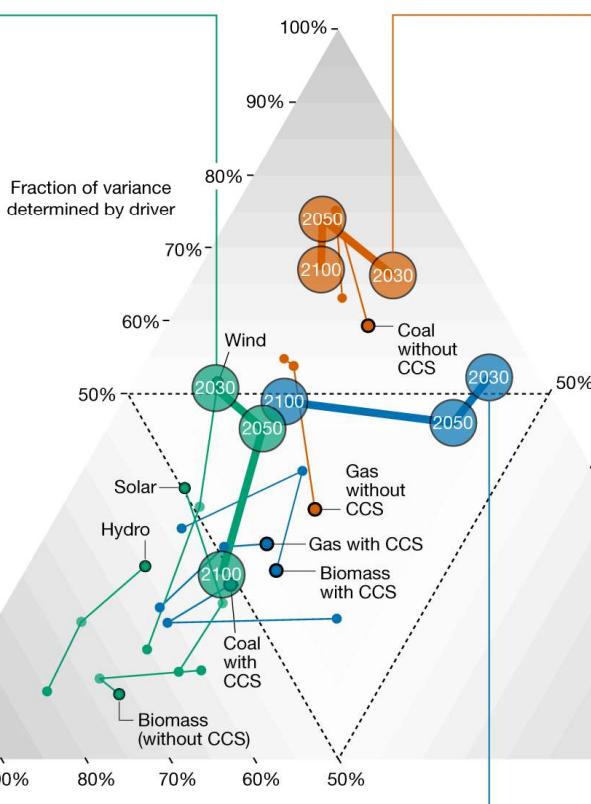
Total renewables: early century determined by climate target, later more model dependent.  
Individual sources: highly model dependent, except early-century wind.

**b****c**

Model differences  
main driver

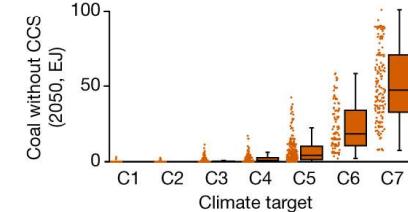
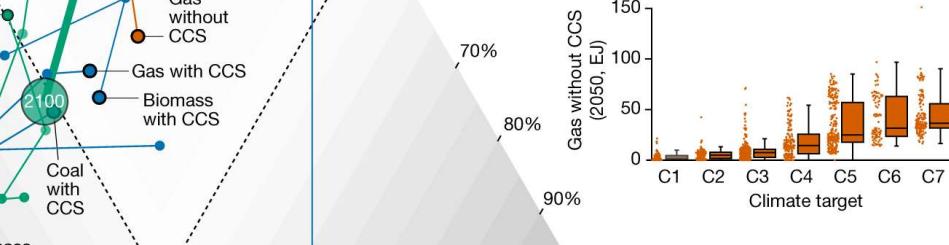
**d**

Climate target  
main driver



Fossil use (without CCS)

Total fossil use: highly determined by climate target.  
Individual sources: coal highly climate target  
determined, gas only after 2050.

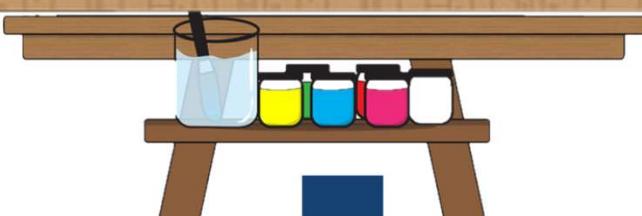
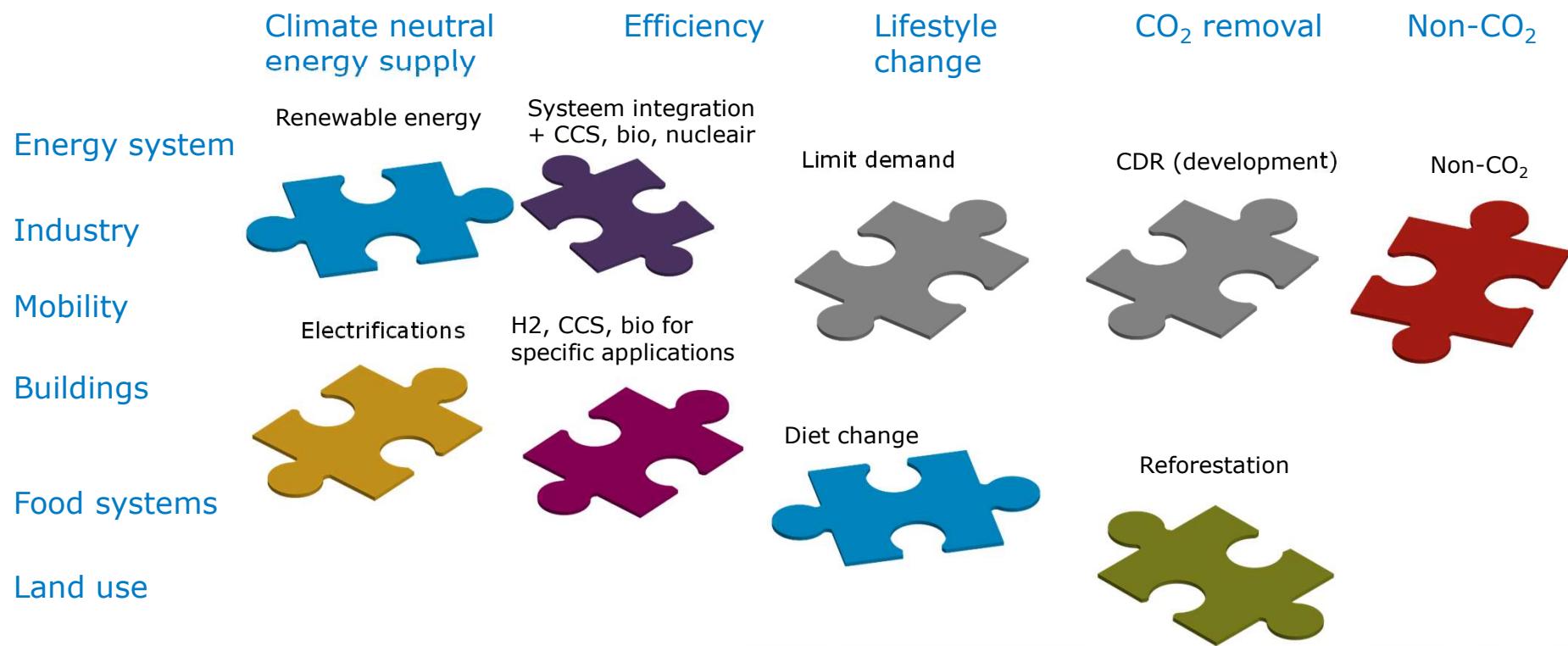
**g****f**

Other scenario assumptions  
main driver

Carbon capture and storage (in electricity generation)

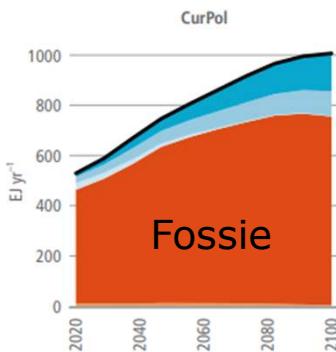
Total CCS: early mostly determined by climate  
target and scenario.  
Individual sources: mostly model dependent.

Dekker et al, 2023

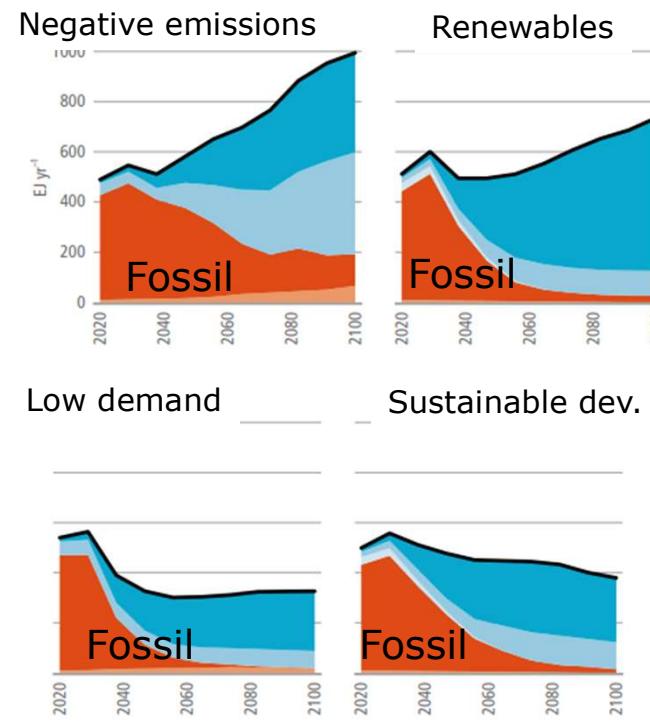


# Implications for fossil fuels

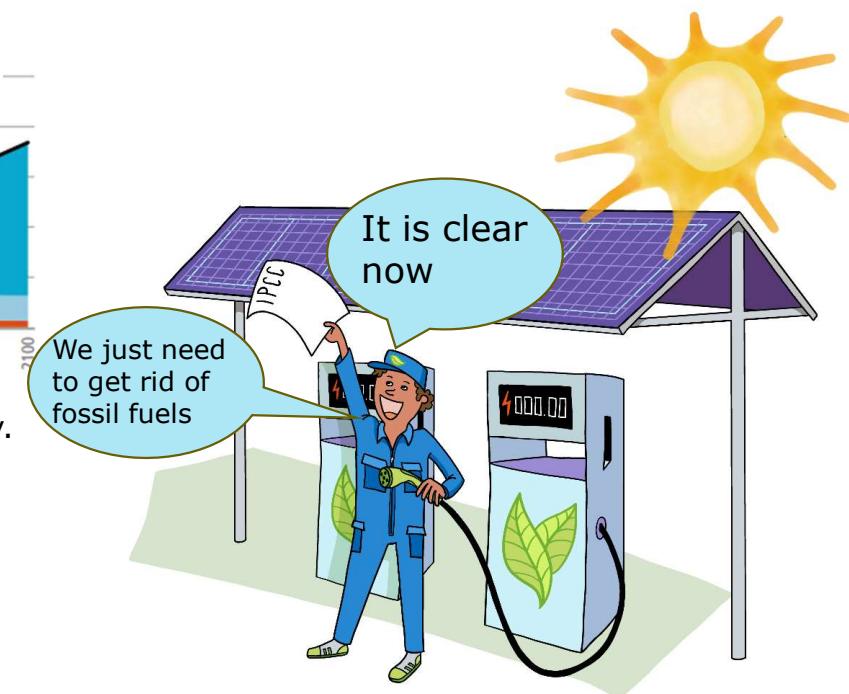
## Current policy



## 1.5 graden

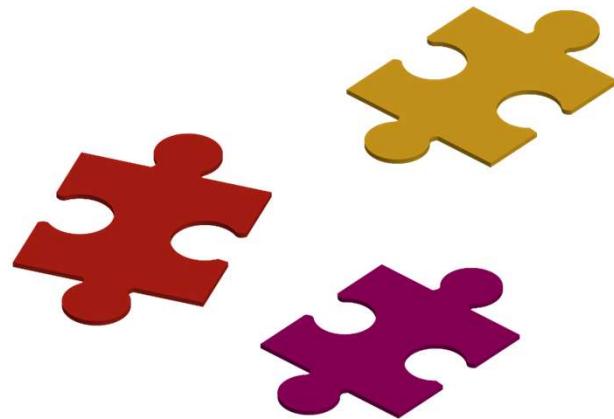


- Renewables (non-biomass)
- Biomass (non-traditional)
- Biomass (traditional)
- Fossil
- Nuclear



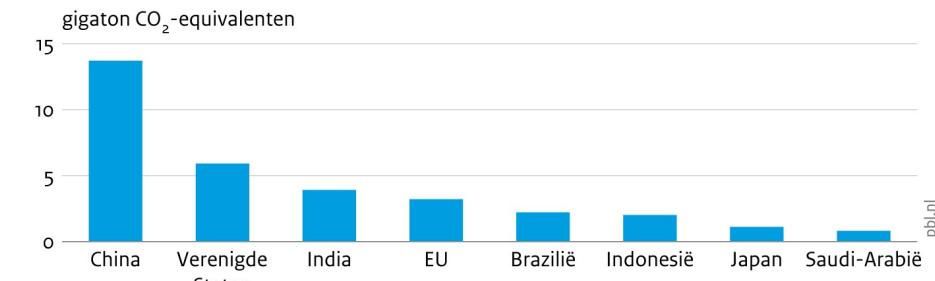
# Clear vision needed....

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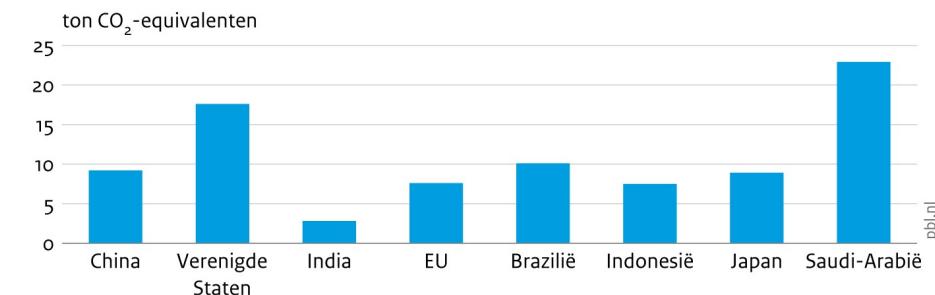


## Emissie broeikasgassen

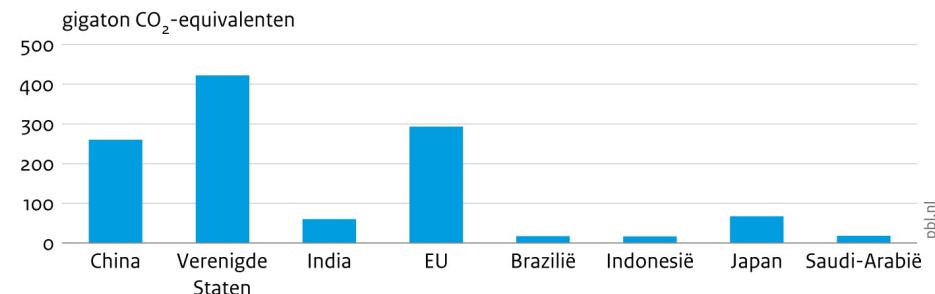
Totale emissie, 2021



Emissie per hoofd, 2021



Cumulatieve emissie, 1850 – 2021



Bron: Global Carbon Budget



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Historic CO<sub>2</sub>  
2019 CO<sub>2</sub>

OECD = 66.8%  
OECD = 35.1%





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# Unique moment in time

Technological breakthrough



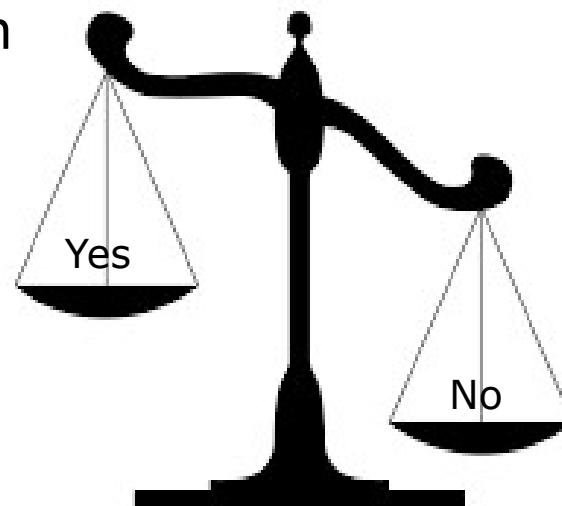
Net zero targets (2050-2060)



IEA: End of fossil



Financial sector changing



Budget almost depleted

Ambition and implementation gap



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# Thank you for your attention



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Twitter @DetlefvanVuuren

