Untying the Knot: Explorations to Meet Climate and Sustainability Goals

Detlef van Vuuren

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International promises to do better…

Paris-agreement

The universal agreement's main 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

Circular Economy Action Plan
The European Green Deal

Convention on Biological Diversity

Aichi targets: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society and reduce the direct pressures on biodiversity and promote sustainable use…

The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action **to end poverty, protect the planet**, and ensure that by 2030 all people enjoy peace and prosperity.

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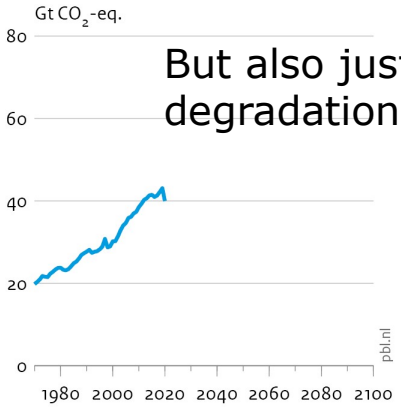

But also just further degradation

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Our common quest should be: What is needed to achieve the goals; how can we bend the trend?

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How will the future evolve?

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How will the future evolve?

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Population

Socio-economic development

Technology

Political change

Policy

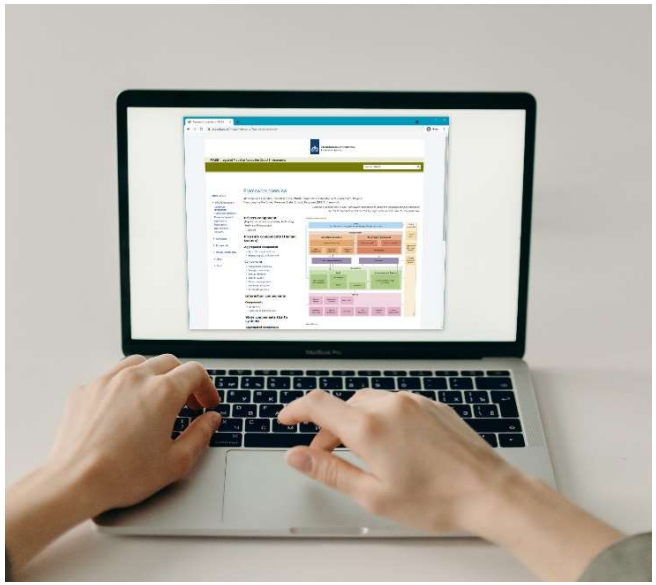
Demand for food, energy and water

Environmental problems
Climate change
Scarcity

Different scales

Different time periods

Uncertainty



How will the future evolve?

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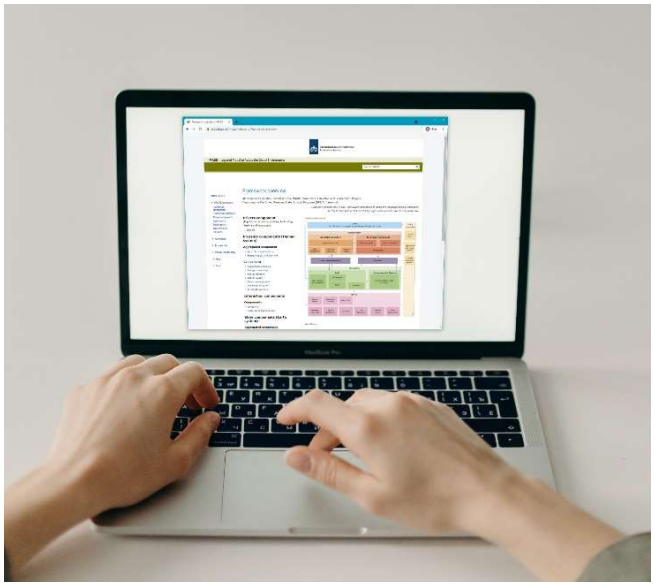

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Sustainable development goals (SDGs)

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Sustainable development goals (SDGs)

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Human development and equity

Efficient and sustainable resource use

Protecting natural environment

Good governance & infrastructure

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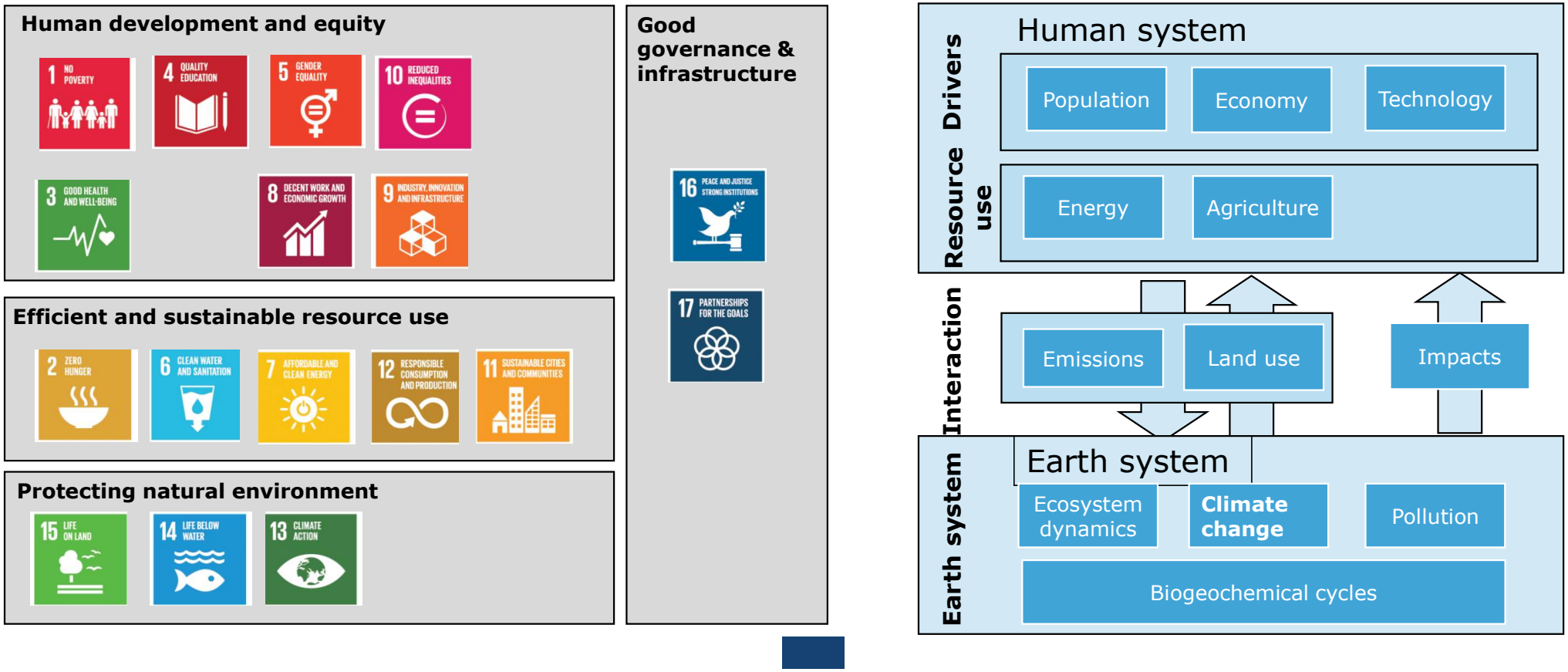

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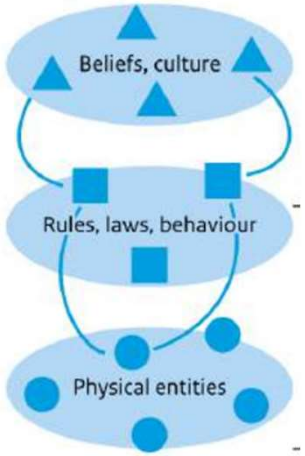
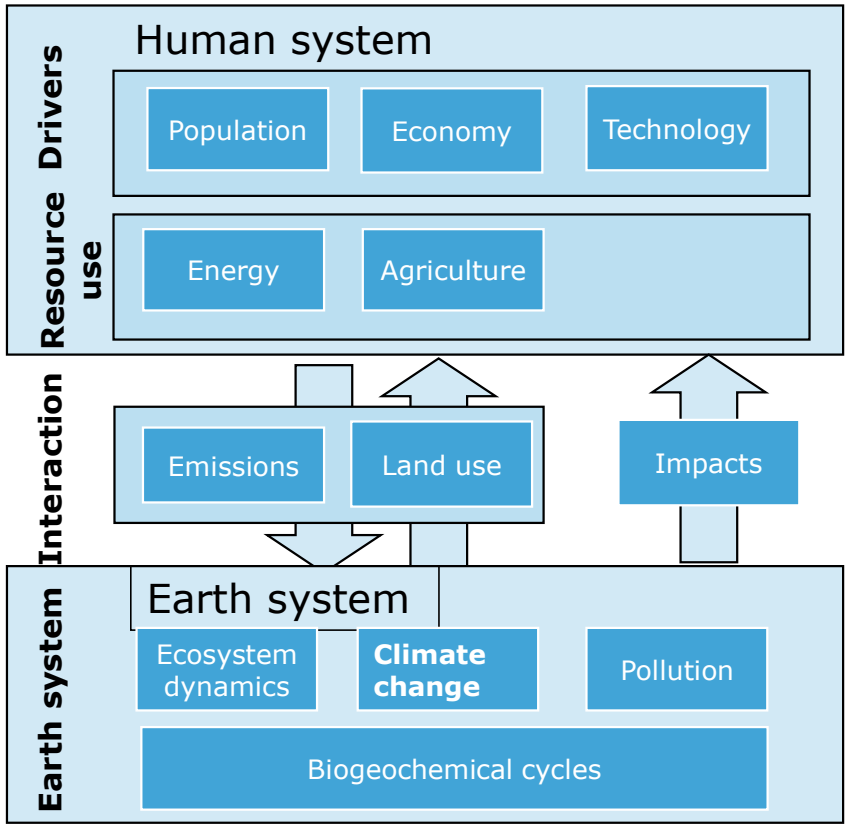
Describe evolution of future systems





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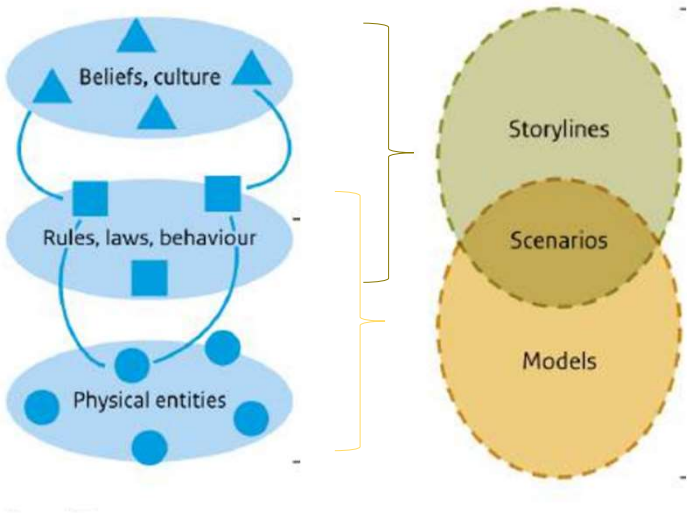
Describe evolution of future systems

Available tools



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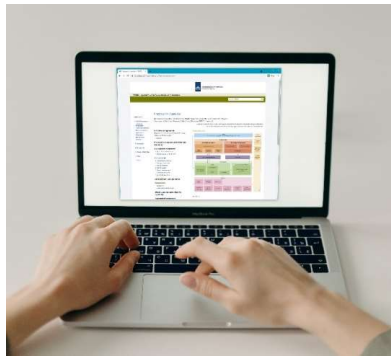


Model-based **scenarios**

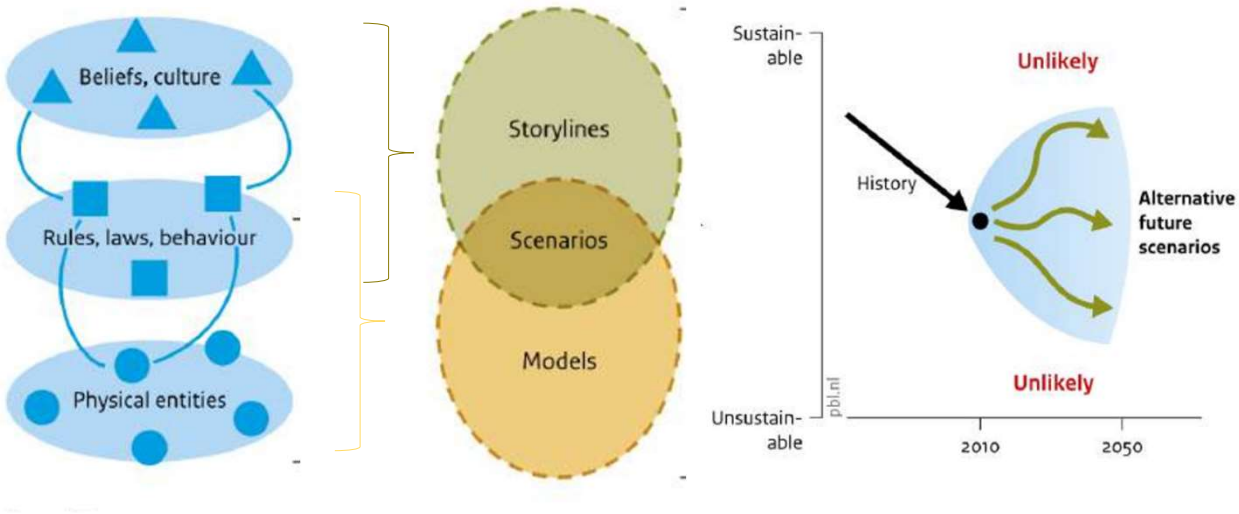
Describe evolution of future systems

Available tools

Scenarios:

- Combination of narratives and modelling

- Modelling where there is enough knowledge to define quantitative relationships
- Narratives where there is need for complexibity and flexibility



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Content of rest of presentation

- Look into area of climate research to see how scenarios can be used
- See how this can be further expanded
- Draw some conclusions

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Climate

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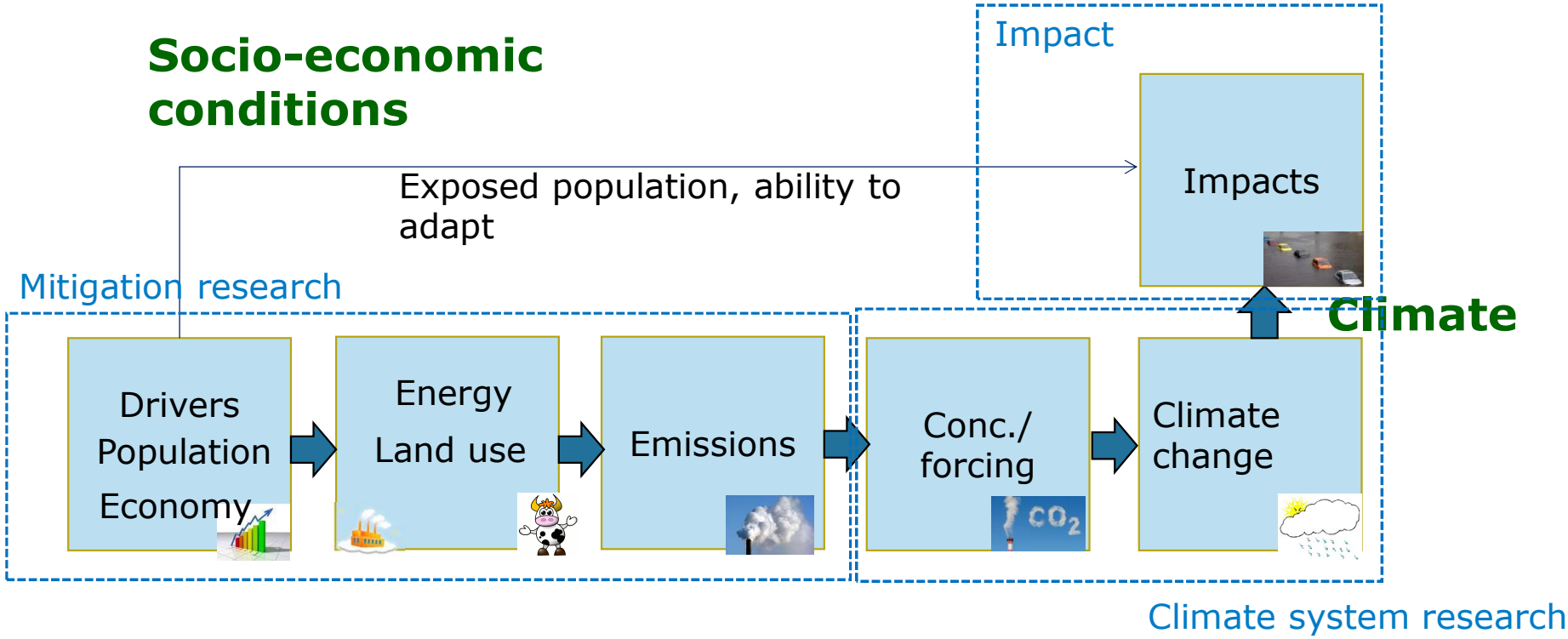

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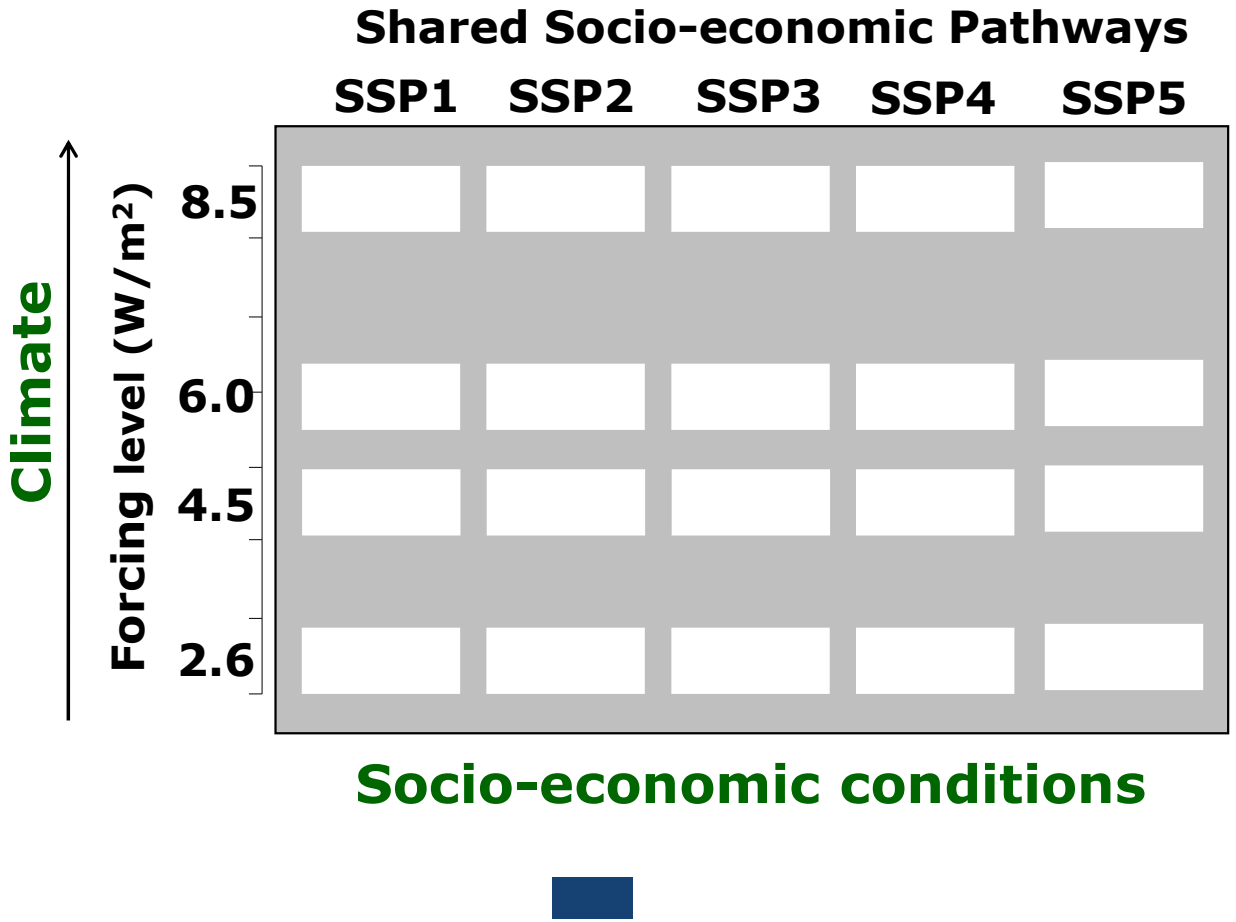
Model-based **scenarios**



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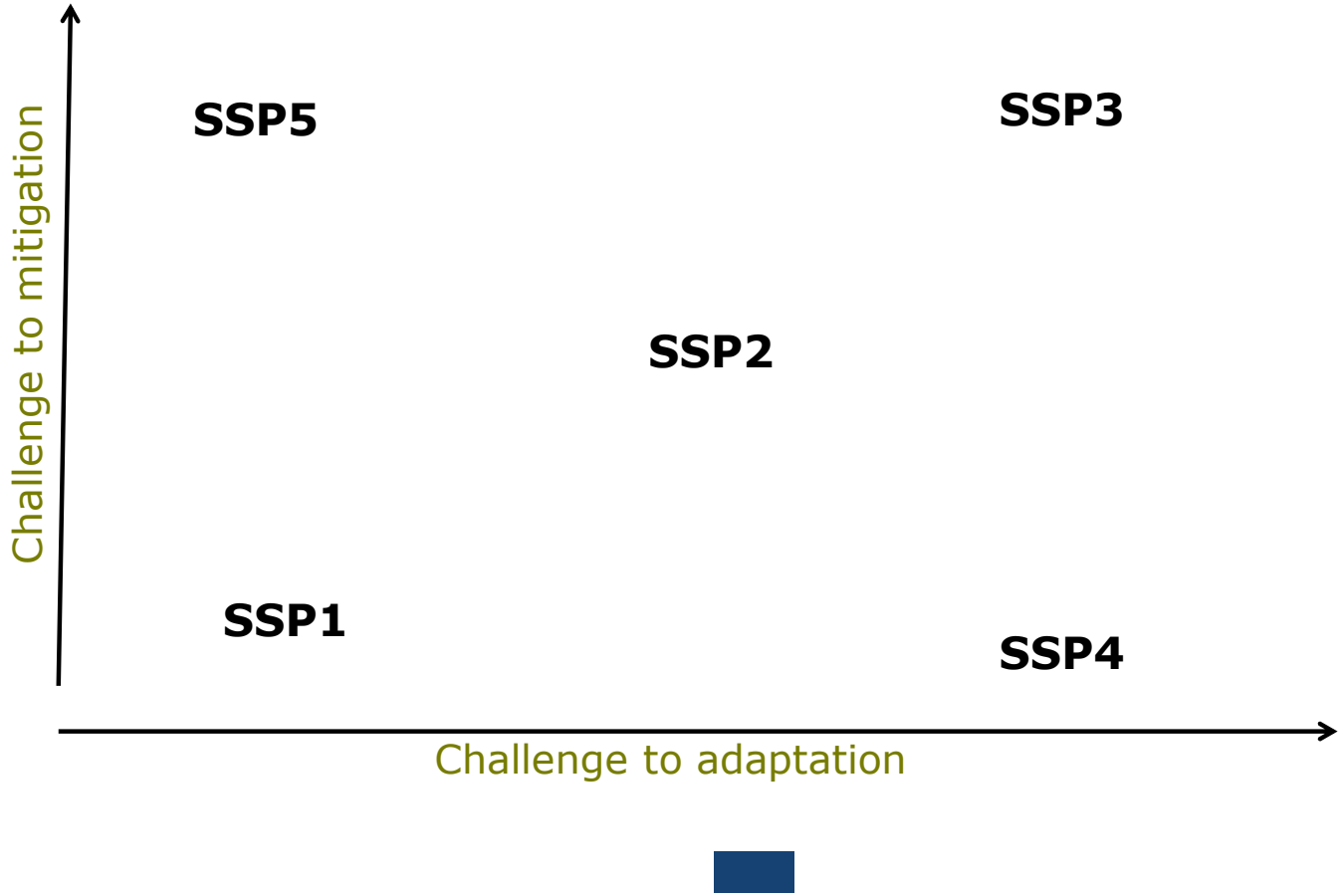
Model-based **scenarios**



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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

Markets first

Clash of civilisations

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

SSP2:
Middle of the Road

SSP1:Green growth

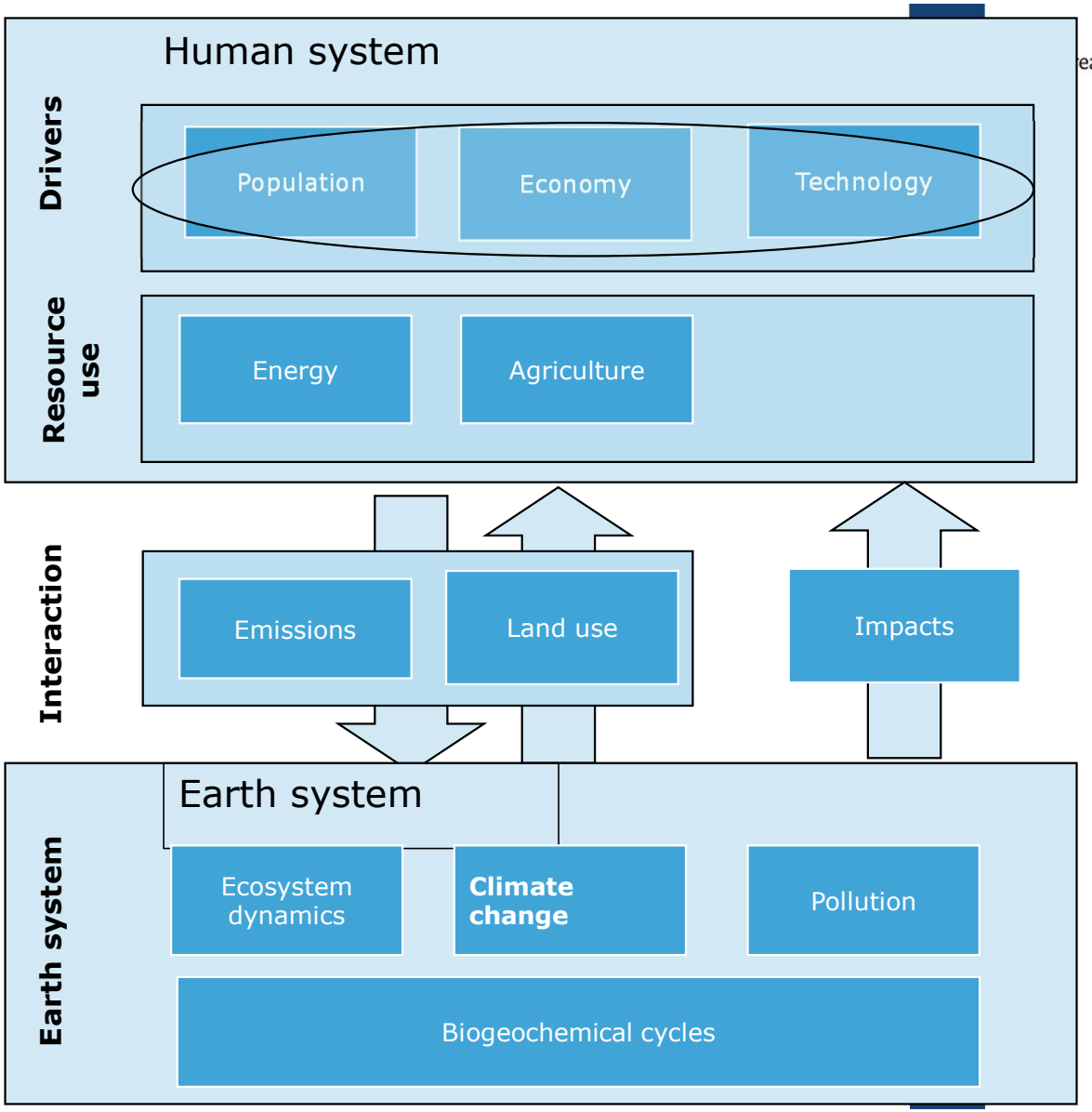
- Global cooperation
- Rapid technology dev.
- Strong env. policy
- Low population growth
- Low inequity
- Focus on renewables and
- efficiency
- Dietary shifts
- Forest protection

UN world

Have's and have not's

SSP4: Inequality

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



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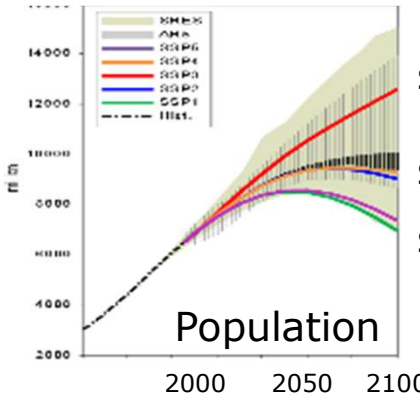
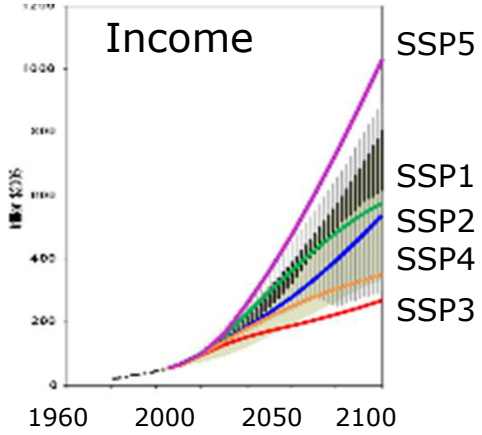
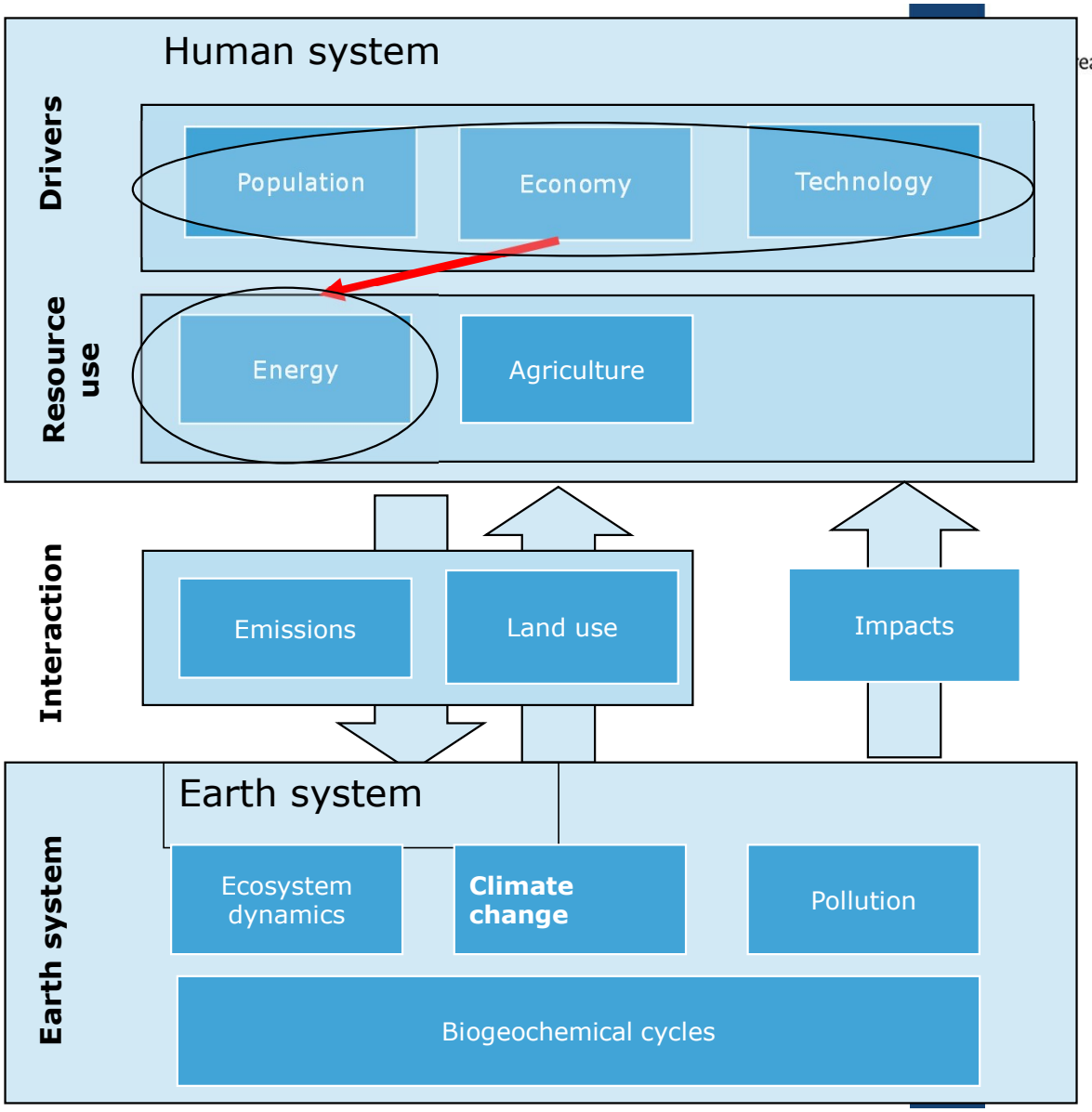




SSP1: Sustainable development
SSP2: Middle of the road
SSP3: Increasing competition
SSP4: Divided world
SSP5: Rapid growth



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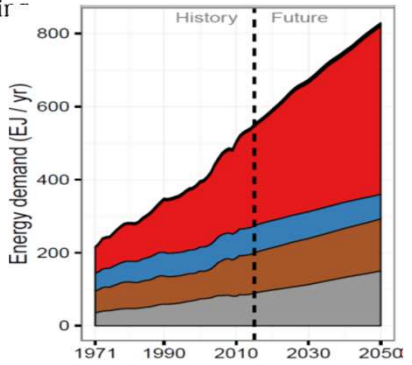
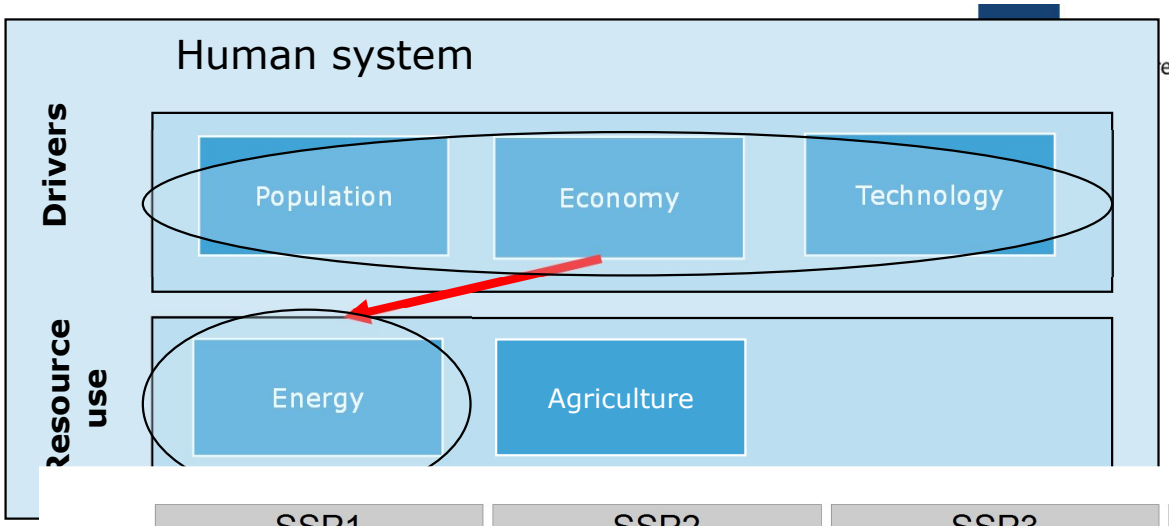


Electricity

Buildings

Industry

Transport



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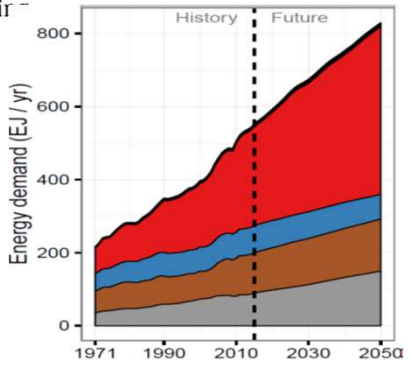

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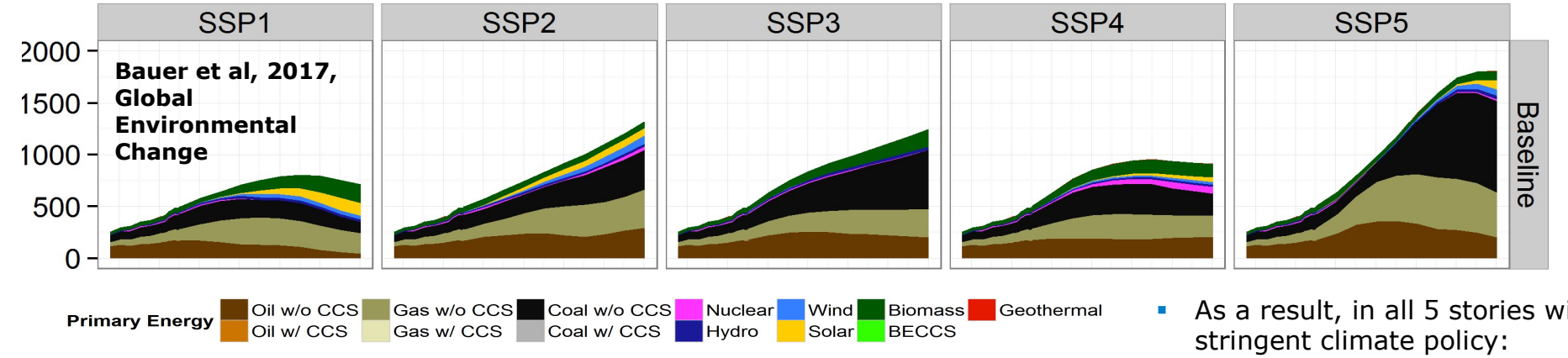
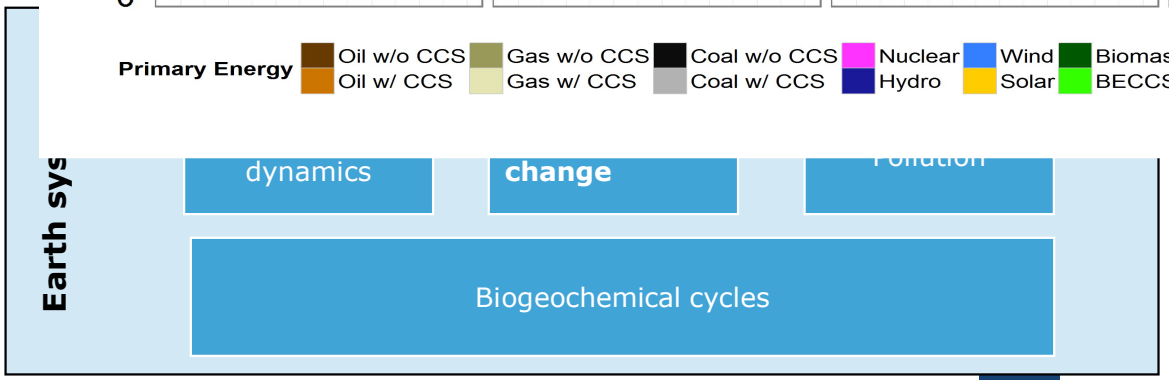
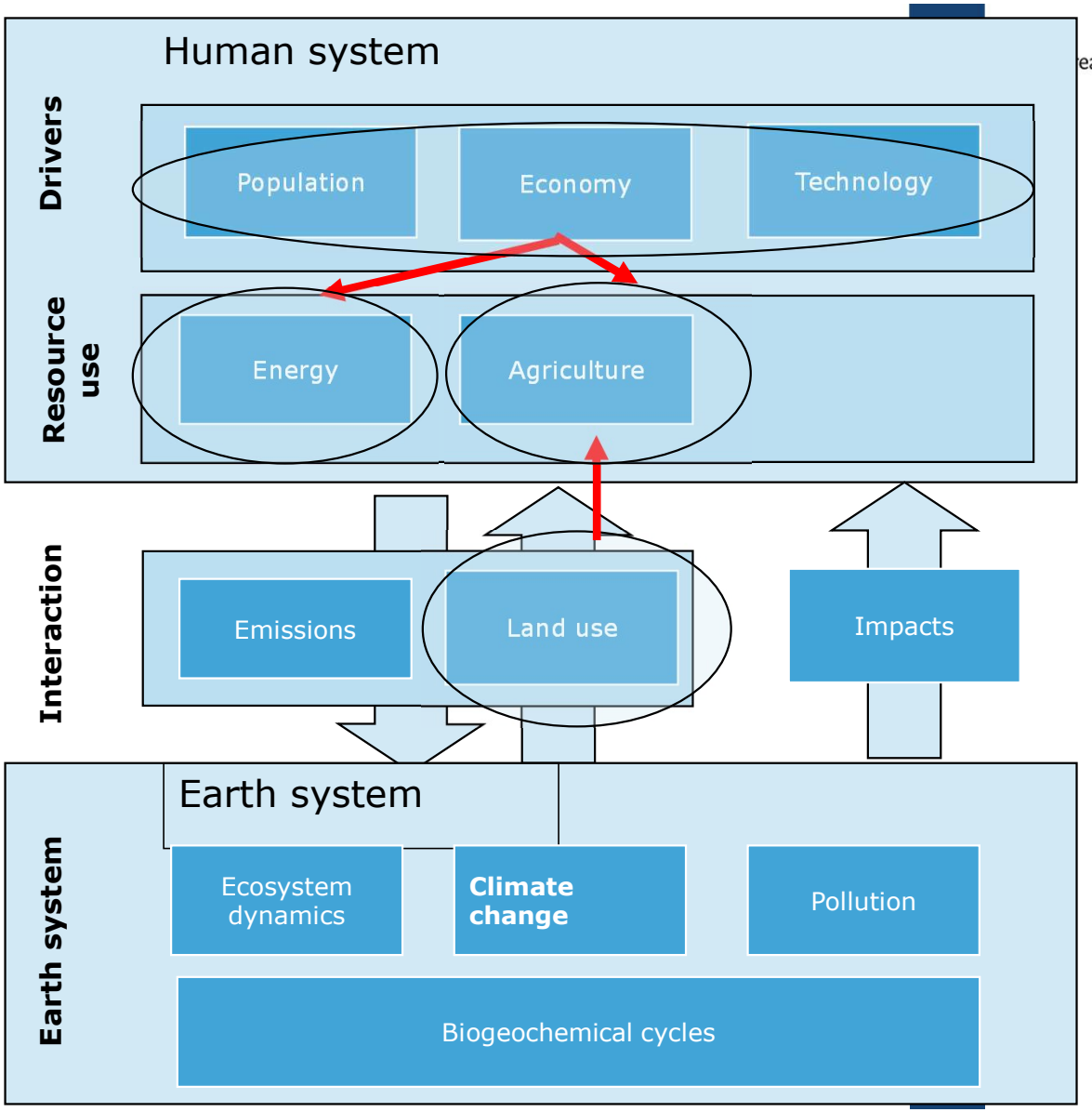




- As a result, in all 5 stories without stringent climate policy:
  - further increase in global energy use
  - Fossil fuels continue to be important
  - Thus increasing greenhouse gas emissions



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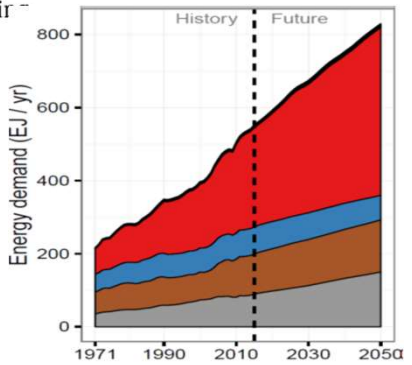

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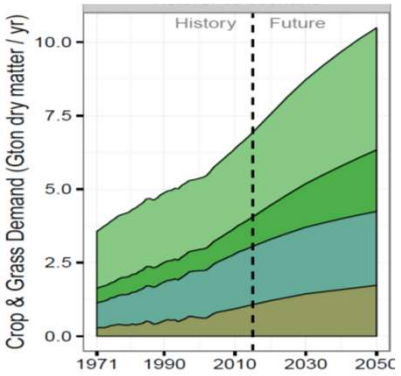


Grass

Crops (feed)

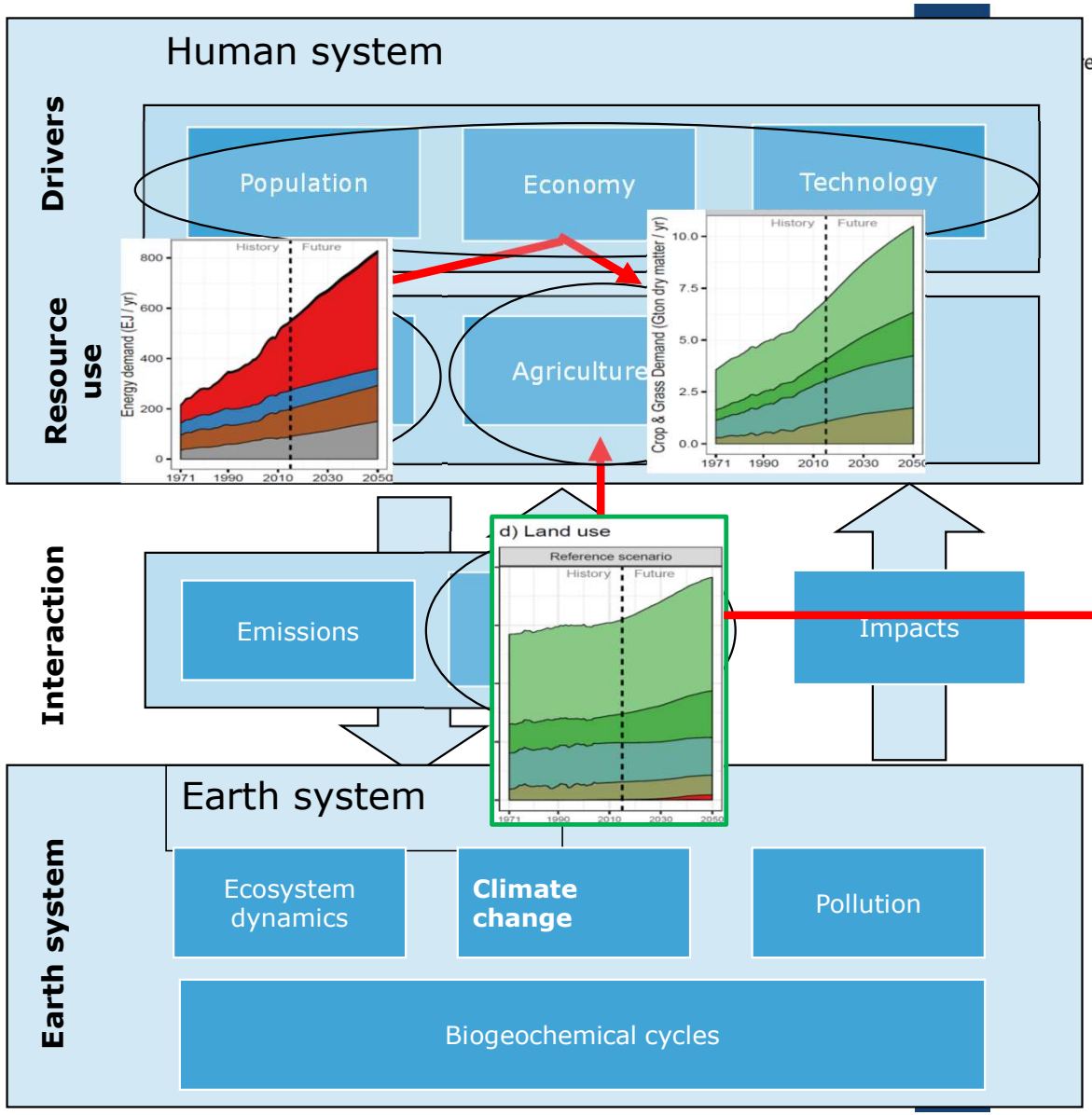
Crops (food)

Crops (other)

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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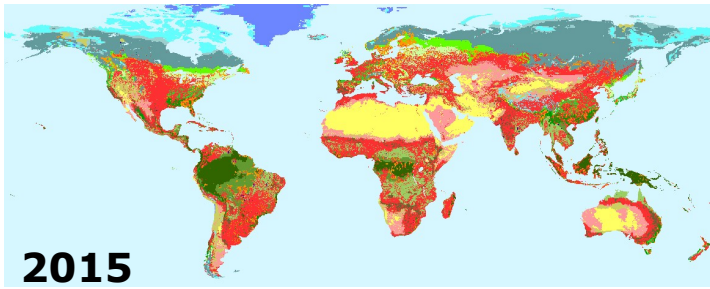
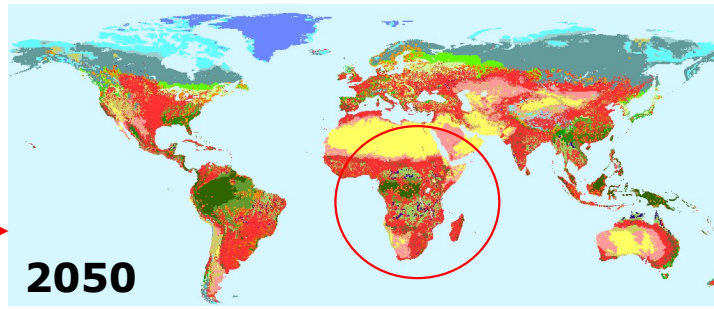
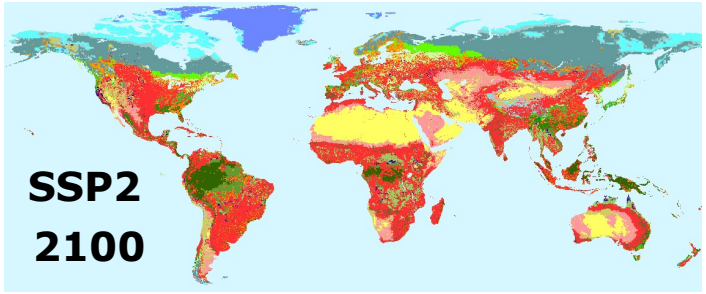
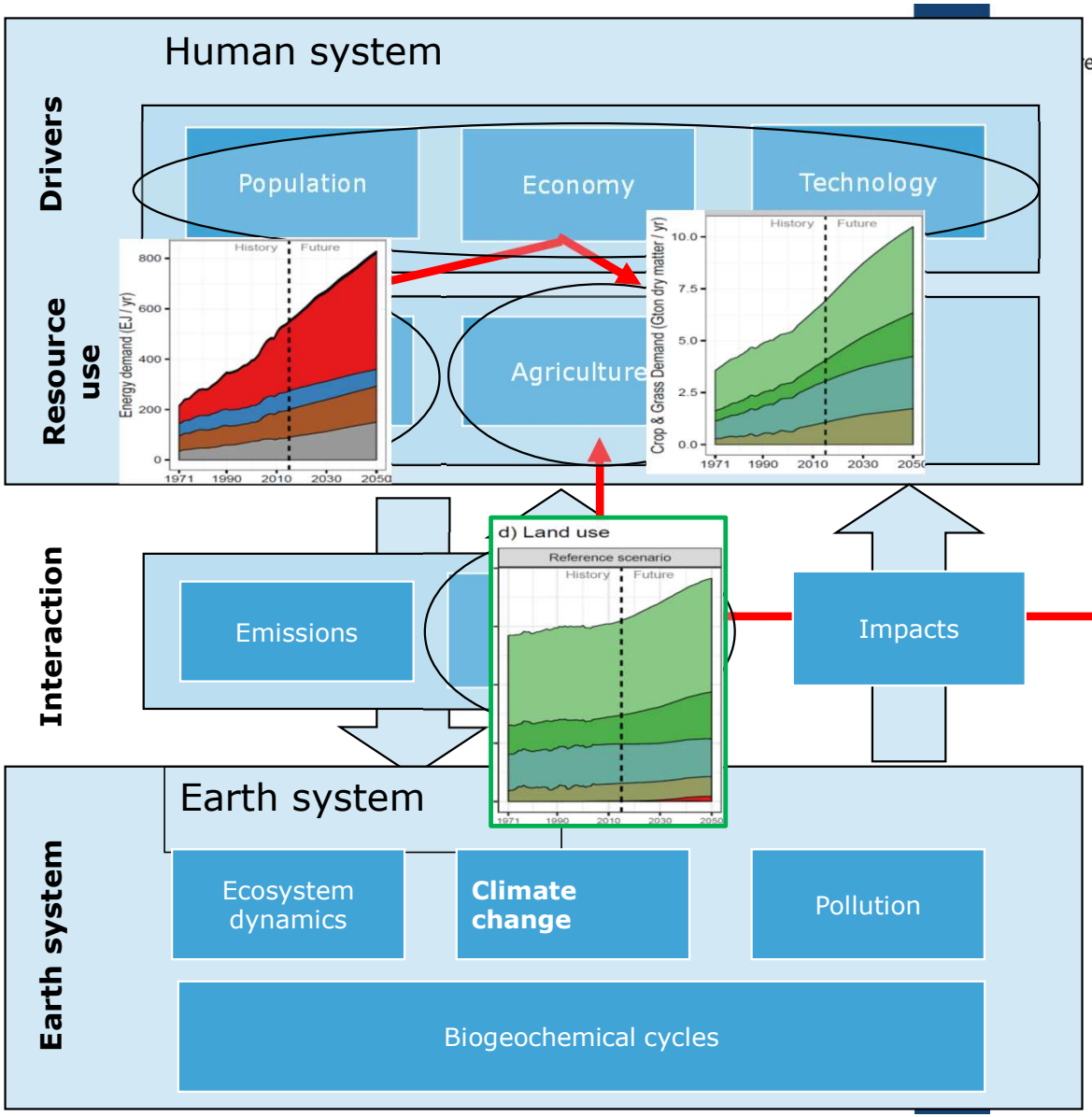
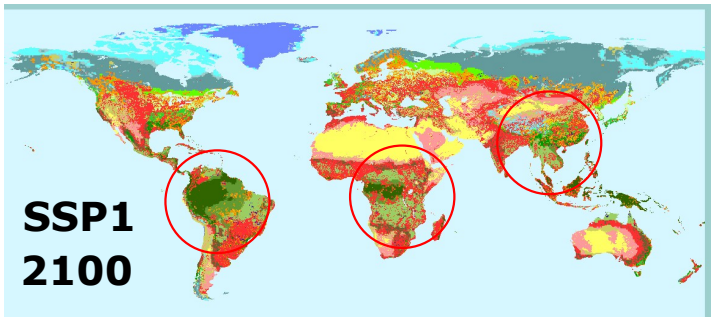
SSP2

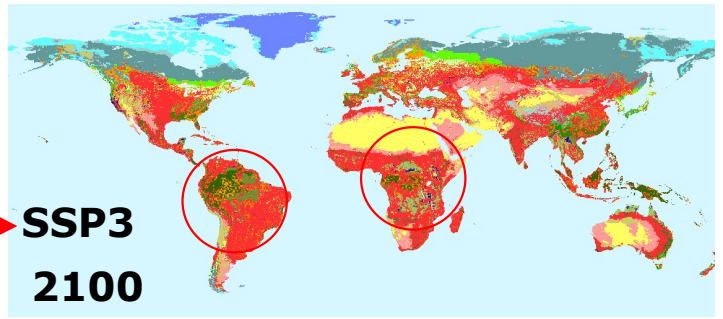


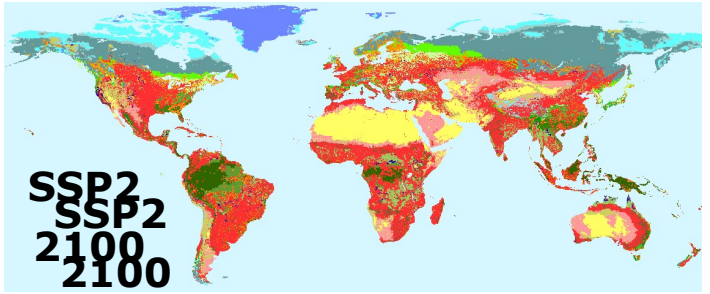


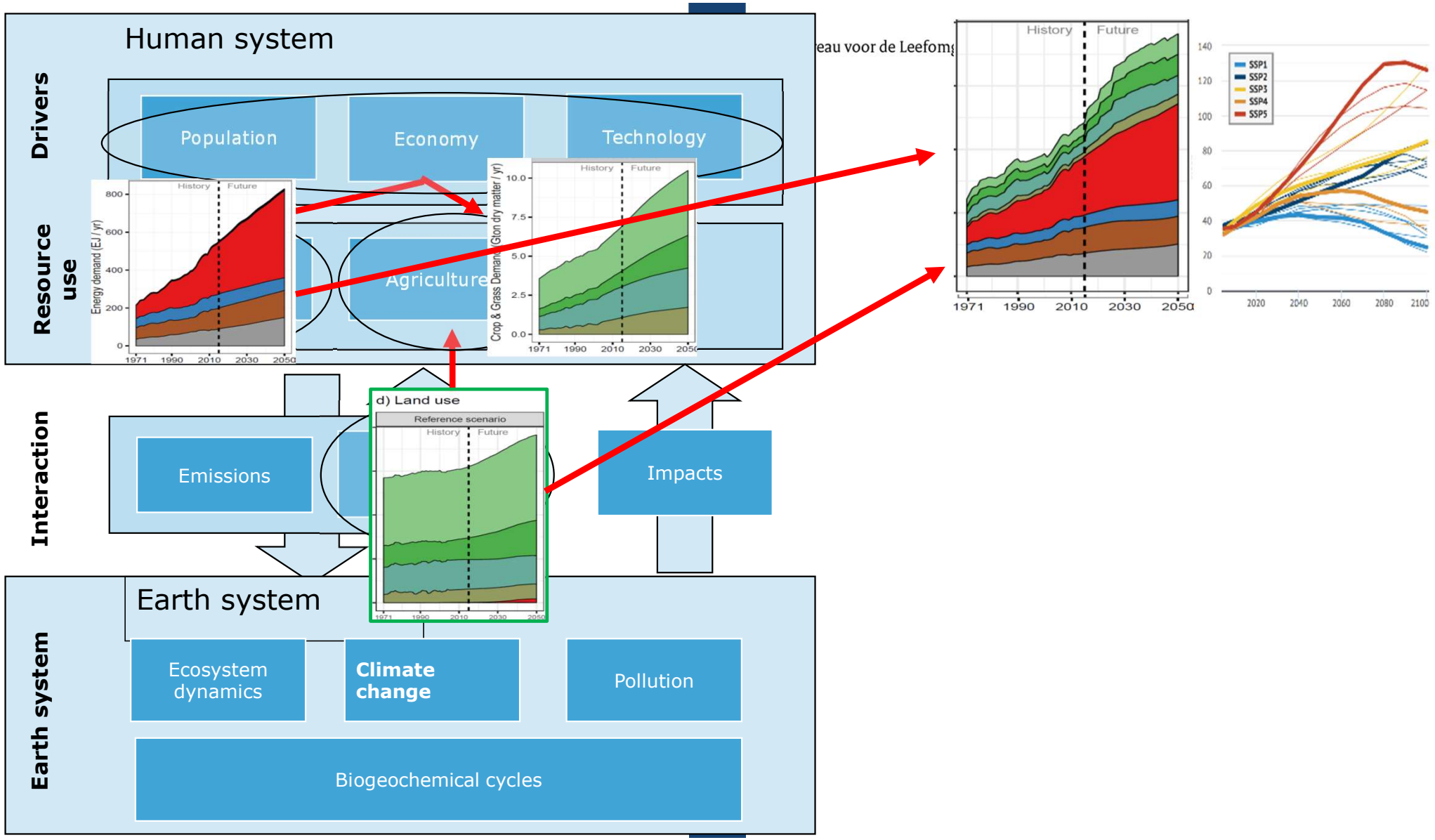



Human system
Drivers
Resource use
Population
Economy
Technology
Agriculture
History
Future
Energy demand (EJ / yr)
Crop & Grass Demand (Gton dry matter / yr)
Interaction
Emissions
d) Land use
Reference scenario
Impacts
Earth system
Earth system
Ecosystem dynamics
Climate change
Pollution
Biogeochemical cycles


SSP1
2100


SSP3
2100


SSP2
2100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eau voor de Leefom
1971
1990
2010
2030
2050
SSP1
SSP2
SSP3
SSP4
SSP5
2020
2040
2060
2080
2100

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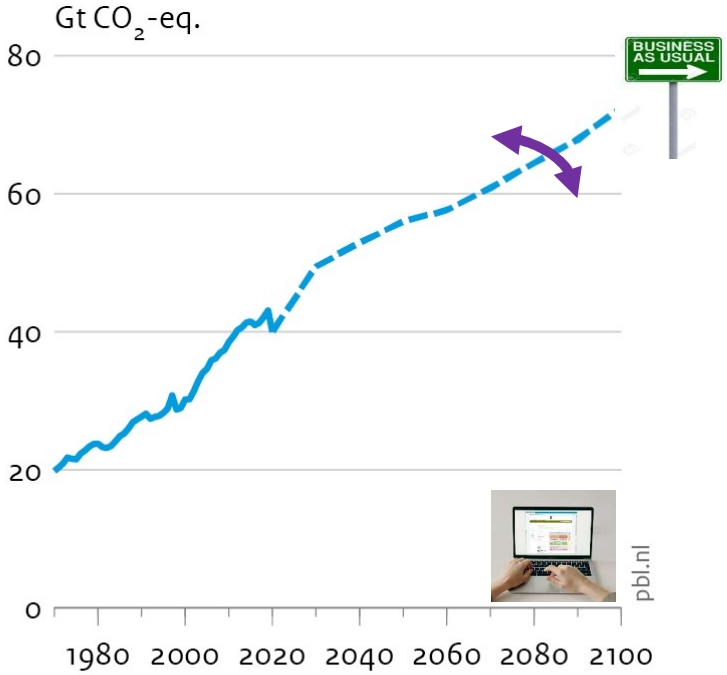
Global CO_2 emissions



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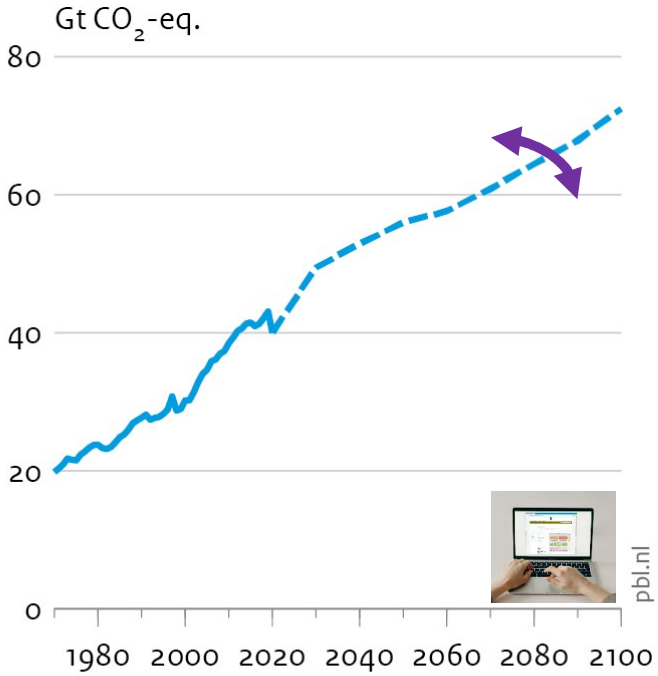
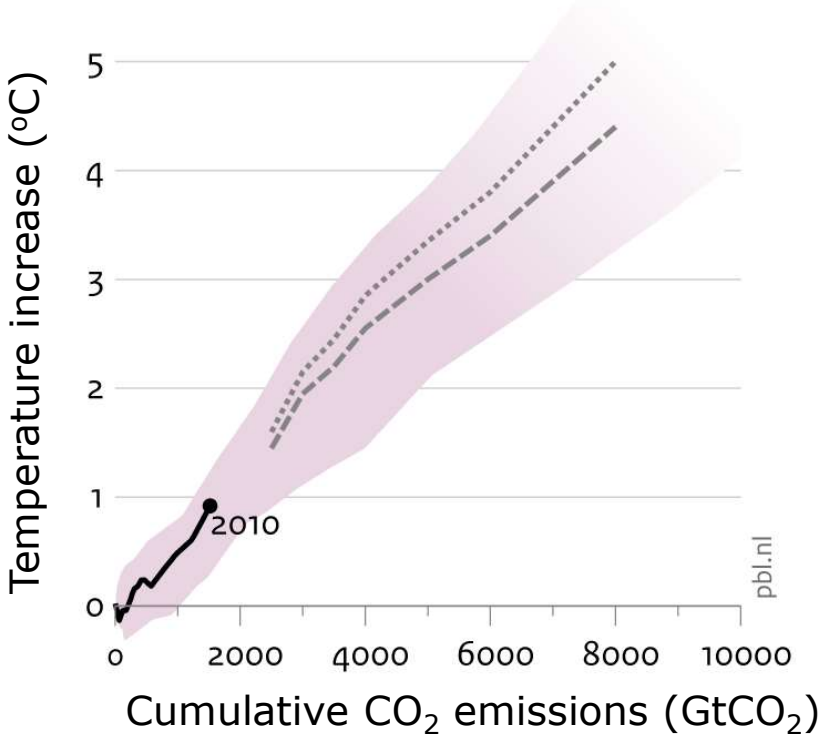
Global CO_2 emissions



Emissions → temperature



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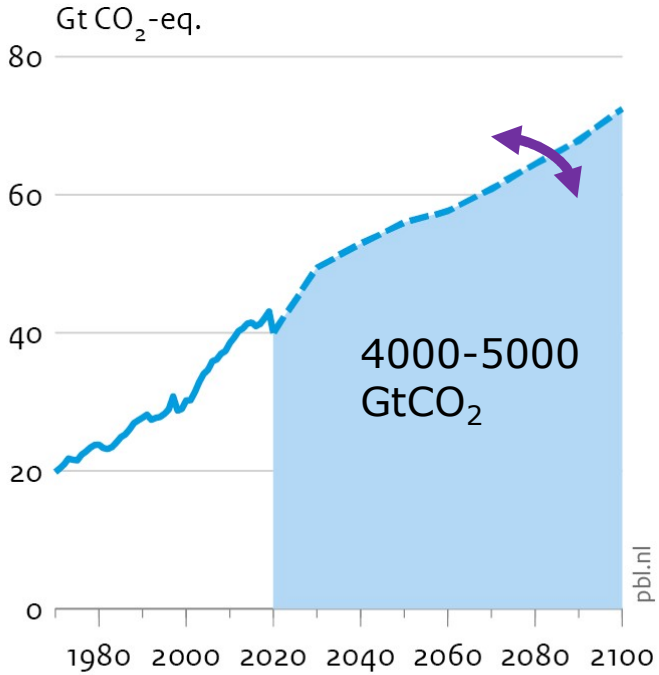
Global CO_2 emissions



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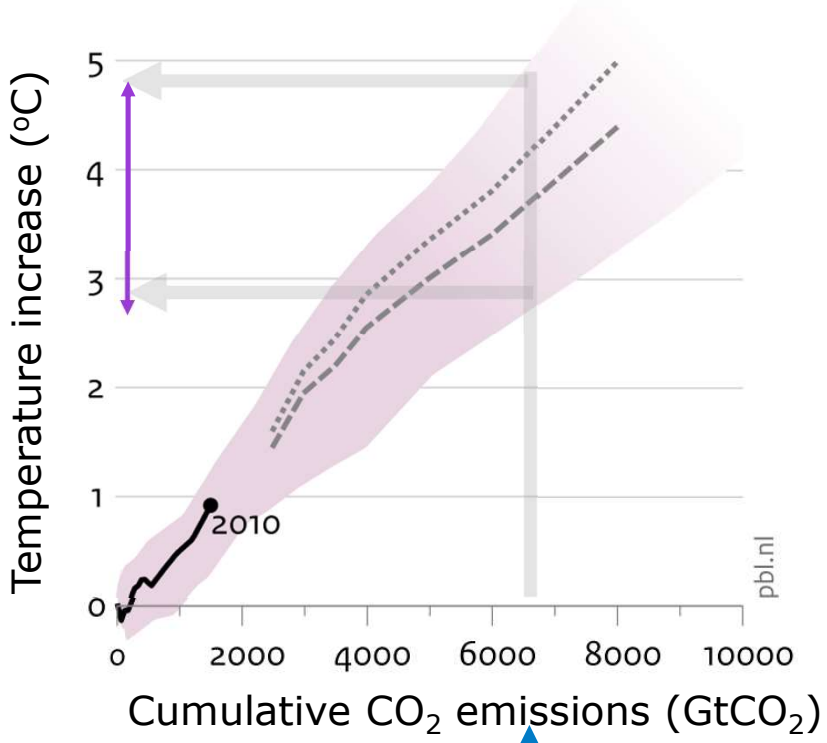

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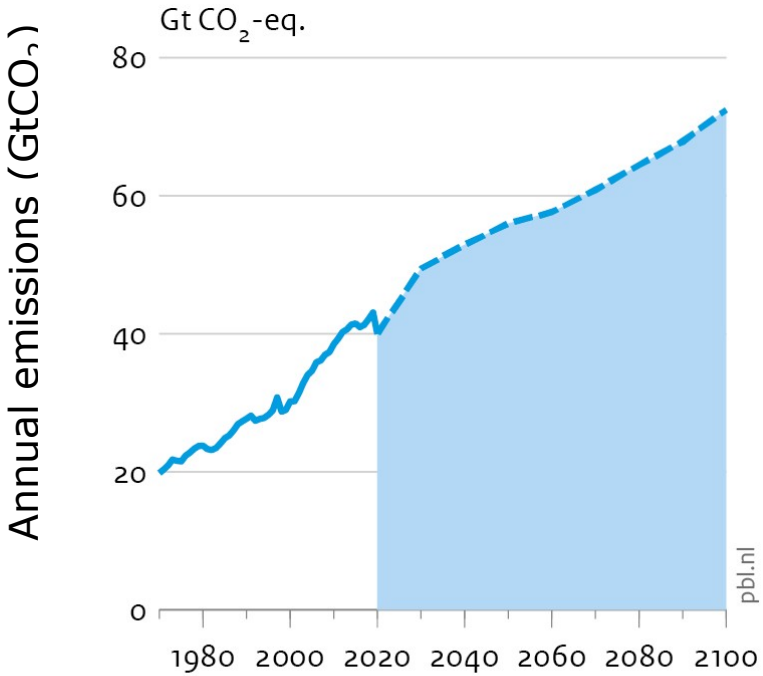
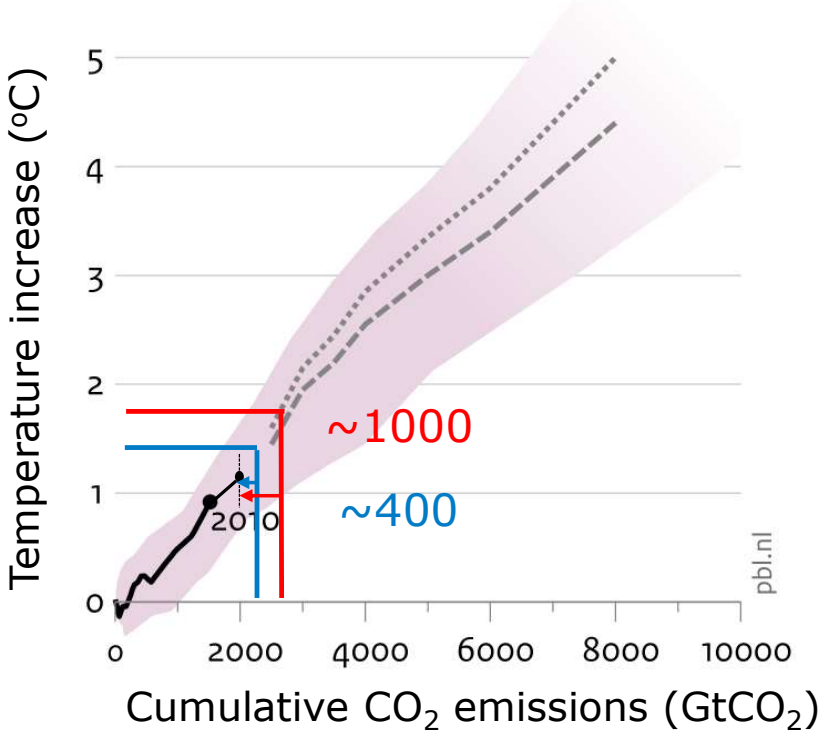
Global CO_2 emissies



Emissions → temperature



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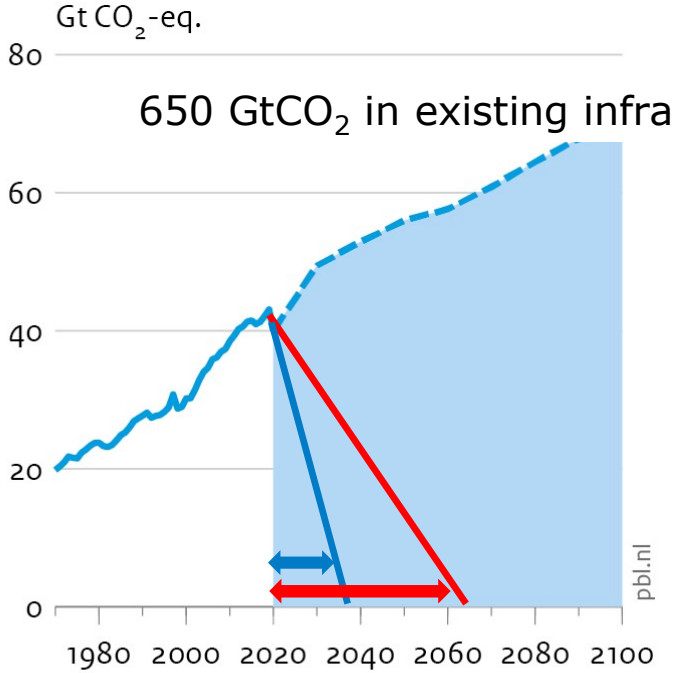
Global CO_2 emissies

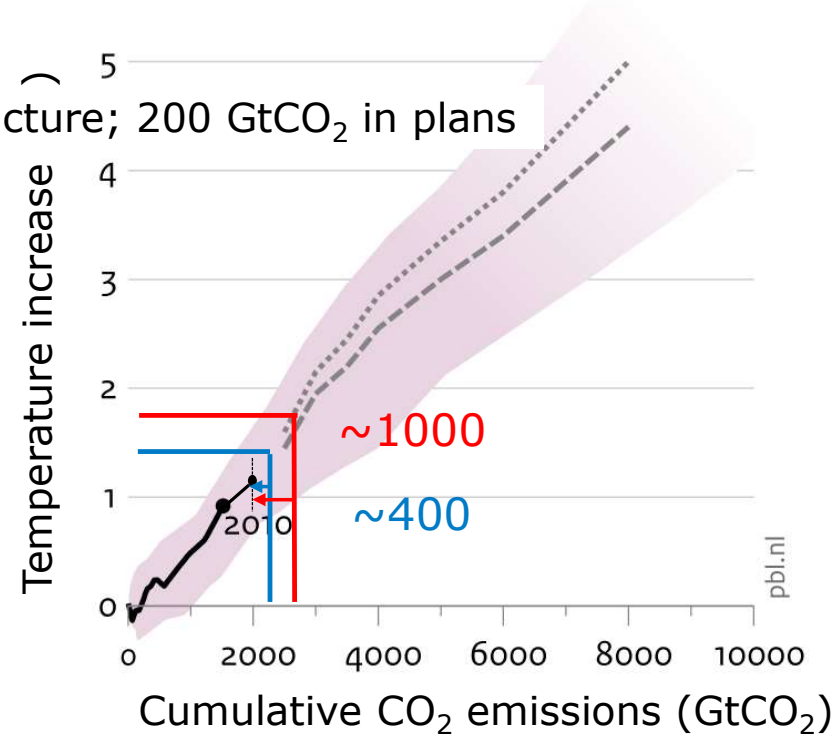


650 $GtCO_2$ in existing infrastructure; 200 $GtCO_2$ in plans

45 year

18 year

Emissions → temperature



Cumulative CO_2 emissions ($GtCO_2$)

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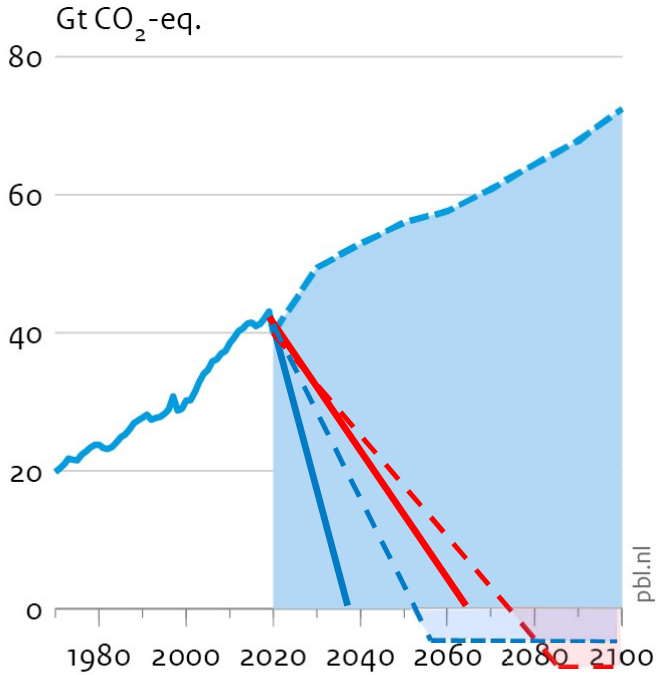
Global CO_2 emissions



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

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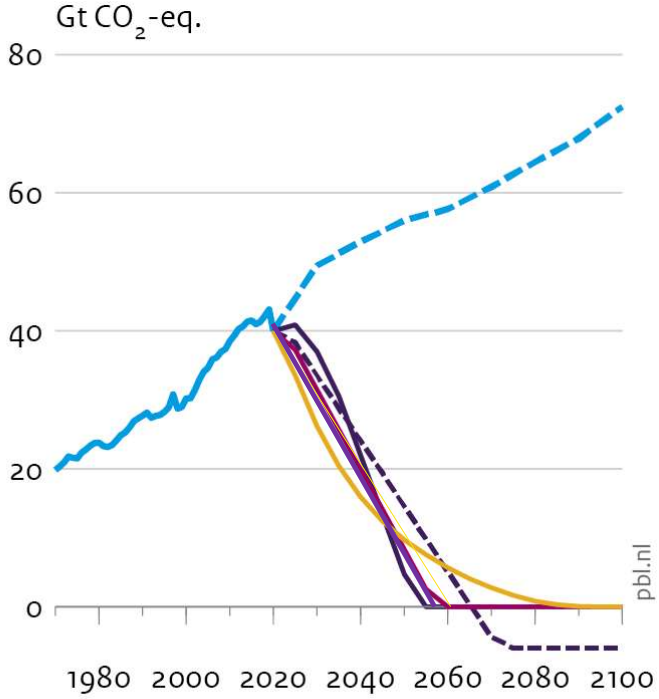
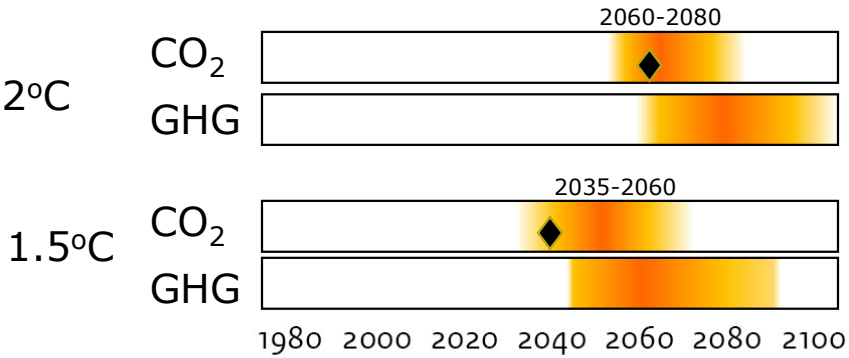
Flexibility in pathways

Global CO_2 emissies



Emerging consensus: net zero ~2050

- Distribution within time
- Non-CO_2



Net zero target is less certain – but sets a clear point at the horizon

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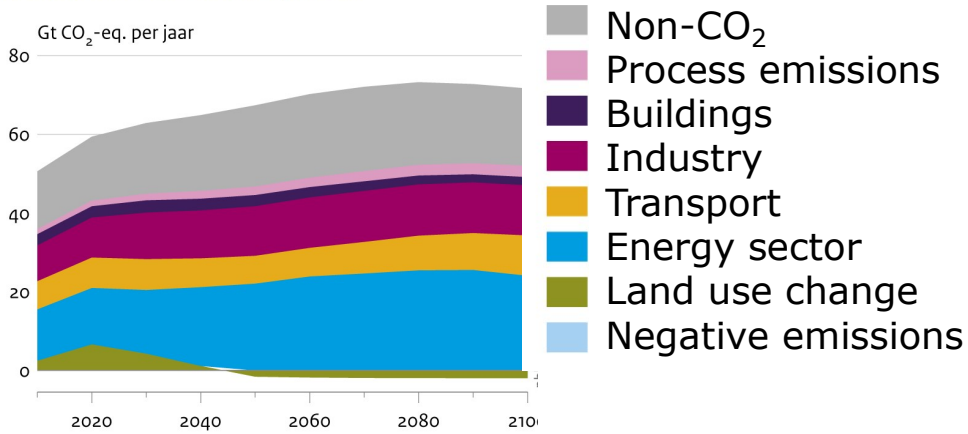
Current policy

Global emissions greenhouse gas



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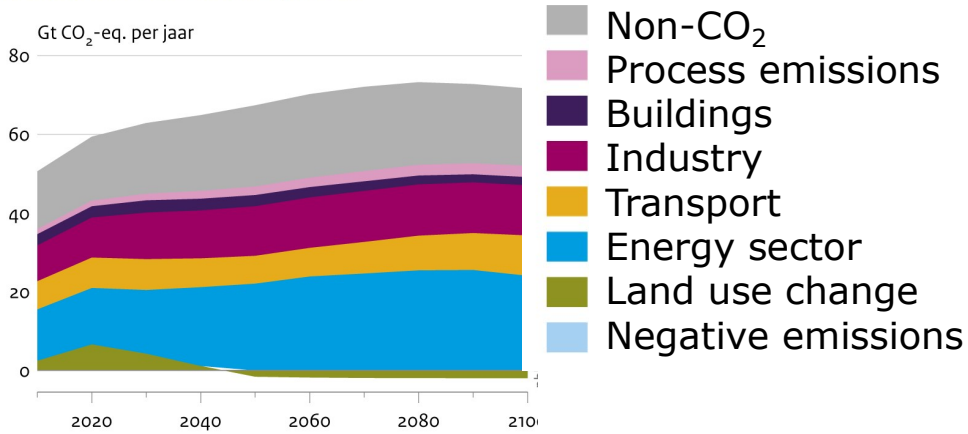
Current policy

Global emissions greenhouse gas



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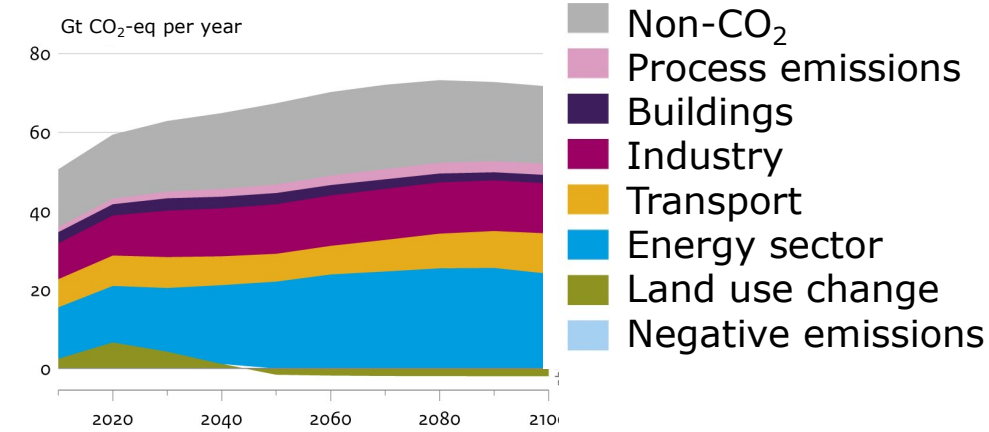
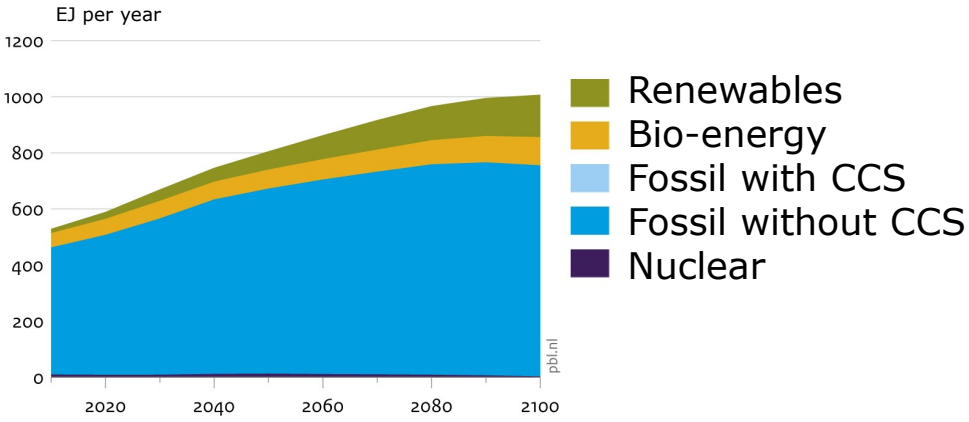
Current policy

Global emissions greenhouse gas



Global energy use



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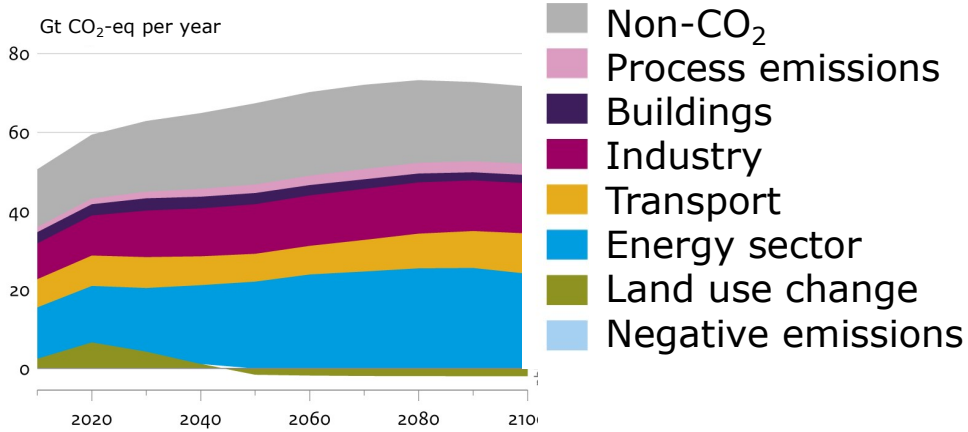
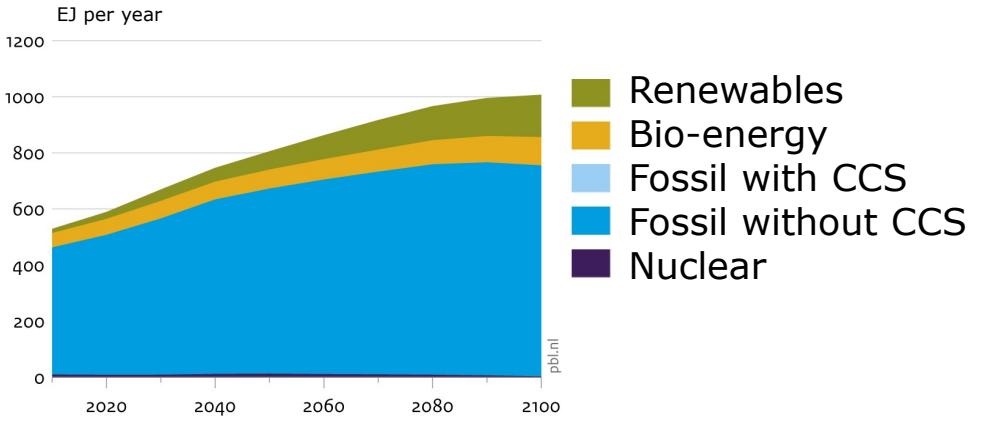
Current policy

Global emissions greenhouse gas



Global energy use

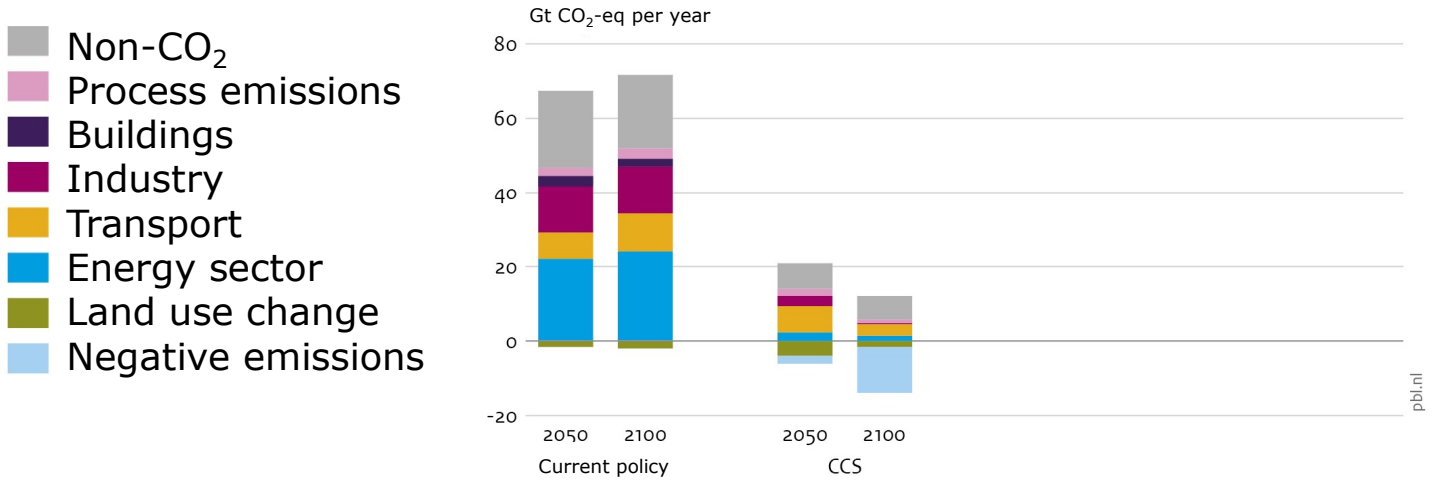


Global emissions greenhouse gas

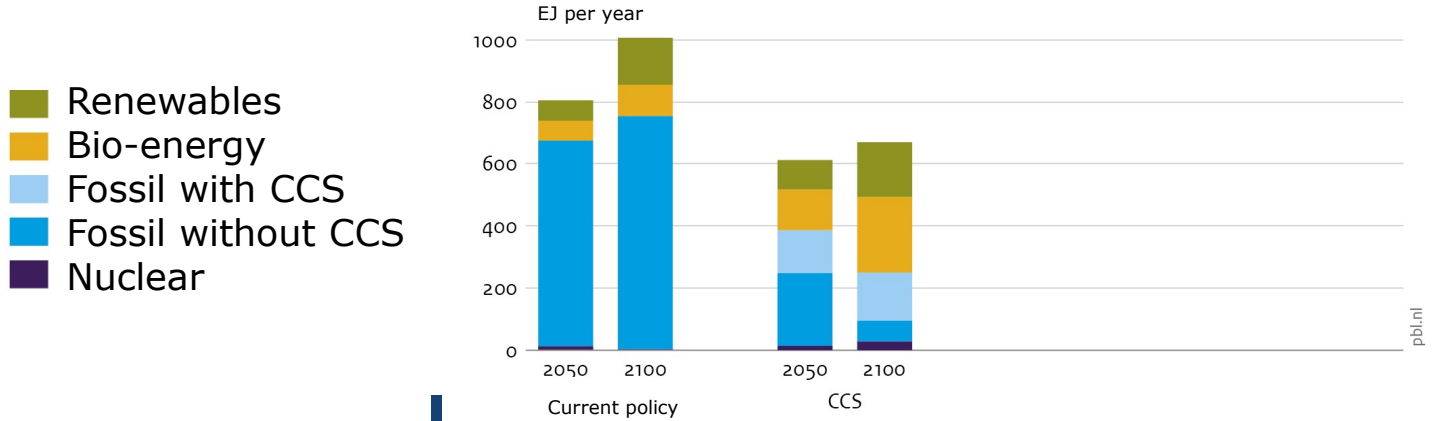
Global energy use

Planbureau voor de Leefomgeving

Global emissions greenhouse gas



Global energy use



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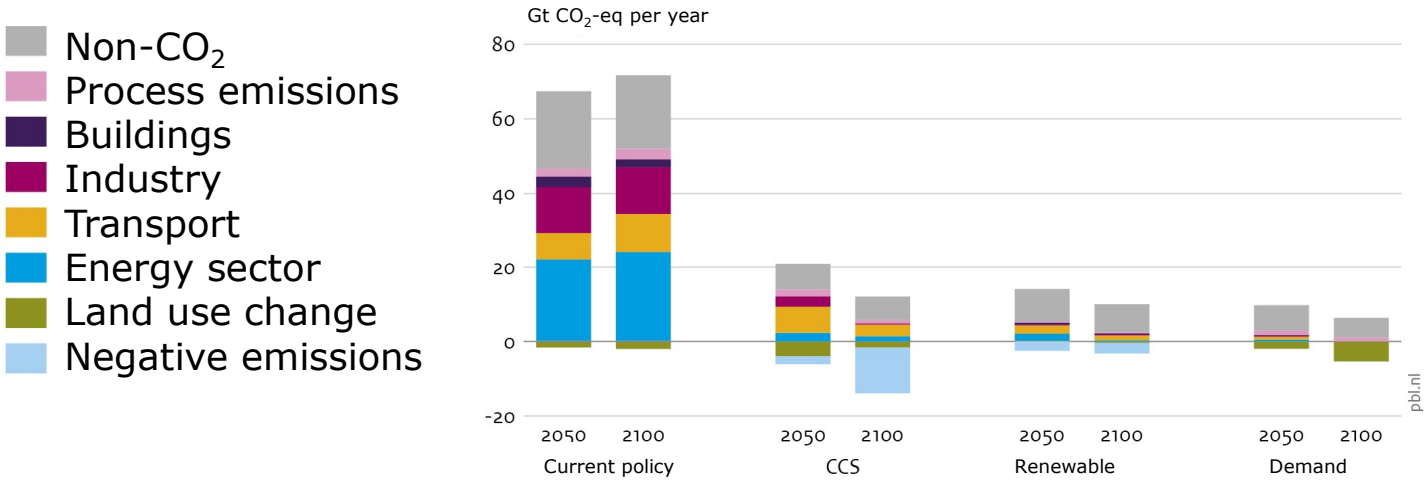
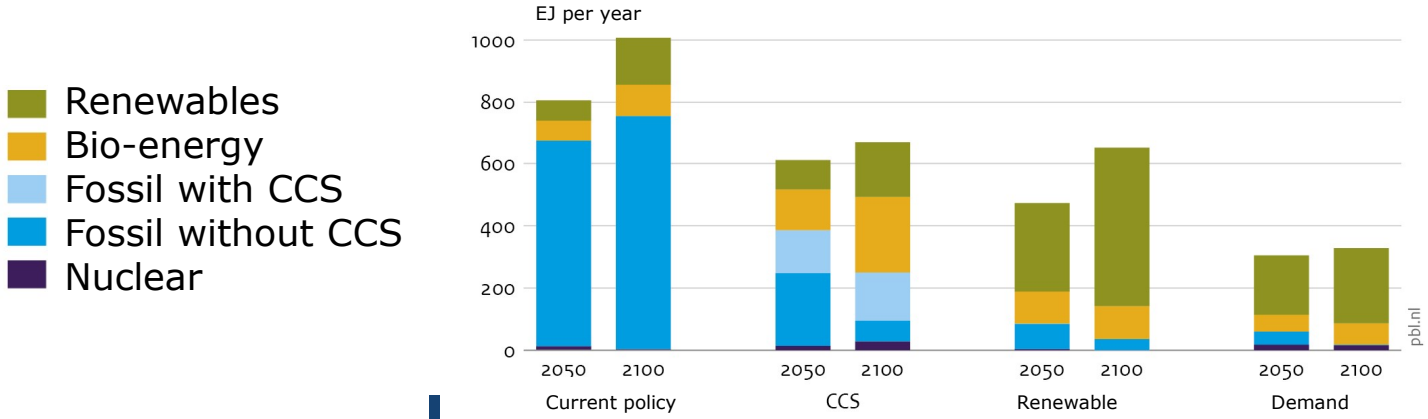
Global emissions greenhouse gas



Global energy use



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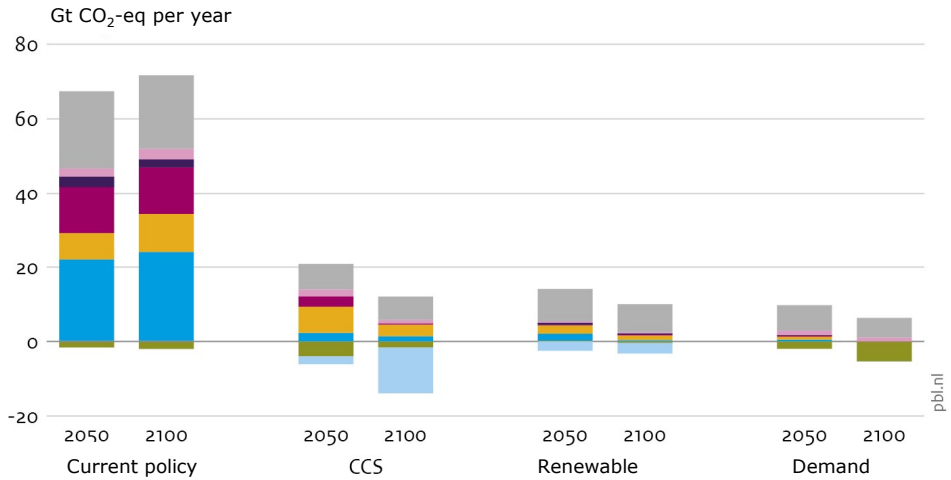
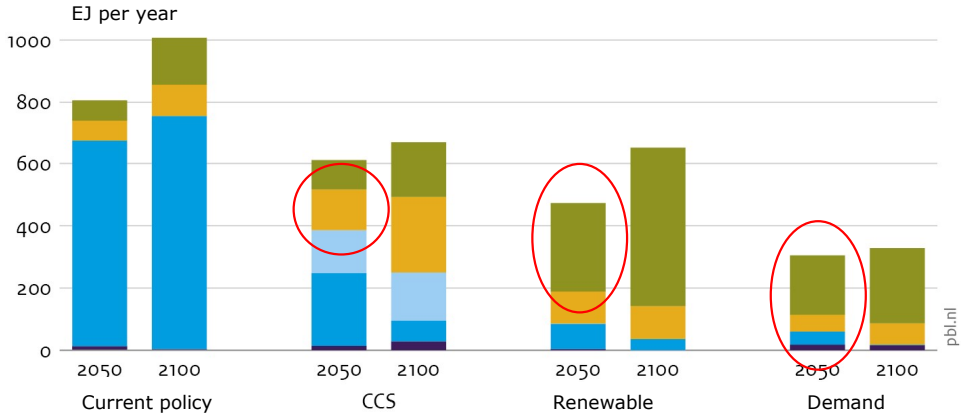
- Non-CO_2
- Process emissions
- Buildings
- Industry
- Transport
- Energy sector
- Land use change
- Negative emissions

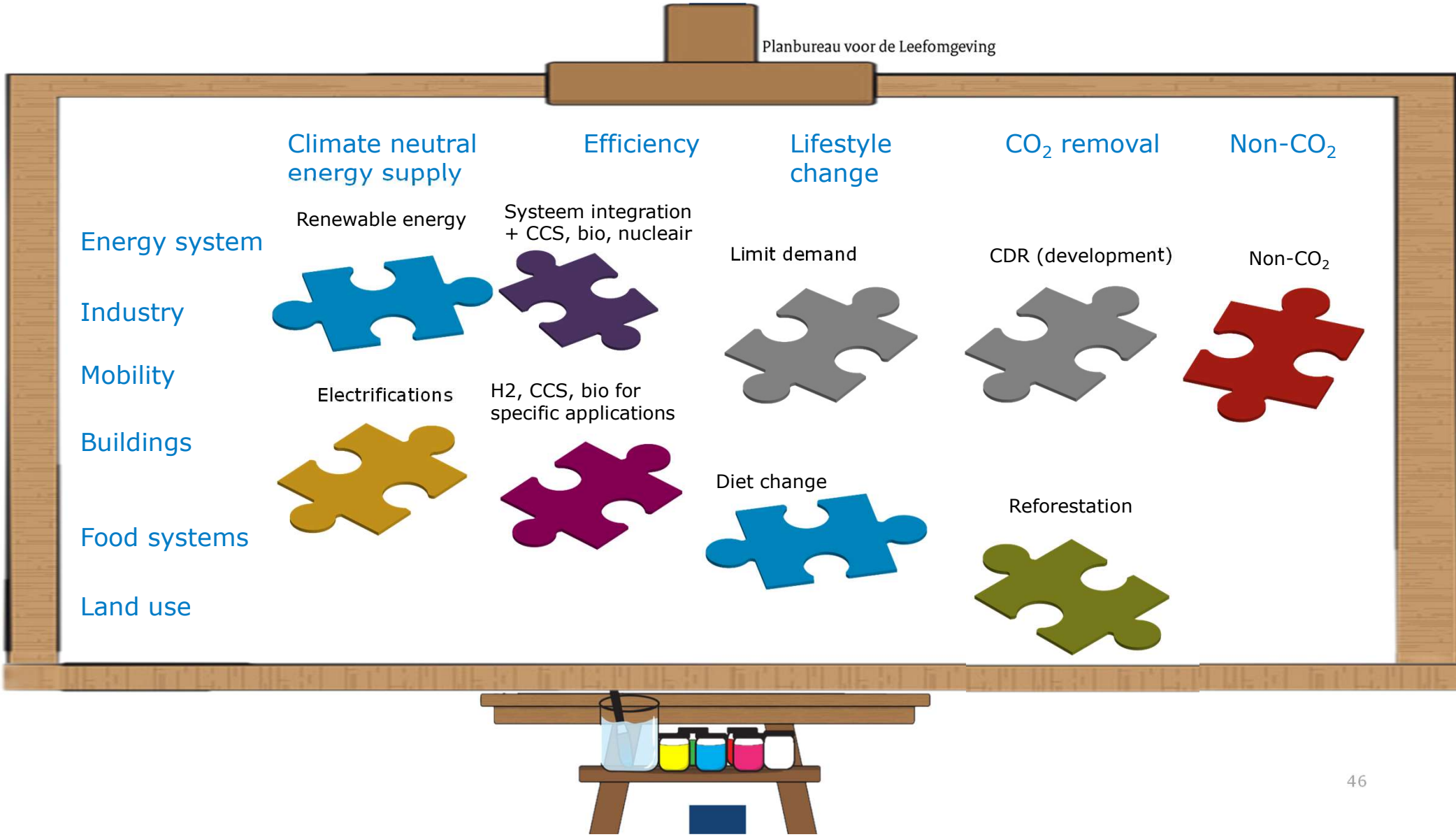
Global emissions greenhouse gas



- Renewables
- Bio-energy
- Fossil with CCS
- Fossil without CCS
- Nuclear

Global energy use




Planbureau voor de Leefomgeving
Climate neutral energy supply
Efficiency
Lifestyle change
CO_2 removal
Non-CO_2
Energy system
Industry
Mobility
Buildings
Food systems
Land use
Renewable energy
Systeem integration + CCS, bio, nucleair
Limit demand
CDR (development)
Non-CO_2
Electrifications
H2, CCS, bio for specific applications
Diet change
Reforestation

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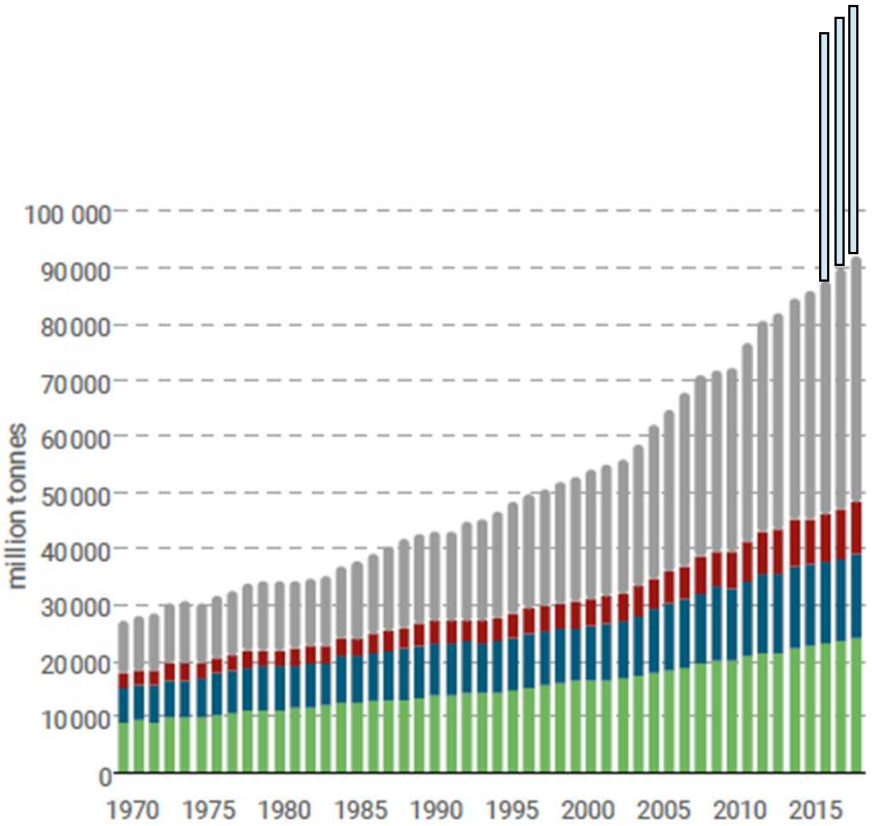
Going beyond climate

Global material extraction



Fresh water

Non-metallic minerals

Metal ores

Fossil fuels

Biomass

Water

Residential

Transport

Industry

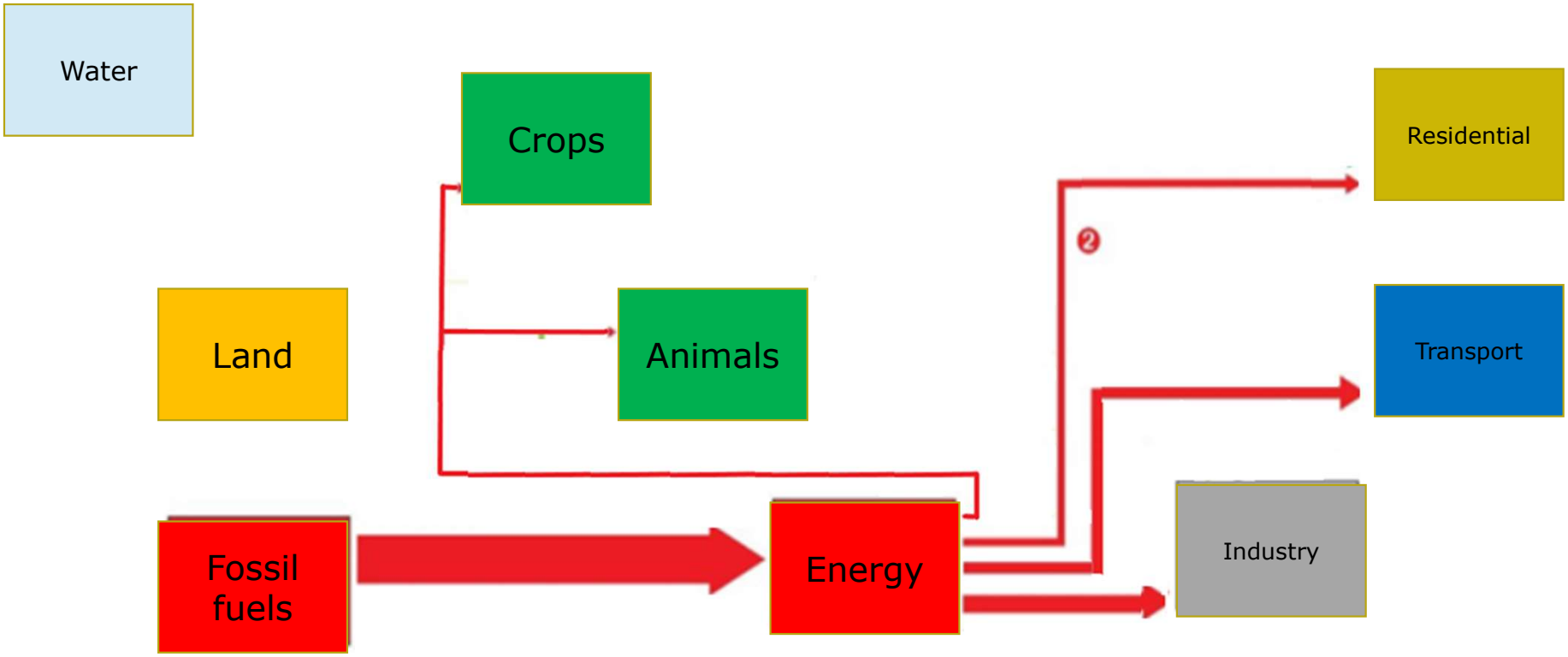
Energy

Food

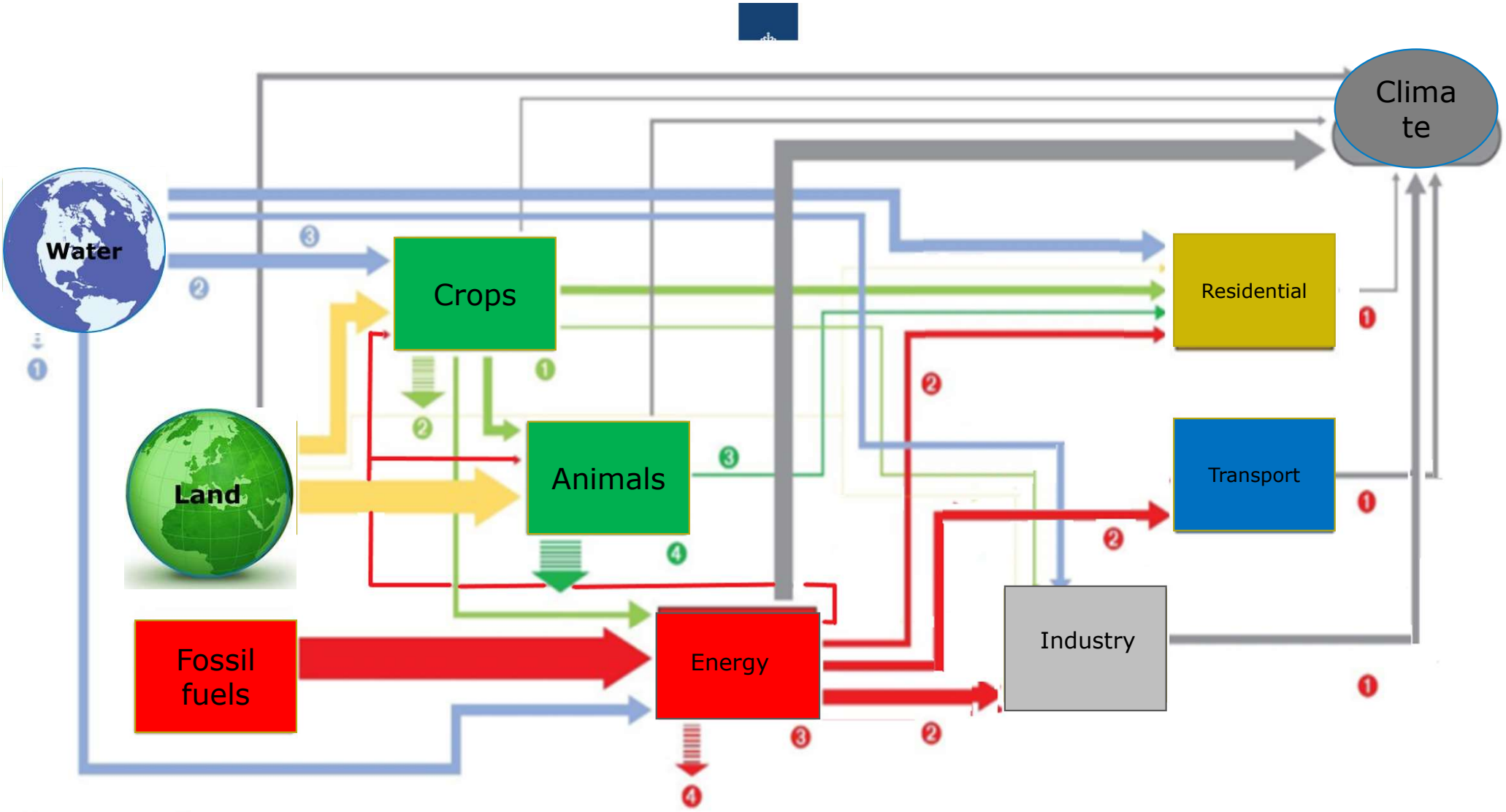
Resource use related to the way:
- We transport
- We eat
- We live

Infrastructure, energy and goods

Source: IRP – Global Resource Outlook 2019



rce: Van Vuuren et al. (2019). Nature Sustainability



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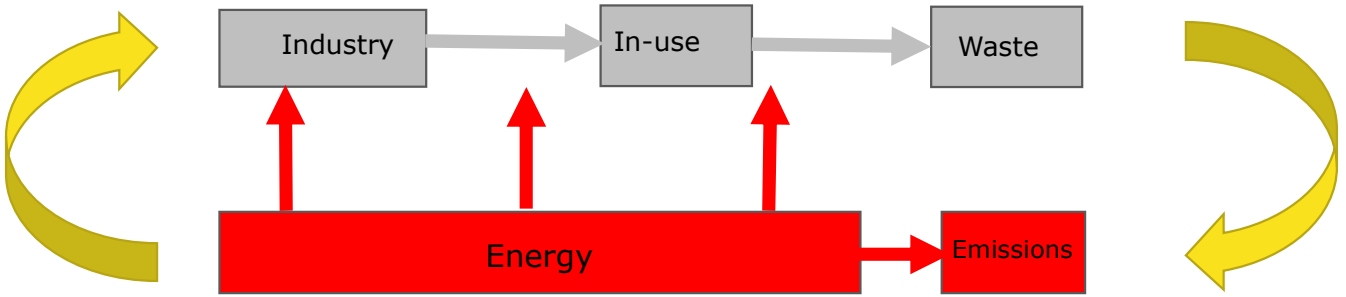
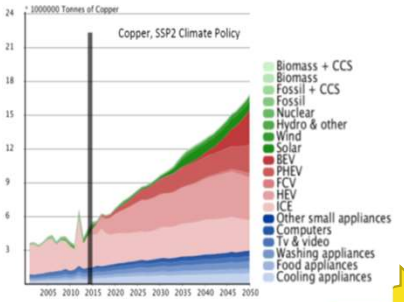
Implications of energy infrastructure



Implications of increasing material demand



Implications of energy transition

Deetman et al, 2018

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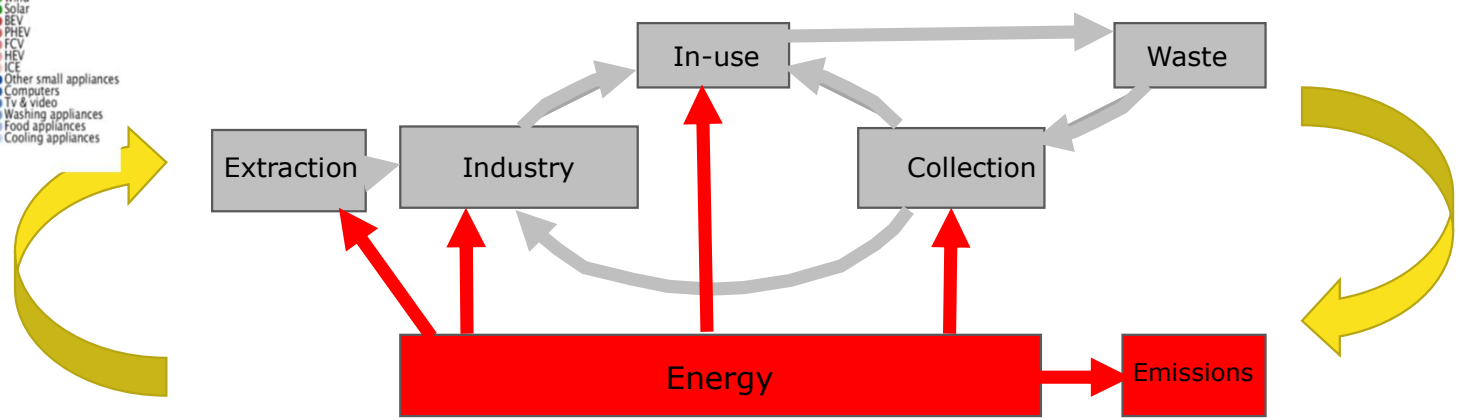
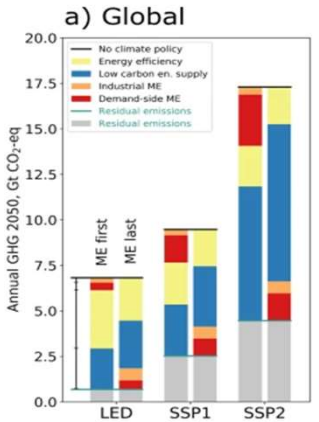
Pauliuk et al (2021), Nature Communications. August 24





Implications of increasing circular economy

Prevent biodiversity loss

Prevent water scarcity

Reduce water scarcity

Protect biodiversity

Eridicate hunger

Meet climate goals

	Scenarios			
Measures	WATER	LAND	FOOD	CLIMATE
Environmental flow requirements	Limit water extraction,			
Biodiversity protection		Increase in protection		
Fertilizer efficiency	++	++		+
Diet change			Willett diet	
Food waste			reduction in food waste	
GHG price				Carbon price

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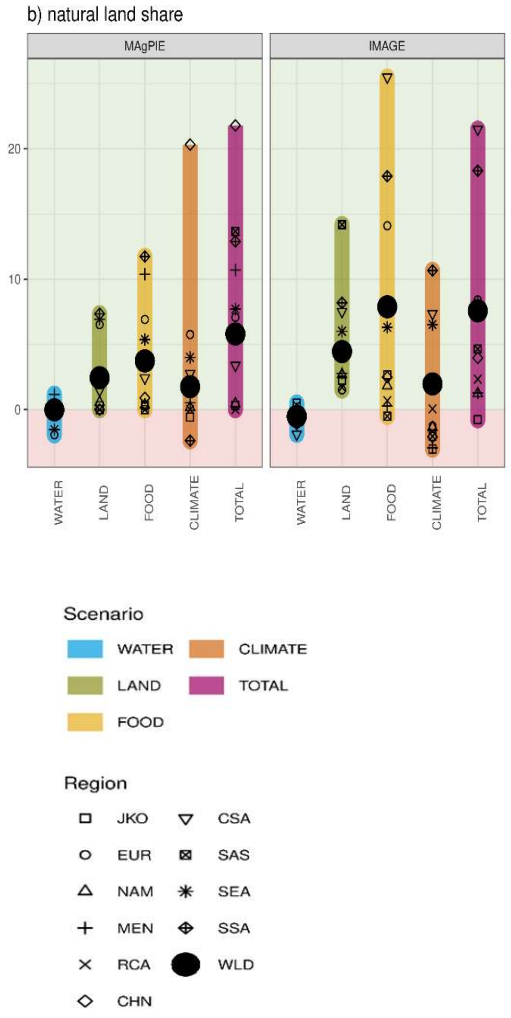

Doelman et al., in review

	Scenarios			
Measures	WATER	LAND	FOOD	CLIMATE
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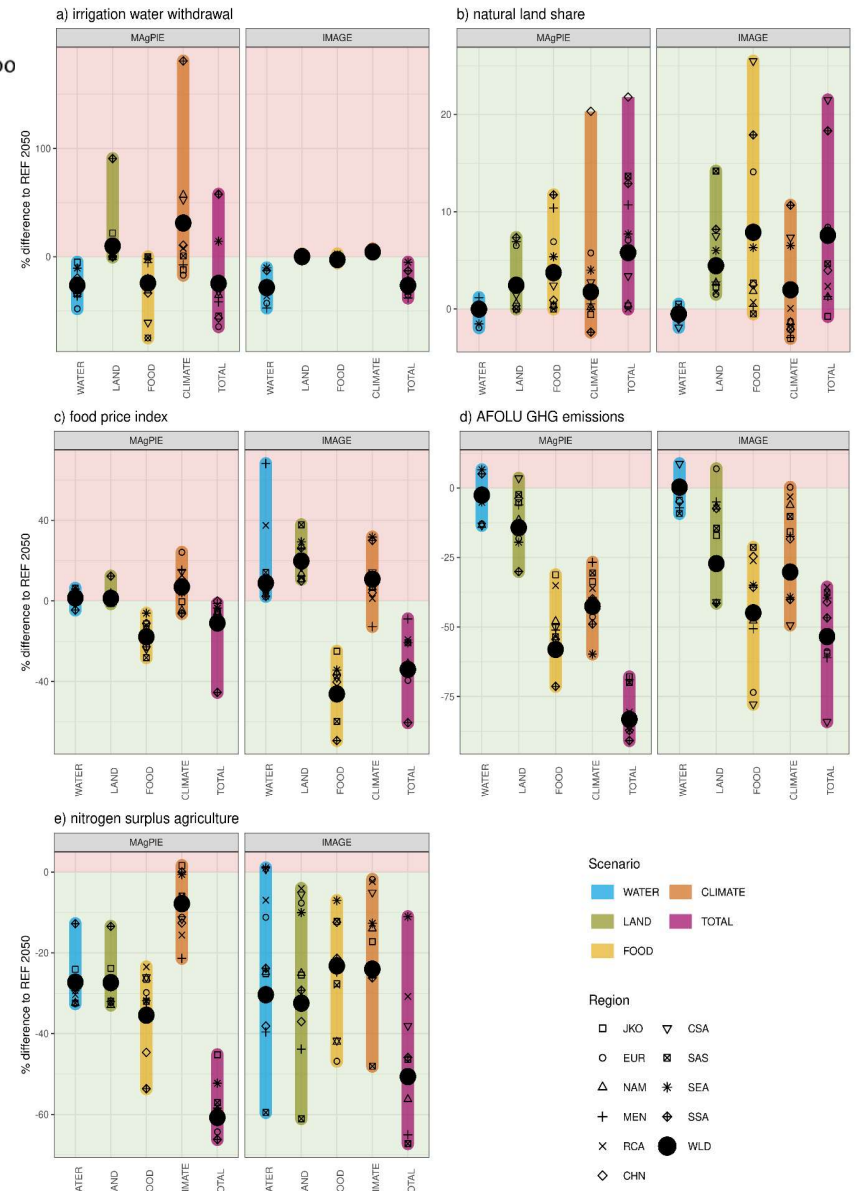
Fertilizer efficiency	++	++		+
Diet change			Willett diet	
Food waste			reduction in food waste	
GHG price				Carbon price

Model	MAgPIE					IMAGE				
Scenario	WATER	LAND	FOOD	CLIMATE	TOTAL	WATER	LAND	FOOD	CLIMATE	TOTAL
Water Withdrawal Irrigation	-26%	+10%	-24%	+31%	-25%	-28%	0%	-3%	+5%	-26%
Natural Land Area	0%	+2%	+4%	+2%	+6%	-1%	+4%	+8%	+2%	+8%
Nitrogen Surplus Agriculture	-27%	-27%	-35%	-8%	-61%	-30%	-32%	-23%	-24%	-51%
Food Price	+1%	+1%	-18%	+7%	-11%	+9%	+20%	-46%	+11%	-34%
AFOLU Emissions	-3%	-14%	-58%	-43%	-83%	0%	-27%	-45%	-30%	-53%

Planbureau voo



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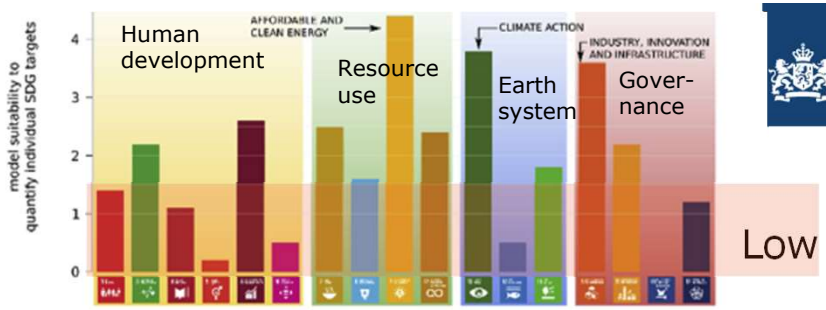
https://eartharxiv.org/repository/view/2386/

Defining a Sustainable Development Target Space for 2030 and 2050

Detlef P. van Vuuren[*1,2], Caroline Zimm[3], Sebastian Busch[4], Elmar Kriegler[5], Julia Leininger[6], Dirk Messner[7], Nebojsa Nakicenovic[3], Johan Rockstrom[5,8], Keywan Riahi[3,9], Frank Sperling[3,10], Valentina Bosetti[11], Sarah Cornell[8], Owen Gaffney[5,8], Paul L. Lucas[1], Alexander Popp[5], Constantin Ruhe[6,12], Armin von Schiller[6], Jörn O. Schmidt[13, 14], Bjoern Soergel[5]

	Indicators		
SDG1			
SDG2			
SDG3			
SDG4			
SDG5			
SDG6			
SDG7			
SDG7			
SDG8			
…			



b SDG interactions and their representation in IAMs

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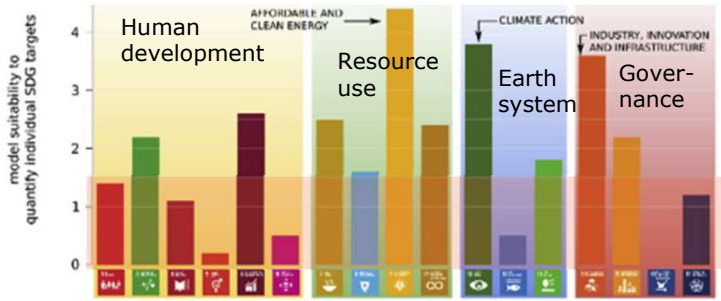
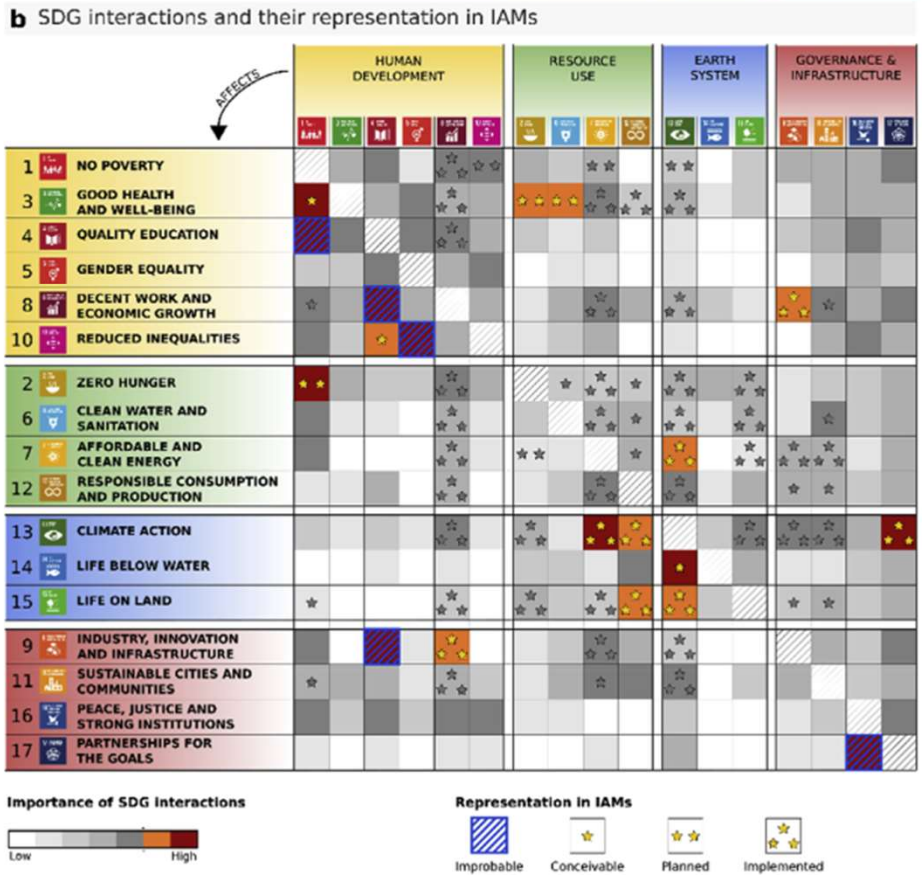
	Indicators		
SDG1			
SDG2			
SDG3			
SDG4			
SDG5			
SDG6			
SDG7			
SDG7			
SDG8			
…			

Van Soest et al., 2019



Low



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	Indicators		
SDG1			
SDG2			
SDG3			
SDG4			
SDG5			
SDG6			
SDG7			
SDG7			
SDG8			
…			

Van Soest et al., 2019

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Untying the knot

- Lot of experience on single issue scenario work regarding solutions…
- But knowledge on the connections is still developing
- Common knowledge base
  - Linking different types of research
  - Use of common scenarios
  - Learning across scales
  - Social science / natural science
  - Different research foci (e.g. CE, nexus, climate, biodiversity)