

18th IAEE European Energy Conference

How Pyrolysis as a Negative Emission Technology Can Guide the Expansion of the German Power System Toward Climate Neutrality

Supported by



Federal Ministry
for Economic Affairs
and Climate Action

On the basis of a decision
by the German Bundestag

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INES Institut für nachhaltige
Energiesysteme

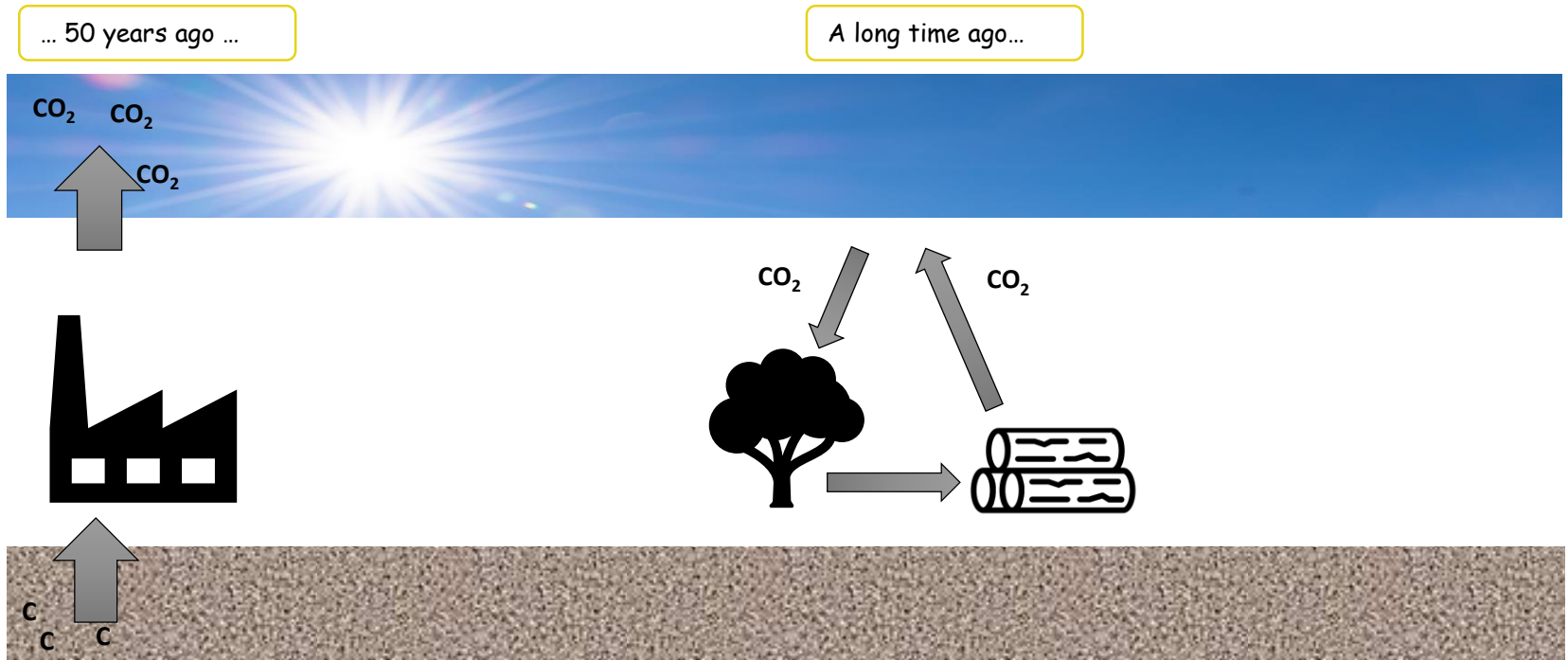
Agenda

1. Why we need negative emission technologies
2. Biochar production by pyrolysis
3. Optimization model MyPyPSA + pyrolysis
4. Scenario settings
5. The impact of pyrolysis on the future power system
6. Take aways

for your information

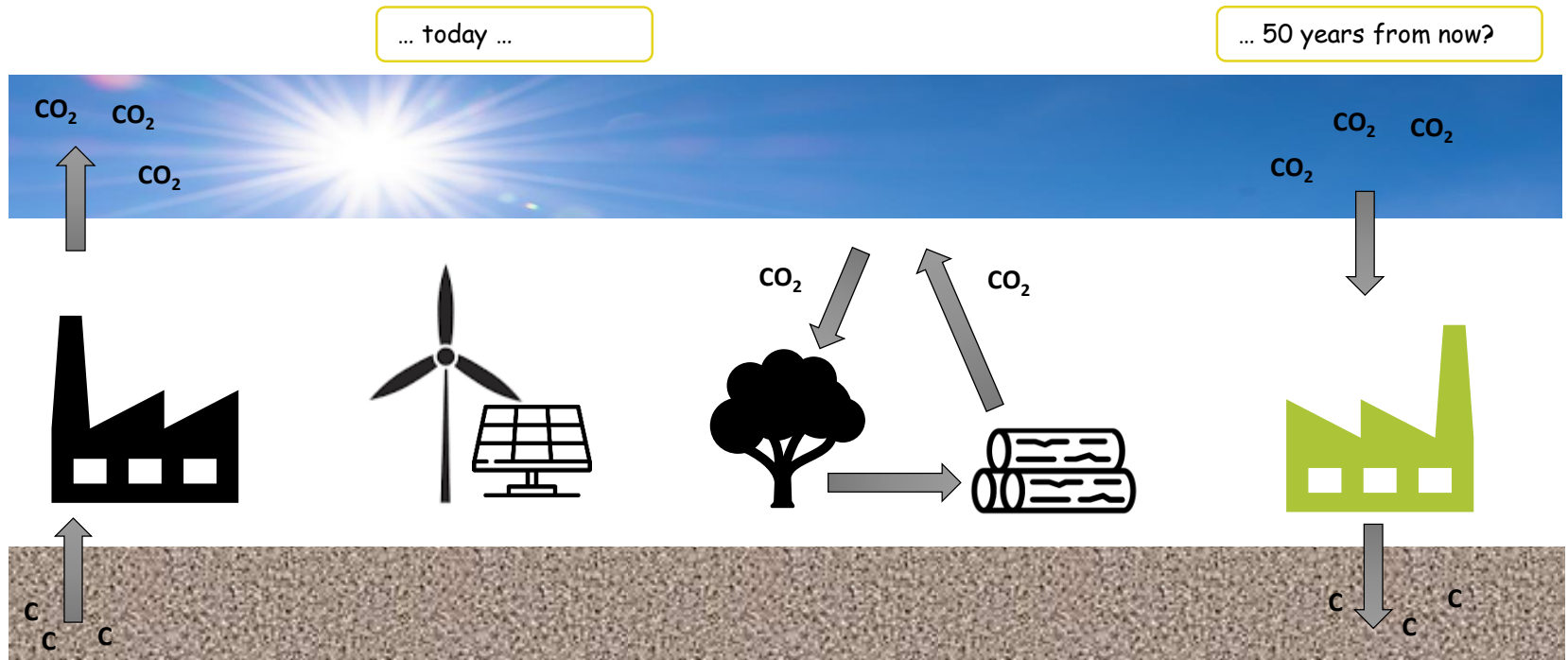
Introduction

Why we need negative emissions to reach the climate goals



Introduction

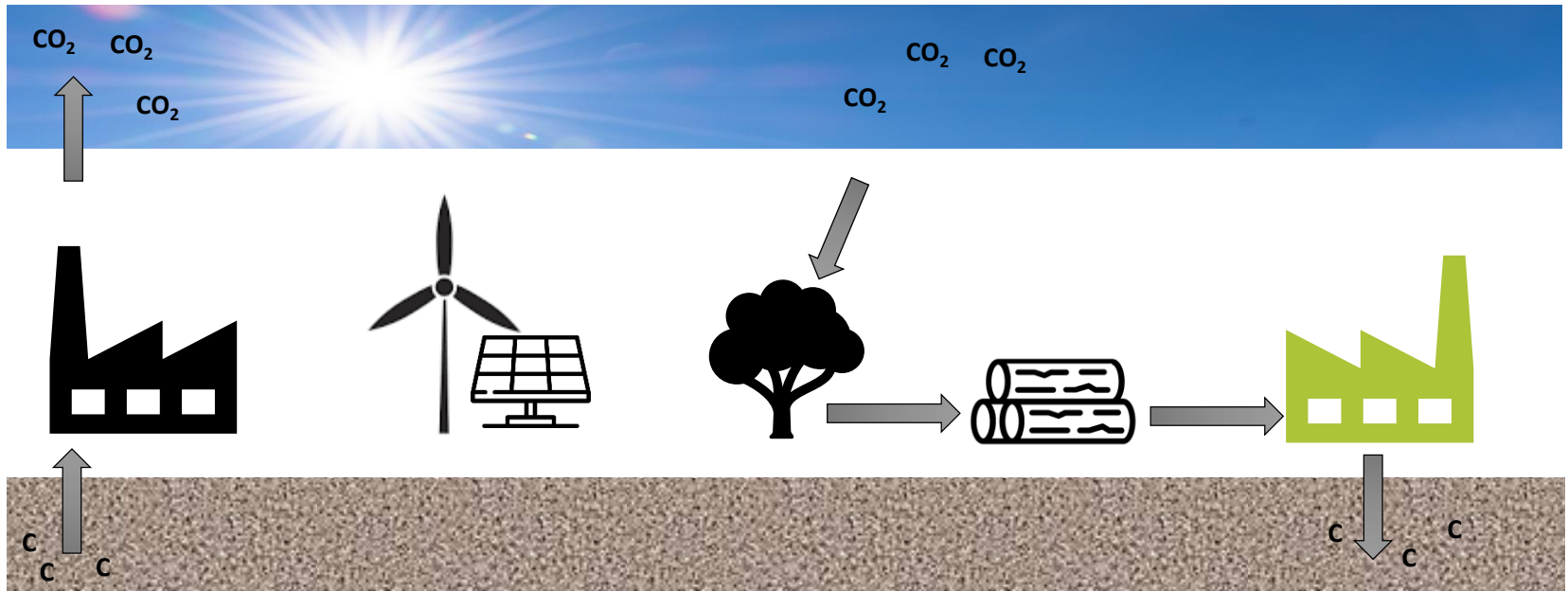
Why we need negative emissions to reach the climate goals



Introduction

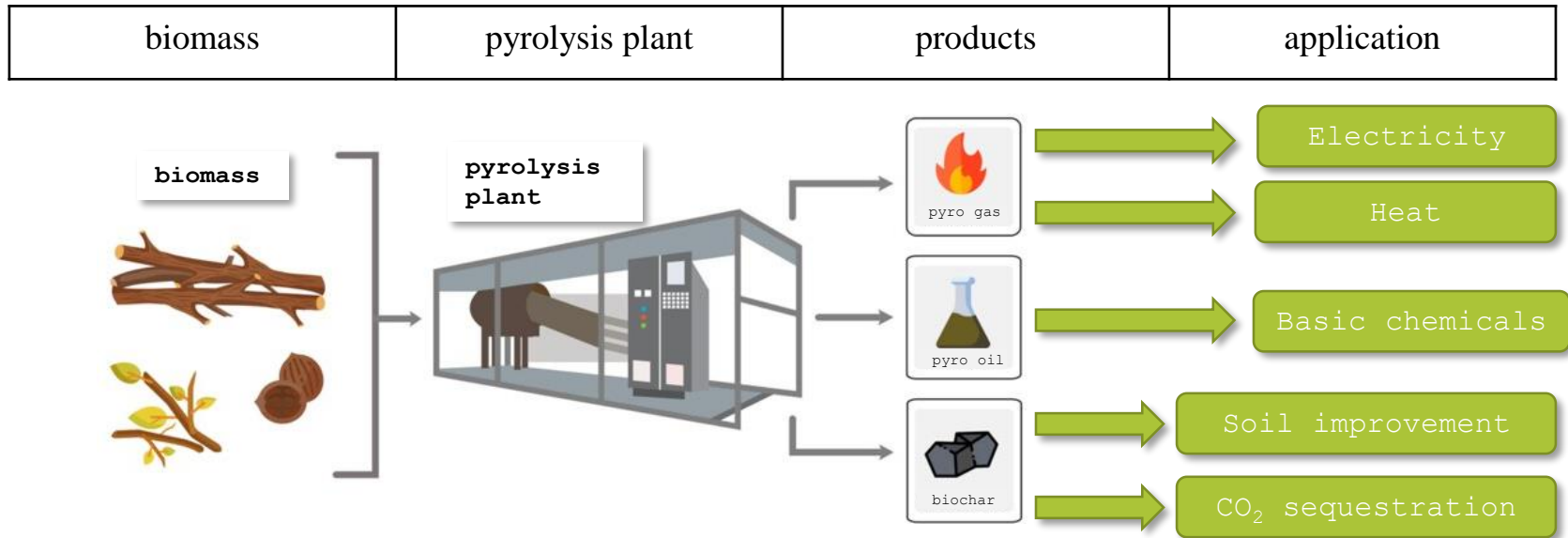
Why we need negative emissions to reach the climate goals

... 50 years from now?



Introduction

Biochar production by pyrolysis



Source: www.sfv.de

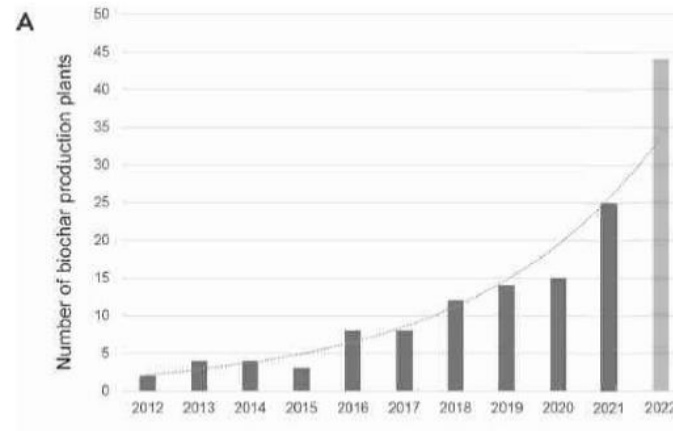
for your information

Introduction

The current status of pyrolysis plants and biochar production

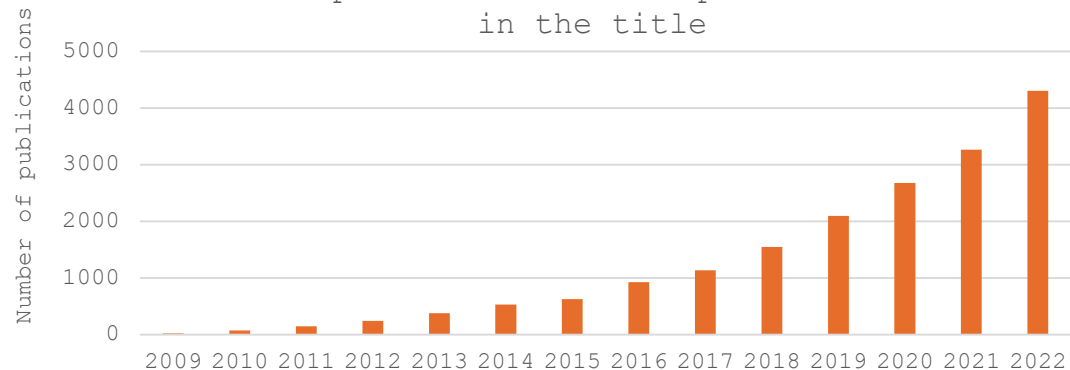
Source: Garcia, Bruno;
Alves et al. (2022)

Number of newly installed pyrolysis plants per year

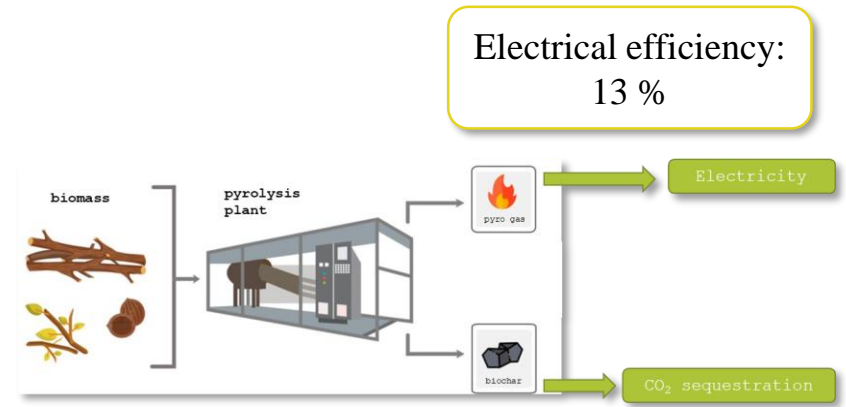
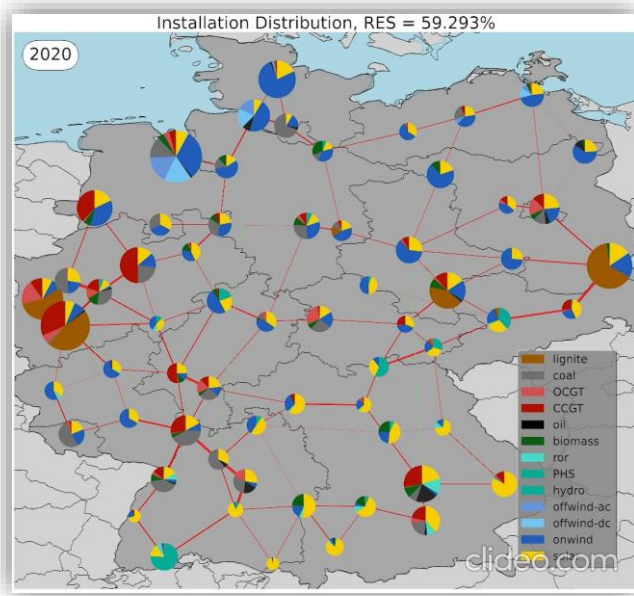


Source: Scopus

Number of publications on Scopus with "biochar" in the title



Optimization model MyPyPSA + pyrolysis

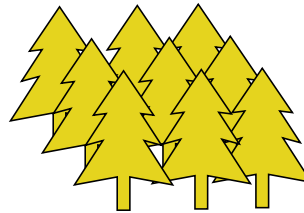


Electrical efficiency:
13 %

Available
biomass:
33 Mt/year

Biochar yield:
58 %

CO₂ storage factor :
1.5 kg_{CO2}/kg_{SBM}



= 2 mio firs



Source: Abuzayed, Anas;
Hartmann, Niklas (2022)

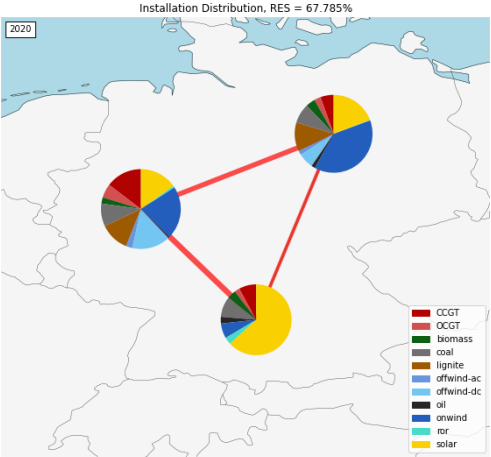
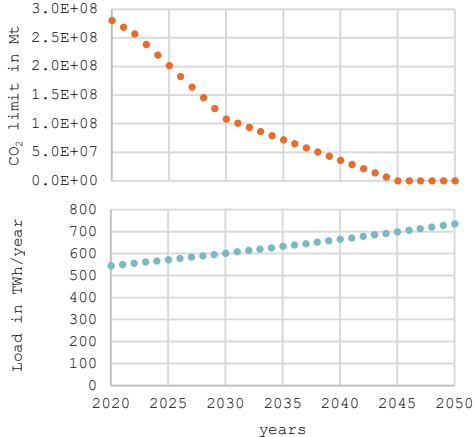
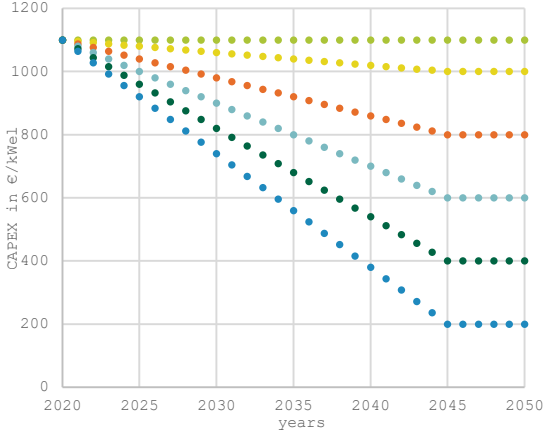
Source: Tsang, Daniel
C.W.; Yong Sik Ok (2022)

Questions we asked



1. What impact does **pyrolysis** have on the future **expansion and deployment of renewable and conventional power plants**?
2. What **purpose** does **pyrolysis** serve in the energy system?
3. What impact do the **costs** have on the implementation of **pyrolysis**?

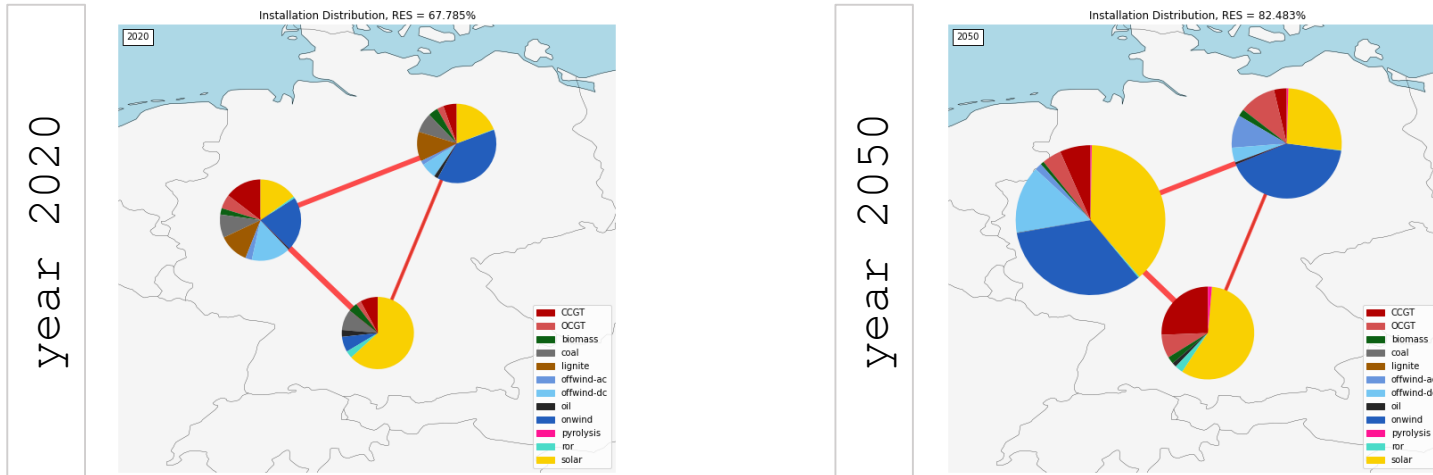
Scenario settings

Starting year 2020	Myopic development 2020-2050	Pyrolysis 2020-2050
<p>Starting year 2020</p>  <p>Installation Distribution, RES = 67.785%</p> <p>2020</p> <p><u>Starting system</u></p> <p>All power plant capacities from the year 2020 integrated</p>	<p>Myopic development 2020-2050</p>  <ul style="list-style-type: none"> ▪ Annual CO₂ emission limit ▪ Load increase of 1 %/year ▪ No storages ▪ No DSM 	<p>Pyrolysis 2020-2050</p>  <p><u>Costs development 2020-2050:</u></p> <ul style="list-style-type: none"> ▪ CAPEX adjustment ▪ OPEX = 0 €

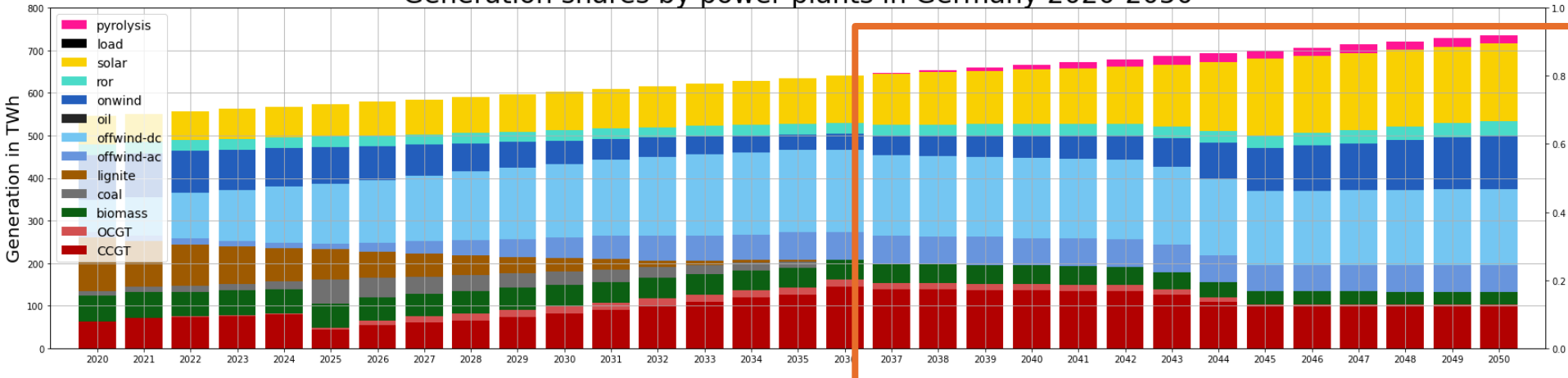
for your information

Results

Installation and generation shares



Generation shares by power plants in Germany 2020-2050

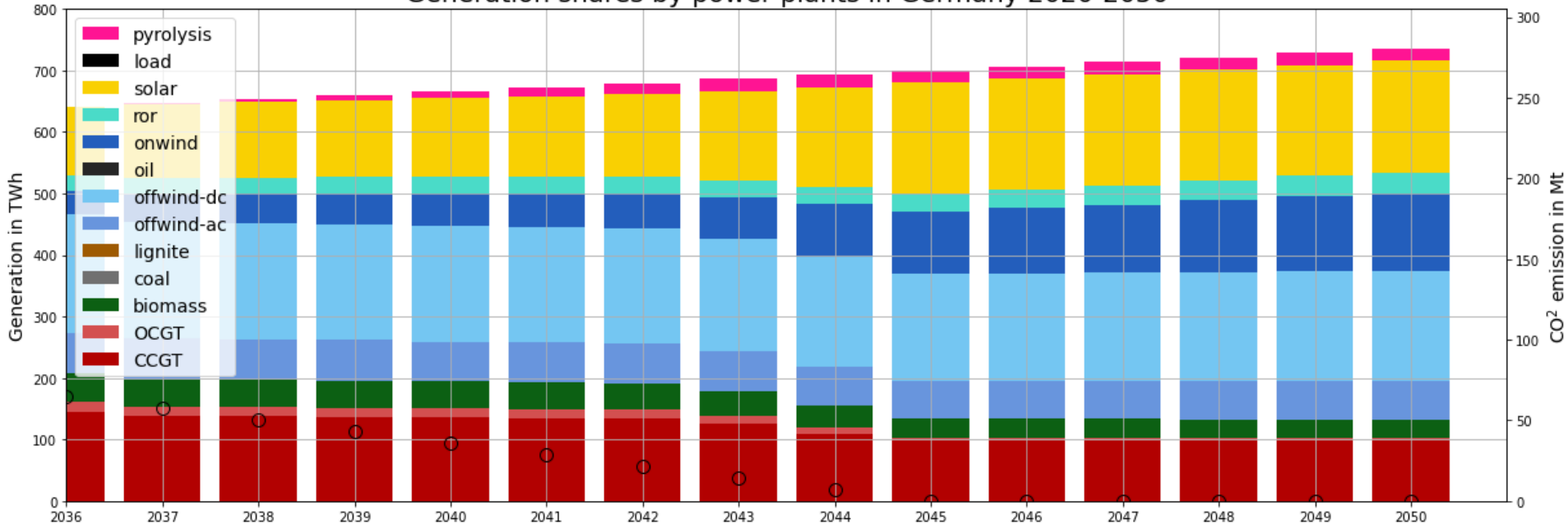


for your information

Results

Scenario: Expensive pyrolysis

Generation shares by power plants in Germany 2020-2050



2037: **CO2 limit** is reached
→ First investment in pyrolysis

2020-2036: No need for **pyrolysis**

2043: The available **biomass** is completely used in the pyrolysis process
→ Shift to more efficient CCGT

2045: CO₂ emission is restricted to **net zero**
→ The mode of operation of the power plants is changing

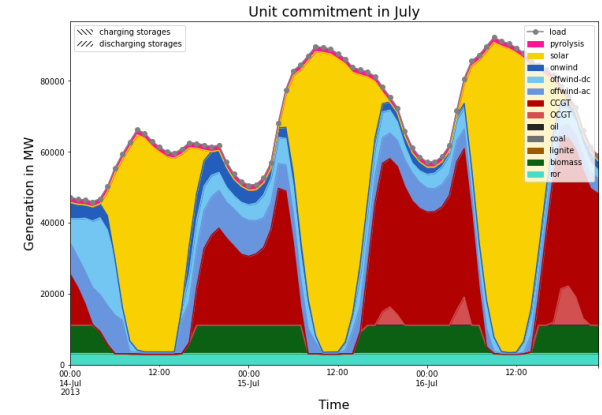
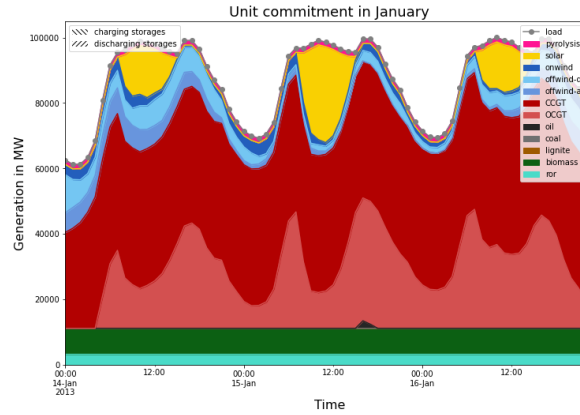
Results

Unit commitment in the year 2050

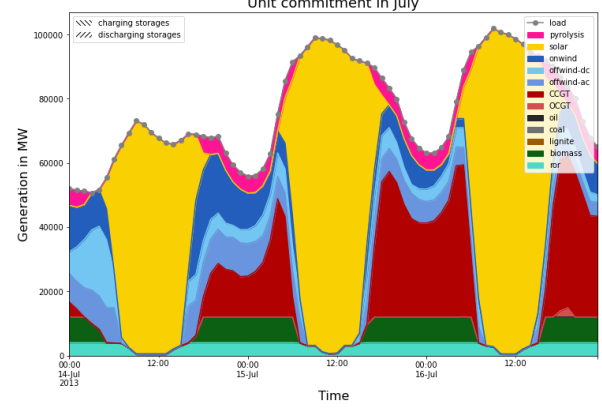
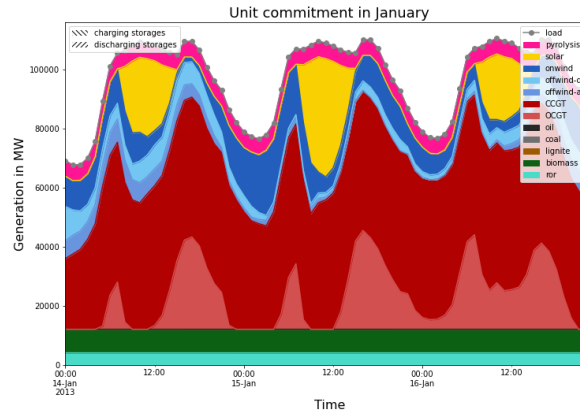
January

July

year 2040



year 2050



Results

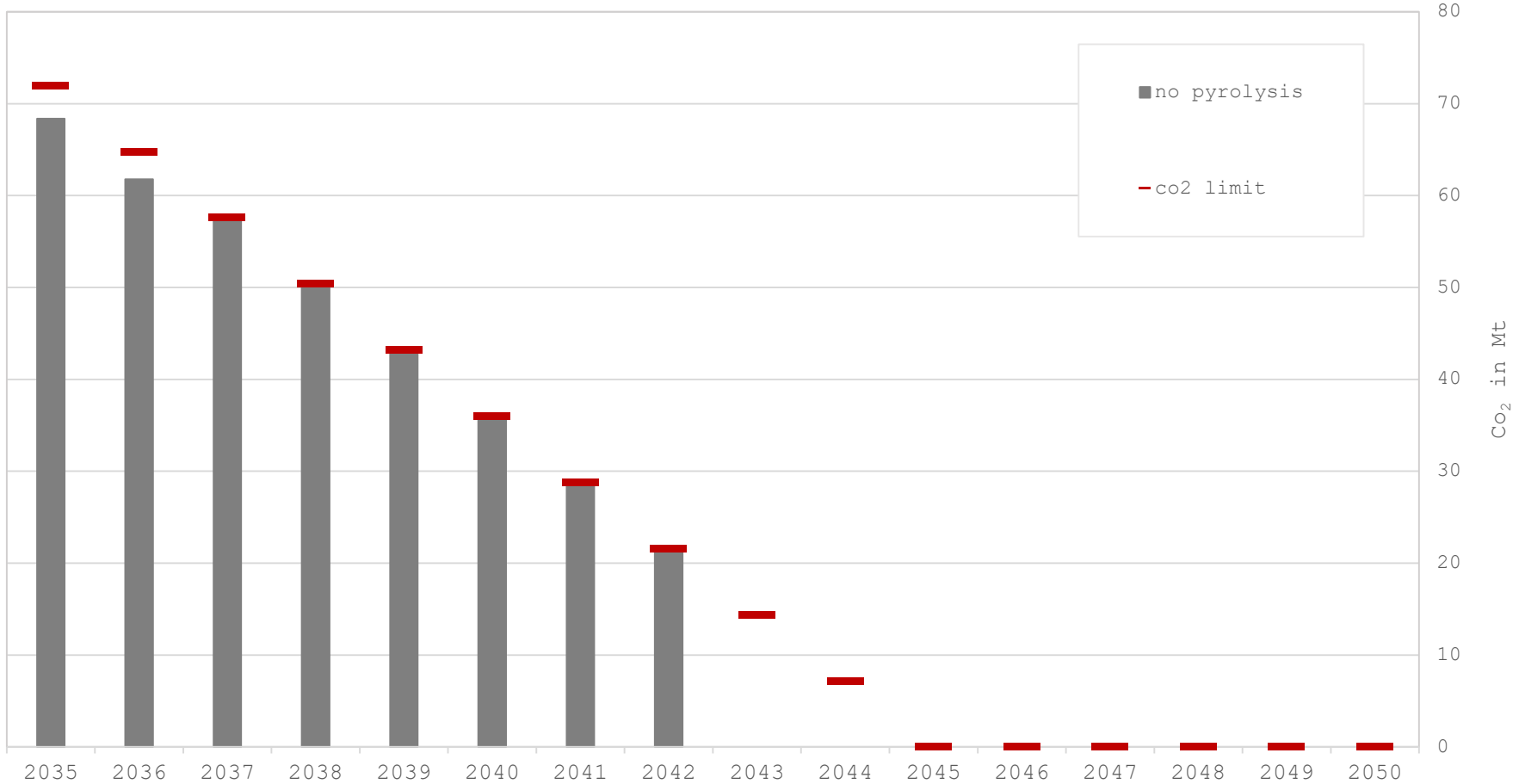
The 4 applications of pyrolysis in the energy system

		Flexibility?	
		FLH = 8760 h → no	FLH < 8760 h → yes

for your information

Results

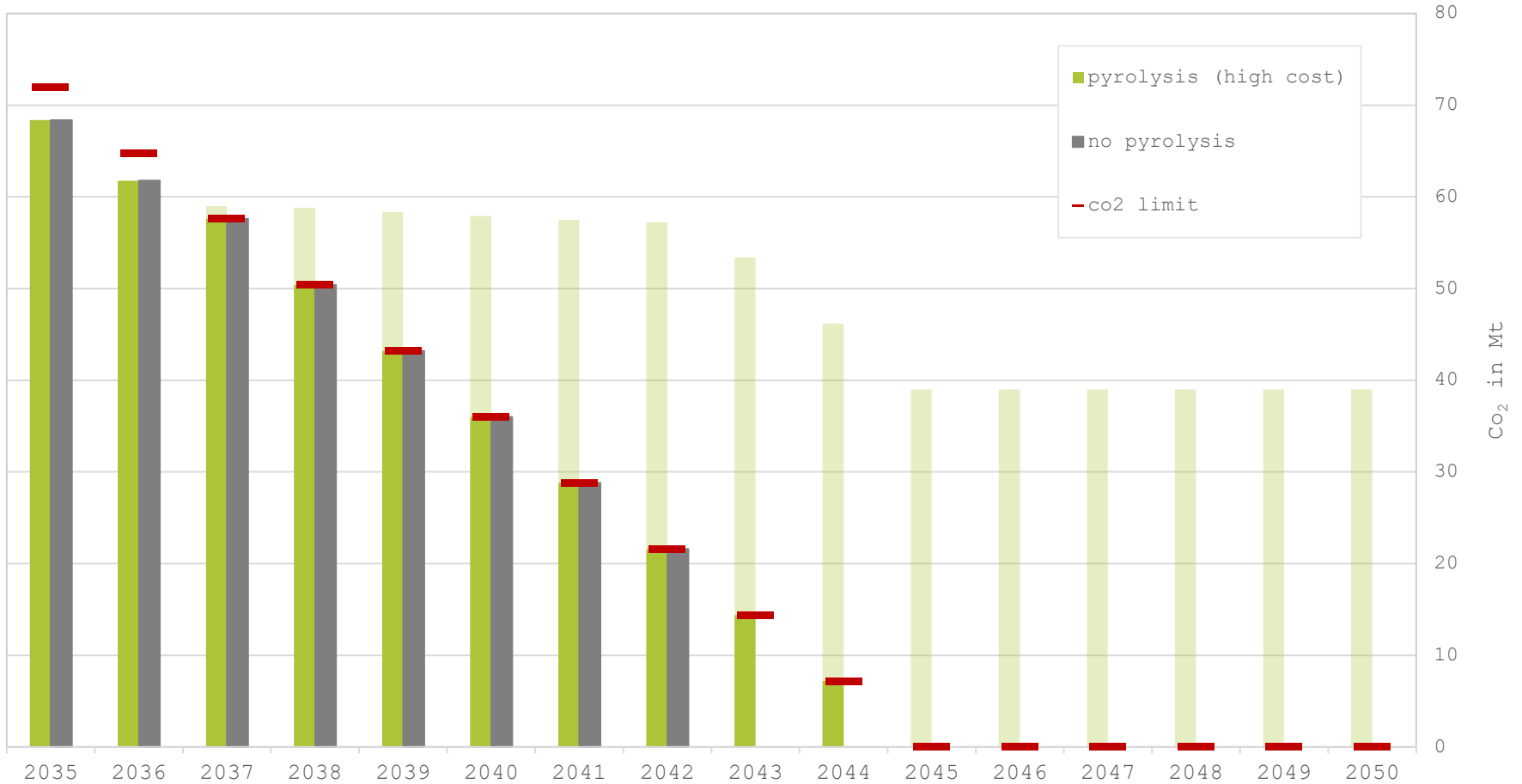
Net emission of CO₂



for your information

Results

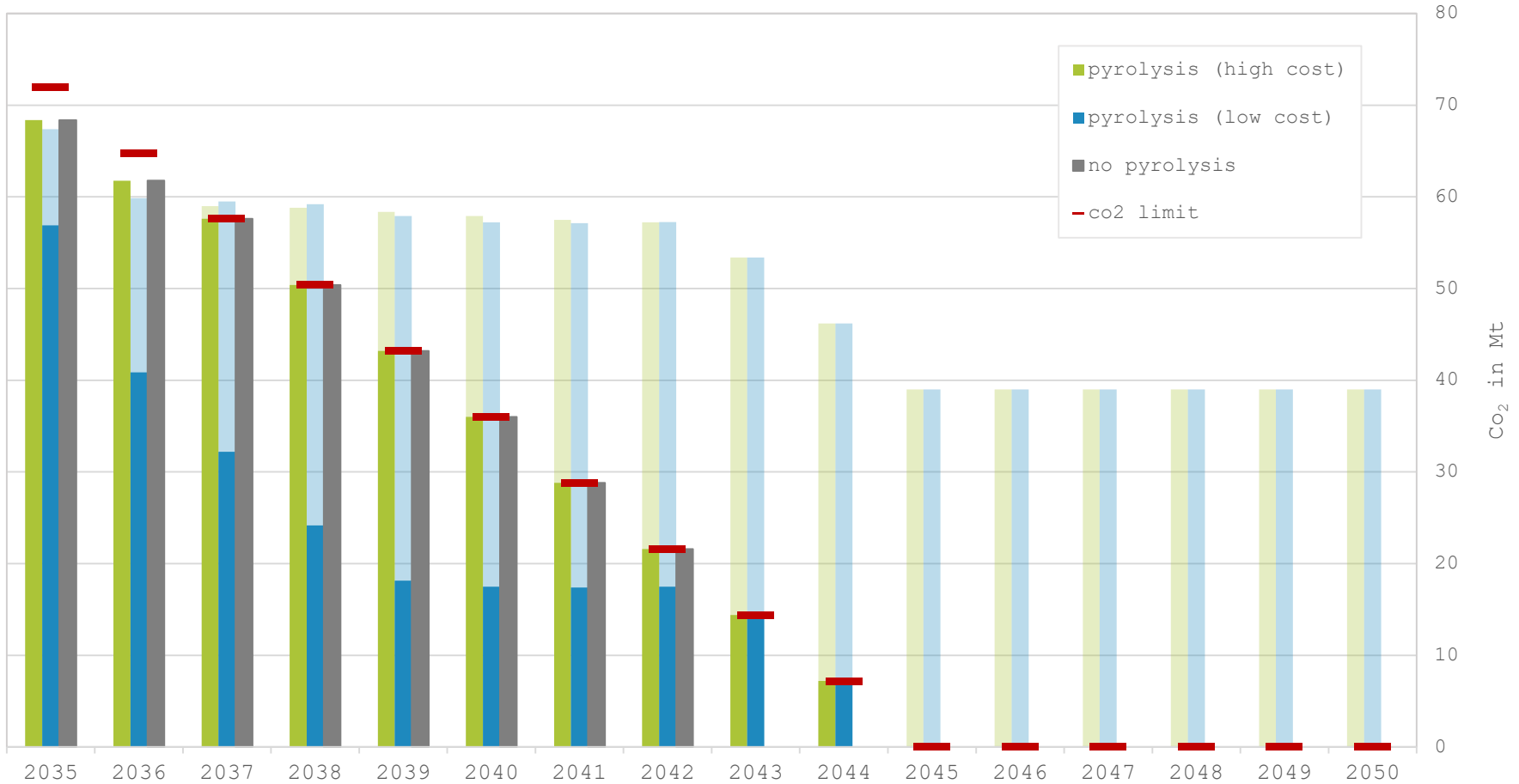
Net emission of CO₂



for your information

Results

Net emission of CO₂

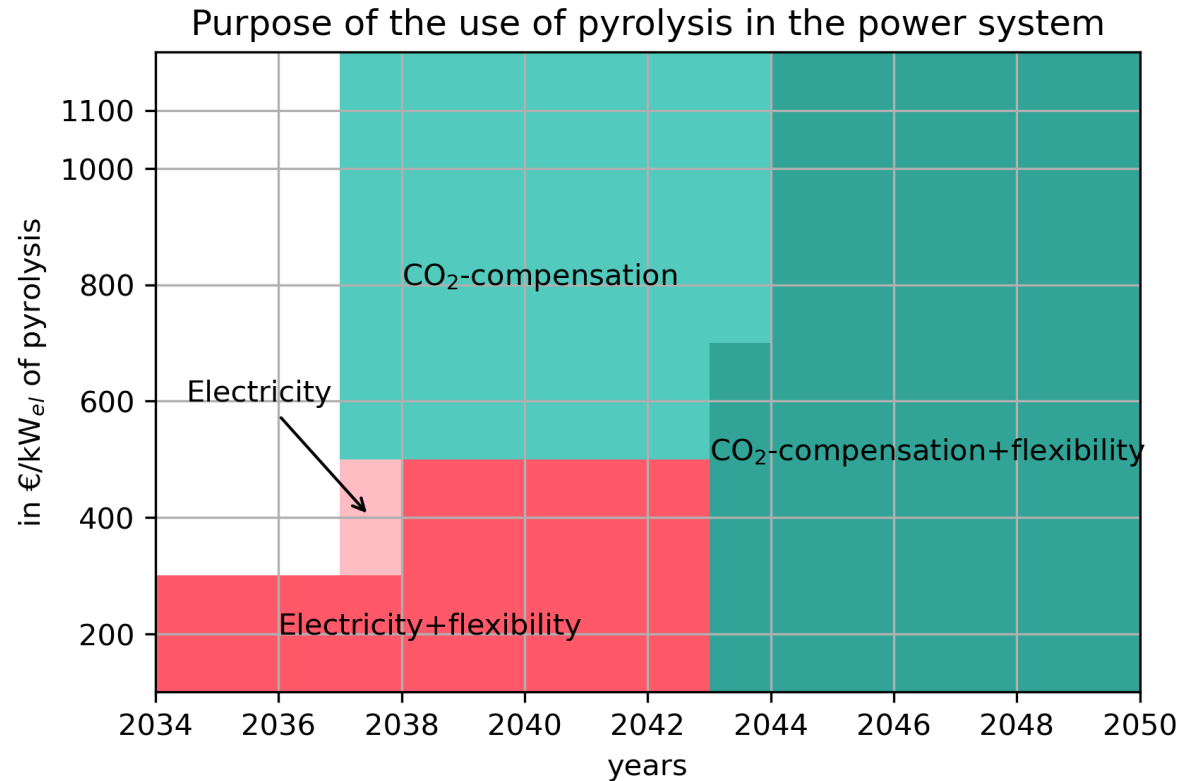


Results

The 4 applications of pyrolysis in the energy system

		Flexibility?	
		FLH = 8760 h → no	FLH < 8760 h → yes
CO ₂ compensation or electricity	CO ₂ emissions = limit	CO ₂ compensation	CO ₂ compensation + flexibility
	CO ₂ emissions < limit	Electricity	Electricity + flexibility

The applications of pyrolysis over time



Take aways

- Energy system is feasible with pyrolysis and without storages
- CO₂ neutrality can theoretically be achieved with the help of pyrolysis
- Pyrolysis takes on different applications in the system, depending on the boundary conditions and the cost of pyrolysis
 - Flexibility to cover residual load
 - CO₂ compensation, to reach the CO₂ emission goals
 - Electricity generation, when CAPEX are low

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Bundesministerium
für Wirtschaft
und Klimaschutz

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Thank you for your attention!



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