

# Mitigation of Climate Change:

## *Key Insights from the AR5 and Challenges in Future Research*

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Gothenburg, Sweden

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IPCC reports are the result of extensive work of many scientists from around the world.

1 Summary for Policymakers

1 Technical Summary

16 Chapters

235 Authors

900 Reviewers

More than 2000 pages

Close to 10,000 references

More than 38,000 comments

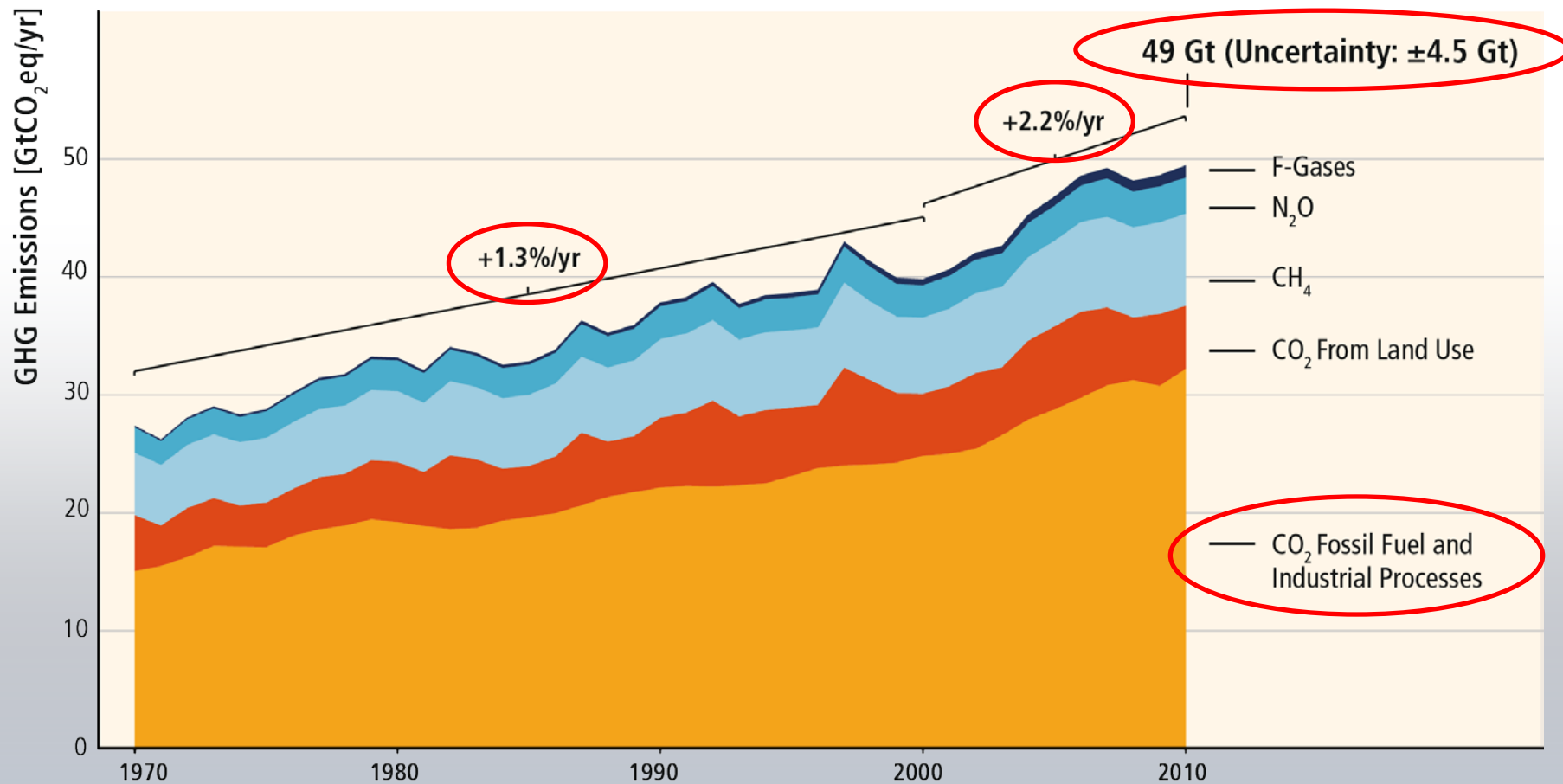




A yellow bulldozer is shown from a high angle, pushing a large pile of dark, granular material, likely coal or ore, in an industrial or mining environment. The bulldozer is positioned in the upper right quadrant of the frame. The material being pushed is piled up on the left side. The background shows more of the same material and some structural elements of the facility. The overall scene is dimly lit, with a blueish tint.

**GHG emissions growth has accelerated  
despite reduction efforts.**

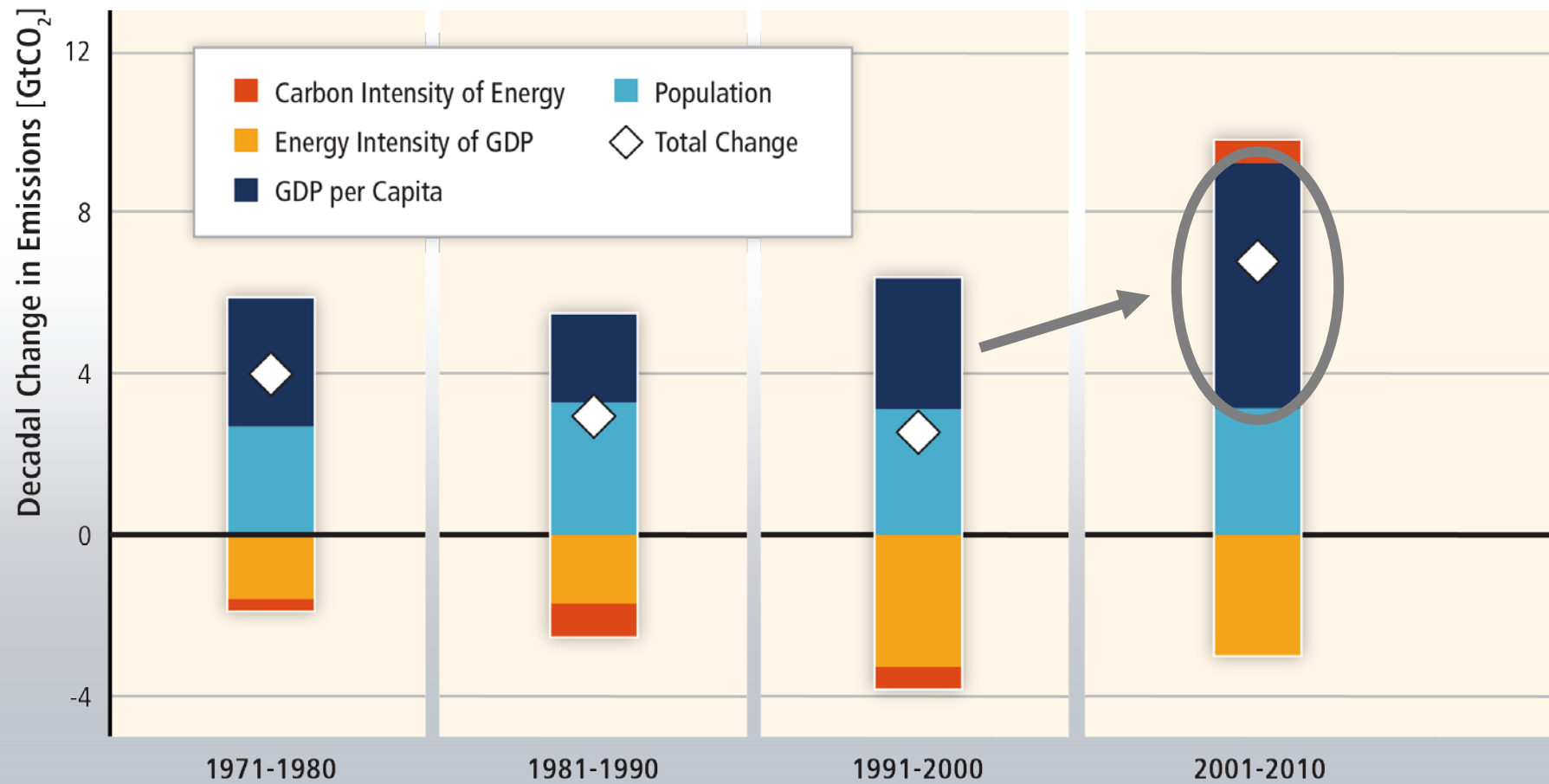
# GHG emissions growth between 2000 and 2010 has been larger than in the previous three decades.



Based on Figure 1.3

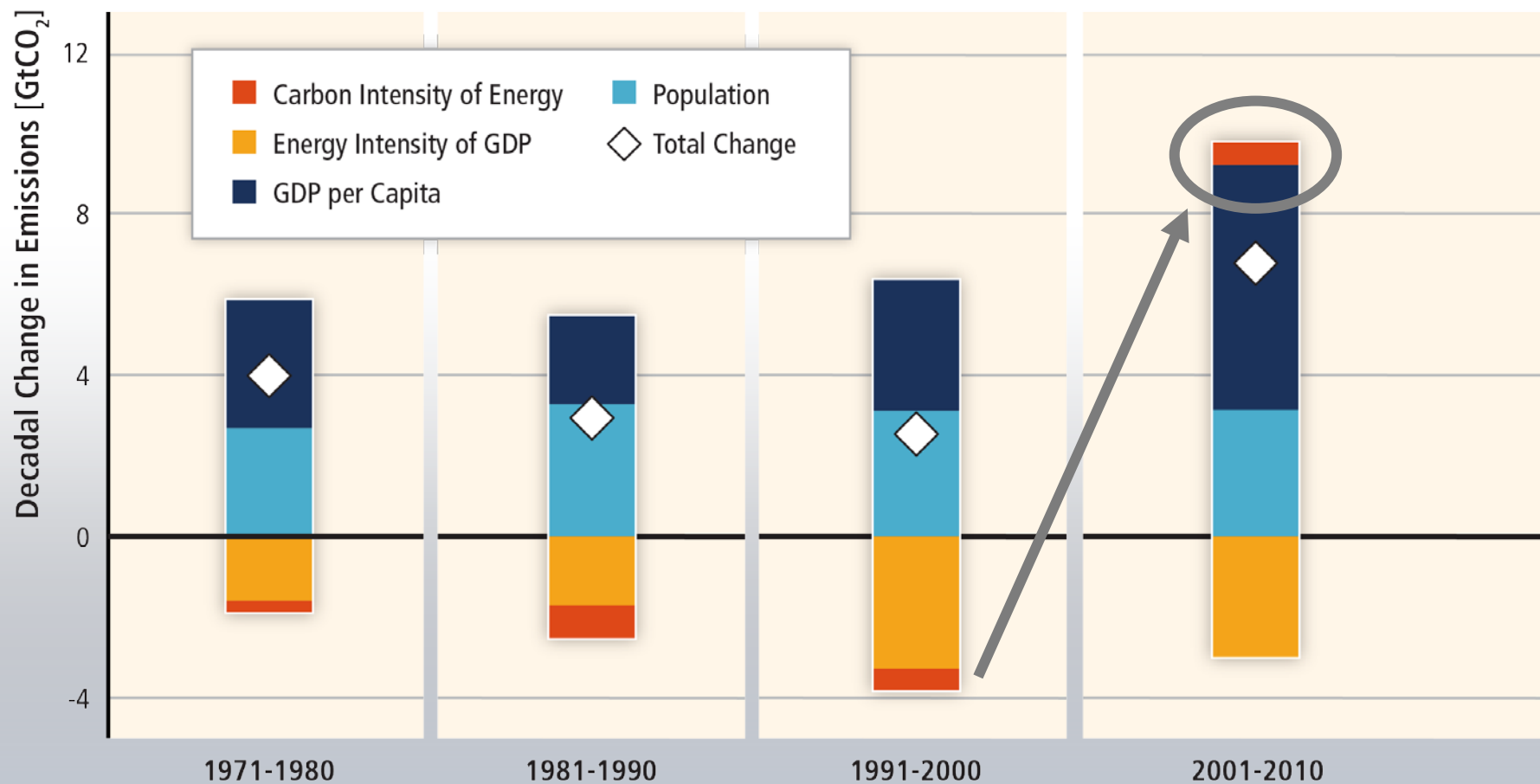


# GHG emissions rise with growth in GDP and population; long-standing trend of decarbonisation of energy reversed.



Based on Figure 1.7

# GHG emissions rise with growth in GDP and population; long-standing trend of decarbonisation of energy reversed.

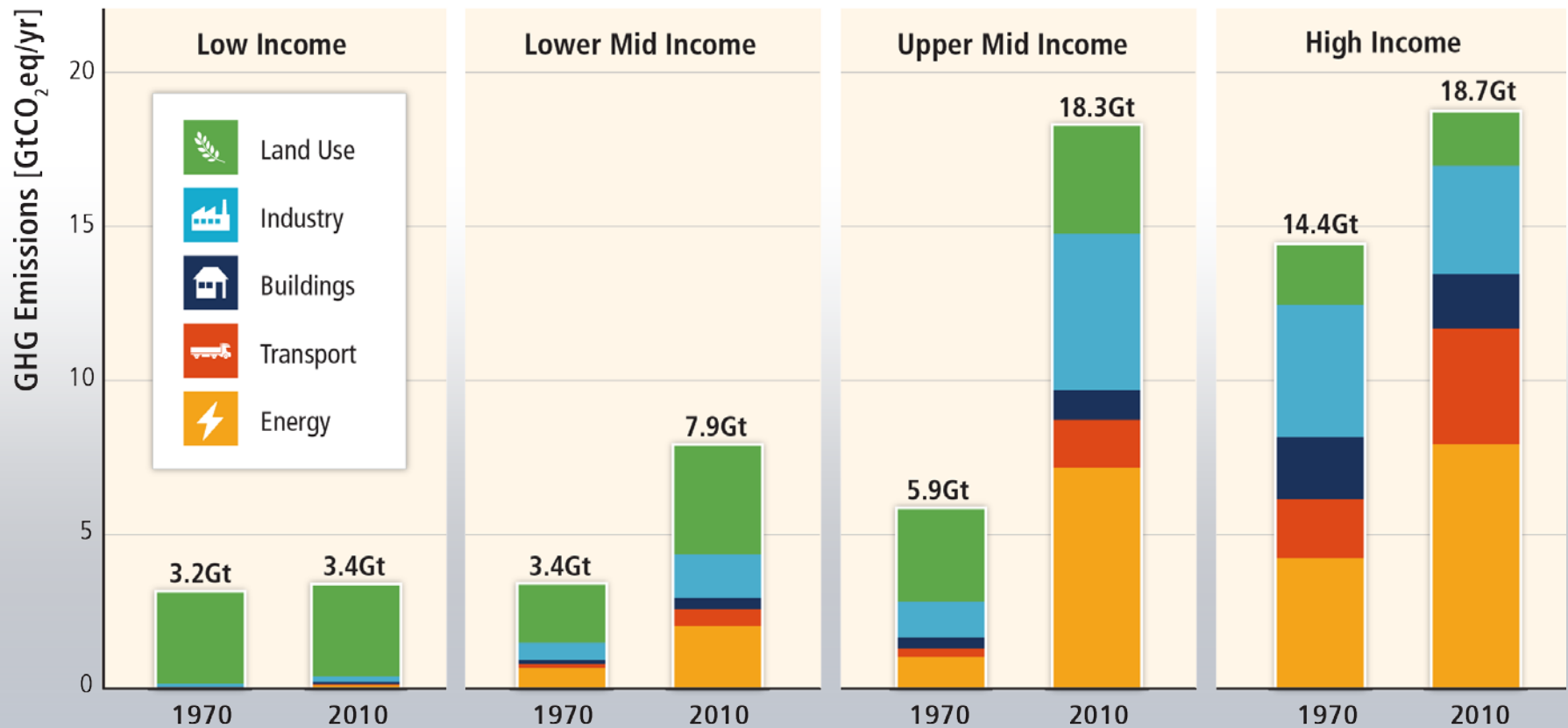


Based on Figure 1.7



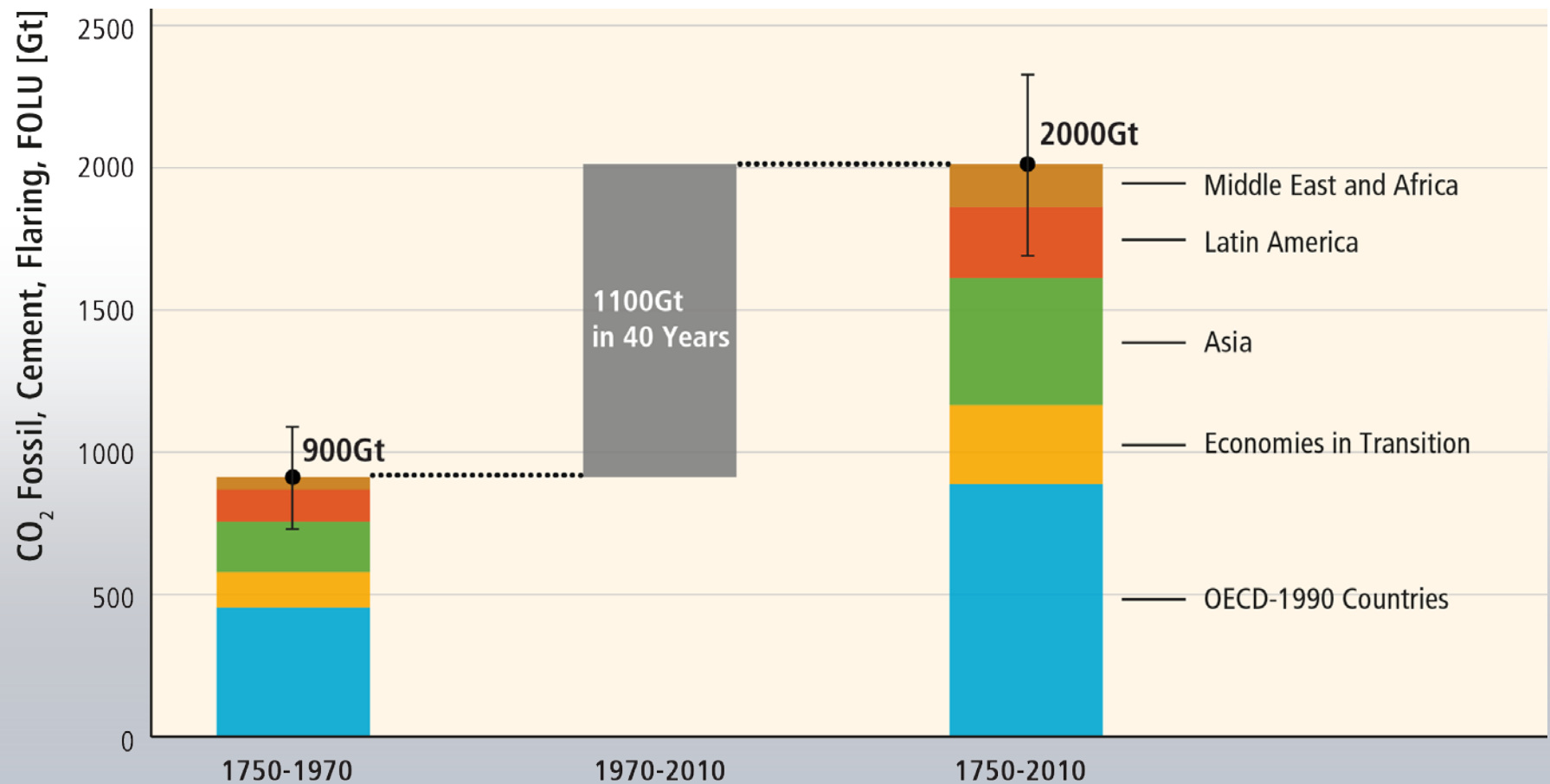
# Regional patterns of GHG emissions are shifting along with changes in the world economy.

GHG Emissions by Country Group and Economic Sector



Based on Figure 1.6

About half of cumulative anthropogenic CO<sub>2</sub> emissions between 1750 and 2010 have occurred in the last 40 years.



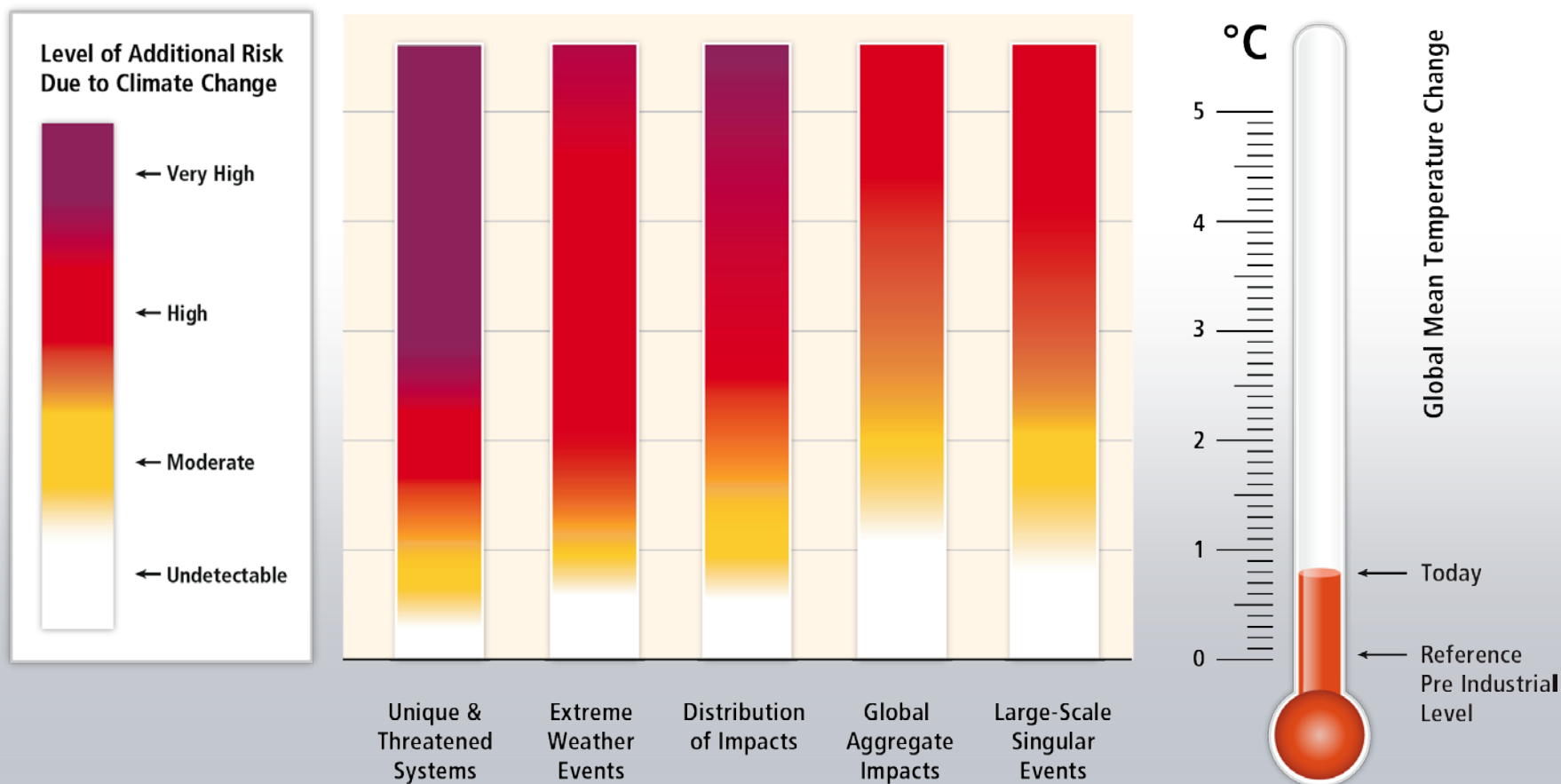
Based on Figure 5.3



**Limiting warming to 2 C involves substantial technological, economic and institutional challenges.**



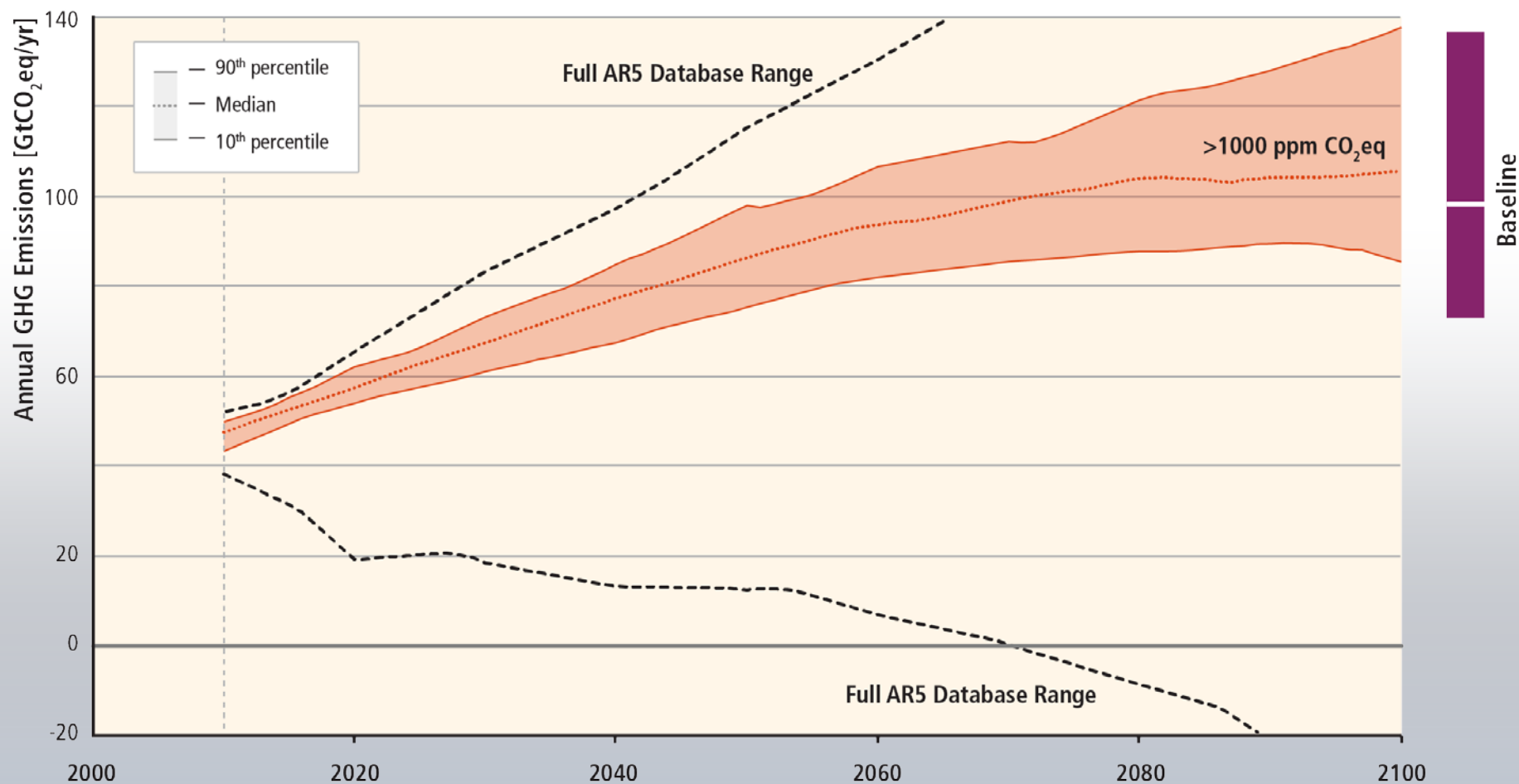
Without additional mitigation, global mean surface temperature is projected to increase by 3.7 to 4.8°C over the 21<sup>st</sup> century.



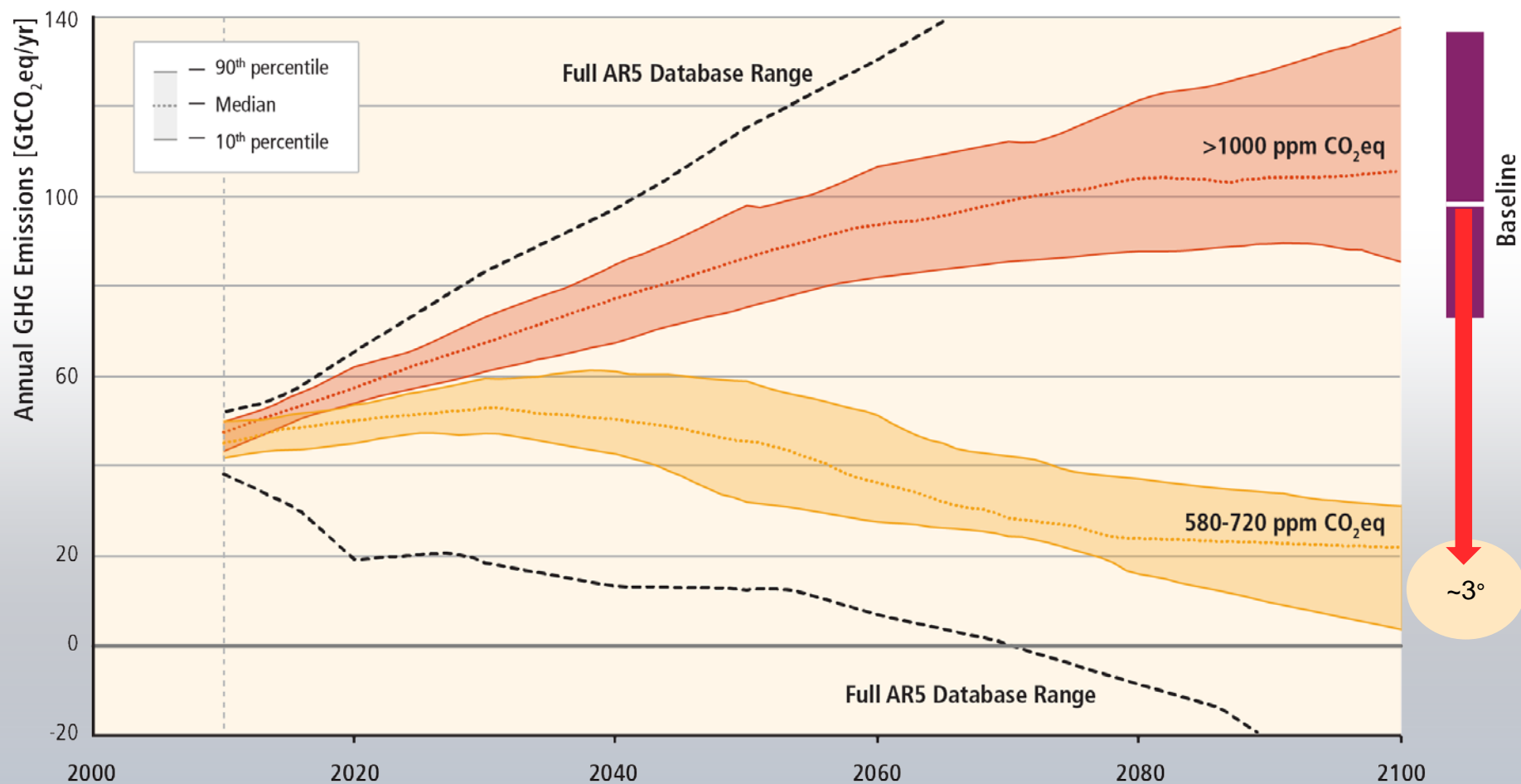
Based on WGII AR5 Figure 19.4



# Stabilization of atmospheric GHG concentrations requires moving away from the baseline, regardless of the mitigation goal.

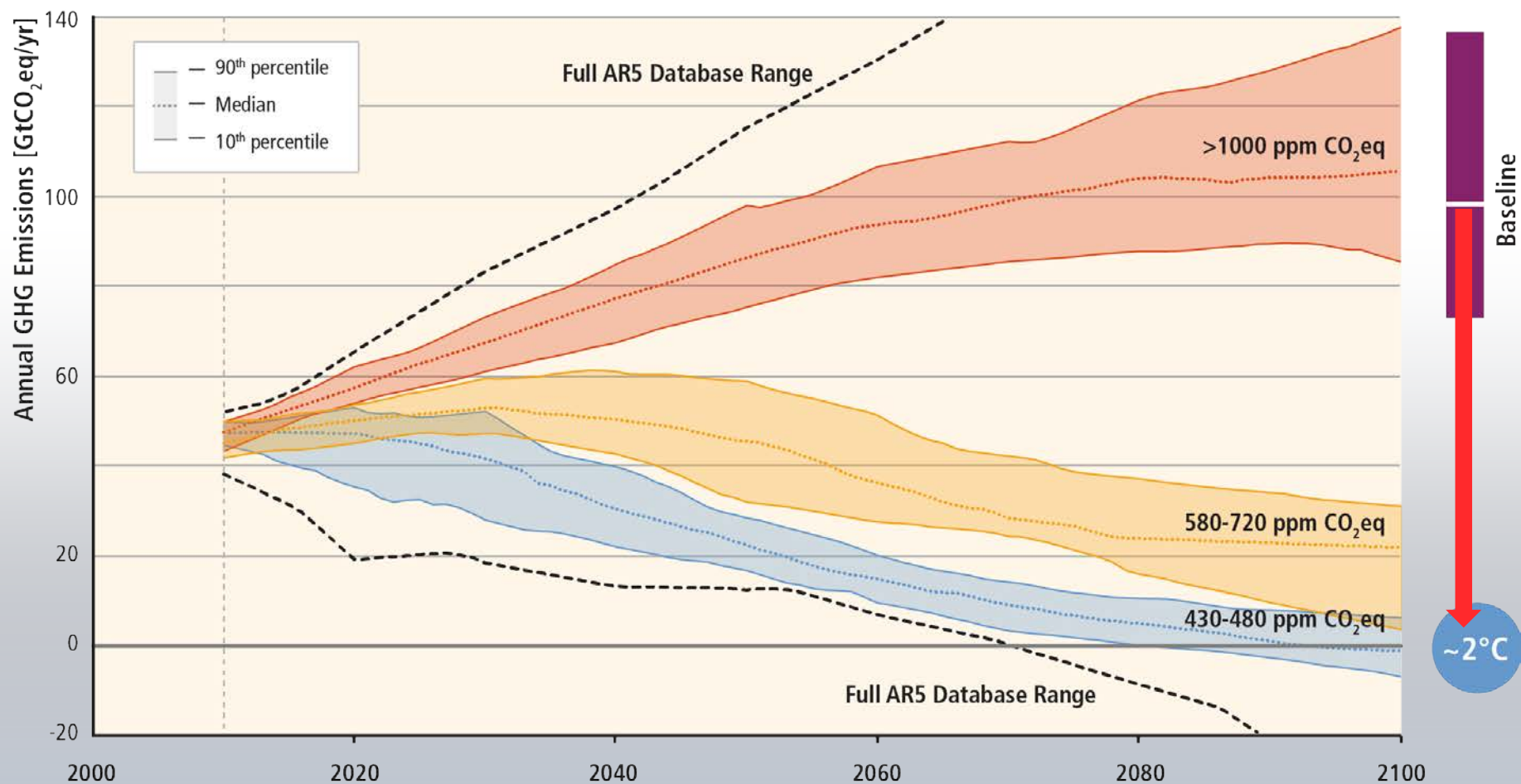


# Stabilization of atmospheric GHG concentrations requires moving away from the baseline, regardless of the mitigation goal.





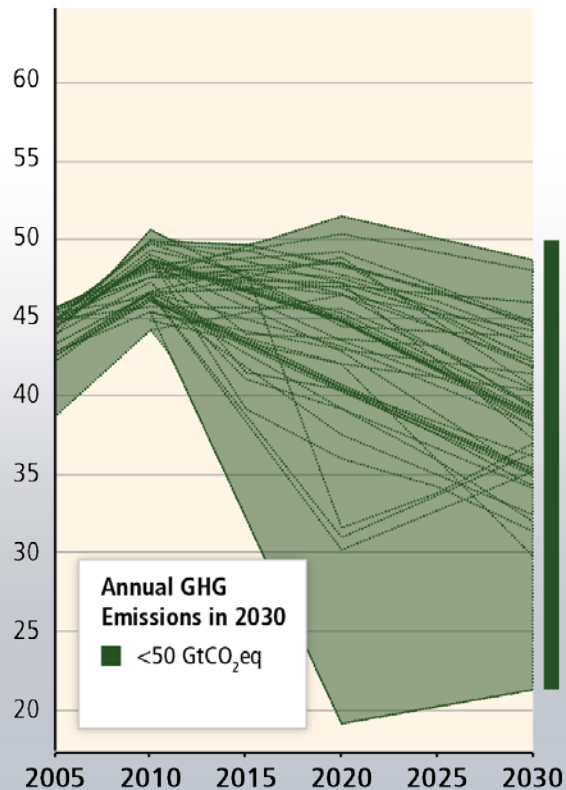
# Stabilization of atmospheric GHG concentrations requires moving away from the baseline, regardless of the mitigation goal.



# Delaying mitigation increases the difficulty and narrows the options for limiting warming to 2°C.

Before 2030

GHG Emissions Pathways [GtCO<sub>2</sub>eq/yr]

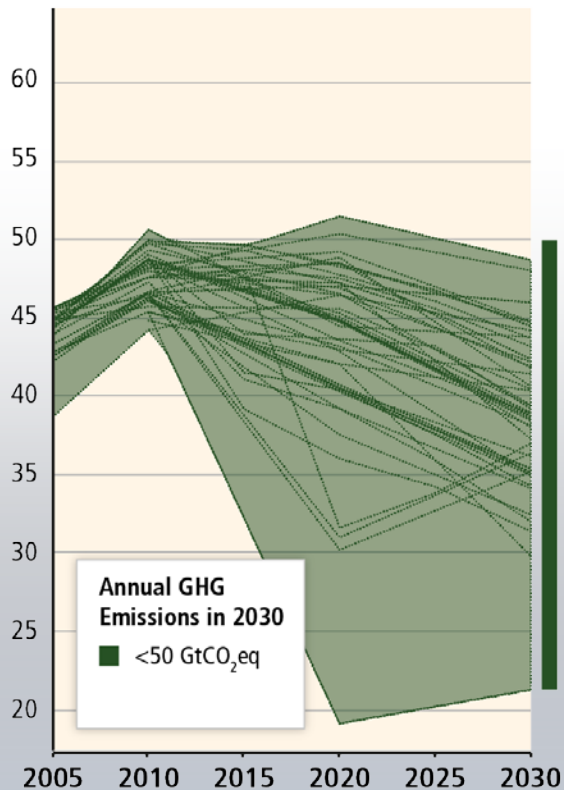


„immediate action“

# Delaying mitigation increases the difficulty and narrows the options for limiting warming to 2°C.

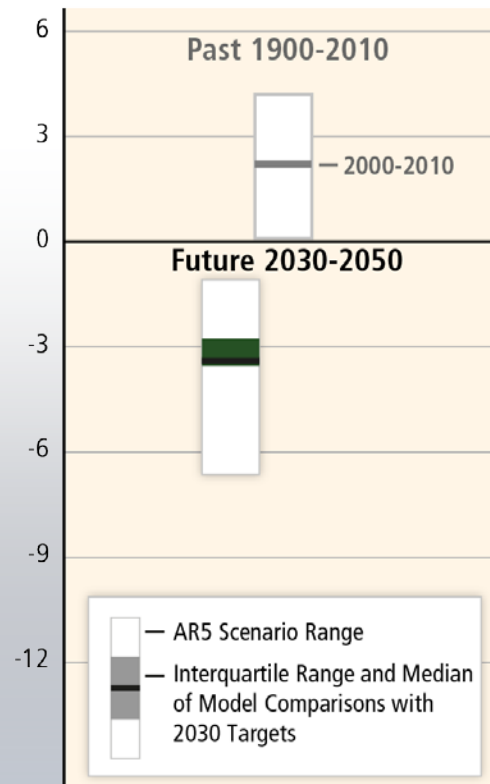
## Before 2030

GHG Emissions Pathways [GtCO<sub>2</sub>eq/yr]



## After 2030

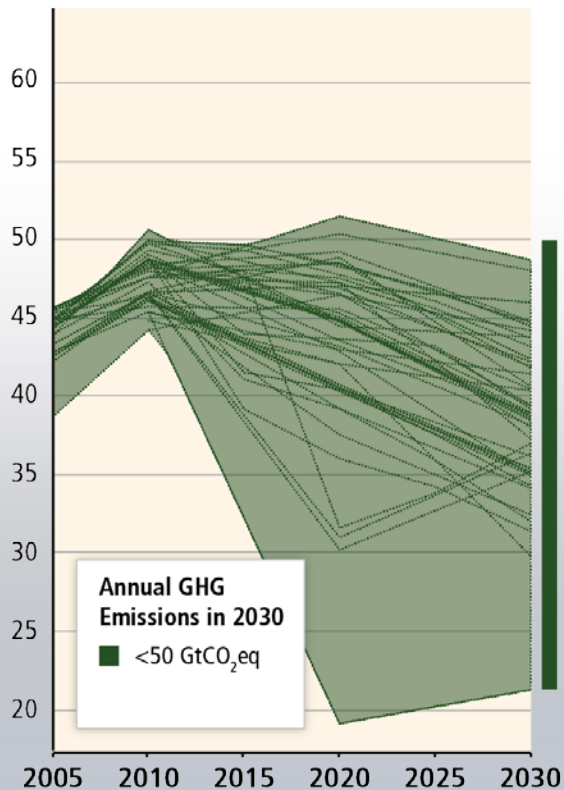
Rate of CO<sub>2</sub> Emission Change [%/yr]



# Delaying mitigation increases the difficulty and narrows the options for limiting warming to 2°C.

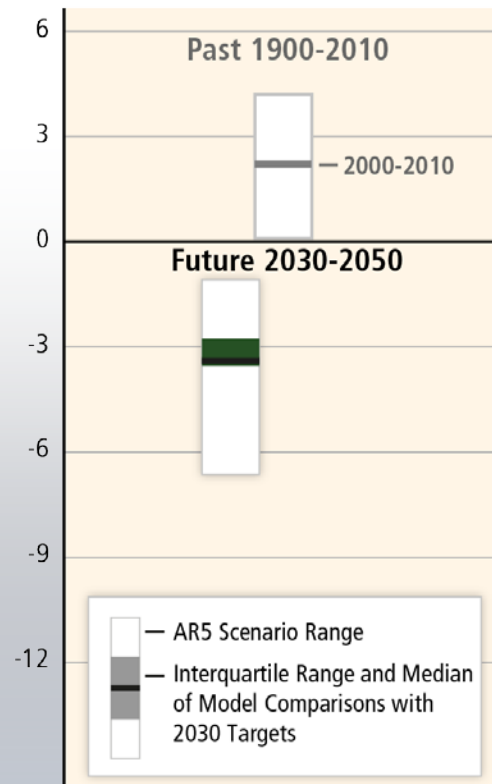
## Before 2030

GHG Emissions Pathways [GtCO<sub>2</sub>eq/yr]

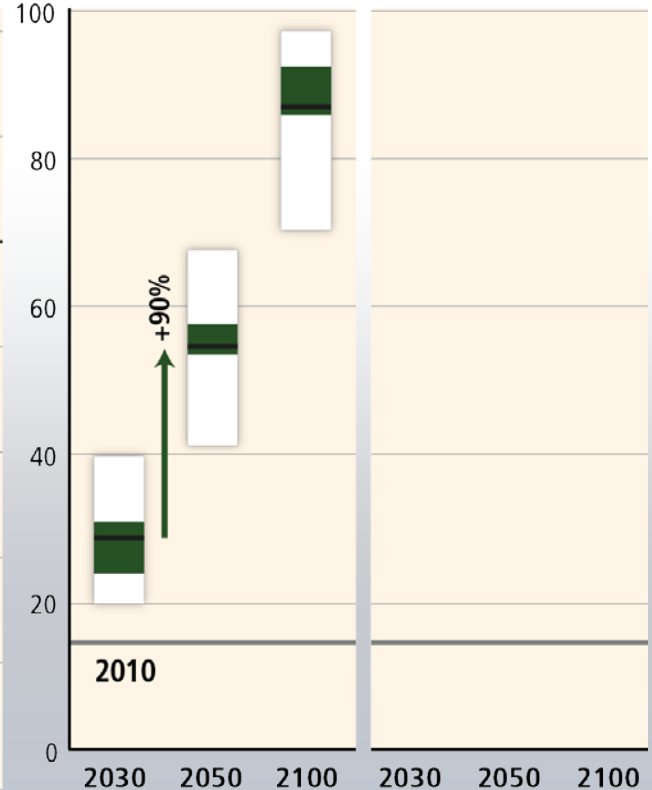


## After 2030

Rate of CO<sub>2</sub> Emission Change [%/yr]



Share of Low Carbon Energy [%]

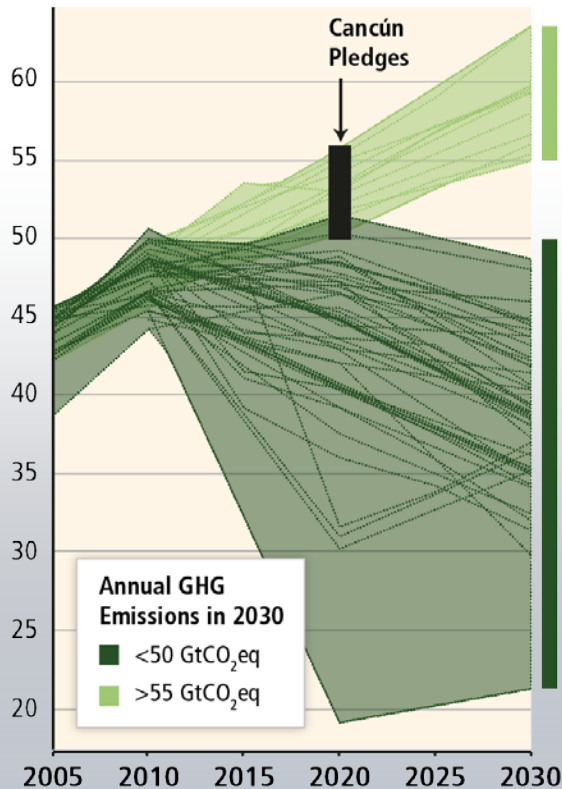




# Delaying mitigation is estimated to increase the difficulty and narrow the options for limiting warming to 2°C.

Before 2030

GHG Emissions Pathways [GtCO<sub>2</sub>eq/yr]



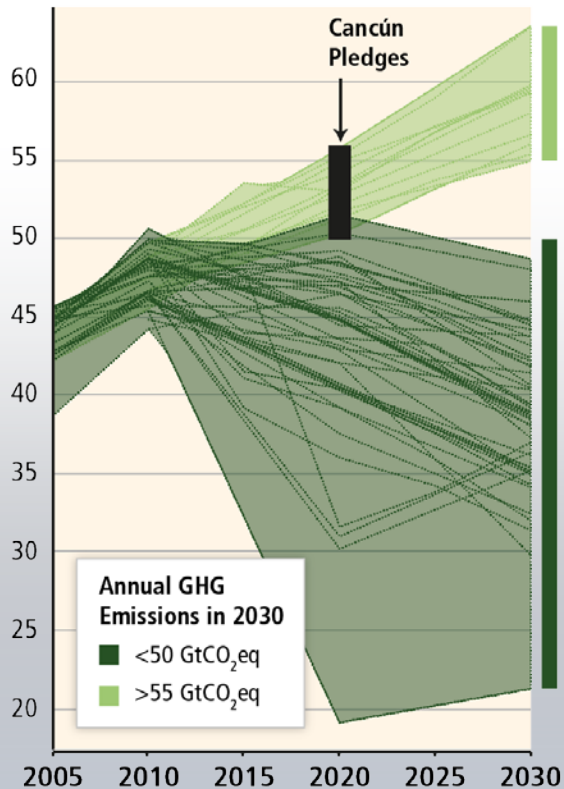
„delayed mitigation“

„immediate action“

# Delaying mitigation is estimated to increase the difficulty and narrow the options for limiting warming to 2°C.

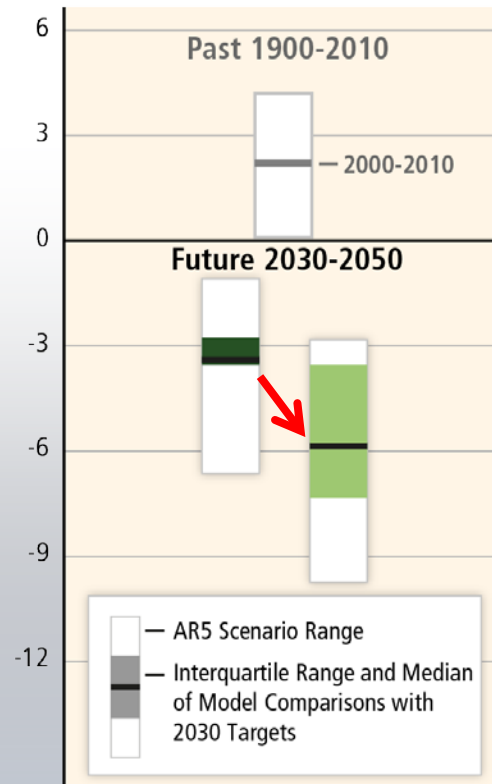
## Before 2030

GHG Emissions Pathways [GtCO<sub>2</sub>eq/yr]

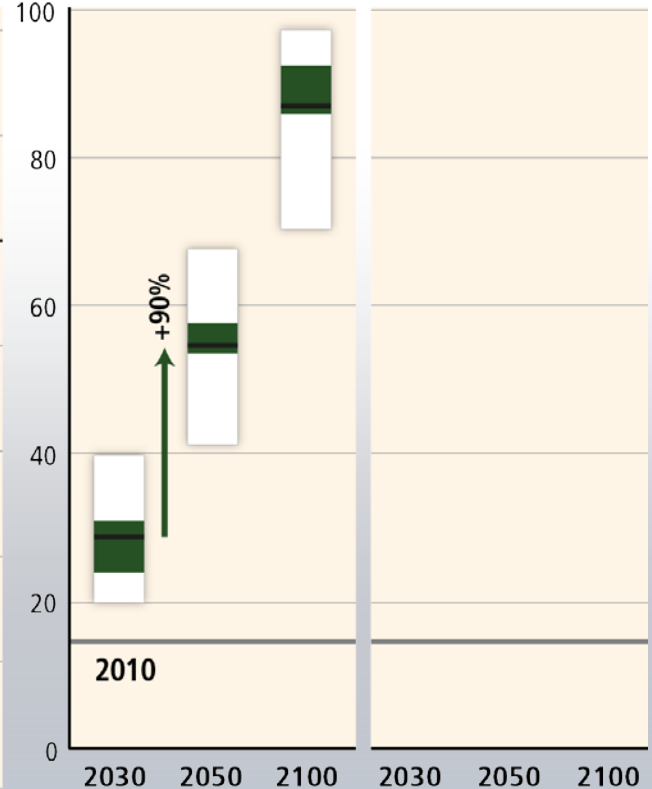


## After 2030

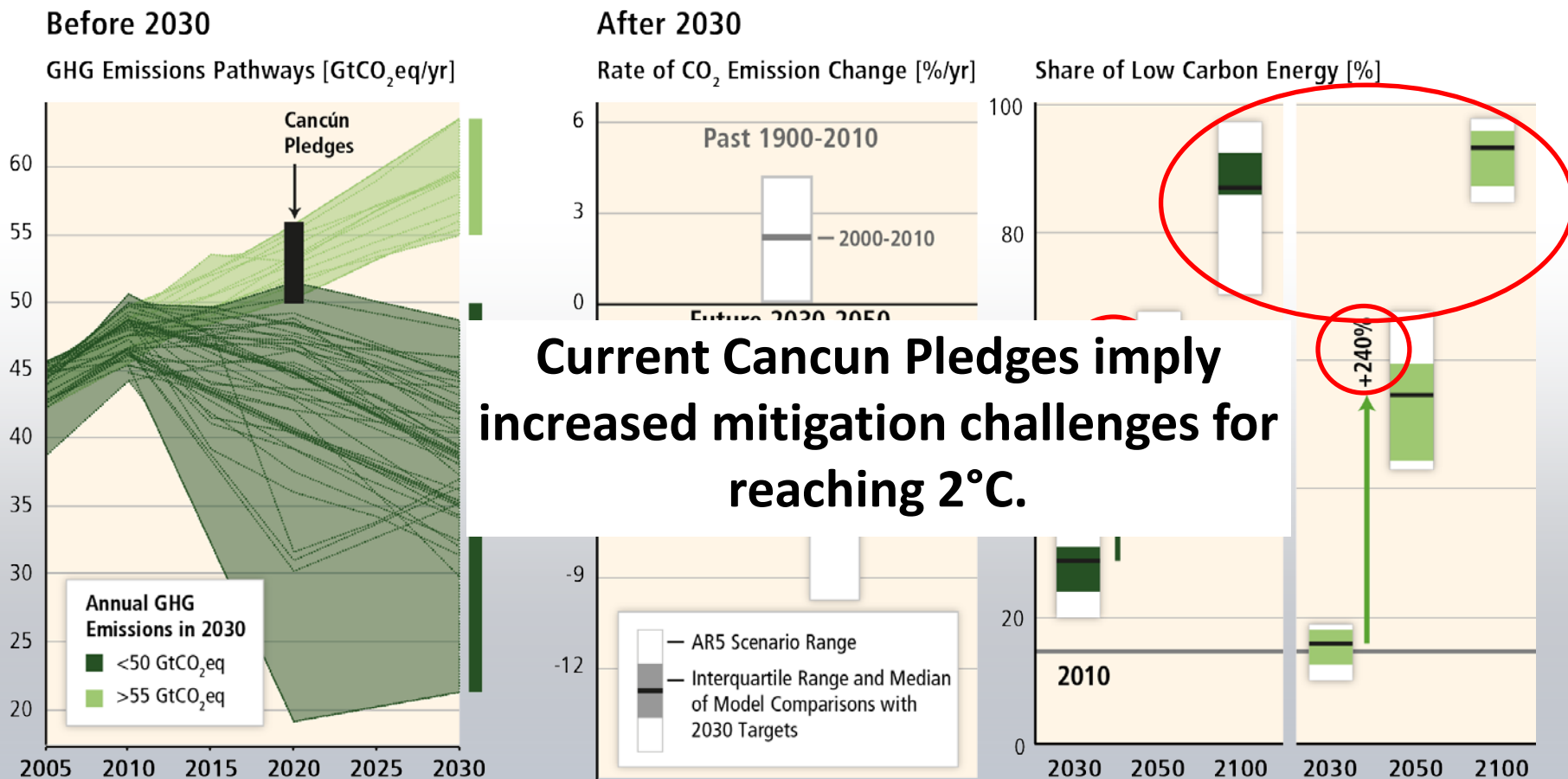
Rate of CO<sub>2</sub> Emission Change [%/yr]



Share of Low Carbon Energy [%]



# Delaying mitigation is estimated to increase the difficulty and narrow the options for limiting warming to 2°C.



Based on Figures 6.32 and 7.16

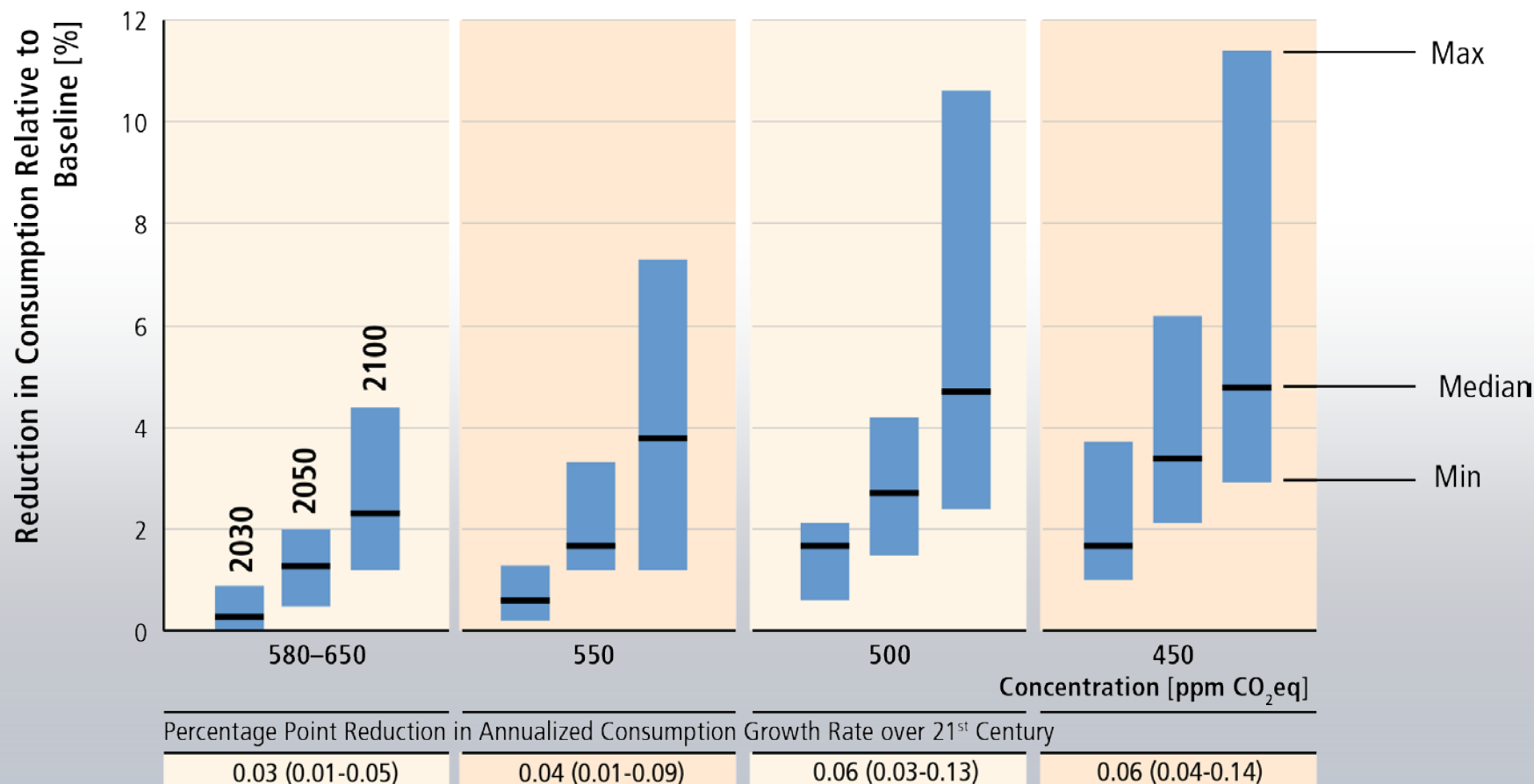




**Mitigation cost estimates vary, but do not strongly affect global GDP growth.**

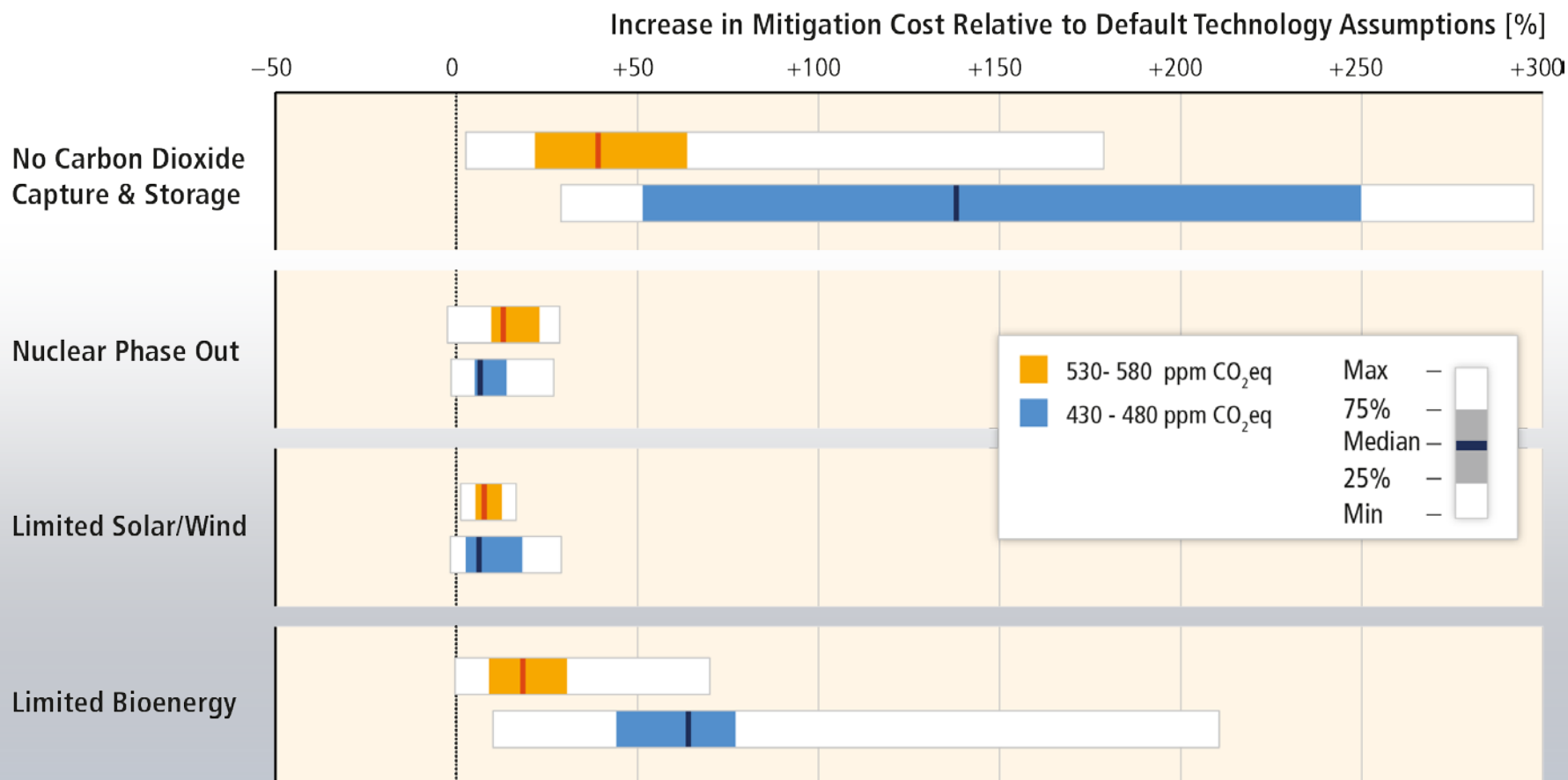


# Global costs rise with the ambition of the mitigation goal.



Based on Table SPM.2

# Availability of technology can greatly influence mitigation costs.



Based on Figure 6.24

An aerial, high-angle photograph of a complex industrial facility, likely a refinery or chemical plant. The image is dominated by a dense network of silver-colored metal pipes, valves, and structural steel frameworks. In the center-left, a worker wearing a bright yellow protective suit and a white hard hat is walking on a metal walkway. To the right, a large, horizontal, cylindrical storage tank is visible. The overall scene is industrial and intricate, with various mechanical components and piping creating a complex geometric pattern. The lighting is somewhat dim, and the image has a slightly desaturated, blue-tinted appearance.

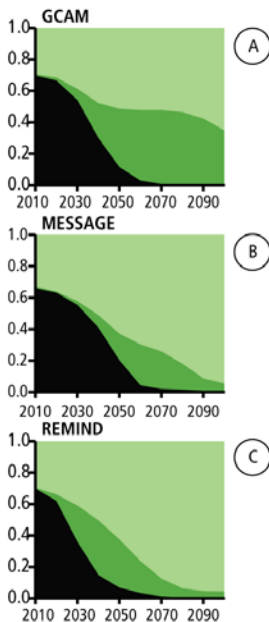
**Low stabilization scenarios are dependent upon a full decarbonization of energy supply in the long term.**



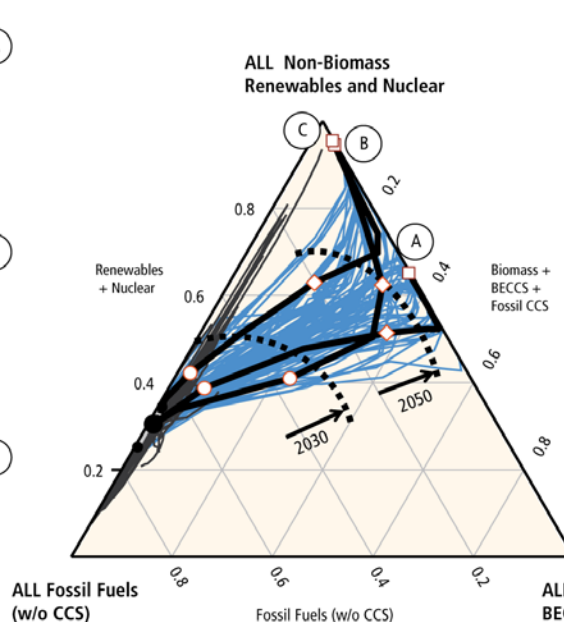
# In low CO<sub>2</sub> concentration stabilization scenarios, fossil fuel use without CCS is phased out in the long-term.

## b) Electricity Generation

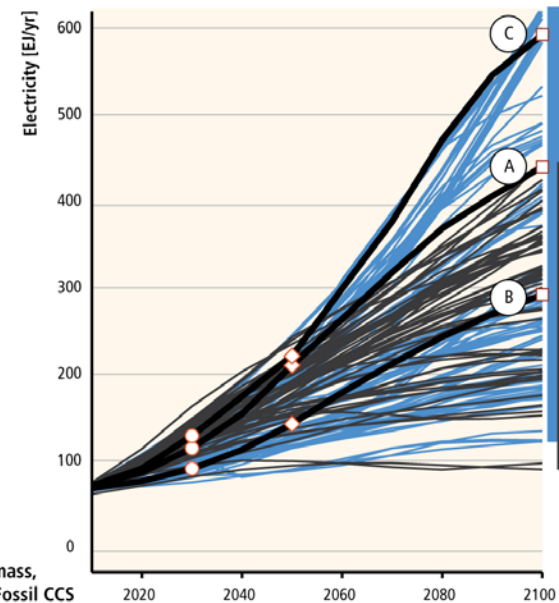
Electricity Shares  
(Three Illustrative Scenarios)



Electricity Shares  
(AR5 Scenarios)



Total Electricity Supply  
(AR5 Scenarios)



Renewables and Nuclear  
Biomass + BECCS + Fossil CCS  
Fossil Fuels (w/o CCS)

430-530 ppm CO<sub>2</sub>eq (AR5 Scenarios)  
Baselines (AR5 Scenarios)

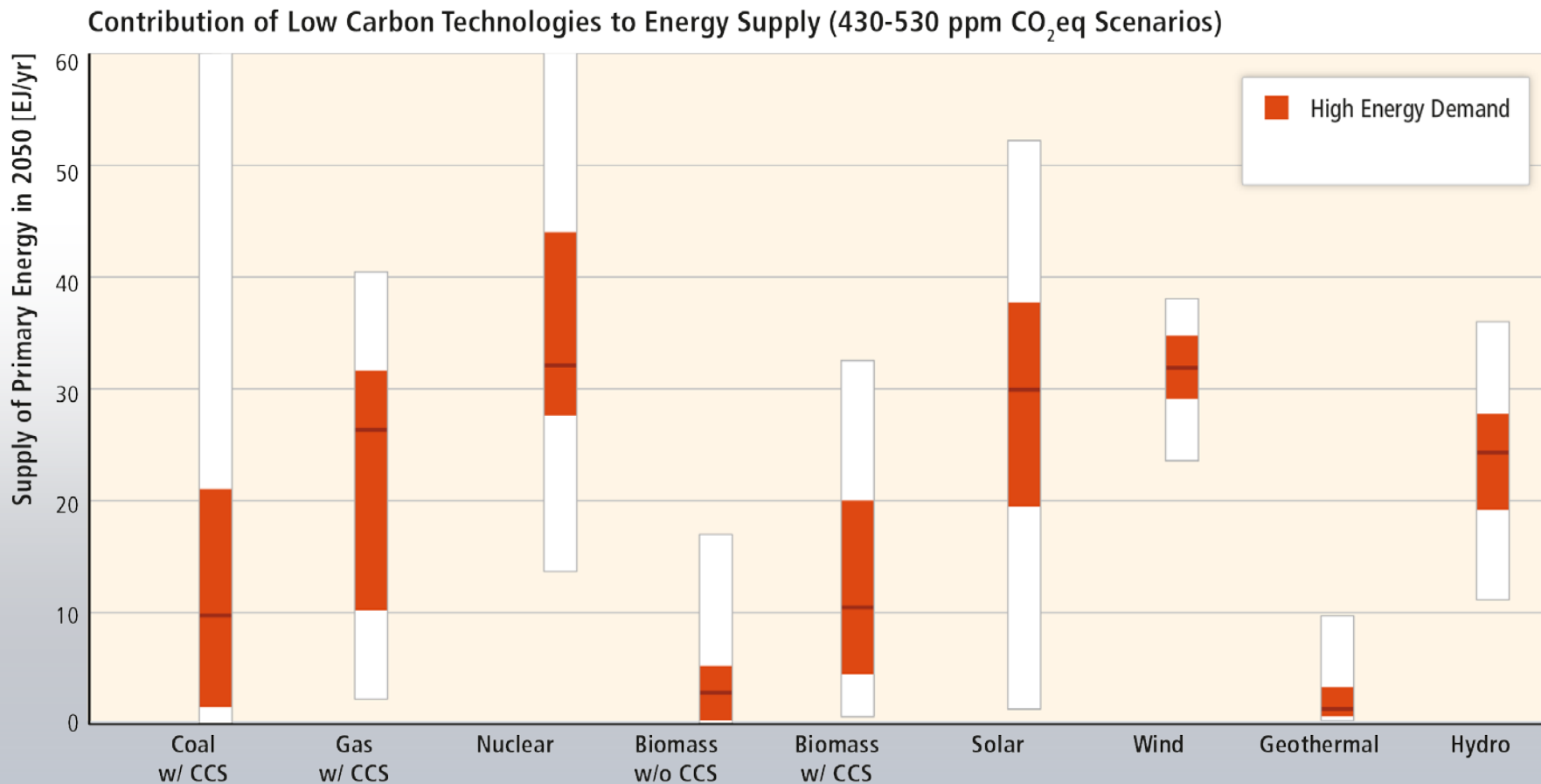
Three Illustrative Scenarios



Based on Figure 7.15b

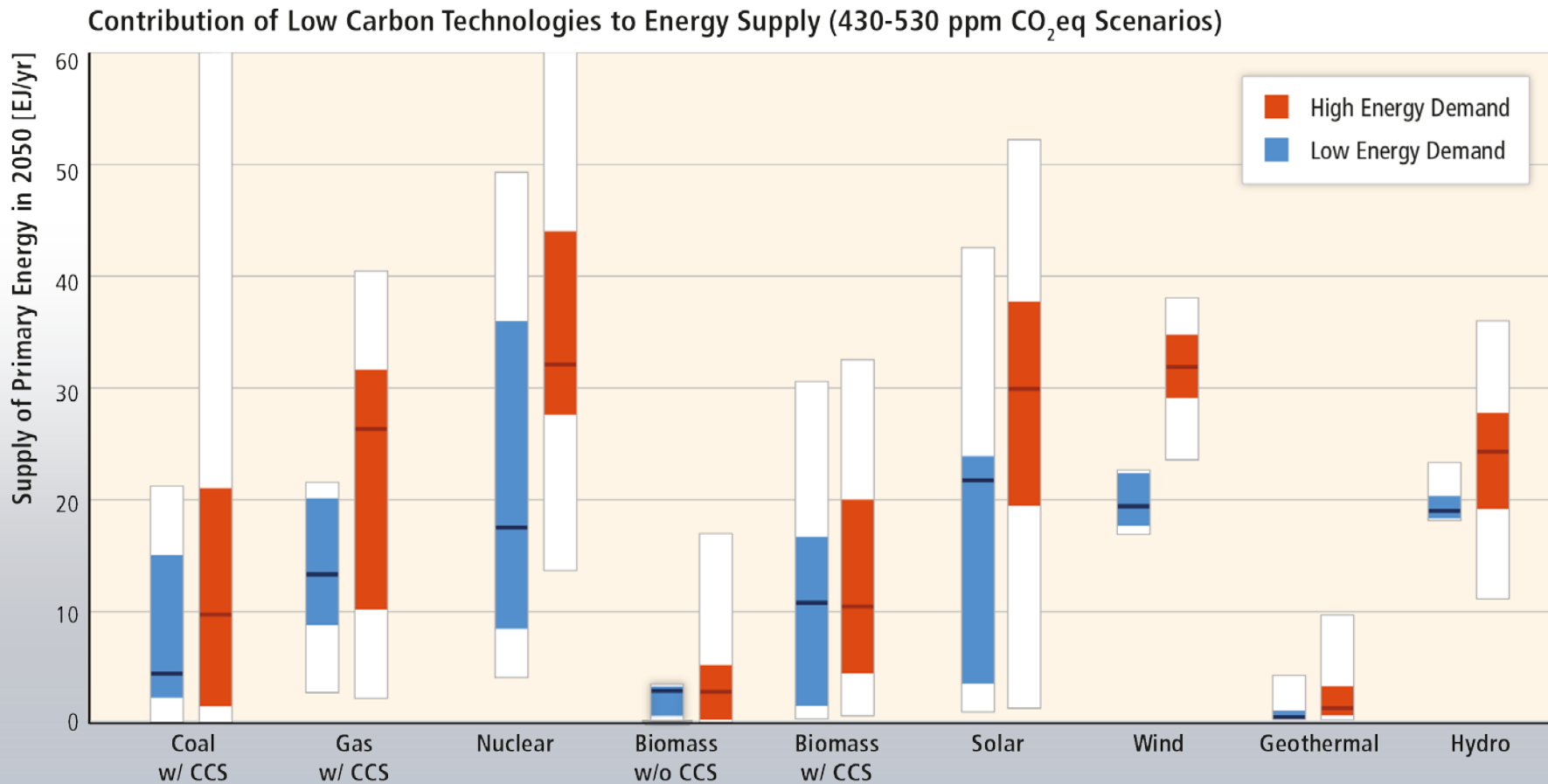


# Decarbonization of energy supply is a key requirement for limiting warming to 2°C.



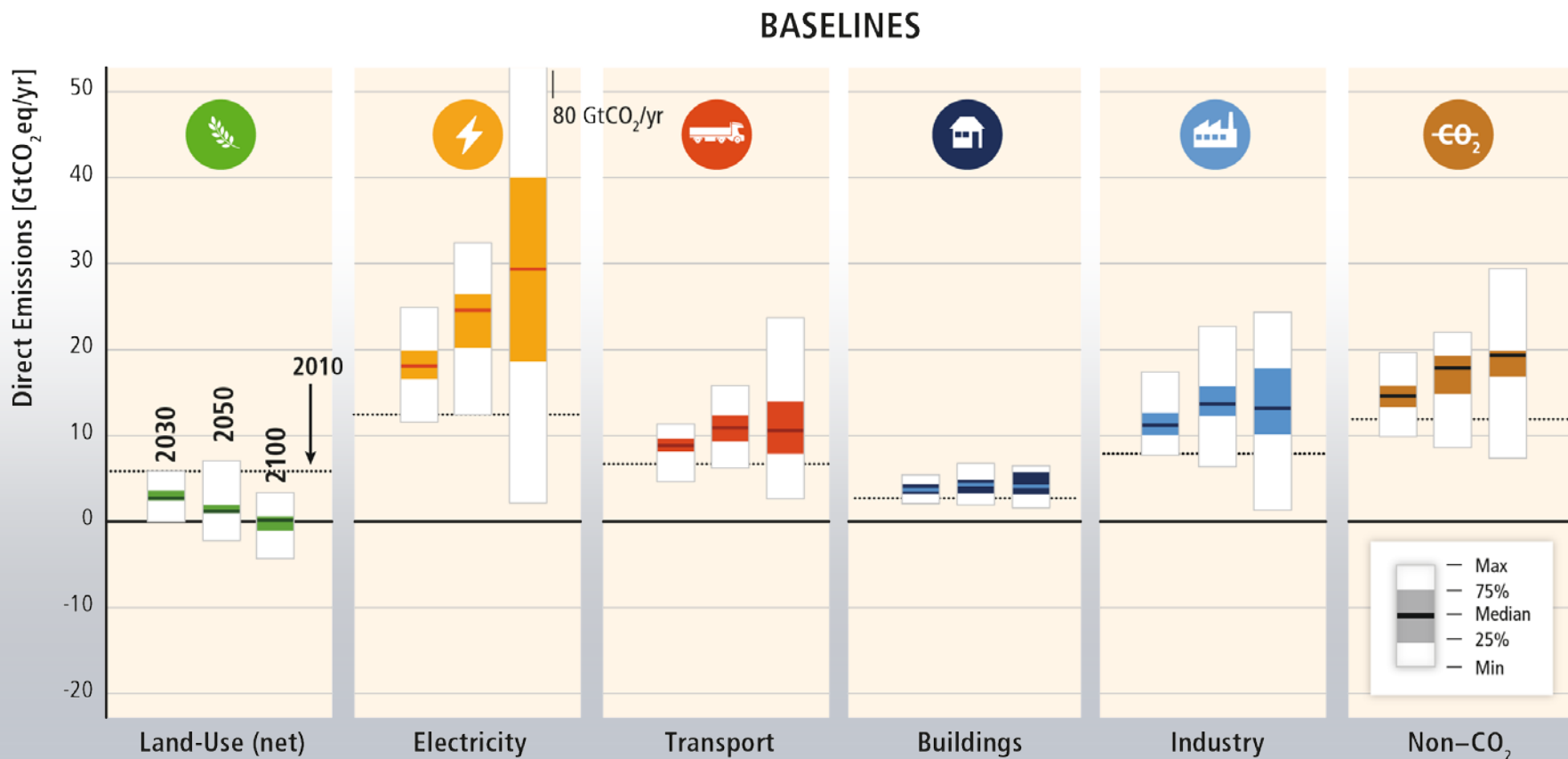
Based on Figure 7.11

# Energy demand reductions can provide flexibility, hedge against risks, avoid lock-in and provide co-benefits.



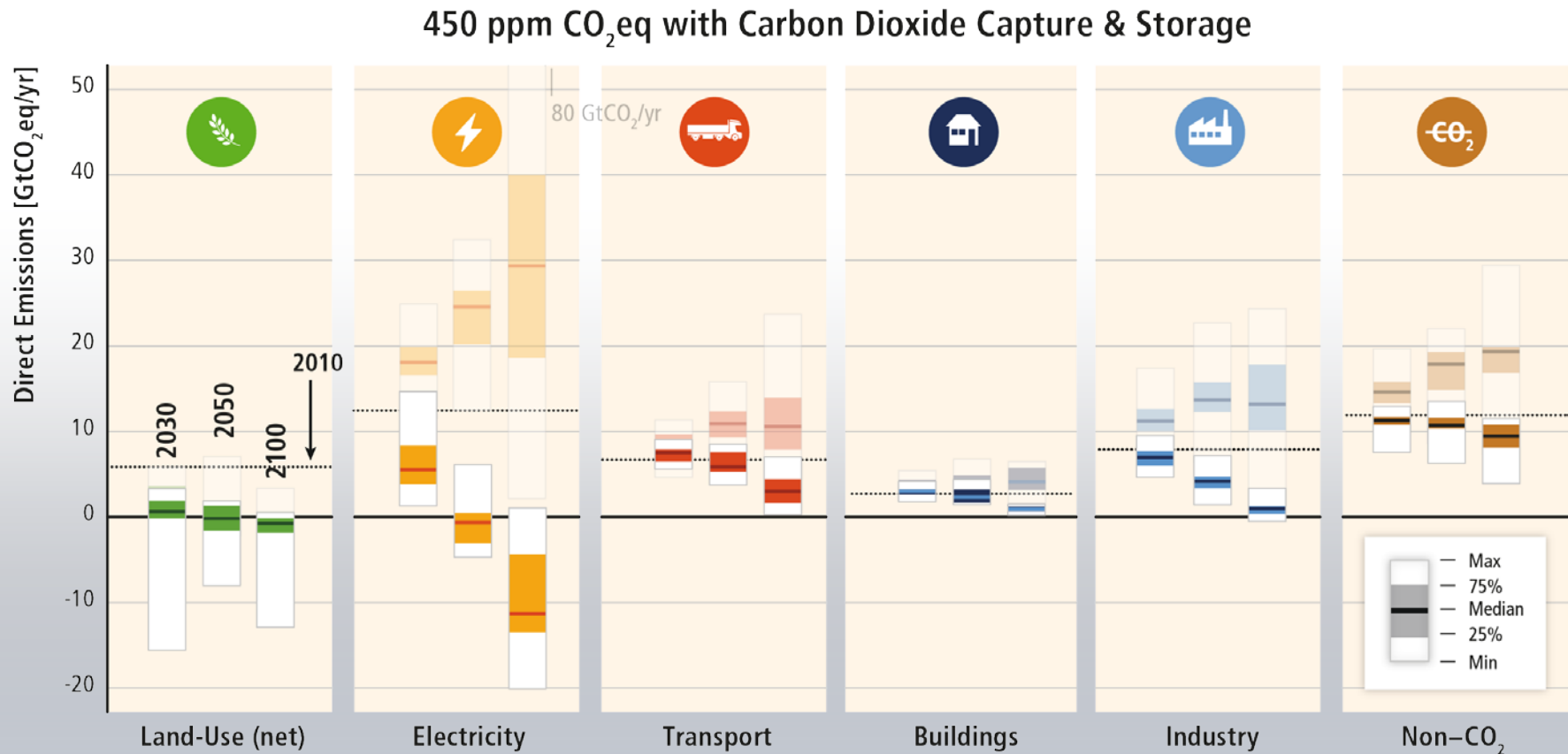
Based on Figure 7.11

# Baseline scenarios suggest rising GHG emissions in all sectors, except for CO<sub>2</sub> emissions in the land-use sector.



Based on Figure TS.17

# Mitigation requires changes throughout the economy. Systemic approaches are expected to be most effective.

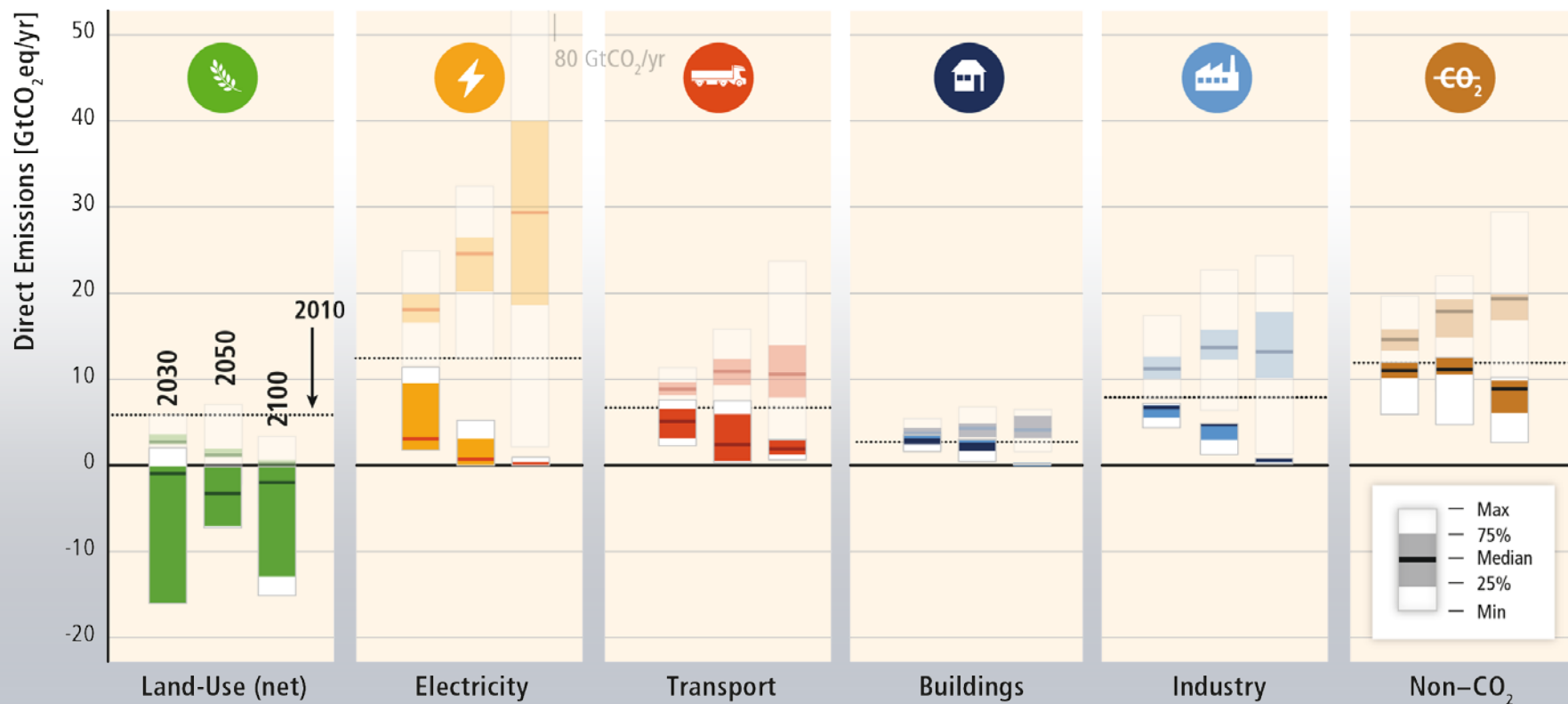


Based on Figure TS.17



# Mitigation efforts in one sector determine efforts in others.

## 450 ppm CO<sub>2</sub>eq without Carbon Dioxide Capture & Storage

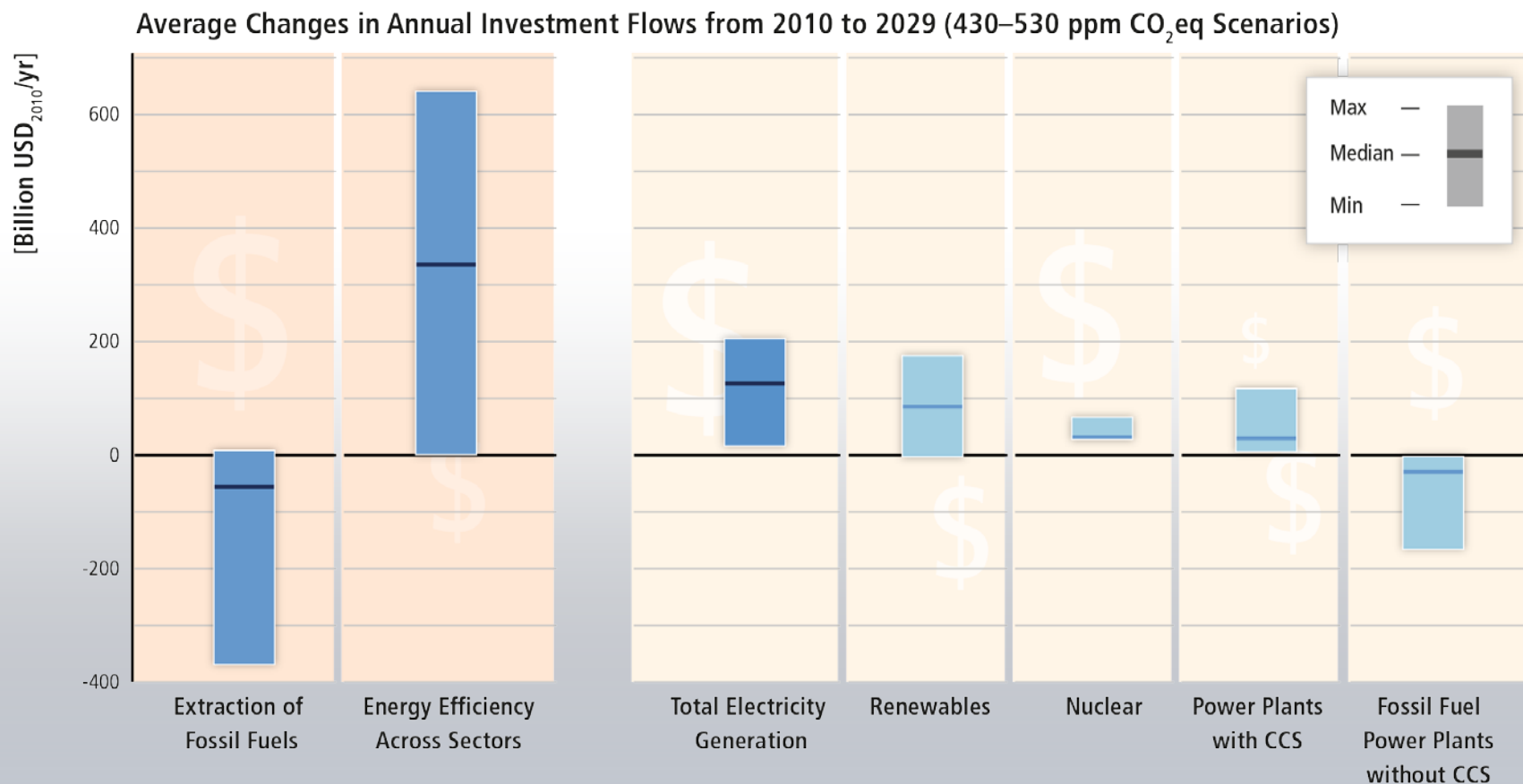


Based on Figure TS.17

A wooden gavel is the central focus, resting on a matching wooden block. The background is softly blurred, showing a stack of books and some papers on a desk. The entire image has a cool, blue-toned overlay.

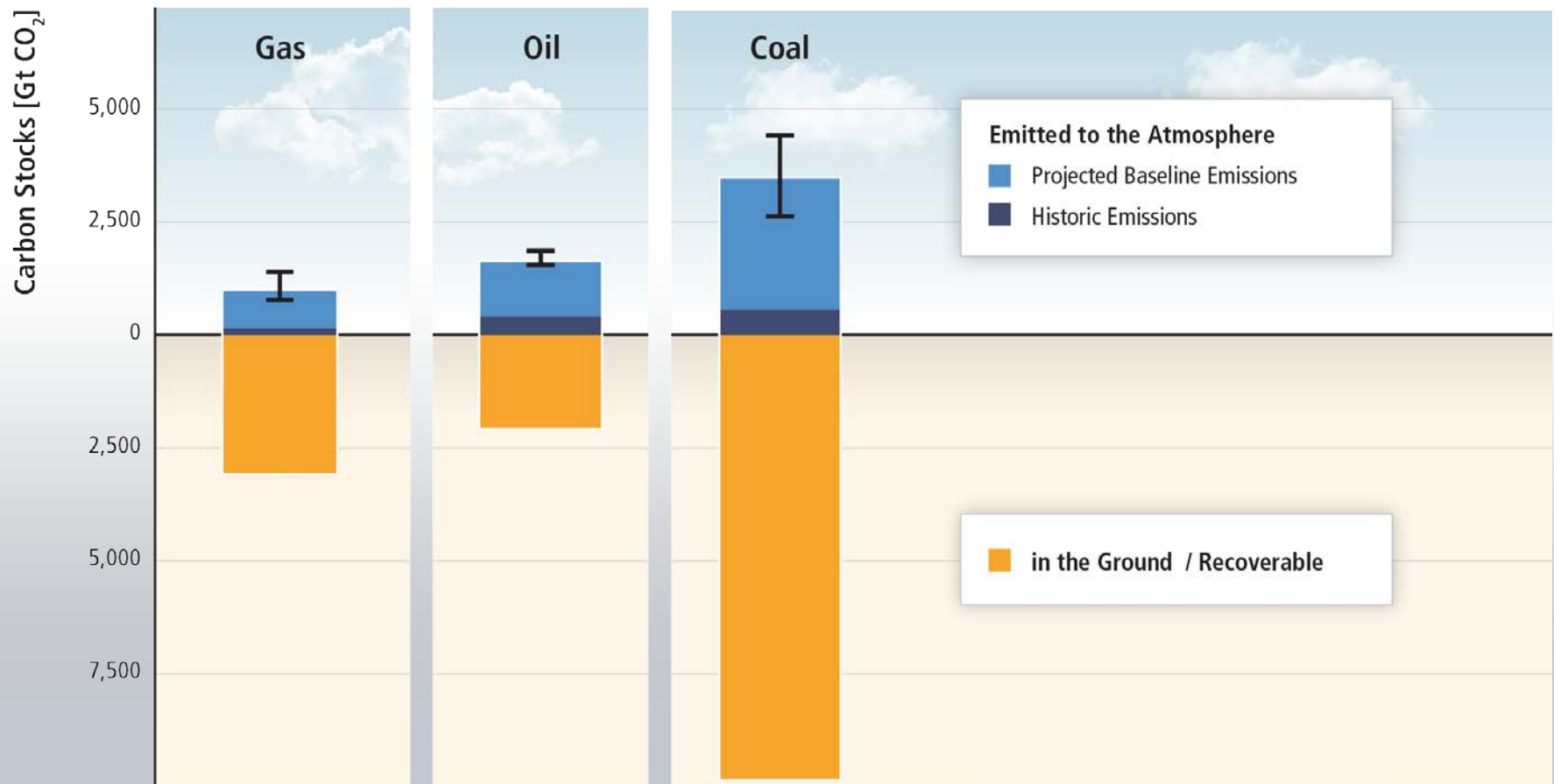
**Effective mitigation will not be achieved if individual agents advance their own interests independently.**

# Substantial reductions in emissions would require large changes in investment patterns and appropriate policies.



Based on Figure 16.3

There is far more carbon in the ground than emitted in any baseline scenario.



Based on SRREN Figure 1.7

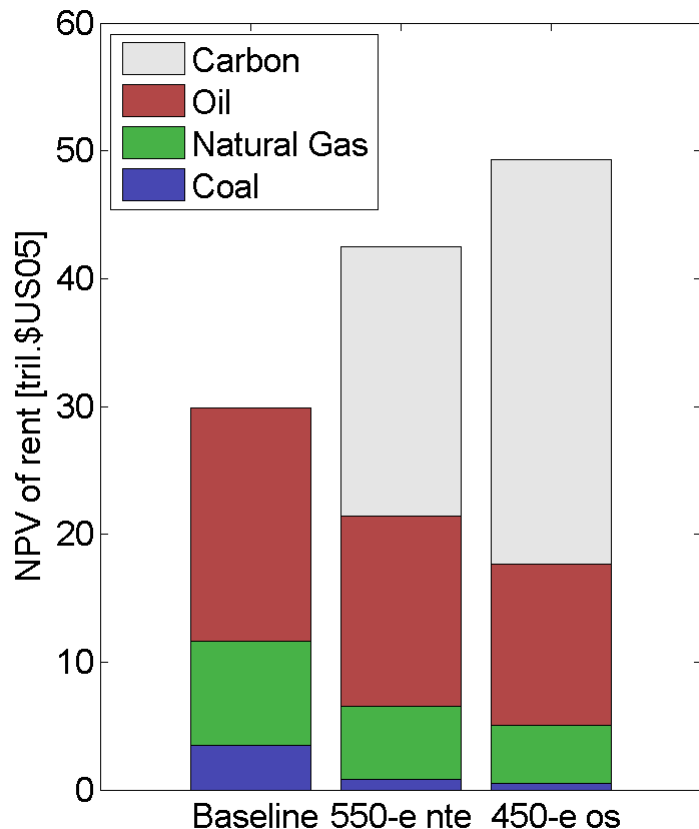


... what does this imply for European  
climate and energy policy?

- Own thoughts -



# The carbon rent: Emission pricing revenues could overcompensate profit losses of fossil fuel owners.



- Fossil resource rents decrease with climate policy ambition
- For a globally optimal carbon price, over-compensation by carbon rent (=permit price or tax \* emissions)
- Carbon rent appropriated domestically via auctioned permits or tax
- Receipts from a CO<sub>2</sub>-tax or auctioning could be used to lower taxes, for investments in infrastructure or to reduce debts

Bauer et al. (2013)

# Massive infrastructure investments are needed globally.



- Telecommunication



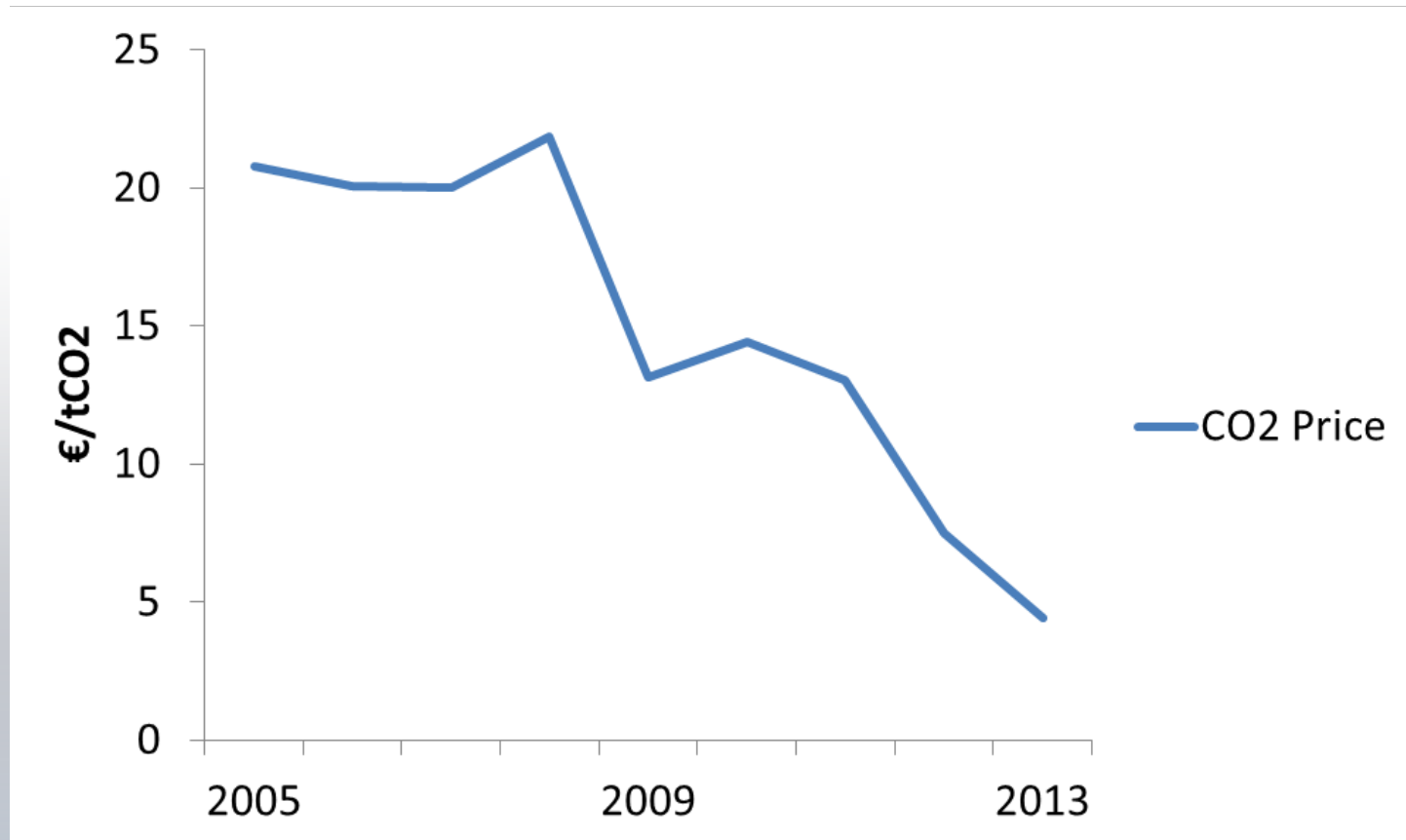
- Access to electricity



- Water availability

# The EU ETS: ex-post analysis

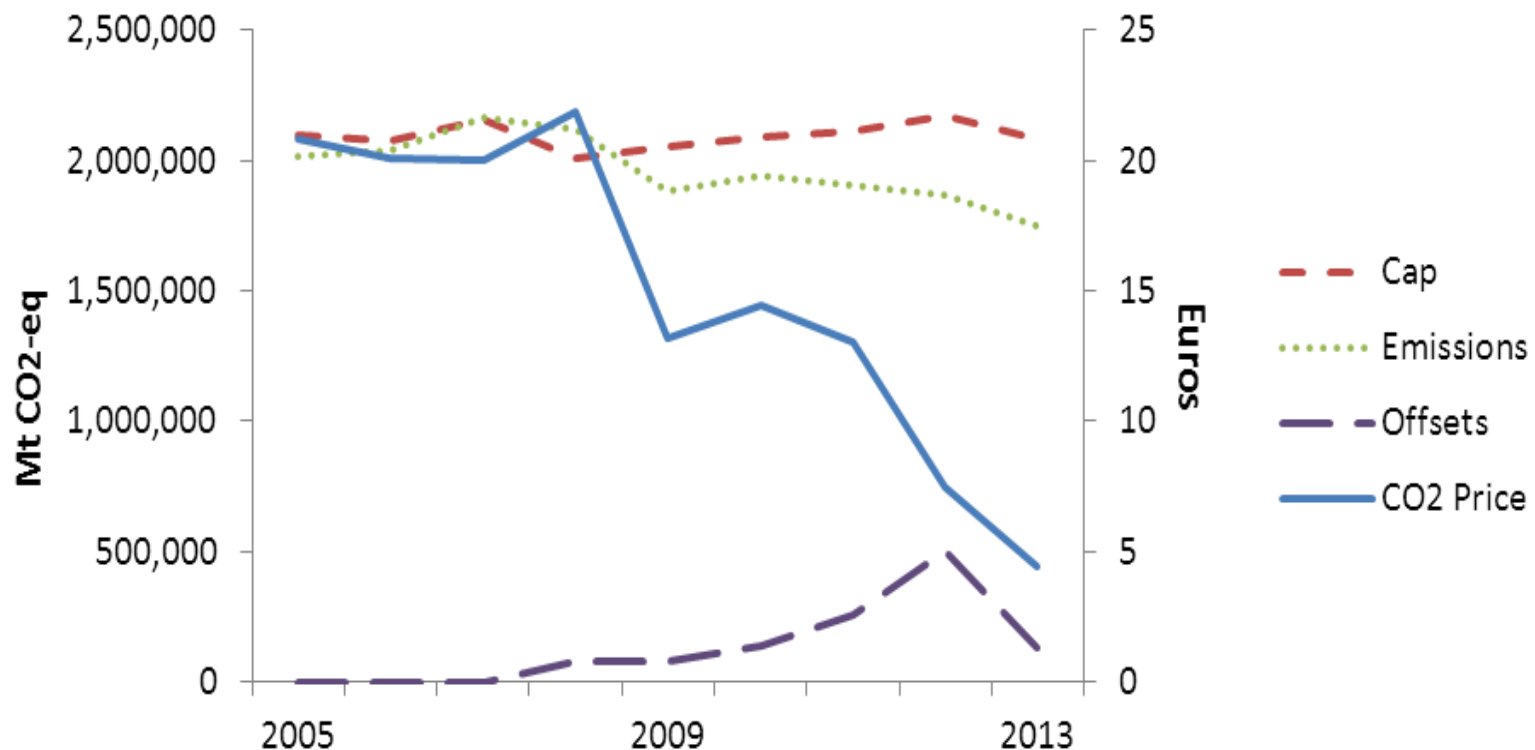
- Strong decline of CO2 price





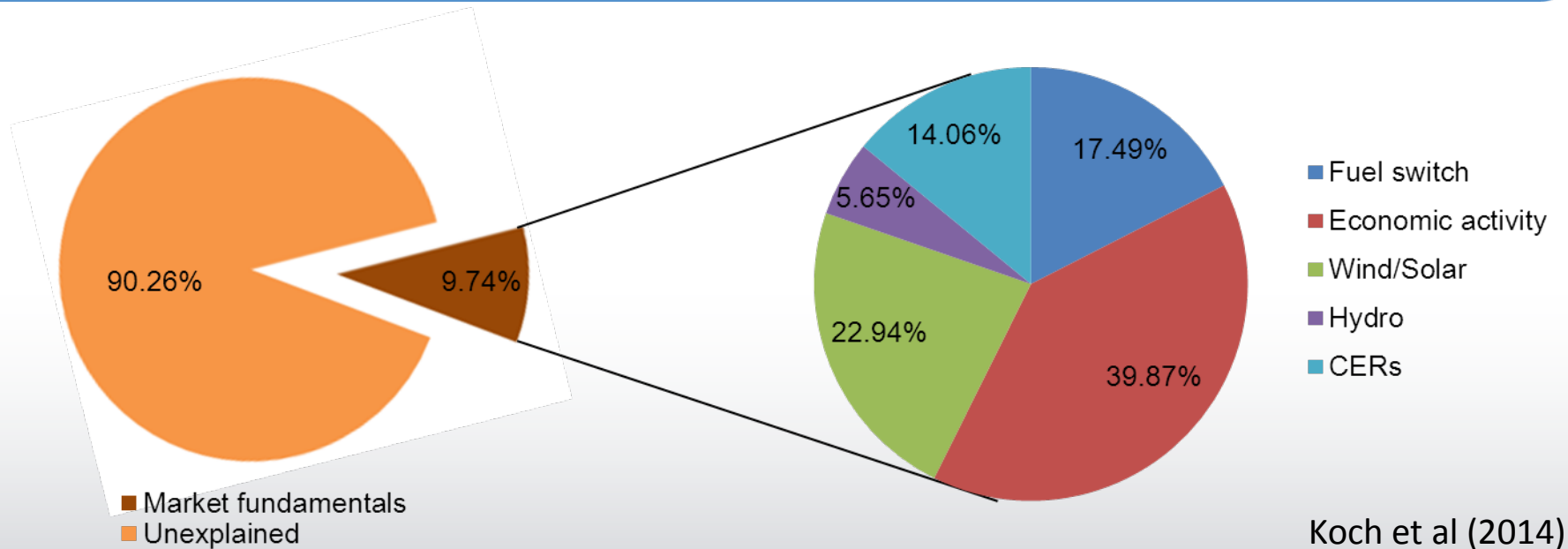
# Evaluation of the environmental effectiveness

- Emission cap was legally binding. But it has not been physically binding as emissions stayed below the cap.



Grosjean et al. 2014

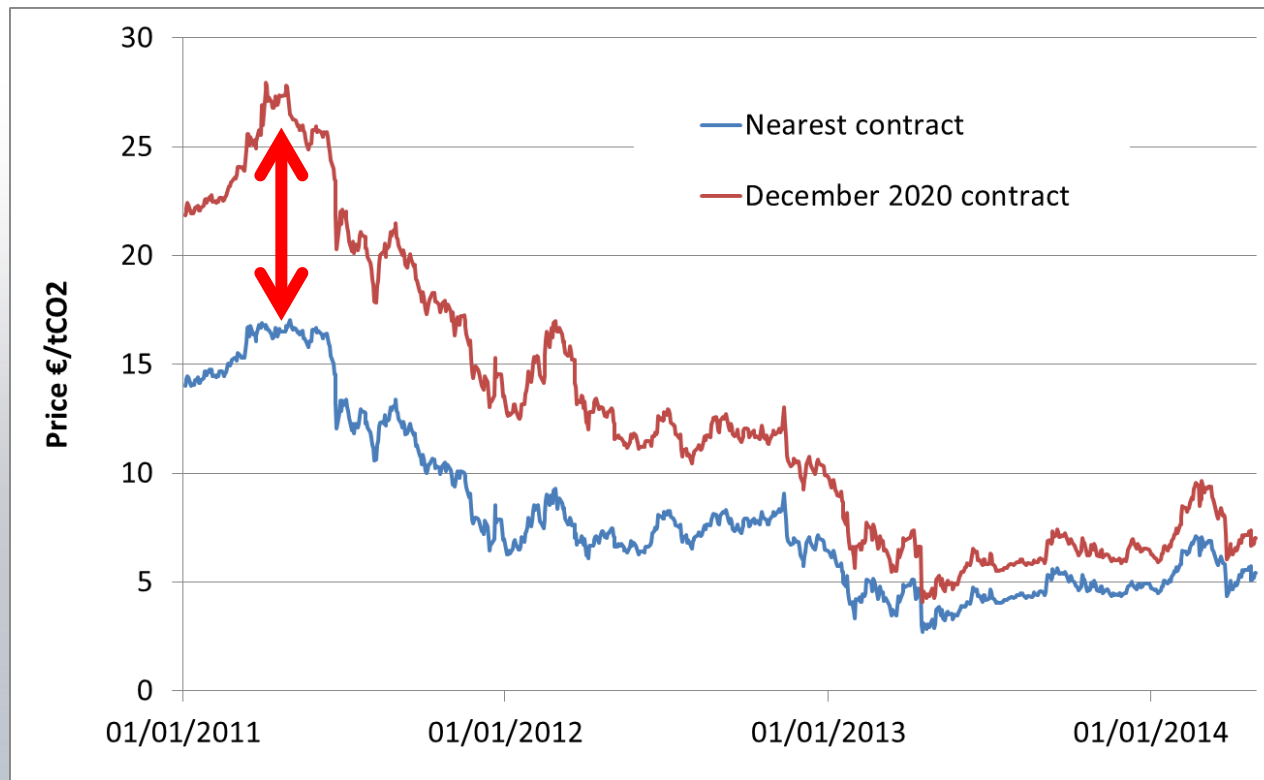
# Empirical evaluation of price drivers of EU emission allowances



- Only 10% of price formation can be explained by market fundamentals (renewable deployment, economic crisis, CDM, ...)
- But when taking into consideration policy events dummies (e.g. backloading vote) explanatory power jumps from 10% to 44%.
- In the situation with the non-binding cap, the standard price formation does not work

# Dynamic cost-effectiveness of ETS is lacking

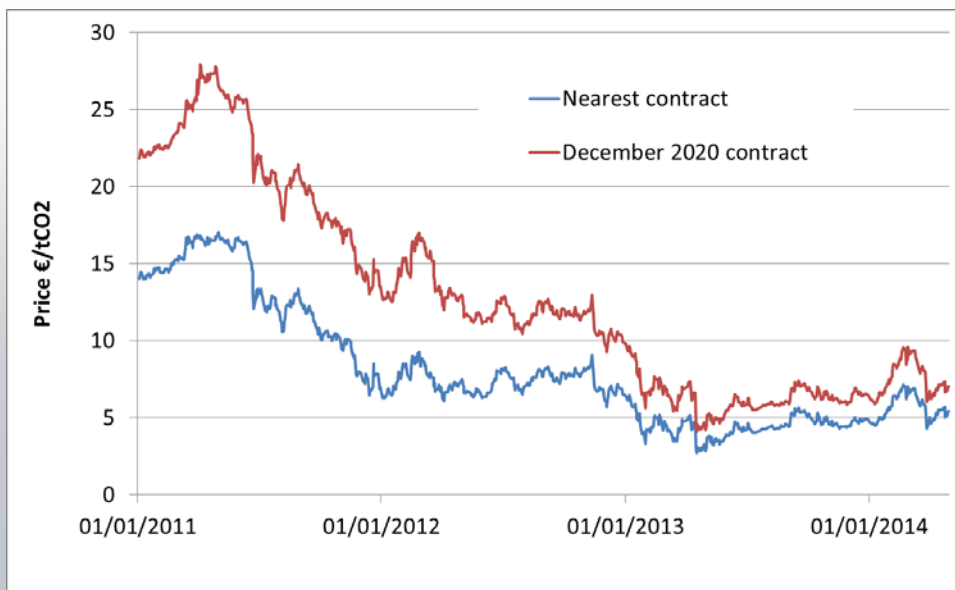
- Declining CO<sub>2</sub> price
- Currently , no substantial price increase expected for 2020 (only little spread between nearest contract and future contract for 2020)



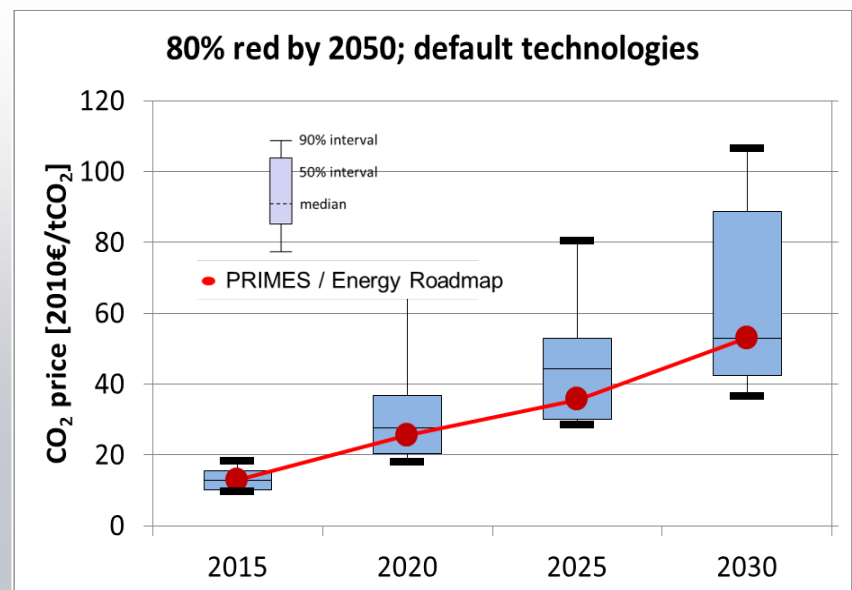
# Dynamic cost-effectiveness of ETS is lacking

- Consider the price in 2020 as a benchmark for evaluating dynamic cost-effectiveness of the ETS
- There is a gap between expectations and models that suggest a cost-effective price higher than 20€ / tCO<sub>2</sub> in 2020

## EUA nearest contract and Futures 2020



## Cost-effective CO<sub>2</sub> price from modeling

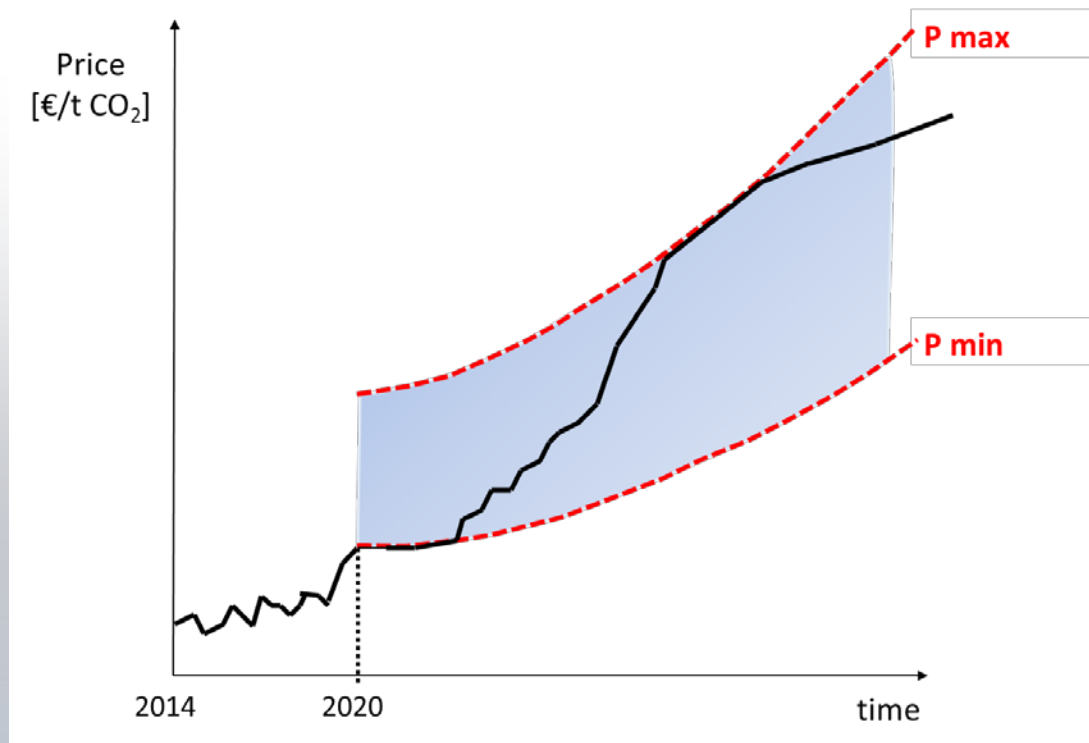


Knopf et al. (2013)



# Setting a price collar

- Gives reliable framework for investment decisions



# Mitigation of Climate Change:

## *Key Insights from the AR5 and Challenges for Future Research*

[www.mitigation2014.org](http://www.mitigation2014.org)