Detailed process IAMs: latest research

Valentina Bosetti
Economics Dept. Bocconi University
RFF-CMCC European Institute on Economics and the Environment

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Environmental Economics

Background

1) **GHG emissions projections for the 21st century:**

    How serious will it be?

2) **Cost Benefit Analysis:**

    Wait and see or act now? How much effort?

3) **Mitigating and adapting to climate change:**

    What polices, investments, strategies?

An Illustration

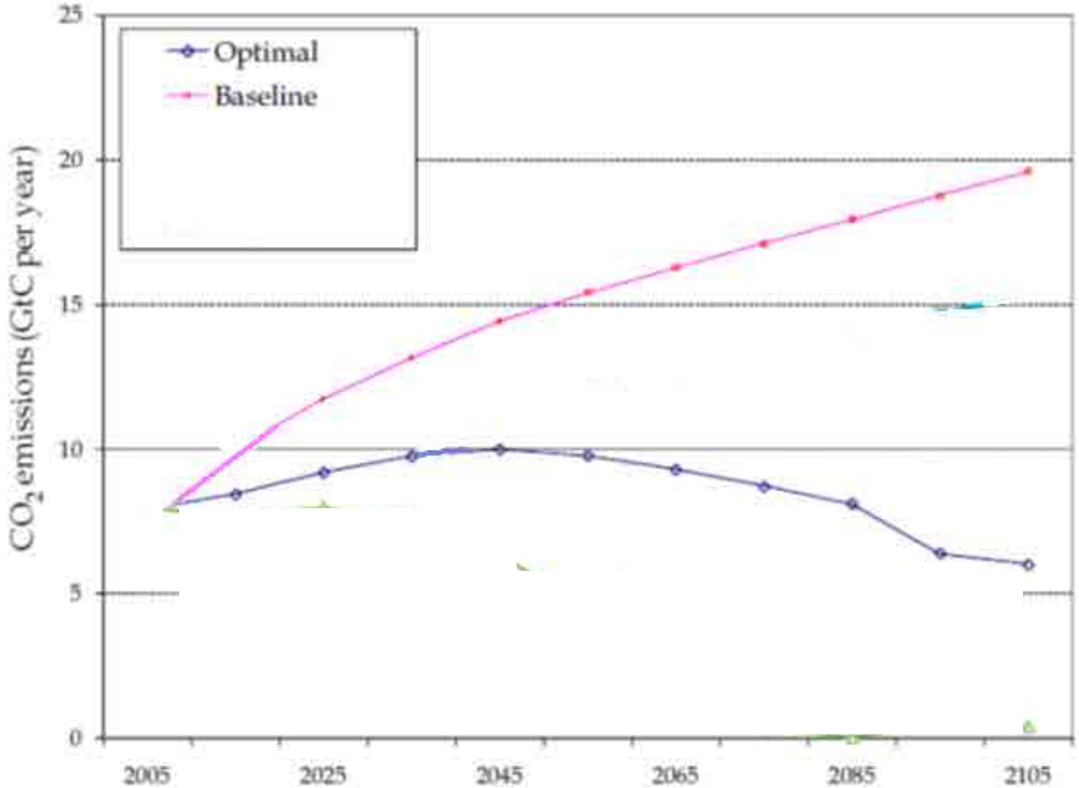


Fig. 1. Projected emissions of CO_2 under alternative policies.

Elaboration of Nordhaus 2010 PNAS

Detailed Process IAMs

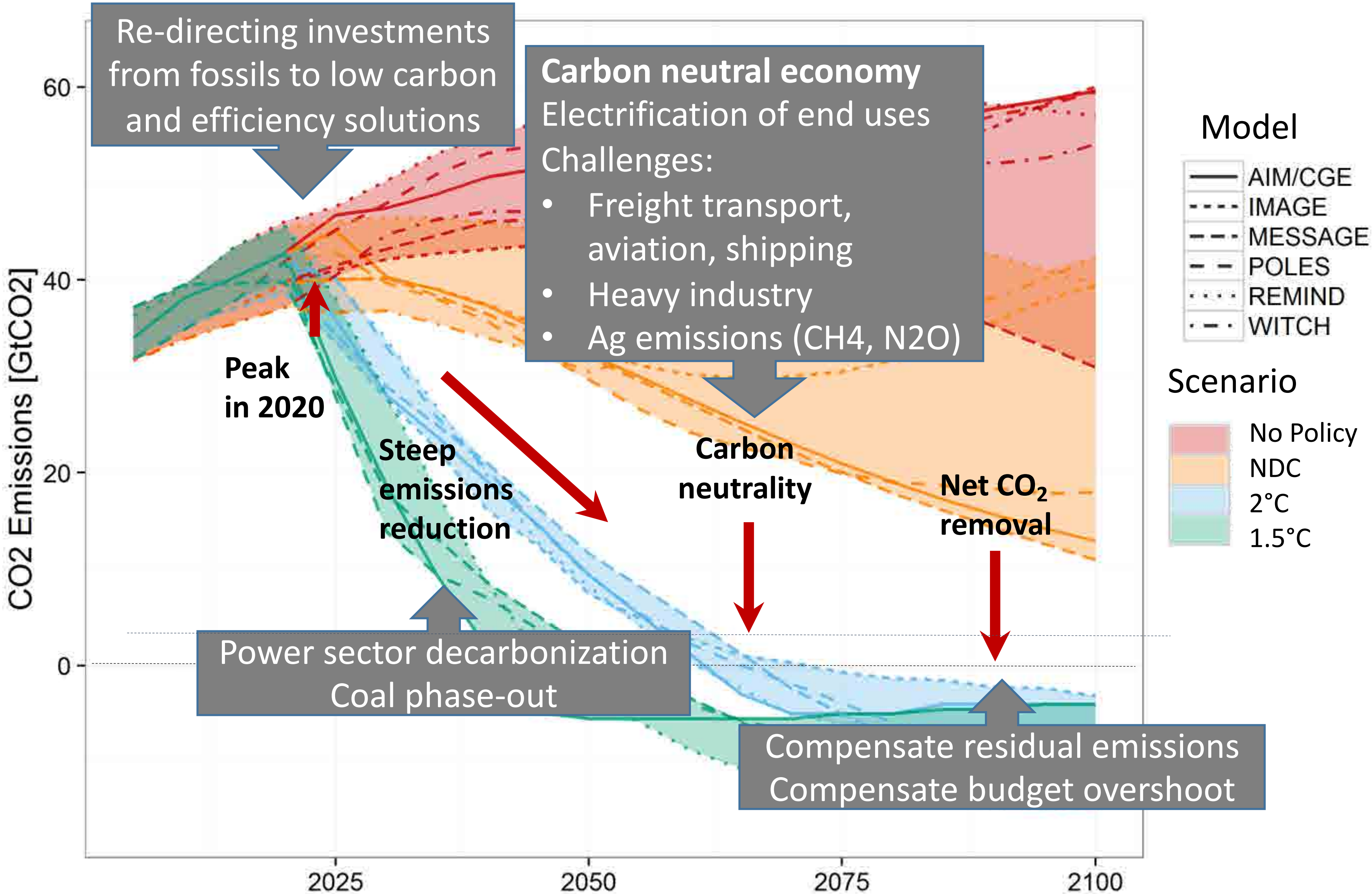
- ***Technologies and technological change***
- ***Sectors***
- ***Trade*** (emissions, fuels)
- ***Integrated*** (medium complexity GCMs, land use, water, etc.)

Realistic policies (e.g. NDSs, technology mandates, innovation policies etc.)

Climate policy implications on ***other societal objectives*** (e.g. energy poverty, air pollution, food security)

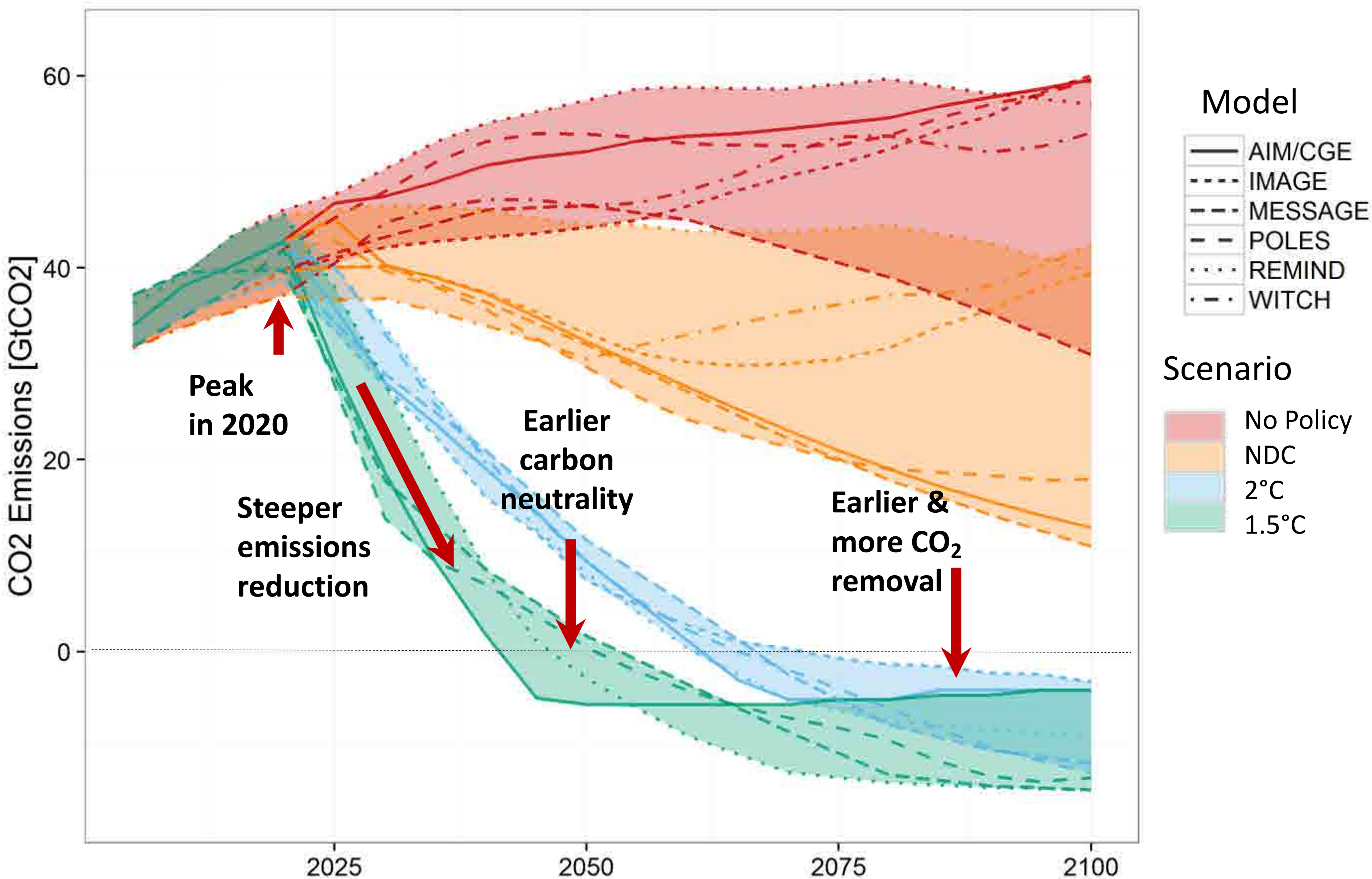
Community Science

Emission pathways: 2°C and 1.5°



Luderer et al., 2019

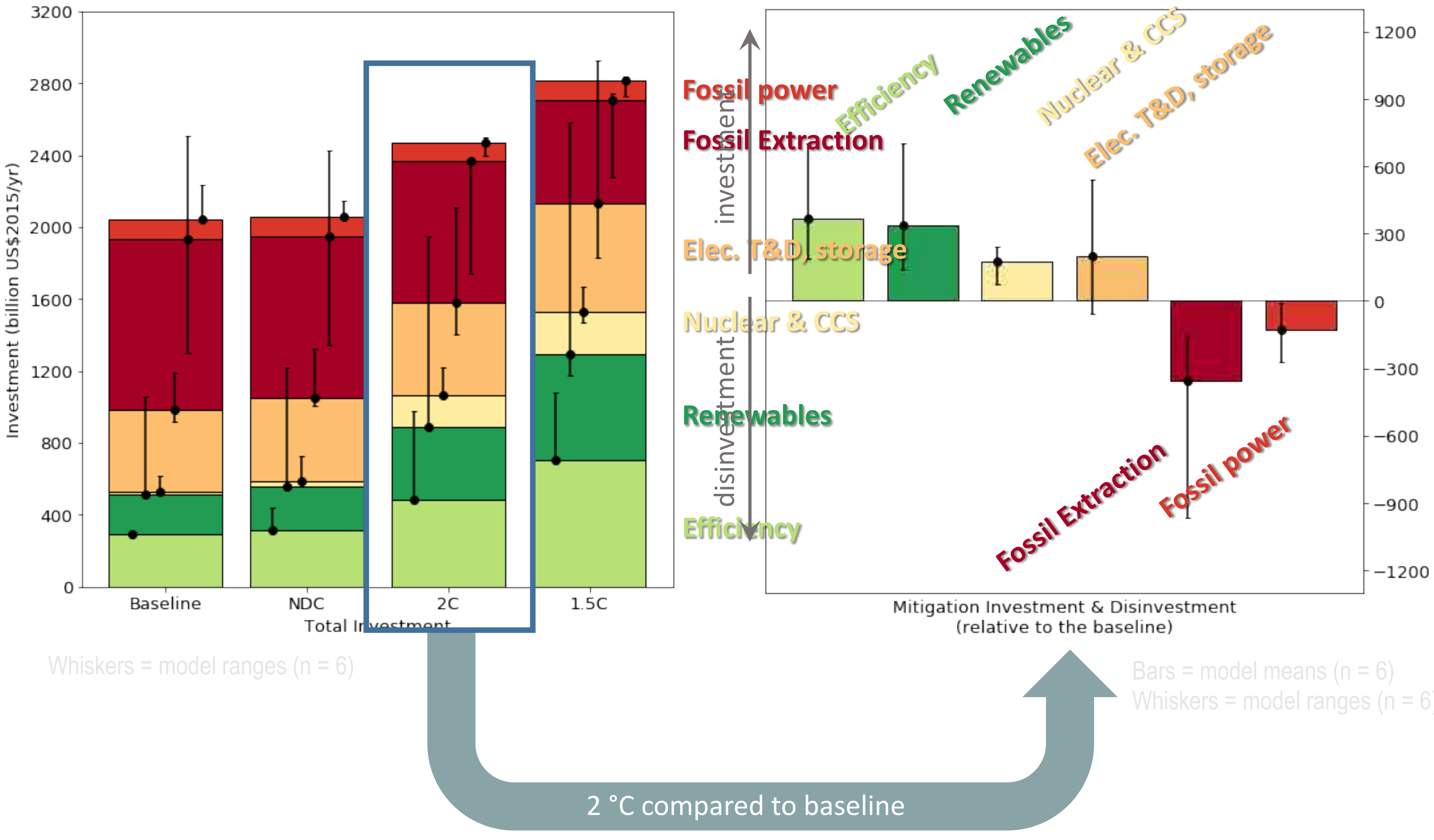
Emission pathways: 2°C and 1.5°



Luderer et al., 2019

Global Investment Portfolios for 1.5°C and 2°C

[average annual investments, 2016-2050]



McCollum et al. 2018

Today's focus

1. The impact of time discounting in cost-effective deep mitigation pathways
2. Multidimensional implications of climate policies

The impact of time discounting in deep mitigation pathways

Emmerling, Drouet, van der Wijst, van Vuuren, Bosetti, Tavoni

The economic case for negative emissions technologies (NETs)

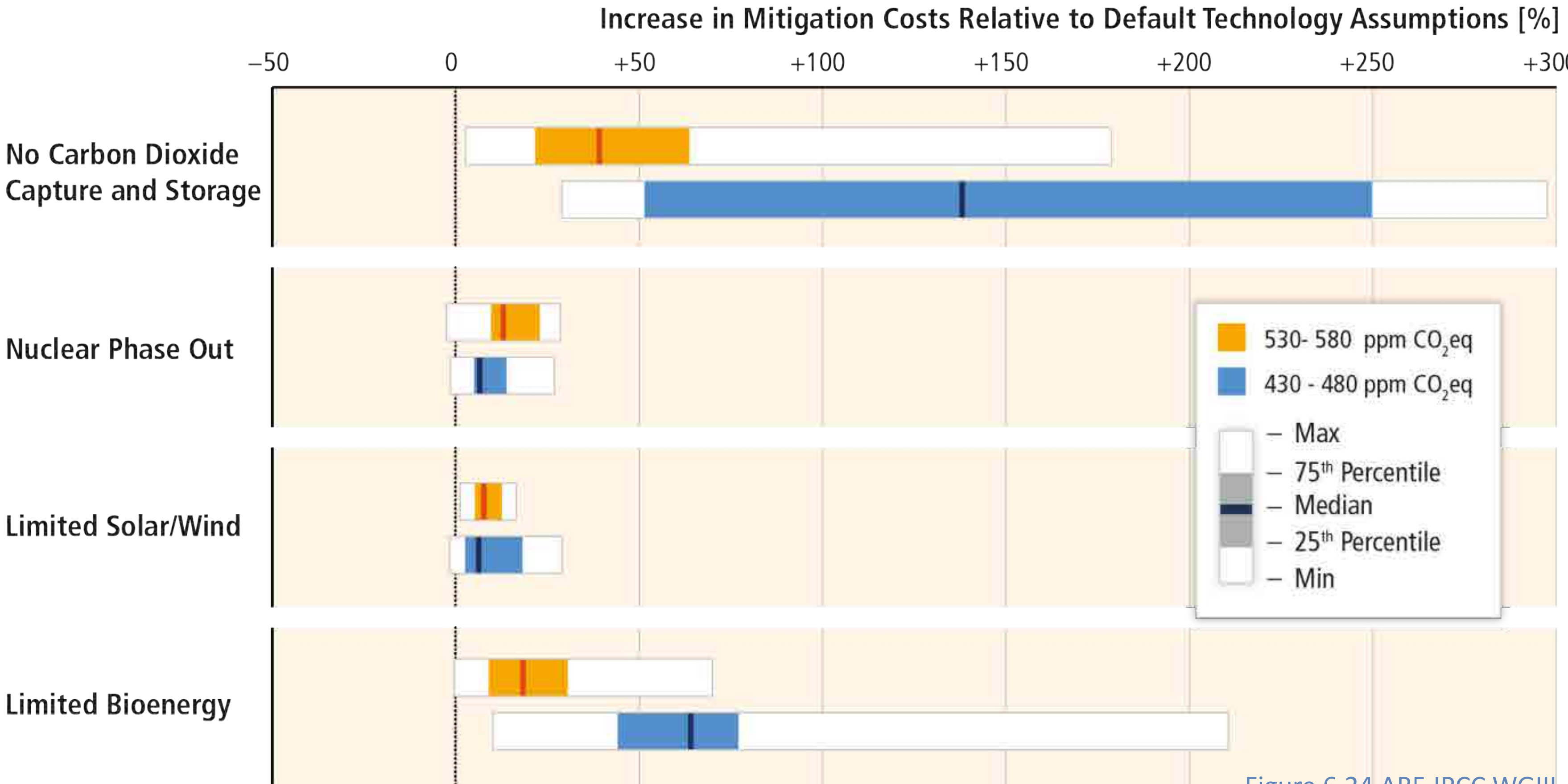


Figure 6.24 AR5 IPCC WGIII

.. the debate which NETs raise

INSIGHTS | *PERSPECTIVES*

CLIMATE CHANGE

The trouble with negative emissions

Reliance on negative-emission concepts locks in humankind's carbon addiction

By **Kevin Anderson**[1,2] *and* **Glen Peters**[3]

until the peak in temperature [updated from

sion trends and emission scenarios. Th

MENU

nature climate change

Commentary | Published: 21 September 2014

Betting on negative emissions

Sabine Fuss, Josep G. Canadell, Glen P. Peters, Massimo Tavoni, Robb

Robert B. Jackson, Chris D. Jones, Florian Kraxner, Nebosja Nakicenovic,

R. Raupach, Ayyoob Sharifi, Pete Smith & Yoshiki Yamagata

Time discounting and NETs

- Time preferences known to be key in **CBA**
- But have not been examined in **CEA** model assessments
- NETs re-allocate abatement over time and thus raise an intergenerational issue

Time discounting in DP-IAMs

Table 1: Time Discounting in DP-IAMs — WIP

DP-IAM	Discount rate	Components
WITCH	$\approx 3.5\%$	$(\rho = 1\%, \eta = 1.5)$
REMIND	$\approx 4.5\%$	$(\rho = 3\%, \eta = 1)$
GCAM	5%	
MESSAGE	5%	
TIAM	5%	
IMAGE/FAIR		
POLES		

Source: (IAMC documentation wiki + online documentation)

Motivation for a lower discount rate

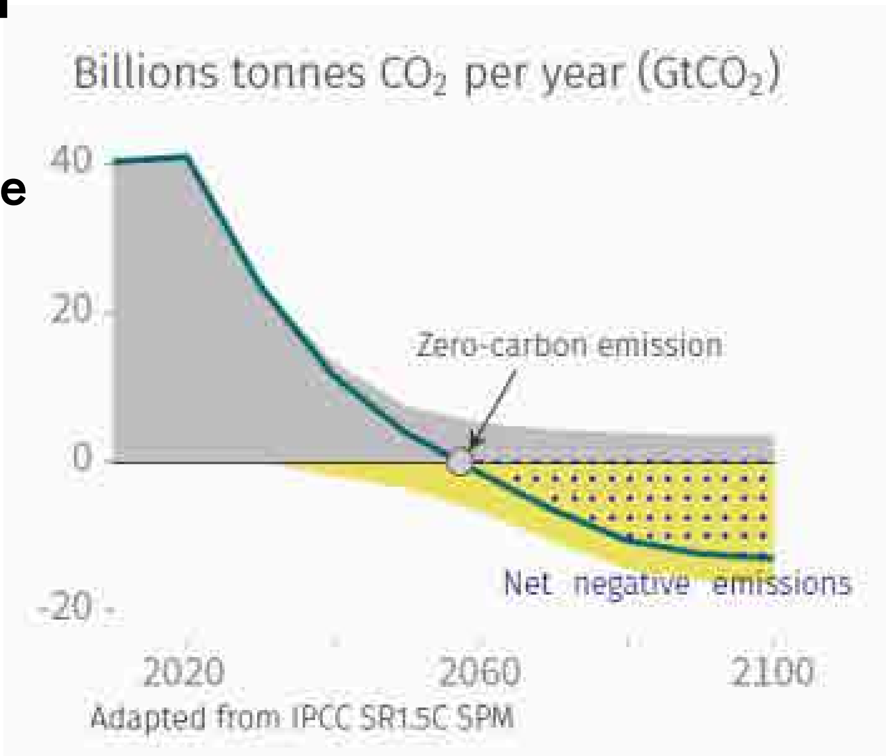
In this context, lower discount rates should be considered:

- Economists suggest to use risk-free, public, long-term interest rates. 2–3% (Drupp et al., 2018)
- Long term Cost-effective analysis and cost-benefit analysis should be consistent.
- Inter-generational equity

We study 3 key indicators:

1. The carbon price [$/tCO2]
2. Zero-carbon emission year
3. Carbon budget overshoot [%]

(Total net negative emissions relative to the carbon budget)



Methods: Simple Hotelling Model

Optimal control problem

Minimization of the discounted abatement costs to implement a carbon budget

$$\min_{p(t)} \int_0^T e^{-rt} BAU(t) \underbrace{\left(\int_0^{MAC^{-1}(p(t))} MAC(a)da \right)}_{\text{abatement costs at t}} dt,$$

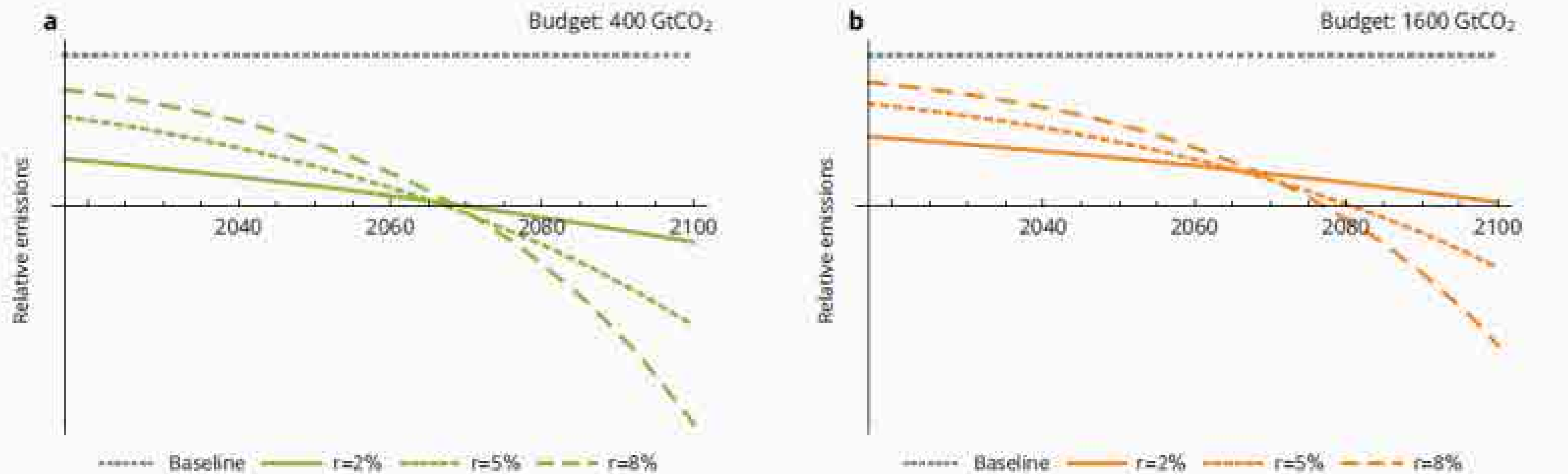
$$\text{s.t. } CE'(t) = E(t),$$

$$CE(T) \leq \alpha \int_0^T BAU(t)dt$$

$\Rightarrow$ Closed-form expressions of the 3 key indicators.

p: carbon price (control variable),
E: emissions,
BAU: baseline emissions,
MAC: marginal abatement cost for share *a* of BAU
r: discount rate,
CE: cumulative emissions, as α share a of BAU cumulative budget

Methods: Simple Hotelling Model

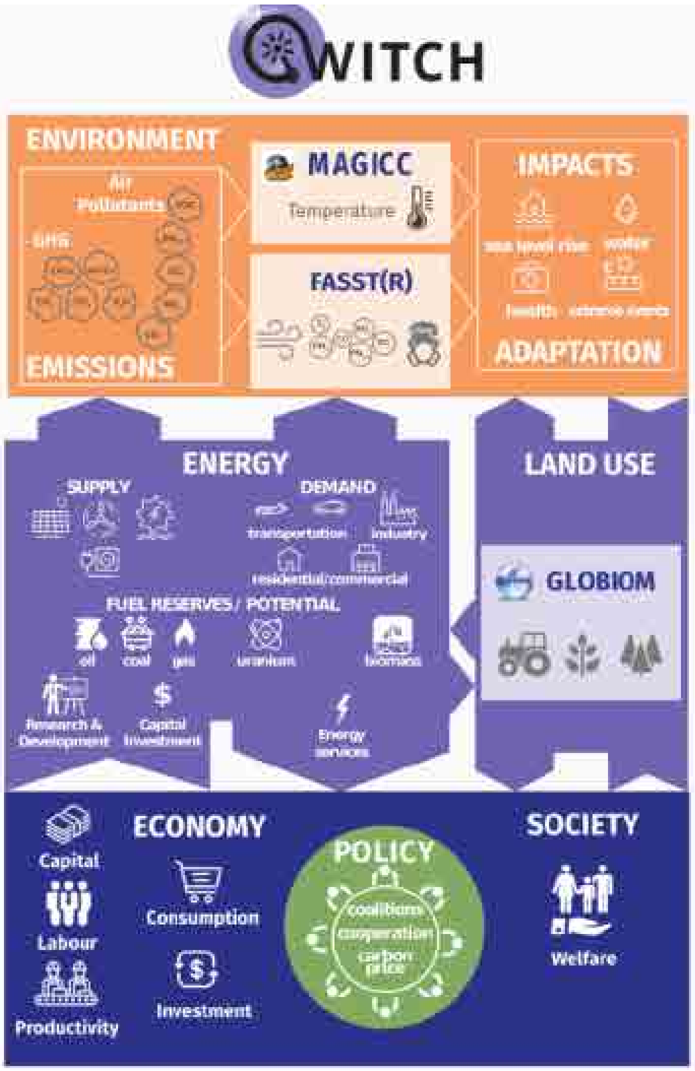


- Constant level of baseline emissions
- MAC has a power-law functional form (calibrated on SSP database)

Carbon price profile

Under these conditions, the carbon price follows the Hotelling's rule, where the initial carbon price is increasing at the discount rate

Methods: DP IAM



Intertemporal growth model

max regional discounted welfare

Runs for optimal carbon tax

- Discount rate 1–8% (var ρ, fix η)
- Carbon budgets: 400–1600 $GtCO_2$
- NETs options: (no, only BECCS, BECCS+DACS)

Methods: DP IAM - WITCH

Economy: top-down intertemporal optimal growth model (Epstein-Zinn), dynamic, perfect foresight

Energy:

Cli

Ai

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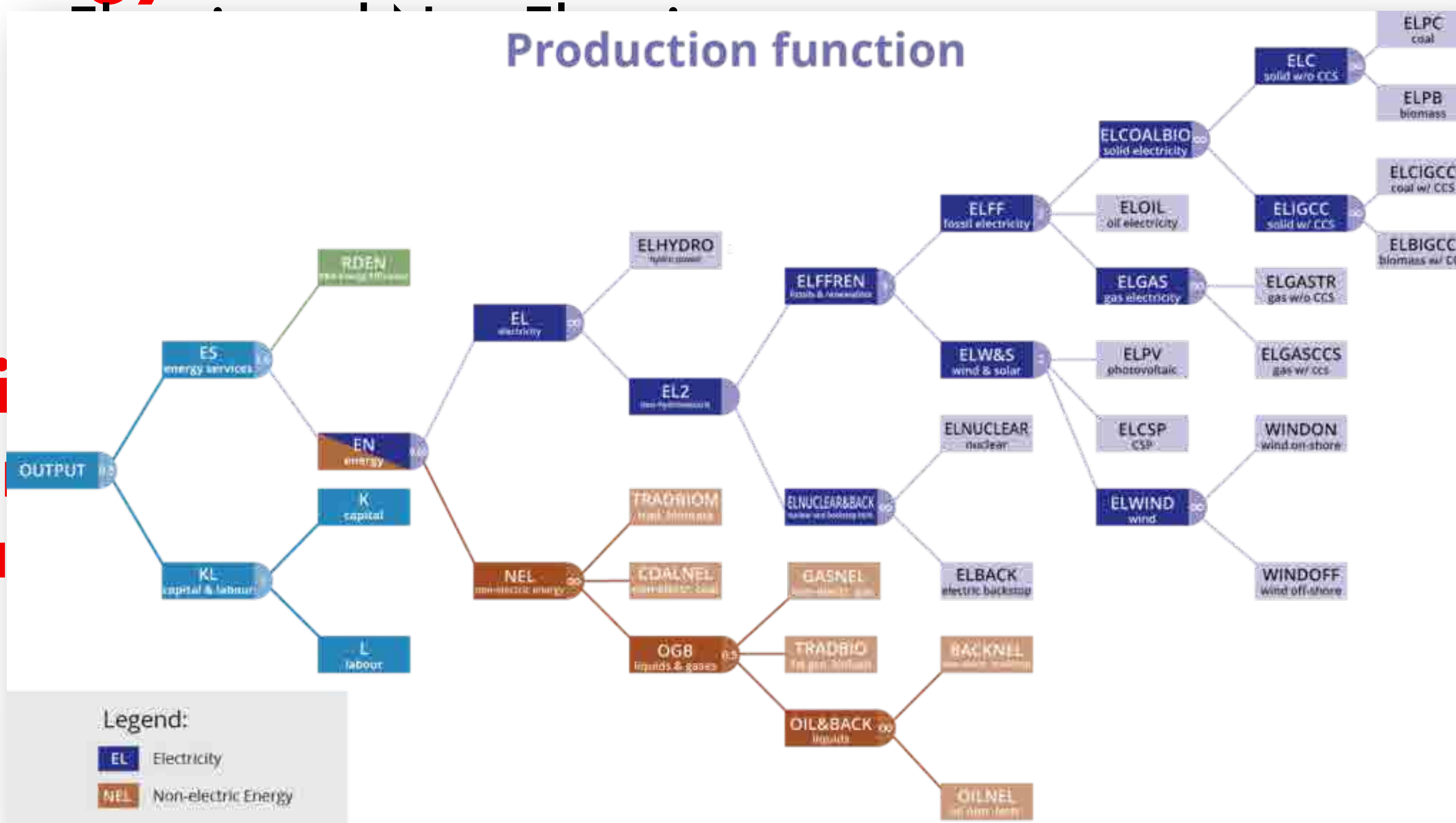

Results

Results: 3 Key Indicators