Global decarbonisation pathways: Contribution of different options in CO2 reduction

TIAM-MSA, Decomposition analysis

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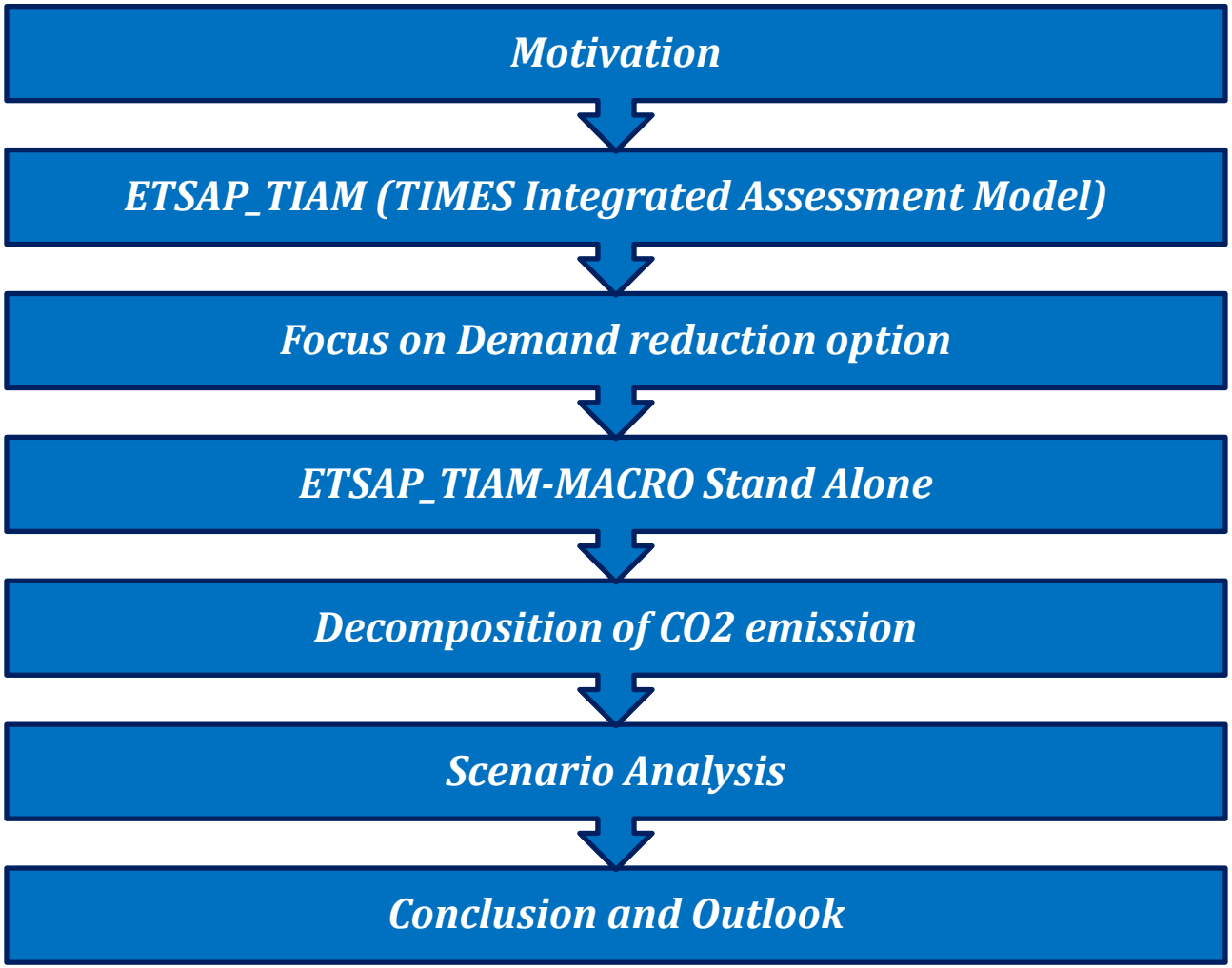
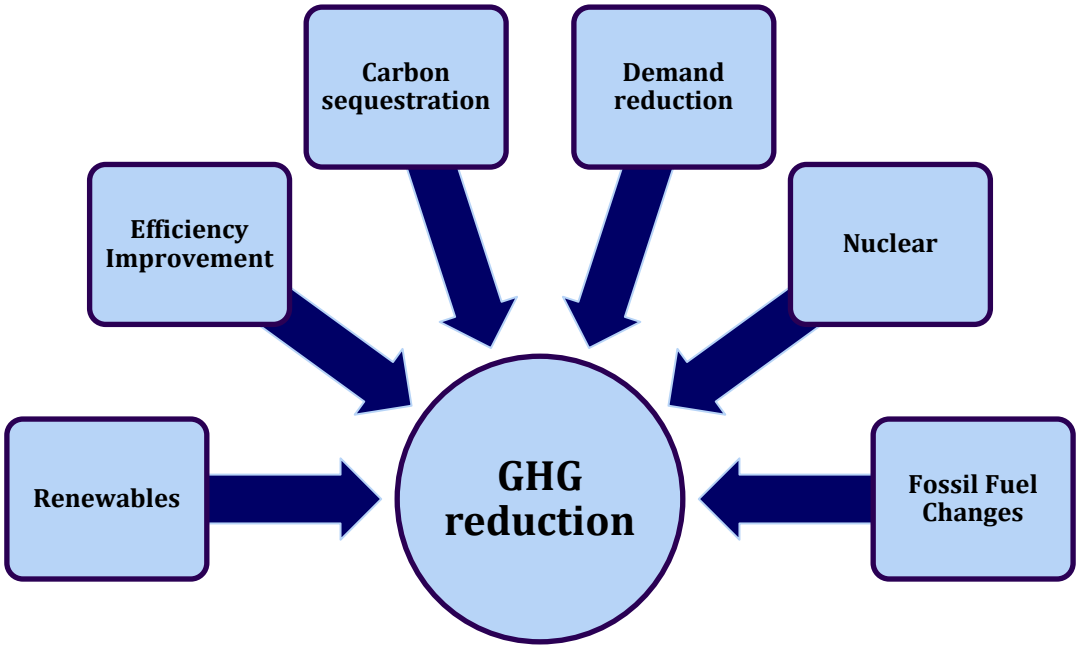
Outline


Motivation
ETSAP_TIAM (TIMES Integrated Assessment Model)
Focus on Demand reduction option
ETSAP_TIAM-MACRO Stand Alone
Decomposition of CO2 emission
Scenario Analysis
Conclusion and Outlook

Motivation

- Climate change is a global concern.
- Different options to reduce energy-related CO2 emissions:



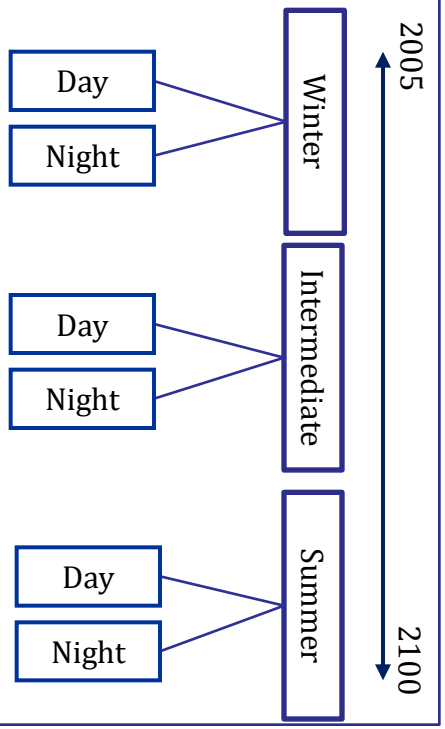
Study the contribution of these options to meet targets of decarbonistion policies and their interaction under different availability assumptions is necessary for an integrated assessment in climate change context.

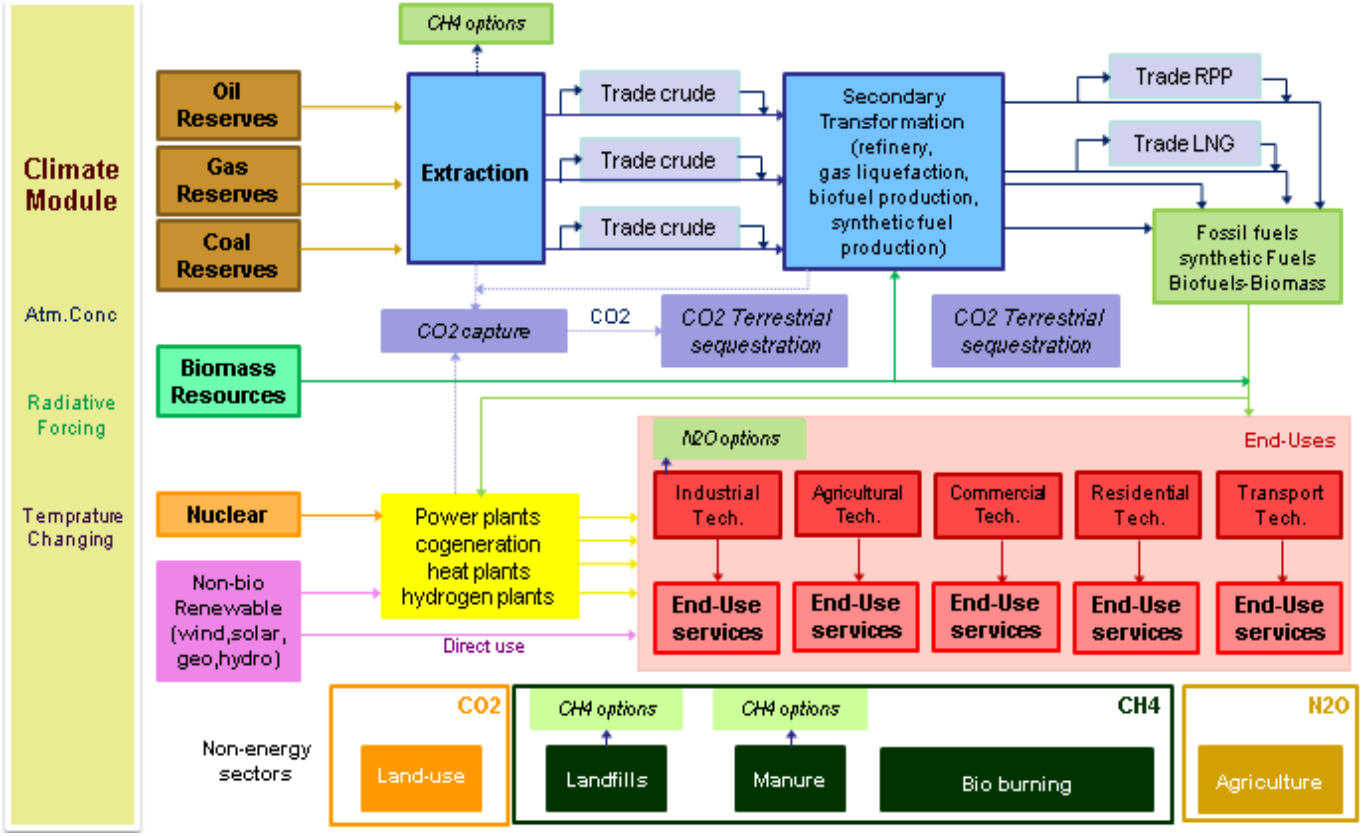
ETSAP_TIAM (TIMES Integrated Assessment Model)

Regions:

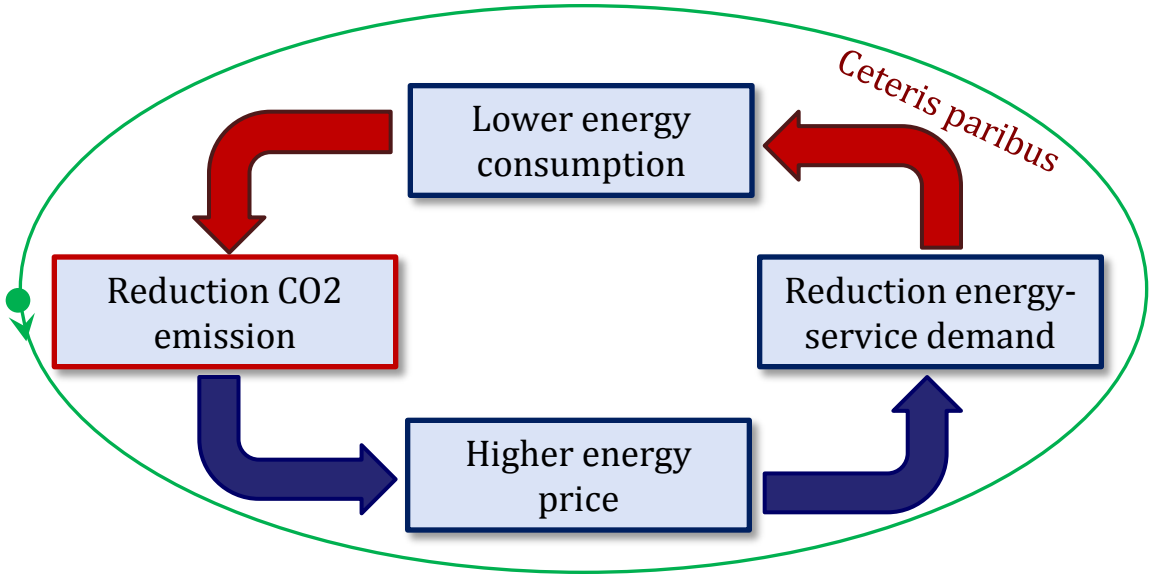
Africa	Eastern Europe	Middle-East	Australia-New Zealand	Former Soviet Union
Other Developing Asia	Canada	India	South Korea	Central and South America
Japan	United States	China	Mexico	Western Europe

Time resolution:





Demand reduction option



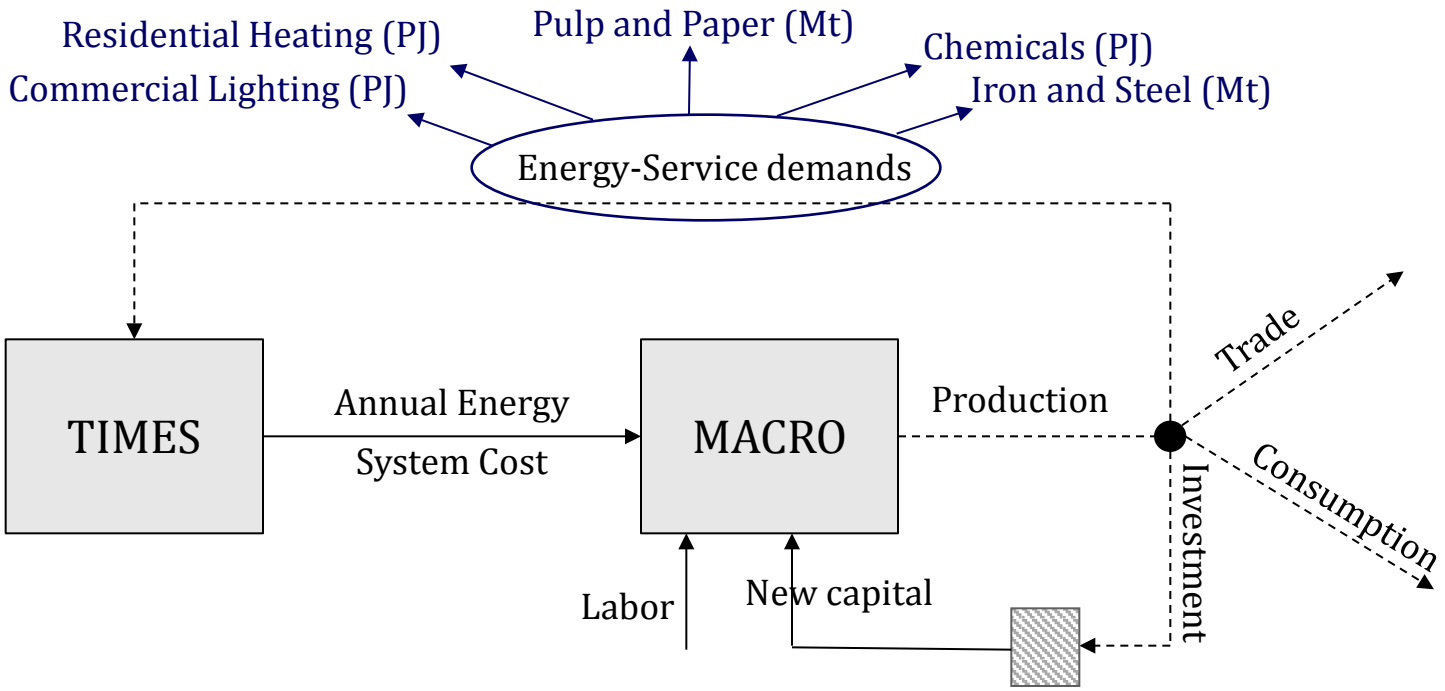
- Since energy-service demands in ETSAP_TIAM model are derived from exogenous drivers, to include demand reduction option to such analysis two alternatives exist:

I. **Using price elasticity in the model** — *critiques* →
- Elasticity factors are highly uncertain and poorly understood.
- Demand response is dependent to elasticity factors and usually in literature is observed as a critical mechanism for CO2 reduction.

II. **Coupling with a Macro model**

ETSAP_TIAM-MACRO[1]

- ETSAP_TIAM model is linked with a top-down macroeconomic module MACRO.
- Maximization an inter-temporal utility function for a single representative producer-consumer agent in each region, using decomposition and Negishi weights.
- Overview of TIMES-Macro[2]:



1: S. Kypreos, A.Lehtila, 2013

2: U. Remme, M. Blesl, 2006

Decomposition of CO_2 emission

- The rate of CO_2 emission change is decomposed with an **extended and modified Kaya identify**. The general formulation is as follow:

$$CO2 = \frac{CO2}{Fossil\quad Fuel} \times \frac{PEC}{demand} \times \frac{Fossil\quad Fuel}{PEC} \times demand$$

- Share of sequestrations is calculated separately.

- **The Logarithmic Mean Divisa Index Method (LMDI)** is used to determine share of each factor:

- Introduced by *Ang et al., 1997*
- Perfect decomposition
- Applicable for problems with zero values
- Formulation for share of demand is as follow (time index eliminated for simplicity):

$$\Delta CO2 = \frac{CO2_2 - CO2_1}{\ln(CO2_2) - \ln(CO2_1)} \times \left[\ln(demand_2) - \ln(demand_1)\right] + \ldots$$

Scenario Analysis

Scenario Definition

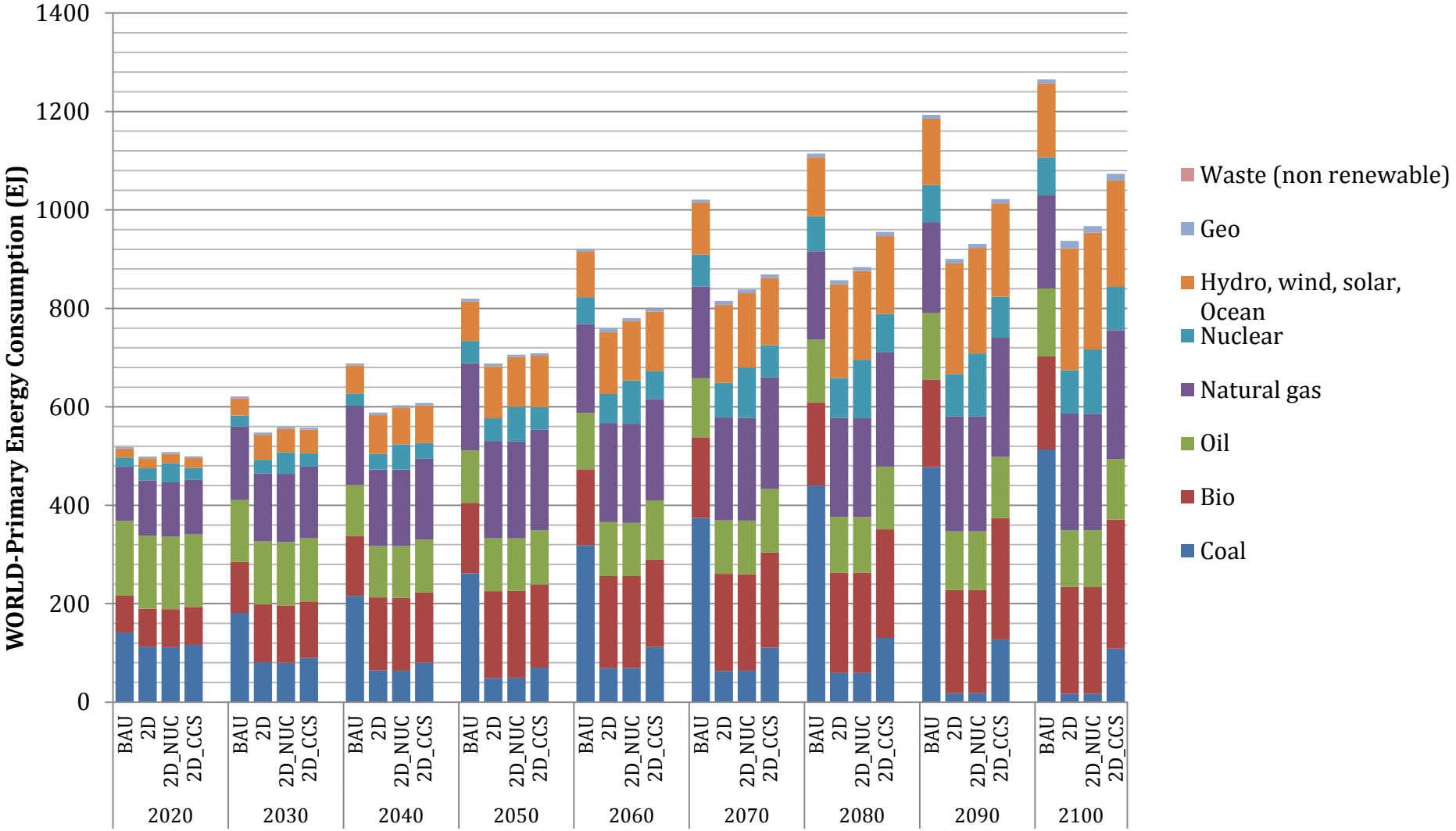
Scenario	CO2 reduction[1]	Higher Nuclear[2]	Higher CCS[3]
BAU	✗	✗	✗
2D	✓	✗	✗
2D_NUC	✓	✓	✗
2D_CCS	✓	✗	✓

1: Level of CO2 emission in 2050 is similar to ETP 2014 2DS (2^{0}C degree target)

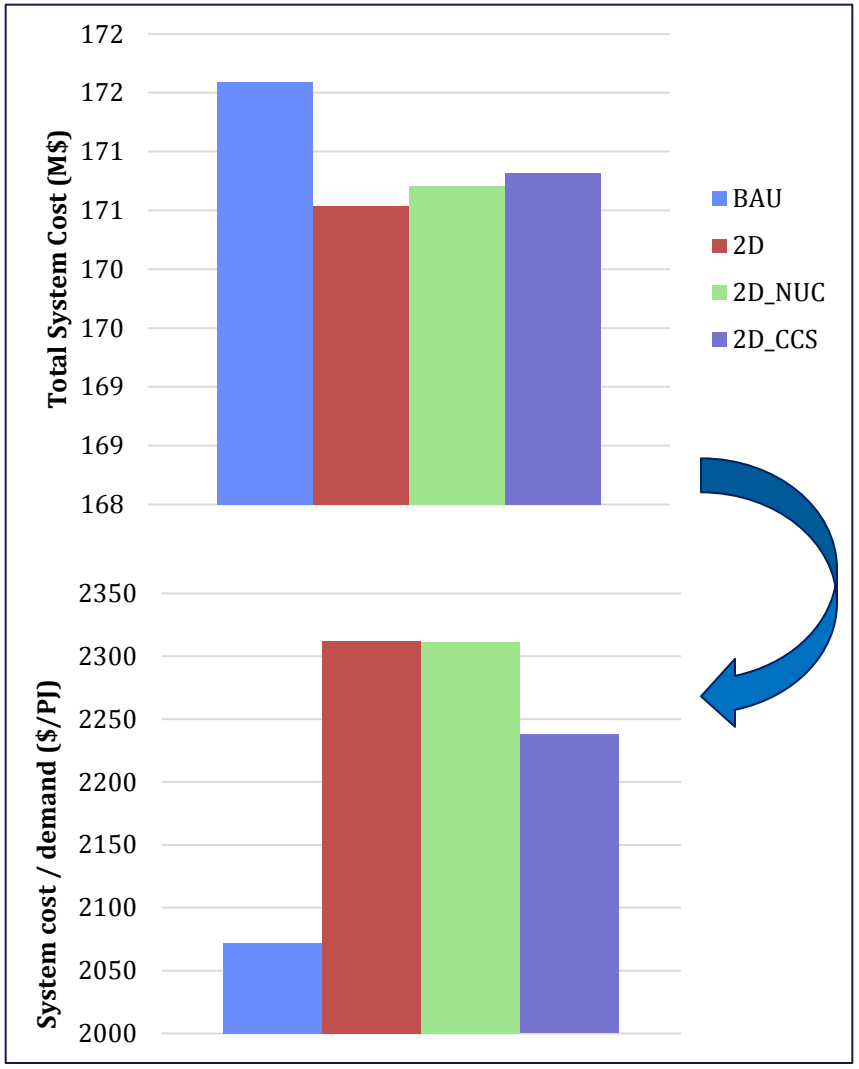
2: 50% higher availability of Nuclear power plants.

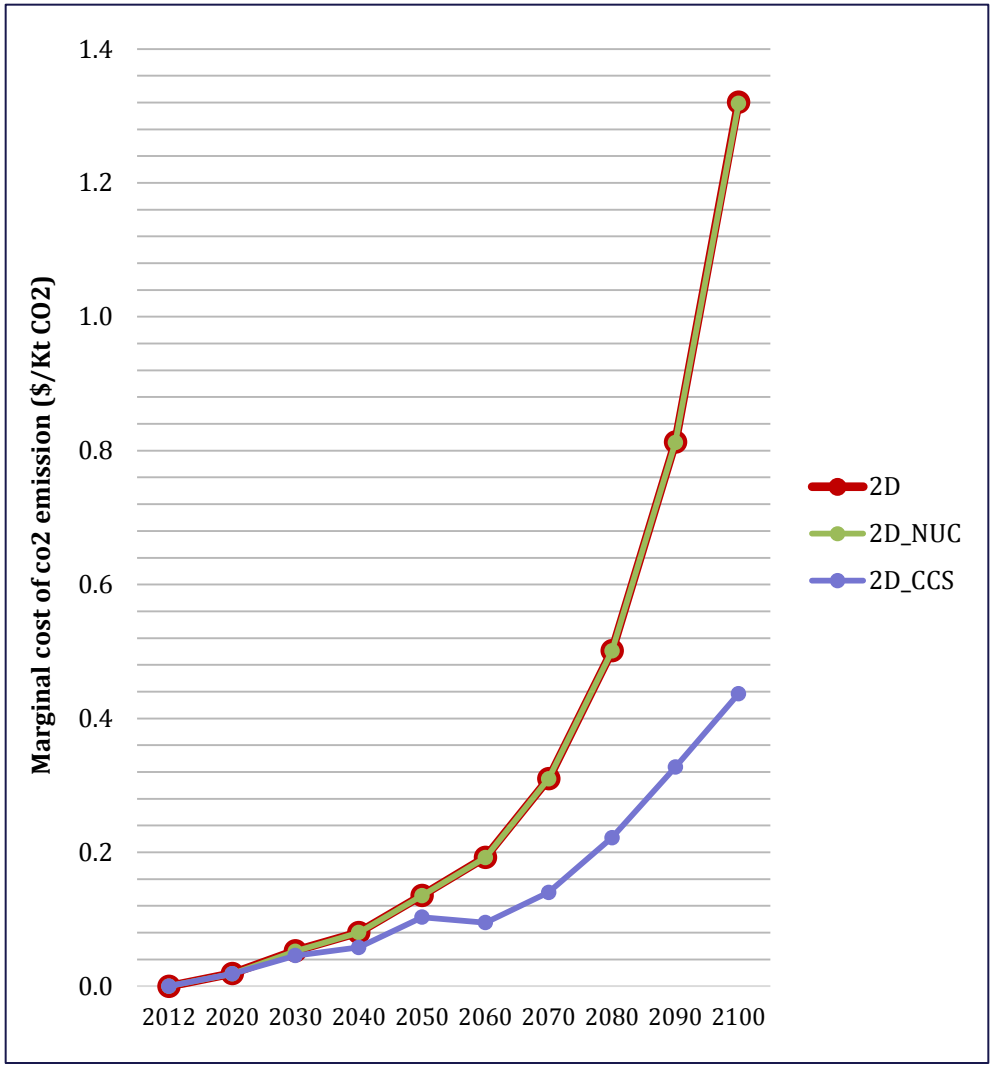
3: Higher CCS availability. CO2 reduction from CCS option in this scenario is similar to the reduction from higher nuclear in *2D_NUC* scenario.

Primary Energy Consumption

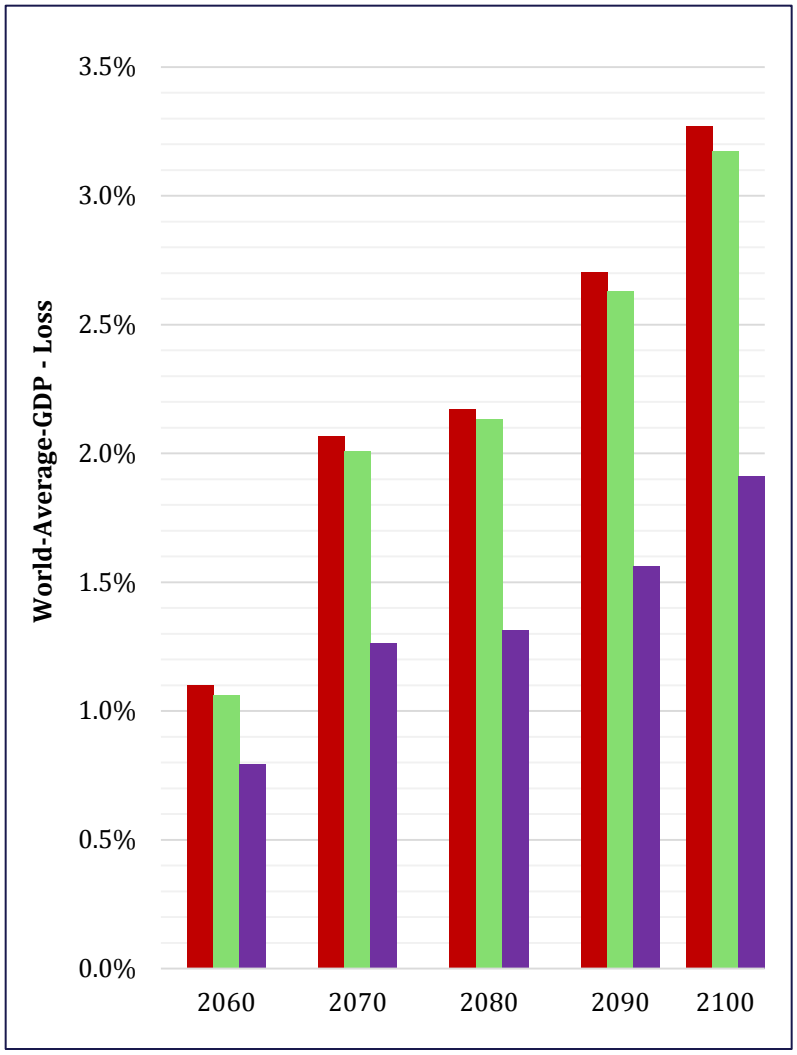


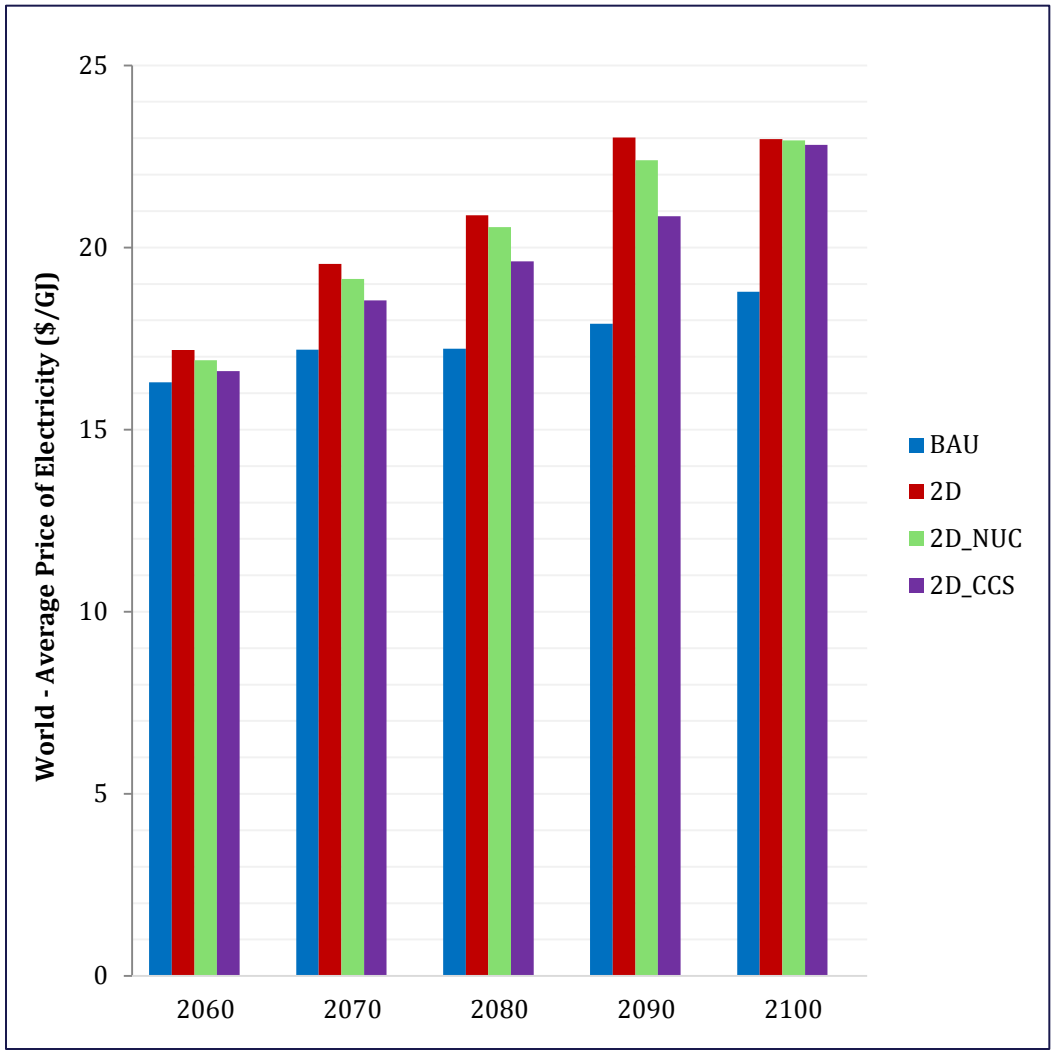
System cost and CO2 Marginal Price



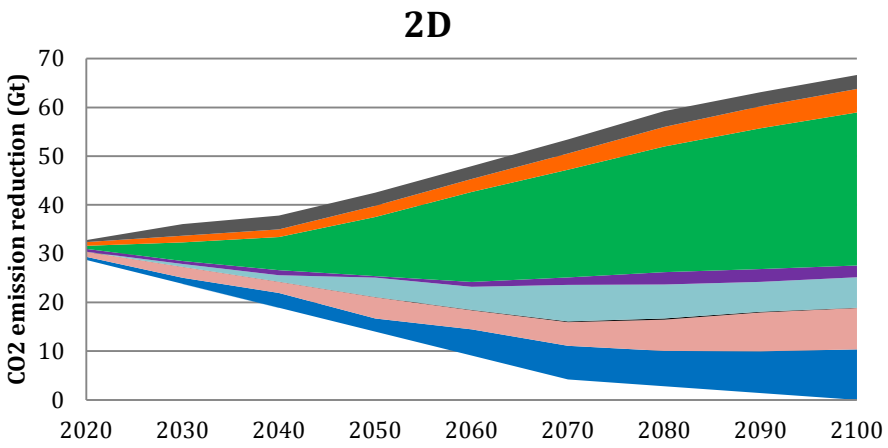


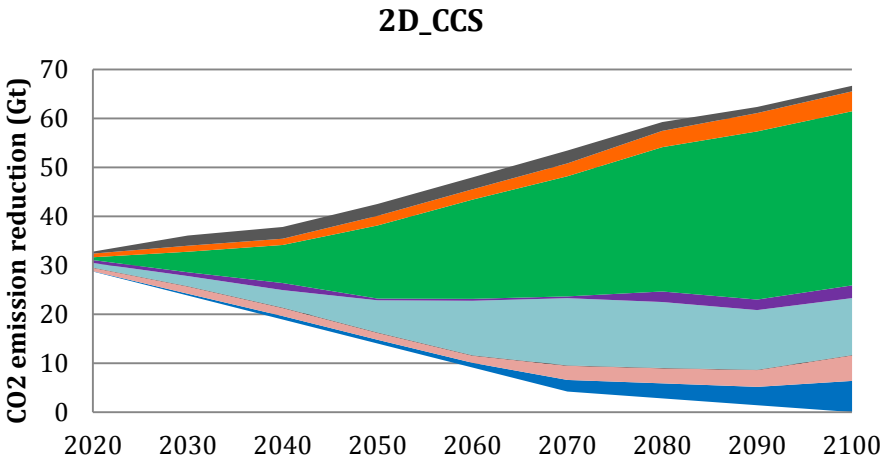
GDP-Loss and Electricity Price

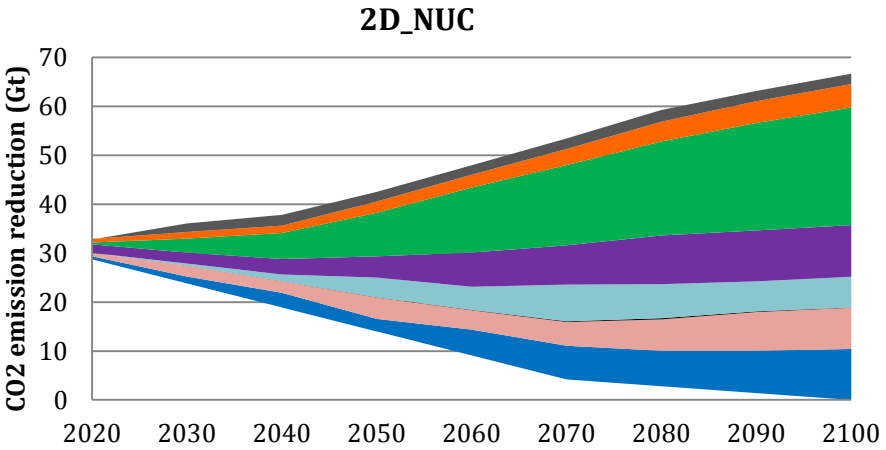


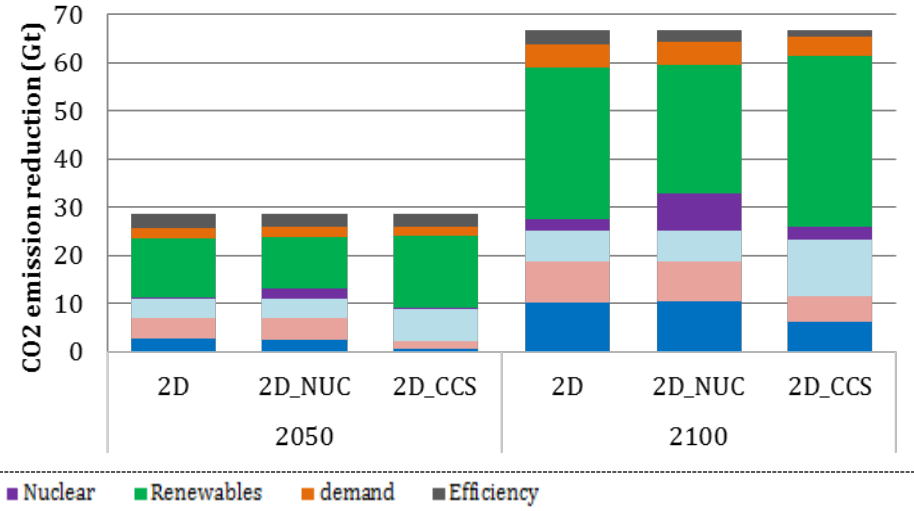


Decomposition of CO2 emission









Conclusion and open questions

PEC under *2D_NUC* and *2D_CCS* is higher than *2D*. Because in first two scenarios lower demand reduction and efficiency improvement are needed to meet CO_2 reduction's target.

Higher nuclear penetration doesn't necessarily mean lower total cost per demand.

In all three decarbonisation scenarios, *Renewable option* is leading in CO_2 reduction.

CCS could overtake nuclear as a relatively better cost-efficient mitigation technology

↓

B.Zwaan and M.Tavoni, 2011

Applying other formulation for MSA instead of NLP (e.g., LP, MCP, ...)?

Suppy more sensible initial values (better starting point)?

Thanks
for your attention