



## Activities with the TIAM model at IER

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## Overview

- Myopic approach
- Coupling of LOPEX with TIAM
- Low Carbon Society



## Options to handle uncertainty in TIMES

Marginal sensitivity analysis



Analyzing the effect of marginal changes in the model input data  $A, b, c$  on the solution

Parametric Programming



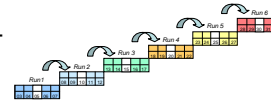
Variation of model input data  $A, b, c$  over larger value ranges

$$\begin{aligned} & \text{Min } c^T x \\ & \text{s.t.} \\ & Ax \geq b \\ & x \geq 0 \end{aligned}$$

Myopic vs. clairvoyant



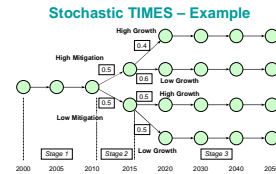
Analyzing the impact of short-term vs. long-term planning horizon on the decisions



Stochastic programming

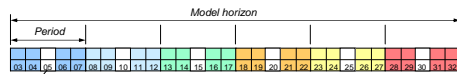


Multi-stage stochastic programming to develop hedging strategies for uncertain future



## Myopic foresight

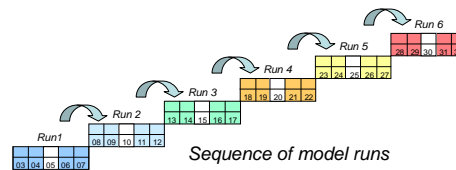
Perfect foresight



Milestoneyear

One optimization run over entire horizon

Myopic foresight  
(Dynamic-recursive)

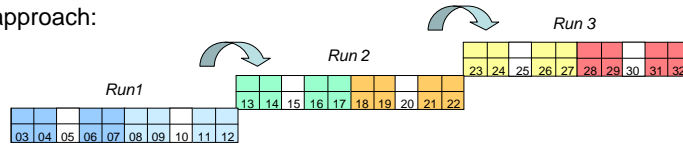


- Perfect foresight:
  - i. Decisions take into account entire future model horizon
  - ii. Model gives optimal strategy under assumed conditions
- Myopic foresight:
  - i. Decisions are based on only limited knowledge of the future
  - ii. Implicitly assumed that current conditions will last forever; to some extent ignorant about future



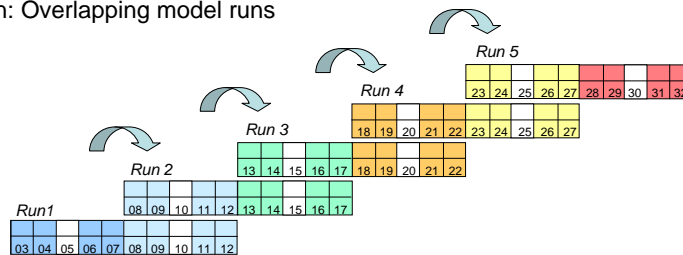
## Extended foresight horizon

- Initial approach:



*Drawback: Unequal foresight within a run*

- Solution: Overlapping model runs



## Scenario definition

- Base scenario: no explicit climate protection policies
- CO<sub>2</sub> mitigation scenario:
  - No continuous reduction pathway, but reduction targets only for last periods:
    - 2040: 20.0 Gt CO<sub>2</sub>
    - 2045: 17.5 Gt CO<sub>2</sub>
    - 2050: 15.0 Gt CO<sub>2</sub>
- Different foresight horizons in both scenarios:
  - 2PER, 3PER, 4PER, 5PER, 6PER, 7PER: foresight horizon of 2-7 periods
  - PERF: perfect foresight over entire model horizon 2000-2050

- Population [million]

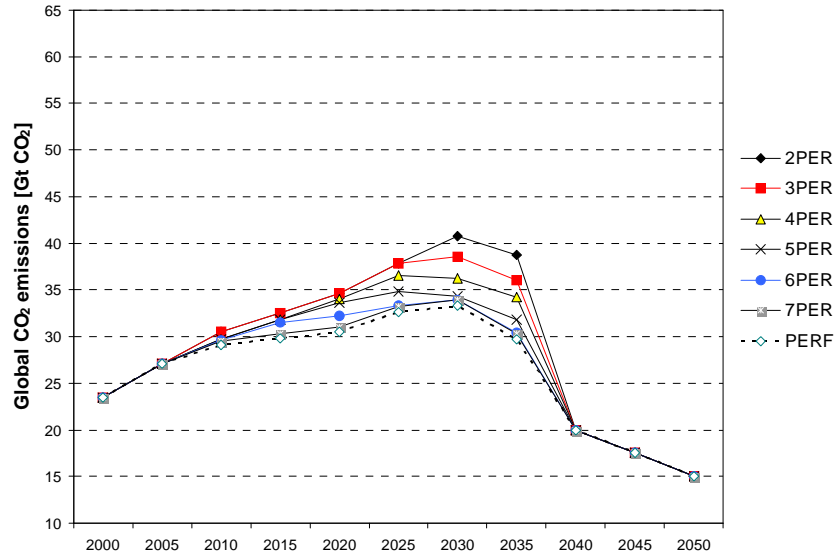
	2005	2010	2020	2030	2040	2050
World	6409	6757	7390	7942	8511	9015

- GDP growth [%]

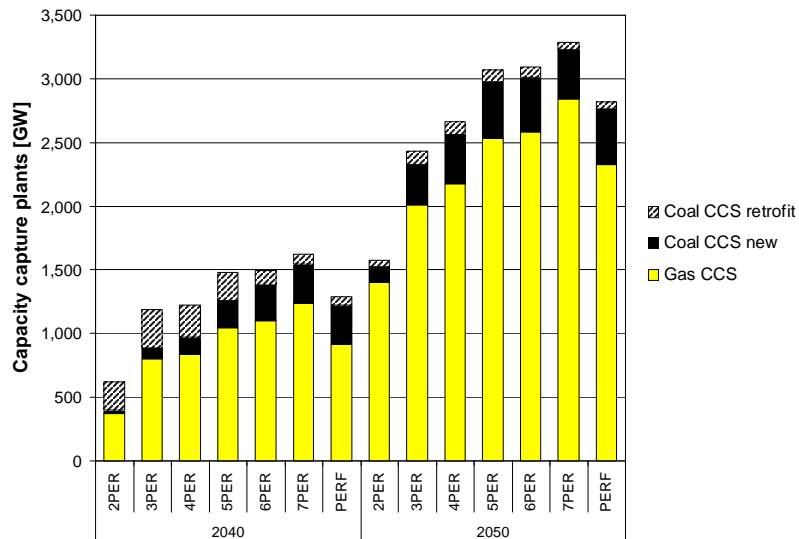
	2005-2010	2010-2020	2020-2030	2030-2040	2040-2050
World	3.1%	2.9%	2.8%	2.6%	2.5%



## Mitigation scenario: CO<sub>2</sub> emissions

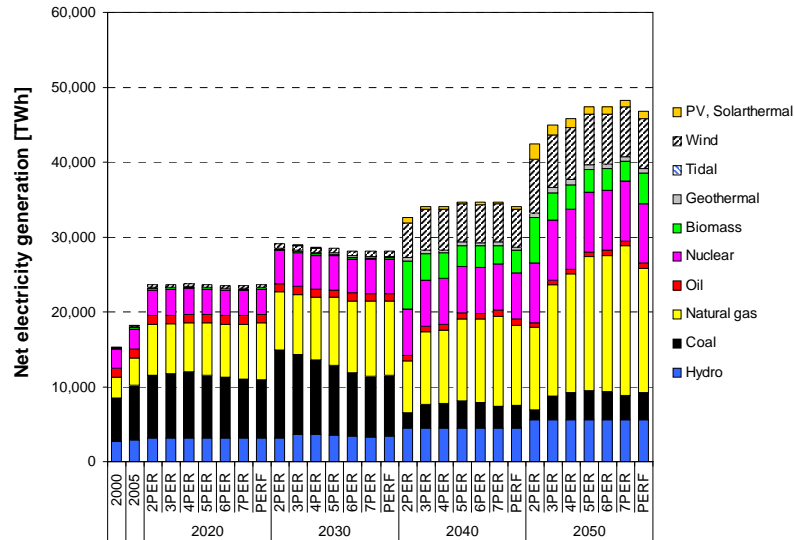


## Capacity of capture plants

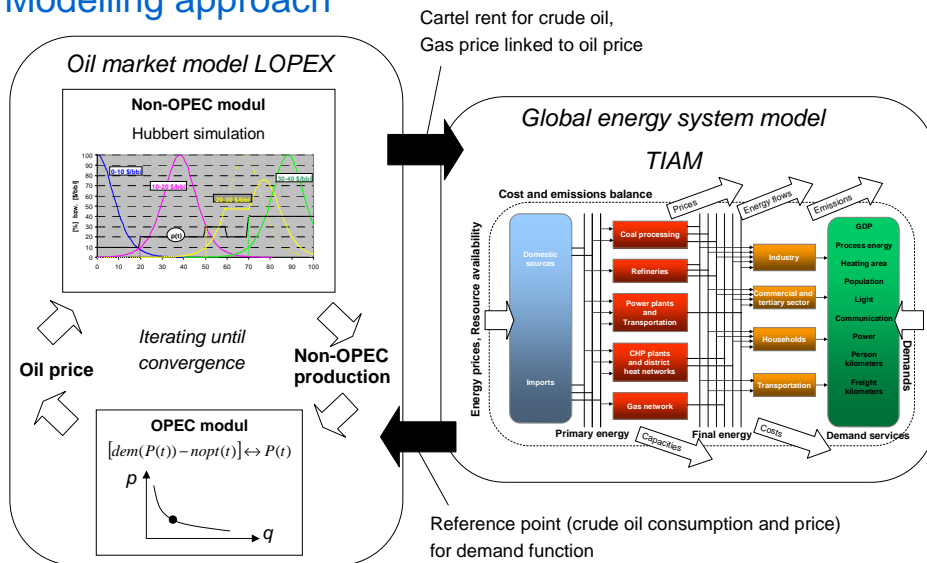




## Mitigation scenario: Electricity generation

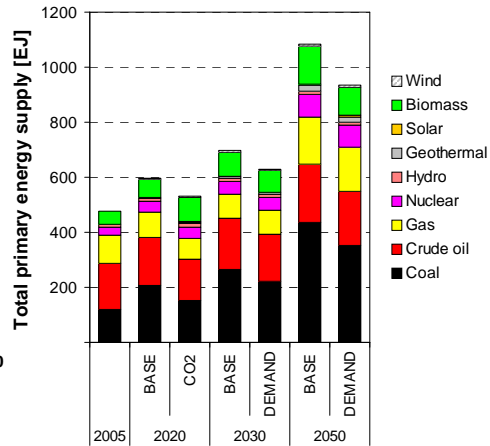
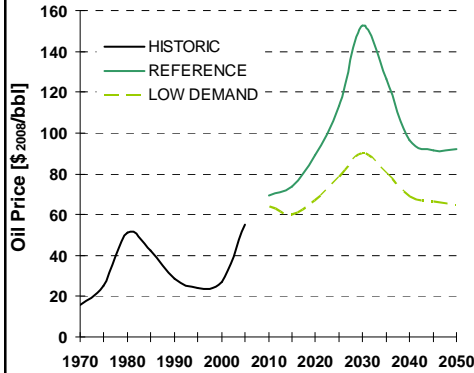


## Modelling approach





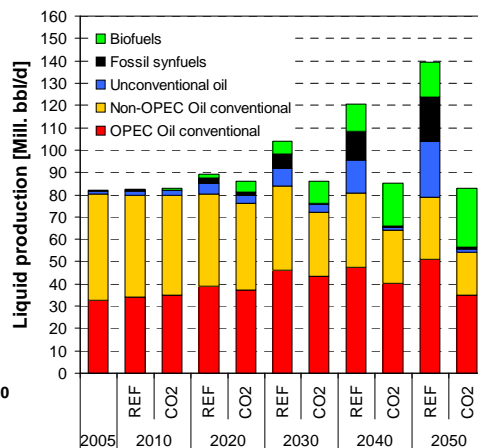
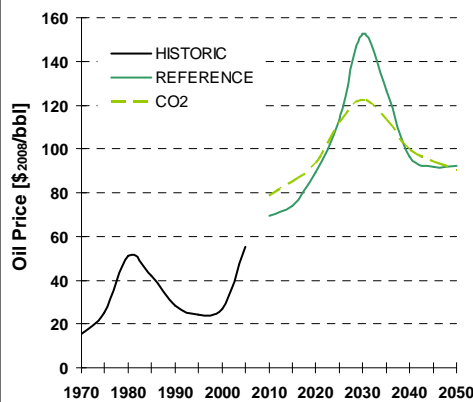
## Lower economic growth



Global GDP growth	2000 - 2010	2010 - 2020	2020 - 2030	2030 - 2040	2040 - 2050
Reference	3.1%	2.9%	2.8%	2.6%	2.5%
Low demand	2.7%	2.4%	2.4%	2.3%	2.2%



## Climate Policy



- Assumption:
  - Global CO<sub>2</sub> price increasing from 25 \$/t to 350 \$/t in 2030 and afterwards staying at that level.

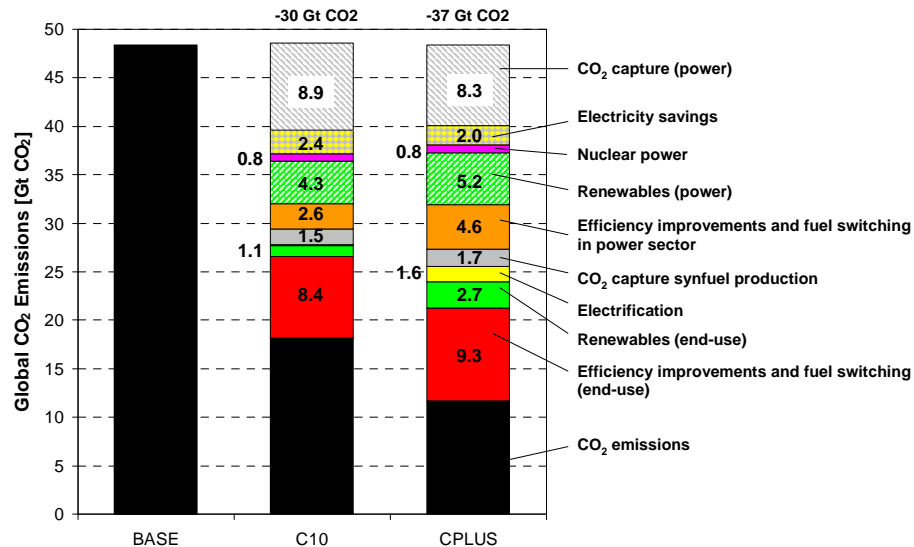


## Scenario analysis to achieve a low-carbon society (LCS)

- **LCS scenarios (time horizon until 2050):**
  - i. Baseline scenario (**BASE**): without explicit CO<sub>2</sub> mitigation efforts
  - ii. CO<sub>2</sub> price scenario (**C10**): Global CO<sub>2</sub> price scenario increasing from 10\$/t CO<sub>2</sub> in 2013 to 100 \$/t in 2050
  - iii. CO<sub>2</sub> Plus scenario (**CPLUS**): Global reduction in CO<sub>2</sub> emissions by 50% relative to 2000; assumption Kyoto is realized in 2010 (-5.2% rel. to 1990)
- **Assumptions:**
  - i. **GDP:**
    1. Global average GDP growth: 2000 – 2050: 2.8%, 2050 – 2100: 2.1%
    2. For comparison:
      - A1 scenario: 2000 – 2050: 3.9%, 2050 – 2100: 2.1%
      - B2 scenario: 2000 – 2050: 2.8%, 2050 – 2100: 1.5%
  - ii. **Discount rates:**
    1. Global discount rate (social time preference rate): 5%
    2. Region and sector specific discount rates for investments: 10-20%
  - iii. **Oil price:** 2005: 50 \$/bbl 2010: 55 \$/bbl 2020: 61 \$/bbl 2030: 65 \$/bbl 2050: 70 \$/bbl

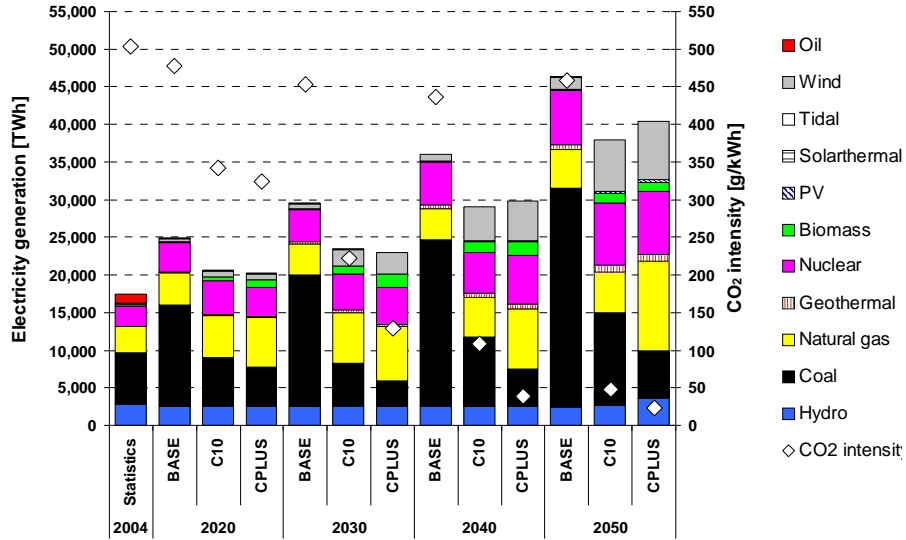


## CO<sub>2</sub> mitigation measures

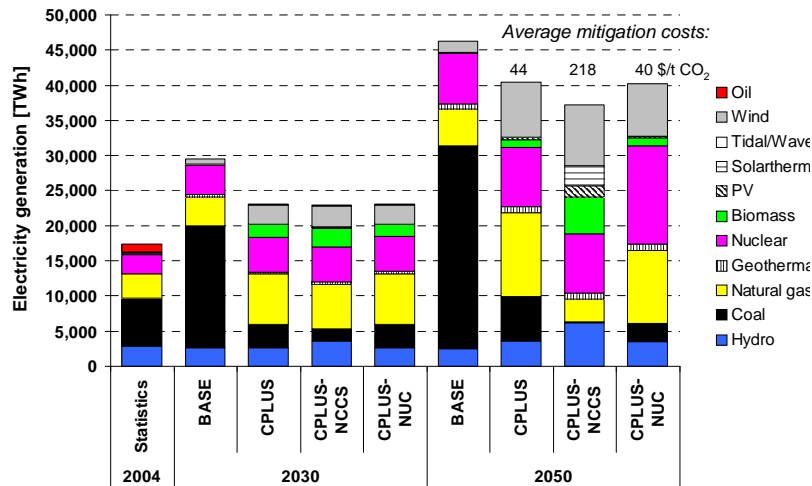




## Electricity generation



## Sensitivity analysis



- **CPLUS-NCCS:** No CCS available
- **CPLUS-NUC:** Increased nuclear generation; 14 GWh in 2050 compared to 8.4 GWh in CPLUS





Thank you!

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