Economic Impacts to Avoid Dangerous Climate Change Using the AIM/CGE Model

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Background Information

- Overall summary of the AVOID Programme and the Work Stream 1 have been explained by Jason Lowe, Rachel Warren, and John Caesar

- From economic aspects of AVOID, calculations of economic consequences (such as GDP and carbon price) when emissions are abated (under some policy scenarios) by economic models are required.
- E3MG (4CMR), PAGE (Judge Institute of Management), and AIM/CGE [Global] (NIES) are participating.

- My role in this programme is provide information on GDP and carbon price for each policy scenario (mainly global level) using the AIM/CGE [Global] model (at this moment).

AIM/CGE[Global]: Overview

- Economic model with energy and environment components
- Computable General Equilibrium model – CES (Constant Elasticity of Substitution) functions
- Dynamic – Recursive type from 2001 to 2100 (10-year time steps), so that economy at equilibrium in each step
- Industrial sectors: 21; World regions: 24; Primary factors: 4
- Gases: CO2, CH4, N2O, SO2, NOx, CO, NMVOC, NH3, BC, OC (F-gases are external)

AIM/CGE[Global]: Overview (*Cont.*)

- Energy:
  - Type: Coal, oil, natural gas, oil products, gas, electricity, (biomass)
  - Power generation: thermal (coal, oil, gas, oil products), nuclear, renewables (hydro, biomass, waste, geothermal, solar, wind, others), and some with CCS technology (fossil fuels and biomass)
  - Biomass energy: conventional and unconventional (purpose-grown energy crops used for electricity, bio-fuel, and bio-gas)

- Output: economic indicators, energy, and emissions

- Data sources: GTAP6, EDGAR, IEA, FAOSTAT, and others including the original data set for the AVOID BAU scenario

Industrial Sectors

Red: Energy sectors

Table: 21 Industrial Sectors

Code	Including Sectors	Code	Including Sectors
COA	Coal	OMN	Other mineral mining
OIL	Crude oil	M_M	Metals & manufacture
GAS	Natural gas	FOD	Food processing
P_C	Petroleum & coal products	OMF	Other manufacture
GDT	Gas manufacture & distribution	CNS	Construction
ELY	Electricity	TRT	Transportation
AGR	Agriculture	CMN	Communication
LVK	Livestock	WTR	Water
FRS	Forestry	OSG	Governmental services
FSH	Fishery	SER	Other services
EIS	Energy intensive industries		

White: Non-Energy sectors

World Regions

Table: 24 Regions

Code	Including Countries	Code	Including Countries
AUS	Australia	XRA	Rest of Asia-pacific
NZL	New Zealand	IDN	Indonesia
JPN	Japan	THA	Thailand
KOR	Korea	XSE	Rest of Southeast Asia
CAN	Canada	IND	India
USA	USA	XSA	Rest of South Asia
MEX	Mexico	ARG	Argentina
XE15	Western EU countries	BRA	Brazil
RUS	Russia	XLM	Rest of Latin America
XE10	Eastern EU countries	XME	Rest of Middle East
XRE	Rest of Europe	ZAF	South Africa
CHN	China & Hong Kong	XAF	Rest of Africa

Blue: Asian Regions

Baseline Scenario

- Harmonization: SRES A1B for population and expected GDP (country basis provided by Rachel Warren)
- However, basic parameters and technology settings are same as the original AIM/CGE model.

  => NOT possible to duplicate the original A1B emissions

- No climate-feedback effect
- Exogenous technology change (so called AEEI: Autonomous Energy Efficiency Improvement), but effect of investment is considered by a putty-clay approach
- Full employment and equilibrium

- Calculation: without emissions control

Baseline Scenario

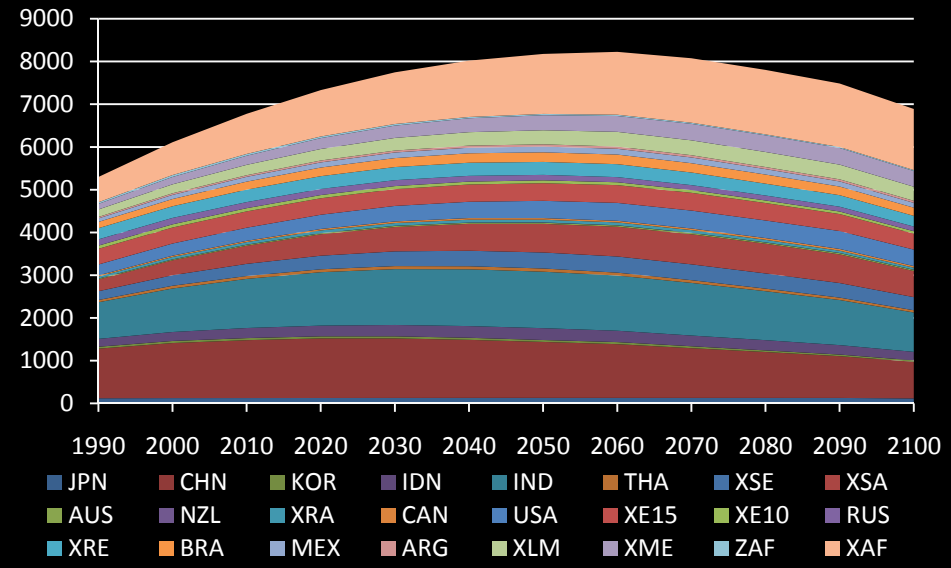


Figure: Population (mil.)

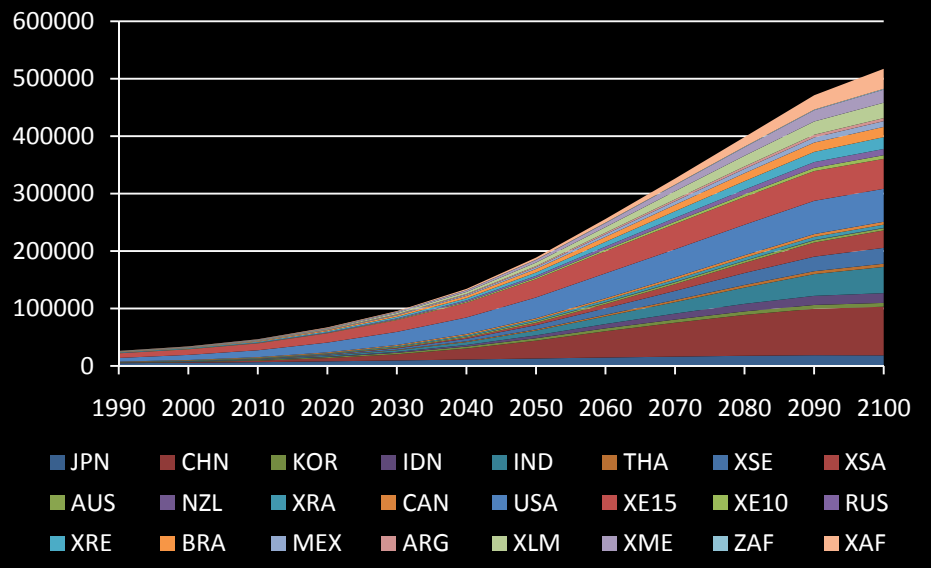


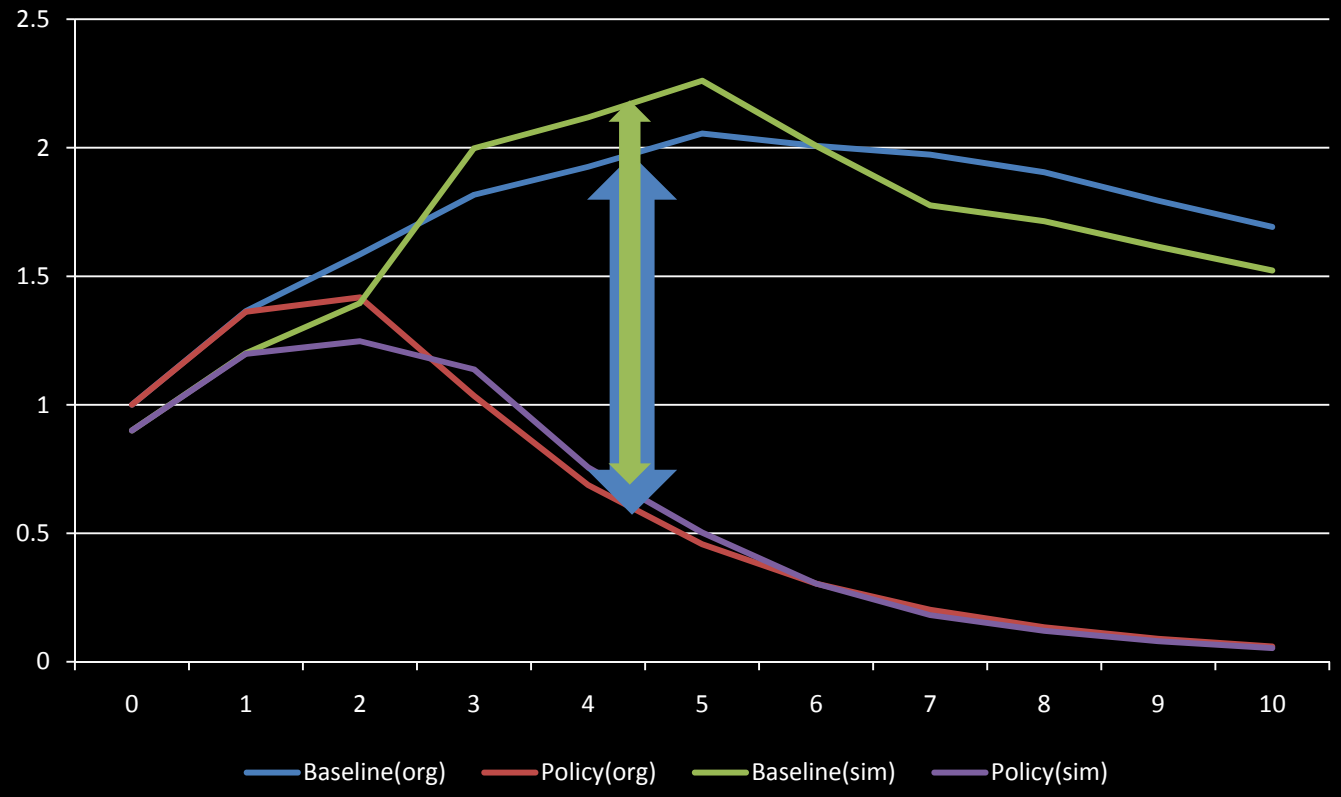
Figure: Expected GDP (bil. $)

Policy Scenarios

- 5 policy scenarios (based on peak and abatement amount: 2016r2high, 2016r4low, 2016r5low, 2030r2high, 2030r5high)
- Gases emissions pathways are provided for each scenario (from Rachel Warren)
- Target gases: CO2, CH4, N2O, NOx, NMVOC, CO, SO2, (some F-gases)

- Calculation: with emissions control for each gas
  - Basic settings are same as the baseline scenario
  - Emission abatement rates (between original baseline and each policy scenario) are used instead of the absolute values for each scenario to control the emissions – because the calculated baseline emissions are different from the original emissions.
  - Output: carbon price, GDP, etc. No climate change damages involved
  - The results are compared with E3MG in AVOID

Policy Scenarios



Abatement rates between the baseline and policy scenarios are applied rather than absolute abatement amount for the policy scenario simulations.

Fossil Fuel CO2 Emissions of Baseline and Policy Scenarios (GtCO2)

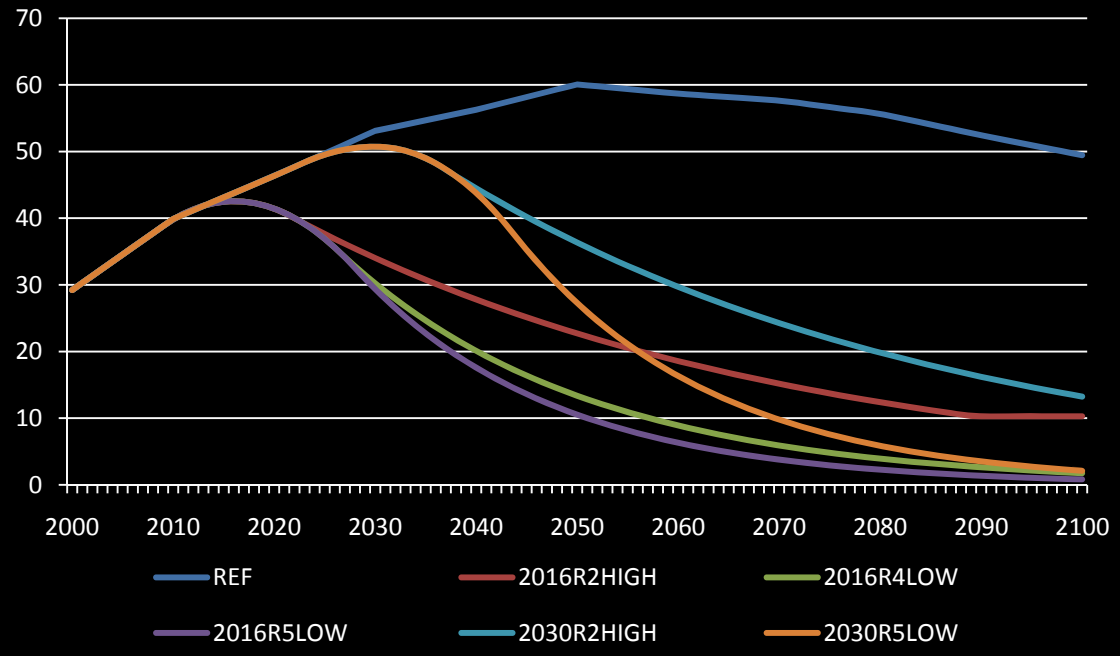


Figure: CO2 Emissions Comparison

Result (Carbon Price: $/tCO2)

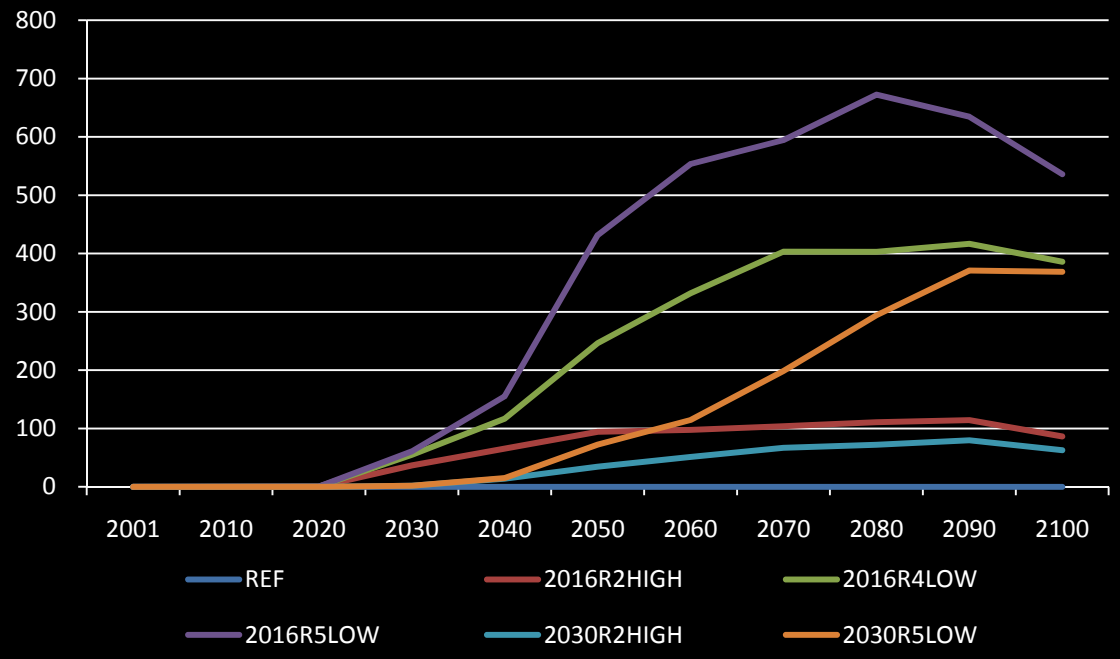


Figure: Carbon Price Comparison

Result (GDP: bil. $)

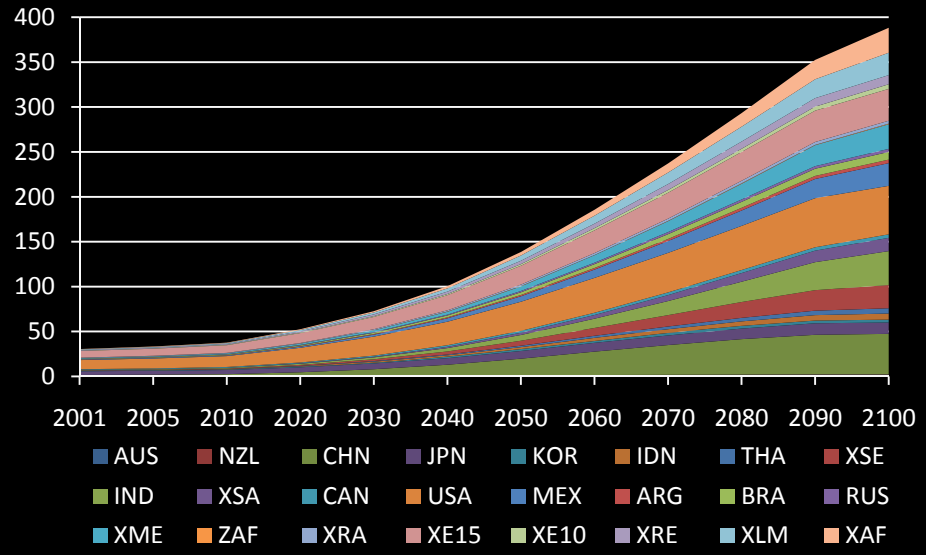


Figure: GDP by Region

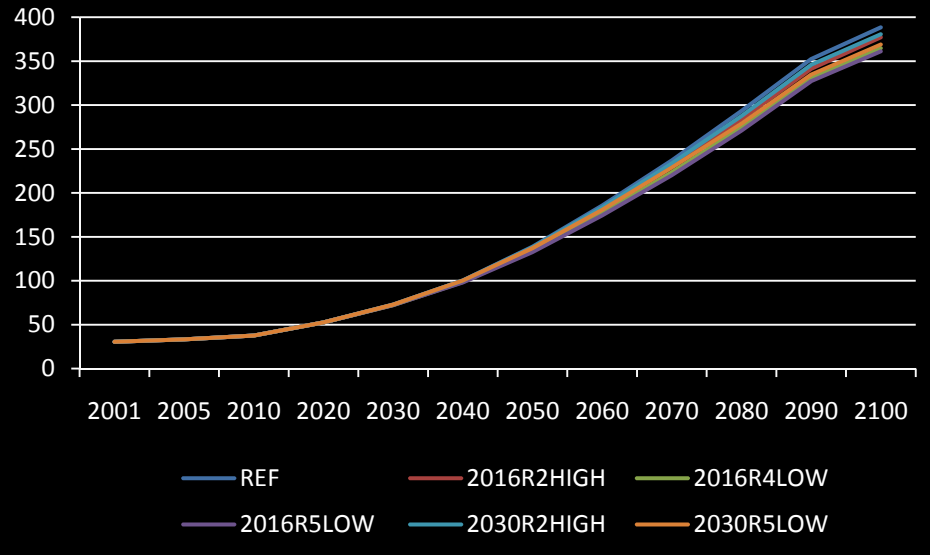


Figure: GDP Comparison

In 2100, GDP decreases 2.9% (2016R2HIGH), 6.1% (2016R4LOW), 7.0% (2016R5LOW), 2.0% (2030R2HIGH), and 5.0% (2030R5LOW) compared to the baseline scenario

Concluding Remarks

- Carbon price:
  - Higher carbon prices are required to cause global emissions to peak in 2016 compared to 2030, and are also required to abate emissions more rapidly.
  - The larger the emissions abatement amount, the higher the carbon prices will be.

- GDP change:
  - GDP decreases for all policy scenarios compared to the baseline scenario.
  - However, the decrease rates are not so large and GDP is still increasing over time. The differences between the policy scenarios are also small.
  - The larger the emissions abatement amount, the higher the decrease rates will be.

Concluding Remarks

- The results from the AIM/CGE model are quite different from those from E3MG. The main reasons are:
  - Technological change: exogenous vs. endogenous
  - Revenue recycling: lump-sum to consumer vs. lowering indirect tax and incentives to low-carbon technology development
  - Timing of emissions abatement (approach): later vs. earlier
  - Modeling approach: equilibrium vs. non-equilibrium