WHY DO WE PREFER BELOW 2 DEGREE WARMING WORLD AND HOW DO WE ACT IN THE DIFFERENT CONDITIONS?

Shunsuke Mori
Department of Industrial Administration
Tokyo University of Science

IAEE Italy, Milan, 30/11/2016 – 2/12/2016

Background

In December 2015, the world has agreed with the need for the stringent global climate change mitigation policy.

"Emphasizing with serious concern the urgent need to address the significant gap between the aggregate effect of Parties' mitigation pledges in terms of global annual emissions of greenhouse gases by 2020 and aggregate emission pathways consistent with holding the increase in the global average temperature to well below 2 Celsius degree above preindustrial levels and pursuing efforts to limit the temperature increase to 1.5 Celsius degree above preindustrial levels." (UNFCC, CP/2015/L.9/Rev.1, 12 December, 2015)

However, large uncertainties remain with respect to the future global temperature rise provided by the current climate models.

For instance, IPCC-AR5 failed to give ***"recommended" climate sensitivity*** unlike previous reports in spite of the scientific and technological progress in the related data acquisition, treatment and modeling.

Why Do We Prefer Below 2 Degree World?

Did we choose “2 Degree World” ***unconditionally*** or ***conditionally***?

⇒ If we stick to the “2 Degree World” as the first priority issue, then we should accept any possible options ***unconditionally*** to keep the target.
⇒ If we employ the “2 Degree World” under ***the certain conditions***, then we will slightly “offset” our behavior according to the new conditions yet keeping our attitude. (*e.g. new knowledge on the climate sensitivity, delay of action due to unexpected event, etc.*)

The purpose of this study:
(1) What assumptions do we have when we agree with the two degree warming world?
(2) How should we shift the climate target ***consistently*** according to the changes in the presumptions?

Methods:

- DICE-2013R by Nordhaus derives “2 degree world” as the optimal solution by imposing 0.1% discount rate and long term optimization horizon as well as relatively optimistic assumptions on the carbon mitigation options.
- However, other IAMs based on Cost-Benefit approaches have failed to generate the “2 degree world” as the inter-temporal optimization behavior.

WHY DO WE REJECT SUCH WARMING WORLD?

- Due to the risk aversion of “tipping events”
- Possible externality in the warming world
- Simply we do not like it.

⇒ These may not be explicitly formulated in the optimization models, but still **we prefer “2 degree world”.**

We expand MARIA to assess the effects of “assumption” changes.

MARIA model and Expansion

MARIA (Multiregional Approach for Resource and Industry Allocation)
- an inter-temporal optimization model integrating top-down macroeconomic activity and bottom-up technology flows

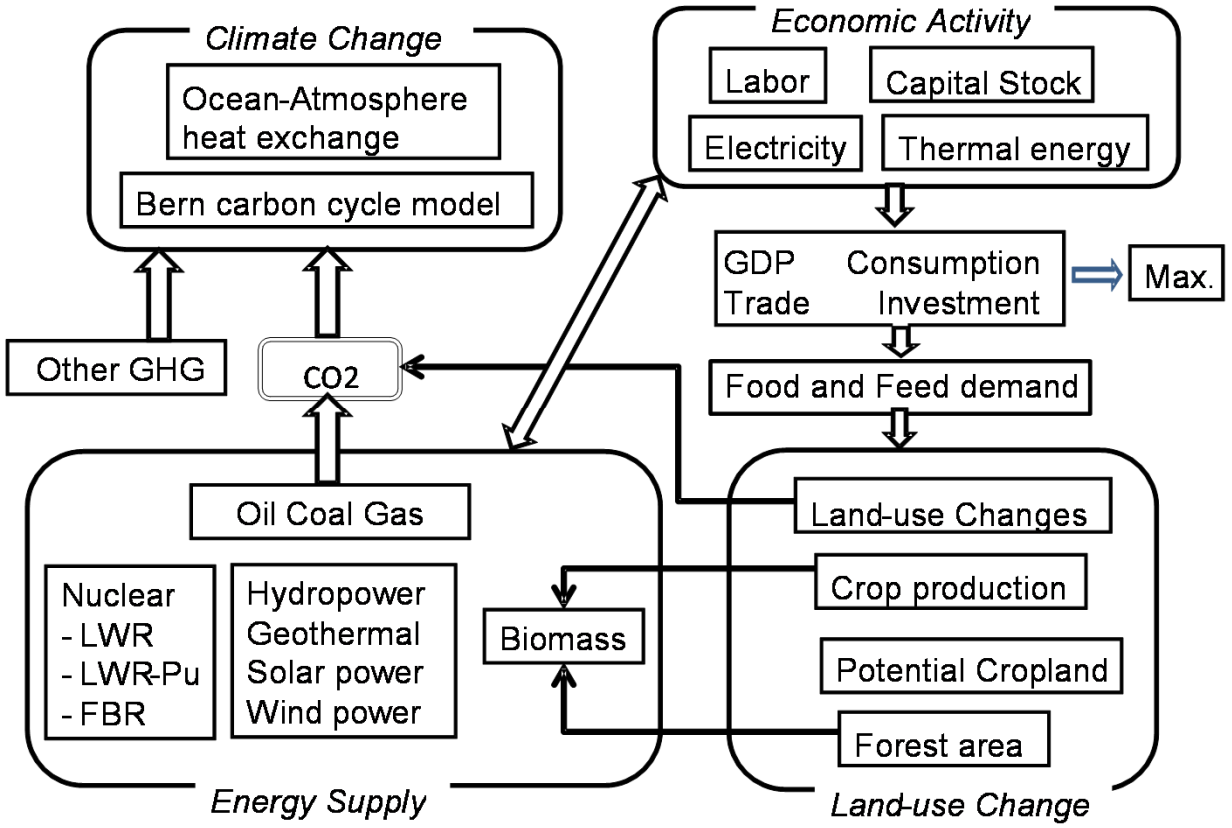


Figure Structure of MARIA model

Expansion of the objective function to represent our Choice

Assumption:
- The utility should be discounted by the atmospheric temperature similar to the DICE warming damage function.

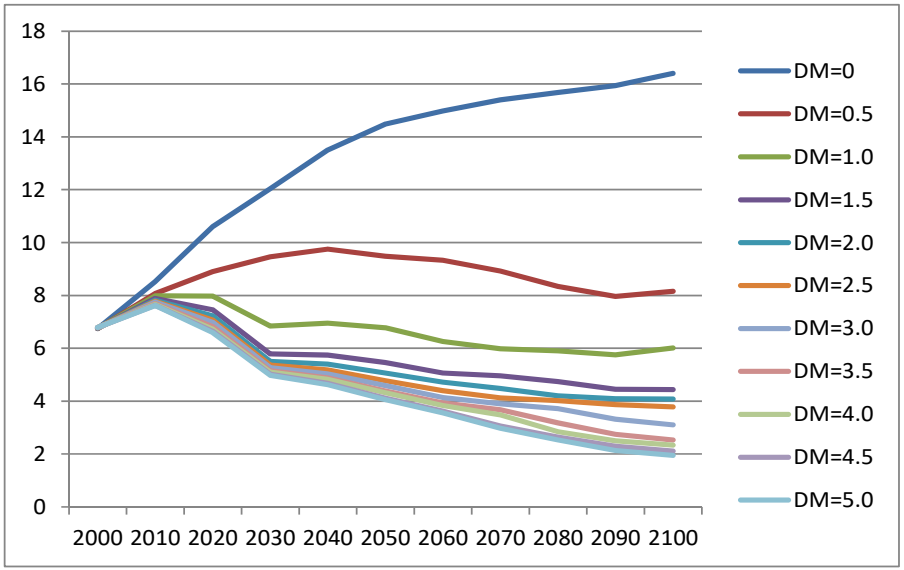
$$U(C,T) = u(C) / \{1 + \delta(T)\}, \quad u(C) = L \frac{\left(C/L\right)^{1-\gamma}}{1-\gamma}$$

$$\delta(T) = \varphi\left(\frac{T}{T^*}\right)^{\theta} \quad or \quad \delta(T) = \varphi\left(\frac{T - T_0}{T^* - T_0}\right)^{\theta}$$

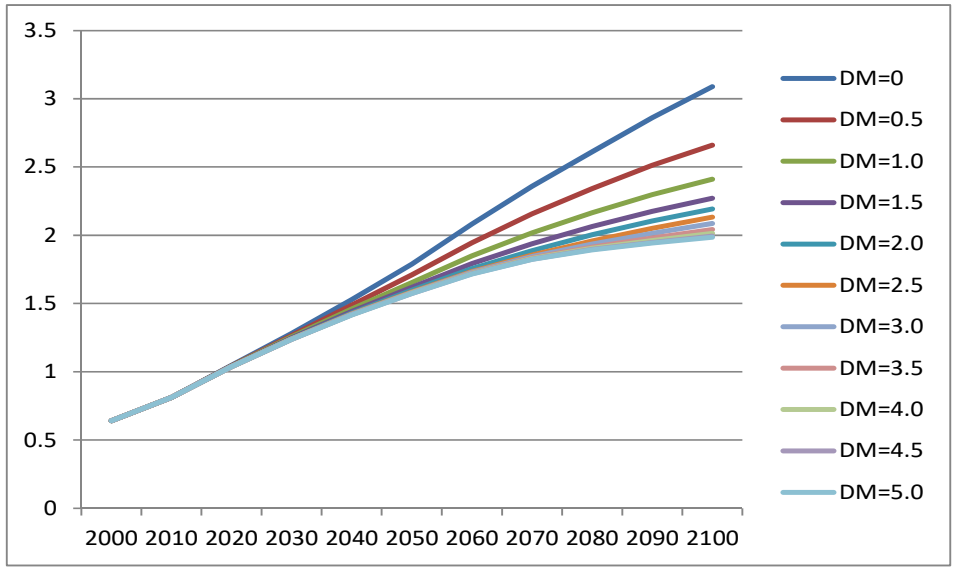
$\theta = 2$, $T^* = 3.0$, $T_0 = T_{1990}$

Parameters are set based on the sensitivity analysis.

Sensitivity Analysis on ϕ : Multiplier on the DICE warming damage parameter



Carbon emission (GtC)



Atmospheric temperature (°C)

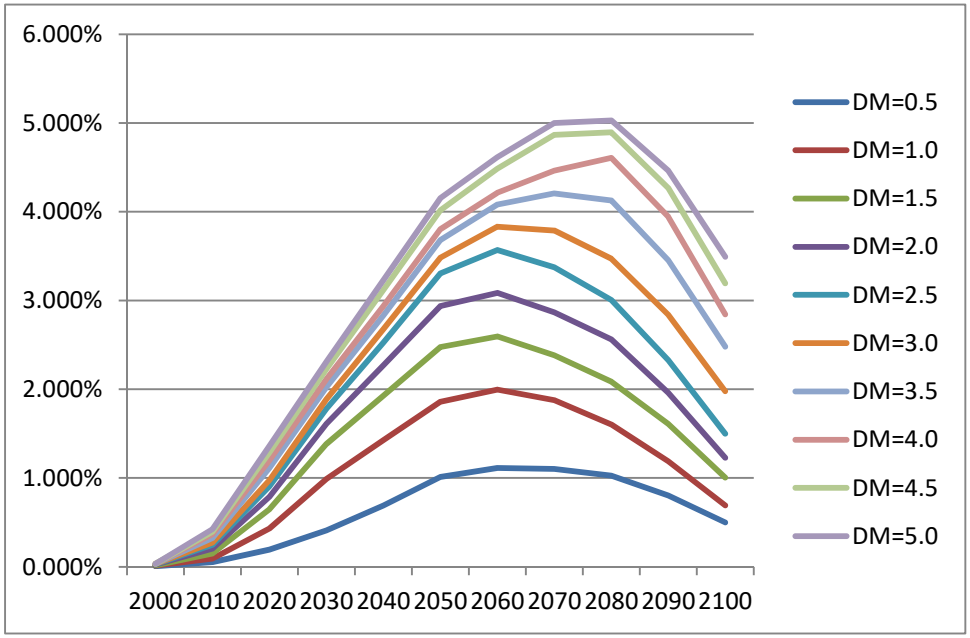
Table 1 Utility damage factor, cumulative CO2 emission for 2005-2100 in Gt CO2 and atmospheric temperature

Damage factor	DM=0	DM=0.5	DM=1.0	DM=1.5	DM=2.0	DM=2.5	DM=3.0	DM=3.5	DM=4.0	DM=4.5	DM=5.0
Cumulative carbon emission (Gt-CO2)	5043.1	3240.4	2437	2053.4	1929.3	1847.1	1752.8	1650.1	1599.9	1534.1	1504
T_{2100}	3.09	2.66	2.41	2.27	2.19	2.13	2.09	2.04	2.01	1.99	1.99

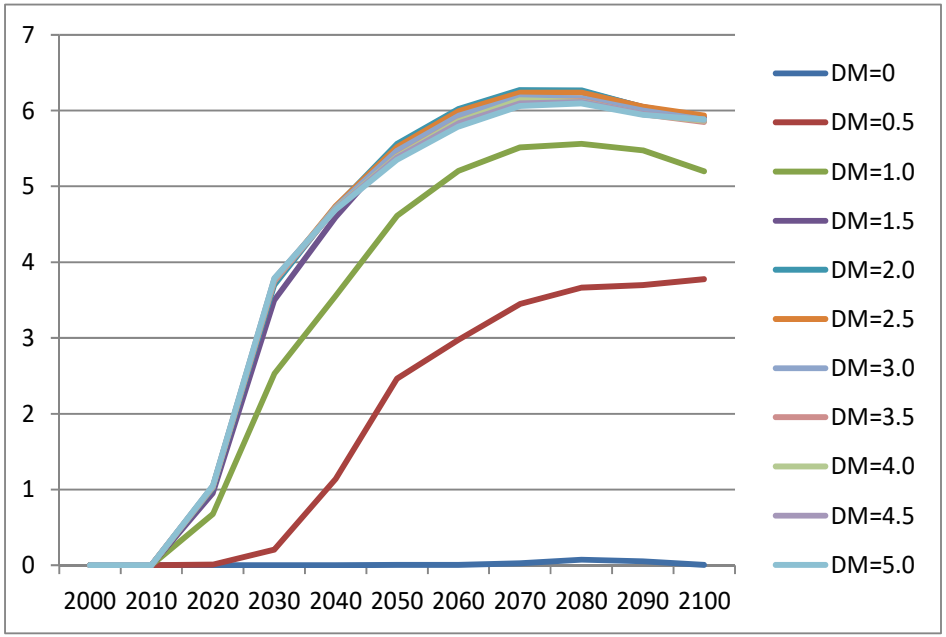
Consistent with AD-DICE CS=3.0 TG=2.0 degree case

MARIA represents the “2 Degree World” in the views of

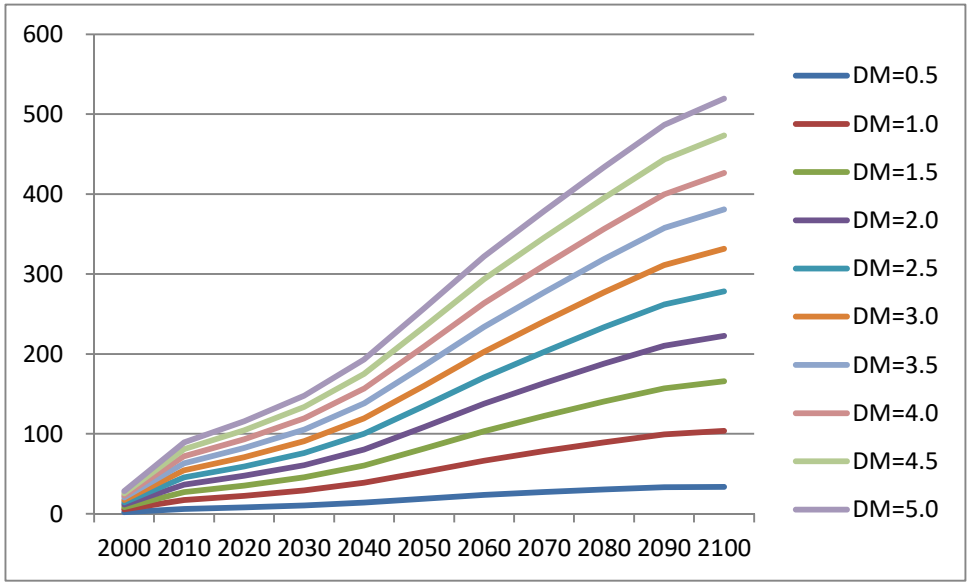
- Climate sensitivity 3.0℃, Improving energy efficiency, availability of biomass and CCS, and potential energy savings in transportation sector (50% energy saving would be possible by additional 1% of GDP expenditure.)
- **Utility damages at the 3℃ rise is around 4.5 times of the market loss by the climate changes**.



GDP Loss from BAU (DM=0.0)



CCS Implementation in Gt-C

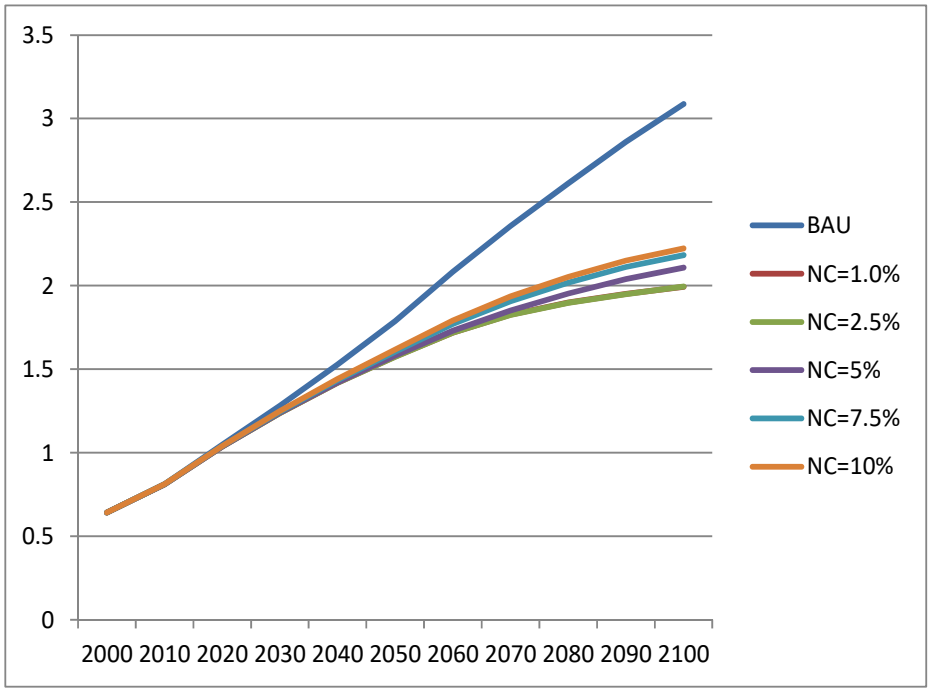


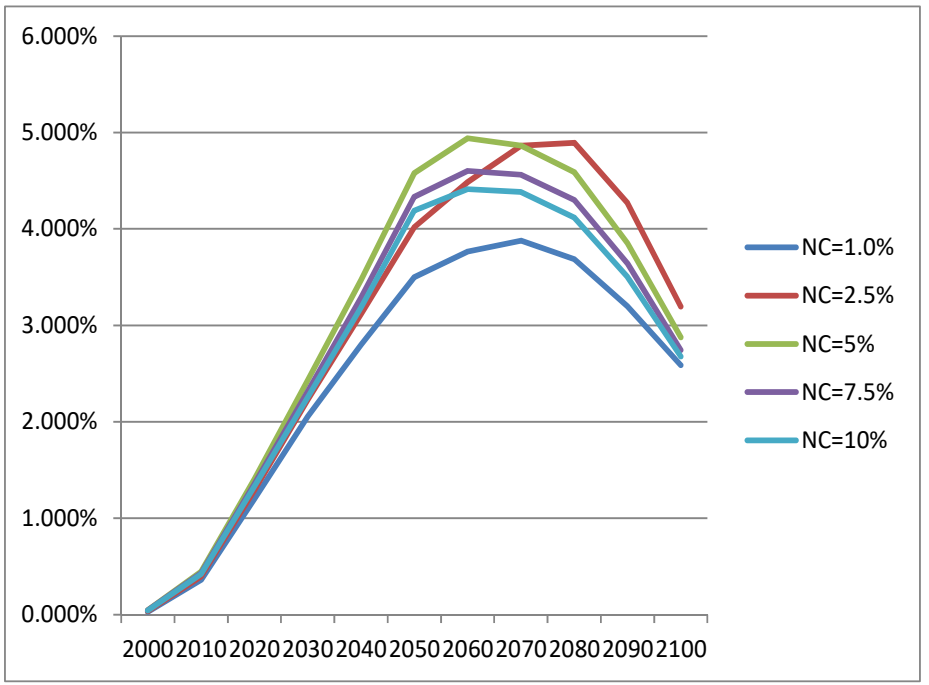
CO2 Emission prices（$/t-CO2)

When DM=4.5:

- GDP loss (around 5% at maximum) is consistent with IPCC-AR5-WG3.
- CO2 emission price (around 450 $/t-CO2) is moderate.

Cost parameters of the potential mitigation of forcing caused by non-carbon GHG emissions:
Additional GDP expenditure (NC) in % to reduce the 80% of non-carbon GHG forcing.



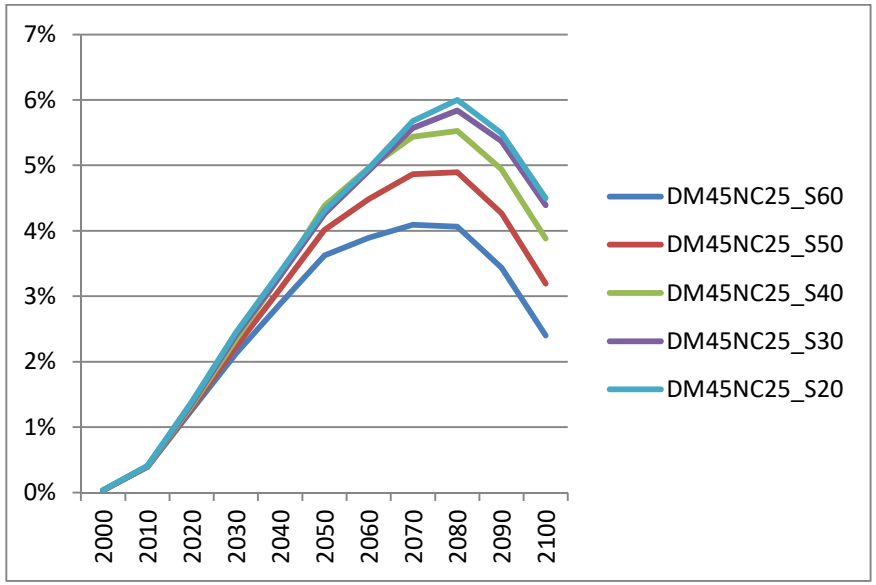


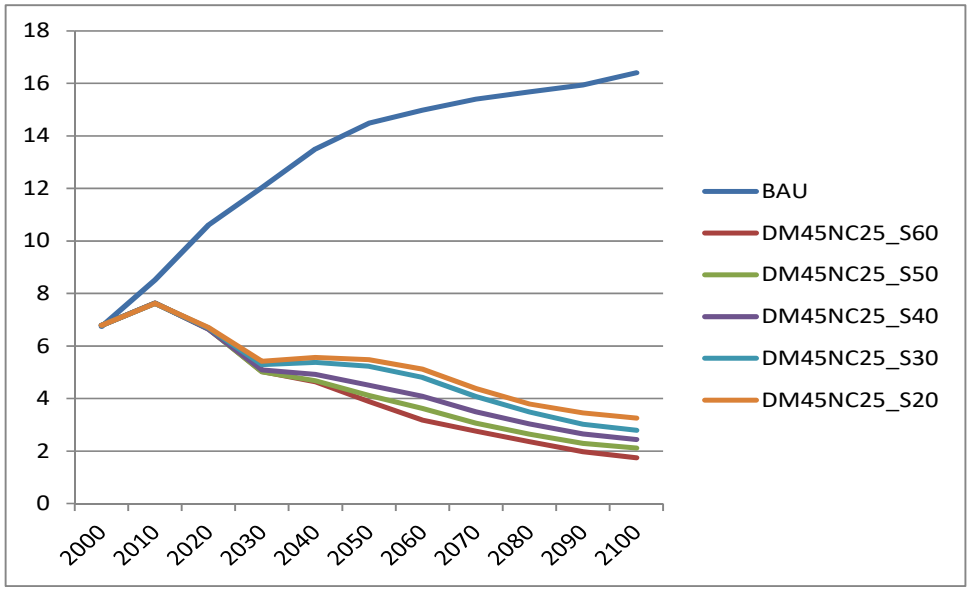
Changes in the atmospheric temperature
- 2.0℃ rise when NC is less than 2.5%, while 2.1℃ rise when NC 5%.

Profiles of GDP losses in %

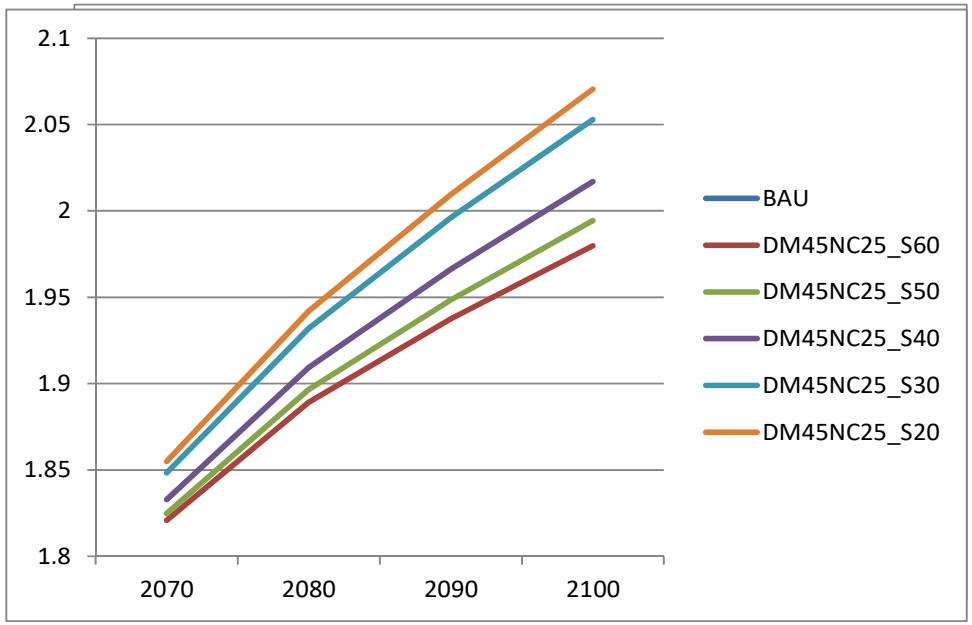
Sensitivity Analysis:

1: Changes in the Energy Saving Potentials





GDP Losses from BAU(DM=0.0 : S50)



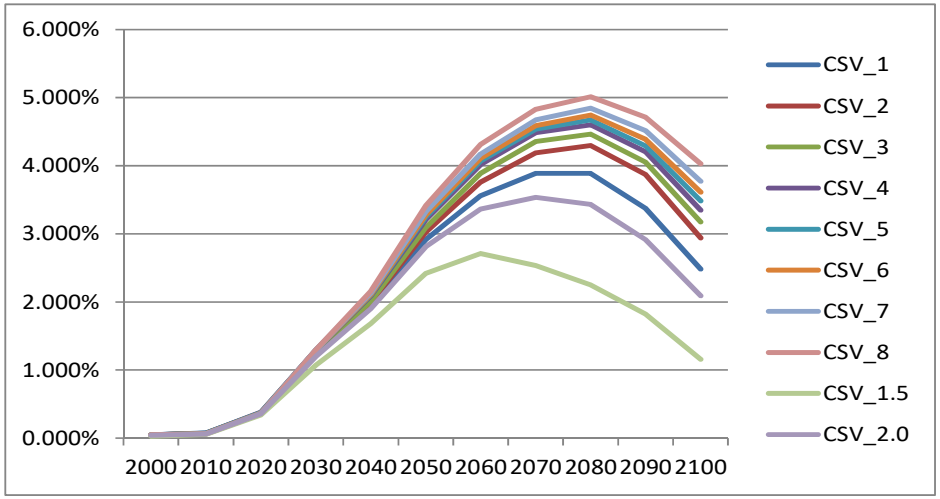
CO2 Emissions in Gt-C

Note: Sxx represents xx% energy saving is available at additional 1% of GDP expenditure.

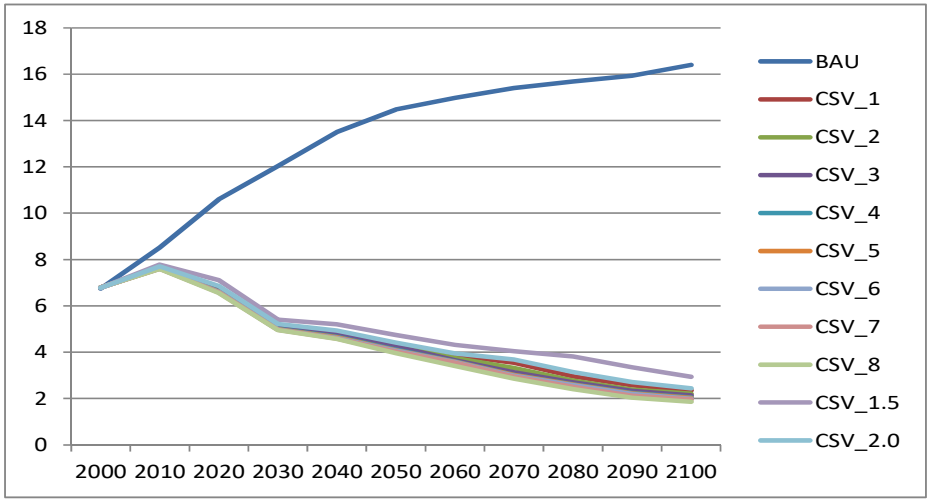
Atmospheric temperature will rise 0.1 degree when energy saving potential is lowered.

Sensitivity Analysis 2: Changes in the climate sensitivity

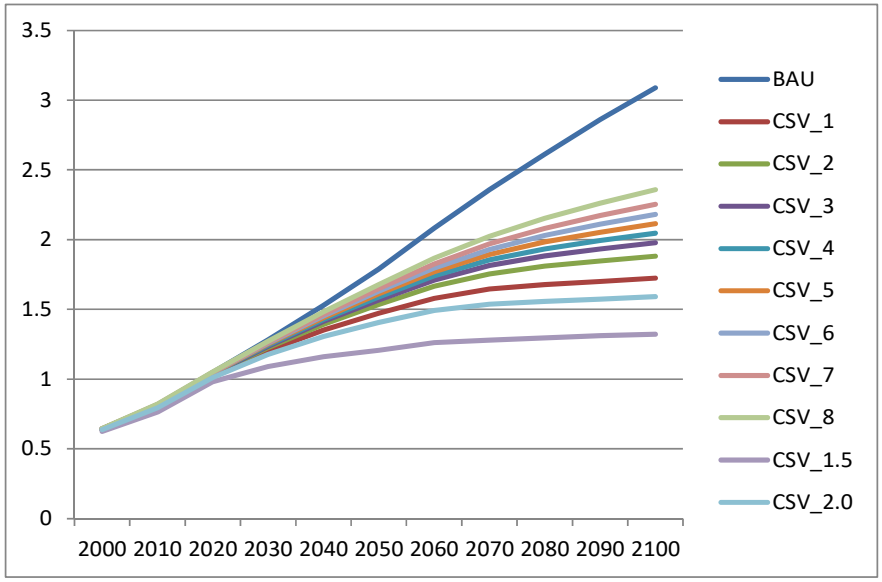
Scenario	1	2	3	4	5	6	7	8
CS	2.285	2.665	2.935	3.165	3.415	3.695	4.055	4.725



GDP Loss from BAU(DM=0.0：S50)

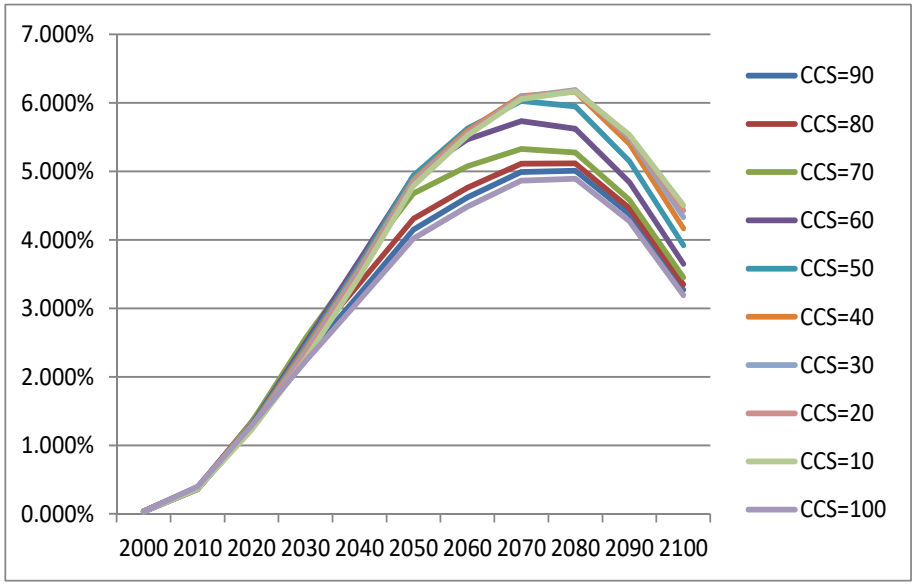


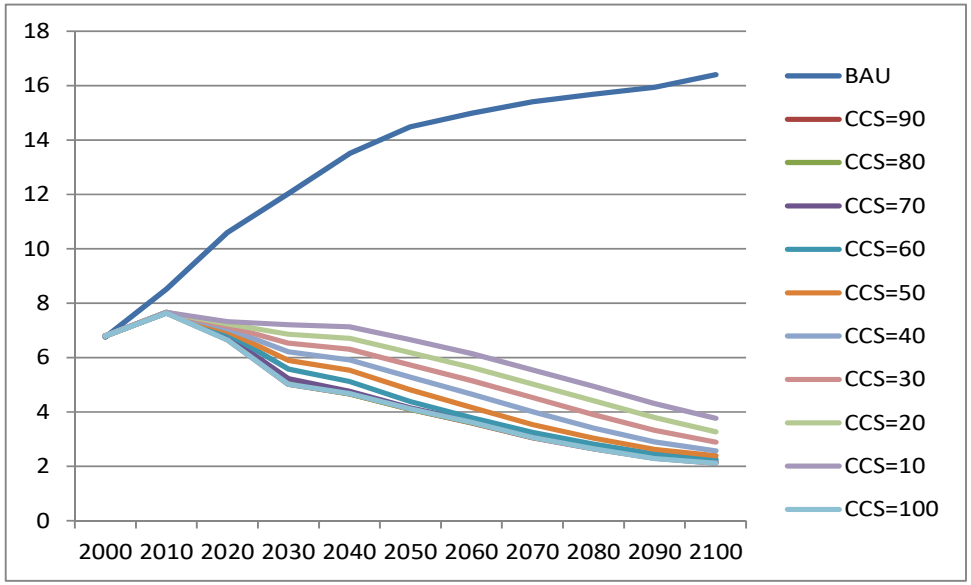
Changes in CO2 Emission



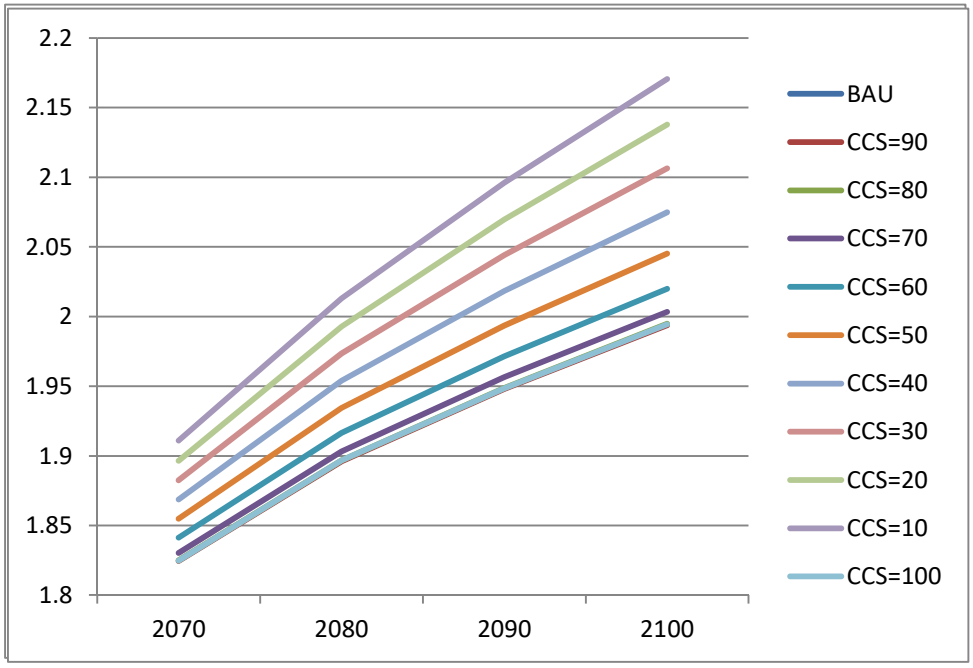
When Climate sensitivity strays from 3.0,
- The efforts to mitigate CO2emissions still continue, but the world accepts the temperature changes less than 0.3 degree.
- GDP loss appears less than 5%.

Sensitivity Analysis 3: Changes in Potential CCS implementation





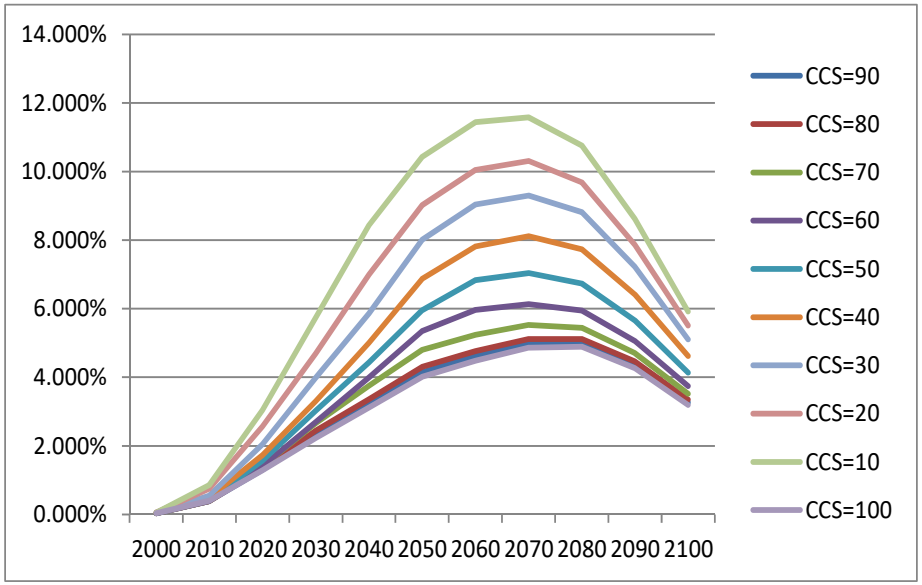
GDP losses from BAU



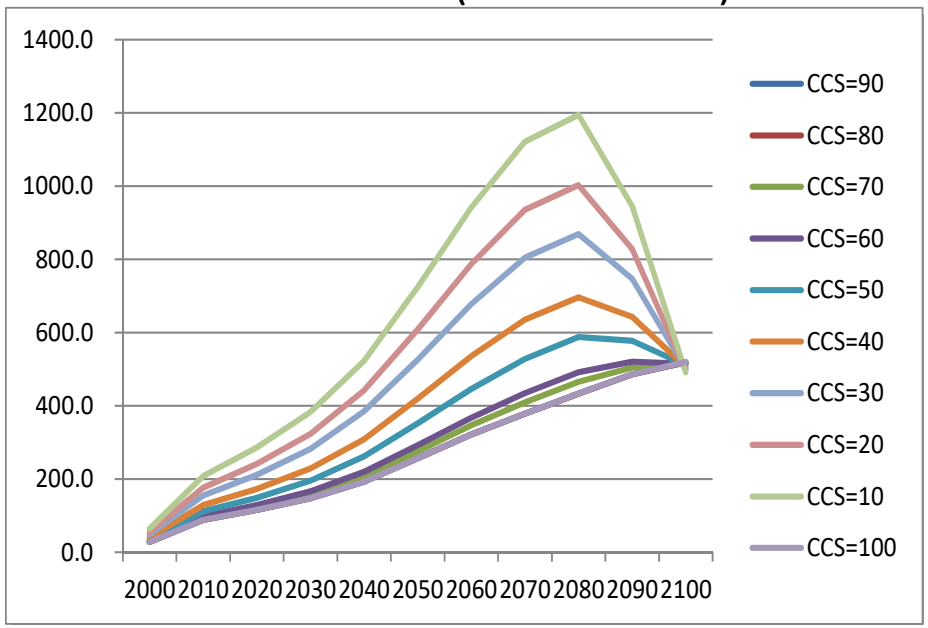
CO2 emission changes

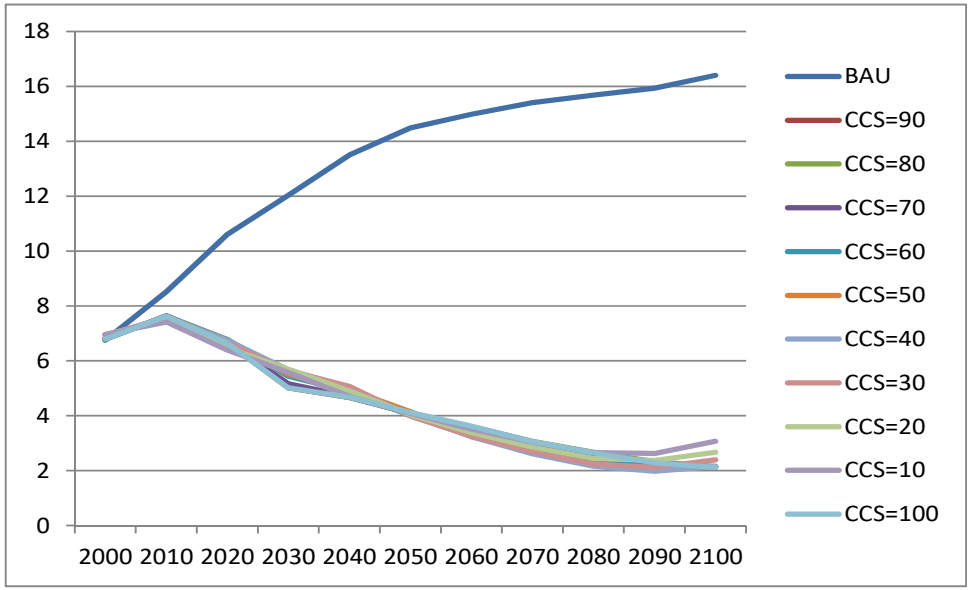
Assumptions on CCS implementation
- GDP losses increase around 1% as CCS is limited.
- Global temperature rises around 0.17℃ as CCS is limited.

Sensitivity Analysis 3': Changes in Potential CCS under 2℃ limit



GDP Loss from BAU(DM=0.0 : S50)



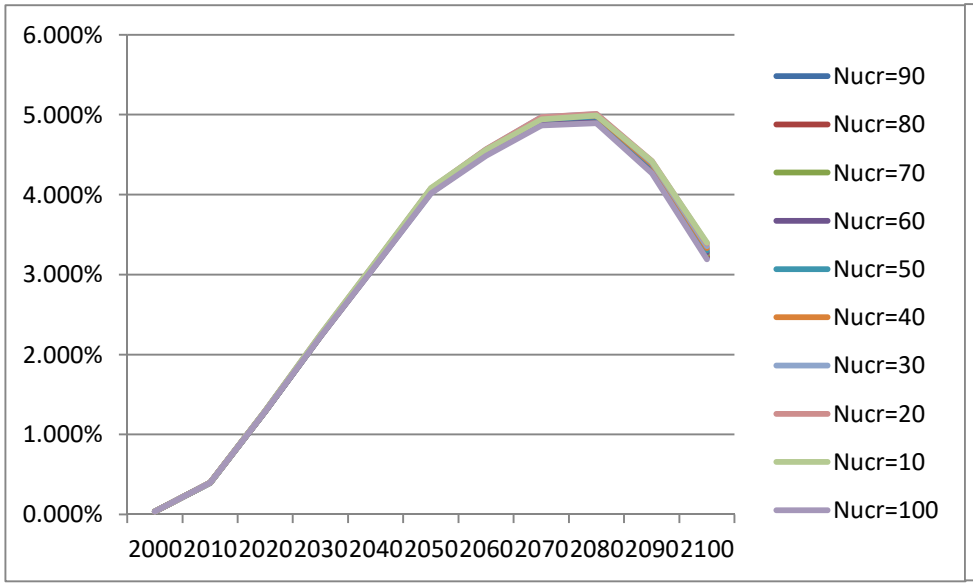


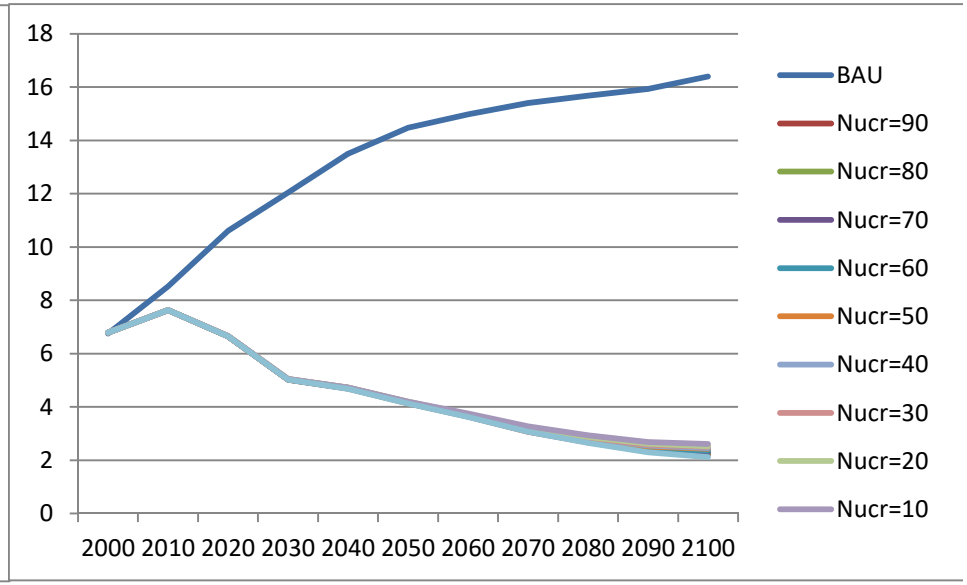
Changes in CO2 emissions

When 2 degree target is strictly kept,

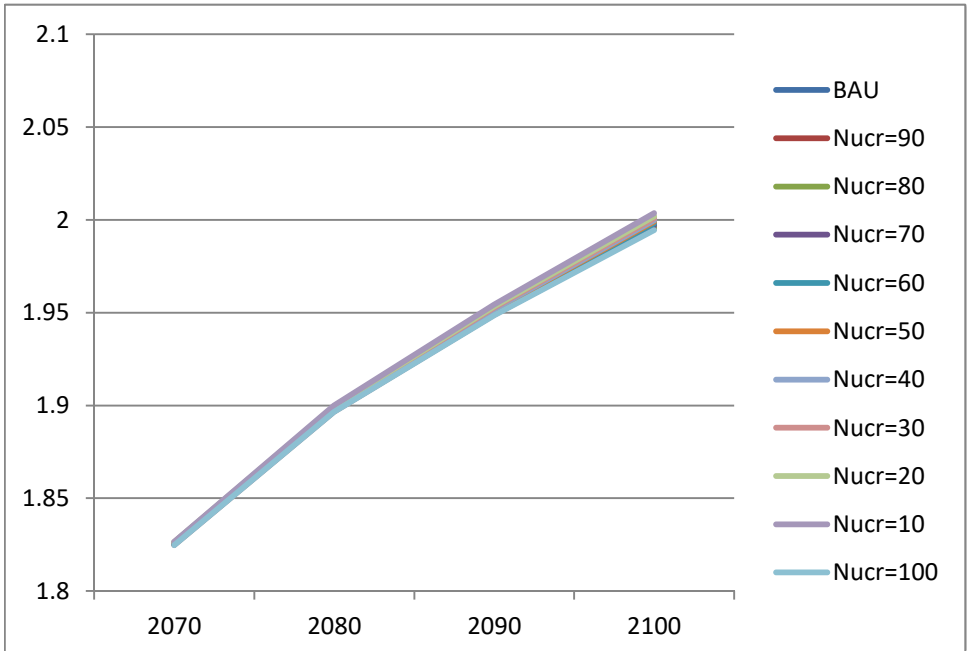
- GDP losses increase rapidly: from 5% to 12%.
- Carbon emission prices also rise around ~1200($/tCO2) , twice of previous case.

Sensitivity Analysis 4: Changes in Potential Nuclear power





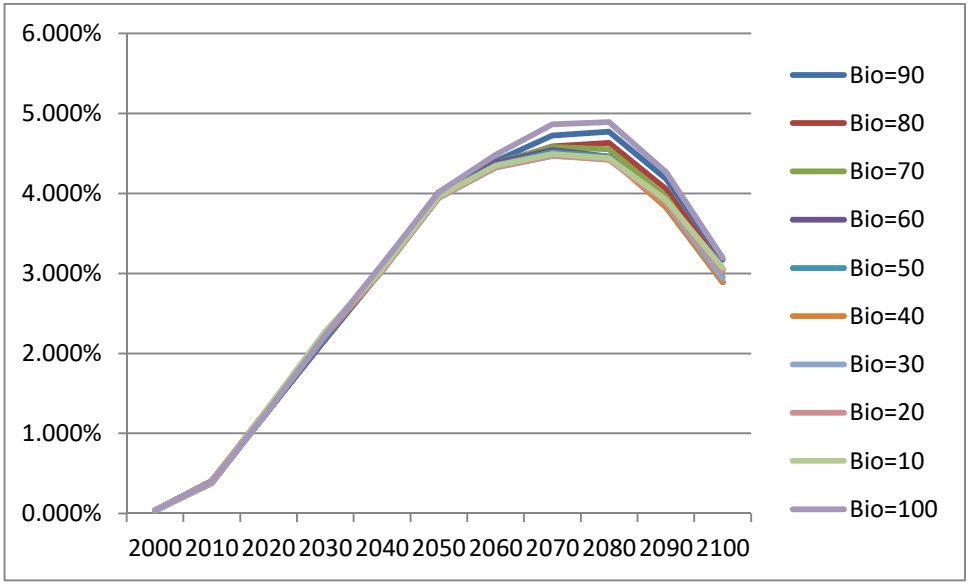
GDP loss from BAU(DM=0.0：S50)

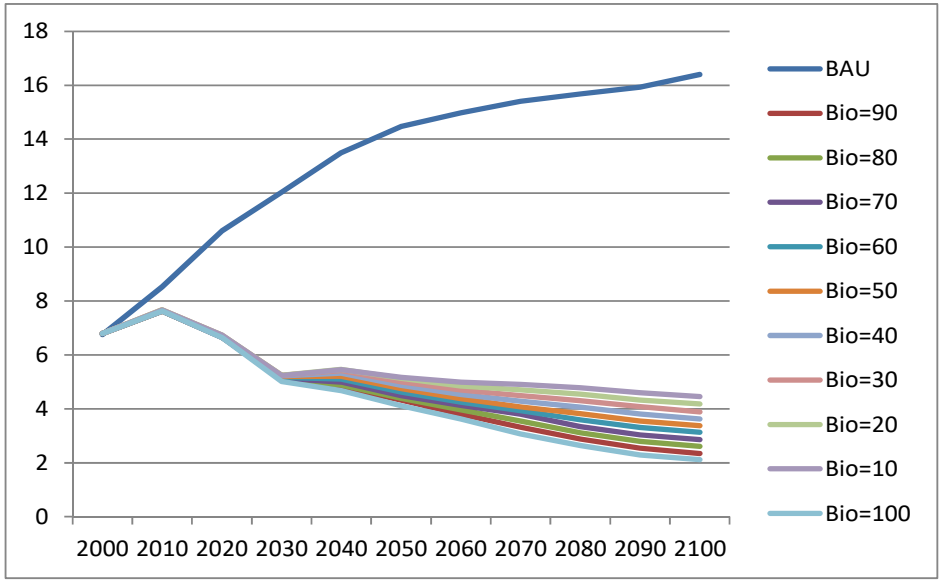


Changes in CO2

- Effects of nuclear power potential is small. This is due to the expansion of CCS.
- Temperature changes are also small.

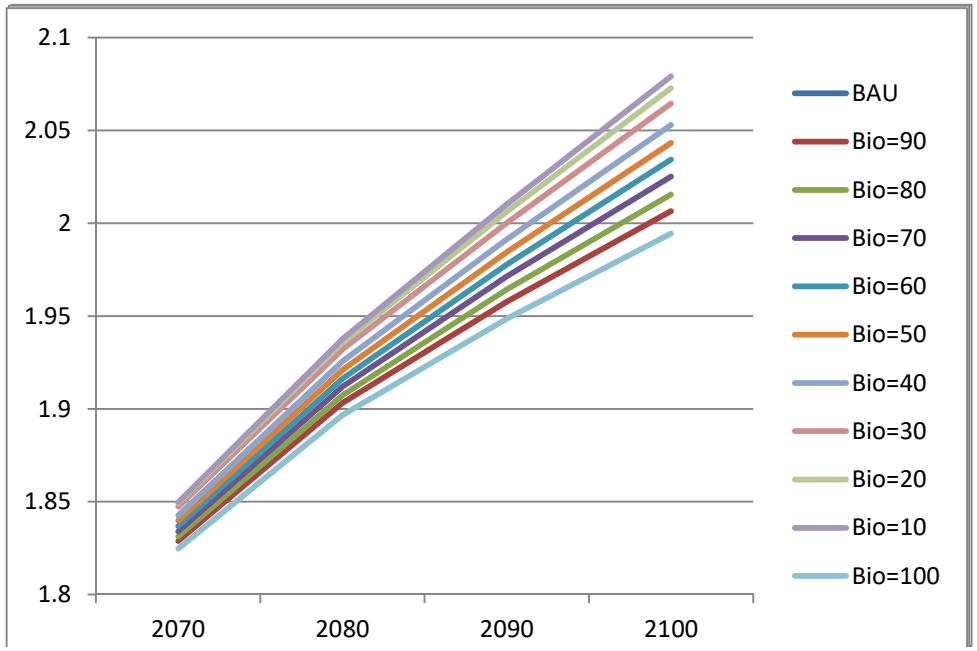
Sensitivity Analysis 5: Changes in Potential Biomass Resources





GDP Losses from BAU(DM=0.0 : S50)

Changes in CO2 emissions



- Biomass potential directly affects the carbon emission especially in the second half of this century.
- Atmospheric temperature rises around 0.07 degree as biomass potential is limited.

Conclusion

1. This study proposes an expansion of existing IAM so as to represent the below 2.0 Celsius degree warming world as optimal solution.
2. The model represents the conditions when people prefer the 2.0 Celsius degree warming world.
3. The “flexible” warming taget **consistent with the “2 Degree world” behavior** would mitigate the climate policy cost.
4. The flexible behavior would relax the climate target **around 0.1 degree**.

Since the above findings are derived by MARIA model assumptions, the multi model comparison will be needed to see how the “flexibility” causes the additional warming and mitigate the societal costs.