Systems Analysis Group

Synthetic Scenario Generation for Climate Change and Sustainable Development

1. Introduction

RITE has been working on development of a synthetic scenario for climate change control and sustainable development in a project called "ALternative Pathways toward Sustainable development and climate stabilization (ALPS)" since FY 2007.

As a result of the 17th Conference of the Parties (COP17) to the United Nations Framework Convention on Climate Change (UNFCCC) held in late 2011, global action to tackle climate change is expected to be taken under the Durban Platform for Enhanced Action in a practical sense, bringing all Parties onto one track, although the agreement was made to extend the Kyoto Protocol as a formality.

As observed in the COP17 negotiations and in the domestic policy making process, different actors have different policy priorities based on their economic levels and other inherent challenges, which leads to a difficulty in creating a well-coordinated uniform policy. Climate change is not the only issue on the global agenda, so it should be addressed in a balanced manner under multiple social objectives. Conventional global abatement scenarios may be too simplified to capture richness of detail and context of the real world situation. The results reveal that climate policy with the highly-idealized premises sometimes does not deliver relevant outcomes, or rather causes unduly confusion to the society.

The ALPS project aims at providing alternative plausible future scenarios through quantification of multiple aspects of society on the assumptions that the real-world society consists of a wide range of values. This approach allows us to inform decision makers of more appropriate strategies toward sustainable development and climate stabilization from longer and wider perspectives. This study is expected to make contribution to create a new climate change framework and to set appropriate climate targets in a timely fashion.

2. Scenarios for quantitative analysis

Modeling simulations are powerful tools to support decision making even though they tend to assume perfect information or perfectly rational behavior. At the same time, it is important to bear in mind that the real world is full of variety and complex. The gap between the real world and virtual model world creates a risk of sending a wrong message. Therefore this ALPS project starts from a deep understanding of the current world situation and historical trends in order to avoid such trap. Based on the insights gained from the socio-economic analysis above, narrative storylines with great details are worked out from broader perspectives.

Three different types of qualitative scenarios are developed: 1) Socio-economic scenarios, 2) Climate Change Policy scenarios, and 3) Representative Concentration Pathways (RCP) scenarios. Furthermore sub-scenarios focus on the subject matter of development and diffusion

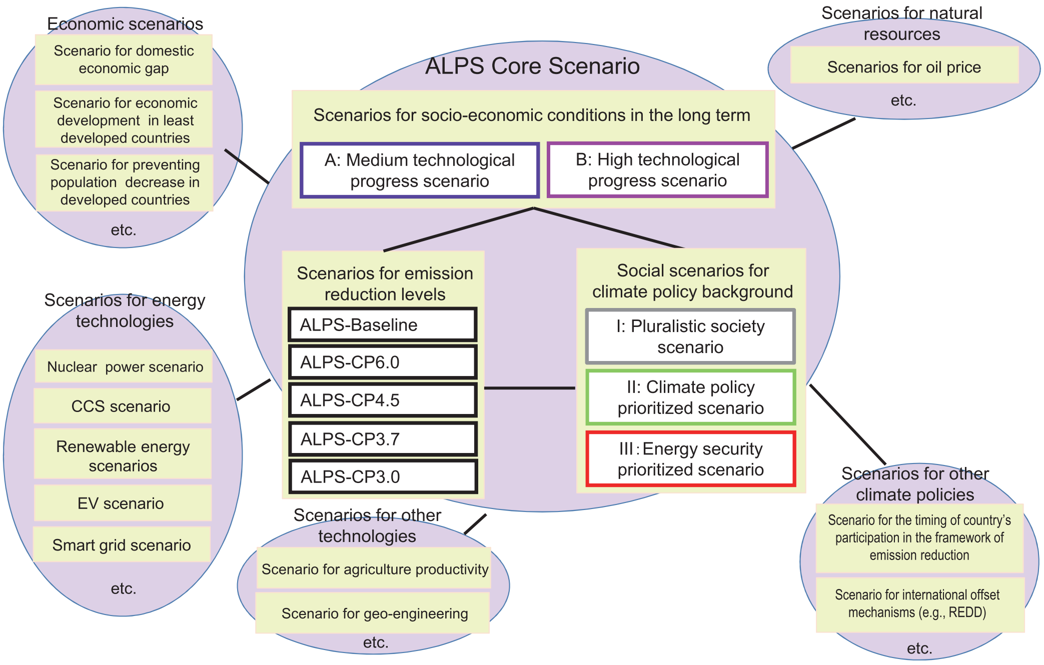

Figure 1 Scenario Groups of the ALPS project

of climate friendly technologies.

With regard to the socio-economic scenarios, a key scenario driver is technological progress, which involves significant uncertainty. Although policy can have a impact on technology progress to some extent, other factors bring larger uncertainty about the future technological change beyond policy impact. It is quite difficult to forecast future innovation and technological progress with high accuracy, so we prepare two discrete scenarios to cover the range of uncertainty. Scenario A (Medium technological progress scenario) illustrates a gradual shift from rapid economic development toward a well matured economy especially in developed countries. Scenario B (High technological progress scenario) describes a future world of very high economic growth with brilliant innovation.

As for scenarios of climate change priority in the broader global agenda, we develop three different narratives. Scenario I named "Pluralistic society scenario" is approximate to the current real world situation with people's diverse values in nature. This scenario is premised on the existence of various barriers to technology diffusion. Scenario II is a "Climate policy prioritized scenario" is a one under which climate change policy is prioritized and people's behavior are rational in the sense that mitigation measures are taken in a cost effective way. This assumption was implicitly adopted by most of the traditional climate change assessment. Scenario III called "Energy security prioritized scenario" in which each nation puts high priority on securing domestic energy resources from energy security perspective.

Our future emissions scenarios are fully harmonized with a set of four RCPs for IPCC AR5. The RCPs have been selecting from existing literature to span the full range of possible trajectories for future greenhouse concentration: a very high emission scenario leading to 8.5 W/m^2, a high stabilization scenario leading to 6 W/m^2, an intermediate stabilization scenario leading to 4.5 W/m^2 and a low mitigation scenario leading to 2.6 W/m^2 (RCP 3-PD). Additionally we go over 3.7 W/m^2 scenario, which comes to five emission pathways in total.

3. Development of models

The ALPS project performs comprehensive modeling scenarios supplemented with the existing models developed by RITE. Scenarios associated with climate change

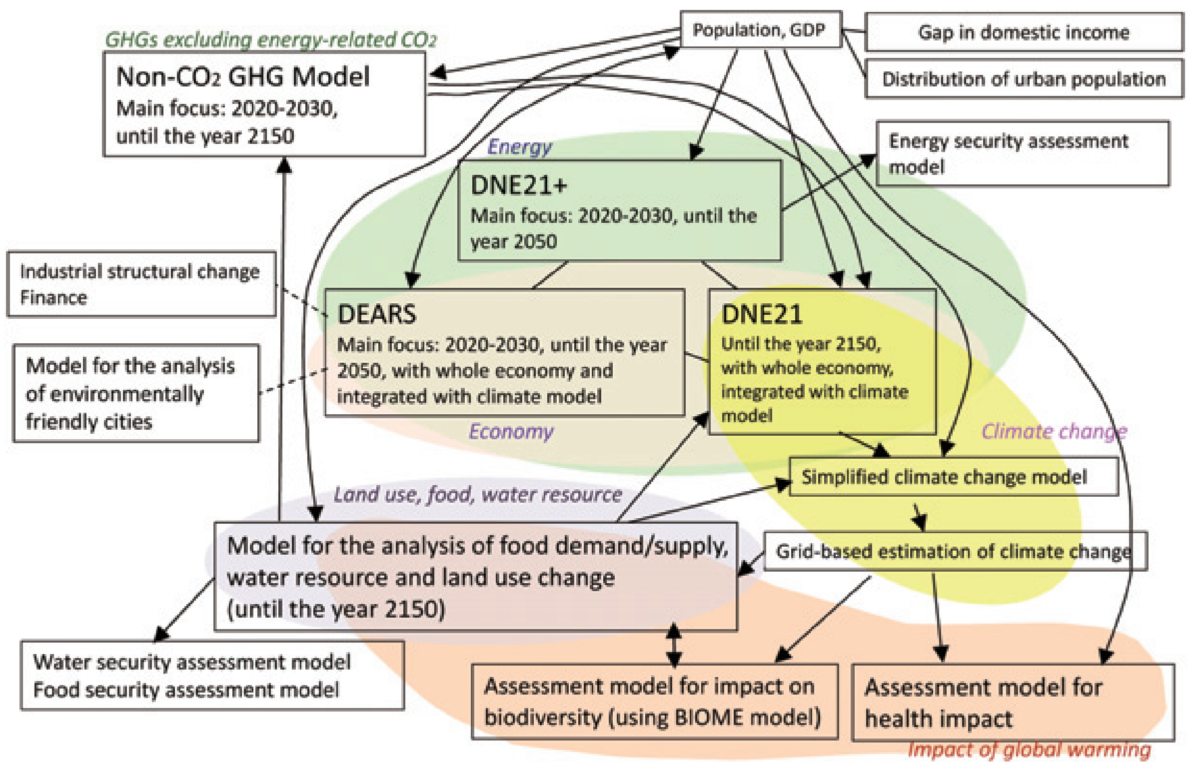

Figure 2 Models for the development of ALPS quantitative scenarios

need to be developed in the context of sustainable development with a wide-ranging set of models to reflect a multifaceted reality. The DNE21+ Model assesses CO_2 emissions from fuel combustion with great details of national, sectoral and technological descriptions. Along with the food demand-supply model, fresh water model, and land use model, a wide variety of plausible future scenarios and narratives are assessed in an integrated and consistent manner.

The models are chosen appropriately in accordance with time frame and objectives of the assessment. For near and medium term analysis, detailed descriptions of the nation, of sector and of technology are highlighted. For longer term analysis, interactions between climate impacts and socio-economic activities are more heavily weighted.

4. Synthetic assessment of socio-economic scenarios for climate change control and sustainable development

Given the diversity in society, a scenario assessment with limited indices related to GHGs emissions and mitigation cost is insufficient. The ALPS project develops quantitative scenarios which are consistent with narrative storylines by using existing models developed by RITE harmonized with data across these models. This enables us to conduct a broad assessment of sustainable development, including a wide variety of socio-economic issues as well as energy and climate change, and to support multi-criteria decision making from broader perspectives.

In accordance with the CO_2 emissions pathways to meet the five specific CO_2 reduction levels as shown figure 3, i.e. ALPS Baseline, CP6.0-stabilization at around 750 ppm-CO_2 eq., CP4.5-stabilization at around 650 ppm-CO_2 eq., CP3.7-stabilization at around 550 ppm-CO_2 eq., and CP3.0-stabilization at around 450 ppm-CO_2 eq., the scenarios are analyzed from multiple aspects respectively. Figure 4 shows the corresponding trajectories of global mean temperature, including estimation of non-CO_2 GHGs emissions that is consistent with each stabilization scenario. In the ALPS CP3.0 scenario, a maximum global mean temperature is expected to increase within 2°C against pre-industrial global mean temperature level. In terms of impacts of climate change, it is desirable to curb GHGs emissions as low as possible, but it is not necessary ideal pathway from multiple criteria because real world trade-offs require us to address a diverse of challenges.

Figure 5 illustrate Marginal abatement cost (MAC) curves. The MAC in 2050 is estimated to amount to 6$/t$CO_2$ for CP6.0, 28$/t$CO_2$ for CP4.5, 137$/t$CO_2$ for CP3.7 and 376$/t$CO_2$ for CP3.0 respectively. Compared with the other scenarios, the CP3.0 scenario indicates rapidly growing MAC, implying huge economic burden on society.

Figure 6 shows energy security index associated with ALPS A-Baseline, CP4.5- stabilization at around 650 ppm-CO_2 eq., and CP3.0-stabilization at around 450 ppm-CO_2 eq. It is commonly believed that energy security will be improved by reducing imports of oil as making progress in mitigation efforts. Our quantitative as-

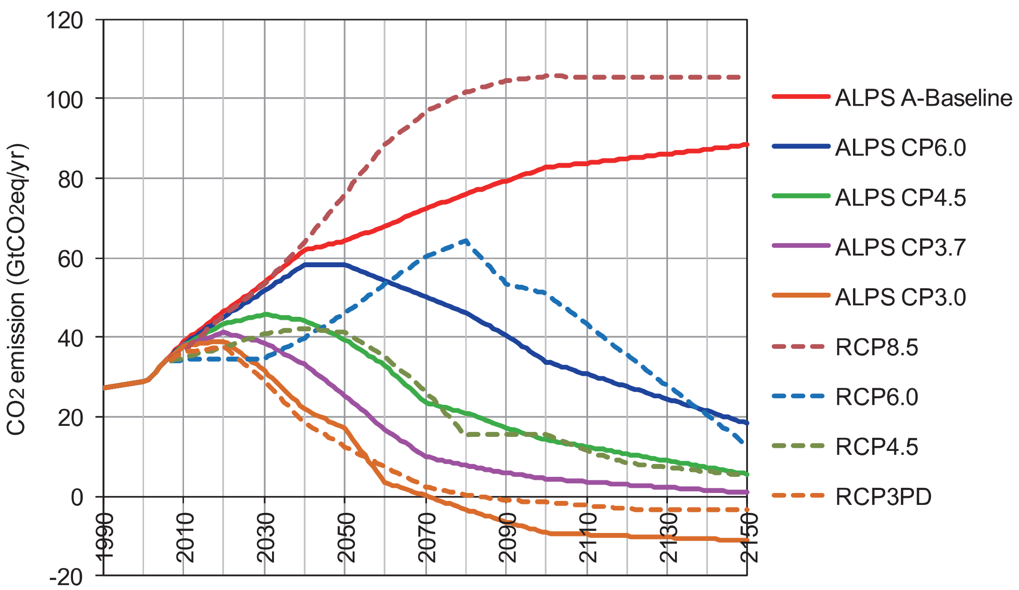

Figure 3 Scenarios of emissions reduction levels in ALPS (Global CO_2 emissions)

Note) The Representative Concentration Pathway (RCPs) are new IPCC emission scenarios to achieve respective four radiative forcing levels.

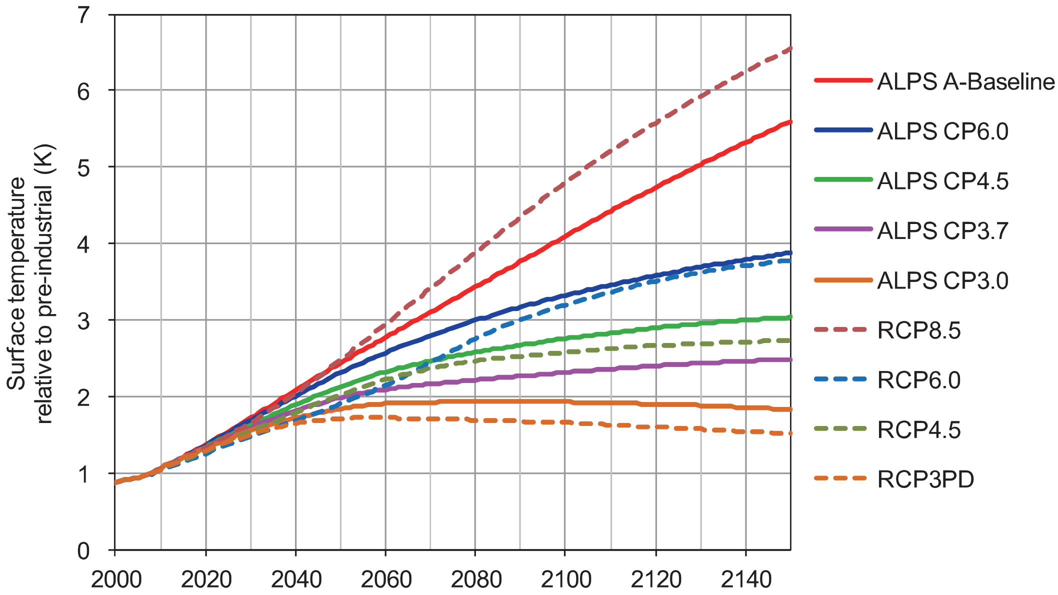

Figure 4 Global-mean temperature change (°C) associated with scenarios

Note) The gap between ALPS scenarios and RCPs mainly comes from the difference in estimation of non CO_2 greenhouse gas emissions.

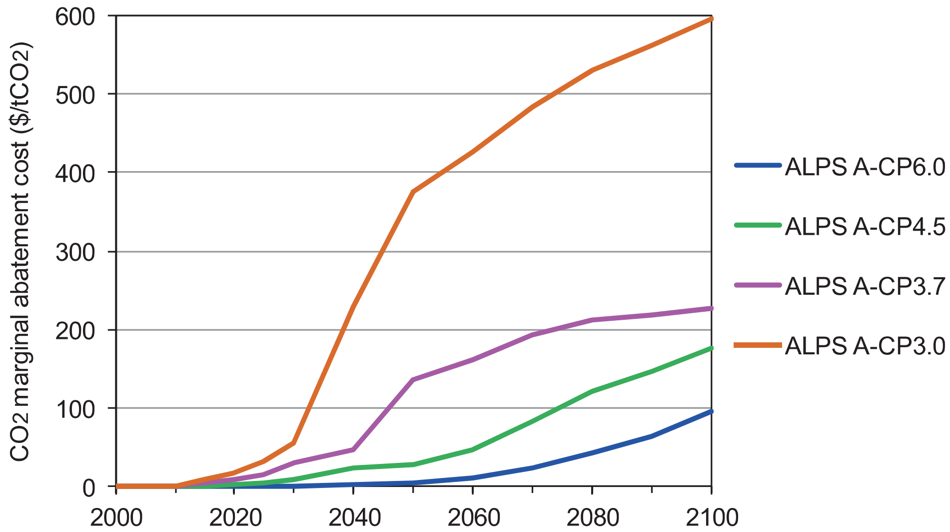

Figure 5 CO_2 marginal abatement cost curves associated with scenarios (Scenario A-I)

sessment, however, shows that energy security can be worsen by reducing domestic coal dependence and by increasing gas utilization in some regions. Energy security can vary across regions depending on emissions reduction levels and other factors.

Figure 7 shows food security index, which is defined as the imports of food in relation to GDP. Given the fact that food is traded globally, it would be appropriate to consider purchasing power for food, rather than degree of self-sufficiency. Food security index will be improved as GDP increase, but it can be fallen when GDP goes down due to excessive mitigation efforts. If food productivity improvement cannot meet the increase of food demand, food security can be degraded due to cropland expansion which potentially pushes up food prices. Climate change has an impact on food production and abrupt climate change can result in adverse effect on the world food supplies and place upward pressure on food prices. Furthermore, growth in the use of food crops for biofuels which compete with them for land resources could potentially exert additional pressure on the food prices. The food security index below takes these factors into account in a consistent and comprehensive manner, and reveals that it is not necessarily improved when significantly reducing CO_2 emissions, which may be counterintuitive results.

We, current generation, need to take appropriate measures for the welfare of future generations in order to realize sustainable development. Without adequate mitigation actions, the wellbeing of the future generation can be

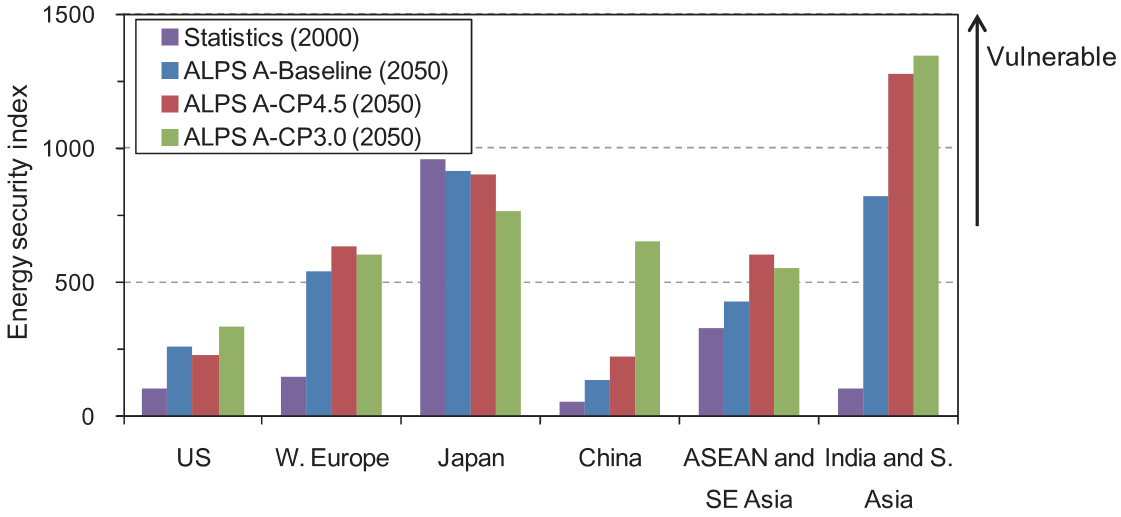

Figure 6 Energy security index across regions
(Scenario A-I, the index is normalized to an US 2000 value of 100)

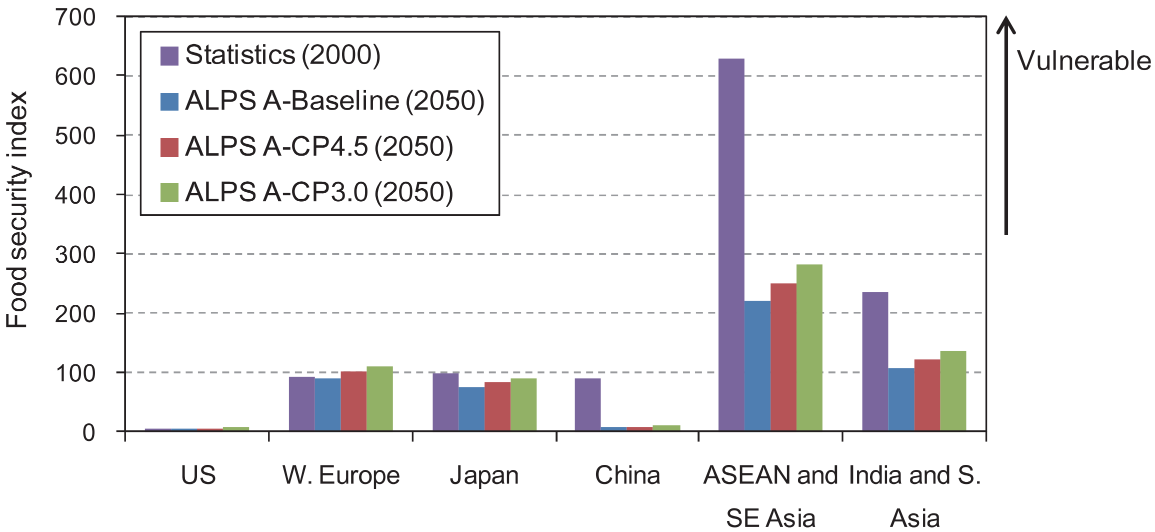

Figure 7 Food security index across regions
(Scenario A-I, the index is normalized to a Japan 2000 value of 100)

damaged. On the other hand, too much burden to the current generation may harm the present economy, debilitating other related activities, and can end up having a negative impact on the future generation. Balancing multiple objectives in society is important to achieve sustainable development, and CO_2 mitigation efforts need to be made in a fair balanced manner as well.

5. Concluding remarks

In the ALPS project, synthetic scenarios toward sustainable development and climate stabilization are generated. For that purpose group of assessment models are developed in order to assess narrative scenarios in a consistent and quantitative manner. The results of this study are expected to not only make scientific contribution to the IPCC but also to serve as fundamental information for decision making in global and domestic climate change policy.