Global Scenario for CO_2 and GHG Emissions

August 15, 2011
Systems Analysis Group, RITE,

1. Introduction

RITE has been developing comprehensive scenarios toward sustainable development and climate stabilization since FY2007 as a part of the "International Research Promotion Program for Global Environment," which is supported by the Japanese government (The ALPS project; ALternative Pathways toward Sustainable development and climate stabilization).[1)-4)] In this paper, the developed CO_2 and GHG emission scenarios by using a global GHG mitigation model[6), 7)] (see Appendix) is outlined. This scenario was developed in FY2010 based on the medium socioeconomic scenario (Scenario A)[5)] of the ALPS Project where latest economic conditions are taken into account.

2. Global CO_2 and GHG emission scenarios

The developed scenario for CO_2 and GHG emissions in this paper is a baseline scenario (scenario without GHG mitigation policy).

2.1 Global energy-related CO_2 emission scenario

Figure 1 shows the energy-related CO_2 emission scenario by world major country / region. The world total emission in the year 2008 was 38 Gton-CO_2/yr. For future, increase in emission is expected to continue by our analysis: emission in the year 2020 is 38Gton-CO_2/yr, emission in the year 2050 is 57Gton-CO_2/yr. Temporary emission reductions are observed in developed countries by the influence of the economic crisis that started in 2008, but the impact on the growing trend of global emission is not large.

As shown in Figure 2, regional emission shares changed substantially from the year 1990 to the year 2008. This change will become larger toward the year 2050 and the share of emissions from Annex I countries who have legal obligation of emission reduction under the Kyoto Protocol including Japan will become smaller. The share of the emissions from those countries will be smaller in the year 2020 than a quarter (23%) in the world. Therefore, it is important to promote the Copenhagen Accord that demands participation of all of the major emitters for achieving effective CO_2 emission reduction.

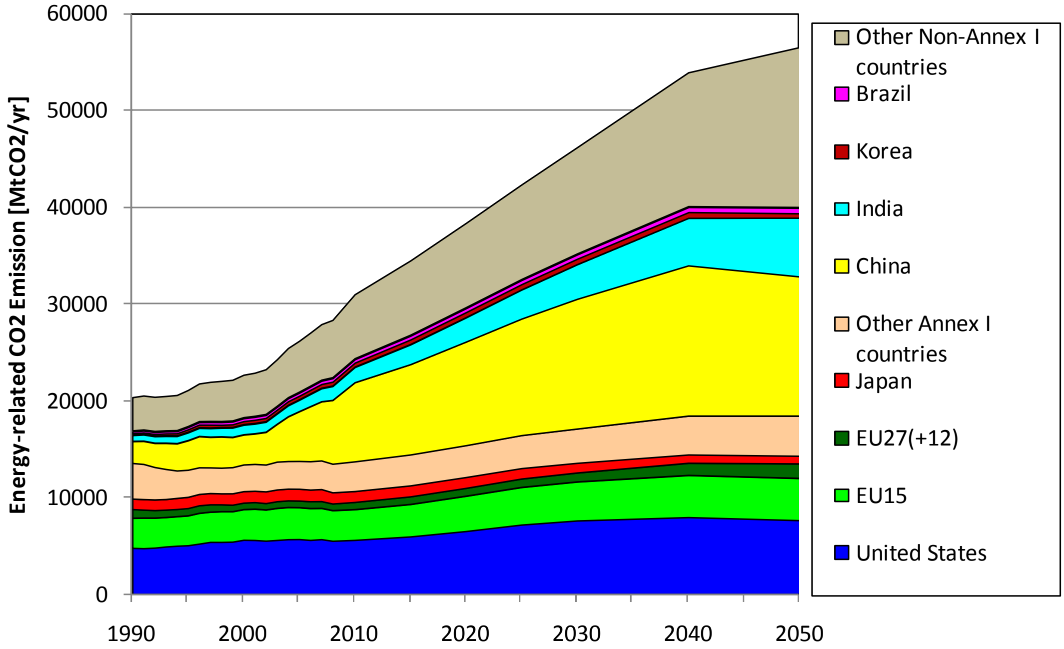

Figure 1 Energy-related CO_2 emission scenario by world major countries / regions
(Historical data from 1990 to 2008 are from IEA[8)])

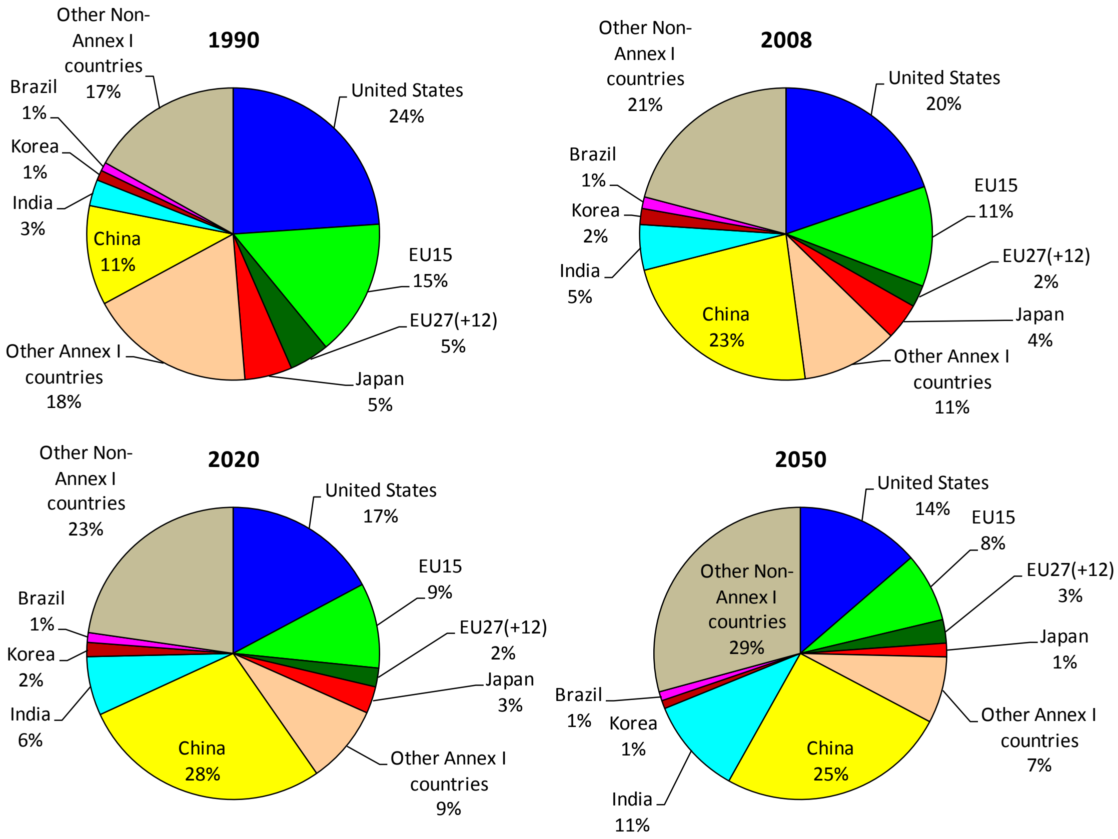

Figure 2 Share of energy-related CO_2 emission
（1990 and 2008:IEA[8)] , 2020 and 2050:RITE estimation）

2.2 Global GHG emission scenario

Figure 3 shows GHG emission scenarios by world major country / region. Increase in GHG emission is also expected as well as energy-related CO_2 emission: emission in the year 2020 is 55Gton-CO_2eq/yr, emission in the year 2050 is 79Gton-CO_2eq/yr.

Figure 4 shows regional shares of GHG emission in the world and the share of "other Non-Annex I countries" is a little larger for GHG than for energy-related CO_2 emission. Correspondingly, the share of Annex I countries, who have legal obligation under the Kyoto Protocol, is slightly decreased (22%) in the year 2020 as compared with the share of energy-related CO_2 emission. This is due to large emission of agricultural CH_4 and N_2O in other Non-Annex I countries.

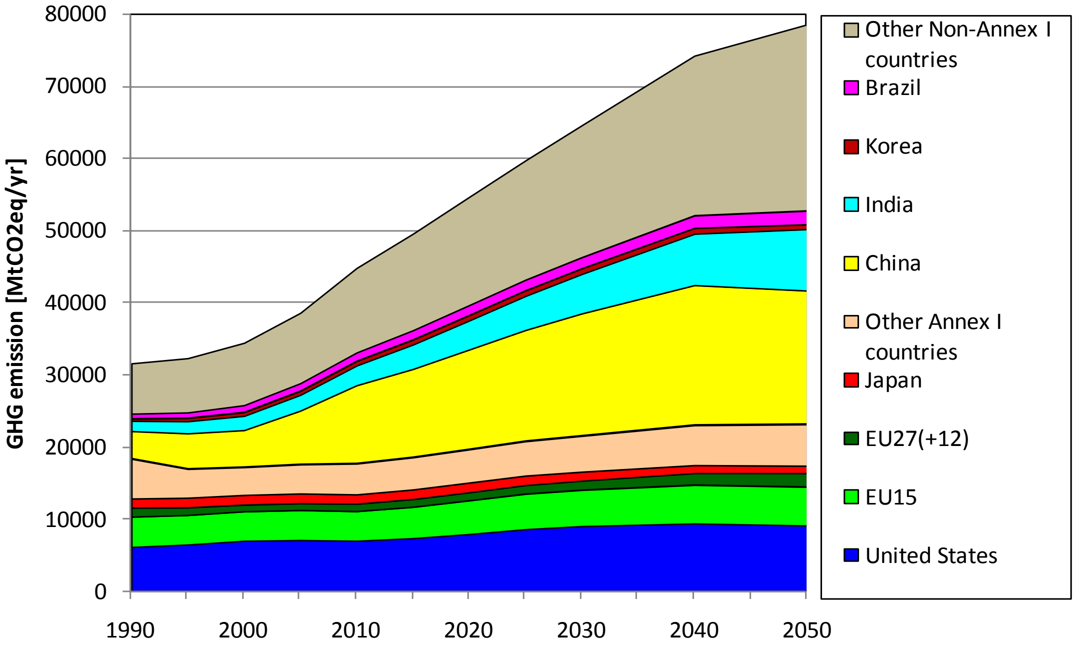

Figure 3 GHG emission scenario by world major country / region
(Historical data are from UNFCCC[9)] for Annex I countries and from IEA[8)] for Non-Annex I countries)

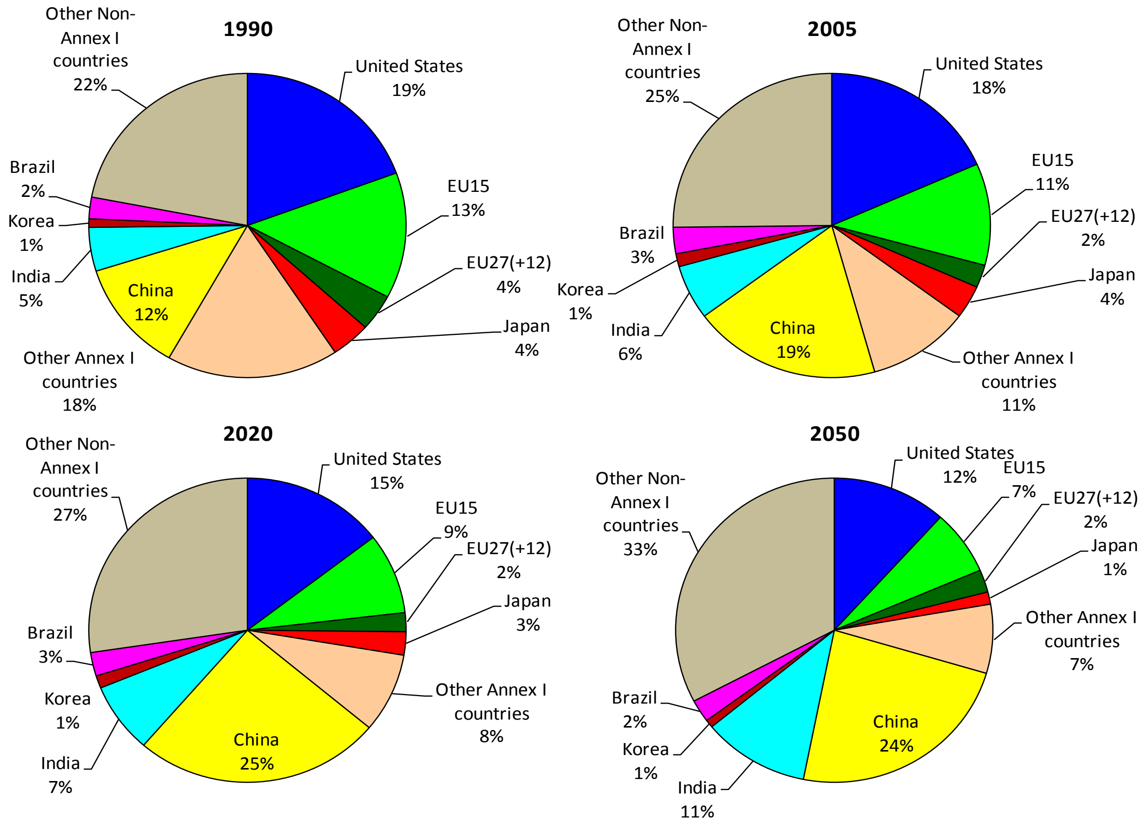

Figure 4 Share of GHG emission

(1990 and 2005:UNFCCC[9] for Annex I countries and IEA[8] for Non-Annex I countries, 2020 and 2050:RITE estimation)

References

1) RITE; ALPS project annual report 2007 (in Japanese), http://www.rite.or.jp/Japanese/h19seikahoukoku/h19ichiran-hyou.htm (2007)
2) RITE; ALPS project annual report 2008 (in Japanese) http://www.rite.or.jp/Japanese/h20seikahoukoku/h20ichiran-hyou0.html (2008)
3) RITE; ALPS project annual report 2009 (in Japanese) http://www.rite.or.jp/Japanese/h21seikahoukoku/h21ichiran-hyou.html (2009)
4) RITE; ALPS project annual report 2010 (in Japanese) http://www.rite.or.jp/Japanese/h22seikahoukoku/h22ichiran-hyou.html (2010)
5) RITE; Development of Long-term Socioeconomic Scenarios –Population, GDP- http://www.rite.or.jp/Japanese/labo/sysken/research/alps/baselinescenario/E-ScenarioOutline_POPGDP_20110815.pdf (2011)
6) RITE; RITE GHG Mitigation Assessment Model, http://www.rite.or.jp/Japanese/labo/sysken/about-global-warming/download-data/RITE_GHGMitigationAssessmentModel_20090529.pdf (2009)
7) K. Akimoto et al., "Estimates of GHG emission reduction potential by country, sector, and cost", Energy Policy, Vol.38, Issue 7, pp.3384-3393 (2010)
8) IEA, CO_2 emissions from fuel combustion, OECD/IEA (2010)
9) UNFCCC, GHG data from UNFCCC, http://unfccc.int/ghg_data/ghg_data_unfccc/items/4146.php (Last Access; 8th, August 2011)

Appendix: Outline of GHG mitigation model of RITE

The global GHG mitigation model[6), 7)] consists of 3 modules; 1) Principal Assessment Model DNE21+, for energy-related CO_2, 2) Non-energy CO_2 emission scenario, that assumes specific non-energy CO_2 emissions independent of mitigation levels of energy-related CO_2 emissions, 3) Non-CO_2 GHG Assessment Model, for 5 kinds of GHG emissions of the Kyoto Protocol (Figure A-1).

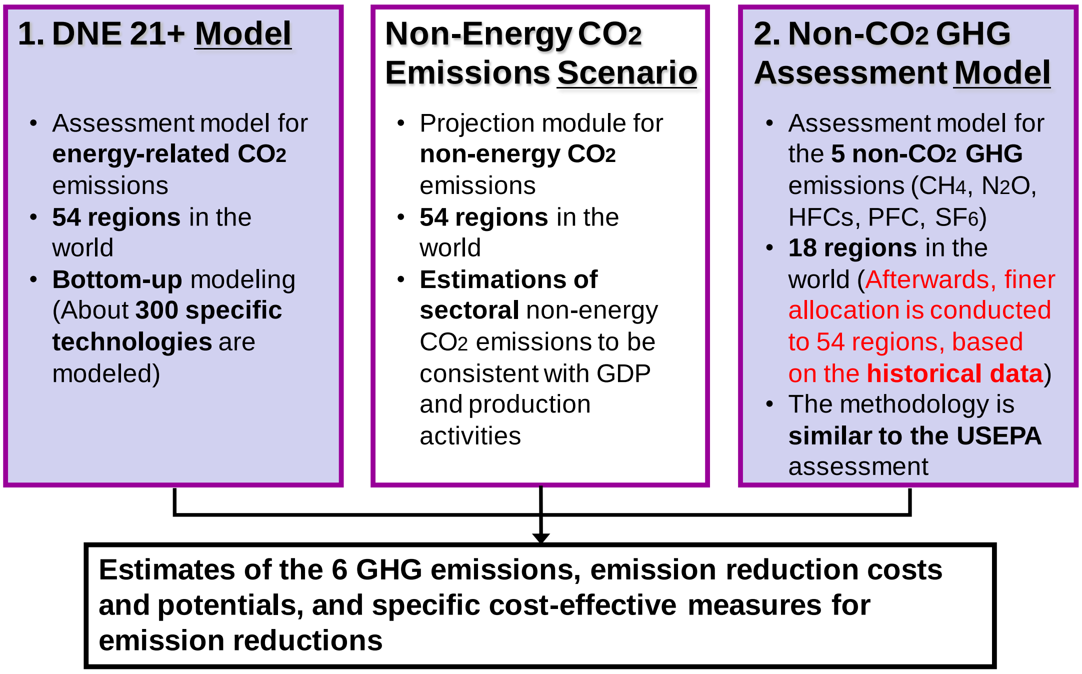

Figure A-1 Outline of GHG mitigation model

DNE21+ model is an optimization type liner programming model, minimizing the total worldwide energy system costs over all the assessment period (up to FY 2050).

Figure A-2 shows outline of energy flows in DNE21+ model. The energy supply sectors are connected to the energy end-use sectors, energy export/import are considered, and the lifetimes of facilities are taken into account, so that assessments are made while maintaining complete consistency across the energy supply & demand sides. Base on the Scenario A, which is a long-term socioeconomic scenario[5)] developed in ALPS project, service demand scenarios (e.g., the production amount of crude steel in Iron & Steel sector, the traffic amount in the transportation sector) are bottom-upped for sectors (energy-intensive industrial sectors, road transportation sectors and some equipments in residential & commercial sectors), and other remaining sectors are top-downed and their energy demands are exogenously assumed. The model solves the best mix of technologies to meet these demand scenarios. Here, costs and energy efficiencies of individual technologies used in both the energy supply sectors and the end-use sectors are explicitly modeled. So, detail evaluation of technologies is conducted and this is one of the salient features of our model. As another feature of the model, the fine regional segregation (the world is divided into 54 regions in country level.) is noted because it enables to analyze with regional differences in consideration (e.g., potentials of renewable energy).

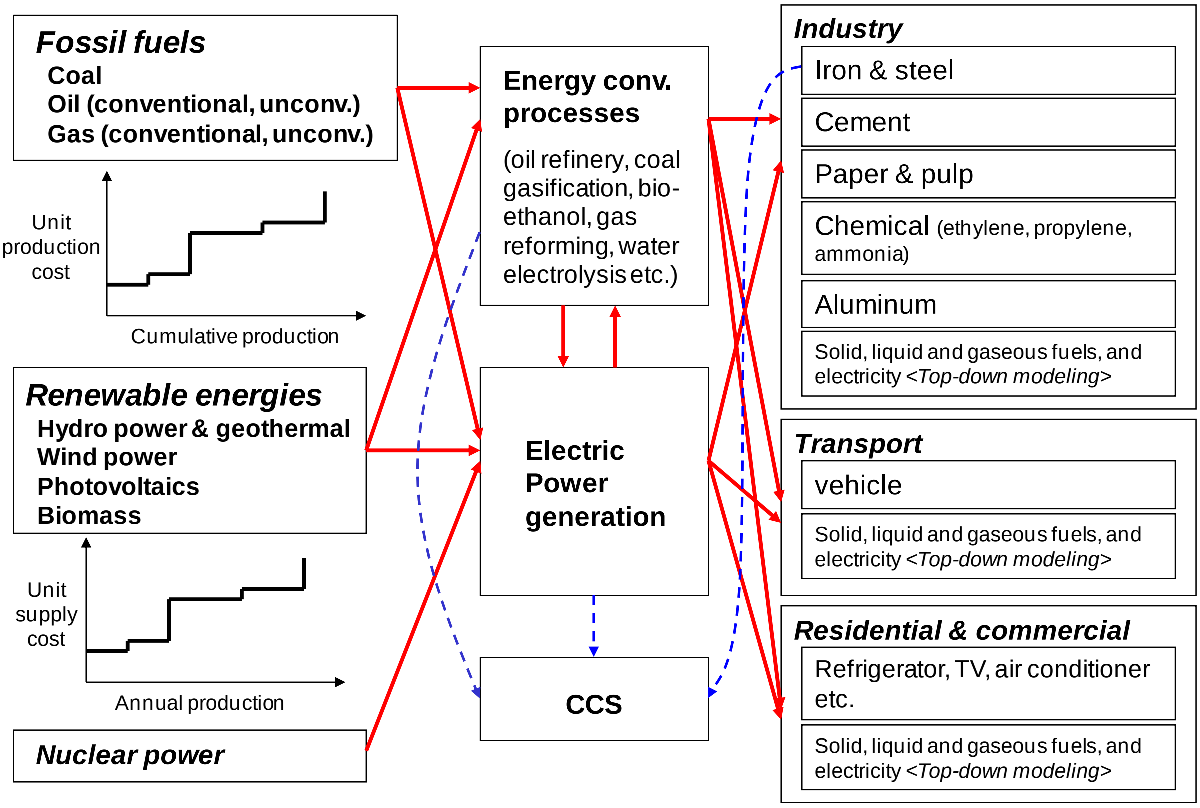

Figure A-2 Outline of energy flows in DNE21+ model

For non-energy CO_2 emission, one specific scenario is developed based on historical data of UNFCCC and IEA and the cement production scenario which is used in DNE21+ model.

The Non-CO_2 GHG model has been developed based on the studies by US EPA with some adjustments by latest historical data. The regional baseline emissions (emissions without GHG mitigation policy) were estimated for five gases: CH_4 in seven sectors, N_2O in six sectors, HFCs in one sector, PFC in one sector and SF_6 in one sector. The emission reduction is calculated by using elasticity representing the relationship between non-CO_2 GHG mitigation ratio relative to the baseline emissions and marginal abatement costs based on the database for emission reduction amounts and reduction costs of individual measures in non-CO2 GHG mitigation. So, the model is not a direct bottom-up model; however, marginal costs and potentials of non-CO2 GHG mitigation are eventually based on the bottom-up analysis of the US EPA.

This is the model outline. More information is available in references 6) and 7). CO_2 emissions from international aviation/marine bunkers and land use, land use change, and forestry (LULUCF) are not evaluated in this model. So, these emissions are not included in the emission scenario in this paper.

■ CO_2 and GHG emission scenarios update

Let us note that this paper may be occasionally updated without notice so that the latest information on historical emissions, economic trends and energy prices can be reflected in the scenario.

Contact to:

Kohko Tokushige, Fuminori Sano, Keigo Akimoto
Systems Analysis Group
Research Institute of Innovative Technology for the Earth (RITE)
9-2 Kizugawadai, Kizugawa-shi Kyoto 619-0292 JAPAN
PHONE: +81-774-75-2304, FAX: +81-774-75-2317, E-mail：sysinfo@rite.or.jp