Executive Summary

Global warming is a threat that must be tackled as a common problem for all humanity. In May 2016, the Cabinet of Japan approved “The Plan for Global Warming Countermeasures,” which aims for an 80 % reduction in greenhouse gas emissions by 2050. This Plan is based on the Paris Agreement adopted at COP21, 2015. Although nations worldwide have been making steady progress in the fight against global warming, we are still far from making the transition into a low carbon society.

The Center for Low Carbon Society Strategy (LCS) promotes the application of science and technology toward the goal of realizing an affluent low carbon society that will also be conducive to economic and social development, in sustainable ways. LCS is developing a number of quantitative scenarios for the period 2030 to 2050 to achieve this transition. These scenarios are based on the results of quantitative backcasting that have enabled us to identify the technology, economic and social systems needed to make the desired transition and to clarify the issues that need to be resolved through further R&D. LCS proposes methodologies to work toward an affluent low carbon society in Japan.

Our research consists of these two categories:

- Quantitative technology scenario research for low carbon technologies contributing to the transition toward a low carbon society, and
- Quantitative economic and social scenario research for achieving a sustainable low carbon society that is conducive to economic development.

We outline social systems for a low carbon society conducive to economic development. In that process, in addition to demonstrating applications for low carbon technologies, we have taken into consideration the multiple issues facing Japan, including the aging of its population and the challenges involved in the ongoing recovery and reconstruction from the 2011 Great East Japan Earthquake.

This report is a summary of our latest research developments in the period 2014 to 2016 and research proposals such as the “Proposal Paper for Policy Making and Governmental Action toward Low Carbon Societies” that we have presented since the publication of our previous summary report in 2014 “Toward the Realization of Dynamic and Affluent Low Carbon Society (Social Scenario 2).” This report summarizes these LCS proposal papers and provides an overview and update of our research on social scenarios.

The Preface and Chapter 1 “Challenges and Perspectives toward the Realization of a Dynamic and Affluent Low Carbon Society” present a framework for promoting research and development of social scenarios, and a roadmap for 2030 to 2050 to allow Japan to achieve its goal of an 80% reduction in greenhouse gas emissions by 2050. It also introduces the importance of promoting renewable energy and energy saving and how to manage the transition to a society that relies primarily on renewable energy. We explain the importance of developing technologies innovatively for these scenarios based on backcasting, and also for even greater goals beyond 2050. We emphasize the importance of creating a social system that will support such technological development in order to make this transition.

Chapter 2 looks at the progress and research trends in low carbon technologies from the

perspective of our main focus, Quantitative Technology Systems Research. In order to achieve an 80% reduction in greenhouse gas emissions by 2050, we need to develop and promote low carbon technologies at an early stage, so it is important to accelerate the strategic development of energy technologies. This calls for a multilateral evaluation of the various technologies that contribute toward a low carbon energy system. We must also identify the R&D agenda and target periods for critical technologies. In this chapter, we discuss the design, evaluation, and prospective costs for the following items:
The latest issues regarding solar cells, fuel cells and batteries, which we have been targeting; renewable energies such as small/medium-scale hydroelectric generation, geothermal power, and biomass as a means of diversifying energy sources; and CCS (carbon capture and storage systems) and hydrogen produced from low carbon energy sources, as components of key energy systems.
This has allowed us to identify issues standing in the way of technological development and cost reductions, and to propose actions to resolve these issues. We also look at the significance of material informatics (materials research with data-utilization toward implementation of low-carbon society), an area of research which has recently become important for backcasting – the assessing and analyzing of social issues to identify the necessary component technologies. We conclude this chapter with a look at issues that need to be considered in developing quantitative technology systems, and case studies we have presented with affiliated organizations.

Chapter 3 examines the latest developments in introducing and promoting low carbon technologies and implementing low carbon social systems from the perspective of research on quantitative economic and social systems. Here, we evaluate the effects of introducing individual energy technologies and systems on improving the economic and environmental conditions of society. We also analyze and evaluate the economic and social systems necessary for the introduction and promotion of low carbon technologies to pave the way for the demonstration, commercialization and implementation toward low carbon societies.

1. In order to achieve low carbon improvements in the household sector without lowering the quality of life, we established a research structure for promoting the spread of various low carbon strategies through social experimentation. Since 2013, in cooperation with 23 local municipalities in the Kanto and Kinki regions, we have been conducting a social experiment called “visualization of real-time electricity consumption in household” involving around 230 households. Based on precise analysis of data from this experiment, we estimated the potential savings achieved by replacing electrical appliances with energy-efficient models and by energy-efficient behavioral changes. Drawing on insights from social psychology, we produced an energy-saving advice system to promote continuous energy-saving behavior. The system is introduced in this chapter, along with the results of our experiment and research.
2. As a framework for introducing and promoting low carbon technologies and systems throughout society, we propose a Pay-as-You-Save scheme to allow households to install energy efficient technology with no up-front costs through a new-type entity we call a “green power moderator.” We estimate that household electricity consumption could be reduced by 25-40% just by replacing refrigerators with the latest models. Households could replace their refrigerators and reduce electricity consumption and CO_2 emissions

with no change in household expenses. The savings on their electricity bill would be used to pay for their new fridges in monthly installments. We explain how the scheme works, with case studies from other countries.

3. As part of the Center of Innovation (COI) Program to envision society 10 years from now, we have deepened our collaboration with the Center for Co-Evolutional Social Systems (CESS) at Kyushu University. We organized a workshop on this with the University of Tokyo's EMS Satellite of CESS. April 2016 saw the start of full-scale deregulation of the household and small business electricity market in Japan. In order to achieve stable electric power supply and demand, we need to propose electricity and energy systems that take into consideration the diversity of energy sources and regional characteristics. To date, LCS has conducted six workshops, attracting many participants from government agencies, research institutions and energy-related companies. Typical themes have been the "International Research Workshop on Policy Design to Induce Energy Efficiency Improvements within the Household Sector;" "Power Systems and Role of Hydrogen in Renewable Energy Massive Introduction;" and "Massive Introduction of Renewable Energy and Innovations in Power Systems after the Paris Agreement."

Chapter 4 focuses on how to construct a low carbon social system. Combining our knowledge from research on quantitative technology systems and economic and social systems, we evaluate integrated power systems and energy systems using various technologies. We then summarize our recommendations for achieving innovation in energy system design and technology. LCS is committed to continued collaboration with affiliated agencies, companies and local governments to stimulate innovation aimed at realizing a better society. In developing our Integrated Simulation Model of a Low Carbon Society, we combined results from our research on quantitative technology and quantitative economic and social systems to describe an affluent low carbon society. When introducing low carbon technologies and policies, it is essential to evaluate and verify the positive effects of such actions in boosting prosperity from both a social and economic perspective. LCS has created an integrated simulation model based on a combination of the applied general equilibrium model, the multi-regional power planning model, and the final energy demand model for households to examine how the application of low carbon technologies and policies across society will affect energy supply-demand, total CO_2 emissions, and the national economy. Any further issues arising from this process we feed back to improve the quantitative technology scenarios. Continued repetition of this feedback process helps us present a more concrete and realistic vision of a low carbon society. Also included is our proposal on how to better promote the transfer of Japan's strengths in low carbon technologies in order to contribute toward the mitigation of global climate change.

Chapter 5 discusses the paths toward realizing an affluent low carbon society in 2050. Fundamental changes can be expected in energy systems, bringing about changes in industrial structures and technologies, which in turn will lead to innovation. We need to propose detailed scenarios describing social systems that come from adapting mutual feedback between quantitative technology system research and quantitative economic and social system research. In addition to promoting our own research into the component

technologies needed to allow the evolution of hierarchical structures reflecting new technological levels, it is imperative that we study future power systems that will be mainly based on renewable energies. Based on detailed and comprehensive analysis of multiple factors, we present proposals on how to make the most of Japan's strengths in innovative technologies to both tackle problems unique to Japan and at the same time to disseminate these technologies effectively throughout the world. What are the scientific and technological challenges? How can Japan gain technology leadership in the both fields of hardware and software? We identify the target issues for research and describe the changes that will take place in society. Technologies will undoubtedly change, as will economies and societies. Our mission is to develop scenarios that will pave the way for such changes. The results of our research on social scenarios have been compiled into our report, "Social Scenario 3," and into individual theme-based LCS proposal papers. These will be actively shared with affiliated government agencies, universities, companies and local autonomies as well as the public. In addition to disseminating these results, we intend to further our collaboration with the other JST programs and other affiliated organizations to promote the widespread application of our research with the goal of contributing toward the realization of a low carbon society.