5. The Role of Technology

This section describes the role of technology that will be of importance as midium- to long-term climate initiatives, including strategies for future technology development and diffusion on the global scale.

5.1 Technology Needed to Create a Low Carbon Emitting Economy

In order to reduce greenhouse gas emissions, the ratio of carbon intensity in energy needs to be lowered more quickly than has been seen in historical precedent, so the development and broad-scale diffusion of technology in the field of low-carbon emission will be important.

<The Role of Technology in Creating a Low Carbon Emitting Economy>

○ The effectiveness and efficiency of future efforts to reduce emissions and the possibilities for realizing goals aimed at stabilizing GHG concentrations and climate change will to a large extent depend on the technologies that are developed and diffused in future. Thus, once mid- and long-term targets are established and the most appropriate scenarios for achieving these goals are considered, describing the outlook for the development and diffusion of relevant technology will also be of great importance.

<Technologies for the rationalization of the work produced, enhancement of energy efficiency and low carbon emission intensity >

○ CO_2 emissions from energy sources can be decomposed into three main factors, namely, work produced, energy efficiency, and the ratio of carbon intensity in emissions. Balance measures need to be utilized with these factors. Moreover, technologies that rationalize the work produced (industrial production, etc.), increase energy efficiency, and decrease the ratio of carbon intensity in energy (CO_2 emissions per unit energy) are very important.

$$\text{CO}_2\text{ Emitted} = \underset{\text{(industrial production, etc.)}}{\text{Work Produced}} \times \frac{\text{Energy Consumed}}{\text{Work Produced}} \times \frac{\text{CO}_2\text{ Emitted}}{\text{Energy Consumed}}$$

To Reduce CO_2 Emissions	Re-think wasteful production/consumption	Increase Energy Efficiency	Low Carbon Emission

○ According to the IPCC Third Assessment Report, a comparison with historical rates of technological change shows that a rate that is higher than historical precedents is now needed for low-carbon intensity in energy technology if goals for stabilizing GHG concentrations are to be met. Thus, development and broad-scale diffusion of technology in this field are particularly important.

<Existing Technology and Innovative Technology>

○ The IPCC Third Assessment Report describes both existing and innovative technologies for increasing energy efficiency and for achieving low carbon intensity in energy. Table 5.1 lists specific technologies for reducing GHG emissions. Development and diffusion of a variety of technologies are expected in future.

○ Japan's Climate Change Policy Programs also takes note of GHG emission reduction through the use of innovative technology. Because in 1998, at the time when these Programs were drawn up for the first time, some of these technologies were not yet being practically applied, they are categorized differently than in the IPCC report. For example, high-performance smokestack technology is listed as an innovative technology in the Programs. Based on the IPCC Third Assessment Report, the present report considers a technology that is in use or in the pilot plant plants stage as an existing technology and new technologies as innovative technology still requiring a significant breakthrough. Thus, technologies that will be ready for introduction by 2010, such as high-performance smokestack technology, are listed as existing technologies.

Table 5-1 Examples of Technology for Reducing GHG Emissions

	Increased energy efficiency (mostly demand-side)	Low-carbon emitting (mostly supply-side) technology	Other
Existing technology	・High-performance smokestacks ・High-efficiency heat pumps ・Building & home energy management systems ・ LED lighting ・Hydrogen absorbing alloys ・Hybrid vehicles ・Biotechnology ・Fuel cell vehicles ・Materials	・Nuclear Power ・Natural gas combined –cycle electric generation ・Fuel cell battery co-generation ・Low-cost high-efficiency photovoltaics ・High-efficiency power generators using super -heat resistant materials ・Super-conducting power generators & transmission cables ・Nuclear fusion ・In-orbit photovoltaics	Enhanced absorption by forests ・Catalysts for removing N_2O&CH4 originating in livestock production ・Carbon isolation/ sequestration technologies
Innovative technology			

Source: Created by Ministry of Environment of Japan, based on the information provided by Mizuho Information Research Institute

<Taking into Account the Uncertainties Inherent in Developing Innovative Technology>

○ Prospects to technology development are associated with the inherent uncertainty in technology development itself. In particular, the more innovative the technology, the greater is the uncertainty about its development. In introducing such technology to the market, not only its ability to reduce greenhouse gases, but its impacts on ecosystems, the environment and society must also be assessed. There is a gap between some innovative technologies in terms of their potential for practical applicability, so discussions about these technologies need to make distinctions among them in accordance with their practical applicability.

○ Moreover, even if an innovative technology will be developed and applied in practical ways, it is necessary to examine whether it can be diffused among the major GHG emitting developed and developing countries before 2050, or even between 2020 and 2030, for instance. No matter what kind of the climate-friendly technology it will be, it is of no use unless it can actually be diffused and contribute to reduce GHG emissions.

5.2 Time and Pre-conditions Necessary for Technology Development & Diffusion

The development and diffusion of technology is concerned not only with single, self-contained technologies, rather, technology must be viewed in the context of the entire systems that support it. Also, in diffusing technology across international borders as opposed to within a single country, various types of difficulties arise at every level, resulting in the likelihood that global-scale diffusion may require several decades.

<Provision of Systems to Support the Diffusion of Individual Technologies>

○ Even when a technology that can reduce GHG emissions has been developed, sometimes that technology cannot be diffused by itself. Thus, not only technology itself, but the entire systems that support the technology also need to be included in any consideration of technology development & diffusion.

○ Because many CO_2 emission reduction technologies are related to energy systems, their development and diffusion must be accompanied by energy system reform. For example, diffusion

of hydrogen requires the development and diffusion of technology at all relevant stages – production, transport, supply infrastructure and equipment for using the energy. Because energy systems are also integrated into the social infrastructure, etc., changing them often poses immense practical difficulties.

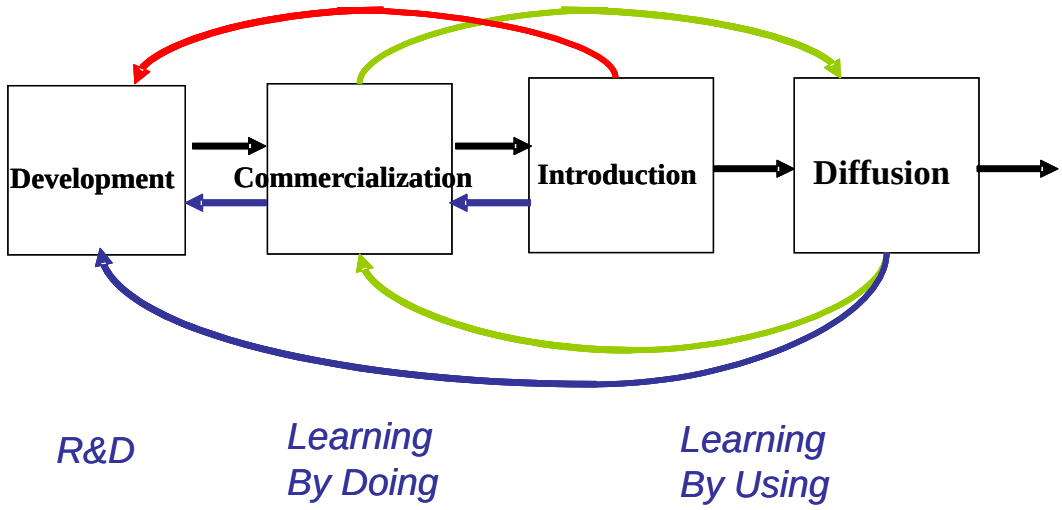
<Intellectual Property Rights>

○ It should be recognized that particular difficulties influence various aspects of technology diffusion on the global level, as compared to technology diffusion within a single country. For example, when technology is diffused across international borders from a rich country to a developing country, the issues of intellectual property rights and patents must be dealt with. Although intellectual property rights and patents function as incentives for developers, from the point of view of those wishing to apply the technology, the higher costs associated with such rights and patents form a significant barrier to countries with little economic strength.

<Feedback in Technology Development & Diffusion>

○ Technology development and diffusion in the real world does not normally progress in a linear fashion from development -> commercialization -> market introduction -> diffusion. Instead, it should be noted that it repeatedly moves back and forth between each stage in the process, while improvements are added and costs lowered as the technology is diffused (see Fig. 5.1).

Fig. 5.1 Technology Development & Diffusion Process



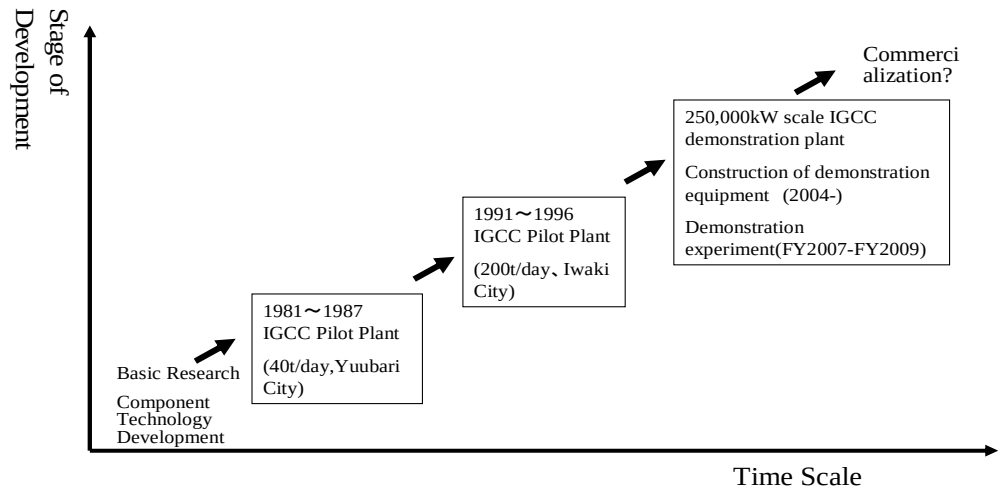
Source: Edwards S. Rubin

<Time and Considerations Needed for Globally Diffusing New Technology>

○ New GHG emission reducing technology requires not only the technology itself, but also the provision of support systems, and there are obstacles to diffusion such as intellectual property rights, etc. As technology development & diffusion progress through the process of repeated feedback, it is likely that the interval between the time a technology is first developed and the time it is diffused and applied on a global scale will extend to something on the order of several decades.

○ Some technologies require long periods of time for development. Figure 5.2 shows the development stages and time-frame for integrated gasification combined cycle (IGCC) technology. This technology has been tried on increasingly large scales and 30 years will have passed since the time when a pilot plant initially started operation until a demonstration experiment was completed.

Figure 5.2 Example- Development of Integrated Gasification Combined Cycle



5.3 Approaches for Promoting Technology Development & Diffusion and the Role of Government

To promote technology development & diffusion, a balance is needed between demand-side technology, which is developed and diffused mainly through the establishment of goals and standards, and supply-side technology, which is promoted mainly through the provision of subsidies for research, development and diffusion. Government also has a major role to play in technology development and diffusion.

< Approaches for Promoting Technology Development & Diffusion>

○ There are two main types of approaches for promoting technology development & diffusion; the "demand-side type" that promotes technology development & diffusion mainly through the establishment of goals and standards, and the "supply-side type" that supports technology R&D and diffusion mainly through the provision of subsidies, etc. A well-balanced combination of both is needed. Other promotion methods include the use of market incentives, such as carbon taxation and emissions trading.

○ The seeds of many new GHG emission reduction technologies have begun to sprout, particularly in the case of demand-side type technologies. To nurture these embryonic technologies, a method needs to be established for clearly evaluating their practical applicability, while greater efforts are made to remove the various types of systemic obstacles in their path.

○ In diffusing new technology on the global scale, the international community must reach mutual agreements not only on the diffusion of the individual technologies themselves, but also on the introduction of the social systems needed to facilitate diffusion of these new technologies into the societies of various countries.

<The Importance of Government's Role in Technology Development & Diffusion>

○ While it is important to take maximum advantage of the power of the market to promote the development and diffusion of GHG emission reduction technology, government also plays an important role. However, the extent of the role government should play depends on what kind of technology is given priority for development. With this in mind, social judgment needs to be applied in order to determine which direction technology development should take in future.

<Government's Role in Providing Infrastructure>

○ Firstly, the government is expected to provide the infrastructure needed to diffuse the GHG reducing technology for which the private sector is taking the initiative. Governments must take into account the fact that in developing & diffusing technology, it will not suffice to merely develop a self-contained technology, but rather that the systems and infrastructure to support that technology must also be built.

<Active Participation by Government in Technology Application>

○ Secondly, governments participate in the practical application of technology that requires very large initial capital outlay. Technology can be said to have been practically applied only when it has diffused through the market, but for promising technologies that require very large initial capital outlay, diffusion cannot be expected to occur if the initial phases depend on market forces. For example, in the case of an innovative technology such as marine sequestration, the initial capital investment requires large sums, and it is not easy to predict whether a return will be forthcoming on the investment. Governments are expected to actively play a major role by supporting the development and creating a set of circumstances that will facilitate the diffusion of this kind technology.

<Guidance to Identify a Direction for Technology Development & Diffusion by the Private Sector>

○ Thirdly, technology development and diffusion can proceed in a clearly planned-out direction, but unexpected technology can also arise that ends up making a significant contribution to society. Thus, an indication by government of a direction for technology development & diffusion can promote technology development by the private sector. The role government can play in this case is not limited to guidance through regulatory measures, but includes awarding economic incentives and creating frameworks that value effort expended in pursuit of development and diffusion of relevant technology.

5.4 Strategy for Future Development & Diffusion of Technology on a Global Scale

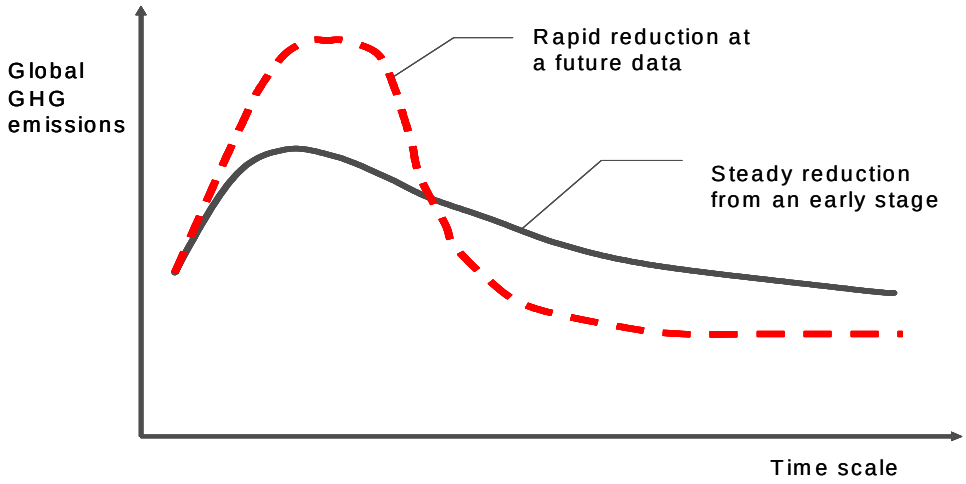
In view of the inertia inherent in the climate system, the characteristics of energy systems and the time needed for the development & diffusion of technology, measures need to be taken as soon as possible in order to avoid the risks posed by global warming. Thus, while taking a long-range view in promoting the development of innovative technology that can potentially achieve substantial emission reductions, during the next few decades existing technologies need to be applied to the maximum extent possible.

<Diffusion of Existing Technology and Development & Diffusion of Innovative Technology>

○ There are two approaches to the question of how to reduce emissions of greenhouse gases; one that would apply existing technology and diffuse it throughout the world to steadily reduce emissions at an early stage, and another that would, for the time being, pour resources into the development of innovative technology that could drastically reduce greenhouse gas emissions, and utilize that technology to rapidly reduce emissions in the future (see Figure 5.3).

○ In the debate over which technological strategy to choose, some assert that the latter approach of relying on innovative technology will result in lower emission reduction costs than the former, existing-technology approach. However, it must be noted that this evaluation fails to take account of the costs to deal with adverse impacts of rapid temperature rises during earlier phases. This issue must be examined in light of various considerations, such as the stabilization level of atmospheric GHG, the time scale for establishing a downward trend in GHG emissions and the need to continue reductions thereafter, the varying levels of certainty about development and practical application of technology, the possibilities for diffusing technology on the global scale, the costs of providing not only the technology but the infrastructure to support it, and so on.

Figure 5.3 Greenhouse Gas Emission Scenarios and Technology



<Realizing Rapid Diffusion of Existing GHG Reduction Technology>

○ In order to stabilize atmospheric concentrations of GHG at a level that will achieve the ultimate

objective of the UNFCCC, an emission peak must be reached for the entire world, including not only developed countries, but also countries currently categorized as developing countries such as China and India, no later than about 2050. In view of the uncertainties and difficulties bearing on the diffusion of innovative technology on the global scale, no assumptions can presently be made about how long it will take for innovative technology development to result in GHG emission reductions. Thus, resolution of these issues cannot be entrusted exclusively to the future development and diffusion of innovative technologies. Also, even in the case of technologies already in use, it is assumed that their diffusion will also take time.

○ Moreover, in view of the irreversibility of climate change, it will be essential during the next few decades to put to complete and comprehensive use existing technologies of both the demand-side and supply-side type. That is, the first task is to take measures to steadily reduce emissions from an early stage.

<Development of Innovative Technology that May Enable Drastic GHG Reductions>

○ Based on a strategy of diffusing to the greatest extent possible existing GHG emission reduction technology over the short- and mid-term, development of innovative technology is also important from a long-term point of view in order to increase the efficiency of countermeasures in future and to make possible more drastic emission reductions. Thus, this kind of R&D should be promoted taking a long-range view.

○ The role of government is particularly important in the development and diffusion of innovative technology. If innovative technology can be developed and applied, this will increase the probability for realizing further GHG reductions after 2050. Practical application and diffusion could be immediate in some developed countries, making even more GHG reduction possible, and if such technology could be diffused to developing countries, this might result in stabilization of atmospheric GHG at an even lower level in future.