Chapter 1
The Message in “Vision 2050”

1.1 Behind the Birth of Vision 2050

1.1.1 The Need for a “Macro” Vision

In 1999, as the world grew excited over the start of a new millennium, I published a
volume titled Chikyū jizoku no gijutsu (Iwanami Shinsho) – “The technology for
global sustainability.” In the second half of that decade, the signing of the Kyoto
Protocol had helped to make people everywhere more broadly familiar with the
problem of global warming, and momentum began building on reducing CO₂ emis-
sions. It was also around this time that many began to sense that the material civili-
zation that had supported the dramatic growth of the twentieth century had reached
an impasse. People conscious of these matters began taking action in an effort to
avoid the difficult state of affairs that the exhaustion of energy resources, global
warming, the generation of large amounts of waste, and similar developments pres-
ent. However, the data and information that provide the grounds for action were
lacking, and discussion likewise had not yet reached a state of maturity.

For people to take action requires them being able to believe that the actions they
are attempting are correct and are being done for the world’s sake. However,

attempts to encourage recycling have been met with people expressing the view that
it merely adds to costs and is unrealistic. Meanwhile, studies on the adoption of
solar batteries have led some specialists to reject them, saying that the payoffs are
not proportionate to the costs and the absolute amounts of energy achieved are
insufficient.

Finding a middle ground among views that directly contradict one another like
this will require a “macro” vision. Such a vision would be one that everyone can
share, that has a consistency as a whole that fully takes into consideration various

crucial, individual items. If there is a shared sense of what the future should look
like, then it will establish the orientation that people should take moving forward as
a matter of course regardless of conflicts over separate arguments like those over
recycling and solar batteries. Regardless of the varied and diverse issues that are brewing, I believe that there was no shared sense of what shape the future should take.

1.1.2 An Affluent Lifestyle for All

It was with this sense of the problems facing us that I formulated my “Vision 2050” and put it forth in Chikyū jizoku no gijutsu. Vision 2050 represents an image to be achieved by the mid-twenty-first century of a material circulating society that relies on renewables in an energy-efficient way. It is based on the three principles of “saturation of man-made objects,” “improved energy efficiency,” and “developing renewable energy.” My premises when I formulated this were to see everyone in the world achieve a standard of living on par with what developed countries enjoy today, while at the same time solve environment- and resource-related problems. In addition, I used the most leading-edge data I could obtain at the time of writing, while taking up such separate topics as making vast improvements in energy efficiency and expanding the use of renewables.

To say “everyone on the planet will enjoy material abundance at the level of developed countries today” was an idea that nearly everyone in the world at the time held to be idealized but an unrealistic theory, and that the planet would not be able to bear if attained. Even today, most people still probably think so. However, did not the United Nations pledge that “no one will be left behind” through its sustainable development goals in 2015? Is there some vision of the world conceivable other than this? For the U.N. to issue such a pledge at the moment when I was thinking about Vision 2050 was unexpected, and it convinced me that I was not wrong. With that in mind, when I logically analyzed the results of all the research I had undertaken about lifestyles and society as of 1995, trends in population and man-made objects, technologies and their future, and the like, I realized that this was not an idealized theory by any means but a feasible vision.

1.1.3 Why a Low-Carbon Society?

The global environment is changing at breakneck speed. According to the Fifth Assessment Report (AR5) issued by the Intergovernmental Panel on Climate Change (IPCC), the average annual temperature of the earth’s surface (both land and the ocean’s surface) has risen 0.85 °C between 1880 and 2012. Furthermore, the change projected for the end of the current century based on data for 1986–2005 is for the average temperature to have risen by 0.3 °C at minimum and by as much as 4.8 °C.

Population growth is one factor behind the rising temperature. Over the 100 years of the twentieth century, the world’s population rose from 1.7 billion to 6 billion.
Furthermore, owing to the modernization of people’s ways of life, the quantity of all the material resources they needed grew and so the volume of agricultural output increased 7.5 times and that of industrial output by 20 times.

In concert with this, the carbon dioxide (CO$_2$) concentration in the atmosphere rose. The average concentration of CO$_2$ in the world a century ago was around 290 ppm; in contrast, observations made at the end of 2015 by the greenhouse gases observing satellite Ibuki showed the concentration to have exceeded 400 ppm.

The atmosphere serves to keep the temperature of the entire globe as a whole at about 15 °C, but when the CO$_2$ concentration rises that equilibrium is upset. The temperature difference may appear to be rather small when you look at the numbers. However, the planet is definitely warming, and that will have incalculable effects on the environment. When temperatures rise, ocean currents and airstreams change and so does the climate. Europe has experienced record-breaking cold weather, while on the other hand, Australia’s dairy industry has taken a major hit from droughts. Japan, too, has seen a rise in both extremely hot days and heavy snowfall-induced damage. These developments are believed to be signs of climate change caused by global warming. If temperatures rise, the resulting situation will not be one that can be dealt with simply by dressing for summer year-round.

The world’s population is forecast to rise by more than 2 billion from today’s figures to reach 9 billion by 2050. Currently, the annual volume of CO$_2$ emissions per person in developed countries stands at about 8.4 tons. If all of humanity is leading lives on par with that of such countries by 2050, the volume of CO$_2$ emissions will reach 75 billion tons per year. By my research team’s provisional calculations, the concentration of CO$_2$ in the atmosphere will be 600 ppm. Even compared to the change in concentration over the past 100 years, that which will occur in the next 40 is overly rapid.

The IPCC’s worst-case scenario of a maximum rise of 4.8 °C assumes that no additional measures are taken to combat warming beyond those of today, while the best-case scenario of 0.3 °C presumes that very strict measures are taken. It goes without saying which scenario is better. In order to maintain the global environment, humanity should be aiming for achieving a low-carbon society that reduces the volume of CO$_2$ emissions as much as possible.

1.1.4 The Threat of Global Warming

Each of the reports the IPCC has issued have included an assessment of the effects that human activities have on warming. The First Assessment Report (FAR) issued in 1990 limited itself to mild comments to the effect that there were concerns that anthropogenic greenhouse gases could cause climate change. However, the expressions used have grown stronger with each report, with AR5 saying in essence that it was extremely likely that the primary factor behind the warming in the second half of the twentieth century was due to human influences. The degree of certainty is greater than 95%.
Temperatures have already risen by 0.85 °C and are projected to rise anywhere from 0.3 °C to 4.8 °C in the next half century. Humanity has never experienced such a dramatic change.

The risk due to warming that people are most familiar with is a rise in sea levels produced by the melting of the polar ice caps. It will take time for such an enormous amount of ice to melt, but once the ice is reduced and ocean temperatures start to rise, it will make it even easier for further melting of the ice. Even if the rise in atmospheric temperature is halted, it will require an enormous amount of time for the ocean temperatures to continue to cool enough for ice to form once again.

It is said that if the sea levels rise, then various islands such as Tuvalu in the South Pacific will sink into the sea. Research indicates the possibility that countries like Thailand with coastal areas may, depending on conditions, see considerable parts of those regions sink out of sight. Japan, too, will not go unaffected. If sea levels rise by around 60 centimeters, it is expected the belts of coastal regions around Tokyo, Osaka, and elsewhere that currently stand at exactly sea level would increase by 1.5 times. This would require social capital investments on measures to cope with flooding and water exposure.

Global warming will also bring about climate change. Even though Europe sits at a higher latitude than Hokkaido, it has a temperate climate. This is due to the general circulation of ocean currents wherein the warm Gulf Stream flows north across the Atlantic Ocean to reach Europe and the waters subside there. However, as warming proceeds, the amount of precipitation will increase and the saline concentration in sea waters will fall. If the specific gravity is not high enough, the waters will not subside to the ocean floor and the flow of the Gulf Stream is quite capable of stopping.

Should that happen, it is possible that Europe will become quite cold even if the Earth’s temperature on the whole rises. Europe would experience a wave of extremely cold weather that would set new records for people dying in the thousands due to electric power and other essential utilities being cut to shreds. The social infrastructure takes the meteorological and climate conditions as its premise, so countermeasures will not keep up in the event of a drastic change.

Furthermore, if the Gulf Stream stops flowing to Europe, its heat will remain in tropical regions and could cause Mexico and the southern U.S. to heat up intensely. Hurricane Katrina, which practically wiped out the city of New Orleans, is thought to have been produced by this sort of mechanism.

Another terrifying projection is that of positive feedback in warming. Lurking beneath the surface of the Siberian permafrost is methane hydrate, with a structure comprising methane molecules that are surrounded by water. Warming will cause the ice to melt, releasing methane gas into the atmosphere. Methane has not received as much attention since the volume of CO₂ emissions has been much higher, but it has a greenhouse effect that is 10 times that of CO₂ per unit volume. This release of methane into the atmosphere through warming could generate feedback in that the greenhouse effects of that methane would cause warming to proceed all the more.
We know from recent climatological research that the global environment exists in a truly delicate balance. Even one slight change to one component in the atmosphere could change the ecosystem dramatically.

1.2 What Is Vision 2050?

1.2.1 The Vision for 2050

To keep global warming in check will require keeping down the CO₂ concentrations in the atmosphere. In Vision 2050, I ran simulations for the supplies of materials and energy as well as CO₂ concentrations for 2050 based on the volume of energy used in 1990.

In 1990, humans consumed a total amount of energy equivalent to 7.5 billion tons of resources, comprising roughly 6 billion tons of fossil resources and 1.5 billion tons of non-fossil resources (biomass, hydraulic power, and nuclear power). The world’s population was around 6 billion people at that time, meaning each person consumed about one ton of fossil resources. There is in fact a considerable difference between developed and developing countries, with developed countries having consumed about 4.5 billion tons. Breaking down the amount of consumption per person by country, we see the figures were 2.4 tons for Japan, 2.5 tons for the UK, 2.6 tons for Germany, and 5.3 tons for the United States. If the figure for the U.S. is excluded as an outlier, then the average amount consumed per person in the developed countries of Europe and Japan was 2.3 tons.

The total population of the world is forecast to be 9.3 billion people in 2050. Of this, the population of developing countries will account for about 8 billion people. If they lead lives on par with those of developed countries, then multiplying that 2.3-ton figure by 8 billion people results in approximately 18.5 billion tons of fossil resources being consumed. Biomass will amount for 1 billion tons of this just as in the benchmark year. Also, if demand in developed countries in 2050 remains the same as in the benchmark year, then this means 5 billion tons of energy – comprising 4.5 billion tons of fossil and 0.5 billion of non-fossil resources – will be consumed. The global total for energy consumption will be 23.5 billion tons, equivalent to triple the figure for the benchmark year. This is what’s behind the tacit understanding of many that the planet will not bear up if all people on it become affluent.

However, these calculations are premised by the technology of the benchmark year. If the technology evolves, then energy use efficiency will improve. For example, if energy use efficiency were tripled by 2050, then the amount of energy consumed would end up around the same as the benchmark year at 7.5 billion tons (Figs. 1.1 and 1.2).

Even so, if the amount of fossil resources used is the same as it was in 1990, then CO₂ would also continue to be emitted at the same levels. It thus would not be possible to return the global environment to conditions prior to that time. To arrest the
progress of global warming will require even greater efforts than just improving efficiency. In Vision 2050, I proposed increasing the ratio of renewable energy. The amount of energy use based on non-fossil resources in the benchmark year converted to carbon stood at approximately 1.5 billion tons. If this figure could be doubled, then the amount of fossil resources used in 2050 would end up at 4.5 billion tons. That is to say, if we could triple energy use efficiency and double our use of renewable energy we could keep the amount of fossil resources used down to three-quarters of the amount in the benchmark year. If Vision 2050 could be achieved and further progress is made in the latter half of the twenty-first century on improving energy use efficiency and expanding the use of renewables, then it might be possible to achieve a scenario in which the amount of fossil resources used is kept even further down.

What effect would that have on the CO₂ concentrations in the atmosphere? In the benchmark year, the concentrations stood at 369 ppm. We have seen the atmospheric CO₂ concentrations rise in proportion to the volume of anthropogenic CO₂ emissions. The amount was increasing by 2 ppm annually as of the late 1990s. If it continues at that pace, the concentration will have risen 100 ppm in 50 years to exceed 469 ppm in 2050.

Meanwhile, if as noted earlier developing countries have attained a living standard on par with developed countries by 2050, and there is no change to either energy use efficiency or the proportion of renewables used, then the amount of fossil resources consumed annually will reach 22 billion tons. Calculations show that the CO₂ concentrations would reach 600 ppm at this point (see Fig. 1.3b). That figure would be far more than double the CO₂ concentration present before the Industrial Revolution.
Fig. 1.2  Figure above; Change in the number of summer days with torrential rains in Japan. Change in the number of summer days (June–August) with torrential rains calculated in Japan between 1900 and 2100 (results for 2001 and later use the “A1B” scenario). If even one the cells covering the Japanese archipelago (approximately 100 km × 100 km) has a daily precipitation exceeding 100 mm, it is counted as a day with torrential rainfall. Since it is based on average values over broad areas, absolute values cannot be directly compared with observation data. Only relative changes are significant. Figure below; Change in the number of hot days (maximum temperature > 30 °C) in Japan (figure below). Change in the number of tropical face calculated in Japan between 1900 and 2100 (results for 2001 and later use the “A1B” scenario). If even one the cells covering the Japanese archipelago (approximately 100 km × 100 km) has a maximum temperature exceeding 30 °C, it is counted as a tropical day. Since urbanization has not been taken into account, and since it is based on average values over broad areas, absolute values cannot be directly compared with observation data. Only relative changes are significant. (Source: Center for Climate System Research, The University of Tokyo; the National Institute for Environmental Studies; and JAMSTEC Frontier Research Institute for Global Change)
Conversely, under Vision 2050 with the amount of fossil resources used at three quarters that of the benchmark year, the CO₂ concentration is calculated to stand at 460 ppm (see Fig. 1.3c). While that figure is not all that different compared to the preservation of the status quo model (469 mm), if we consider that the population will have grown by 1.5 times and energy demand will have tripled, then keeping the level down to this degree is the correct option. Moreover, if Vision 2050 can be realized and its orientation maintained from the second half of the twenty-first century onward, then the pace of the rise in CO₂ concentrations will be blunted and drop to a level such that the oceans will finally absorb CO₂. Under the Vision 2050 scenario, it is even not impossible that the CO₂ concentrations could be returned in the twenty-second century to the 280 ppm level of the pre-Industrial Revolution world (see Fig. 1.3d).

The three objectives of Vision 2050 may be summed up into the following three items.

1. Create a material-circulating system
2. Triple energy use efficiency
3. Double the amount of renewable energy

### 1.2.2 A Happy Low-Carbon Society Is Achievable

Vision 2050 is meant to reduce the CO₂ concentrations in the atmosphere, but it does not impose excessive compromises or sacrifices toward that goal. It seeks to realize the three above objectives not through idealism but rather with scientific technology.
1.2.3 Saturation of Man-Made Objects and the Material-Circulating System

First, saturation of man-made objects is the key point of a material-circulating system. Man-made objects such as steel and cement continue to accumulate. They will fill every nook and cranny relative to the population and ultimately reach saturation. Demand is not something that will grow forever, even in China or India. Saturation should be welcomed at the proper time. An analysis using steel and cement – two key materials for infrastructure – as indices predicts that in 2050 they will reach near saturation worldwide.

Saturation of man-made objects means the amount of materials that are newly required is equivalent to the amount of man-made objects that are discarded. If waste was recycled and used for new products, then the need for extracting natural resources would disappear. That is to say, at the very least, there would be no anxiety at least about metallic resources drying up, and they perhaps would no longer even be necessary in the first place. The form of society that we should have in the future is a completely circulating one that has minimized the volumes of both waste and resource mining.

1.2.4 Tripling Energy Efficiency

Setting the target value for energy efficiency starts having a theoretical value for total energy consumption. The difference between this theoretical value and actual energy consumption is the maximum possible value of energy-saving. Analyses of just how close we can approach this maximum value through technology is tantamount to a projection just how far we can push ahead with energy-saving.

For example, the theoretical value of energy consumption for transportation is zero. An object with a weight of zero requires no energy to travel. Accordingly, reducing the weight of automobiles and trains will be effective toward reducing power use, as well technologies that convert energy resources into an efficient force to power travel. I projected that by studying the possibilities of weight-reduction and drive technologies, it will be possible to cut energy consumption for transportation to one-quarter that of the benchmark year.

Heating demand ranks alongside automobiles as the largest source of energy consumption in the world. My thinking was that it will be possible reduce this to one-quarter by 2050 by improving the efficiency of a variety of factors in homes and offices by curtailing air-conditioning costs with improved heat insulation performance for buildings; reducing power consumption through the use of high-efficiency air conditioners, LED lighting, and the like; and improving efficiency on the power generation side of the equation.

Furthermore, efficiency increases will also continue in the areas of monozukuri (making things). Most metals oxidize in the air. Making metals from waste in a
metallic state consumes markedly less energy than making it from natural resources in an oxidized state. In short, directing ourselves toward becoming a circulating society will also contribute to energy saving. Furthermore, the construction, home electronics, and other such industries could also cut their energy consumption in half. If such rates of reduction are averaged out to cover energy consumption for each of these categories, the amount that people consume as a whole could be kept down to less than one-third that of the benchmark year.

Thus, I came up with a projected amount based on a detailed study of each energy consumption item and a meticulous theoretical and technological analysis of those items that made the greatest contributions. I then took the resulting value, added the weights of the amounts of energy each consumed and averaged it to determine the appropriate amount a tripling of efficiency would be.

1.2.5 Doubling the Amount of Renewable Energy

The third point is to make it our objective that we double the amount of renewable energy. As of 1995, fossil resources accounted for an overwhelming amount of energy consumption at 80%. Renewable energy came next at 15%, comprising firewood at 10% and hydraulic power at 5%. Nuclear power also provided 5%. Accordingly, given that only 20% of the energy produced came from renewables that did not generate CO₂ including nuclear power, I set increasing that proportion to 40% through the use of renewable energy as the objective.

1.2.6 Increases in Both Comfort and Economic Performance

Each of the foregoing goals have been set rather high, but they certainly are not so reckless that they are unachievable. The discussions in the next chapter will show how progress has gradually been made toward achieving them in the two decades since 1995. Moreover, as we draw closer to a form of society we should have in the future, the quality of life will not decline. The amount of energy consumed can be kept down just by regularly replacing old air conditioners and refrigerators with new ones (Fig. 1.4). The convenience and ease of use of the new products should be better than before. Fuel consumption is not the only thing that improves with automobiles; their safety and comfort also improves. New enjoyments have arisen from choosing the car you want from among a variety of environmentally friendly options. Furthermore, the recycling rates for steel and concrete are rising in the industrial sector.

Are people creating inconveniences for themselves as the recycling rate rises, the efficiency of automobiles and home electronics improves, and the use of solar power spreads? Even if there are improvements to economic development, convenience, and a sense of safety, this will not be harmful. Furthermore, it will create new busi-
1.2 What Is Vision 2050?

Vision opportunities such as the prospect of mega solar power. This is the true worth of Vision 2050.

A low-carbon society is one that keeps the use of the fossil resources that emit greenhouse gases under control. However, this does not mean the aim is to suppress human activities or economic development. A happy low-carbon society is not some pipe dream. Rather, it is a vision for feasible sustainable development.

1.2.7 Premises Consequent on Being a Realistic Vision

Vision 2050 is premised by growth in developing countries and standards of living being maintained in developed countries. If the people of developing countries have standards of living on par with those of developed countries in 2050, then the amount of energy consumed will swell to triple the level of the benchmark year. However, this does not mean that anyone has the right to say that for this reason developing countries want to maintain their statuses of living at current levels. The modernization of developing countries cannot be denied. Moreover, it is clear in the first place that if this happened, then we would be faced with a world of terrorism, coups d’état, and gloom.

Furthermore, while it is crucial that we rethink our lifestyles when it comes to reducing energy use, we must avoid being excessive in our expectations. There are

Fig. 1.4 Toward zero CO₂ emissions from houses by energy saving and creation. (Source: Created by the authors based on various materials)
things we can do in our daily activities like using bicycles when possible or tamping down on excessive packaging or not making photocopies we do not really need, but getting large groups of people to make extreme changes in their ways of life in a short period of time is difficult. The world does not operate on idealism alone. Vision 2050 also keeps reassessments of our lifestyles in mind, but it is limited in its expectations of any quantitative effects. The emphasis is on finding avenues for technologically improving energy consumption efficiency.

Another one of the premises of Vision 2050 is that there is little chance that renewable energy will have replaced fossil resources across the board in 2050. If we set aside hydroelectric power and the use of firewood in developing countries, then the percentage of total energy that renewables contributed as of 1999 stood at less than 1%. In contrast to fossil resources such as gasoline and coal that have a high energy density and can be used at any time, renewable energy sources such as sunlight and wind power have a sparse energy density and the volume of energy they produce has extreme time fluctuations. It is extremely difficult to come up with a scenario in which people will rapidly switch across the board from sources of energy that are easy to use and convenient to renewables that require planning when it comes to making use of them.

These are the premises that support Vision 2050. I undertook countless studies using the most up-to-date and detailed data I could acquire at the time I drafted it. Close to two decades have passed since it was formulated, but I still believe that everything in it to be current, including its premises.

The difference between developed and developing countries is likely to be a crucial factor that should be ascertained in the future. The amount of energy consumed in developed countries will definitely decrease. Their populations have already peaked out and are similarly shifting to a declining pattern. Japan’s population peaked at 128,060,000 people in 2008. According a National Institute of Population and Social Security Research estimate, it might reach a maximum of 129,200,000 in 2050, or fall below 100,000,000, if the population decline accelerates. These population projections are based on suppositions about birthrates and average longevity, but assuming there are no major changes in conditions by 2100, it will drop to somewhere between 38 million and 65 million people.

When the size of the population falls, the total volume of energy consumed likewise falls. Furthermore, given that automobiles, houses, and household appliances will be even more energy efficient, the amount of energy they consume will drop even if we are still using them in the same ways. The amount of energy consumed in Japan rose continuously through 2004, but since then, it has been falling. Current levels of energy consumption are practically the same as those of the late 1990s when I worked out Vision 2050.

The amount of energy consumed drops as the population decreases and energy efficiency improves. Similar trends can be seen not only in Japan but also to varying degrees in all developed countries. It seems likely that developing countries will also navigate the same sorts of changes as development proceeds, their populations will reach their upper limits, and they will reach the saturation point with man-made objects. Vision 2050 was formulated as a realistic and rational vision statement.
Japan stands in the lead of the changes headed toward Vision 2050. This is because it is striving to move forward on becoming a happy low-carbon society in light of its population aging quickly, its birthrate being low, its population projected to shrink, and the country being faced with an enormous budget deficit. In short, in order to maintain affluence and the global environment, Japan is moving forward on the development of rational recycling systems, making energy use more efficient, and expanding the use of renewables as it strives to adopt new technologies and systems and improve productivity to make up for the decrease in population size. To achieve this, it is becoming increasingly necessary to have venues where hardworking and superior personnel can regularly acquire new knowledge, learn new ways of thinking, and develop new skills. People who have improved their abilities to cope with rapid changes can be made to skillfully recycle a variety of elements in the world around them. Doing so will enable a shift toward becoming a happy low-carbon society. It is incumbent upon us to design such a complex social system that includes all these elements, and then have the courage to put it into practice.

Note 1: In the present work, I use the expression “xxx tons of fossil resources.” The “xxx” figure presented is a carbon conversion that takes into account the proportion of coal to petroleum to natural gas at the time. To express this in terms of CO₂ volume, multiply the number of tons of fossil resources by 3.1 to get the amount of CO₂. Please note that the proportions of coal, petroleum, and natural gas vary depending on the country and time period under discussion, so some deviations may arise.

Note 2: “Natural” energy (shizen enerugi) used as a technology used for sustaining the earth and “renewable” (saisei kanō) energy as used in the present work are the same thing. Recently, it has become commonplace to speak of “renewable energy” in English and its equivalent in Japanese for this kind of energy, so I follow that usage in the present volume.