From Environmental Protection

To Environmental Creation

From Environmental Protection to Environmental Creation

Offering an optimal solution through prediction and assessment

Research for environmental management is drastically shifting the helm, "from environmental protection to environmental creation." In the past, every time new environmental issues arose, environmental regulations were reviewed and new environmental protection measures were developed in response to the issues. These include, for example, the instrumentation technology for detecting environmental pollutants in industrial effluents/gas emissions, technologies for predicting environmental impacts based upon elucidation of advective diffusion behavior of pollutants, and decontamination technologies, all of which have already become widely used in industry as production management technologies. However, with the heightening of environmental awareness in society, new technologies are emerging as our trump for "environmental creation" aiming at a harmony between man and environment. These technologies are completely different from the after-the-fact approaches that only work for the conventional "environmental protection" and will provide an effective measure of prevention by predicting the rise of new environmental issues beforehand.

Meanwhile, the Ministry of Economy, Trade and Industry is taking action by revising the Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances (Chemical Substances Control Law), as well as enforcing the Law Concerning Reporting, etc. of Releases to the Environment of Specific Chemical Substances and Promoting Improvements in Their Management (PRTR Law), the Law Concerning Special Measures against Dioxins, and the Law Concerning the Recovery and Destruction of Fluorocarbons. In addition, movements are under way to initiate full-scale efforts targeting 2010-2020 regarding "optimal management based on risk trade-off," which will meet a global trend as a future-generation technique for chemical substance management. Consequently, urgent demands are arising for consideration for sustainability of technologies and thorough enforcement of risk management.

In light of such social demands, AIST works to develop the following technologies, and has been establishing the seeds thereof: chemical substances risk assessment, life cycle assessment (LCA), global environmental impact assessment, environmental measurement and monitoring which enable the detection of trace amounts of environmental load substances, and environmental cleanup and restoration technologies capable of catering to widely diffused environmental load substances. In the future, we plan to challenge further integration and fusion of these key technologies to achieve an innovative technology for prediction, prevention and action - consisting of a trinity of instrumentation, assessment, and action technologies - and to offer it to society in a timely manner.

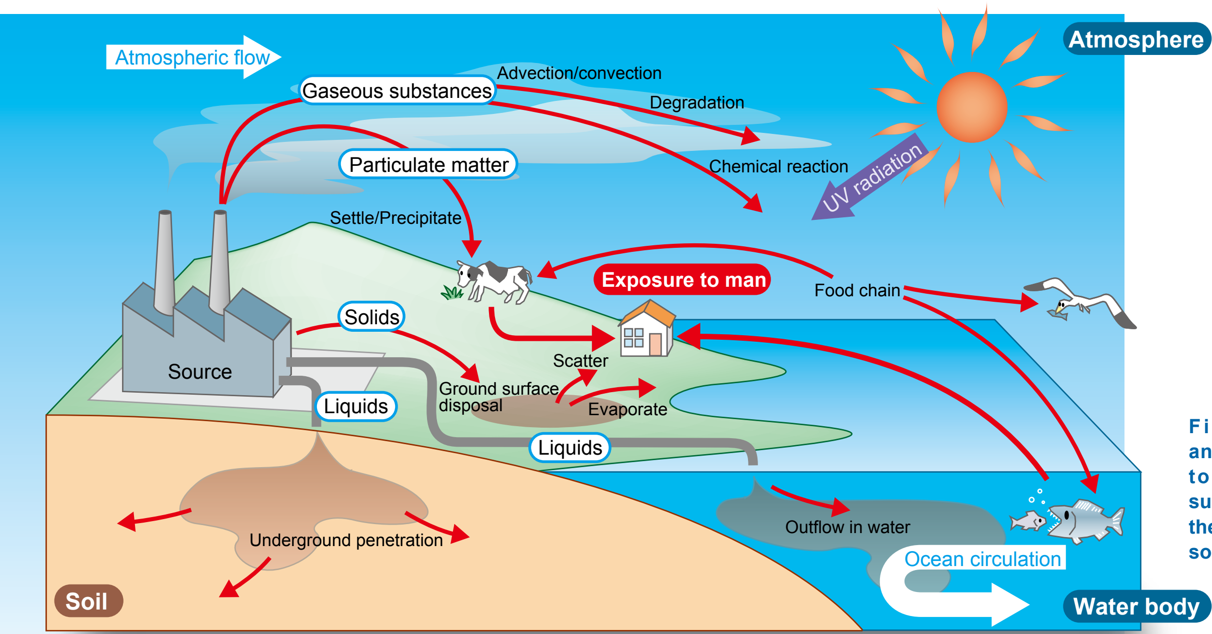

Figure 1: Behavior and route of exposure to man, of chemical substances emitted into the environment from a source

It is the common goal of mankind to realize a sustainable society so that global people may live rich lives extending into the future. In the "Second Period Research Strategy" formulated by AIST in April 2005 as well, "To offer optimal solutions in terms of environment and safety measures through the fusion of prediction, assessment and protection technologies" is set forth as a priority strategic goal characterizing AIST's environmental research. This feature article presents carefully selected researches regarding "assessment techniques leading to prediction" and "optimal solutions leading mankind to a rich future," which constitute the core of the strategic issues to be overcome in achieving our strategic goals.

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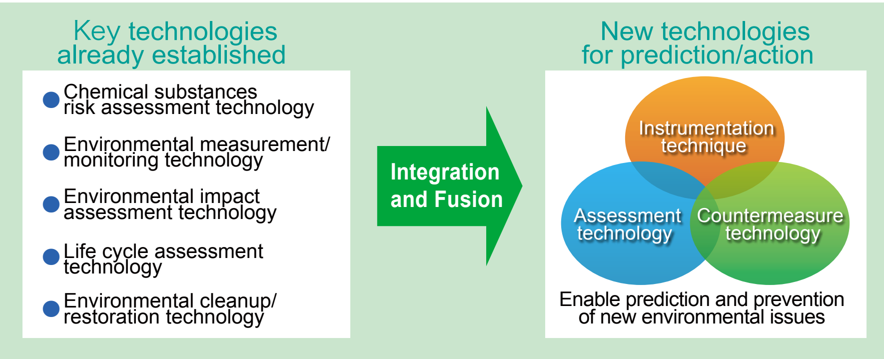

Figure 2: Concept of the environmental management technology which AIST aims for

VOCs control measure using nonthermal plasma

For the removal of volatile organic compounds (VOCs) emitted from stationary sources, we are utilizing a kind of miniaturized thunder, one of the three notoriously fearful things for Japanese such as earthquakes, thunder, and fire. While only electrons are activated in small volumes of nonthermal plasma reactors, the gas temperature itself is kept nearly ambient as Figure shows. Besides oxygen gas, water can be used as an oxidant with this approach, and any kinds of VOCs can be decomposed oxidatively: toluene, dichloromethane, methanol, etc. Our goal is the removal of VOCs from exhaust gases with feasible minima of energy consumptions. For this purpose, several factors have been investigated: reactor type, operating conditions, etc. As the distribution of electron energies is uncontrollable at this moment, hybridization of nonthermal plasma and catalysts is our main theme to improve energy efficiency. For these five years, we have implemented the six joint projects sponsored by private sectors to facilitate collaborative researches with them. We have published thirty-six papers and have received the six paper awards from the overseas and domestic academic societies and publishers.

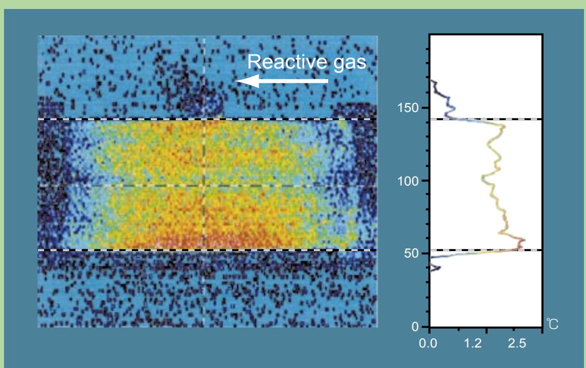

Figure: Temperature distribution of a nonthermal plasma reactor in operation

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The Future of Risk Management of Chemical Substances

Toxic substances – such as PCB and lead of long ago, dioxins from garbage incineration facilities and formaldehyde, a causative agent of sick-house syndrome in the 1990s, as well as the recent asbestos – have each independently caused a public sensation, and each time, regulations have been tightened on the relevant substance. However, such ad hoc responses only result in dragging the villain hunt on forever, and will never let us achieve safety or security.

Therefore, we need an approach for reducing the total risk, by prioritizing while keeping sight of the overall picture. To this end, AIST's Research Center for Chemical Risk Management (CRM) has been conducting development and implementation of techniques in "the science of simulating risk." The results of our efforts constitute risk assessment documents of 30 substances currently in progress. It covers most of the substances which are considered to be of high risk at this point, but also leaves us with the following doubts. The first is the question of whether or not our 30 substances are really sufficient when the number of chemical substances is said to be as high as 20-100 thousand. Another is the reservation regarding the potential of a vicious cycle, in which if Substance A is deemed bad, we go on to Substance B, and if B is dangerous, we then substitute Substance C. In order to resolve these issues, CRM has progressed on to the next level, which is multiple risk assessment and management. Below, we present a broad overview of a new risk assessment and management paradigm in a multiple risk society.

From single to multiple

We are not only exposed to numerous toxic substances, but are faced with various risks including disasters and accidents as well. In other words, we are living in a multiple risk society (Figure 1). In order to reduce the risks in society as much as possible, we need to prioritize our risk measures by considerations for cost effectiveness, to decide how much of a limited budget should be allotted to each measure. Thus, we require a technique for efficiently assessing large numbers of substances from little data and for assessing the trade-off relationships between risks. Regarding the former, we examine a method for supplementing the data gaps through statistical methods and judgment of specialists. The latter is what we call risk trade-off analysis.

Owing to the Pollutant Release and Transfer Register (PRTR) system, emissions of substances targeted for PRTR reporting have been reduced significantly, while in their place, substitutions to non-target substances are increasing. However, it cannot be said that substances targeted for reporting are dangerous while substances not targeted for reporting are safe. We need to examine whether or not the risk is really reduced with use of the alternative substance, taking into account changes in the emission volume as well. In so doing, we need to compare the risks of the non-target substance of which little data are available, with the target substance having relatively abundant data. In

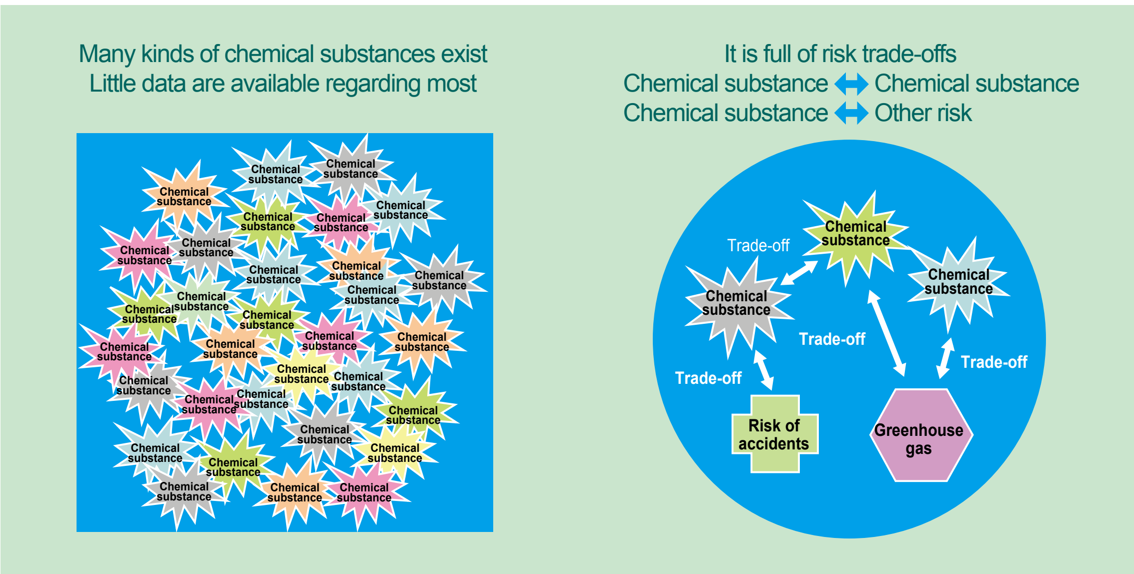

Figure 1: Characteristics of a multiple risk society

addition, we need to make considerations for factors other than risk of chemical substance exposure. For example, treating exhaust gas by combustion by crude oil eliminates emission of the relevant substance but results in emission of CO_2. Alternative substances of low toxicity may possibly increase the danger of explosion or make a chemical change into another toxic substance when in the environment.

From point to distribution

The assumptions employed in risk assessment up to now were designed to fall on the safe side in cases of uncertainty or variation in data. In other words, they protected the high-risk party. This approach is effective in the case, for example, of determining environmental standard values. However, as the degrees of assumption to the safe side differ between substances, it is difficult to compare the relative levels of risk between substances. In multiple risk assessment, we need to treat uncertainties and variation in data as distributions where possible so that inter-substance and inter-event risks may be compared, and so that we may grasp an overall view of risks, and not just the point estimates.

From defensive to offensive

Risk assessment and management up to now have been conducted on a 'defensive' stance, of avoiding violating regulations. However, by performing risk assessment in parallel with the development stage when developing new substances and new technologies in the future, it will become possible to take an initiative in planning the framework of the controls which were conventionally taken passively. This will lead to reduction of waste and uncertainties related to research and development investments. The recent approaches of European Union (EU), including RoHS regulations which prohibit the content of specified toxic substances in electrical and electronics equipment and REACH, the new bill regarding registration, evaluation, approval, and control of chemical substances, may be considered 'offensive' approaches aiming to gain international leadership.

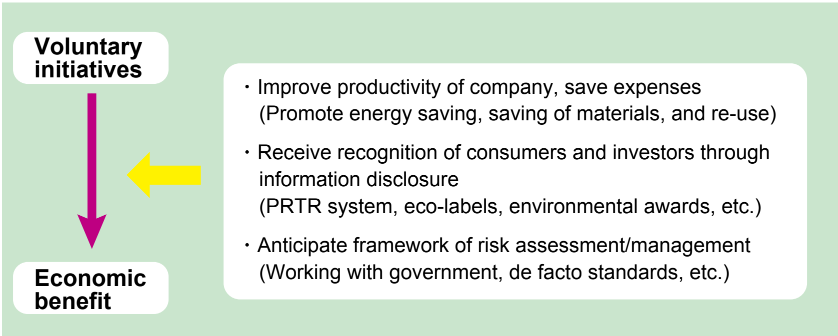

Figure 2: The route by which voluntary initiatives lead to economic benefit

From the aspect of risk management as well, there is a new recent trend shifting from regulatory control to voluntary management. Environmental reports show that corporations are taking action by conducting reductions in emissions cutting widely below regulatory levels and by voluntarily increasing the variety of target substances. The incentives for engaging in voluntary initiatives are believed to be as shown in Figure 2. However, voluntary management in the true sense is not simply to implement emissions reduction measures ahead of regulatory values, but consists of a series of operations, of performing voluntary risk assessment and disclosing in a comprehensible manner the results as well as the grounds of any decisions based upon considerations thereof, to the stakeholders.

From management to governance

Whether or not nanomaterials and biotechnologies are accepted by society is not determined solely by the size of risk involved; the mutual balance between risk and benefit becomes the key. The risk in this case is not limited to health risks, but consists of the large concept which includes impacts to anxieties of the public and ethical aspects as well. In the case of a new technology, evaluation should not be based upon the one attribute of health risk, but upon the collection of many attributes including convenience as well as public perception and preference.

This type of evaluation is called technology assessment, and the form of management based upon it is referred to as governance. In other words, what we require is not a one-sided management from government to corporation, but a form in which various bodies are involved -including citizens, NGO, corporation, and government – as society at large, to control the technology.

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Progress from Product-Oriented LCA to Social LCA

Life cycle assessment (LCA) is the quantitative assessment of the environmental impact of a product over its entire life cycle, from manufacture through use and disposal. Backed by government aid for the establishment of techniques and accumulation of data, use of LCA is spreading in the industrial world. It is employed by many companies, and the results are increasingly disclosed in environmental reports and websites of corporations.

Such methods for evaluating every aspect related to a system are being utilized in various areas. Now, it is no longer applied only to evaluation of products, but increasingly to evaluation of corporate activity, recycling-oriented social systems, and regional measures as well.

Of the various types of LCA, AIST's Research Center for Life Cycle Assessment tentatively refers to the LCA oriented in application to various constituent bodies of society as mentioned above, as 'social LCA.' And the Research Center works to lead the development of such social LCA by developing the necessary techniques, implementing case studies, and preparing an environment for its implementation.

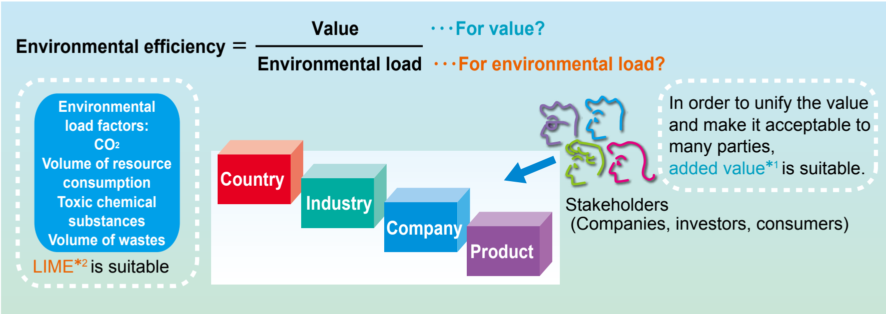

Figure 1: Concept of environmental efficiency
*1 The total of added values is the GDP
*2 Environmental load integrated using the Japanese version of Life-cycle Impact assessment Method based on Endpoint modeling (LIME)

Evaluation of corporate and industrial activity –Using "environmental efficiency"–

"Environmental efficiency" is a ratio of the function (service) provided by the company/product to the environmental load calculated by LCA. The concept is as follows: regarding identical functions in products, the one causing a lower environmental load is preferable, and regarding identical environmental loads, the one offering more comprehensive functions is preferable. Presently, environmental efficiency is utilized in many advanced corporations. However, its definition varies, and may cause confusion on the part of the receiving end (mainly the "consumers"). In addition, as the types of products and services offered differ between manufacturing and service industries, comparisons hold no significance. It is difficult to compare different industries or companies in terms of environmental efficiency. We have therefore proposed a calculation method which unifies on the levels of country, industry, company and product, as shown in Figure 1, and we are working to develop an environmental efficiency index which will allow comparison at each level. It may be used on various levels, for example, to compare GDP and CO_2 emission on a country level, and the added value of a company and environmental load on a corporate level. This index enables formulation of environmental strategies within companies and offers support to consumers in decision-making when purchasing products/services. We are currently implementing case studies through corporate collaboration efforts in which we are working to define and resolve the issues as well as to develop the environmental index which incorporates corporate views.

Evaluation of regional measures

We are developing a method which evaluates the environmental impacts by local measures accompanying their implementation from the perspective of life cycle, in order to reduce the environmental loads. We are working in cooperation with local governments to implement regional measures, such as industrial development, biomass utilization and waste treatment.

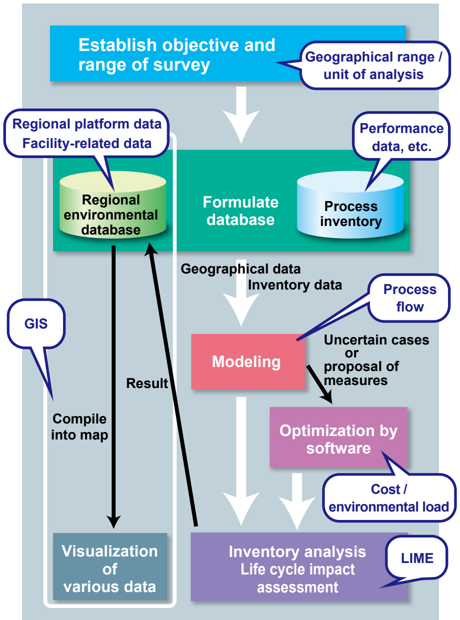

Figure 2: Procedure for applying LCA to regional measures

As shown in Figure 2, the method of

Table: Estimations for reduction in CO_2 emission in eco-lifestyles

Lifestyle	Eco-life type	Network type	Economizing type	Return-to-tradition type	Service-using type
Lifestyle image	Unchanged inclinations regarding material possessions and consumption, but purchases eco-products	Uses the Internet to avoid movement such as commuting as much as possible and lives regionally dispersed	Not concerned with public appearances, and economizes to spend savings on leisure activities or hobbies	Utilizes the resourcefulness of the traditional lifestyle to control wasteful consumption	Switches to rental and purchasing of services instead of buying and possessing a range of objects
Approval rating	17.0%	19.2%	32.2%	18.6%	3.5%
Reduction effect [A] CO_2 (kg) / Month	−102.3	−55.4	−76.9	−61.8	−27.5
Rebound effect [B] CO_2 (kg) / Month	+29.7	+50.4	+32.9	+21.1	+1.7
Reduction effect [A-B] CO_2 (kg) / Month	−72.6	−5.0	−44.0	−40.7	−25.8

application of LCA to local measures is based upon conventional procedures for ISO-LCA, and it uses an inventory database which organizes the inputs/outputs of each process. It also constructs a regional environmental database on the geographical information system (GIS) in order to include considerations for regional characteristics of population distribution, land use and transportation network. Furthermore, we are developing software linked to the regional database to optimize material cycles and energy use within regions. This method is compiled in a practical guide (to be disclosed in the NEDO website), to be offered for practical utilization.

Presently, we are progressing with new efforts including time-axis considerations and the implementation of environmental efficiency. The method is anticipated for utilization in various scenes as a technique for countermeasures designing against global warming as well as environmental management in local communities.

Approach regarding consumer activities

In order to allow the spread of environment-conscious products and achieve a reduction in environmental load, the products need to be accepted by the consumers and be actually used. An environment conscious lifestyle is also required. Here, the lifestyle must be easily accepted by each consumer, and the actual load reduction effect must be quantified and reflected in product development and policy proposal. The Research Center for LCA has been tackling these issues in terms of "sustainable consumption."

The Table classifies environment-conscious lifestyles into five categories, and shows the approval rating and behavior of each. According to the Table, consumers in favor of the "economizing type" are largest in number, however, these people demonstrate a tendency to use the funds which they saved by economizing to take behavior which increases environmental load, such as going on overseas trips (corresponding to the "rebound effect" in the Table), thereby diminishing the overall reduction effect. Through the perspective of such actual load reduction effects and consumer preferences, we hope to contribute in proposing measures for environmental load reduction.

Towards evaluation of sustainability

The triple bottom line (environment, economy, and society) has been recognized as an element indispensable to sustainable development, and evaluation along this axis is now expected in the assessment of the activities of various bodies of society. Evaluation is possible by various economic indices from an economic aspect, whereas from an environmental aspect, development of LCA is demanded, and from a social aspect (referring generally to the concepts of poverty, education, culture, and safety, thus differing from the "society" mentioned above in the application of LCA to "society"), much discussion and accumulation of evaluations are required to allow quantification of assessment. The Research Center for LCA, finding a handhold in the benefit evaluations of consumers and local citizens, has begun work on evaluation of this social aspect as well. Long-term approaches, as well as the efforts of many not limited to the Research Center for LCA, are required in order to establish assessment techniques aiming for sustainability.

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Consideration of Global Warming Assessment Indices

Global warming and future technologies

Progression of global warming is believed to cause a serious impact on the future global environment. As global warming proceeds gradually over an extended period of time, it will generate a large burden on the citizens of the future. It is the obligation of modern man towards the people of the future to carry out the countermeasure technologies which are the most effective for global warming. We need to select the technologies which are superior as global warming countermeasures, keeping in mind the amounts of our resources and progresses in science and technology. For this purpose, we need to predict scientifically the global warming caused by a countermeasure technology before proceeding on with it, to accurately determine the suitability of the technology. Scientific global warming assessment can potentially suggest the technical issues indispensable to the future. The accurate assessment technique is the key to protect the future environment.

Scientific global warming prediction

Evaluation methods using GWP (Global Warming Potential) are generally used in global warming assessment. GWP is a numerical expression of the global warming effect of a gas over a certain period of time, based upon the global warming effect of carbon dioxide during the same time period set as "1." For example, the 100-year value of HFC-134a, a fluorocarbon refrigerant, is 1300. This indicates that in a 100-year comparison, HFC-134a (1 kg) will cause a global warming effect of 1300 times that of carbon dioxide (1 kg). In GWP evaluations, when the period of evaluation is extended, the reference value itself consisting of the integrated value of the global warming effect of carbon dioxide also increases. In GWP, as this increasing value is always defined as "1," a "1" of another evaluation period means something different, thus it is difficult to compare evaluation results of differing times. The HFC-134a mentioned above has a GWP over 500 years of about 400 times that of carbon dioxide, greatly reduced from the 1300 times for 100 years. HFC-134a is eliminated rapidly from the atmosphere, and thus does not cause global warming after 100 years, while carbon dioxide exists in the atmosphere for a long time and continues to cause global warming over an extended time period after 100 years. However, as evaluations including time cannot be compared at present, assessments are performed only for 100 years.

In addition, as GWP is the integrated value of global warming from the time of emission of the gas into the atmosphere through the evaluation period, it is not possible to differentiate between those that cause strong global warming only in the initial stages and those that cause lower global warming over extended long periods. It therefore does not allow discussion regarding the time change of the global warming effect.

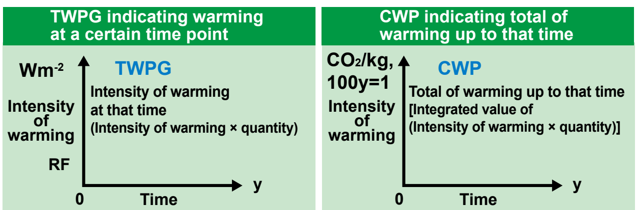
Despite these issues, the 100-year evaluation value has been used regardless and independently as the "GWP value," to allow the GWP to be used in the Kyoto Protocol for policy evaluation. Furthermore, GWP fundamentally evaluates the direct global warming of compounds emitted into the atmosphere but does not include the indirect global warming caused by degradation products and such.

A new assessment method

In global warming assessment, it is important to predict the warming to be caused in the future by the gas emitted in the present. In addition, the assessment should preferably reflect as many of the conceivable global warming effects as possible. From this perspective, we propose two alternative methods to replace GWP.

TWPG (Total Warming Prediction Graph), prediction of future warming

We have developed TWPG as a new method for expressing global warming, from the need for a scientific and easy-to-understand global warming assessment method capable of visualizing future warming. In this assessment method, the warming caused by 1 kg of gas emitted into the atmosphere at present is expressed in a graph showing the relationship between elapsed time (x-axis) and intensity of global warming (y-axis). Of course, it can be expressed in table form as well. TWPG was developed as a scientifically-backed assessment method, as it adds up not only the intensity of warming due to absorption of infrared radiation by the emitted gas, but also the warming effect of the degradation products generated upon degradation of that gas in the atmosphere and the warming effect due to the tropospheric ozone generated due to atmospheric degradation. It also includes the cooling effect of the troposphere caused by degradation of ozone in the stratosphere regarding chemical compounds which destroy the stratospheric ozone. (Figure 1, left)



Items evaluated in TWPG and CWP
(1) Warming by target gas
(2) Warming by degradation products in atmosphere
(3) Warming by generated tropospheric ozone
(4) Cooling caused by reduction of stratospheric ozone

Figure 1: What are TWPG and CWP analyses?

Table: Examples of CWP analysis of gases

Compound	Life in atmosphere (years)	CWP				GWP
		100 years	500 years	1000 years	∞ years	100 years
CO_2	–	1.0	3.2	5.4	60.0	1
CF_4	50000	5700	28386	56490	2466760	5700
NF_3	740	10800	41968	63322	85443	10800
HFC-134a	13.8	1300.8	1303.7	1305.5	1347.2	1300
HFC-245fa	7.9	951.0	953.2	955.3	1005.9	950
HFC,c-$C_5F_7H_3$	3.4	251.2	253.7	256.1	317.5	250
c-C_5F_8	0.98	91	93	96	152	90
HC,n-C_3H_8	0.04	10.9	17.6	24.1	187.9	–
HC,n-C_5H_{12}	0.01	17.0	23.8	30.4	197.1	–
COF_2	–	0.7	2.1	3.6	40.0	–

CWP (Composite Warming Potential), an expression of the integrated amount of warming by time axis

CWP shows the integrated values of TWPG. In this case, the integrated warming of carbon dioxide over 100 years is always set as "1," thus evaluations going beyond 100 years in the same unit are possible. In addition, as it indicates integrations of the four values of warming provided in TWPG, it enables the scientific and objective evaluation of compounds. (Figure 1, right)

Evaluation of gases

TWPG and CWP are based upon evaluation of the warming effect of the gas itself. Here, CWP which is the integrated value of the quantity of warming is shown in the Table. Although evaluations by the conventional GWP were limited to the 100-year value, we can see that by changing the time of evaluation, the situation changes completely.

Example of evaluation by alternative techniques (system evaluation)

Figure 2 shows an example where data from a recent document on a car air-conditioner refrigerant analyzed by LCCP (Life Cycle Climate Performance), a method for comprehensively assessing the warming effect of air-conditioners and freezers, has been converted into TWPG and CWP analysis. From it, we can understand that even in the cold district of Boston, which is at a disadvantage in terms of fluorocarbons, HFC-134a is superior to carbon dioxide as a car air-conditioner refrigerant. HFC-134a is inferior to carbon dioxide refrigerant in the initial stages, however, surpasses carbon dioxide with time. Global warming indices showing such time changes were achieved for the first time through TWPG and CWP analyses. They show superior characteristics as new indices for global warming.

Alleviation of global warming and selection of alternative technologies

Global warming may be regarded as none other than a repercussion of present-day human activity on the global environment of the future generation. Prediction of global warming needs to have sights on the future. To this end, TWPG and CWP analyses enable us to predict the global warming caused by a technology, so that we could select the best technologies. As is obvious from the example of the car air-conditioner, it is not uncommon for the analysis to yield ranking results opposing GWP evaluations in the case of foaming and cleaning agent usages as well, implying the weight of our task of assessing what technologies are truly good for the environment.

The potential of TWPG and CWP analyses

TWPG and CWP analyses show us the technologies necessary from the perspective of global warming. Using the methods of assessment, we may not only evaluate fluorine compounds, but may also gain knowledge regarding the superiority of alternate energies, or regarding which part of a certain usage causes the warming and how much effect can be achieved by improving that part. It goes without saying that the most important factor in maintaining a better global environment for as long as possible is to perform solid assessment and implement active measures conforming to the assessment. We are working to spread TWPG and CWP methods as a means for making this decision.

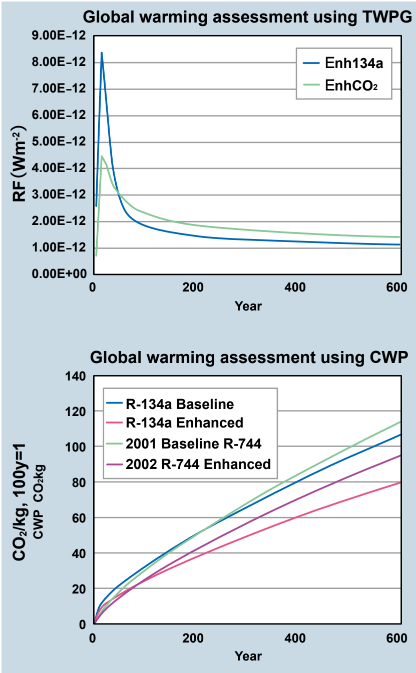


Figure 2: Car air-conditioner analysis in Boston
Calculations based on data from "Stella Papasavva, Bill Hill, New Delhi, India, 2005, p.21"

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Technologies for Earth Observation and Measures to Counter the Problem of Global Warming

Mankind has been emitting massive amounts of carbon dioxide into the atmosphere by consuming fossil fuels such as coal and petroleum, causing widespread concerns including progression of global warming, sharp climate changes, rises in sea levels, changes in the ecosystem, as well as serious impacts to food production.

As the strategy for controlling the accumulation of global warming gases in the atmosphere in order to counter global warming is an issue encompassing the energy utilization and industrial structures of countries worldwide and even extends to review of individual lifestyles, finding a solution for it is not an easy task. It requires the collective wisdom of all mankind.

The role of scientists here is to minimize the uncertainty of the present knowledge through observation and experiment, to perform future prediction with higher accuracy, and to propose countermeasure technologies and validate/evaluate the effects thereof. This is exactly the “fusion of prediction, assessment and protection technologies” that AIST works for in the “Second Period Research Strategy.”

A new “earth observation” system

The first step in countering global warming is to become aware of the present state and predict the future. Observation of the atmospheric carbon dioxide concentration has been implemented continuously since the International Geographical Year conducted in 1957, and presently, is performed at over 100 observation points. In addition, diverse observation systems for capturing global-scale phenomena are being proposed and implemented, including satellites and ground/marine observation systems.

However, suggestions have been made that conventional observation systems are weakly coordinated and that we are entering an era in which earth observation strategies should be shifted from seed-oriented to utilization need-oriented technologies. The enhancing of international cooperation on global earth observation was advocated in the G8 summit of 2003, and as a result, the Earth Observation Summit was held in which the GEOSS (a global earth observation system consisting of multiple systems) 10-year execution plan was approved. The plan aims to implement observation catering to the needs of users, based upon international cooperation. It maintains the existing observation systems, and develops systems and sensors which cover their deficits, to thereby establish an earth observation system which integrates satellite and on-site observations.

In Japan, the Council for Science and Technology Policy has formulated the “Global Earth Observation Promotion Strategy” targeting the next 10 years, and will contribute to construction of GEOSS through a system of collaboration among the Cabinet Office and ministries.

AIST has been implementing observation of the carbon dioxide balance in the forest ecosystem and the ocean. We are presently initiating research to develop new observation systems and sensors to be used at these observation sites, as well as methods for their evaluation and standardization. In addition, as the GEOSS observation concept shown in the Figure is consistent with the view of the GEO Grid System (AIST TODAY July 2006, P20-21) under development at AIST, AIST is expected to play a significant role in this area in the future.

Technologies for measures against global warming

In order to resolve the issue of global warming, we need to not only “become aware of the present state and predict the future” but also to implement strategies to control the warming gas concentration in the atmosphere. However, establishing a society which does not need to rely on fossil fuels is expected to take some time. Until

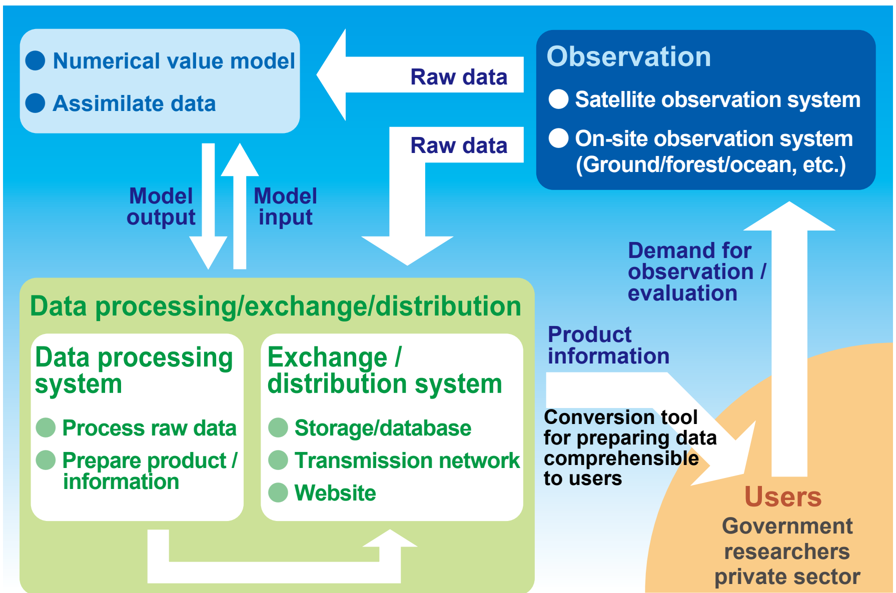

Figure: Concept of international earth observation system of GEOSS

then, while accepting the use of fossil fuels under international agreement, we may need to select a method for rigorously controlling the emission of carbon dioxide into the atmosphere. Such methods include carbon dioxide recovery/storage technologies, for which underground aquifers and deep sea are presently under consideration as sites of storage. It is highly likely that systems resembling GEOSS mentioned above will become necessary for evaluating the adequacy of storage and in selecting suitable sites, as well as in post monitoring.

AIST conducts research which contributes to GEOSS establishment, and promotes research linking countermeasure technologies to it as well.

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Environmental measurement for diagnosis and evaluation

Similar to the progression seen in medical care, from examination to diagnosis, treatment and prevention, we are aiming to advance from environmental measurement to diagnosis, remediation and prevention as well. Therefore, not only are we conducting research on environmental measurement technologies, but also on the environmental science to serve as an intellectual platform of diagnosis.

We have newly incorporated the concept of “field” to develop a technology for simultaneous observation of substance and field. Here, “field” refers to the ecosystem into which substances are emitted. By bilateral viewing of the effect of a chemical substance upon the ecosystem and reversely, the “purifying” function of the ecosystem upon that chemical substance, we collect useful data for environmental diagnosis and the industrialization of environmental function. Analogically speaking, in watching a baseball game, we find it interesting only because we watch the ball and the players at the same time. Until now, the chemists have been watching the ball (chemical substance) while the biologists have been watching the players (microorganism in the ecosystem) independently of each other, which leads to the loss of useful information. Therefore, we are developing techniques such as electrophoresis and mass spectrometry, familiar to chemists, which can be applied as new methods of analyzing microorganisms. While existing methods that involve culturing and DNA analysis require extended periods of time, we are targeting measurement on the order of minutes. These new methods of analysis will propagate to areas such as food (salmonella, etc.), hygiene (O-157 bacillus and in-hospital infections), and safety (airport quarantines), in addition to environmental areas such as bioremediation. They are also useful in the search for microorganisms that possess new functions among the 99% of environmental microorganisms said to be as yet unknown, and investigation of their potential application to industry. By substituting “biological system” for “ecosystem” and “biomolecules” for “microorganisms”, respectively, the technology may also develop into a health science consisting of a collaboration between medical and environmental science.

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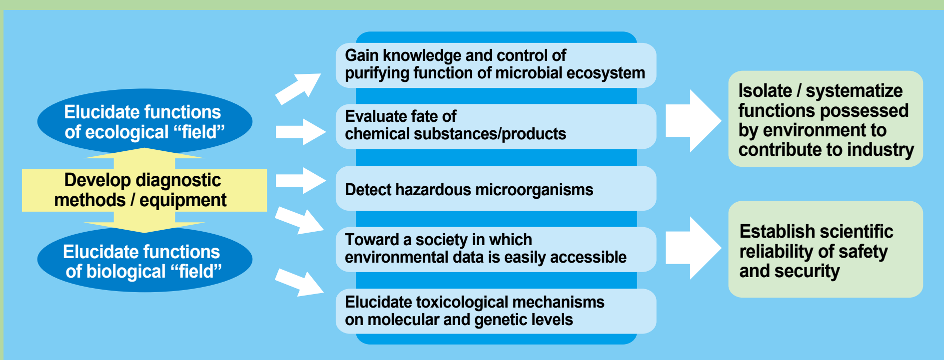

Figure: Towards diagnosis of interaction between “Substance” and “Field”

From Environmental Protection to Environmental Creation

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