Action by All toward Sustainability

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Extensive Use of Scientific Methods for 
Observation of Environment in the Past

--- Case of Global Warming ---
Observation and Warning by Scientists

Global Warming

1800

(Scientists)

J. Fourier (1827)  "Greenhouse Effect"

1850

J. Tyndall (1860)  Effect of air constituent to climate

1900

S. Arrhenius (1896)  Calculation of CO₂/Temperature

1950

C. Keeling (1958)  Measurement of CO₂

S. Manabe, R. Wetherald (1967)  Calculation of CO₂/Temperature

J. Bruce (Villach Conf., 1985)  Consensus of Scientists

2000

G. Brundtland (UN Commission, ‘87)  Agenda 21

(?)  Sustainable Action
Sustainable Development

Sustainable Development by G.H. Brundtland (1987)

= (Sustain the earth) ^ (Develop Less-developed Regions)
We must design evolitional loops in society for sustainability.

We have successfully observed changes of global environment by science and technology. Now, we should make more scientific and technological efforts toward actions to prevent the growth of and to protect us from the deterioration of sustainability.

Here, we shall discuss manufacturing industry, as an example, that is the most useful to develop less developed regions and, on the other hand, the most crucial to influence the global environment,

and try to find a way for society to realize sustainable development by industry.
Move of Centre of Gravity of Industries (Japan)
Preliminary Metrics by AIST

<table>
<thead>
<tr>
<th>Raw-material Industry</th>
<th>Manufacturing Industry</th>
<th>Service Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>100,000</td>
<td>1,000,000</td>
<td>10,000,000</td>
</tr>
<tr>
<td>100,000,000</td>
<td>1,000,000,000</td>
<td>100,000,000</td>
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</tbody>
</table>

Value added (million yen)

Expansion of Size
Diminution of Size
Direction of Improvement

1990-1995-2000
Inverse Manufacturing

(A manufacturing toward sustainability)

Nature

(resources)

Manufacturing

Artifacts

(products)

highly systematized

Artifacts

(resources)

Inverse Manufacturing

“Nature”

(products)

Remedied nature, Ecosystem recovered, Ecosystem services resumed, Chemical-free agriculture, Resource by recycle,
Practices of Manufacturing and Inverse Manufacturing

Manufacturing
- Mining,
- Reclamation,
- Construction,
- Cultivation and agriculture,
- Production of materials,
- Production of goods, etc

Inverse Manufacturing
- Forestation of desert,
- Fish planting,
- Recovery of contaminated lands,
- Biomass in devastated coast,
- Carbon sequestration,
- Bio decomposition of plastics,
- Waste processing,
- Maintenance, etc

For sustainability, it is necessary to;
1. improve efficiency of either manufacturing,
2. keep good balance between both manufacturing, mutually dependent, for optimality, and
3. integrate manufacturing and inverse manufacturing toward a system.

METHODS:
1. STRUCTURE OF HUMAN ACTIONS
2. SUSTAINABILITY METRICS
Coupling of both Manufacturing
Closed-Loop Manufacturing

- Resources
- Nature
- Products
- Inverse manufacturing
- Manufacturing
- Artifacts
- Resources
- Products
Values of a Product

1. What people value is not a product itself, but its functionality.

2. Functionality of a product is service embedded in the product.

3. Latent functionality appears as service when the product is used.
   Use is physical interaction between specific part of the product and user.
   (People receive the service someone embedded in the product, when they use the product.)

4. Functionality of a product decreases when it is used.
   \[ \text{functionality} = \sum \text{service} \]
   (Life of a product terminates when services embedded are exhausted.)

5. Therefore, we can measure the potential value of a product by functionality, that is total amount of service available.
Loop in the Aspect of Functionality

- **Implementation of functionality**
- **Construction of functionality**
- **Extraction of functionality**
- **Dissolution of functionality**
Minimal Manufacturing and Maximal Servicing for Sustainable Society

Minimal Manufacturing

Maximal Servicing

Manufacturing

Inverse Use

Use

Inverse Manufacturing

Construction of functionality

Dissolution of functionality

Implementation of functionality

Extraction of functionality
Minimal Manufacturing

**DEFINITION:**
A manufacturing system to produce products of maximal functionality with minimal resource and energy consumption and with minimal waste

**ENABLING TECHNOLOGIES FOR MINIMAL MANUFACTURING:**
- High-density functional materials,
- Nano-structures,
- Nano-bio materials,
- Energy efficient material processing,
- Compact processes,
- Self-organizing processes,
- Localized clean room,
- Mobile machine tools,
- etc
Maximal Servicing

**DEFINITION**
A service system to do maximal services to people with minimal resource and energy consumption and minimal waste.

**ENABLING TECHNOLOGIES FOR MAXIMAL SERVICING**
Design of products with highest “density” of service contained,
Design of products that efficiently generate services when used,
Low-cost allocation of products that allow people to access easily,
Appropriate social systems to access products such as architecture,
Enough social velocity of information transmission,
Reasonable social rules to get services from products,
Sufficient longevity of products,
Automation of maintenance,
Self-repair of products,
Easy collection of wastes,
etc.
### Scientific Technology and Social Technology

<table>
<thead>
<tr>
<th>KNOWLEDGE</th>
<th>TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common knowledge</td>
<td>Scientific knowledge</td>
</tr>
<tr>
<td>Nature</td>
<td>Natural science</td>
</tr>
<tr>
<td>Society</td>
<td>Social science</td>
</tr>
<tr>
<td>Human</td>
<td>Humanities</td>
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\[
\text{Object} \rightarrow \text{actor} \\
\text{Object} \sim \text{actor} \\
\text{Object} = \text{actor} \\
\text{action: introspection} \\
\text{action: observation} \\
\text{the law} \rightarrow \text{advice to action} \\
\text{analysis} \rightarrow \text{synthesis}
\]
Related Basic Researches in AIST
for Minimal Manufacturing and Maximal servicing

Nanotechnology
Photonics
Quantum electronics
Novel processing
Green sustainability chemistry
Compact Chemistry
Biotechnology
Energy source technology
Energy systems
Bio informatics
Metrology
Artificial intelligence
Brain science
Human stress
Quality of life
Digital human
Robotics
Grid technology
Security system

Sustainable design
Service science
Environmental control
Risk management
Computational science

Sustainable material
Earth Science
Bio remediying
Biomass technology

inverse Manufacturing
Manufacturing
Use
Inverse Use

Life cycle engineering
Theory of deterioration
Ten Rules of AIST

1. Remove the lid (ふたを取る)
2. People gather, and then an organization (人がいて組織が)
3. Autonomy of research unit (研究ユニットのオートノミー)
4. Full research (本格研究)
5. Research strategy written in scientific words (科学の言葉で書かれた戦略)
6. Division of the three powers (三権分立)
7. Fractal of organizations (組織のフラクタル)
8. Time constants of people and organization (人と組織の時定数)
9. Network of excellence (卓越した機関のネットワーク)
10. Common target (共通の目標)
   “Research to move the centre of gravity of industries toward sustainability”
   (“産業の全体がサステナビリティに向けて重心移動するために必要な研究”)

HY
“Full Research”

People’s Reaction (expectation)

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<tr>
<th></th>
<th>Years</th>
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<tbody>
<tr>
<td>Dream</td>
<td></td>
</tr>
<tr>
<td>Nightmare</td>
<td></td>
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<tr>
<td>Reality</td>
<td></td>
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Type-1 Basic Research

Type-2 Basic Research

Product Realization

Universities

Industries

National Research Institute (AIST)

Full Research
Type-2 Basic Research

(1) Type-1 basic research aims at creating new knowledge about facts, but type-2 basic research aims at creating new values* for society.

(2) Type-1 basic research is conducted by an authorized method: “scientific method”, but type-2 basic research has not yet an authorized method.

(3) Type-2 basic research has two missions: creating values for society and establishing a general method of value-creation.

(4) Type-2 basic research is “basic” because of the latter mission of (3) that would contribute to accumulate systematic knowledge for value-creation.

(5) Results of type-2 basic research can not be verified systematically due to lack of general method of research, hence social acceptance is the criterion.

(6) Type-1 basic research is analytical but type-2 basic research is synthetic.

(7) Type-1 basic research is normally conducted within a single scientific discipline but type-2 basic research is basically discipline-free.

* The word “value” is used here in a broad sense: some knowledge effective to society
Research Unit in AIST for Full Research

Aim of AIST: Create technologies necessary to realize sustainable industry

Management

Head of Unit

AIST has 50 research units, covering NT, BT, MT, IT, Energy, Geology and Metrology; all aiming at sustainability.

(1) Unit has a mission to innovate particular knowledge/technology for society/industry.
(2) Head of unit directly communicates the management of AIST.
(3) Head of unit is given full autonomy for conducting the research.
(4) Management keeps the authority of start/reform/abolition of unit.
(5) All researchers in the unit always bear its mission in mind.
(6) Type-1 basic researchers aim at generating new scientific knowledge.
(7) Type-2 basic researchers aim at creating new values for society.
(8) Product-realizing researchers aim at creating products/knowledge for society.
(9) Three groups are integrated by the head to conduct research coherently and concurrently.
(10) Researchers are free to move among three categories.
(11) In order to realize such research unit, head of unit must be an “autonomous thinker”, who is ethical and philosophical.
Diversified Disciplines of Researchers in Research Units

Disciplines: Math, Physics, Chemistry, Biology, Geology, Mechanical, Electrical, Inf/Com, Material, Arch/Civil, Nuclear, Medical, Pharmaceutical, Agricultural (14)

National Institute of Advanced Industrial Science and Technology (AIST)
Peirce’s Classes of Science (separation of knowledge)

Charles Sanders Peirce (1839-1914)

- Mathematics
- Metaphysics
- Nomological science
  - Psychology
  - Linguistics, Anthropology
  - Sociology
- Classification science
  - Technology (Social rules/manners)
  - Geology, Geography, Astronomy, Hydrology
  - Dynamics (Manufacturing technology)
- Descriptive science
  - Chemistry
- Actions in real world
  - Technology (Social rules/manners)
  - Geology, Geography, Astronomy, Hydrology
  - Dynamics (Manufacturing technology)

Progress of science (abstraction, disciplinarisation)

Design (materialization)

Metaphysics of knife and fork

Theory of knife and fork

Classification/description of knife and fork

Scientific Knife and fork

Knife and fork: table manners (Use)

Knife and fork: techniques of forge and finish (Fact)

Example Aspects
Topological Structure of Human Knowledge

- \( t \): an abstract concept
  \[ T = \{ t \} \]: abstract concept set
  - Abstract concept is defined by view and knowledge derived by particular value and interest.

- \( s \): an entity concept
  \[ S = \{ s \} \]: entity concept set
  - Entity is that exists, existed and will exist.

- Human knowledge, \((S,T)\), is a topology. A discipline has an intrinsic topology.
Integration of Different Topologies

Fact Knowledge / Knowledge about real world
(common set)

Difficult to communicate

Discipline A

Classification / Relations
(different topologies)

Discipline B

?
Collective Intellect in Science

- Collective knowledge/data is the key for multi disciplinary science, and
- Diversity is nature of scientific data
  - Geographical distance,
  - Multiple ownership (individual/organization)
  - Variety of data access protocols
- Design and Solution
  - Keep the data AS IS, and provide users with SIMPLE VIEW.
    Data sets are so huge, single archive impossible
    - Maintain Multiple (distributed) archive sites corresponding to geographical diversity and retaining the data policy
    - Provide Single VIEW for users easily to access the data
    - Diminish geographical distance by high speed network

GEO Grid - a good example to implement this concept, is AIST’s initiative intends to integrate earth observing data over network including multiple Satellite imageries, geology data, CO2 monitoring etc. by using advanced information technology such as Grid.
Making a Shift toward Sustainability

“Industrial transformation”

Development = Artificial value

Environment = Natural value

\[ V_N + V_A = \text{constant} \]

Increase of \( V_N + V_A \) by Minimal Manufacturing and Maximal servicing
We should develop many other evolutionary loops that include society and science community.

Followings are important actions already started, that will be discussed elsewhere, from the view point of loop.

*International Conferences:*
- World Economic Forum (Davos)
- World Science Forum (Budapest)
- STS(Science and Technology in Society) Forum (Kyoto)
- BioVision (Lyon, Alexandria)
- World Knowledge Dialogue (Crans-Montana)

*United Nations:*
- Framework Convention for Climate Change (FCCC~IPCC)
- Commission of Sustainable Development (Major Groups ~ Governments)
- Global Compact (UN ~ Business)

*UNESCO:*
- Decade of Education for Sustainable Development
  (UNESCO ~ Nation educators)

etc.

【End of Presentation】