Regional Low Carbon Innovation through Hybrid Approach with Monitoring and Modelling

Prof. Tsuyoshi Fujita
Director of Center for Social Environmental Systems Research
National Institute for Environmental Studies
Alliance Professor, Nagoya Univ.
New Challenges for Modelling and Monitoring Research

Research challenge to compile innovative modelling and monitoring approach

- **Low Carbon Solutions on Local Contents**
- **Technology and policy Solution Design Adapting to Local Characteristics**
- **Integrated Model for Future Vision**
- **Normative Targets by General Equilibrium Model**

Graph showing Long Term Integrated Model for Future Vision with Back Casting and Future Targets.
New Challenges for Modelling and Monitoring Research

Research challenge to compile innovative modelling and monitoring approach

Low Carbon Solutions on Local Contents

Technology and policy Solution Design Adapting to Local Characteristics

Integrated Model for Future Vision

Normative Targets by General Equilibrium Model

Low Carbon Solutions on Local Contents

Technology and policy Solution Design Adapting to Local Characteristics

Integrated Model for Future Vision

Normative Targets by General Equilibrium Model

QUANTUM LEAP!
Or Social Transition
Innovative Modelling and Monitoring Research Project

Low Carbon Solutions on Local Contents

Technology and policy Solution Design Adapting to Local Characteristics

Integrated Model for Future Vision

Normative Targets by General Equilibrium Model

Present

Short Term

Long Term

Low Carbon Monitoring System

Dual Direction Low Carbon Monitoring Information System

Future Targets

Environmental load

BaU

Back Casting

CO₂ emissions (MtCO₂)

Agriculture, Forestry and Fish

Transport, Energy

Transport, Freight

Transport, Passenger

Commercial

Residential

Other Manufacturing

Construction

Machinery

Non-Ferrous Metals

Other Non-Metallic Minerals

Glass Products

Other Chemical Products

Textiles, Wearing Apparel and Food Products

Paper, Pulp and Printing

Petrochemicals

Cement

Iron and Steel

Electricity and Heat Production

Energy Conversion

Back
Smart Symbiosis Initiatives for Eco town Innovation

Smart ICT network will promote and complement the synergetic network functions among stakeholders

Energy and consumption demand control system for urban sectors

Information support for optimizing local and regional material and energy circularization

Smart industrial complex supported by synergetic information network among industries

Local energy supply and demand

High value substitutive

Local symbiosis

Power plant

Steel

Cement

Chemical

Demand

Urban and Regional symbiosis

Local Data Collection Center

Energy demand information

Energy demand response

Energy and consumption information

Smart Recycle Center

Renewable energy

 BY-product information

incineration

methane

Smart Recycle Center

Smart community

Smart industrial complex

Smart ICT network will promote and complement the synergetic network functions among stakeholders
AIM (Asia-Pacific Integrated Model) is an integrated assessment model to assess mitigation options to reduce GHG emissions and impact/adaptation to avoid severe climate change damages.

What are assessed and how?

Mitigation Target, Climate Policy, Capacity building, ...

Emission Model
- Account model
- Enduse model
- Economic model

Climate Model
- long-term vision
- temperature

Impact/Adaptation Model
- IPCC/integrated scenario
- IPCC/WG2
- IPCC/WG3
- carbon tax

AIM/Impact [Policy]

Feedback

Modeling
- low carbon scenario
- future society

Other Models
- Population
- Transportation
- Residential
- Burden share
- Stock-flow
- Accounting

What are assessed and how?

Mitigation Target, Climate Policy, Capacity building, ...

What are assessed and how?
Development of Regional Integrated Models (Regional AIM) and Spatial Planning Model to design sustainable regions and cities

**Integrated Model (AIM)**

- **Design of Vision and Road Map for National Scale**
  - National End Use Model
  - *CGE model*
  - National Targets
  - National Road Maps

- **Regional Rebuilding Parameter**
  - 【Population】Policies for aging
  - 【Industries】Policies for low carbon
  - 【Bio-Sys】Natural habitat restoration
  - 【Land Use】Compact city Policies

- **Spatial Planning Model**

- **Eco Growth Modules**
  - Local Heat/Energy Management
  - Low Carbon Industrial System
  - Strategic Spatial Zoning System
  - Forestry Eco System Service Model
  - Spatial Policy/ Tech. Process Packages

- **Analysis for Fukushima Pref. Scale**
  - Regional Parameters
    - End Use Model
    - Fukushima CGE Model
    - Fukushima Targets
    - Fukushima R. Maps

- **Planning for Local Scale**
  - Snap Shot Models
  - Policy Support Tools
  - Local Targets

- **Local Startaitistics and Project Data**
  - Buildings
  - Industries
  - Agriculture/ Forestry
  - Life Style
Integrative Model Application toward Low Carbon Cities and Regions
NIES Dr. Gomi

**AIM Region Model**

**Energy Model**

\[ p_{tot} = \frac{P_{work}}{WR_{agg}} \]

**Population Model**

\[ \text{POP}_{tot} = \frac{\text{Pop}_{work}}{WR_{agg}} \]

**Transportation**

\[ \text{PTD}_{fs} = \sum_{ft} \sum_{in} \left( \text{Pop}_{agri} \times \text{Pgs}_{agri} \times \text{LHD}_{fs} \times \text{AAWH} \times \text{DER}_{fs} \right) \]

**Local Economy**

\[ \text{Income} = \left[ \text{Inam} - (1 - \text{IMR}) \times \text{Amat} \right] \]

**Policy Options**

\[ x_{fs} = \text{IMP}_{fs} \times \text{IMP}_{fs} \times \text{IMP}_{fs} \times \text{IMP}_{fs} \]

**Land Use Model**

\[ \text{Area}_{fs} = \sum \text{LUCM}_{fs} \]

**Future Scenario**

**Life**

**Industry**

**Planning**

**Energy**

**Decision Planning for Stakeholders**

**Low carbon planning**

**Citizen participation**

環境共生型まちづくりの進展

Feed back toward the Sub module modelling

Technology Inventory and Suitability Analysis

Priority setting for the focal policy targets and scope
Future Simulation for Alternative Scenarios

**Population**

- **Bau**: Population decreases over time.
- **LNG Base**: Population decreases initially but shows recovery by 2050.
- **Indus.Location**: Population remains stable with slight growth.
- **Green Growth**: Population increases over time.

**Local GDP**

- **Bau**: GDP decreases over time.
- **LNG Base**: GDP decreases initially but shows temporary growth for construction.
- **Indus.Location**: GDP remains stable with slight fluctuations.
- **Green Growth**: GDP increases over time.

Key Points:
- **Population recovery by green growth**
- **Population keeping with industrial locations**
- **Limited population effects by LNG base**
- **Additional 70 mil US$ effects by green growth**
- **Additional 110 mil US$ by industrial locations**
- **100 mil US$ by LNG base construction and operation**
Multi Stage Approach for Eco-City and EIP Planning

① Macro-scope

- Alternative future vision
  - population, industries
  - core developments
  - energy locality

② Spatial-scope

- Land use zoning / network design
  - land use distribution patterns
  - local energy network
  - location of core developments

③ Project Design

- Core projects for revitalization
  - zoning and regulation
  - district planning
  - key industries

Future frame

Feasibility Study
Environmental Measures Analysis in Tokyo Metropolitan Region

**Scenarios** (2020, 2030, 2050)

- Locally suitable env. measures
- Compact land-use

- Energy supply & demand
- Economic impact

**Models**
- Building Stock Management Model
- Local Energy Model
- Heat Island Model
- Resource Recycling Model
- Env. Technology Assessment Model
- Computation General Equilibrium (CGE) model
- Land Use and Transport Model

- Future macro-frame (population, industry, material production, etc.)
- Urban & env. policy options
- Urban & env. technology options

- Effect of env. measures
  - Energy saving & LCS
  - 3R
  - Heat island mitigation
  - Convenient transport
  - Economic impact
Primary application case in Tokyo region, Japan

An application case in Tokyo region (macro to spatial scale). Regional condition, resource and energy circulation, and future industrial and urban symbiosis are analyzed.

Analyze and plan future socio-economic change, e.g. pop, GDP, industries.

Analyze and Predict future resource, energy and waste condition.

Help to infrastructure analysis, planning and future technology projection.

Analyze and plan future socio-economic change, e.g. pop, GDP, industries.

2010 Population 2020

2010 Waste generation 2020

Facilities

Low-carbon technologies

Waste heat potential

Heat demand

Local Energy System

Outside: demand
Inner: supply potential

Supply-demand match

Cost simulation

Cost effective region

Resource

Heating

Cooling

Power plant waste heat

Industrial plant waste heat

Heat demand (T/yr)

Heat transport cost

Total cost of introduction

Heat distribution cost

Waste heat purchase cost

Effective width: \( l_e = \beta \cdot A_{12} + y \)

National average 640 0.0037, y=480

Tokyo: 6=0.0028, y=0.0011

(Kanakidani et al., 2008)

2010 Waste generation

2020 Waste generation

Population

Facilities

Analyze and plan future socio-economic change, e.g. pop, GDP, industries.

Analyze and Predict future resource, energy and waste condition.

Help to infrastructure analysis, planning and future technology projection.

Analyze and plan future socio-economic change, e.g. pop, GDP, industries.

2010 Population 2020

2010 Waste generation 2020

Facilities

Low-carbon technologies

Waste heat potential

Heat demand

Local Energy System

Outside: demand
Inner: supply potential

Supply-demand match

Cost simulation

Cost effective region

Resource

Heating

Cooling

Power plant waste heat

Industrial plant waste heat

Heat demand (T/yr)

Heat transport cost

Total cost of introduction

Heat distribution cost

Waste heat purchase cost

Effective width: \( l_e = \beta \cdot A_{12} + y \)

National average 640 0.0037, y=480

Tokyo: 6=0.0028, y=0.0011

(Kanakidani et al., 2008)
BAU Land Use Scenario (2050)
現状の熱供給事業を踏まえた設定

<table>
<thead>
<tr>
<th>Districts</th>
<th>70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>1,500ha</td>
</tr>
</tbody>
</table>

現状の熱供給事業を踏まえた設定（推計地域は現状の熱供給事業区域。大きさは現状の熱供給事業区域の大きさを参考に設定した半径260m円）

Strategic Land Use Scenario (2050)
鉄道駅を中心とする地域に大規模な導入を行う設定

<table>
<thead>
<tr>
<th>Districts</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>256,000ha</td>
</tr>
</tbody>
</table>

鉄道駅を中心とする地域に大規模な導入を行う設定（推計地域は鉄道駅周辺半径900m円内のうち、熱需要密度4.2TJ/ha以上または開発計画区域と重複する熱需要密度1TJ/ha以上の地域）
BaU scenario in Shinchi town in 2030

- MLS Power Plant
- LNG base
- Newly located industries
- Soma city
- Komagamine
- Energy management
- Mega solar
- To Natori
- New town around Station
- Plant factories
- LNG base
- LNG Power Plant

Legend:
- Heat
- Cool
- Gas (LNG)
- Electricity
Integrative Energy System in Fukushima Shinchi town in 2030

- Food industries
- Data center
- LNG Power Plant
- LNG base
- New town around Station
- Mega solar
- Energy management
- Komagamine
- Plant factories
- To Natori
- Plant factories
- LNG base
- New town
- Soma city
- Heat
- Cool
- Gas (LNG)
- Electricity
Estimation of Alternative Future Recovery Scenarios

Alternative Spatial Scenario

Quantification of Impacts and Costs

Effects of Local Energy Management

Green growth can double the Carbon Efficiency
Research framework targets

- **Location theory**
- **Regional science** (Weber, Alonso, etc.)

**Regional Future Scenario**
(Local GDP, Population Land area)

**Spatial Distribution**
- (Residential)
- (Industrial)

**Future Spatial Scenario**

- **Land Use Scenario**
- **Local Energy Management System**
  - *CEMS*
  - *ADR*
- **Energy Supply Infrastructure System**
- **Industrial Energy Management System**
- **Waste Management System**
  - *Local energy*
  - *FEMS*
  - *Industrial Symbiosis*

- **Eco Finance / Behavior Science**
- **Multi-Variable Integration Theory**

**Industrial Location Scenario**
Smart Symbiosis Initiatives for Eco town Innovation

Smart ICT network will promote and complement the synergetic network functions among stakeholders.

- Energy and consumption demand control system for urban sectors
- Information support for optimizing local and regional material and energy circularization
- Smart industrial complex supported by synergetic information network among industries

Local Data Collection Center

- Energy demand information
- Operation information
- By-product information

Smart Recycle Center

- Renewable energy
- Methane from incineration

Smart community

- Energy demand response
- Local energy supply and demand

Smart industrial complex

- High value substitutive
- Local symbiosis
- Power plant, Steel, Cement, Chemical

Urban and Regional symbiosis

- Demand
- Waste and material energy
- Waste recycle center

Information support for optimizing local and regional material and energy circularization
Monitoring sites of Bogor City in 2014-2015

Shopping mall is targeted in 2015FY
50 monitoring points in Bogor city

<table>
<thead>
<tr>
<th>Sector</th>
<th>Number of facilities</th>
<th>Number of point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government building</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Residential house</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Commercial facilities</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>
Action framework of urban monitoring system in Asia

- Advanced internet security technologies effectively manage and protect the data
- Excellent recovery data collection capability
- Relationship analysis between human behavior and energy use

1. Monitoring Electricity Data
   - Energy Meters
   - Lightings
   - AC
   - Production Line

2. Collecting Electricity Data
   - Sensor for human activity

3. Analysis of collected data
   - Data Center (Indonesia/ Japan)
   - Visualization
   - System Design through User Participation

4. Promoting Low Carbon Activities/Behavior
   - Green Room (Management center)
   - Tablets

Robust Data Traffic under Uncertain Condition
Integrative Analysis of Multi-Sectoral Data
Analysis example in Residential Unit

Potential of energy-saving is 15% in Residential Unit

Air conditioner has 50% of Electricity Consumption

1. Raising the set temperature 2 degrees (4%)
2. Maintenance of equipment (3%)
3. Replacing to latest air conditioner (8%)

Potential of CO2 reduction in Residential Unit:

\[ 199\text{[kwh/year]} \times 0.814\text{[kg/kwh]} \div 0.162\text{[tCO}_2\text{/year]} \]

(Indonesia <Java> FY2012)
Traffic monitoring plan

Goal: Eco-friendly and More Comfortable City

Phase 1: Visualize traffic congestion

Visualize traffic congestion and travel time data by using several smartphones as GPS sensors on vehicles.

- **Sensing**
  - App.
  - Smartphone App.
  - GPS sensor

- **Target Vehicle**
  - Public Bus (*TransPakuan*)
  - The target: 20 vehicles

- **Collection and output**
  - Positioning info.
  - Time and speed

- **View**
  - Traffic data with GHG info.

**Schedule (Tentative)**
1. Preparation (~Feb, 2015)
2. App. Installation
3. Monitoring (Mid. of Mar)
4. 1st Report (End of Mar)

Phase 2: Calculate traffic volume

With CCTV

Phase 3: Suggest Environ impact in traffic congestion

With environment sensor
• Conventionally, local scenarios are developed with limited statistical data and "default" parameters from national or international information.

• Our approach combines monitoring of local activity and modeling so that we can propose the most suitable mitigation scenario and Action plans for the city/region.
4. Implementation of Monitoring System Preparatory Demonstration

4) Future Project Extension

**Case Study**

**AI x Image Analysis (Deep Learning)**

*Artificial Intelligence (AI) can contribute to factory optimization from the viewpoint of human information, such as facial expression, activity etc.*

**Visualization of trends**

**Activity map**

**Human Flow**

**Green Operation**

**Temperature sensor**

**Temperature Heat Map**

**Optimization of working environment**
Monitoring framework for industrial sector

1. Selecting monitoring points
   The points expecting large energy saving are selected based on site survey.

2. Monitoring of facilities / factories
   The points expecting large energy saving are selected based on site survey.

3. Data analysis and solution design
   Factory scale solution
   EIP scale solution
   Region scale

#Monitoring device is used for verification after implementation
4. Implementation of Monitoring System Preparatory Demonstration

3) Intelligent Dashboard

Intelligent dashboard contribute to total factory management and enhance company’s business evolution.

Case Study

Automotive components manufactures

Improve factory issue with real time monitoring and control

Evaluate factory management → Business evolution

More than 10% energy saving with Intelligent Dashboard system

Easy to business evolution!

https://www.youtube.com/watch?v=BPqunfV-Rts&feature=player_embedded
3. Objective and Process Design of Industrial Monitoring System

4) Optimization of production process

*With the visualization and diagnosis operation, factory production process will be conducted to optimize energy usage etc.*

**Diagnosis of a factory**
- Finding out an effective solution to improve energy efficiency
- Power vs. Production Volume
- Best Practice

**Factory scale solution**
- Optimization of operation condition
- Introduction of advanced technology
  - High efficiency facility

**Diagnosis of factories**
- Seeking possibility of integrated energy management of multiple factories in an EIP

**EIP scale solution**
- Energy management in an EIP
- Auto Demand Response
- Co-generation / heat cascade

**Local National Green Industry Policy Solution**

Questionnaire survey for industrial park
3. Objective and Process Design of Industrial Monitoring System
5) Localization of green industry scenarios by using monitoring system

i) Conventionally, local scenarios are developed with limited statistical data and “default” parameters from national or international information.

ii) Our approach combines monitoring of local activity and modeling so that we can propose the most suitable mitigation scenario and Action plans for the factory/industrial park.
PJ1MONITORING; Community Network System (CNS)

1. Local Energy Management System
   - Energy Use Monitoring System
   - Multi-use Smart Tablet
   - Information for energy saving, and low carbon activities
   - We saved 800 g of CO2
   - Let’s share with friends
   - Let’s join the neighborhood club in the Library

2. Rebuilding Community Support System
   - Rebuilt Houses
   - Collective Houses
   - Local life information

3. Local Transportation Support Systems
   - Demand bus
   - Transportation data
   - Base Information for Town Planning

4. Smart Hybrid Center
   - Dual Direction Network System
   - Use Patterns
   - Energy Monitoring
   - Green energy generation
   - Data platform

Future Network with Industries
- Mega-Solar
- Fire Power Plant
- LNG Base Plant
- Regional Energy Supply Center
- Agri-Facilities CO2
- Industries

Let’s share with friends
We saved 800 g of CO2
Environmental Monitoring : GREENAGES

Any particle data can be stored in a centralized DB and visualized.

Customer benefits

Flexible system design enables the system operators to easily add the parameters by themselves.

Accumulated data enables business owners to predict the causes of exceedance trend and/or specific situation and to begin working on it.
Interactive Eco-policy Planning System in Asia

Fukushima Shinchi Township

National Institute for Env. Studies

Community Assist Tablet Network

Local Needs

Energy Assist

Regional Environment Information

Life Assist

Community Information Assist

Urban Spatial Analysis

Local environment diagnosis

Simulation for recovery roadmap

Integrated Modelling

Future scenario assessment

Planning for Sustainable Future

Tech. and policy inventory

- low carbon tech
- circulation tech
- industrial symbiosis
- policy / regulation
- land use control
Regional Network
- Networking with regional and locale energy supply system

● Compact low carbon neighborhood transition

Collective Energy Cloud Storage and Control System

Efficient Energy Demand Management

Electric and Thermal Energy Management

Demand Management

From Monitoring to Smart Community Energy Management (Smart Electric and Thermal Demand Management System)
Innovative Monitoring and Reporting, Verification System in Asian Countries

Greenhouse gas Observing SATellite GOSAT

Ground Monitoring System of GHG

Smart Monitoring Network System for Eco Cities

Joint carbon Credit Mechanism Projects

International Financial System for Low Carbon City Development

Eco-city Evaluation and Validation
Innovative Modelling and Monitoring Research Project

Low Carbon Solutions on Local Contents
Technology and policy Solution Design Adapting to Local Characteristics

Integrated Model for Future Vision
Normative Targets by General Equilibrium Model

Low Carbon Monitoring System

Dual Direction Low Carbon Monitoring Information System

Present → Short Term → Long Term

Environmental load

Future Targets

Low Carbon Monitoring System

BaU

Back Casting

Future Vision

Normative Targets

Technology and policy Solution Design Adapting to Local Characteristics

Low Carbon Solutions on Local Contents
1. Interdisciplinary monitoring system research and development for sustainable future of the society, cities and regions

2. Multi-scale and time horizon simulation for optimal socio-environmental solutions

3. Integrative simulation and co-design process development through innovative communication systems
List or related publications

- Yong Geng, Fujita Tsuyoshi, Xudong Chen; Evaluation of Innovative Municipal Solid Waste Management through Urban Symbiosis: A Case Study of Kawasaki, Environmental Sci and Tech., 2009 (revised)
- Yong Geng, Qinghua Zhu, Brent Doberstein, Tsuyoshi Fujita; Implementing China’s Circular Economy Concept at the Regional Level: a review of progress in Dalian, China, Journal of Waste Management, vol.29, pp.996-1002, 2009
- Yong Geng, Rene Van Berkel, Tsuyoshi Fujita; Regional Initiatives on Promoting Cleaner Production in China: A Case of Liaoning, Journal of Cleaner Production, 2008 (submitted)
- Zhu Qinghua, Yong Geng, Tsuyoshi Fujita, Shizuka Hashimoto; Green supply chain management in leading manufacturers: Case studies in Japanese large companies, International Journal of Sustainable Development and World Ecology, 2008 (submitted)

Thank you for your Attention