5th Annual Meeting
Low Carbon Asia Research Network (LoCARNet)
Innovating Monitoring Session;
October 25th, 2016 Session

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

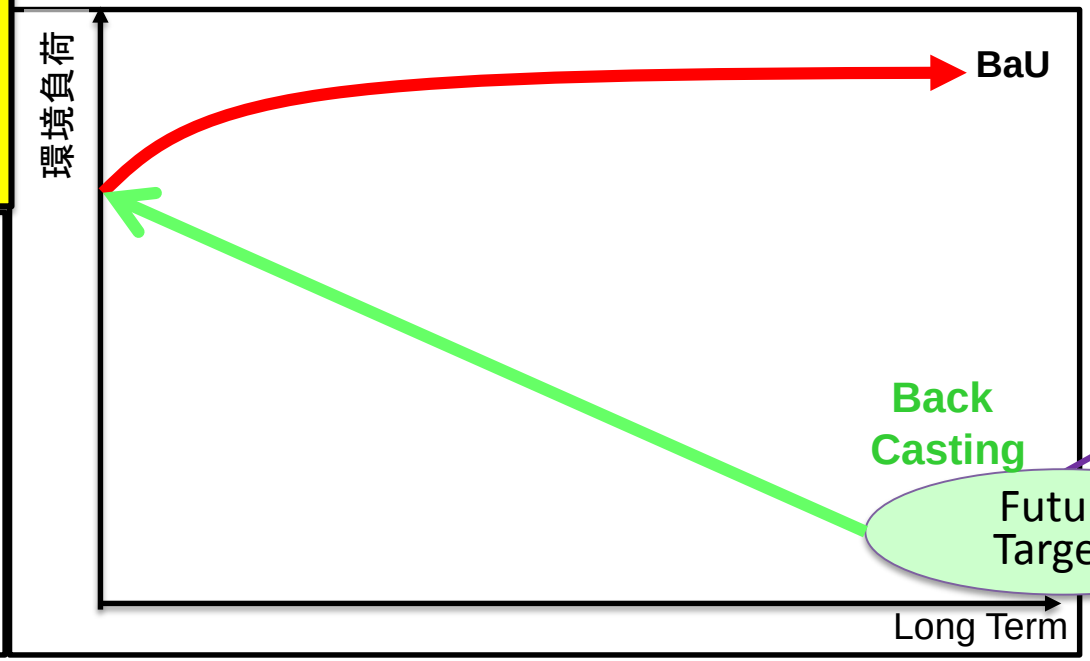
Alliance Professor, Nagoya Univ.

New Challenges for Modelling and Monitoring Research

Research challenge to compile innovative modelling and monitoring approach

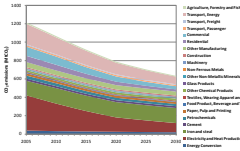
Low Carbon Solutions on Local Contents

Technology and policy Solution Design Adapting to Local Characteristics



Integrated Model for Future Vision

Normative Targets by General Equilibrium Model



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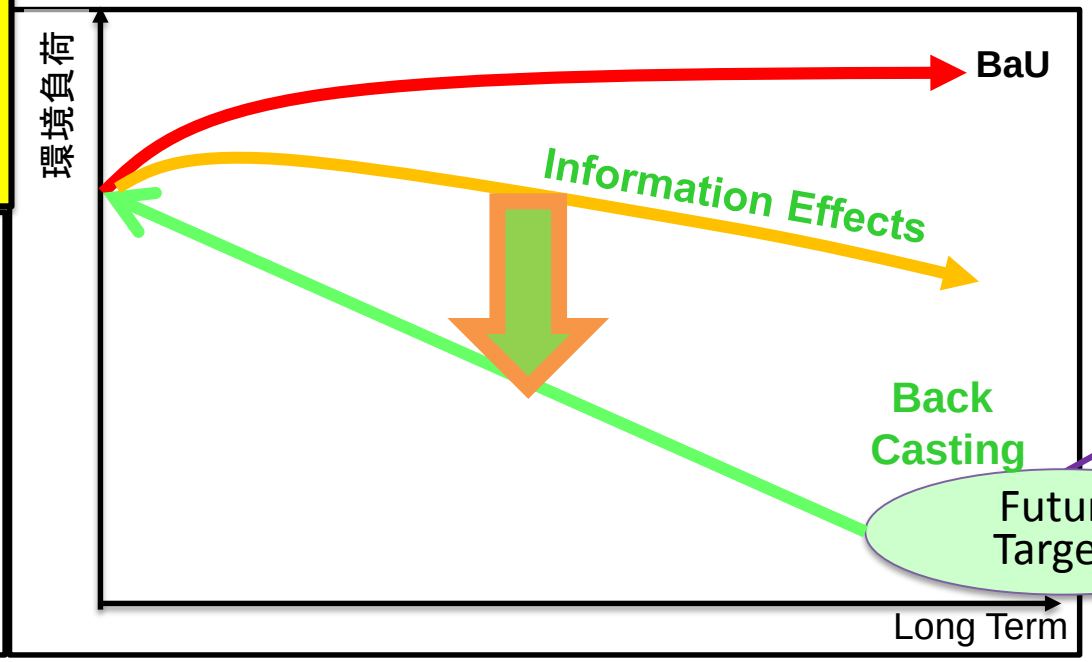

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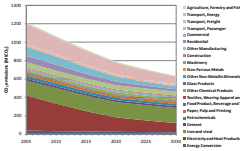

QUANTUM LEAP!

Or Social Transition

Innovative Modelling and Monitoring Research Project

Low Carbon Solutions on Local Contents

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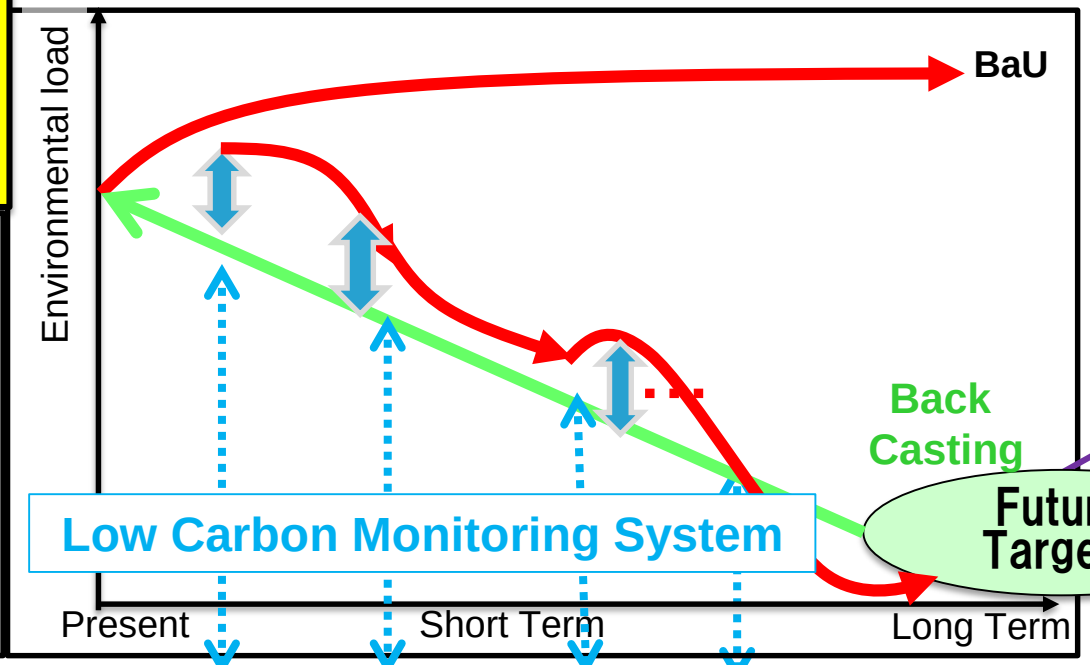

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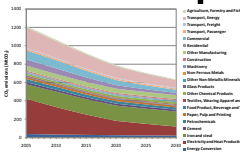
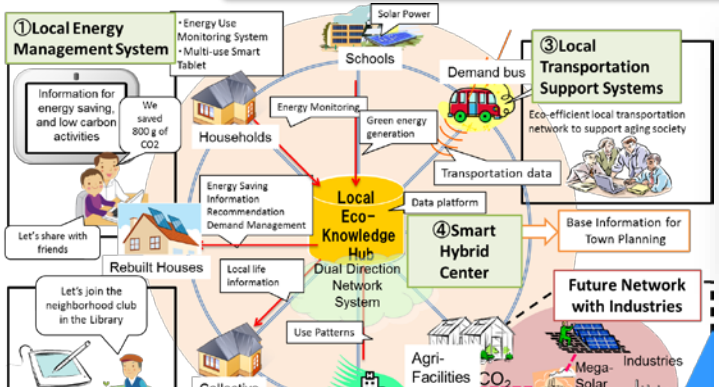
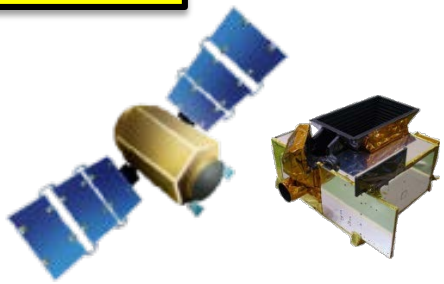


Dual Direction Low Carbon Monitoring Information System





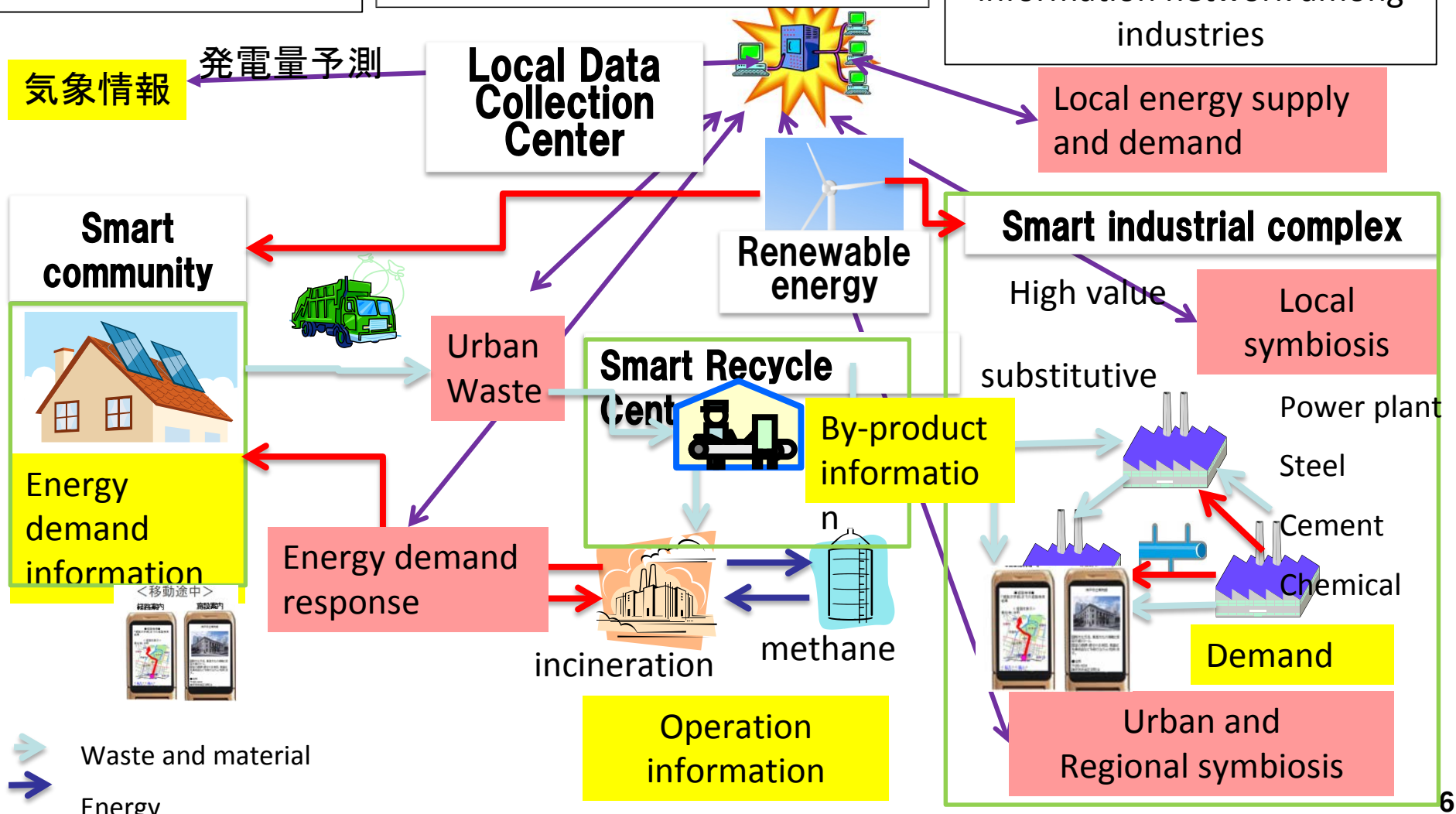
Smart Symbiosis Initiatives for Eco town Innovation

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

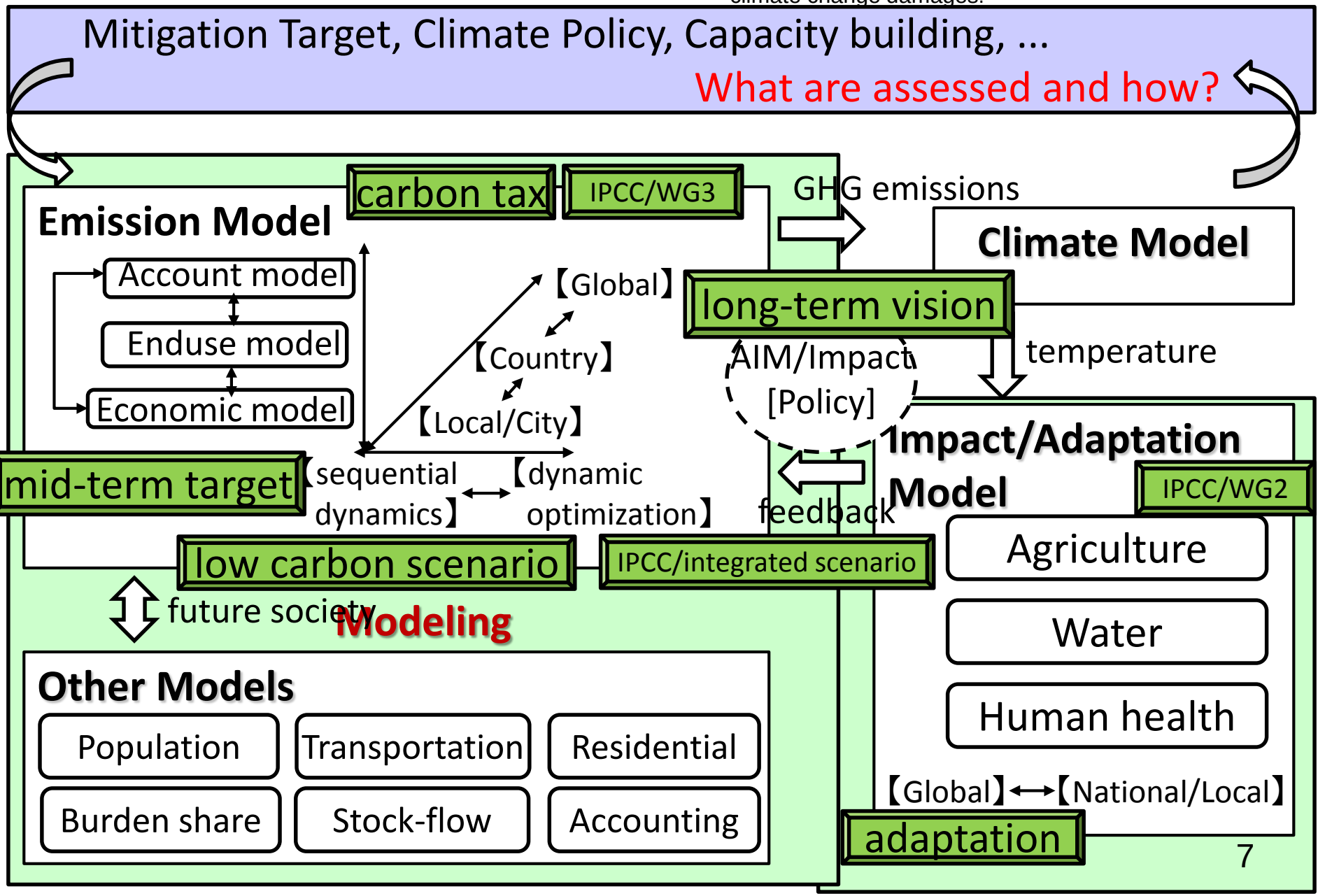
Smart industrial complex supported by synergetic information network among industries



Structure of AIM model

Dr. Masui

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.



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

*Computational General Equilibrium

Regional Rebuilding Parameter

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

Regional Parame-ters

Analysis for Fukushima Pref. Scale

End Use Model → Fukushima CGE Model → Fukushima Targets → Fukushima R. Maps

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

Planning for Local Scale

Snap Shot Models, Policy Support Tools → Local Targets

Local Startistics and Project Data

- Buildings
- Industries
- Agriculture/ Forestory
- Life Style

Integrative Model Application toward Low Carbon Cities and Regions
NIES Dr. Gomi

AIM Region Model

Energy Model

$$1-F_{dcb}(t,m,hr) \geq \frac{S_{b,tech}(t,m,hr)}{denom}$$

$$FUEL_{tech}(t) = \frac{1}{\eta_{tech}(t)} \times \left(\sum_{m,hr} O_{srvtech}(t,m,hr) \right)$$

$$COST_{fuel,tech}(t) = ucfuel_{tech}(t) \times FUEL_{tech}(t)$$

$$crf_{tech} = \frac{r \times (1+r)^{dpr_{tech}}}{(1+r)^{dpr_{tech}} - 1}$$

Population Model

$$POP\_tot = Pop\_work / \underline{WR\_agg}$$

$$LNtot_{inin} = \sum_{pds} (LHD_{pds} \times AAWH \times \underline{DER_{pds}})$$

$$LNtot_{outin} = \sum_{pds} (LHD_{pds} \times AAWH \times (1 - \underline{DER_{pds}}))$$

Transportation

$$PTD_{ptm} = \sum_{td} \sum_{age} \sum_{hht} Pop_{age,hht} \times Ptg_{age,td} \times Pts_{td,ptm} \times Ptad_{td,ptm} \times 365 \times (1/10^6)$$

$$FTD_{ftm} = \sum_{pss} \sum_{td} PD_{pss} \times Ftg_{pss,td} \times Fts_{td,ftm} \times Ftad_{td,ftm} \times (1/10^6)$$

Local Economy

$$Ainv = \left[\underline{Imat} - (1 - \underline{IMR}) \times \underline{Amat} \right]^{-1}$$

$$X = Ainv(I-(I-Mr)F+Ex)$$

$$Income = LNtot_{inin} \times WagePP + LNtot_{inout} \times \underline{WperL\_inout} + POP\_tot \times \underline{SSget}$$

Policy Options

$$x_{et} = IMP2_{et} \cdot \overline{f}^{MUL} \cdot \overline{f} + IMP1_{et} \cdot \overline{f}$$

$$imp1_{et,et1} \cdot f_{et1} = I^{(0.5)}_{et,et1} \cdot b_{et1} \cdot f_{et1}$$

$$imp2_{et,et2,et1} \cdot f^{MUL}_{et2} \cdot f_{et1} = 0.5 \cdot b_{et1} \cdot \left(\sum_{et3} I^{(1)}_{et,et2} \cdot a_{et2,et3} \cdot I^{(0)}_{et3,et1} \right) \cdot f^{MUL}_{et2} \cdot f_{et1}$$

Land Use Model

$$Area_{lu} = \sum_{lup} LUCM_{lup,lu}$$

$$HA_{crp,cropland} = DP_{crp} \cdot \overline{CRPS}_{crp,cropl} / \overline{YLD}_{crp,cropl}$$

$$LUCM_{lup,lu} = \overline{Area\_prev}_{lup} \cdot LCC_{lup,lu}$$

$$\sum_{lup,lu} \left(\overline{RLCC}_{lup,lu} \cdot \log \frac{LCC_{lup,lu}}{\overline{RLCC}_{lup,lu}} \right) \rightarrow \min$$

Feed back toward the Sub module mondelling

Future Scenario

Life　Industry　Planning　Energy

政策分析

Decision Planning for Stakeholders

Technology Inventory and Suitability Analysis

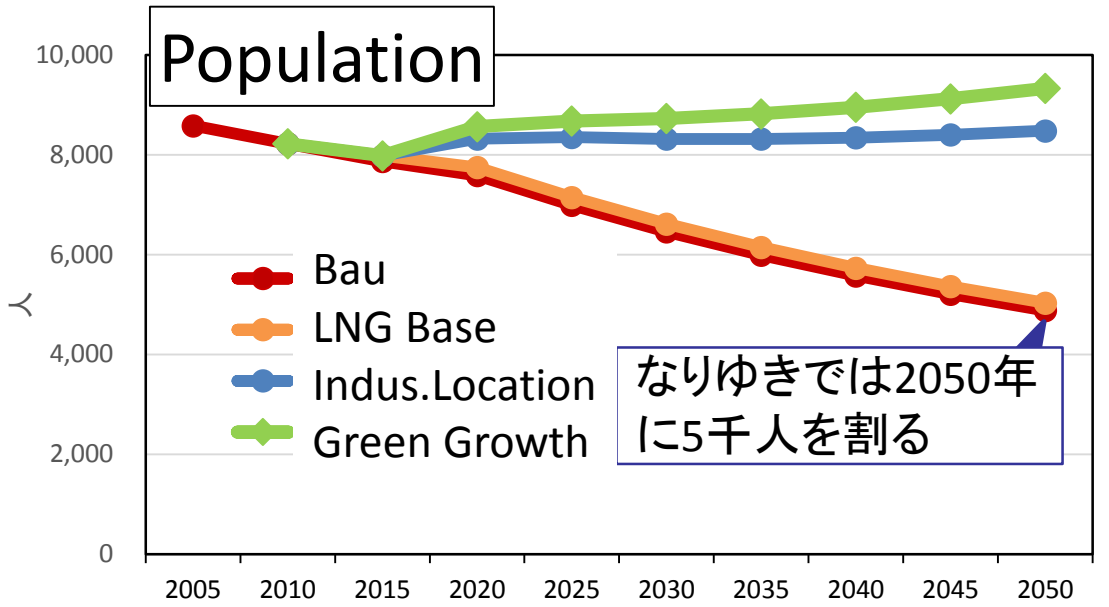
Priority setting for the focal policy targets and scope

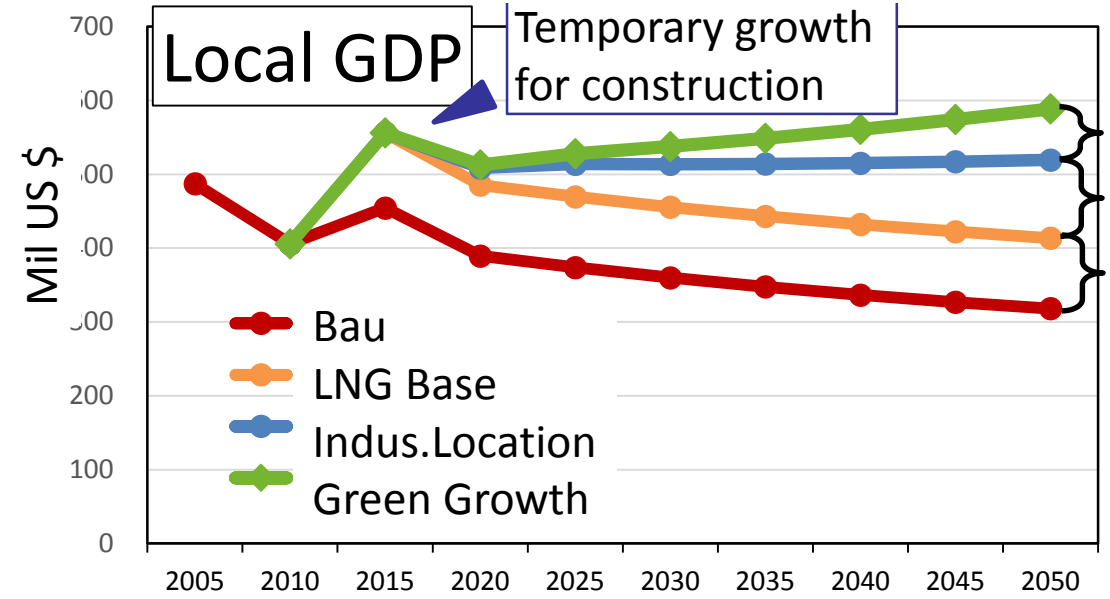
Low carbon planning

Citizen participation

環境共生型まちづくりの進展

Future Simulation for Alternative Scenarios





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

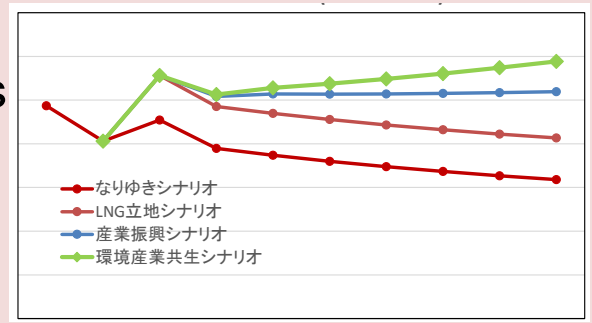
10

Multi Stage Approach for Eco-City and EIP Planning

①Macro-scope

Alternative future vision

- population, industries
- core developments
- energy locality



Future frame

②Spatial-scope

Land use zoning /network design

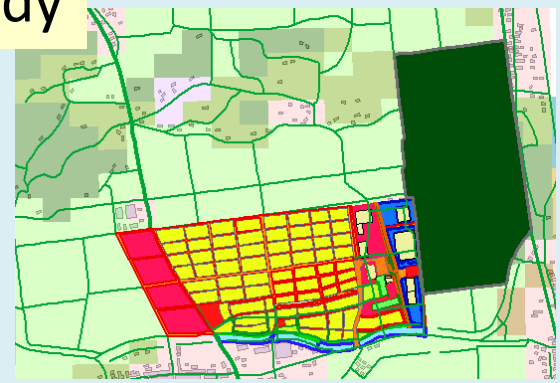
- land use distribution patterns
- local energy network
- location of core developments

Feasibility Study

③Project Design

Core projects for revitalization

- zoning and regulation
- district planning
- key industries



Environmental Measures Analysis in Tokyo Metropolitan Region

- Locally suitable env. measures
- Compact land-use

Scenarios
(2020, 2030, 2050)

Effect of env. measures
- Energy saving & LCS
- 3R
- Heat island mitigation
- Convenient transport
- Economic impact

Future macro-frame
(Population, industry, material production, etc.)

Models

Energy supply & demand
Economic impact

Env. Technology Assessment Model

Computable General Equilibrium (CGE) model

Building

Building Stock Management Model

Tokyo Metropolitan Region

Transport

Land Use and Transport Model

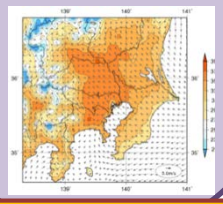
Waste

Resource Recycling Model

Local Energy System

Local Energy Model

Heat env.



Heat Island Model

- Urban & env. policy options
- Urban & env. technology options

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.

Socio-economics

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

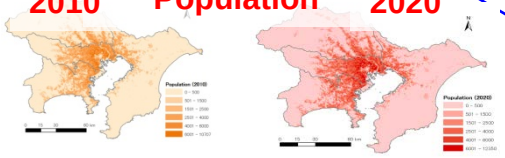
Resource Energy

Analyze and Predict future resource, energy and waste condition.

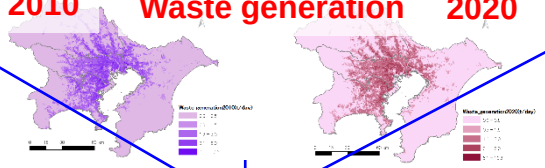
Infrastructure, technology, land use

Help to infrastructure analysis, planning and future technology projection.

2010 **Population** **2020**



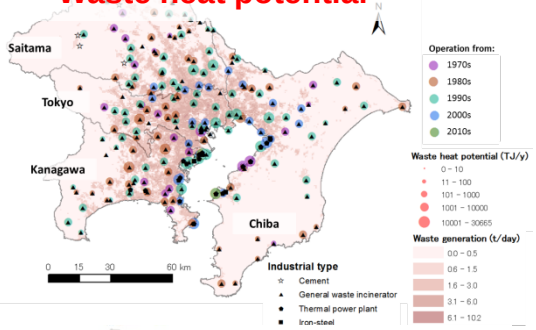
2010 **Waste generation** **2020**



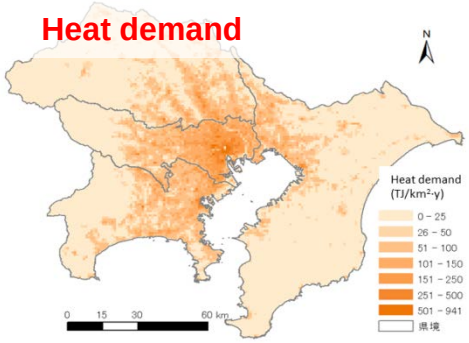
Facilities

Low-carbon technologies

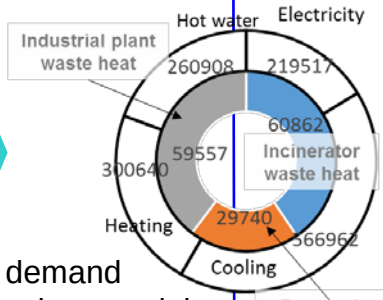
Waste heat potential



Heat demand



Local Energy System



Outside: demand
Inner: supply potential

Supply-demand match

IS design/implementation

Land Use Control System

Total cost of introduction = Heat distribution cost + Heat transport cost + Waste heat purchase cost

$C_{d,z} = a \cdot c_n \cdot l_z$ $C_t = (a \cdot c_w + p^e \cdot t) \cdot W$ $C_p = p_w \cdot (Q_d + Q_{ls})$

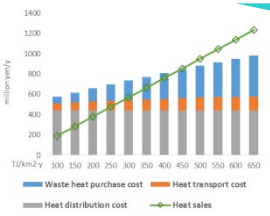
Effective width: $l_z = \beta \cdot A_{i,z} + \gamma$

National average β=0.0037, γ=840

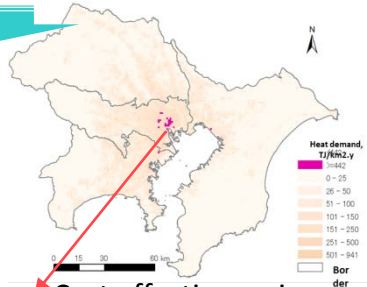
Tokyo: β=0.0018~0.011

(Kawakami et al., 2008)

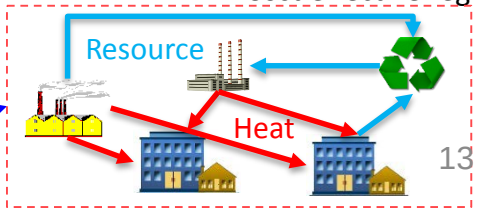
Minimum heat demand: $\widetilde{Q_d} = (C_d + C_t + C_p)/p_s$



Cost simulation



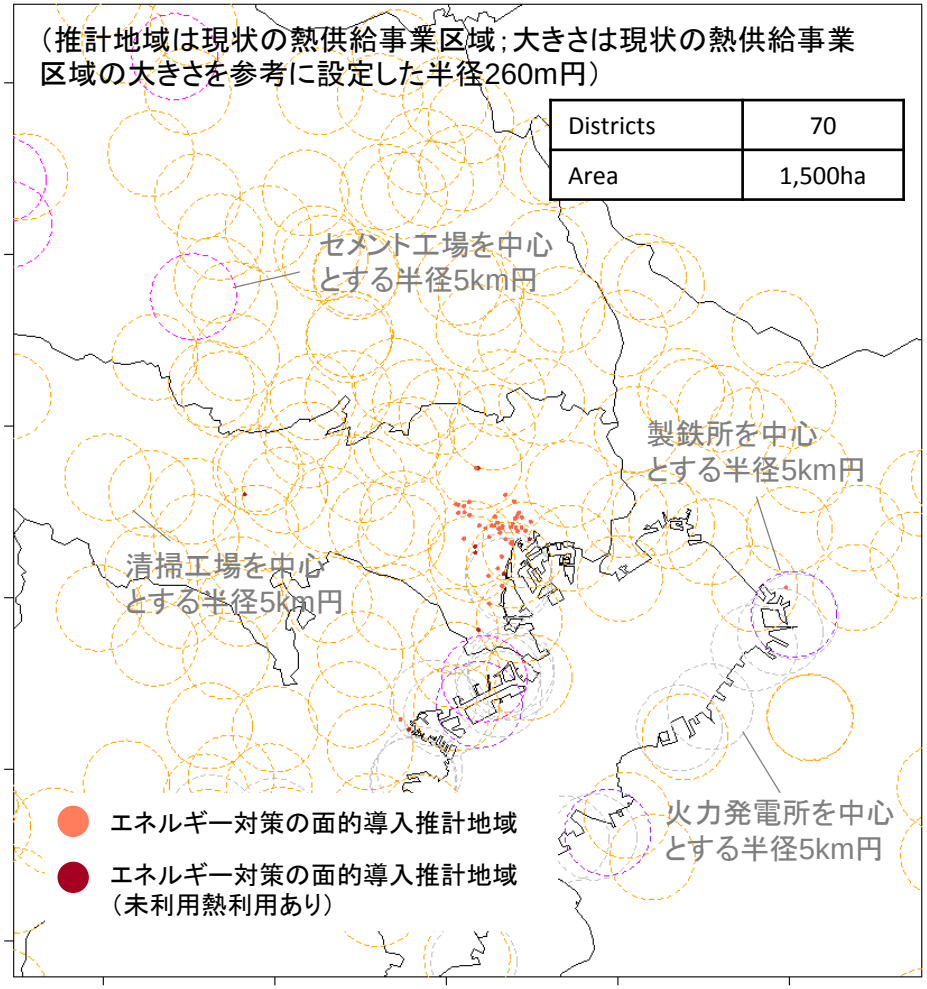
Cost effective region



Locational assessment for smart thermal grid system in Tokyo Region

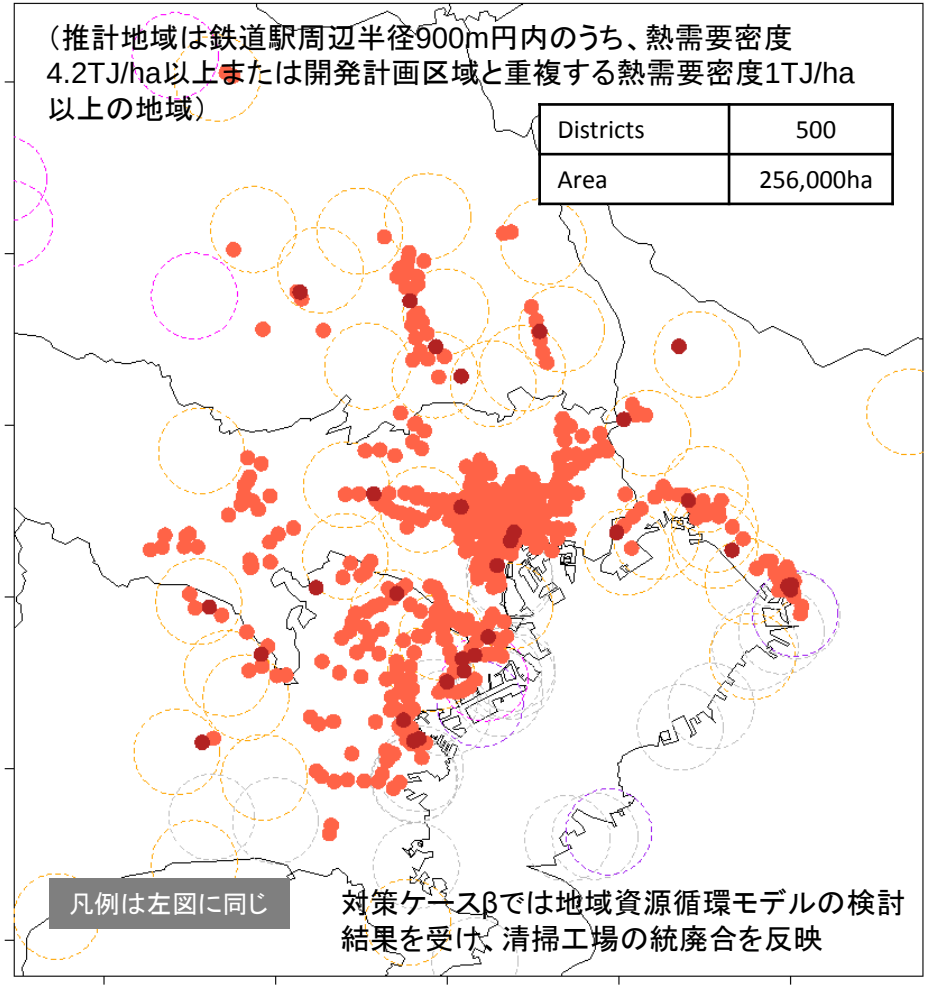
BAU Land Use Scenario（2050）

現状の熱供給事業を踏まえた設定

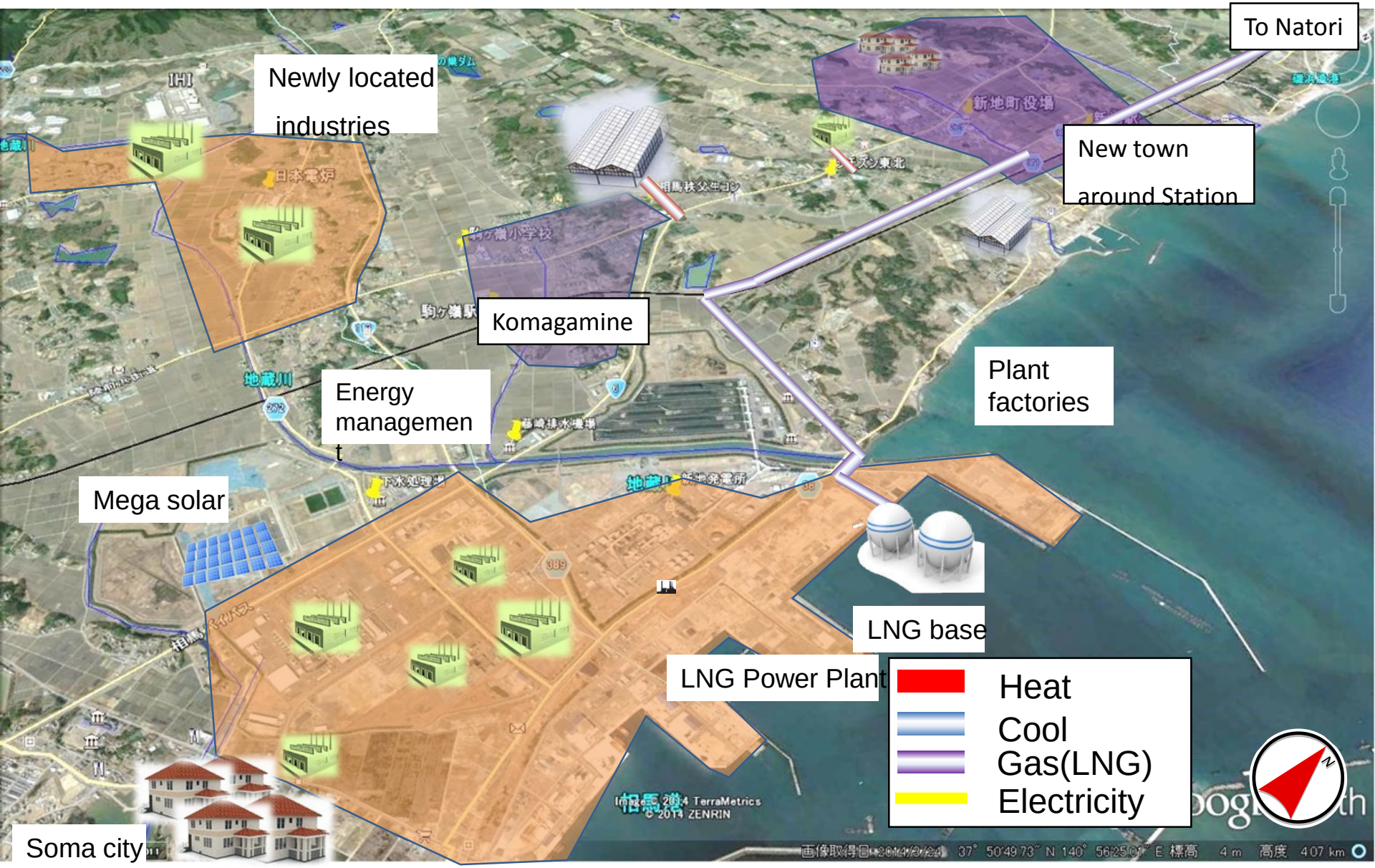


Strategic Land Use Scenario（2050）

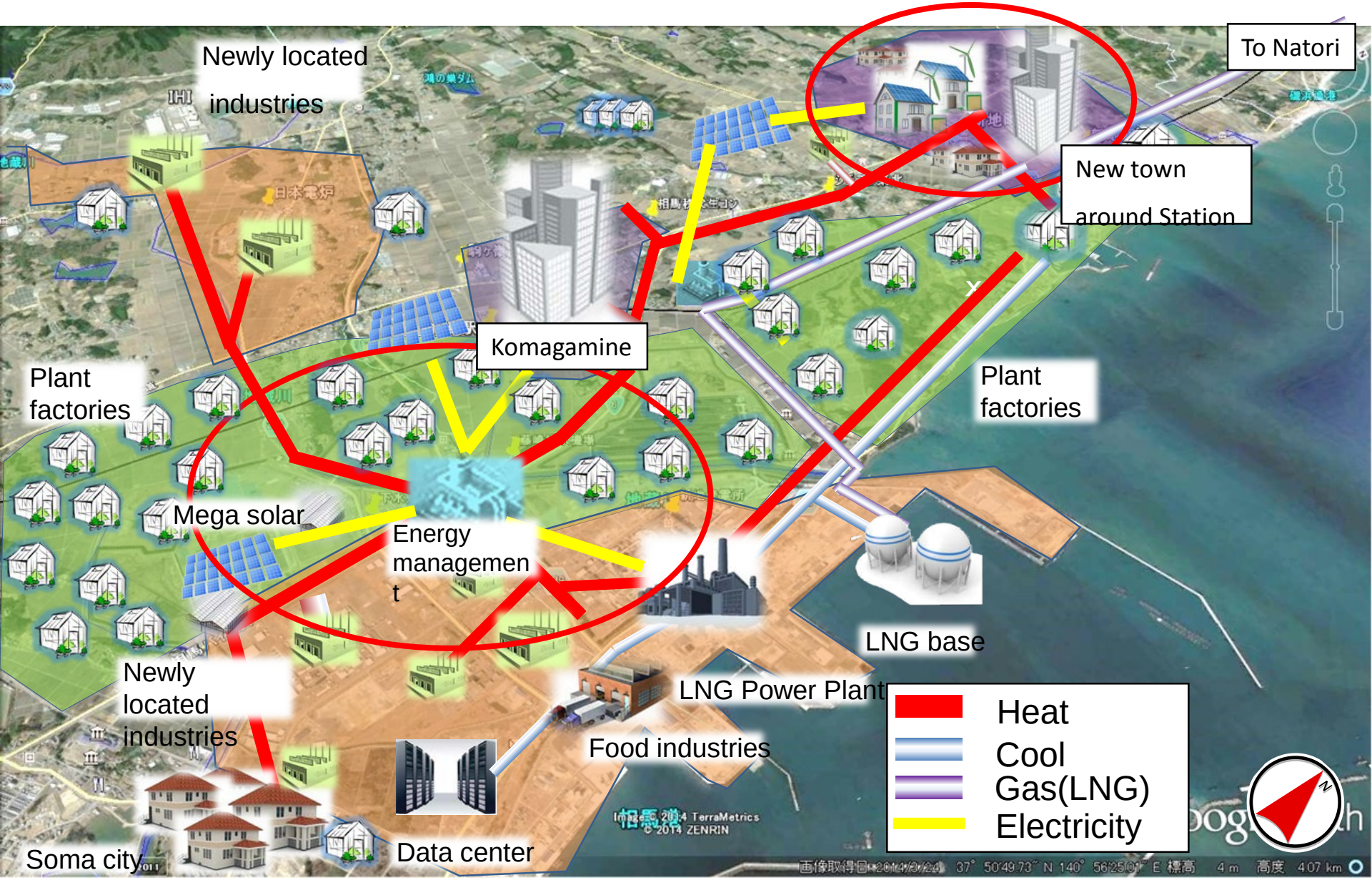
鉄道駅を中心とする地域に大規模な導入を行う設定



BaU scenario in Shinchi town in 2030



Integrative Energy System in Fukushima Shinchi town in 2030



Estimation of Alternative Future Recovery Scenarios

Alternative Spatial Scenario

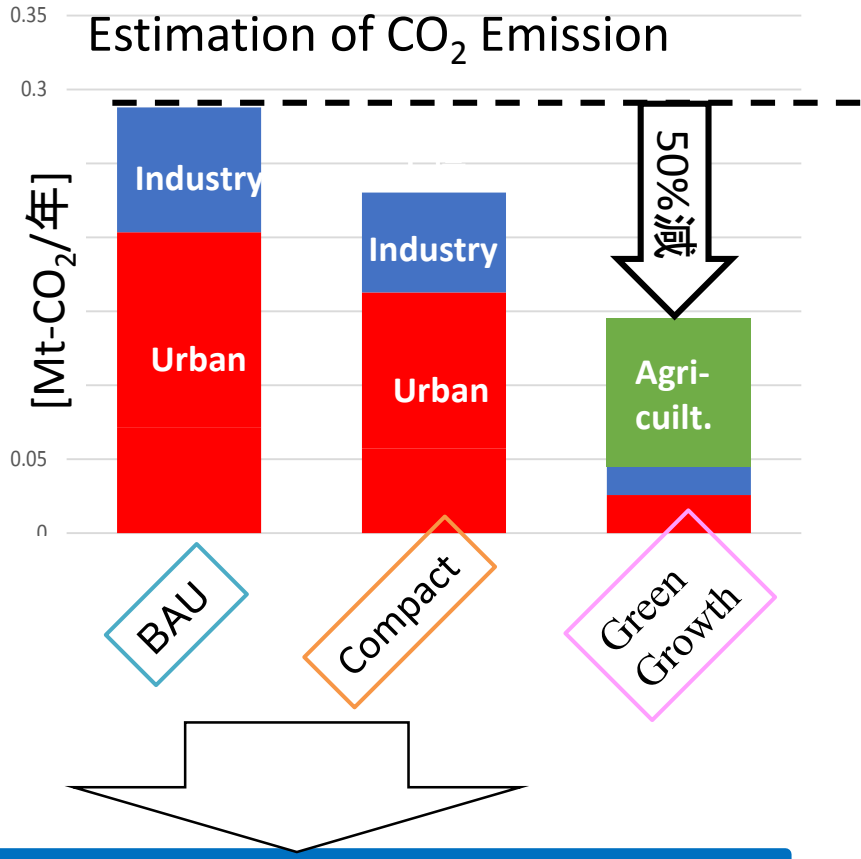
BAU

+Compact City

+Green Growth

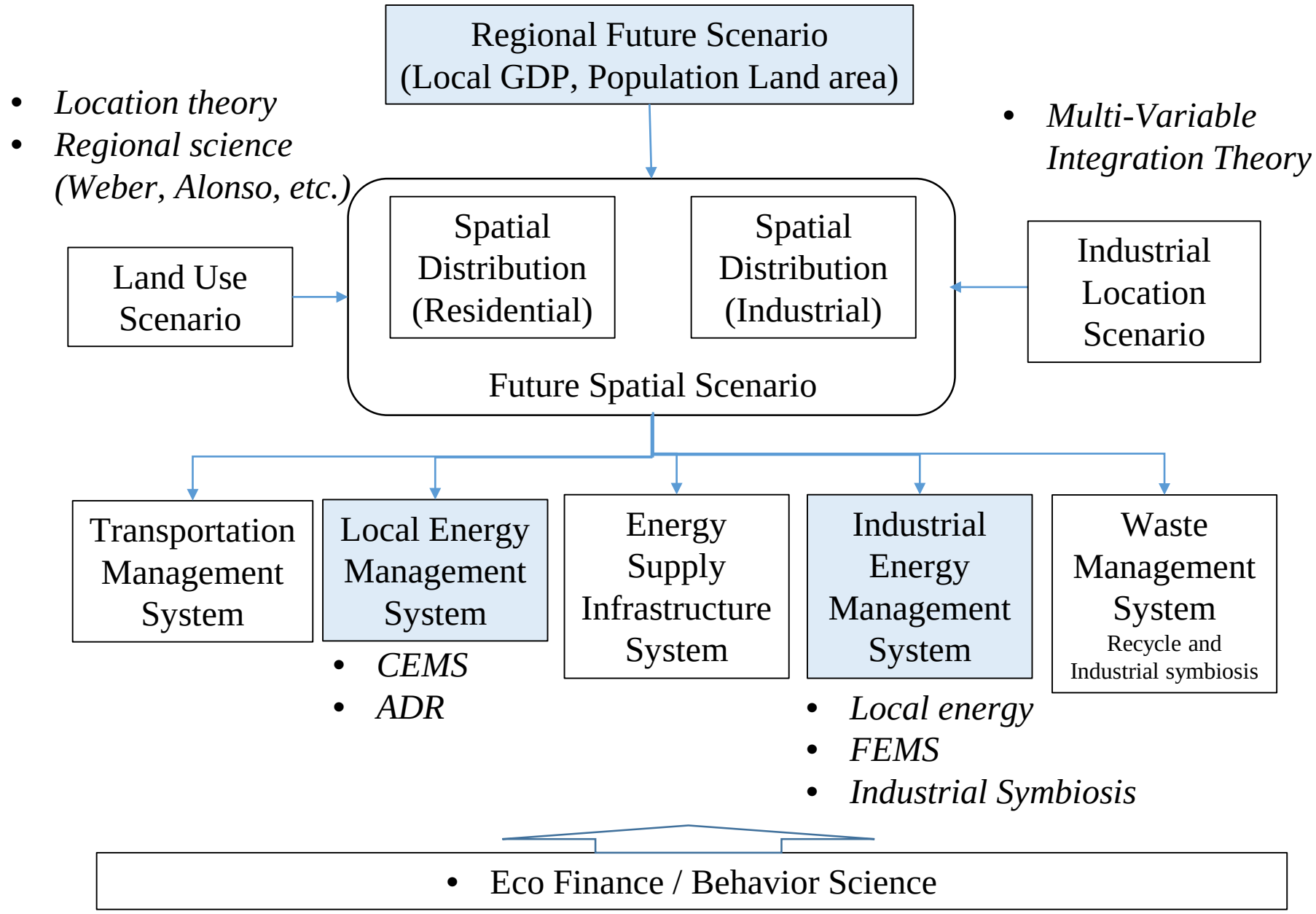
Effects of Local Energy Management

Quantification of Impacts and Costs



Green growth can double the Carbon Efficiency

Research framework targets



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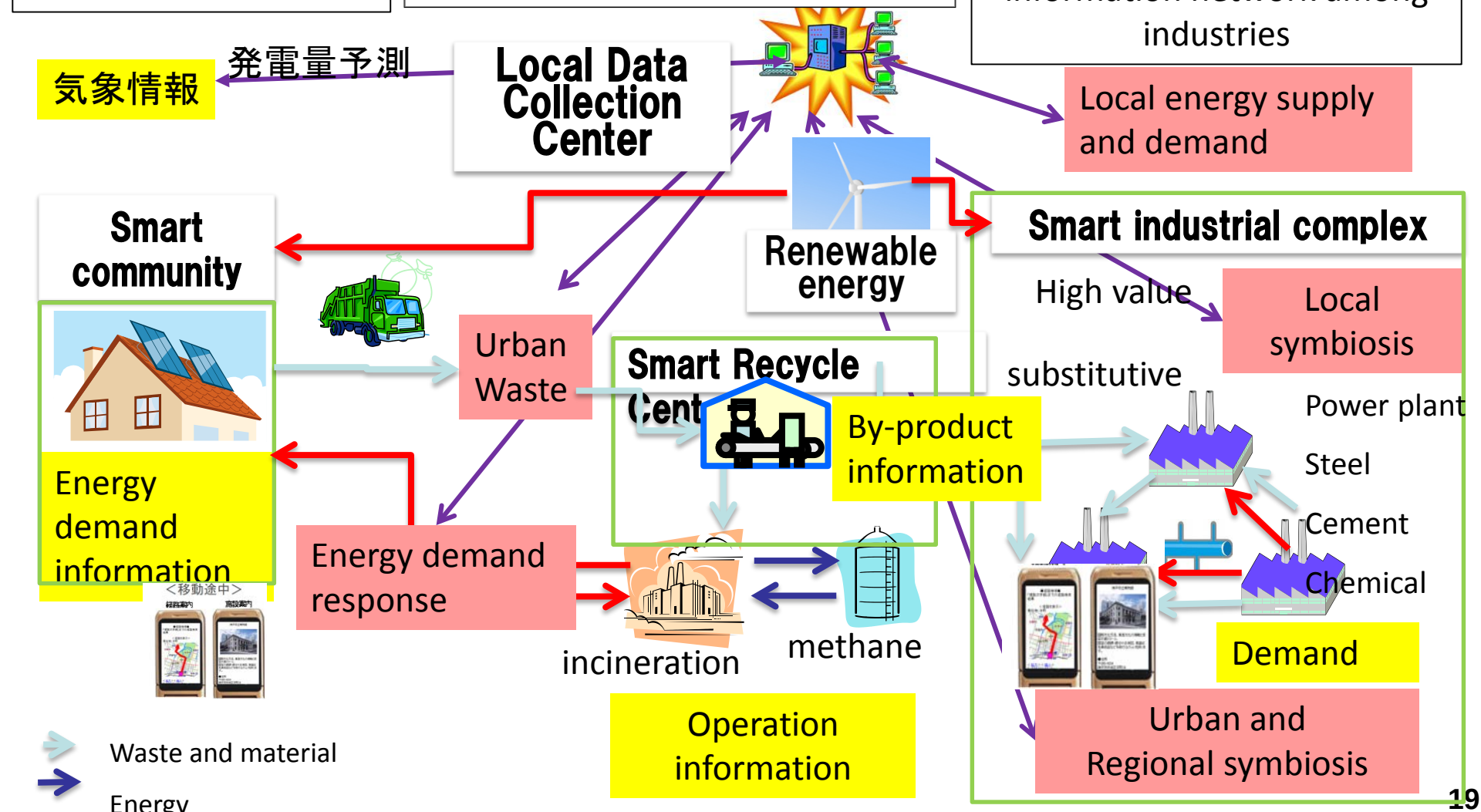
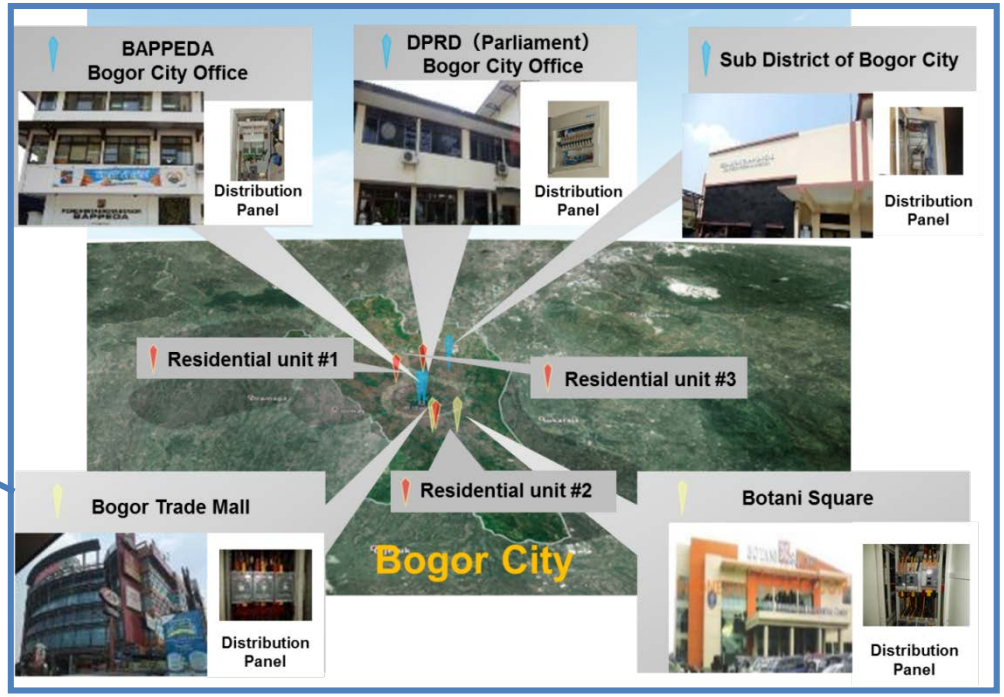


Monitoring sites of Bogor City in 2014-2015

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



Sector	Number of facilities	Number of point
Government building	3	30
Residential house	3	12
Commercial facilities	2	8

Action framework of urban monitoring system in Asia

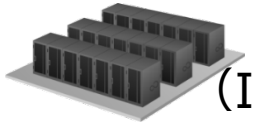
- Advanced internet security technologies effectively manage and protect the data
- Excellent recovery data collection capability
- Relationship analysis between human behavior and energy use

Robust Data Traffic under Uncertain Condition

Integrative Analysis of Multi- Sectoral Data

2 Collecting Electricity Data

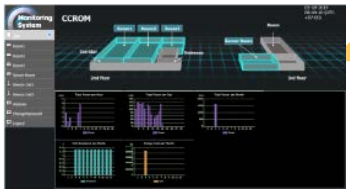
3 Analysis of collected data



Data Center (Indonesia/ Japan)

1 Monitoring Electricity Data

Visualization



Data access・ Analysis

Sensor for human activity

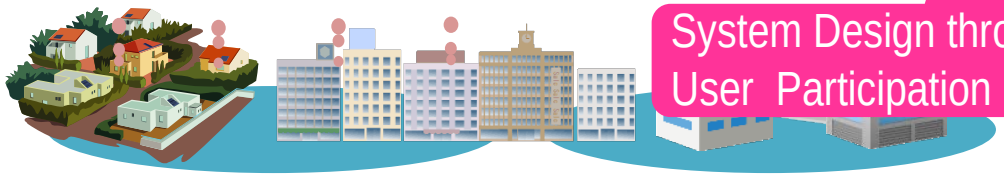
Energy Meters

4 Promoting Low Carbon Activities/Behavior

Lightings AC

Production Line

System Design through User Participation



Residential Commercial Industrial

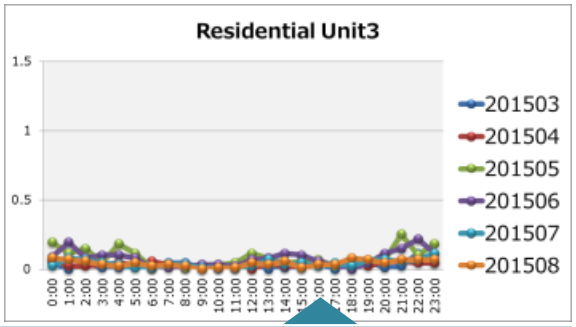
Green Room (Management center)

Tablets

Analysis example in Residential Unit

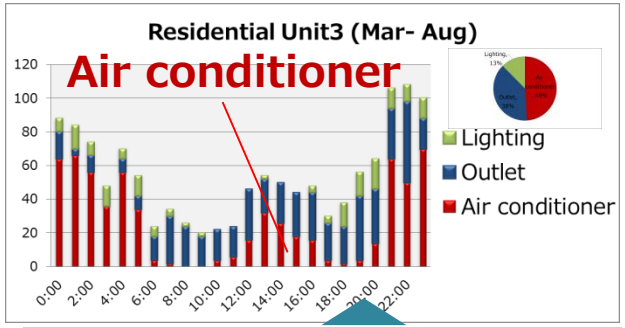
Potential of energy-saving is 15% in Residential Unit
Air conditioner has 50% of Electricity Consumption

1 **Electricity demand of each month [kwh/h/m²]**



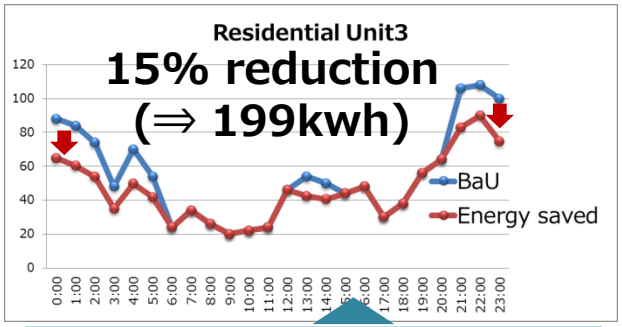
Variation of each month is small

2 **Electricity demand characteristics [kwh/h]**



Air conditioner has high percentage (50%)

3 **Simulation of energy-saving [kwh/h]**



Potential of Energy-saving is 15%

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

Potential of CO_2 reduction in Residential Unit:
199[kwh/year] × 0.814[kg/kwh] ≒ 0.162[tCO_2/year]
(Indonesia <Java> FY2012)

Traffic monitoring plan

Goal: Eco-friendly and More Comfortable City

Data Oriented
Innovation Center

Phase1

Visualize traffic congestion

Visualize traffic congestion and travel time data
by using several smart phones as GPS sensor on vehicle.

<Sensing>

App.

Smartphone App.

Smartphone
(Android)

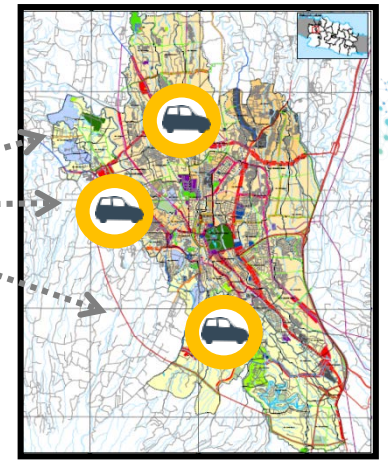
<Target Vehicle>

・Public Bus (**TransPakuan**)

The target: 20 vehicles

※to be arranged

<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)

Phase2 : Calculate traffic volume
With CCTV

Phase3 : Suggest Environ impact in traffic congestion
With environment sensor

技術モニタリングシステムの活用①低炭素シナリオ

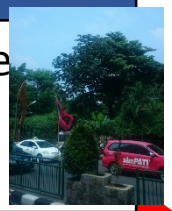
- Conventionally, local scenarios are developed with limited statistical data and “default” parameters from national or international information.
- Our approach combines monitoring of local activity and modeling so that we can propose the most suitable mitigation scenario and Action plans for the city/region.

Statistical information

Current environmental initiative

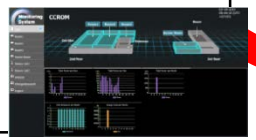
Transport Monitoring

- Transport structure
- Vehicle speed
- Fuel efficiency etc.

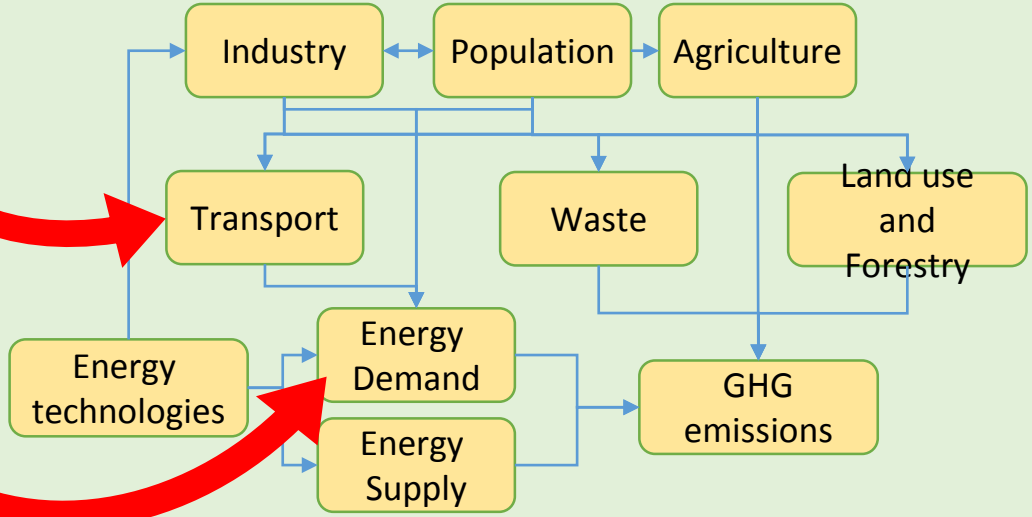


Energy Monitoring

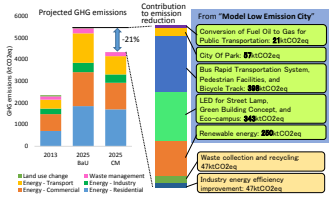
- Current and future energy consumption pattern
- Energy saving potential



The model to project future scenarios: ExSS/AFOLUA



Locally suitable mitigation scenarios



Mitigation potential in 2030

Actions to introduce the measures in 2030

Roadmap and investment towards 2030

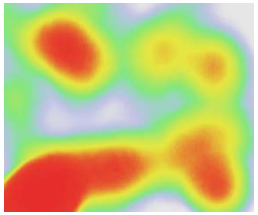
24

4. Implementation of Monitoring System Preparatory Demonstration
4) Future Project Extension

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

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

Visualization of trends

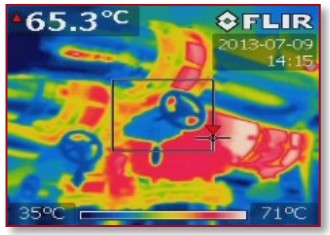


Activity map

Human Flow

Green Operation

Temperature sensor



Temperature Heat Map

point **Optimization of working environment**

Monitoring framework for industrial sector

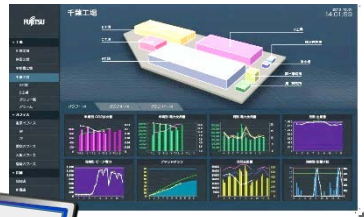
1. Selecting monitoring points

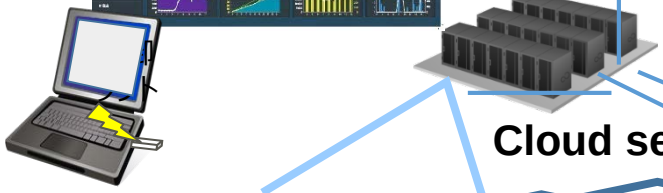
The points expecting large energy saving are selected based on site surv...

Stakeholders meeting

2. Monitoring of facilities / factori...

Urban Area





Cloud server

3. Data analysis and solution design

Factory scale solut...

EIP scale solution

Region scale

#Monitoring device is used for verification after implementation

Factory A

Electricity

Raw material

Sensor

Sensor

Sensor

EIP

Factory B

Factory C

Pretreatment

Assembling / Processing

Finishing

Product

Heat

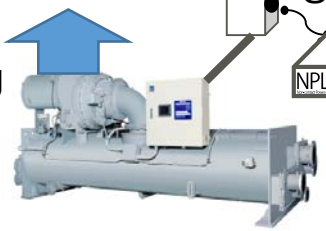
Boiler

FM

Sensor

Fuel

Cooling



Chiller

Sensor

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**

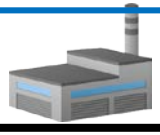
More than 10% energy saving with Intelligent Dashboard system

Easy to business evolution!

https://www.youtube.com/watch?v=BPqunfV-Rts&feature=player_embedded

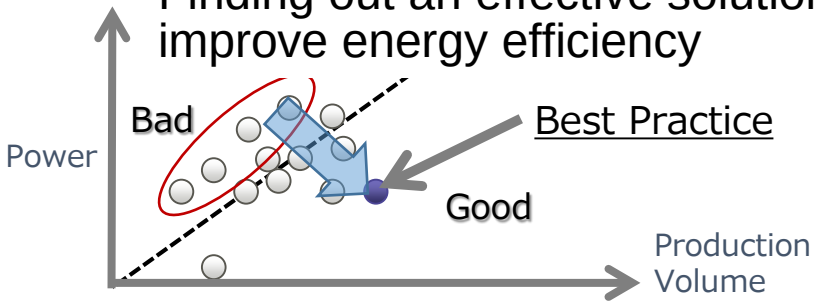
3. Objective and Process Design of Industrial Monitoring System
4) Optimization of production process

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



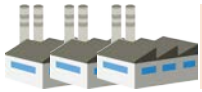
Diagnosis of a factory

Finding out an effective solution to improve energy efficiency



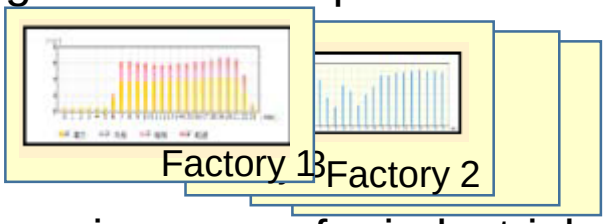
Factory scale solution

Optimization of operation condition
Introduction of advanced technology
- High efficiency facility



Diagnosis of factories

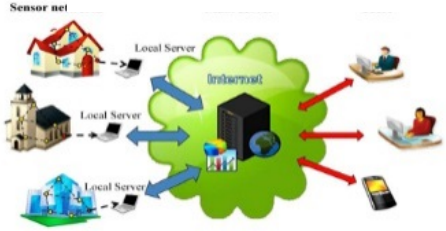
Seeking possibility of integrated energy management of multiple factories in an EIP

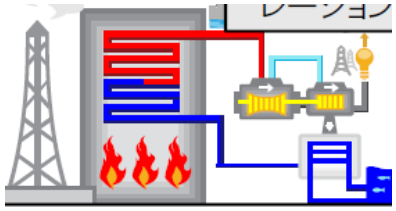


Questionnaire survey for industrial park

EIP scale solution

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





Local National Green Industry Policy Solution

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.

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Eco industrial park survey

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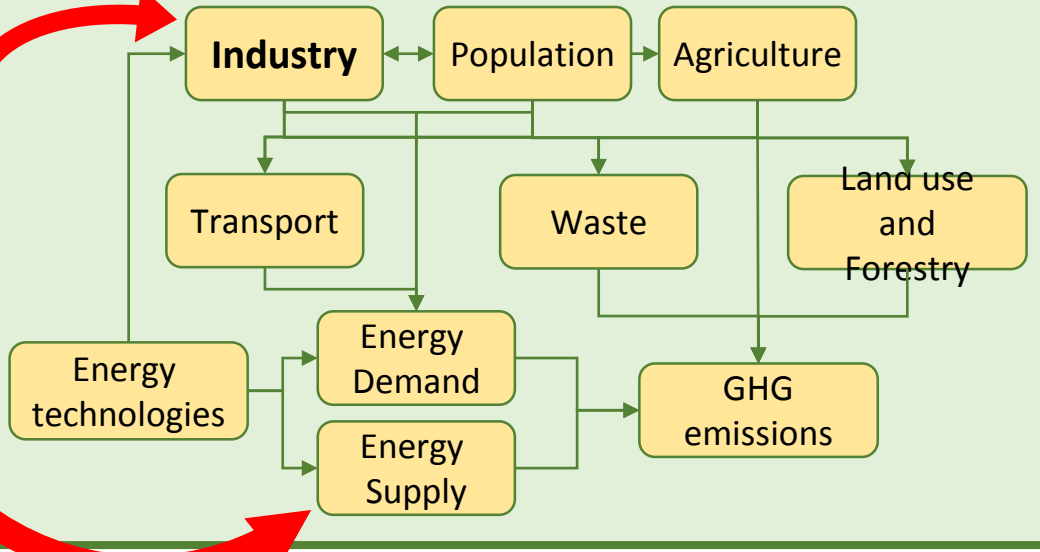
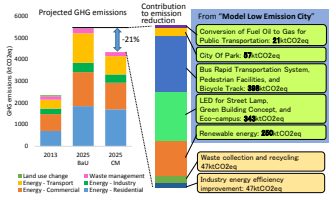


Locally suitable mitigation scenarios



Mitigation potential in 2030

Actions to introduce the measures in 2030

Roadmap and investment towards 2030

PJ1 MONITORING ; Community Network System(CNS

①Local 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

Rebuilt Houses

Solar Power

Schools

Households

Energy Monitoring

Green energy generation

Demand bus

③Local Transportation Support Systems

Eco-efficient local transportation network to support aging society

Transportation data

Energy Saving Information Recommendation Demand Management

Local Eco-Knowledge Hub

Data platform

Dual Direction Network System

④Smart Hybrid Center

Base Information for Town Planning

Local life information

Use Patterns

Let's join the neighborhood club in the Library

Collective Houses

Public Facilities

Agri-Facilities

CO_2

Future Network with Industries

Industries

Mega-Solar

Regional Energy Supply Center

Fire Power Plant

LNG Base Plant

②Rebuilding Community Support System

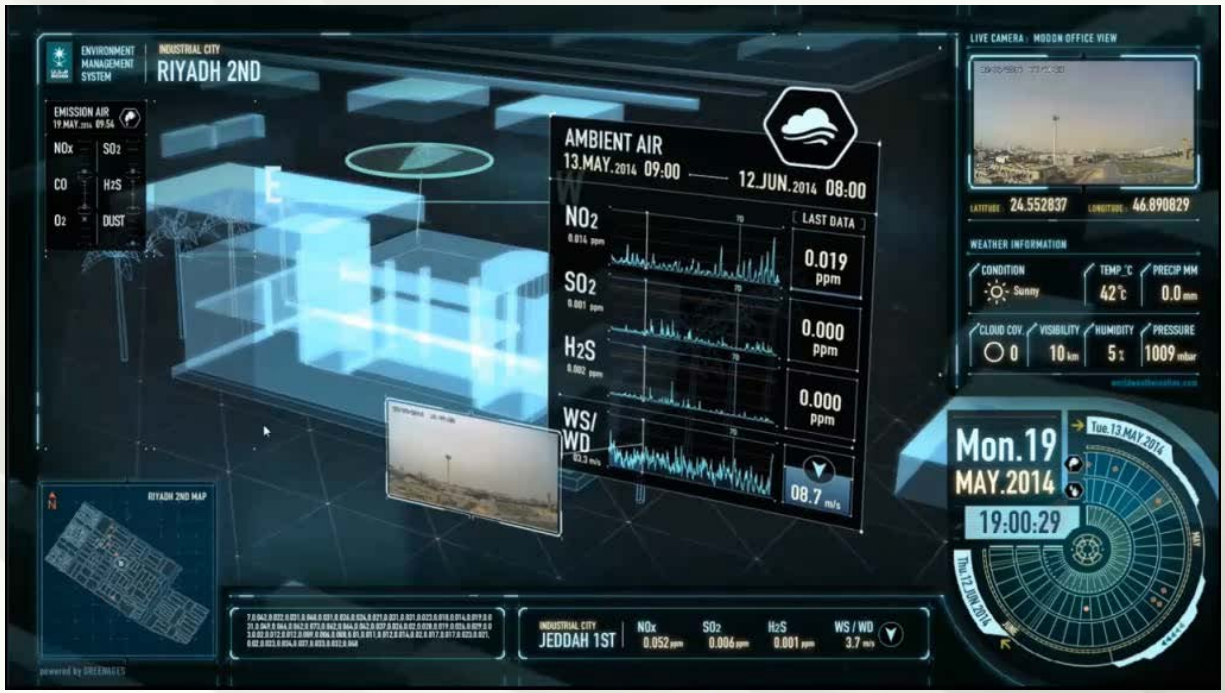
Environmental Monitoring : GREENAGES

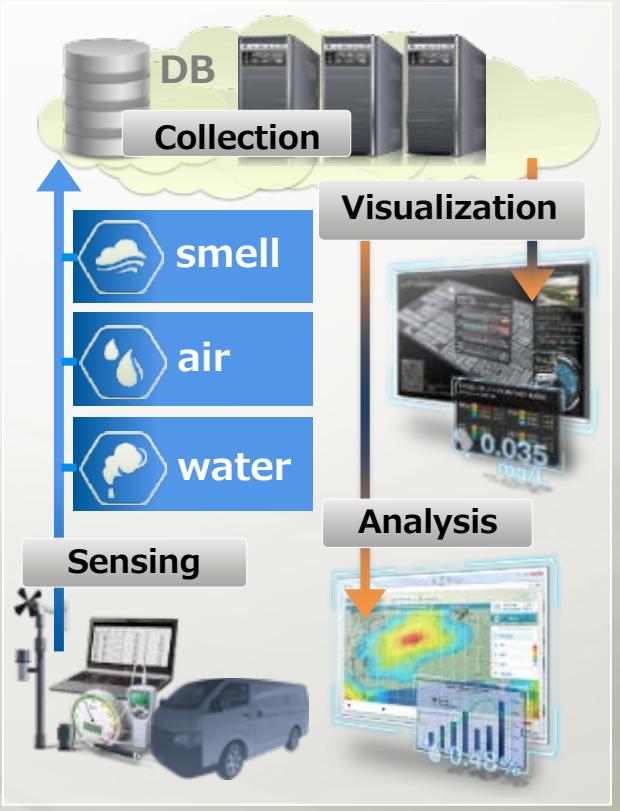
FUJITSU

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

Community Assist Tablet Network

Local Needs

Regional Environment Information

Planning for Sustainable Future

National Institute for Env. Studies

Urban Spatial Analysis

Local environment diagnosis

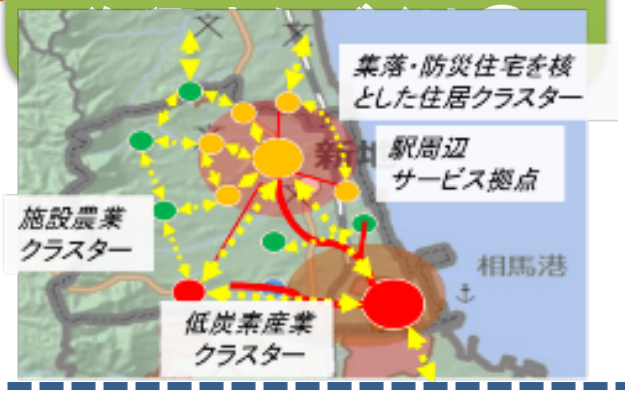
Integrated Modelling

Future scenario assessment

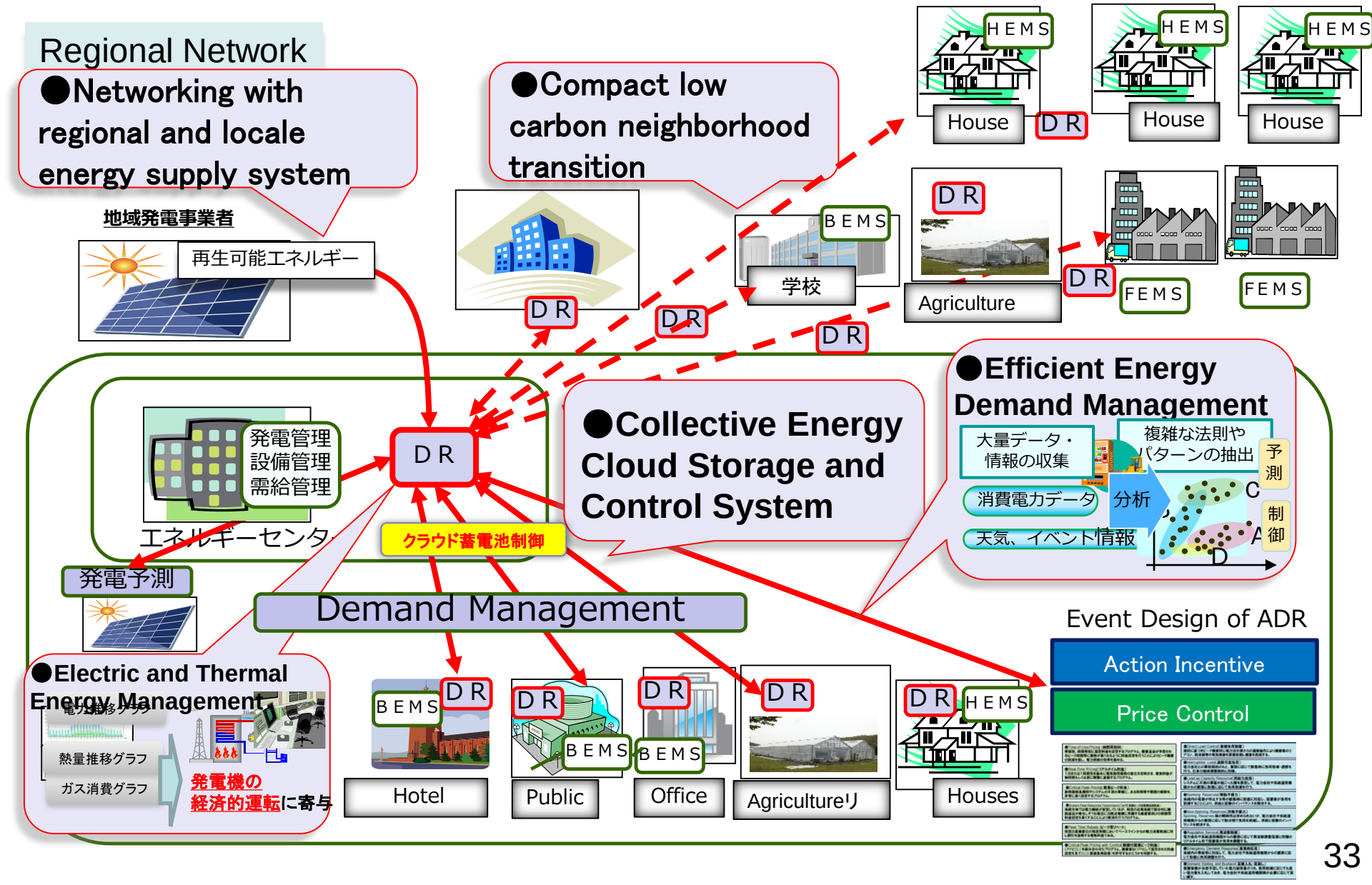
Tech. and policy inventory

- low carbon tech
- circulation tech
- industrial symbiosis
- policy / regulation
- land use control

Simulation for recovery roadmap

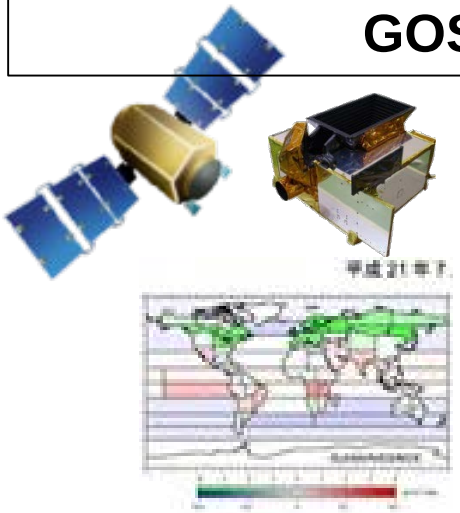


From Monitoring to Smart Community Energy Management (Smart Electric and Thermal Demand Management System)



Innovative Monitoring and Reporting, Verification System in Asian Countries

Greenhouse gas Observing SATellite GOSAT



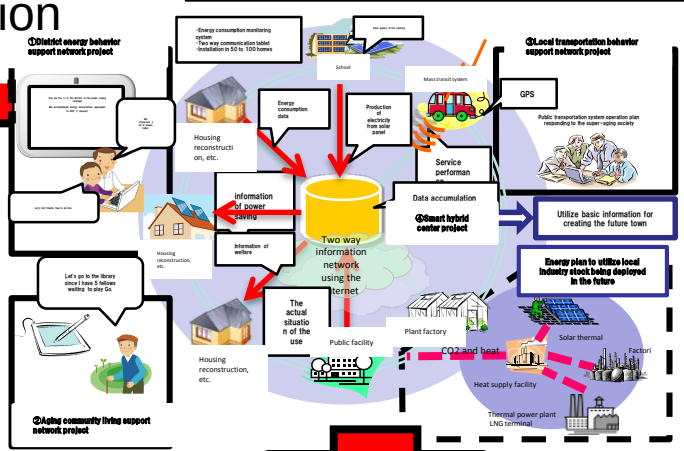
Ground Monitoring System of GHG

Validation

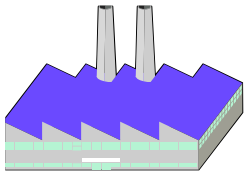
Smart Monitoring Network System for Eco Cities

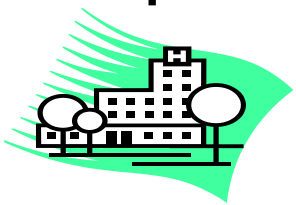
Verification

Joint carbon Credit Mechanism Projects



International Financial System for Low Carbon City Development





Eco-city Evaluation and Validation

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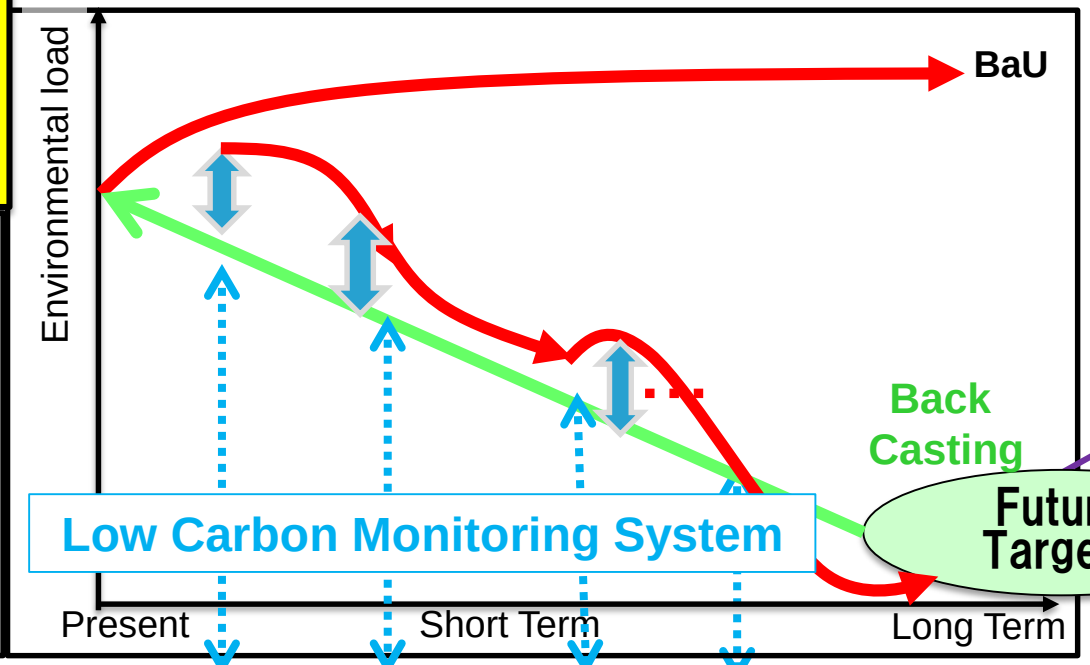
Innovative Modelling and Monitoring Research Project

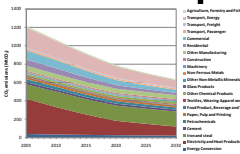
Low Carbon Solutions on Local Contents

Technology and policy Solution Design Adapting to Local Characteristics

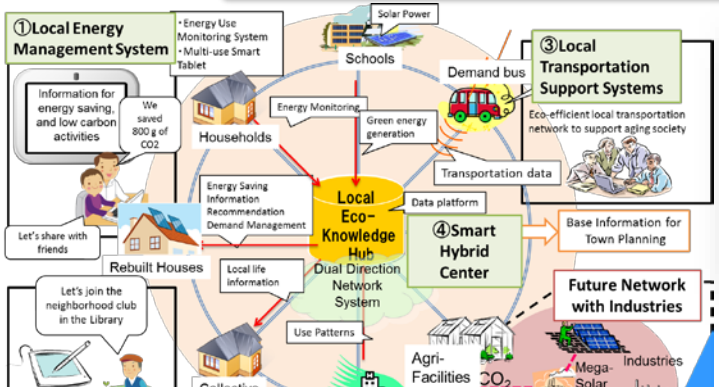


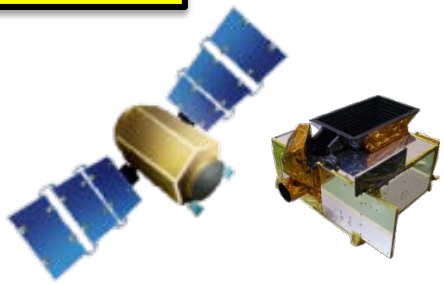
Integrated Model for Future Vision

Normative Targets by General Equilibrium Model



Dual Direction Low Carbon Monitoring Information System





Research Challenges of Innovative Monitoring

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-deign 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)
- Rene Van Berkel, Tsuyoshi Fujita, Shizuka Hashimoto, Minoru Fujii；Quantitative Assessment of Urban and Industrial Symbiosis in Kawasaki, Japan, Environmental Science & Technology , Vol.43, No.5, 2009 ,pp.1271-1281,0129.2009
- Rene van Berkel, Tsuyoshi Fujita, Shizuka Hashimoto, Yong Geng；Industrial and Urban Symbiosis in Japan : Analysis of the Eco-Town Program 1997-2006；Journal of Environmental Management, vol.90,pp.1544-1556,2009
- Shizuka Hashimoto, Tsuyoshi Fujita, Yong Geng, Emiri Nagasawa； Achieving CO2 Emission Reduction through Industrial Symbiosis: A Case of Kawasaki , Journal of Environmental Management, 2008 (submitted)
- 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,pp996-1002,2009
- 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)
- Yong Geng, Pang Zhang, Raymond P. Cote, Tsuyoshi Fujita；Assessment of the National Eco-industrial Park Standards for Promoting Industrial Symbiosis in China, J. of Industrial Ecology, Vol.13, No.1, pp.15-26, 2008
- Looi-Fang Wong, Tsuyoshi Fujita, Kaiquin Xu； Evaluation of regional bio-energy recovery by local methane fermentation thermal recycling systems, Journal of Waste Management,vol.28, pp.2259-2270, 2008

Thank you for your Attention