Land/Agriculture Modeling of GRAPE – Preliminary Results

Atsushi KUROSAWA
The Institute of Applied Energy (IAE), JAPAN

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The views are solely those of the individual author and do not represent organizational views of IAE.

Outline

1. EMF22 runs

2. Coupling of Mitigation and Adaptation

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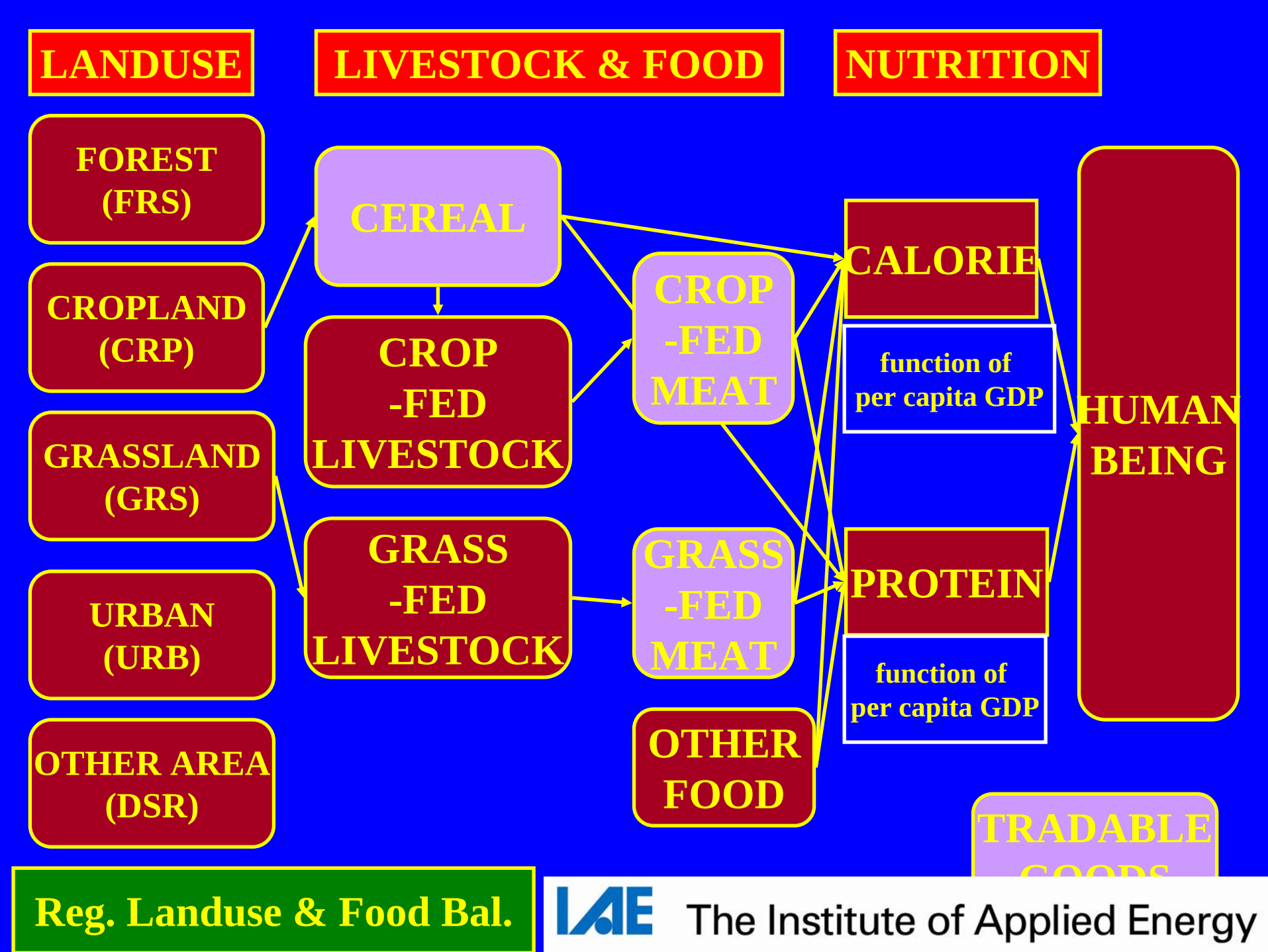
2. Coupling of Mitigation and Adaptation


LANDUSE
LIVESTOCK & FOOD
NUTRITION
FOREST (FRS)
CROPLAND (CRP)
GRASSLAND (GRS)
URBAN (URB)
OTHER AREA (DSR)
CEREAL
CROP -FED LIVESTOCK
GRASS -FED LIVESTOCK
CROP -FED MEAT
GRASS -FED MEAT
OTHER FOOD
CALORIE
function of per capita GDP
PROTEIN
function of per capita GDP
HUMAN BEING
TRADABLE
Reg. Landuse & Food Bal.
The Institute of Applied Energy

EMF22 runs

- 4 scenarios w/o CO2 and climate feedbacks

* Modeler's reference (REF)
* High yield (HI)
* Low yield (LO)
  Common food nutrition intake
  (Calorie, Protein)
  Different yield growth with upper limit

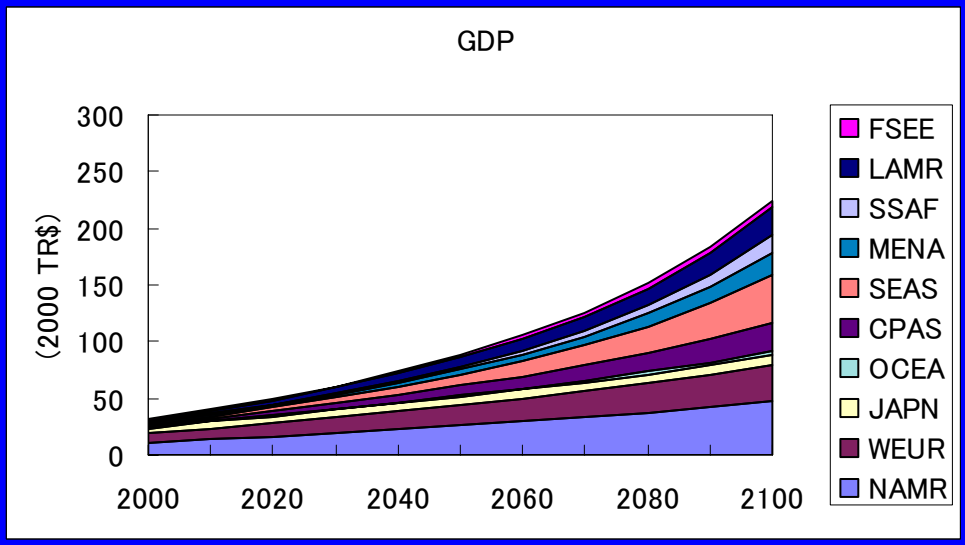
* Coordinated Scenario (CS)
  Designated GDP, Population
  >>> Changes in Food Nutrition Intake
  IFPRI Yield Growth

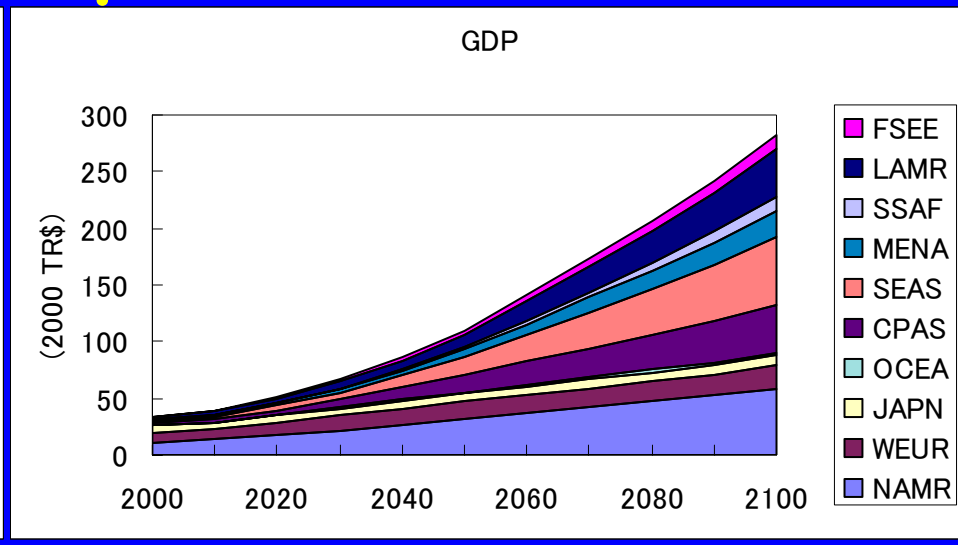
EMF22 runs (cont.)

* Food habit
  Difficult to change food habit and agriculture protection in a short timeframe.

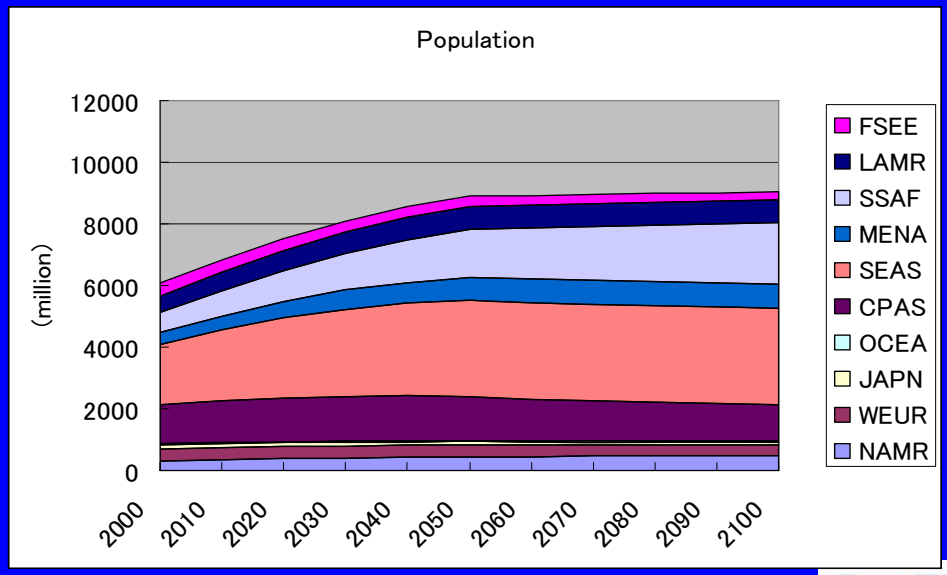
* Ratio of crop-fed and grass-fed animal meat
  REF and HI – constant
  LO and CS – gradual changes
    (grass-fed meat, -2% per decade)

GDP and Population

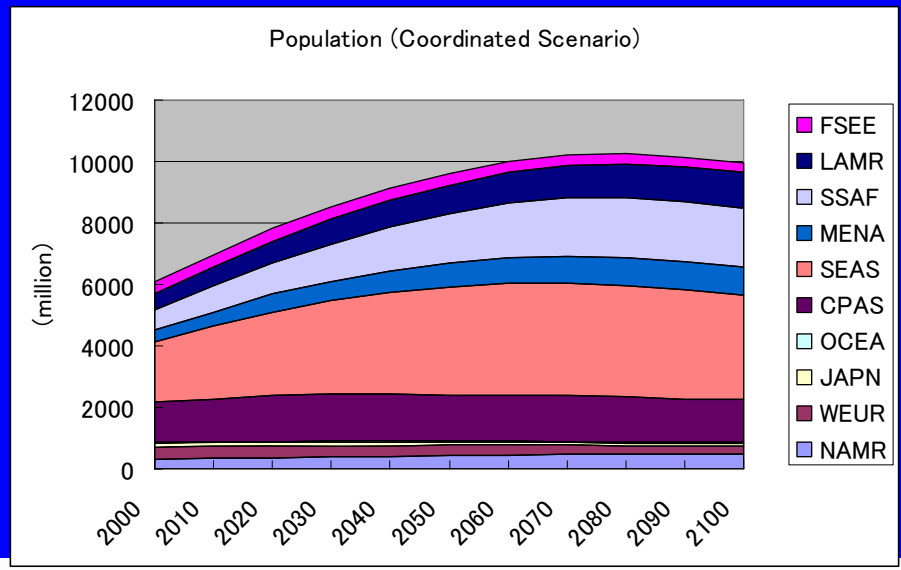




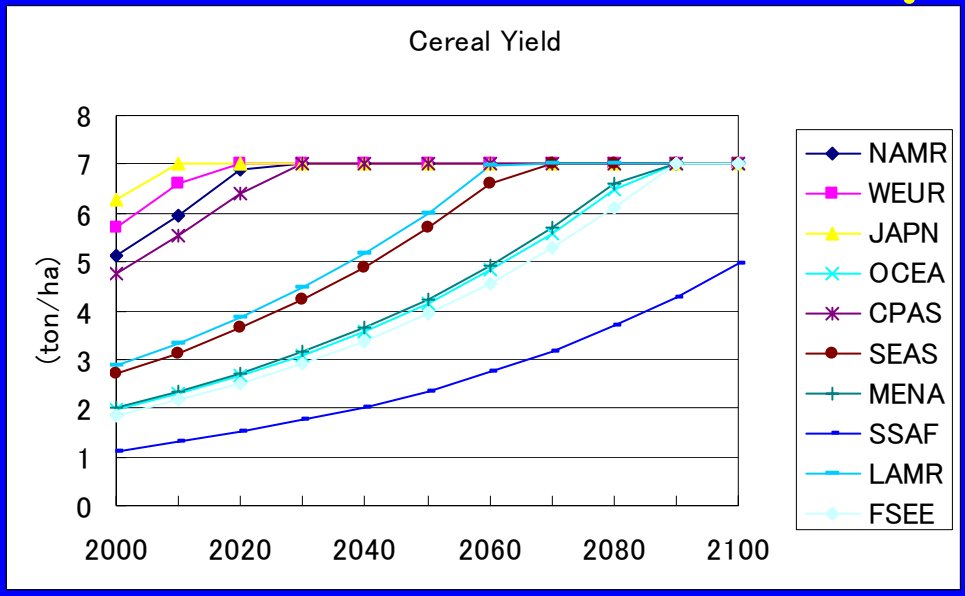
REF,HI,LO

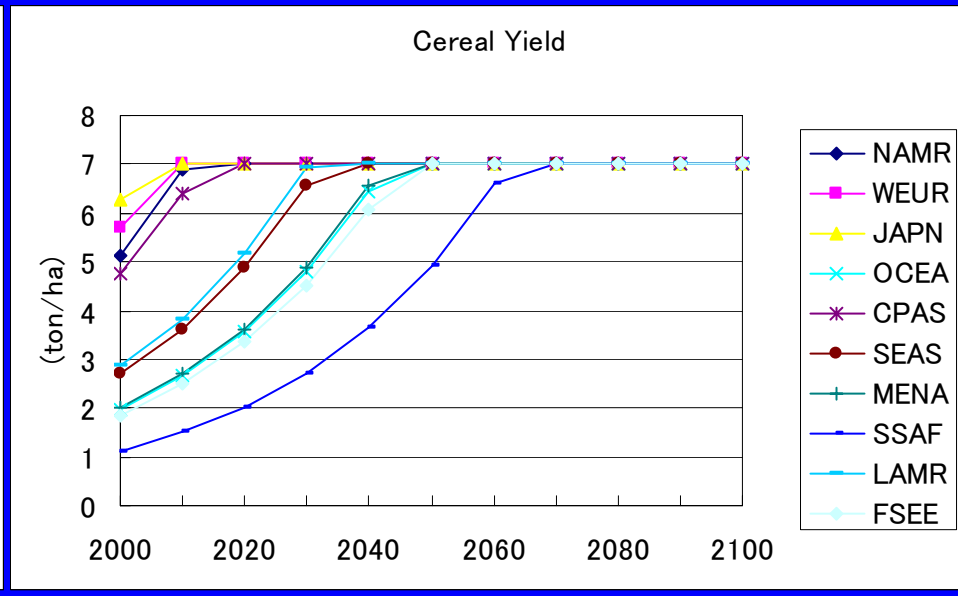


CS

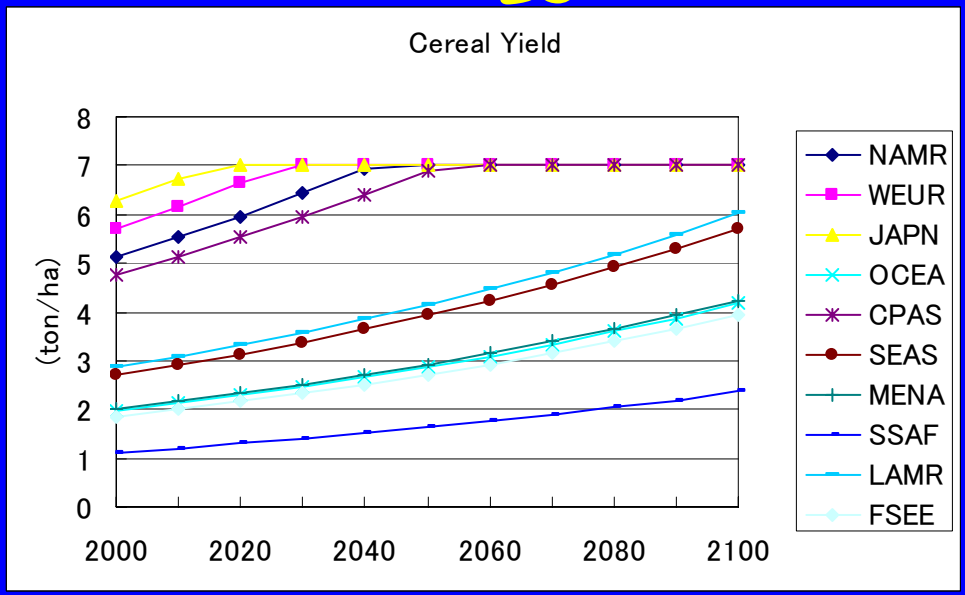


Crop Yield

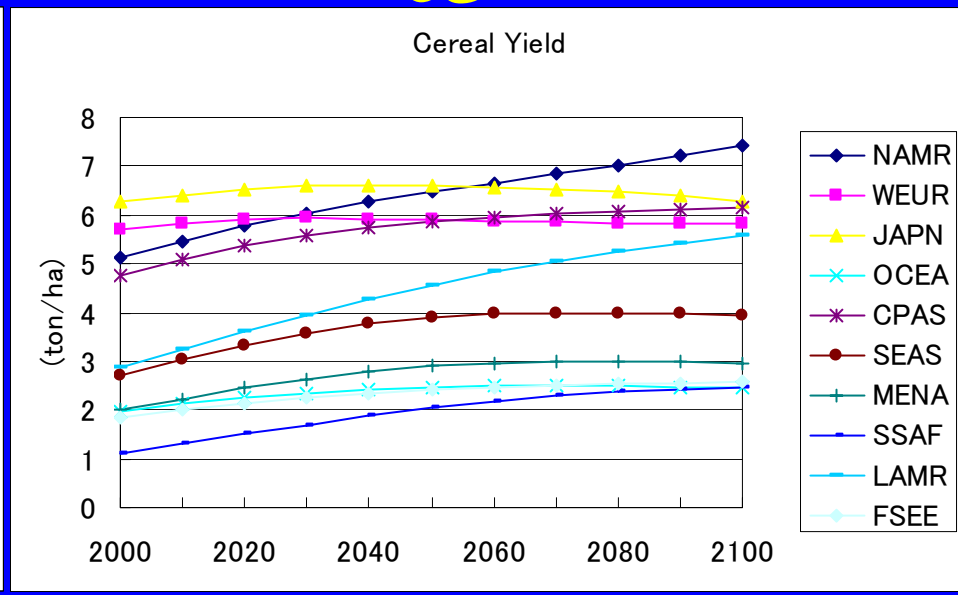




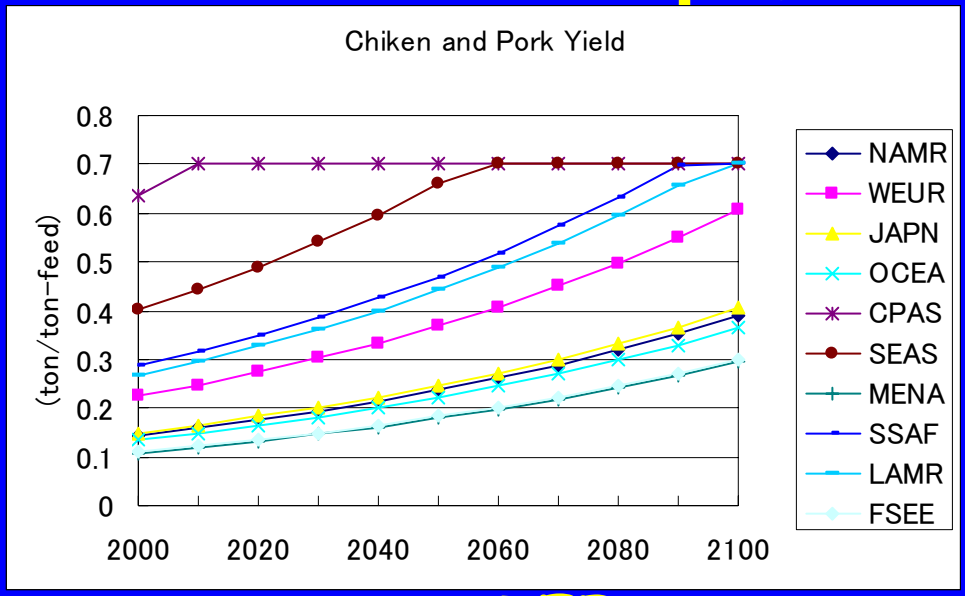
REF
LO

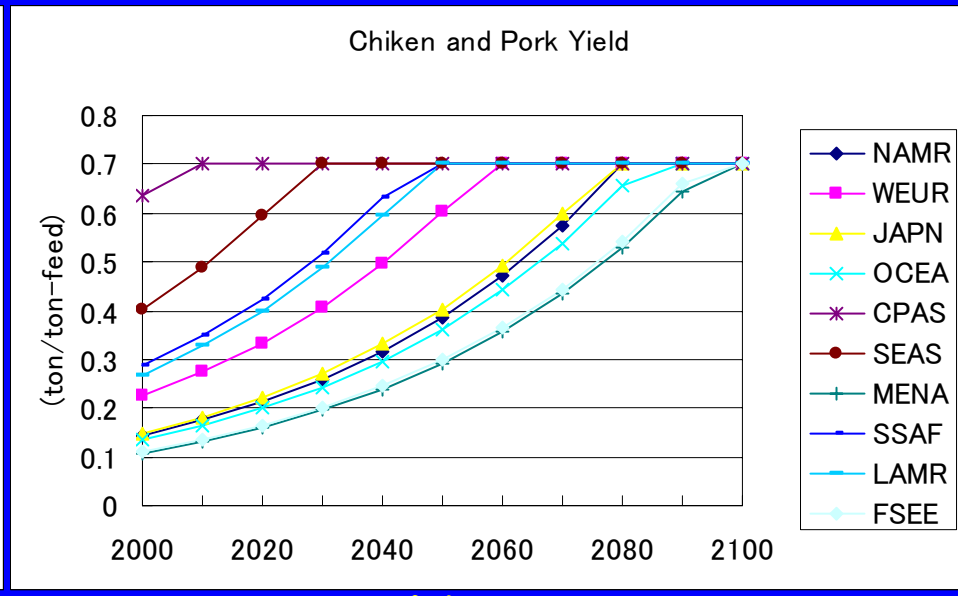


HI
CS



Crop-Fed Meat Yield





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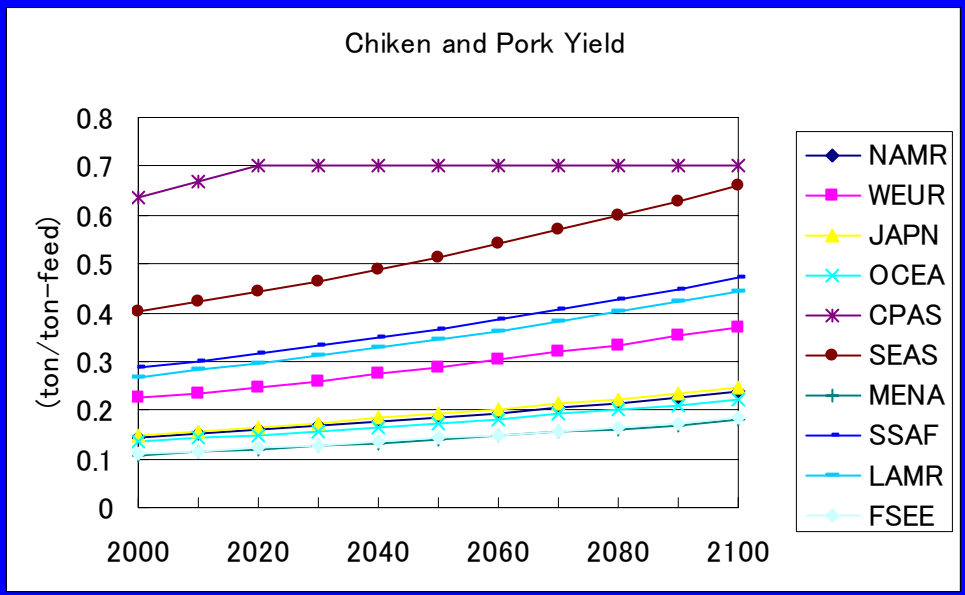

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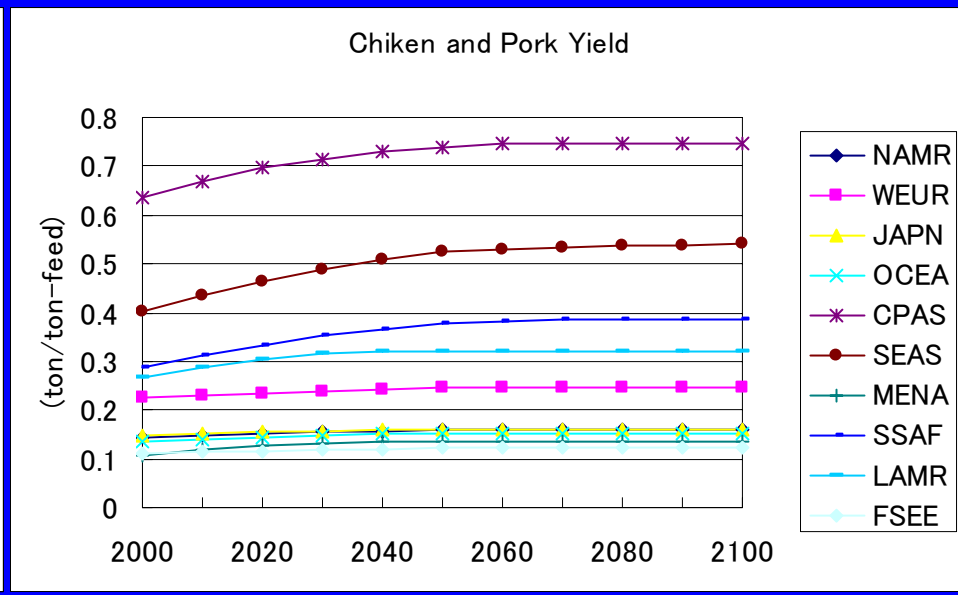
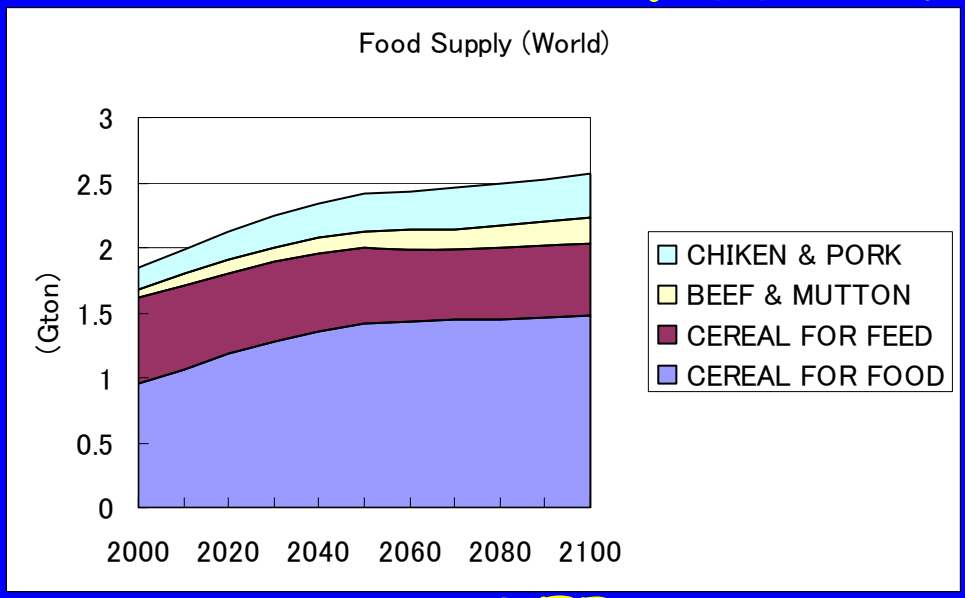


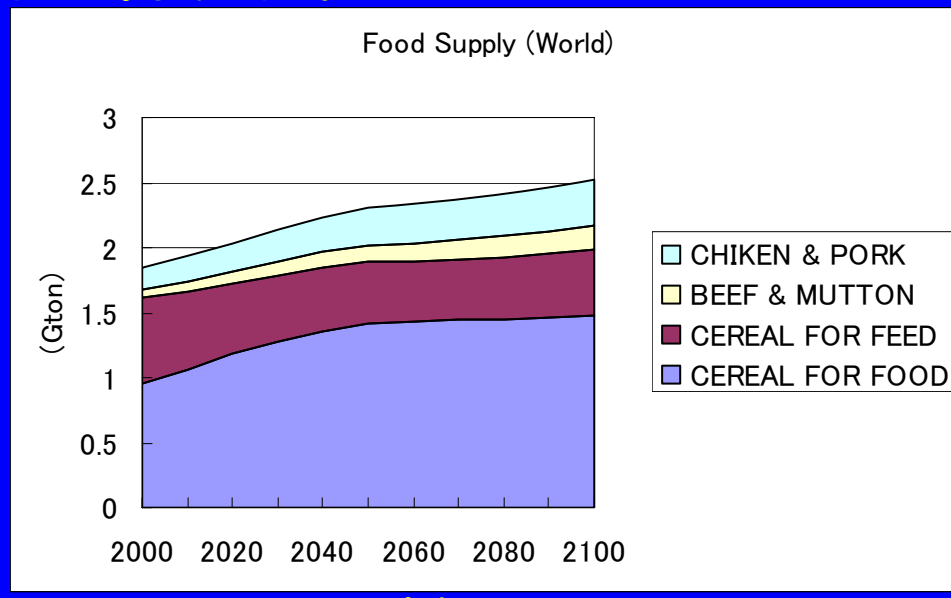
Yield Growth in Agriculture Production

* Crop Production Yield
  = (Fertilizer Applied) * (Other Factors)
  Management
  Gene Tech., etc.

* Meat Production Yield
  = (Feed required) * (Other Factors)
  Grassland Area Management
  Feed Amount Growth Hormone

Food Production





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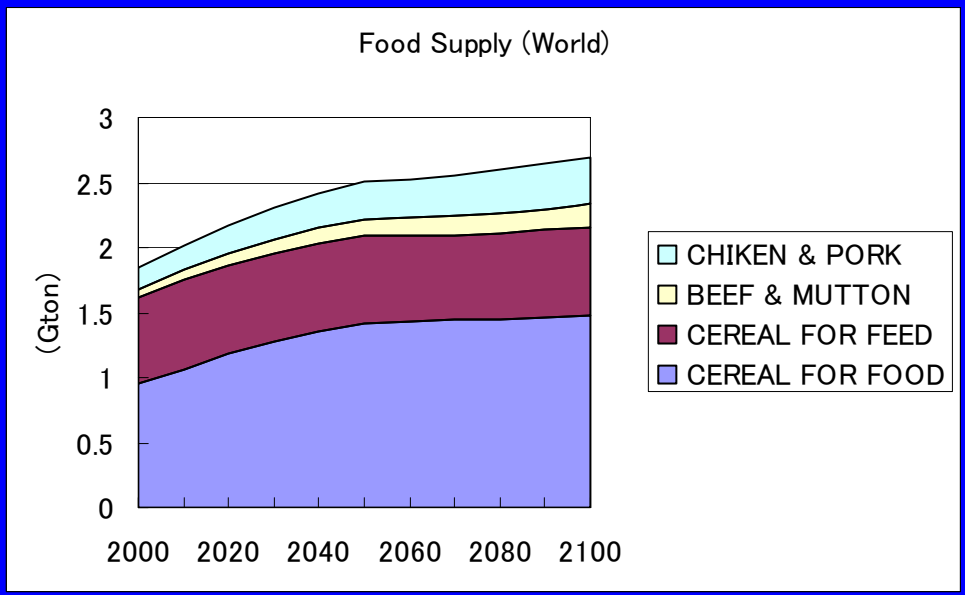

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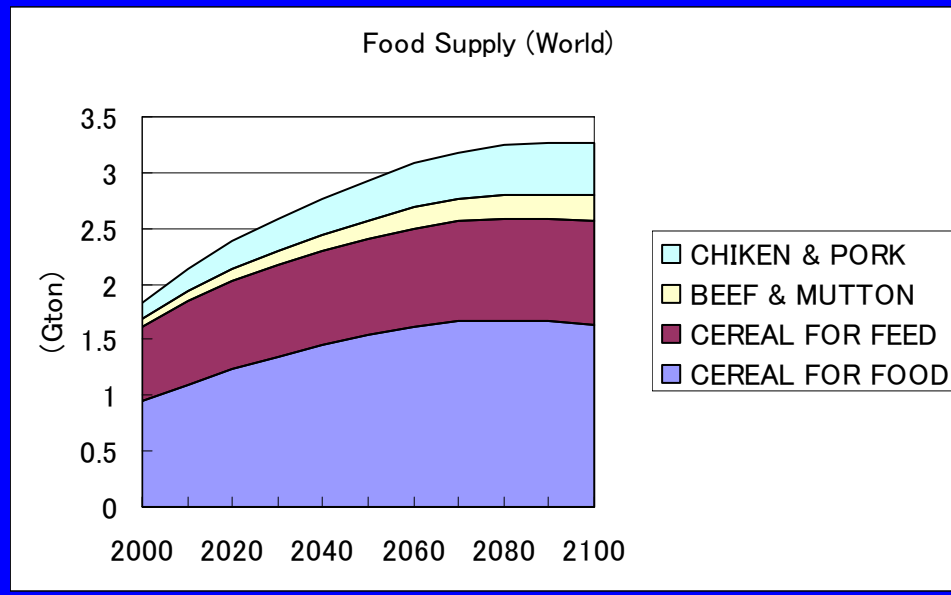
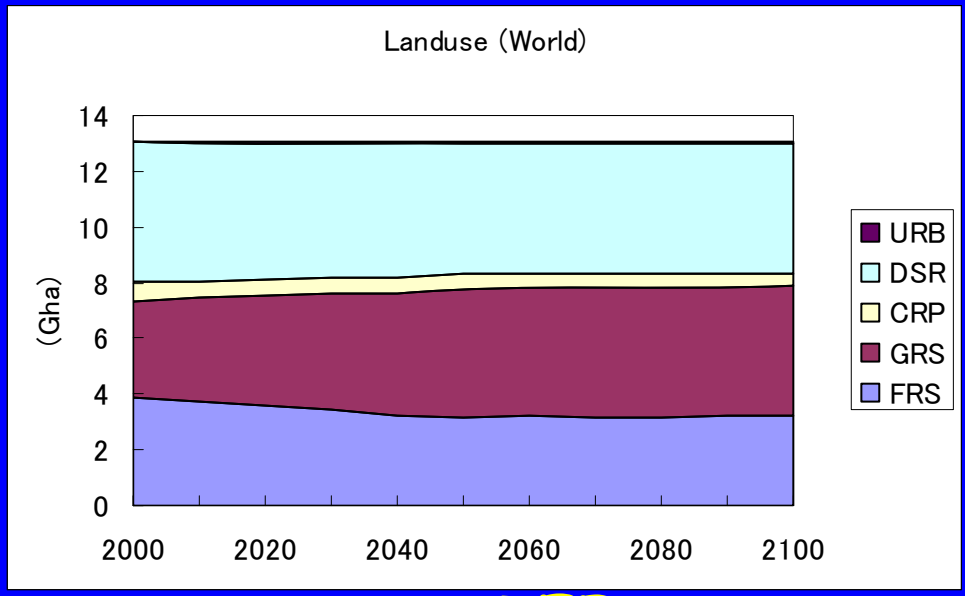
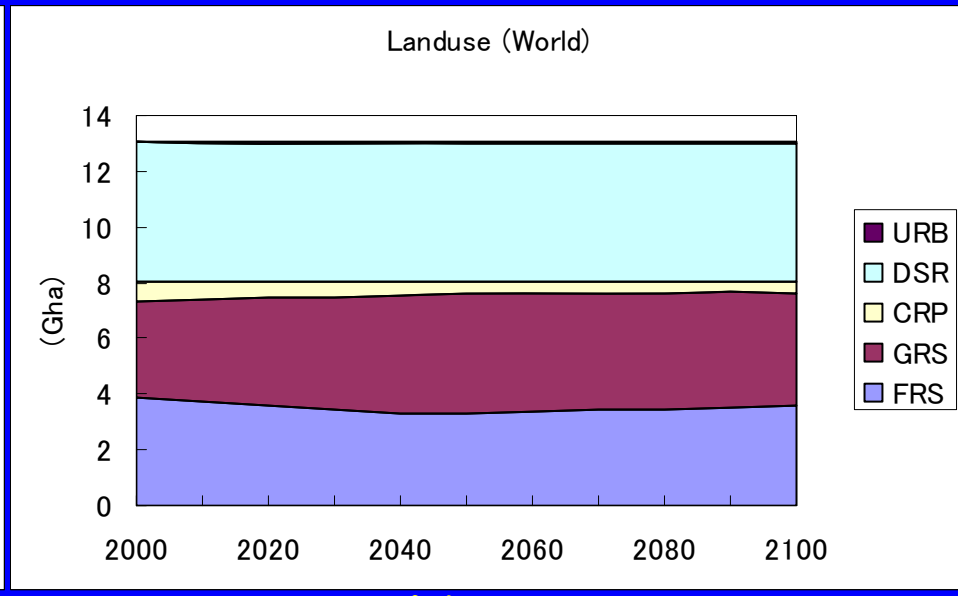


Global Landuse





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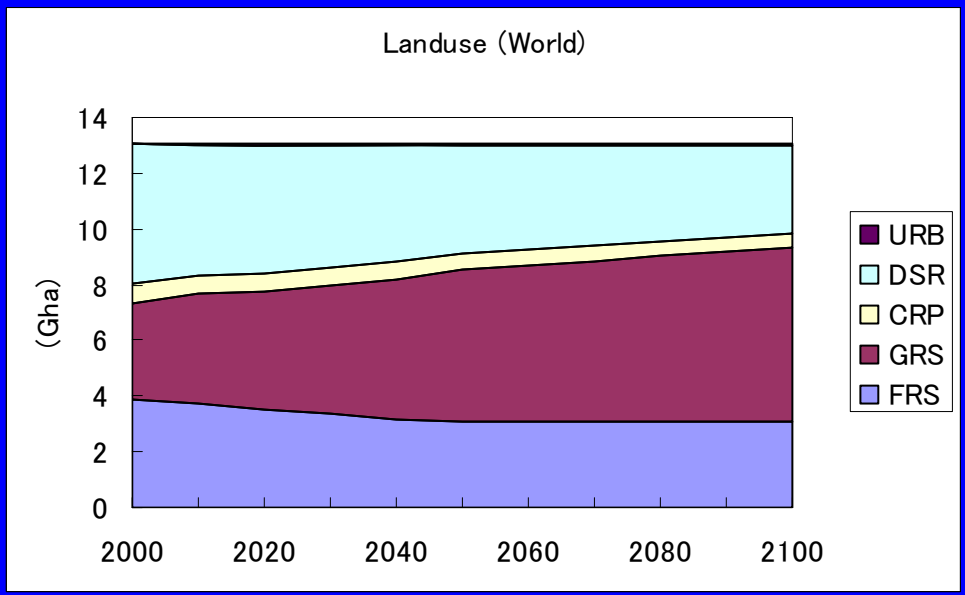

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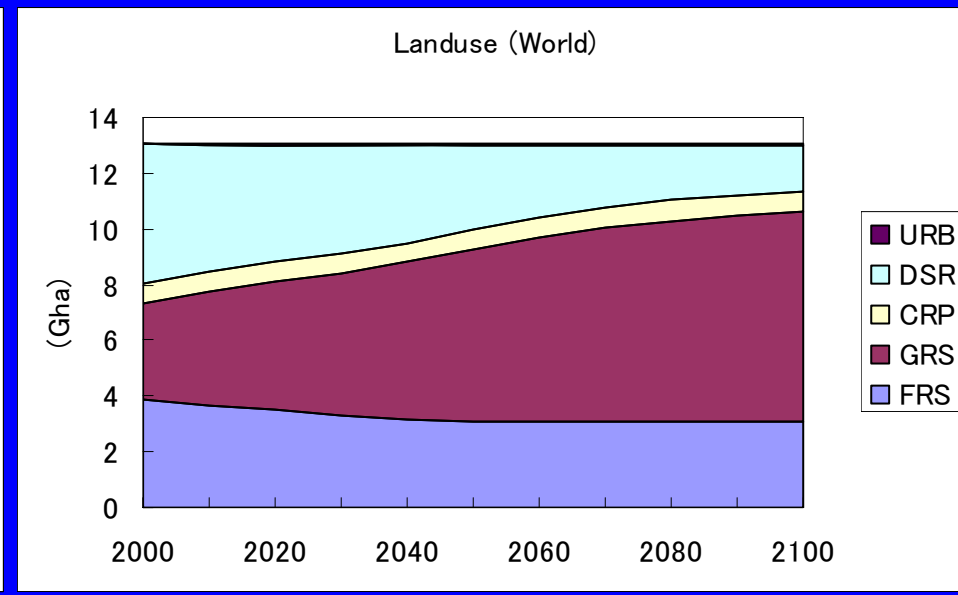
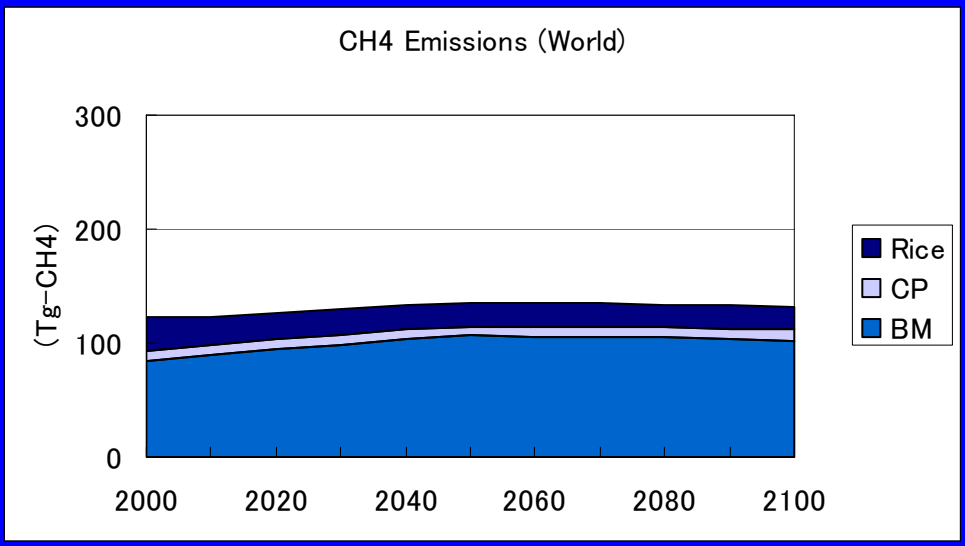


CH4 from Agriculture



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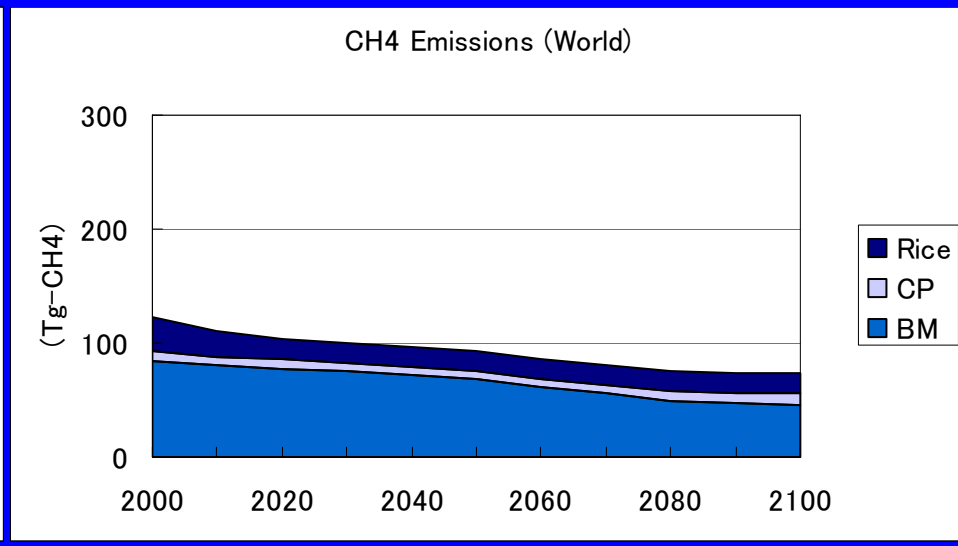

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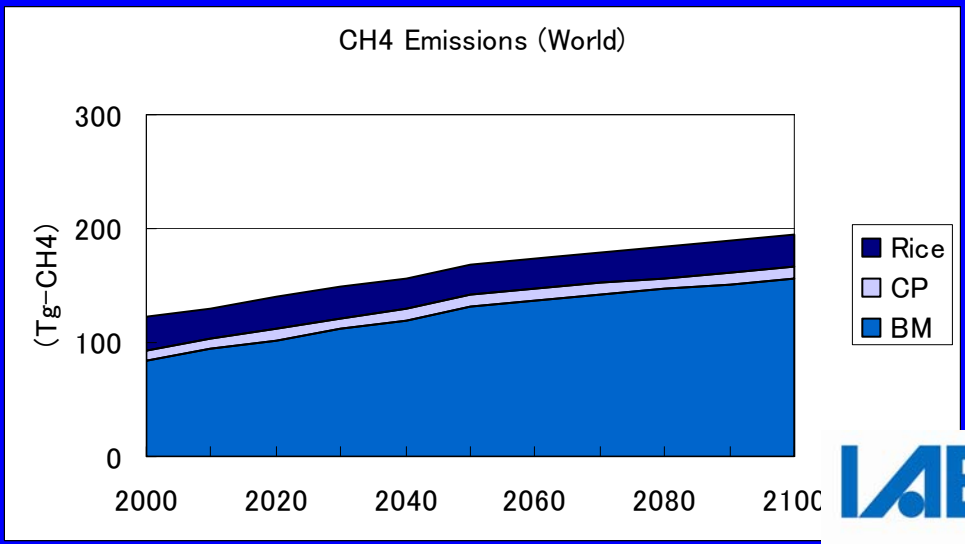
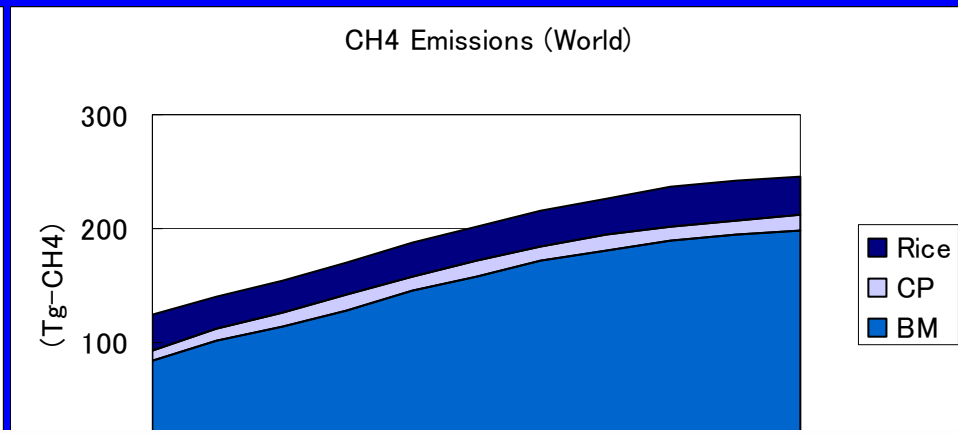
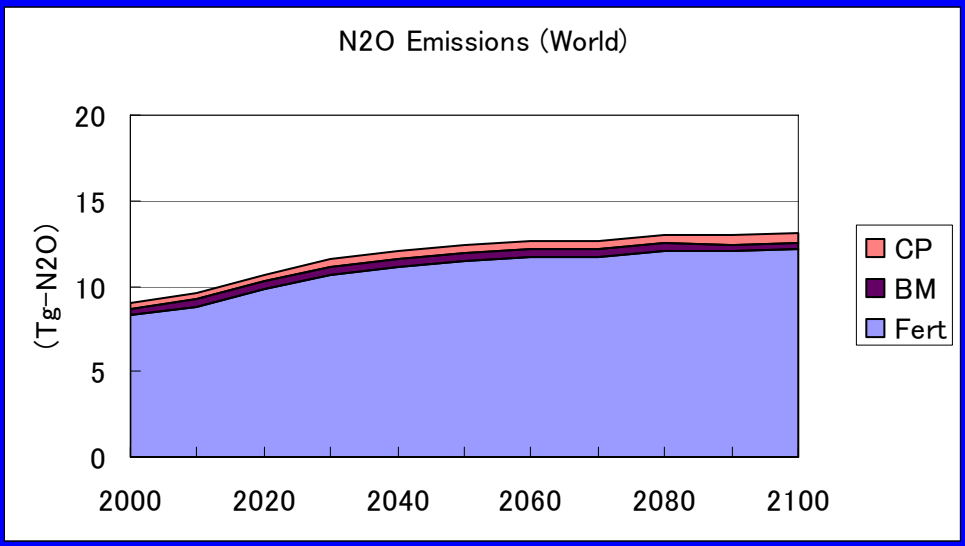
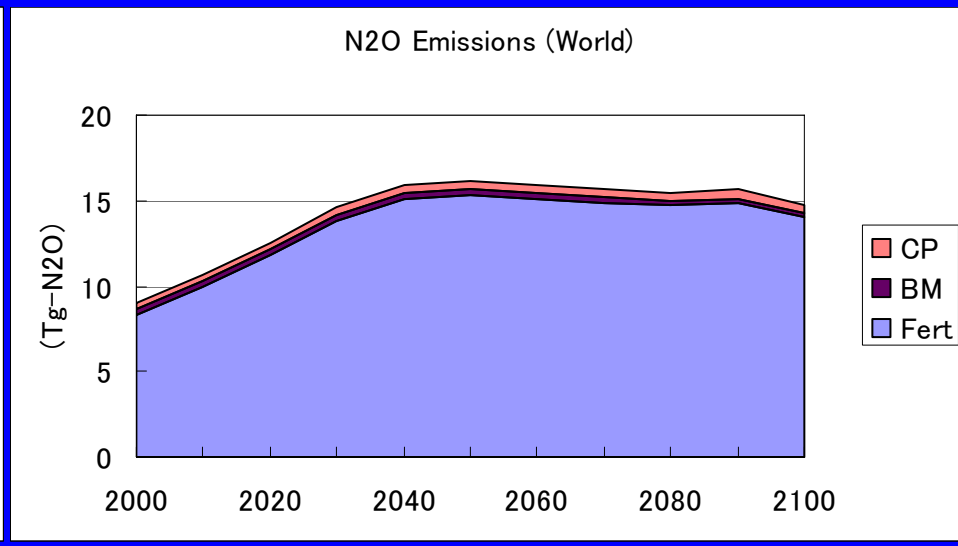




N2O from Agriculture





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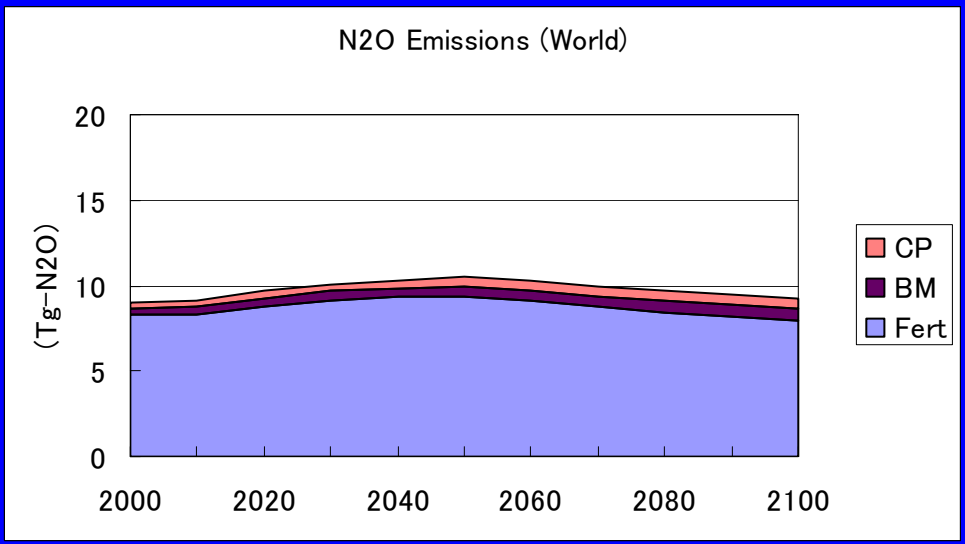
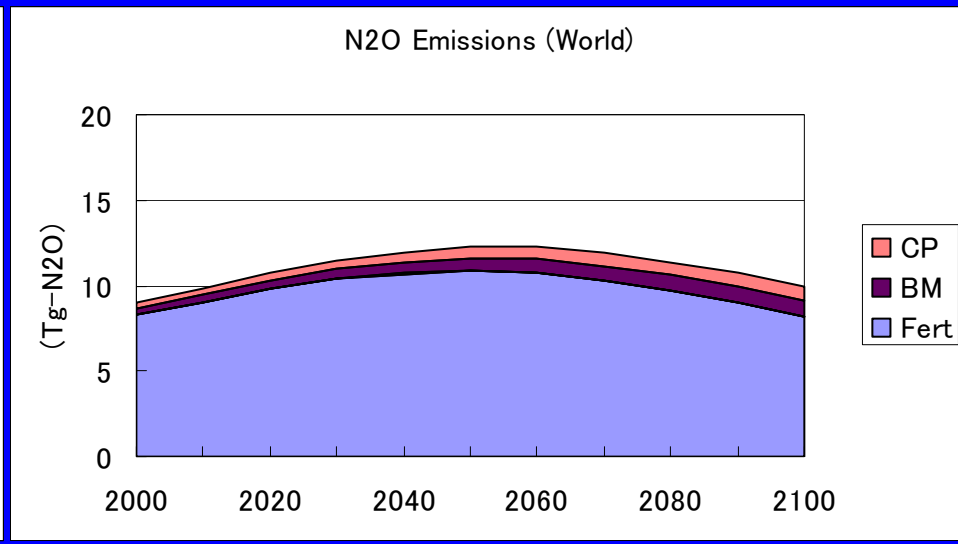




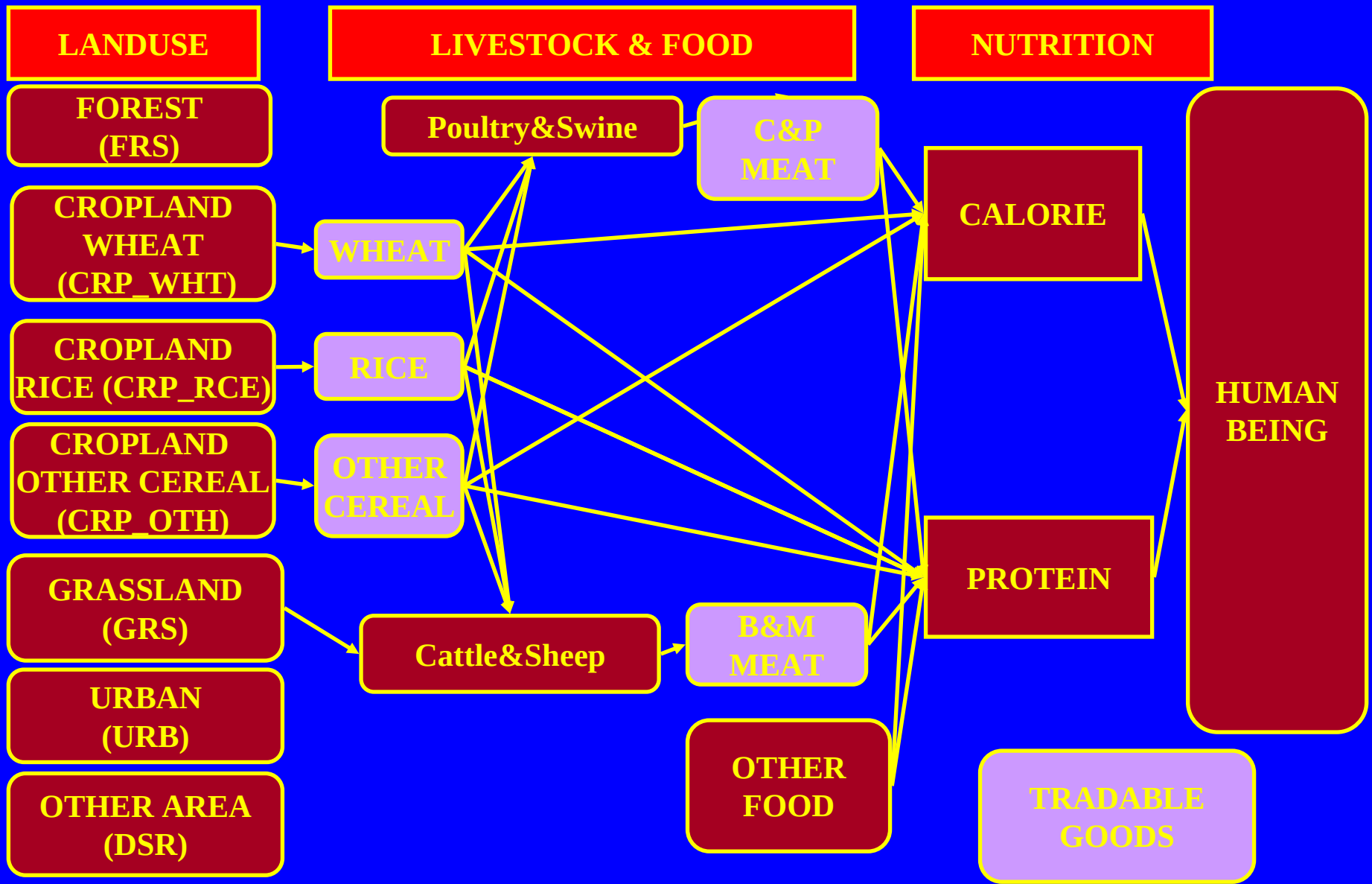
Discussions Needed

* Food Culture
  - Inertia
    - Crop - Rice in Asia, etc.
    - Protein – Meat, Fish, Milk,,,
  - Food Safety
    - Gene Tech.,

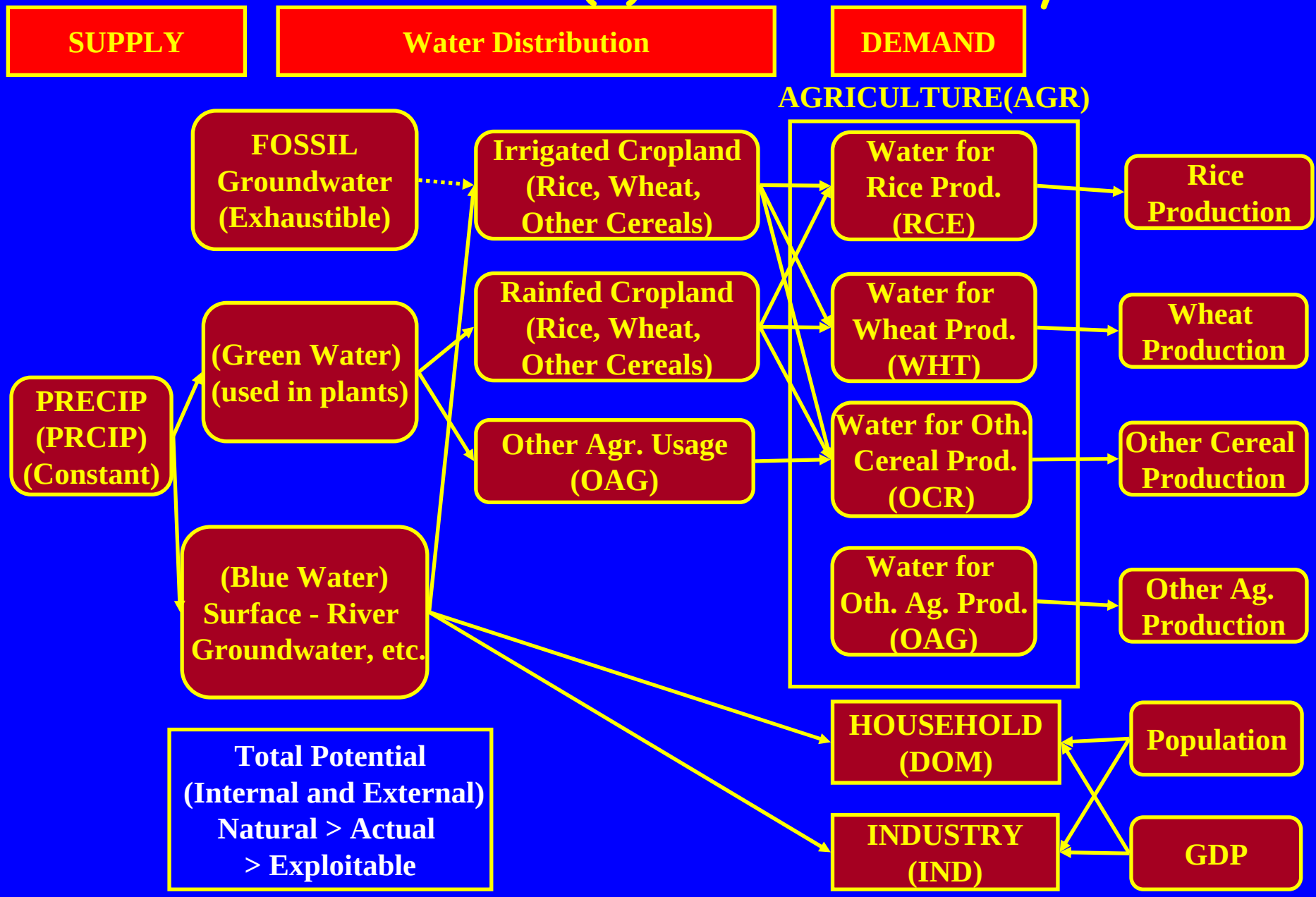
* Food Service Industry
  - Dine Out & Food Waste

* Other Issues

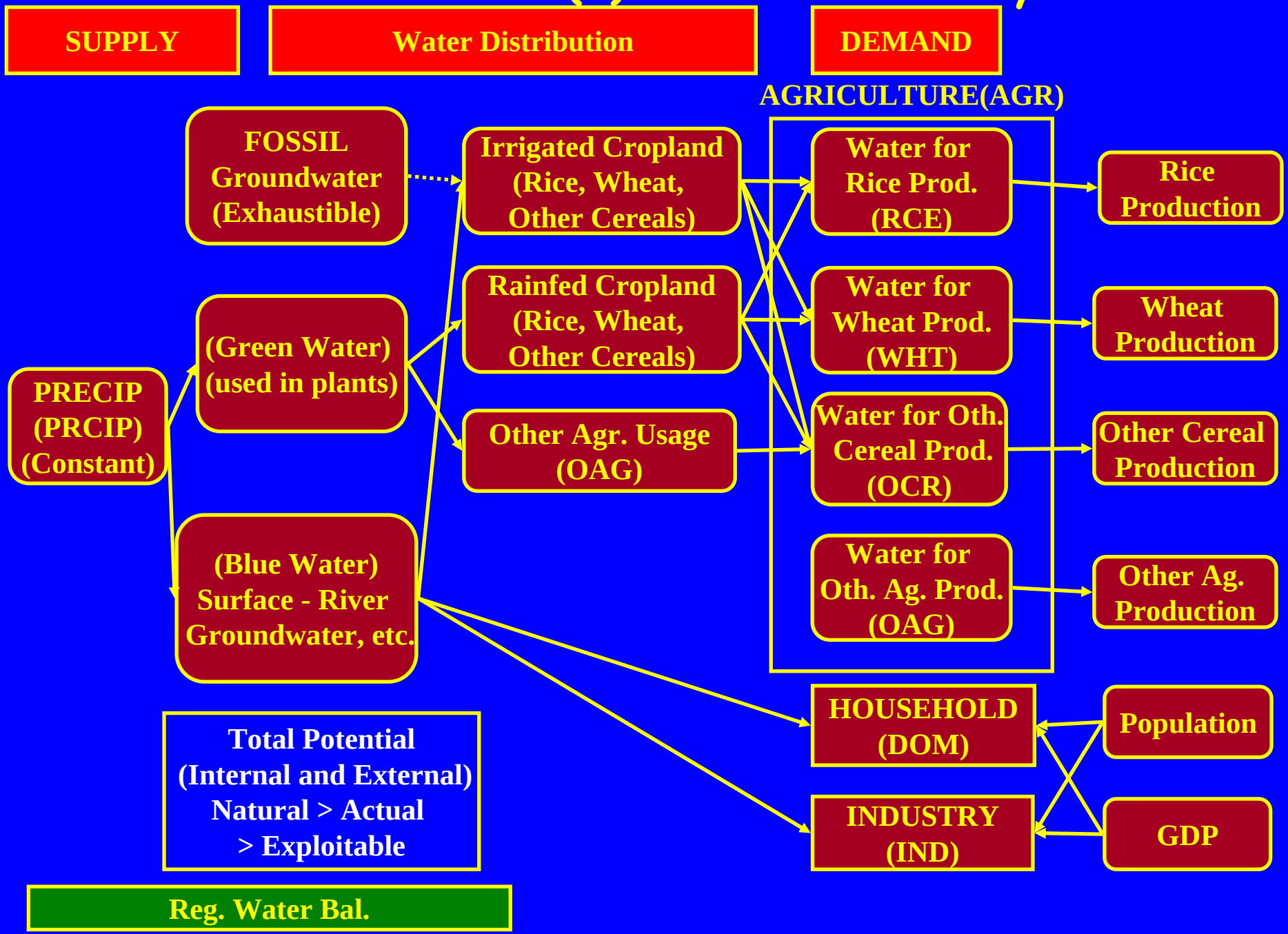
Possible Future Extension (1) Crop Disaggregation



Possible Future Extension (2) Water Availability



Possible Future Extension (2) Water Availability



Outline

1. EMF22 runs

2. Coupling of Mitigation and Adaptation

Motivation

* Existing Frameworks

- Integrated assessment models (IAMs) to analyze climate change mitigation strategies.

- Life cycle impact assessment (LCIA) to make comprehensive analysis of environmental effects of product life cycle.

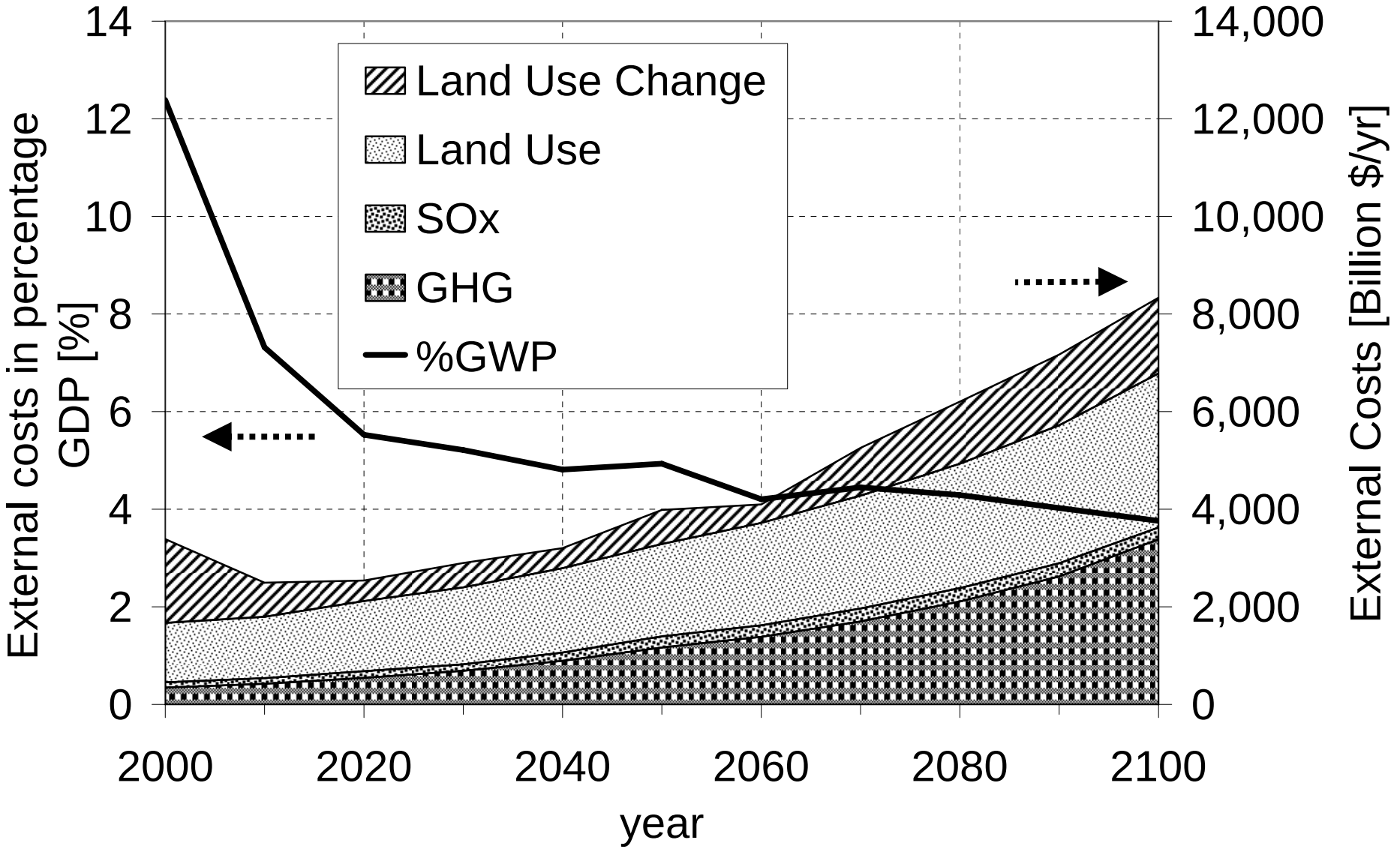
* Application to Adaptation Study

Coupling of IAM and LCIA can provide common and consistent framework basis for bottom-up and top-down integration in climate change impact assessment.

GRAPE output and "Impact Categories" &"Safeguard Subjects" of LIME

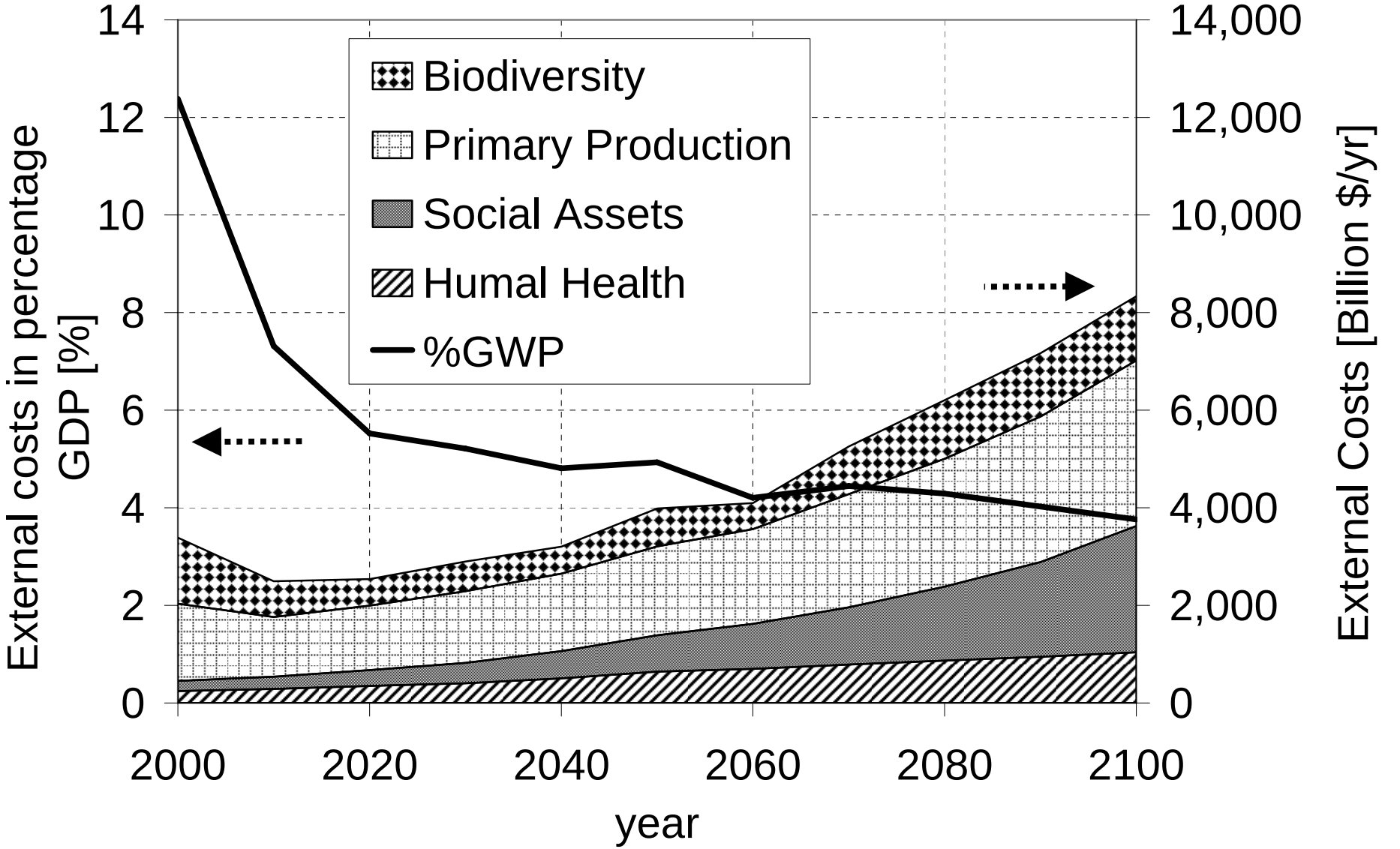
GRAPE output (Inventories in LIME)	LIME	
	Impact Categories	Safeguard Subjects
6 Kyoto GHGs	Global Warming	Human health, Social Assets
SO_x	Acidification, Urban Air Pollution	Human health, Social Assets, Primary Productivity
Land Use (LU)	Land Use	Primary Productivity
Land Use Change (LUC)	Land Use	Primary Productivity, Biodiversity

Global Total External Costs by Inventories



Tokimatsu, Itsubo, Kurosawa, Kosugi, Yagita and Sakagami, A simulation study of merging a lifecycle impact assessment (LCIA) with integrated assessment model (IAM) – a optimal economic growth via interlizing external costs by environmental impacts – (in Japanese), Kankyo Kagaku Kaishi, vol.19 no.1, pp25-36, 2006.

Global Total External Costs by Safeguard Subjects



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The 7th International Conference on EcoBalance
Nov. 14-16, 2006, at EPOCHAL TSUKUBA, Tsukuba, JAPAN

Global Sustainable Development Indices for the Future:

A Simulation Study Linked IAM with LCIA

Takanobu Kosugi*[1], Koji Tokimatsu*[2], Atsushi Kurosawa*[3],
Norihiro Itsubo*[2,4], Ryota Ii*[5], **Hiroshi Yagita***[2,6], Masaji Sakagami*[7]

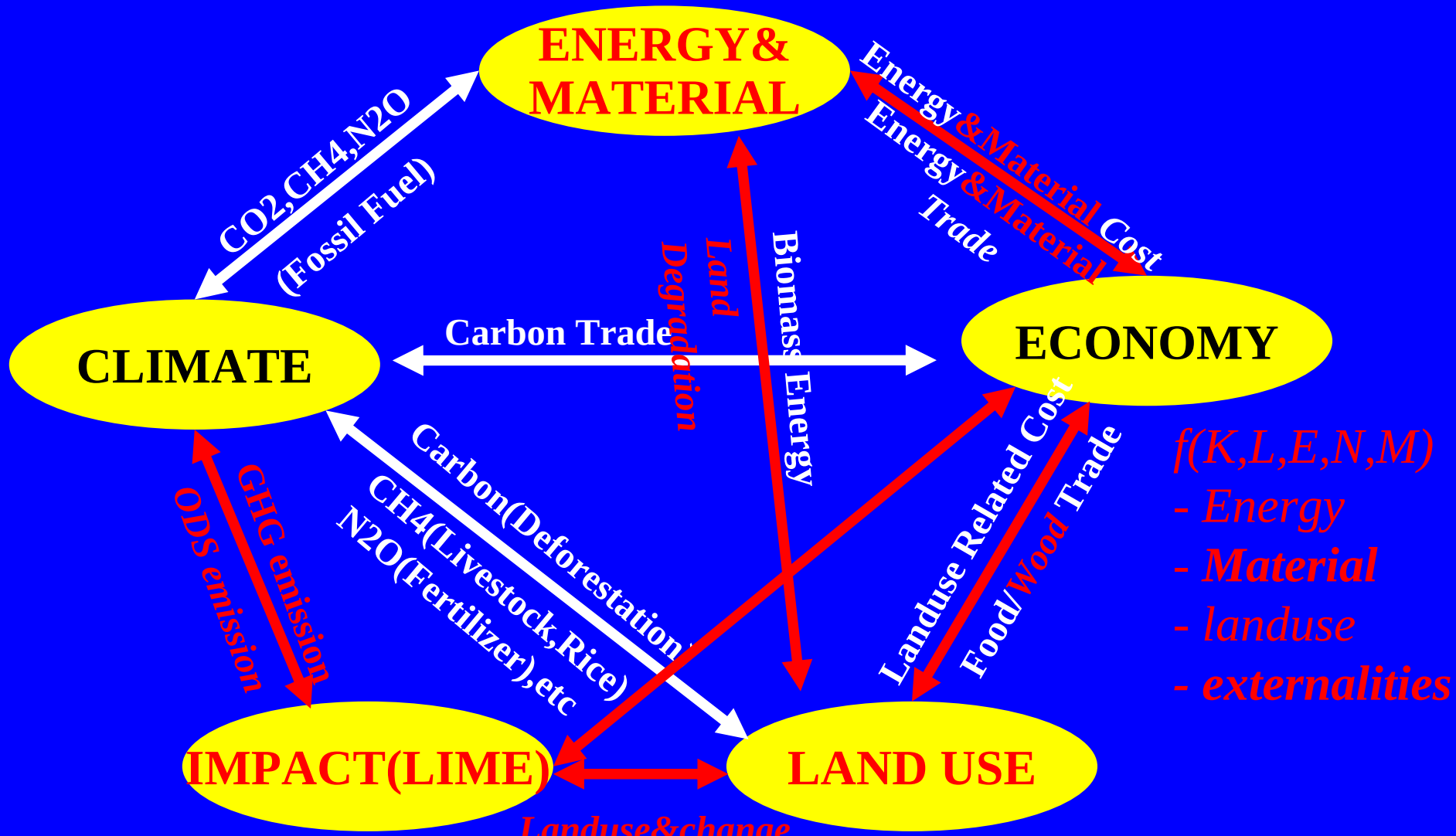
*[1] College of Policy Science, Ritsumeikan University
*[2] Research Center for Life Cycle Assessment,
National Institute of Advanced Industrial Science and Technology
*[3] The Institute of Applied Energy
*[4] Musashi Institute of Technology
*[5] Pacific Consultants Co., Ltd.
*[6] Nippon Institute of Technology
*[7] Nihon Fukushi University

Objective

- Presenting
  - a methodology to assess energy and materials systems from a viewpoint of sustainable development in the future;
  - preliminary results giving insights on energy and material-related policies for sustainable development in 21st century.
- Core methodology: extension and application of GRAPE/LIME model, which merges an IAM ***GRAPE*** and a LCIA method ***LIME***.
  - ***GRAPE*** is extended to be coupled with a new submodel that explicitly deals with the materials supply and demand systems including mining, refining and recycling of iron and steel, aluminum and copper.

Kosugi, Tokimatsu, Kurosawa, Itsubo, Ii, Yagita, Sakagami, Global Sustainable Development Indices for the Future:A simulation study of merging a lifecycle impact assessment (LCIA) with integrated assessment model (IAM), The 7th International Conference on EcoBalance, 2006, Tsukuba, JAPAN

Structure of GRAPE/LIME linkage



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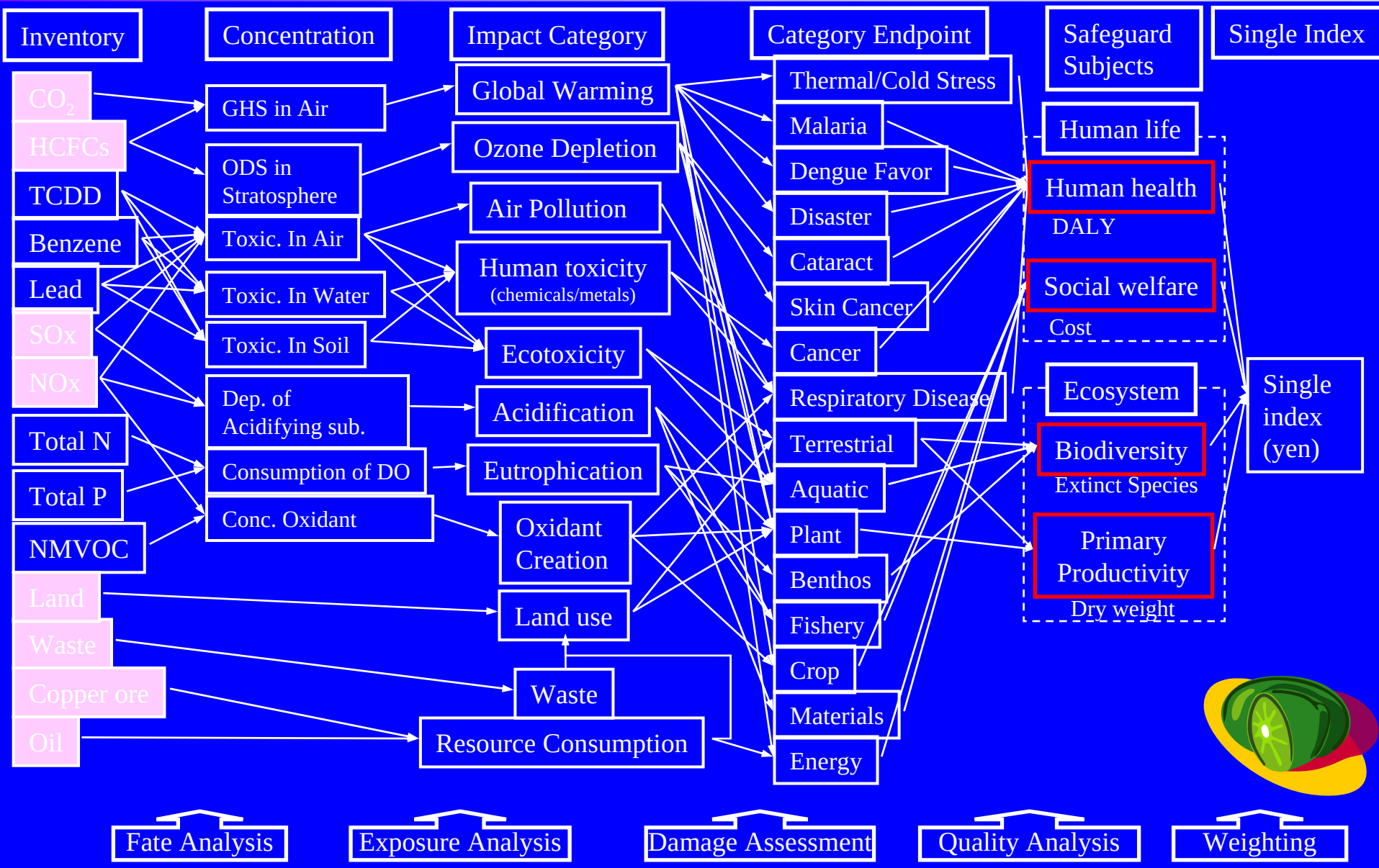
LIME – A Life Cycle Impact Assessment Method



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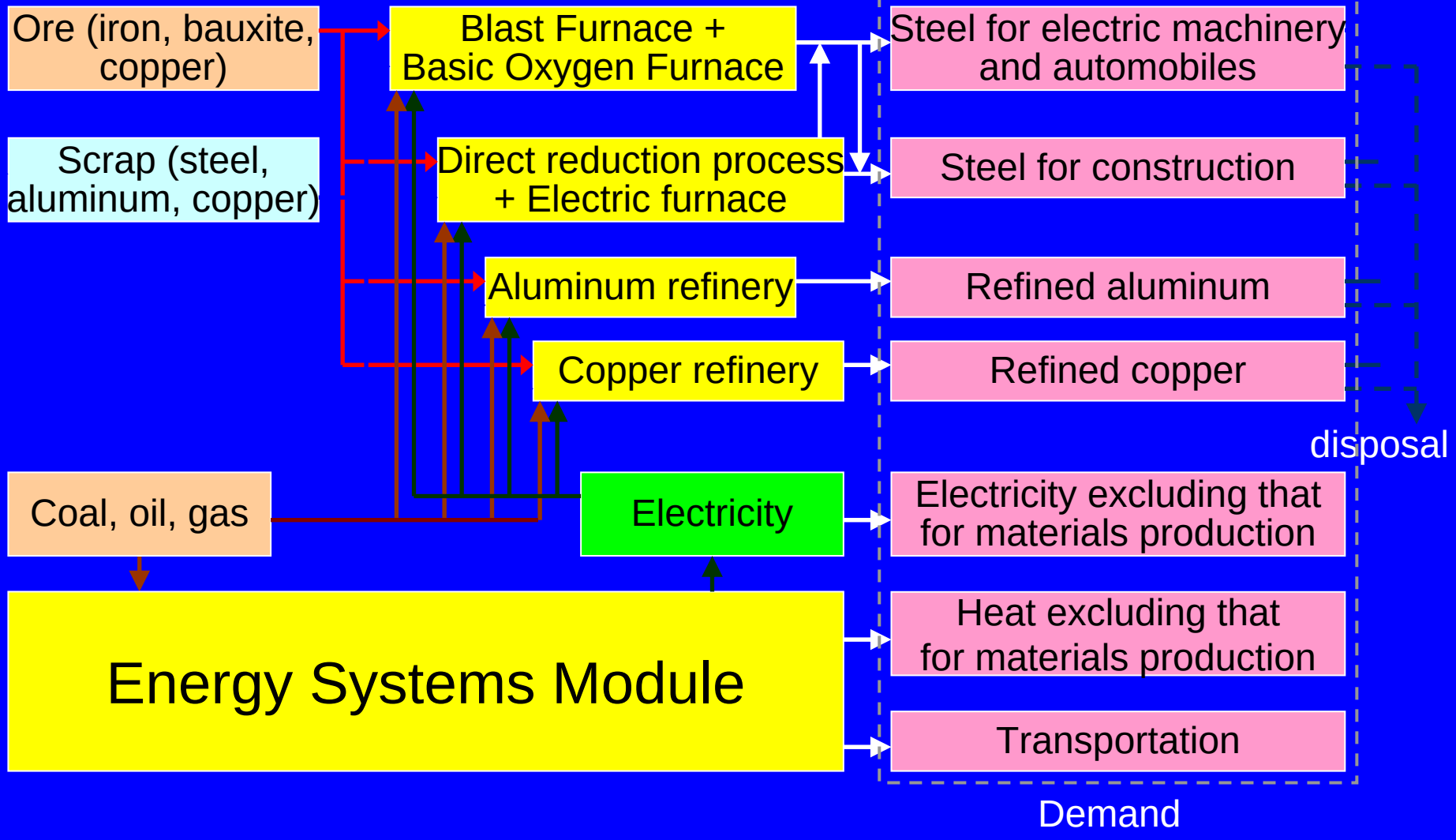
Model extension: from Energy module to Energy & Materials module



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GRAPE/LIME linkage

Integrated assessment model for energy/economy (GRAPE)

$$K_{rg,yr+1} = (1-\delta_t)\cdot K_{rg,yr} + T_0 \cdot I_{rg,yr}$$

$$Y_{rg,yr} = f(K,L,E,N,\underline{M}) - \underline{EMC}_{rg,yr} - LUC_{rg,yr}$$

$$C_{rg,yr} = Y_{rg,yr} - I_{rg,yr}$$

$$U = \sum_{yr}\sum_{rg}(1+r)^{-yr\cdot T_0}\cdot L_{rg,yr}\cdot\log\left(\frac{C_{rg,yr}}{L_{rg,yr}}\right)\rightarrow \max$$

Japanese version of lifecycle impact assessment (LIME)

$$EXT = \sum_i\sum_s\left(Inv._S \times IF_{i,s}\right)$$

EXT : total amount of environmental impacts: externalities

Inv_s : inventory of environmental impact substance

IF_{is} : monetary value of environmental impact for a unit of the substance

Margining two models of GRAPE and LIME, and carrying out of optimal growth simulation by internalizing externalities

$$Y_{rg,yr} = f(K,L,E,N,\underline{M}) - \underline{EMC}_{rg,yr} - LUC_{rg,yr} - EXT_{rg,yr}$$

Kosugi, Tokimatsu, Kurosawa, Itsubo, Ii, Yagita, Sakagami, Global Sustainable Development Indices for the Future: A simulation study of merging a lifecycle impact assessment (LCIA) with integrated assessment model (IAM), The 7th International Conference on EcoBalance, 2006, Tsukuba, JAPAN

Other topic

Japanese Energy Technology Roadmap

Long-Term
FY2004-2005

Short- and Medium- Term
Started Oct. 2006

Strategic Technology Roadmap (Energy Sector) ~ Energy Technology Vision 2100 ~

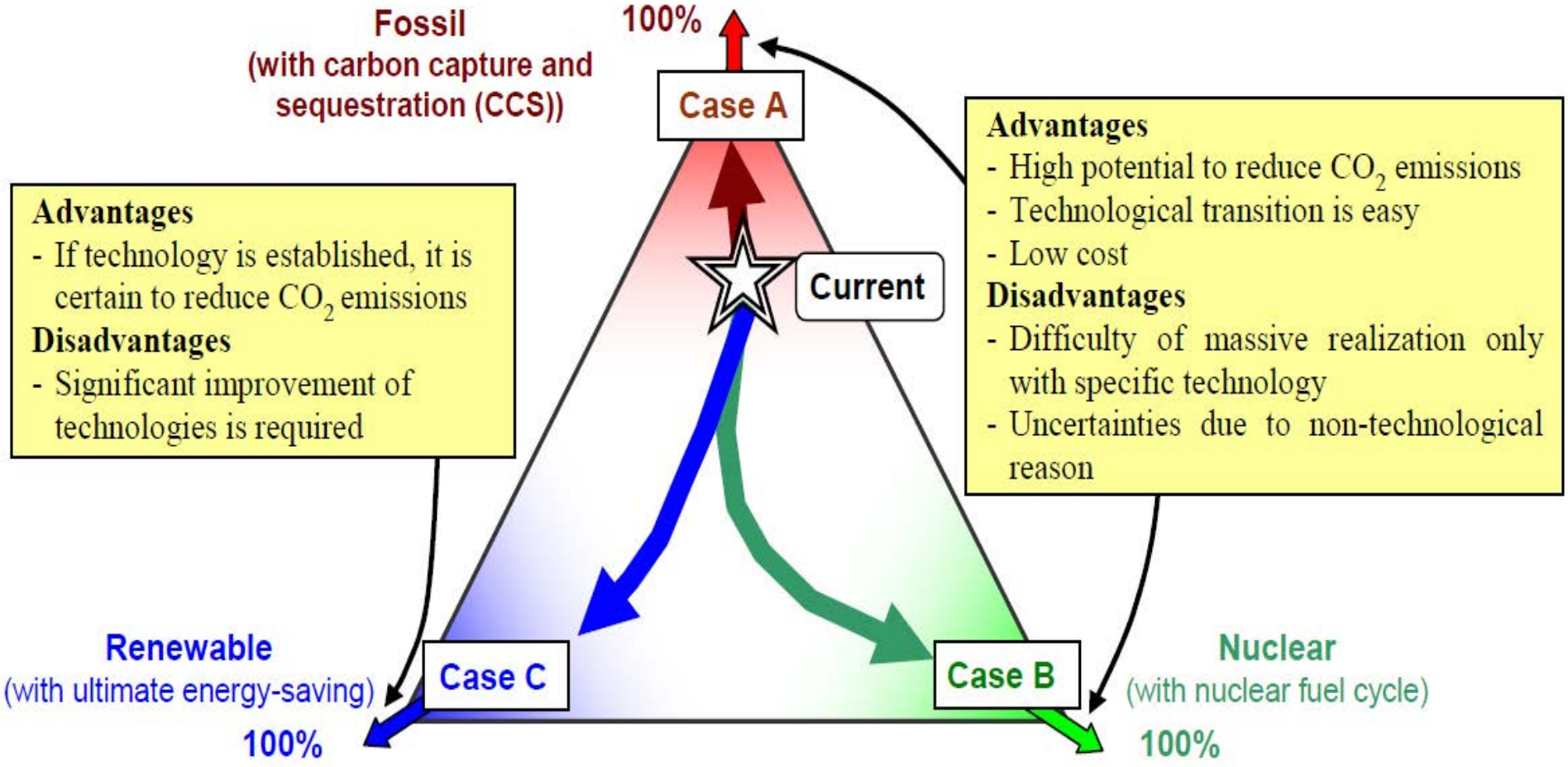
http://www.iae.or.jp/2100.html

* Contract Research from METI, Japan
* One of the Strategic Tech. Roadmaps of METI
* Identify Long Term Energy Tech. Role under Climate (CO2/GDP) and Energy Resource Constraints
* Detail Roadmaps incl. Tech. Performance Targets

Transformation (Prim. Supply & Conversion (Elec. &H2))

Demand / Industry, Residential & Commercial, Transport

Energy Supply
Which Direction Should We Go?



Images of the three cases of primary energy supply structures

Energy Technology Roadmap – Example of Res/Com please see the website for detail.

Res/Com		2000	2030	2050	2100
Total energy demand		1 time		1.5 times	2.1 times
Energy supplied from transformation sector*	Residential / Commercial		45% / 35% reduction	60% / 55% reduction	80% / 80% reduction
CO_2 intensity	Residential	3.5 t-CO_2/household (1 time)	1.9 t-CO_2/household (1/2 times)	1.1 t-CO_2/household (1/3 times)	0 t-CO_2/household
	Commercial	118 kg-CO_2/m^2 (1 time)	77 kg-CO_2/m^2 (2/3 times)	40 kg-CO_2/m^2 (1/3 times)	0 kg-CO_2/m^2

*The percentage of reduction of energy per unit should be supplied from the transformation sector, compared with total energy demand increases in proportion to GDP.

Energy saving

Efficiency improvement of equipment

- *Lighting with less heat loss* → *Equipment with less heat loss*
- *Improving thermal performance of housing and building* → *Active control of sun shading and thermal insulation*
- *Efficient heating* → *Efficient heat transfer, preheating by unused energy*
- *Improving electric power conversion efficiency* → *Electric power conversion with least loss*
- *Food storage at room temperature*

Use of ubiquitous energy
(minute pressure, temperature difference, vibration, radiowaves, etc.)

- *Energy saving enables equipment using little energy*
- *Energy creation from ubiquitous energy*

Photovoltaic generation

- *Installation in all places such as PV paint*
- *Installation in windows*
- *Installation in curved surfaces*
- *Installation facilitation*

Energy creation *Efficiency improvement and increase of durability*

Energy management

BEMS•HEMS

Self-sustainable housing and building

Demand management → *Management of demand and energy creation* → *Energy accommodation in community*

(Energy supply in community) → *Supply and storage*

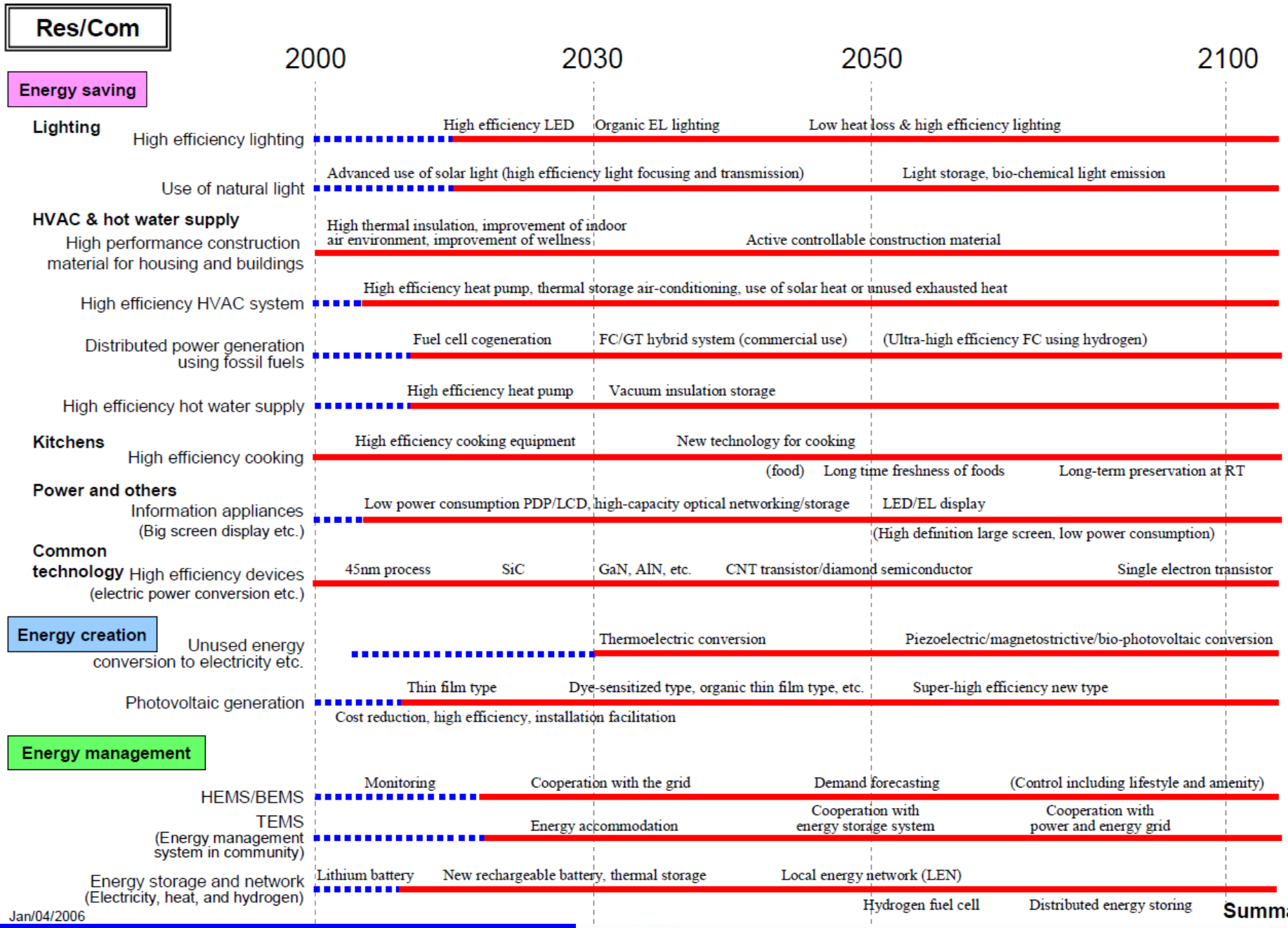
Self-sustaining

0 t-CO_2/household

0 kg-CO_2/m^2

Jan/04/2006

The Institute of Applied Energy


Res/Com
2000
2030
2050
2100
Energy saving
Lighting
High efficiency lighting
High efficiency LED
Organic EL lighting
Low heat loss & high efficiency lighting
Use of natural light
Advanced use of solar light (high efficiency light focusing and transmission)
Light storage, bio-chemical light emission
HVAC & hot water supply
High performance construction material for housing and buildings
High thermal insulation, improvement of indoor air environment, improvement of wellness
Active controllable construction material
High efficiency HVAC system
High efficiency heat pump, thermal storage air-conditioning, use of solar heat or unused exhausted heat
Distributed power generation using fossil fuels
Fuel cell cogeneration
FC/GT hybrid system (commercial use)
(Ultra-high efficiency FC using hydrogen)
High efficiency hot water supply
High efficiency heat pump
Vacuum insulation storage
Kitchens
High efficiency cooking
High efficiency cooking equipment
New technology for cooking
(food)
Long time freshness of foods
Long-term preservation at RT
Power and others
Information appliances (Big screen display etc.)
Low power consumption PDP/LCD, high-capacity optical networking/storage
LED/EL display
(High definition large screen, low power consumption)
Common technology
High efficiency devices (electric power conversion etc.)
45nm process
SiC
GaN, AlN, etc.
CNT transistor/diamond semiconductor
Single electron transistor
Energy creation
Unused energy conversion to electricity etc.
Thermoelectric conversion
Piezoelectric/magnetostrictive/bio-photovoltaic conversion
Photovoltaic generation
Thin film type
Dye-sensitized type, organic thin film type, etc.
Super-high efficiency new type
Cost reduction, high efficiency, installation facilitation
Energy management
HEMS/BEMS
Monitoring
Cooperation with the grid
Demand forecasting
(Control including lifestyle and amenity)
TEMS (Energy management system in community)
Energy accommodation
Cooperation with energy storage system
Cooperation with power and energy grid
Energy storage and network (Electricity, heat, and hydrogen)
Lithium battery
New rechargeable battery, thermal storage
Local energy network (LEN)
Hydrogen fuel cell
Distributed energy storing
Jan/04/2006
Summary-4

Thank you for the kind attention.