Future AIM modeling

~Focused on global models and national assessment tools~

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(Not Ohyama Memorial Hall)
National Institute for Environmental Studies, 305-8506,Tsukuba, Japan

AIM model family FY2007

Global model for climate policy assessment

National scale models toward low carbon society

Category	Name	Category	Category			
Top-down models	Ecosystem	Conservation of ecosystem/ water stress/ landuse/ pollution in developing countries	Modeling of relationship among economic activities, land use and ecosystem	Multi-regional CGE + various environmental process models	~2100	Merge and extend to one global/CGE model as a plat home of AR5 scenario activity
	Global/CGE	Energy, GHG Control	Projection of long-term GHGs emission	Multi-regional CGE model	~2100-2150	
	Material	CO2 reduction, energy consumption, waste management, environmental industry	Economic and material flow impact by climate and	One regional national CGE model	~2030-2050	Connecting with stock models, houshold models, transport models
	Econometric	Forecasting macro-economic frame	energy for cases			
	Backcasting	GHG, Energy, Low carbon society	Establishing scenarios toward saustainable society from view points of environment and economy	Country-level dynamic optimization model	~2050	Implementation and Operation
Models /Tools for scenario making	Population/Household	Population, household	Establishing scenarios toward saustainable society from view points of environment and economy	Cohort-component model, houshold transition matrix model	~2050	Quantitative shinario making tools for mid-term national/regional integrated assessment
	Building	Residential, non-residential building	Estimation of building demands related to houshold change, economic change and so on	Stock dynamics model	~2050	
	Transport	Passenger and Freight transport demand	Estimation of transport demand related to national/regional/urban land planning	Trip generation, modal share modeling	~2050	
	Stocks	Infrastructure, capital, buildings	Estimation of raw material needs, waste generation related to recycling and economic activity	Stock dynamics model	~2050	
	Energy supply and demand regulation	Temporal and spatial regulation of electlicity, heat and hydrogen	Adjustment among temporal and spatial fluctuation of energy demand and supply	Simulation and optimization type model	~2050	
End-use, Energy, Technology Bottom-up	Enduse[global]	GHG,SO$_2$,NO$_X$,PM abatement technology	Technology selection for global warming, regional air pollution	Country-level or regional-level bottom-up model	~2050	Still developing. Estimation of feasibility and economic burdens of low carbon world
	Enduse[country]	GHG,SO$_2$,NO$_X$,PM abatement technology	Technology selection for global warming, regional air pollution	Country-level or regional-level bottom-up model	~2050	Keep maintainance
	Enduse[local]	GHG,SO$_2$,NO$_X$,PM abatement technology	Technology selection for global warming, regional air pollution	Country-level or regional-level bottom-up model	~2030	
Impact Assessment	Impact	Impact assessment of climate change	Impact assessment at global scale	Process model based on raster GIS data	~2100	Keeping maintainance and reinforcement ? Anyway, it is necessary to reconfirm the developing policy, to review and to reorganize it.
	Impact[Country]	Impact assessment of climate change	Impact assessment at country scale	Process model based on raster GIS data	~2100	
	Impact[policy]	Integration of mitigation policy evaluation and impact assessment	Investigation of stabilization level and mitigation policy with considering consequent impacts	Calculating global GHGs paths	~2200	Change to multi-regional emission model, improve climate and carbon cycle modules
	Water	Impact assessment	Integrated assessment of water supply and demand focusing on urban area	Coupling process model with and statistics	~2050	Coupling with AIM/GBDB(Global basin database)
	Enduse[Air]	Environmental Assesment	Regional and country scale atmospheric environmental analysis	Atmospheric quality model + GIS	~2050	Coupling with AIM/Enduse[local], for assessing long-range and urban air pollution issues.

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Focusing points

- AR5 new scenario activity
- LCS/APEIS activities
- Others

- Three global climate policy assessment models
  Impact[Policy], Global[CGE], Enduse[Global]
- Two tools for national sustainable study
  Extended Snapshot(ESS), Backcasting Model(BCM)

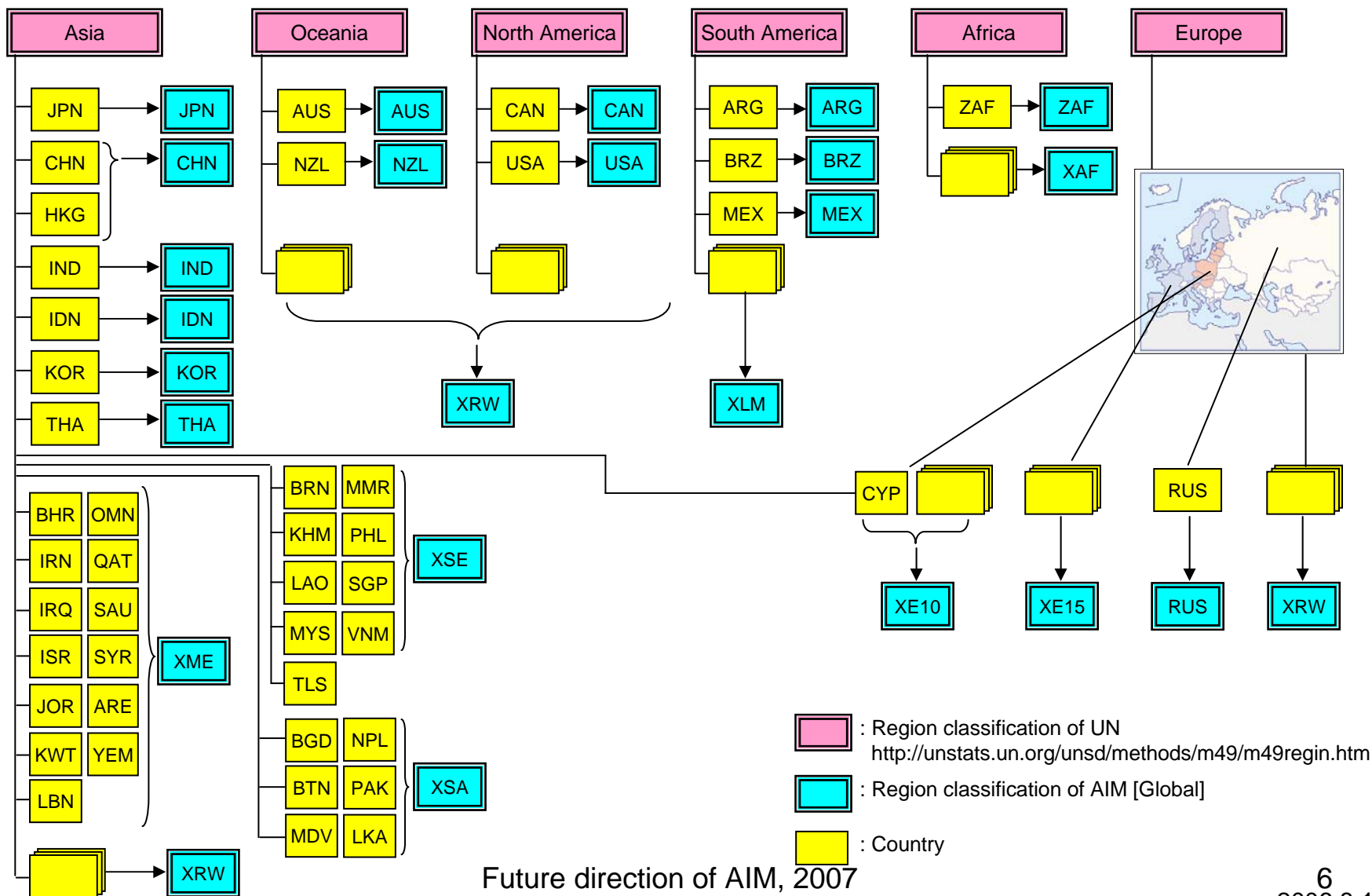# Three global climate policy assessment models
Impact[Policy], Global[CGE], Enduse[Global]

- Impact[Policy]: Calculating <u>long-term global GHGs paths</u> under various climate stabilization targets, main focus is on global characteristics of paths as well as the rough global scale assessment of climate impact/benefit of mitigation

- Global[CGE]: Describing <u>regional details of energy system and economic impacts</u> under global climate policies in this century. Expected as <u>a common platform of AR5 by national teams</u>.

- Enduse[Global]: Describing <u>regional details of mitigation potential and engineering characteristics</u> under various global and national climate policies in the first half of this century

AIM/Impact[Policy]

- Global and Long-term climate-economic-energy integrated model
   multi-regions (< 10), year 2000 to year 2200

- Dynamic global model consisted with;
   Dynamic economic CGE module maximizing social utility
      + Simplified climate module (global surface energy balance model)
      + Carbon cycle module with feedback mechanism
      + Simplified chemical reaction module
      + Climate impact module

- Gases : CO_2, CH_4, N_2O, BC, SO_2, and F gases

- Now, developing mainly by AIM impact group,
   updating with latest climate mechanisms and information

- Immediate refinements: 1)to multi-regional, 2) inclusion of climate
   feedback mechanism, 3) systematic and organized methodology of impact
   assessment.

World regional classification of global AIM activity
(top-down/bottom-up)

Asia
- JPN → JPN
- CHN → CHN
- HKG
- IND → IND
- IDN → IDN
- KOR → KOR
- THA → THA

BHR, OMN, IRN, QAT, IRQ, SAU, ISR, SYR, JOR, ARE, KWT, YEM, LBN → XME

BRN, MMR, KHM, PHL, LAO, SGP, MYS, VNM, TLS → XSE

BGD, NPL, BTN, PAK, MDV, LKA → XSA

(yellow) → XRW

Oceania
- AUS → AUS
- NZL → NZL
- (yellow) → XRW

North America
- CAN → CAN
- USA → USA
- (yellow) → XRW

South America
- ARG → ARG
- BRZ → BRZ
- MEX → MEX
- (yellow) → XLM

Africa
- ZAF → ZAF
- (yellow) → XAF

Europe
- CYP, (yellow) → XE10
- (yellow) → XE15
- RUS → RUS
- (yellow) → XRW

Legend:
- (pink) : Region classification of UN
  http://unstats.un.org/unsd/methods/m49/m49regin.htm
- (cyan) : Region classification of AIM [Global]
- (yellow) : Country

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AIM/Global[CGE]

- Global and Long-term economic model
    23 regions (same as AIM/Enduse[global]), year 2000 to year 2100
- Recursive dynamic multi-regional CGE model
    Implemented on GAMS/MPSGE or GAMS/MCP
    Factor markets: land, labor, and capital
    Product markets: industrial, agricultural, energy
    Production sectors: industry, agriculture, energy
    Final demand sectors: households, governments, investment
    CES/Leontief production function, putty/clay capitals
- Detailed energy resource information
    Fossil fuels (conventional, non-conventional)
    Renewables (hydro, wind, solar, biomass...)
    Nuclear
- Gases : CO_2, CH_4, N_2O, BC, SO_2, and F gases
- Calibration (year 2001) with
    GTAP ver.6 database, IEA energy data, FAOSTAT etc.
- <u>Distributed to AIM members in the next AIM workshop</u>

AIM/Enduse[Global]

- Regional bottom-up type model
  23 regions (same as AIM/Global[CGE]), year 2000 to year 2050
- Regional energy enduse module coupled with
  Regional energy resource module
  International energy, basic materials balance module
  Regional macro-economy and energy service demand module
- Emission sectors (activities)
  Industrial, residential and commercial, transport, agriculture,
  non-agricultural non CO2 emission sectors, F gases
- Systematic reconciliation of base year information among
  stocks of energy devices, energy efficiency, energy services, and
  energy consumption
- Gases: CO_2, CH_4, N_2O, BC, SO_2, and F gases
- Compatibility with national AIM enduse modeling activity
  using same methodology and classification of
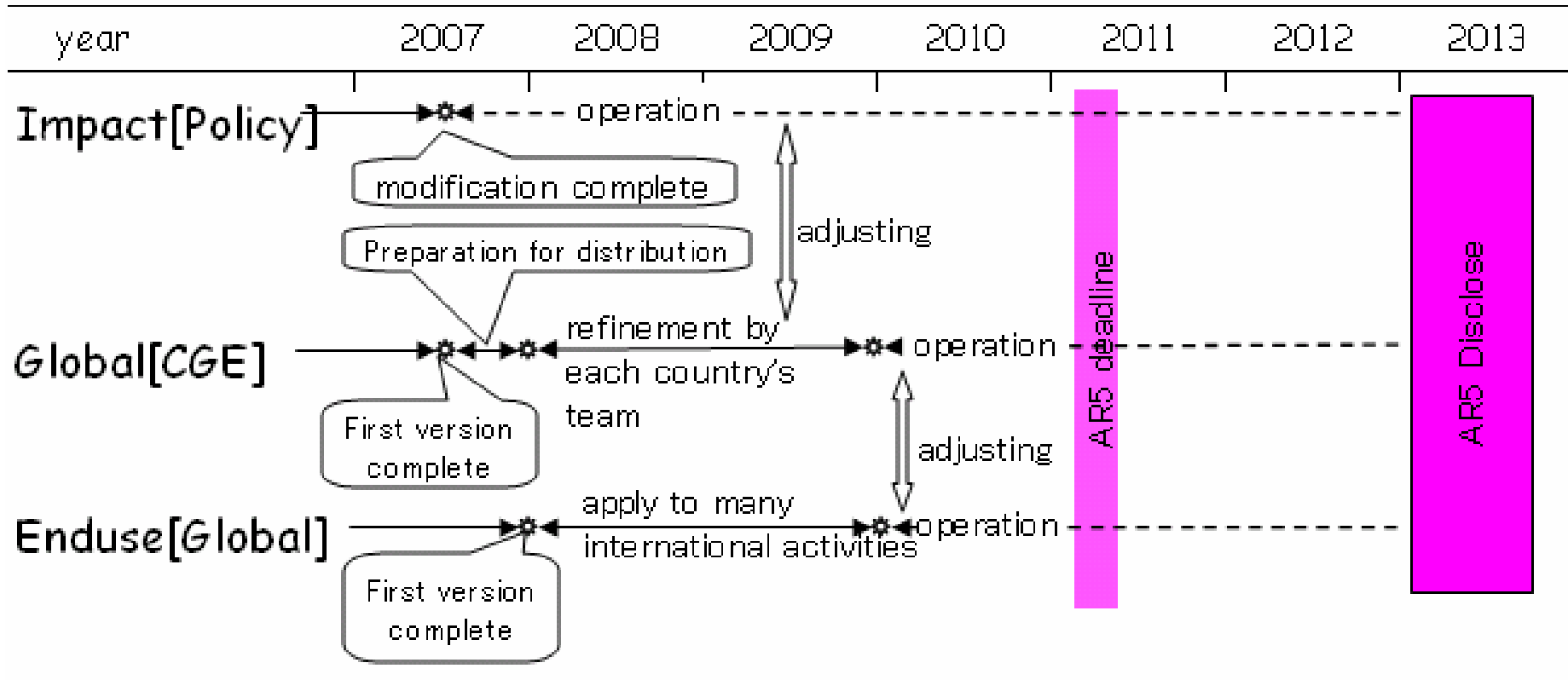 energy/device/service

AIM/Enduse[Global]
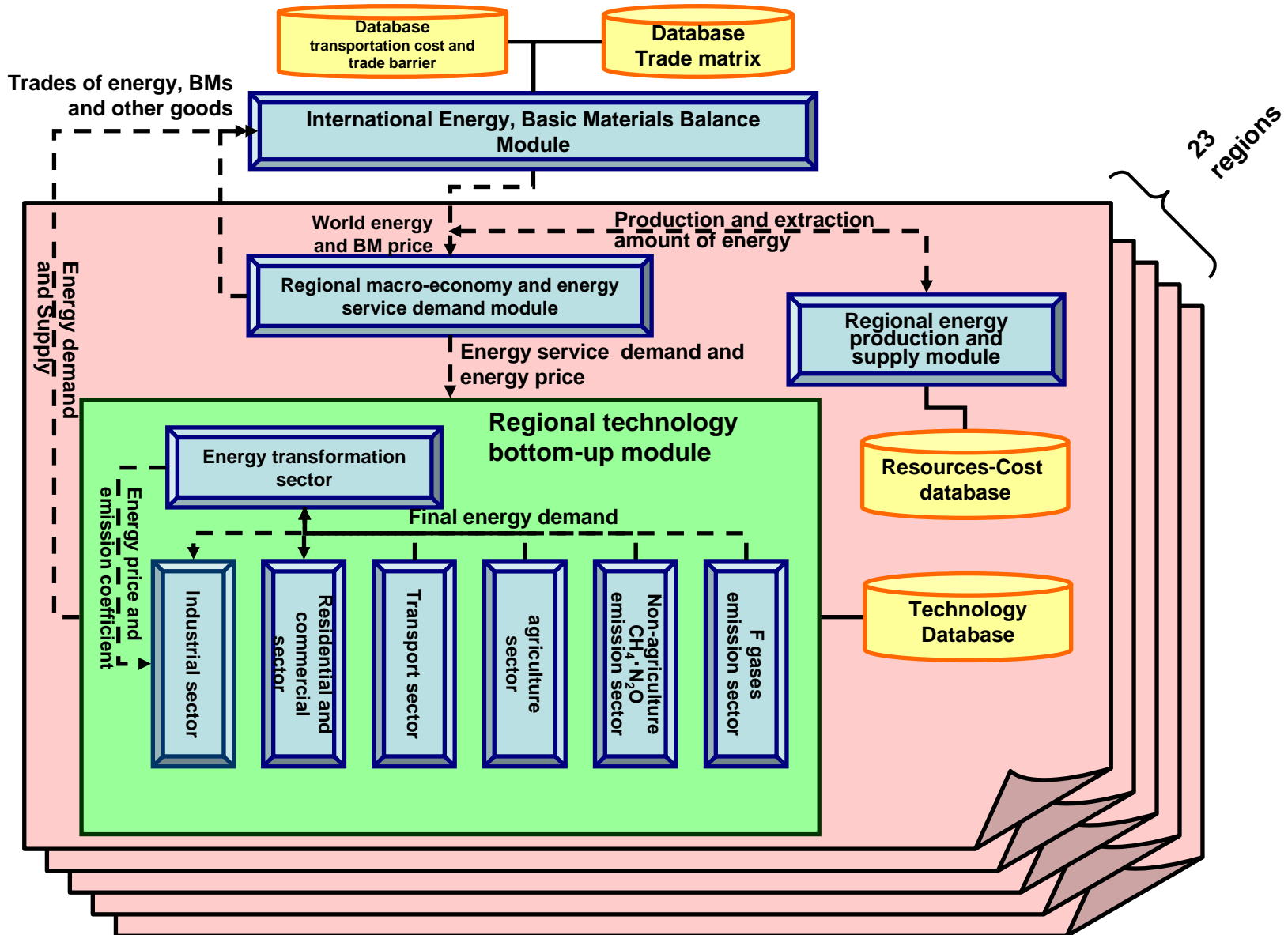
Relation among three global models
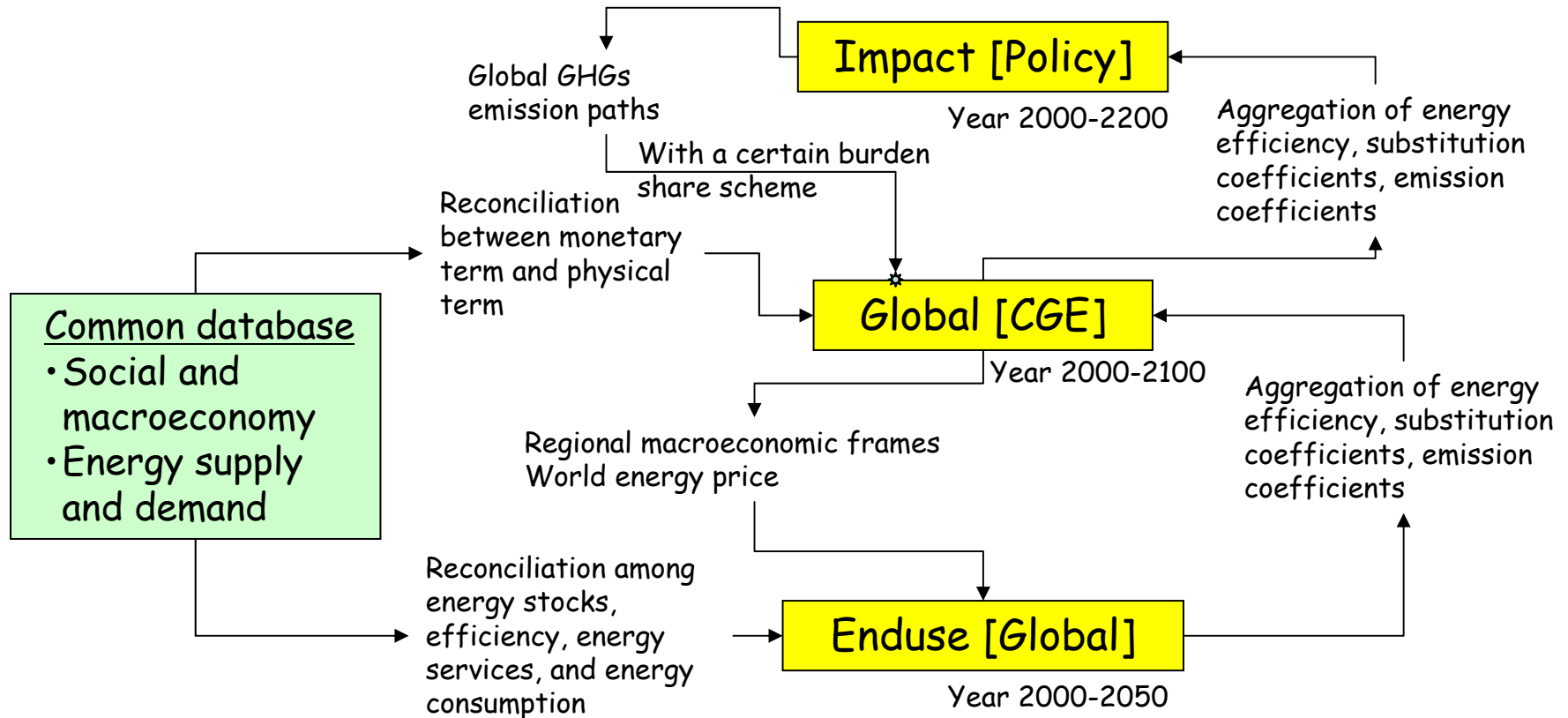
Schedule of global models' development
Impact[Policy], Global[CGE], Enduse[Global]

Tentative schedule of global models' development
Impact[Policy], Global[CGE], Enduse[Global]

- <u>Impact[Policy]:</u>
  Finishing immediate modification, and fully operational by [this summer]

- <u>Global[CGE]:</u>
  First version completed by [this summer]
  Completion of Manuals and documents in [this Autumn]
  Start distribution by [the end of FY2007]

- <u>Enduse[Global]:</u>
  Global version completed by [this Autumn]
  Completion of Manuals and documents by [the end of FY 2007]
  Reviewing the output by AIM international members in [the early period of FY2008]

Models/Tools for national sustainable society study
LCS/APEIS as immediate applications

Element models;
    1) Snapshot models;
       - Quasi steady Computable General Equilibrium (CGE) model
       - Energy technology bottom-up models

       - Energy supply model
       - Household production/lifestyle model
       - Transportation demand model

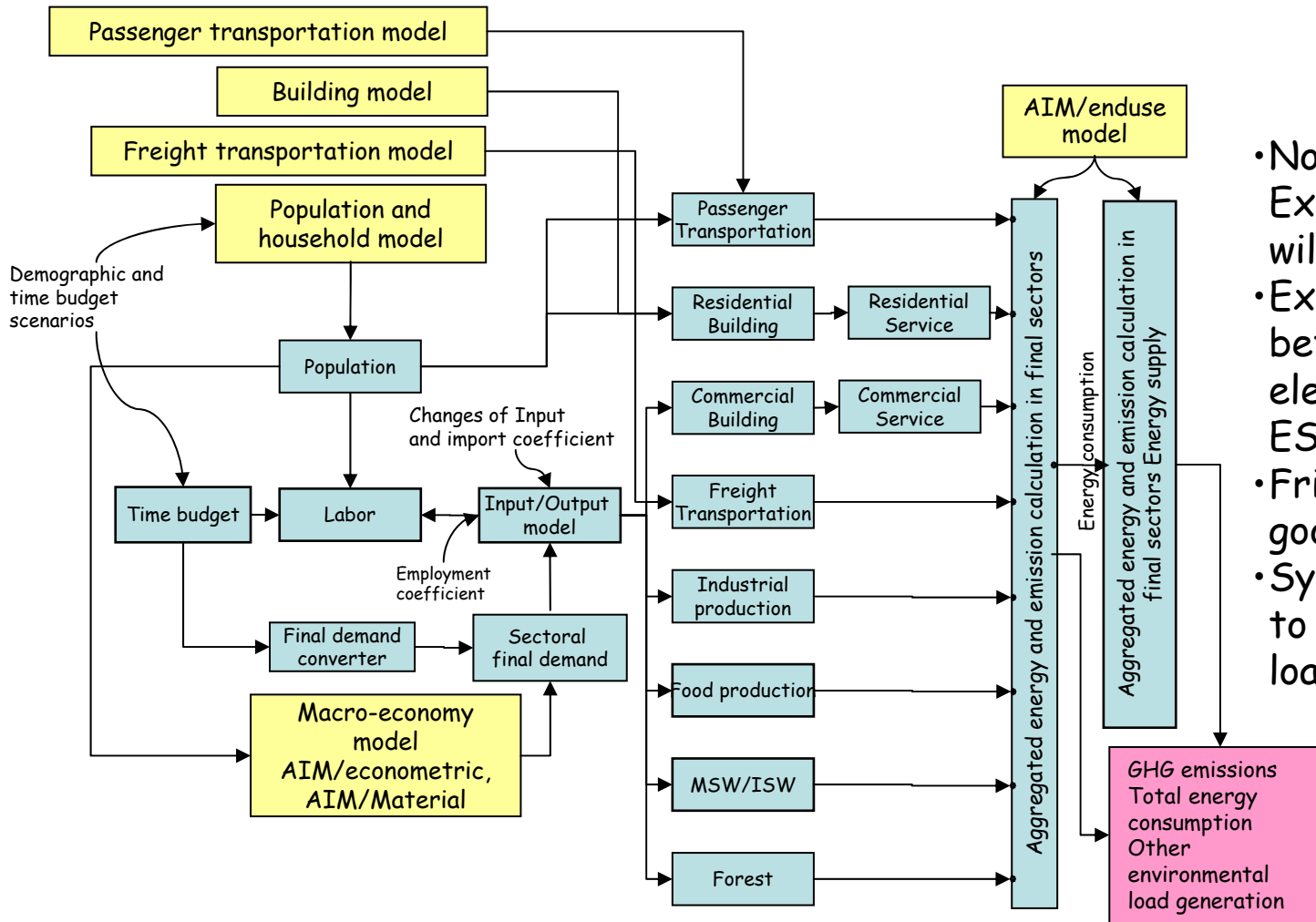   2) Transition models;
       - Population and household model
       - Building dynamics model
       - Econometric type macro-economy model

Integration models (tools);
    Extended Snapshot Tool (ESS)
    Backcasting Model for transient control (BCM)

Extended SnapShot (ESS)

REQUIRED IMPROVEMENT

- Now written with Excel, GAMS version will be also prepared
- Explicit relationship between parameters in element models and ESS
- Friendly interface and good operationality
- Systematic extension to other environmental loads

Diagram labels:

- Passenger transportation model
- Building model
- Freight transportation model
- Population and household model
- Demographic and time budget scenarios
- Population
- Changes of Input and import coefficient
- Time budget
- Labor
- Input/Output model
- Employment coefficient
- Final demand converter
- Sectoral final demand
- Macro-economy model AIM/econometric, AIM/Material
- Passenger Transportation
- Residential Building → Residential Service
- Commercial Building → Commercial Service
- Freight Transportation
- Industrial production
- Food production
- MSW/ISW
- Forest
- AIM/enduse model
- Aggregated energy and emission calculation in final sectors
- Energy consumption
- Aggregated energy and emission calculation in final sectors Energy supply
- GHG emissions Total energy consumption Other environmental load generation

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Element models

Description and quantification of dynamic characteristics and changing mechanism of social / energy services with a bottom-up approach

1. Road maps of Energy technologies, and production / consumption technology progress

2. Transition models
● Population / household dynamic model
● Macro-economic model
● Infrastructure / building dynamic model

3. Snap shot models
● Household production / lifestyle model
● Passenger / freight transportation demand model
● Energy supply and demand balance model
● Energy technology bottom-up model

Backcasting model (BCM)
(multi-sector dynamic optimization model)

- Integrating information of point 1 to 3, as a system of linear equations.

- Identify optimal path of infrastructure and capital investment in order to maximize cumulative social utility (present discounted value, final consumption level and social service level) from 2005 to 2050 under the following constraints:

  ✓ Demand-and-supply balance of goods and services
  ✓ Balance of energy services and energy demand-and-supply
  ✓ Demand-and-supply balance of labor
  ✓ Balance of international payment
  ✓ Balance of infrastructure, buildings, and production capital stock

Object

- Quantify specific measures for required transition control

- Analyze required conditions for trend breaks in each sector, and identify the feasibility of achieving the CO_2 reduction target

REQUIRED IMPROVEMENT

- Explicit relationship between mechanism or parameters in element models and BCM
- Enhancement of feasibility analysis/goal programming module
- Friendly interface and good operationality

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Relations among ESS, BCM, and Element models

Element models

- Macro-economy model
- Population and household model
- Building model
- Passenger transportation model
- Freight transportation model
- Energy supply model
- Material stock dynamics model
- Energy enduse models

Supply transient and dynamic parameters based on more physically realistic mechanisms

Supply social, physical parameters based on more physically realistic mechanisms

Supply target vision quantitatively

Backcasting Model (BCM)
Design roadmaps toward future visions

Extended Snapshot Tool (ESS)
Check and analyze quantitative consistency of future societies

Check and verify the future visions and transient paths from the points of economic reality

Supply values of parameters based on more physically realistic mechanisms

Sequential CGE type model such as AIM/ material

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Tentative schedule of these two tools' development

- <u>Extended Snapshot Tool (ESS)</u> :
  ▪Preparing user and technical manual by [the first half of FY 2007]
  ▪Holding a training workshop in [summer/autumn of FY 2007]
  ▪Reporting outputs in [the next AIM workshop]

- <u>Backcasting Model (BCM)</u> :
  ▪Testing the model within Japan LCS study during the first half of FY 2007]
  ▪Preparing user and technical manual by [the next AIM workshop]
  ▪Start collaborative study with each national team from [FY 2008]