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science for global insight

IIASA's Integrated Assessment Framework:

Modelling approach

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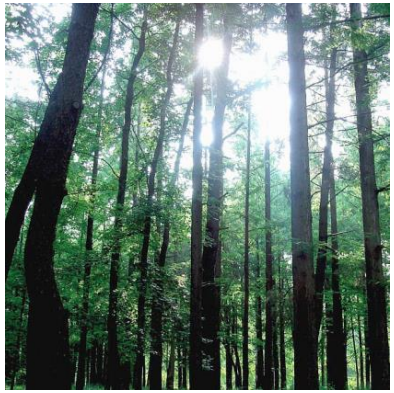
Key (energy) challenges

Energy Access

Energy Security



Land & Food

Climate Change

Water Scarcity

Local Air Pollution

Image sources: NASA, http://www.powernewsnetwork.com/white-house-releases-plan-to-cut-oil-imports-by-13-by-2025/1798/, http://wheresmyamerica.wordpress.com/2007/08/26/i-cant-see-my-america/, http://www.americanprogress.org/issues/green/report/2009/05/14/6142/energy-poverty-101/, http://today.uconn.edu/blog/2010/12/reclaiming-water-a-green-leap-forward/, http://te.wikipedia.org/wiki/%E0%B0%A6%E0%B0%B8%E0%B1%8D%E0%B0%A4%E0%B1%8D%E0%B0%B0%E0%B0%82:Forest_Osaka_Japan.jpg

Integrated Assessment Modelling (IAM)

How to address the challenges?

- Single sector analysis vs. **systems analysis**
- A coherent framework for assessing the impact of climate change – requires **multi-disciplinary** approach
- Understanding sources of uncertainty in **complex systems**: interrelationships between natural and social systems
- Evaluating different **policy options**

IAM ➔ Integrated planning and policy formulation with full appreciation of nexus issues

The 2030 Agenda for Sustainable Development

New field for IAM research and applications

IAM and SDGs

SDGs are not independent of each other

- **Synergies (win-win configurations)**
- **Trade offs – implementation of one SDG at the detriment of other SDG(s)**

Integrated policy-making:

- **Accounting for interdependences between dimensions and sectors**

IAM: integrated approaches for promoting most of the dimensions of sustainable development (SDGs) in a balanced manner: <u>one of the key principles</u> of the 2030 agenda

Integrated Assessment Models (IAM): Nutshell

- Cross-sectoral and interdisciplinary
- A coherent framework for different type of information- climate, economics, ecology, health, technology, etc.
- Geographical coverage is global– temporal scope is long-term
- Highly data and assumption intensive
- IAMs provide insights not answers
- IAMs are instrumental in facilitating the science-policy interface

IIASA's Integrated Assessment Model:

MESSAGEix

MESSAGEix

- MESSAGE developed at IIASA (Austria) since 1982
- International Atomic Energy Agency (IAEA) has adapted and distributed the model for capacity building and energy planning
- Policy analysis, electricity sector expansion, optimal supply mix, scenario development, energy-environment-economy analyses, NDCs, etc.
- Geographical scope: User defined
- Sectors: All energy relevant economic sectors (supply & demand)
- Methodology/solution structure: Usually dynamic linear programming (LP) energy-engineering model
- Level of foresight: Perfect foresight; myopic mode possible
- Complexity: Flexible – depending on problem formulation

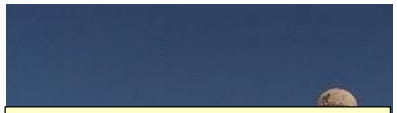
IIASA Integrated Assessment Framework

Macro-economy
MACRO

Consumer vehicle choice
TRANSPORT

Income Distribution Projections
-
Fuel choice model
Access

Energy Access



Energy++ system (including all GHGs and energy sector)
MESSAGE

Spatially explicit forest management
G4M

Integrated agricultural, bioenergy and forestry
GLOBIOM

Land & Food

Long-term climate pathways
MAGICC

Climate Change

Hydro-economy
WAT

GHG & air pollution mitigation
GAINS

Local Air Pollution

IIASA Integrated Assessment Framework

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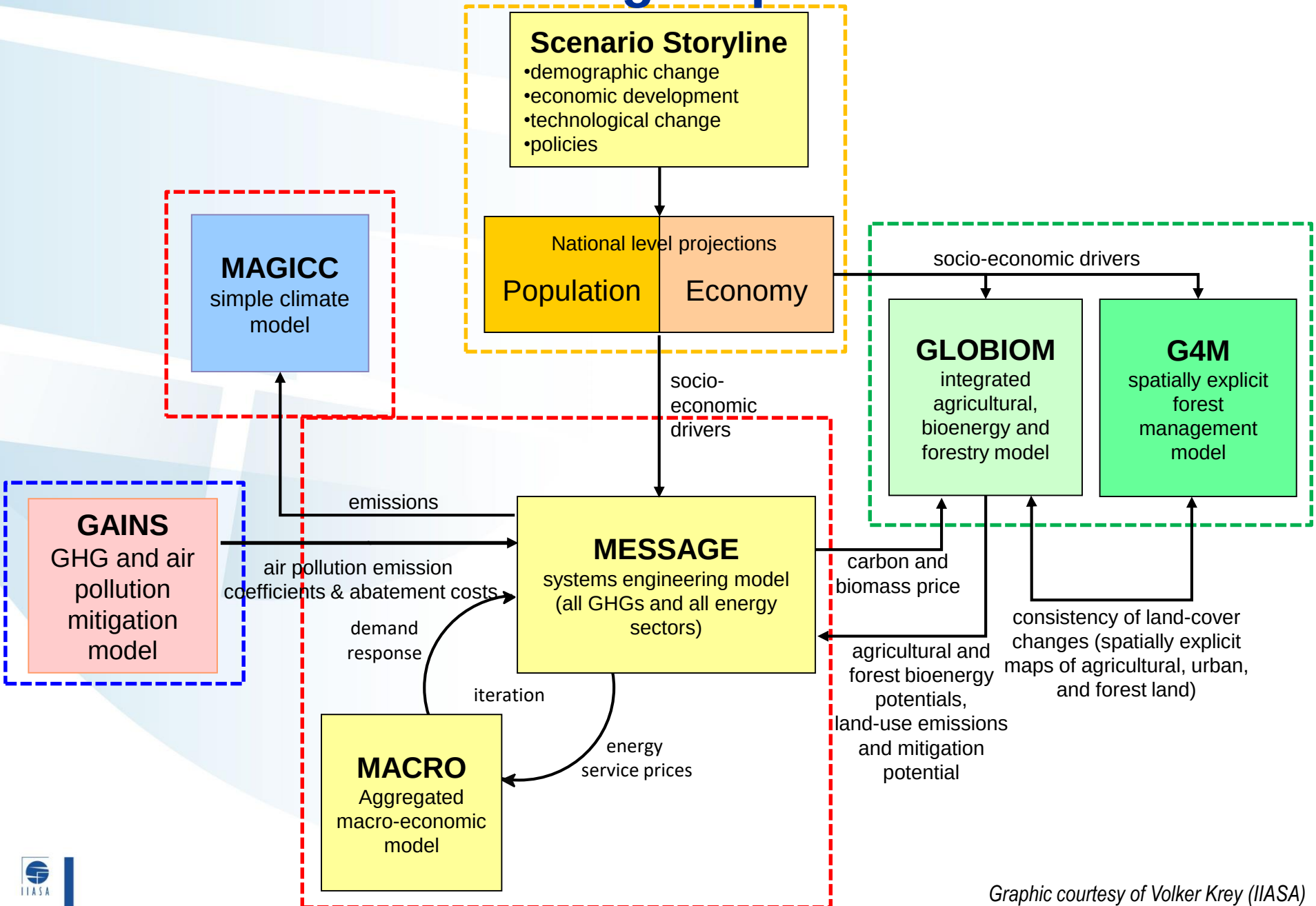
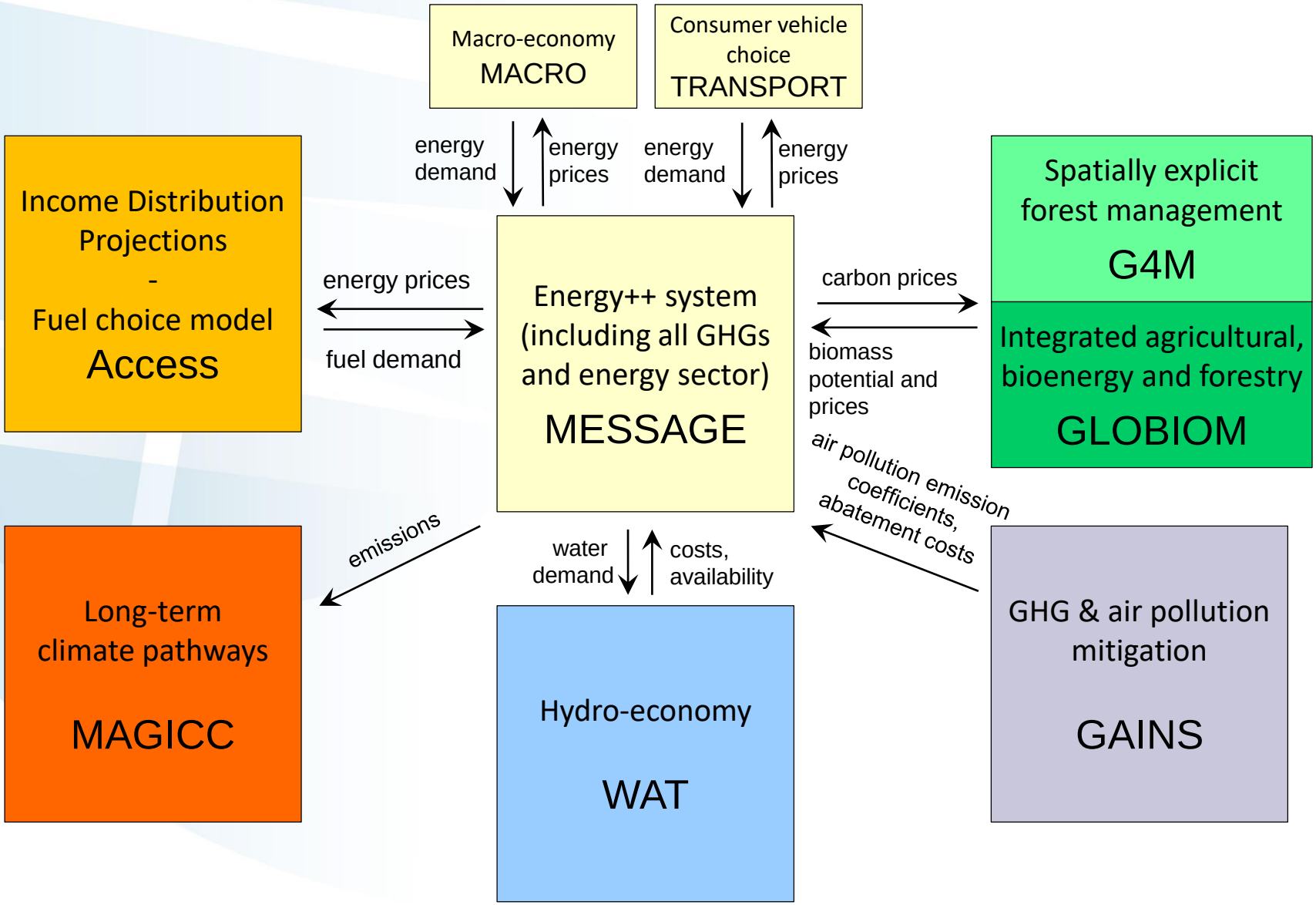
MESSAGE: modelling steps



Graphic courtesy of Volker Krey (IIASA)

IIASA Integrated Assessment Framework



Input Data and Cost Estimations

- Historical energy balances: mainly IEA Statistics
- Vintage capacity of power plants, cooling technologies, planned capacities
- Renewable energy resource potentials (hydro, biomass, wind and solar)
- Fossil energy resources

- IIASA's Global Energy Assessment (GEA) model

- Cost estimation of technologies over time (extraction, conversion, transfer, etc.)

Model adjustments for the Pathways Project

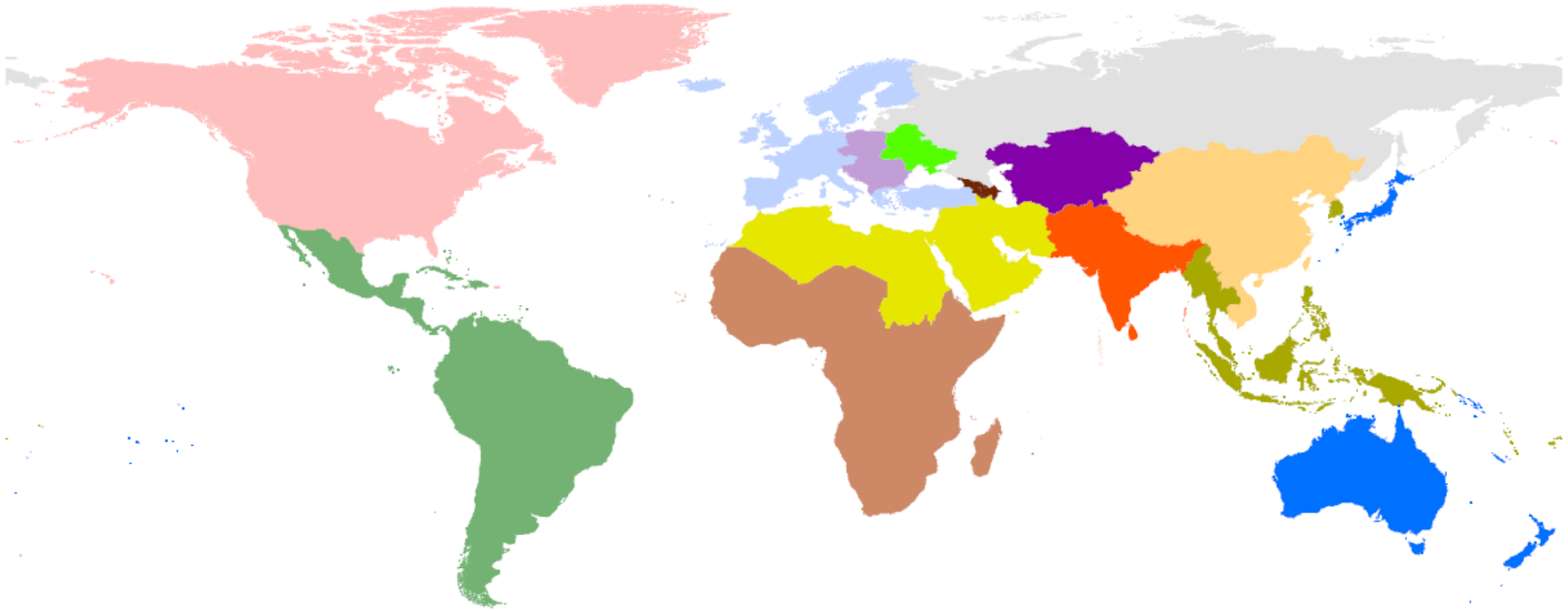
- Regional resolution
- SSP2 trends/philosophy introduced for the new regions (MESSAGE and MACRO)
- Base year updated to 2015
- Introduction of 5 year time steps
- Update of energy resources of UNECE regions (remaining regions to follow)
- Energy trade adjustments
- Introduction of nationally determined contributions (NDCs)
- MACRO regions revised - now consistent with new MESSAGE regions
- Note: New regional resolution only implemented for MESSAGE and MACRO – not the full suite if IAM models

MESSAGE

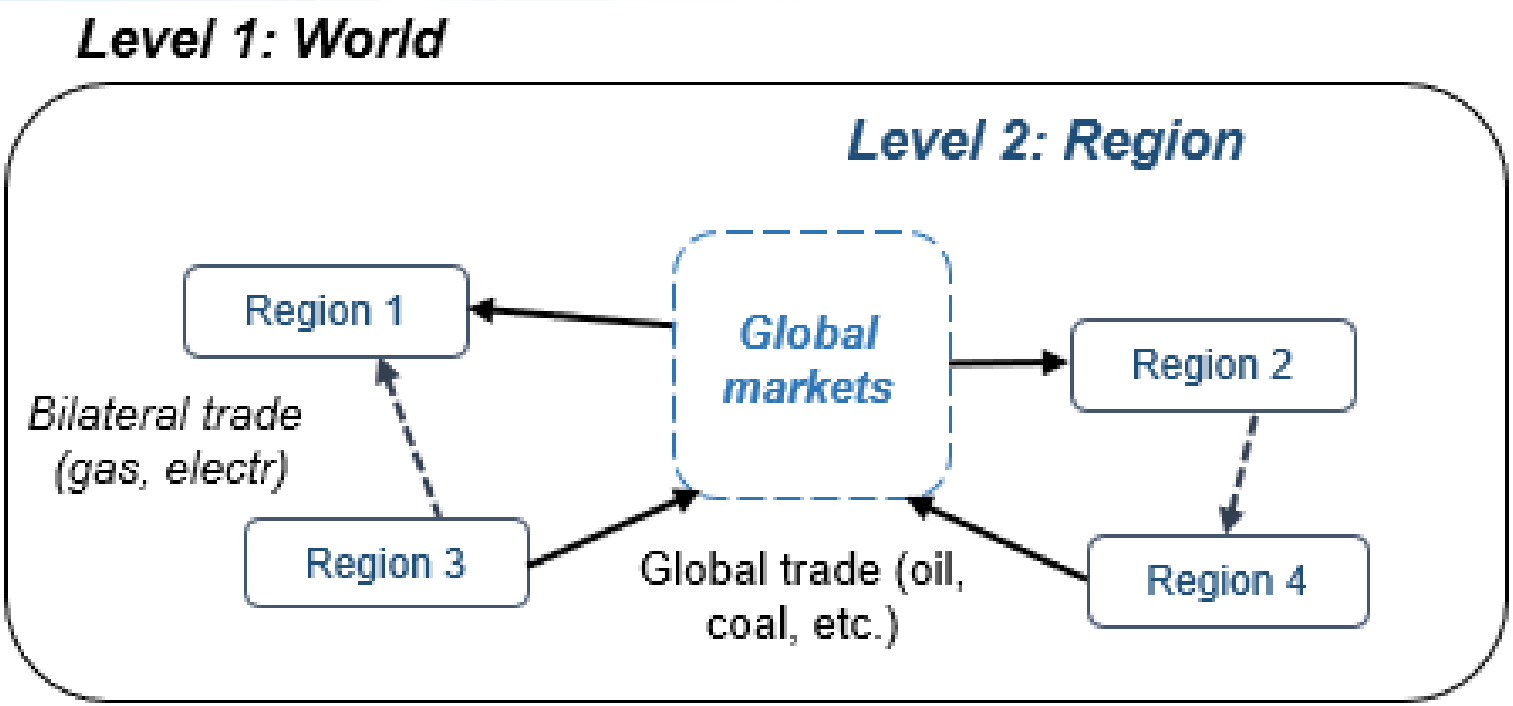
Regions modelled

ENERGY

AFR	Sub-Saharan Africa	LAC	Latin America and the Caribbean	RUS	Russian Federation
BMU	Belarus, Moldova, Ukraine	MEA	Middle East and North Africa	SAS	South Asia
CAS	Central Asia	NAM	North America	SCS	South Caucasus
CPA	Centrally planned Asia & China	PAO	Pacific OECD	WEU	Western Europe
EEU	Central and Eastern Europe	PAS	Other Pacific Asia		



MESSAGE$_{ix}$ Inter-regional trade



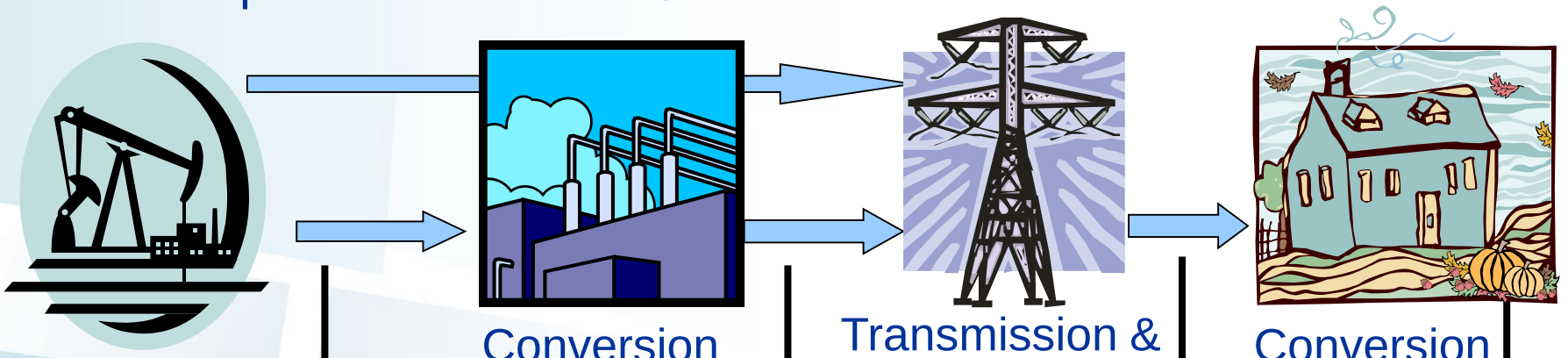
MESSAGE$_{ix}$ Energy System

Oil extraction
Coal import

Power plant
Refinery

T&D Network

Consumer



Conversion

Transmission &
Distribution

Conversion

PRIMARY

- crude oil
- natural gas
- coal
- uranium
- water
- wind
-

SECONDARY

- diesel
- kerosene
- gas
- electricity
- coal
- heat
-

FINAL

- diesel
- kerosene
- gas
- electricity
- coal
- heat
-

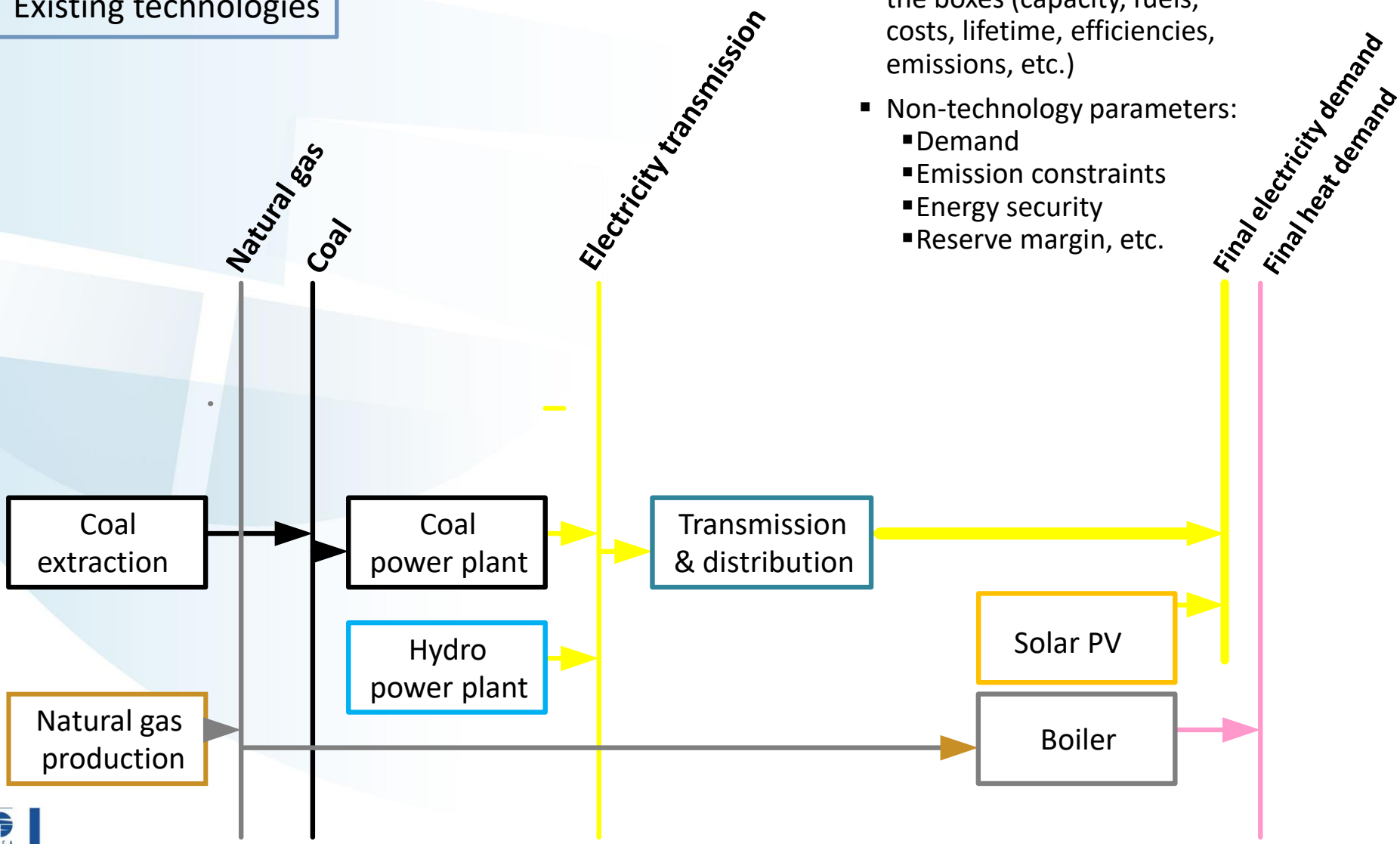
USEFUL

- heat
- light
- mechanical energy

A more discernable view

Existing technologies

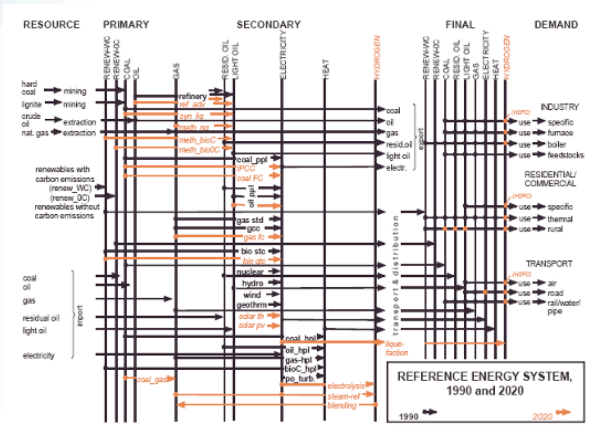
- Most parameters are assigned to technologies – the boxes (capacity, fuels, costs, lifetime, efficiencies, emissions, etc.)
- Non-technology parameters:
  - Demand
  - Emission constraints
  - Energy security
  - Reserve margin, etc.



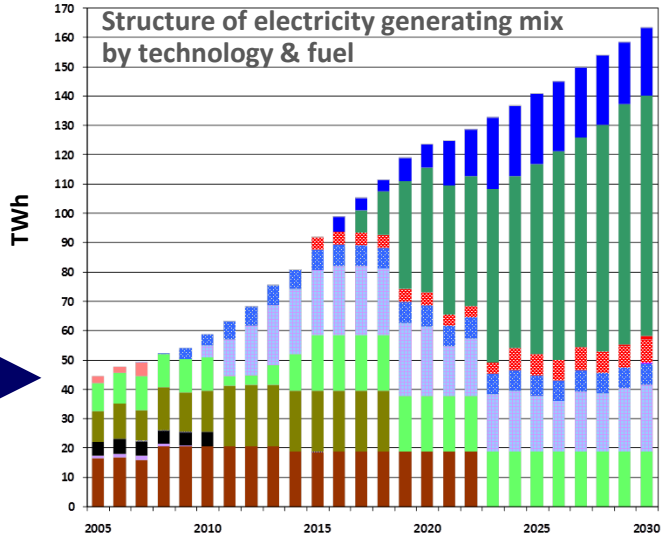
MESSAGE: Model for Energy Supply System Alternatives and their General Environmental Impacts

INPUT

- Energy system structure (including vintage of plant and equipment)
- Base year energy flows and prices
- Energy demand via link to MACRO
- Technology and resource options & their techno-economic performance profiles
- Technical and policy constraints



OUTPUT

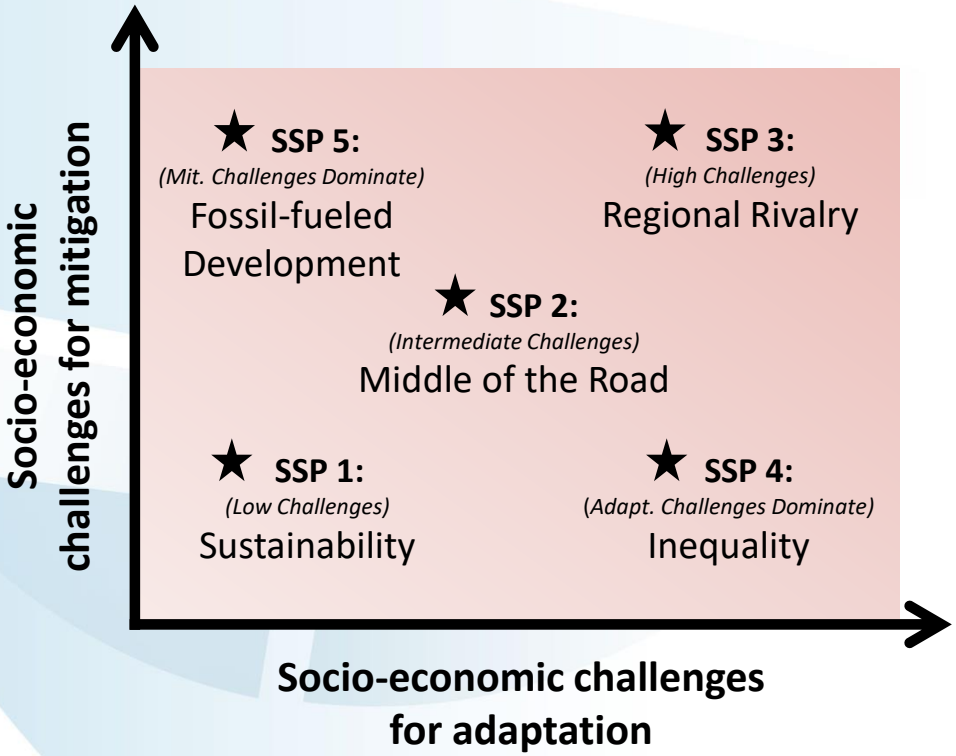


- Primary and final energy mix
- Electricity generating mix, capacity expansion/retirement, investments
- GHG missions, air pollution, wastes
- Health and environmental impacts - via link to GAINS and LCA module
- Resource use - energy, water, land (via link to GLOBIOM), materials
- Trade & import dependence
- Prices

Summary

- Some methodological adjustments may become necessary along the way with adequate mathematical representation of signposts or adaptive policy pathways (low probability)
- Following scenario activities provide the point of departure
  - No policy (climate or SDG related)
  - Implementation of NDCs
  - A global carbon budget consistent with a max 2^{o}C limit
  - Assessing different policy pathways for reaching climate and SDG targets
  - Analysis of the agreed metrics and performance targets
  - Iteration
- Based on the plausibility of the results obtained from these three scenarios, additional scenarios may be designs pending on available resources

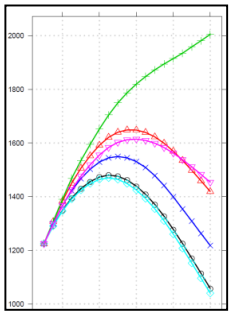
Shared Socioeconomic Pathways (SSPs)



Narrative

Qualitative description of broad patterns of development

Logic relating elements of narrative to each other



Quantitative elements

National:

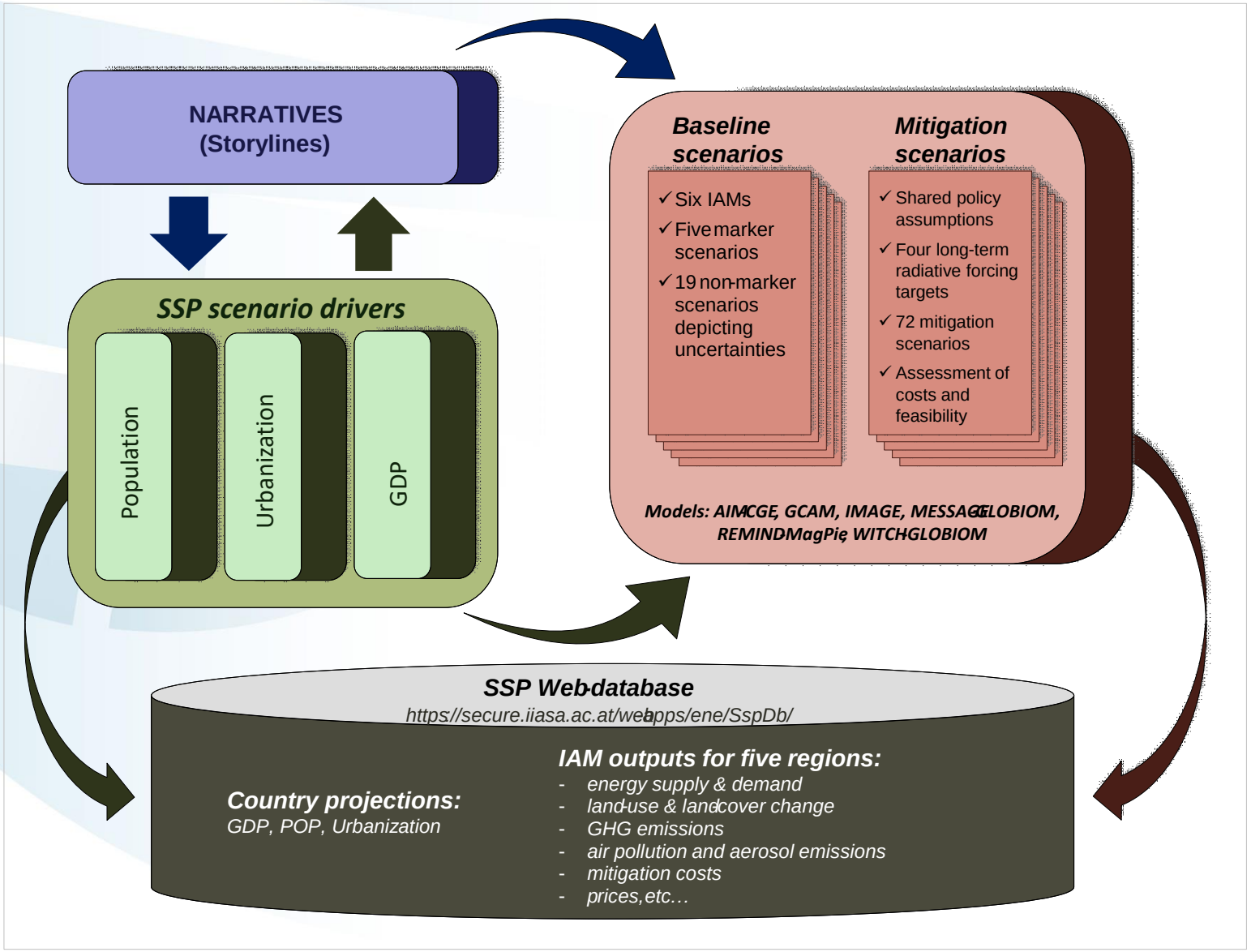
- Population
- Education
- Urbanization
- GDP
- Technology

SSP narratives, quantitative elements: **2017 special issue of *Global Environmental Change***.
SSP Database, hosted by IIASA.

Reference SSP Scenarios

- Well established in the IAM and climate change communities
- Consistent with the Representative Concentration Pathways (RCPs) – SSPs substitute for the key driving forces of future GHG emissions used by RCPs
- No need to add yet another set of scenarios
- Five SSPs cover a wide range of futures
- Six IA modeling teams – different methodologies, geographical resolutions, energy system representation, IAM linkages and features
- One representative Marker Scenario for each SSP
- For each SSP multiple IAM runs exploring uncertainty ranges

Illustration of SSP development



Source: Riahi et al., 2016

The Scenario Matrix Architecture

Challenge to mitigation

Challenge to adaptation

SSP5: Fossil fueled development

- Rapid economic growth, free trade fueled by carbon-intensive fuels
- High technology development
- Low regard for gobal environment and SDGs
- Technology fixes Low population and high mobility

Markets first

Clash of civilisations

SSP3: Regional rivalry

- Competition among regions
- Low technology development
- Environment and social goals not a priority
- Focus on domestic resources
- High population growth
- Slow economic growth dev. countries

SSP2: Middle of the Road

SSP1: Sustainability

- Global cooperation
- Rapid technology dev.
- Strong env. policy
- Low population growth
- Declining inequity
- Focus on renewables & efficiency
- Dietary shifts
- Forest protection

UN world

Have's and have not's

SSP4: Inequality

- Inequality across and within regions
- Social cohesion degrades
- Low technology development
- Environment priority for the few affluent
- Limited trade

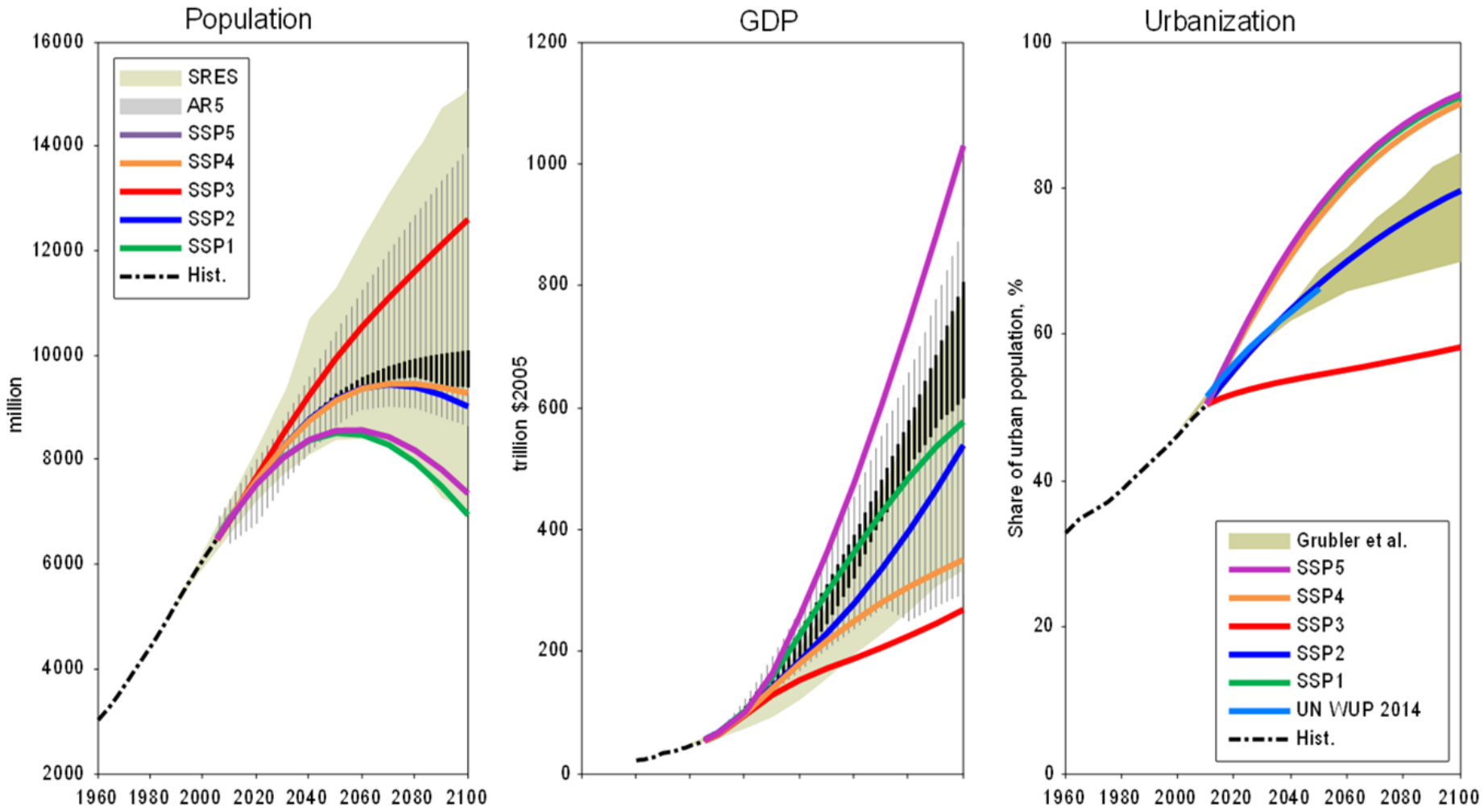
SSP2: Middle of the road

Social, economic, and technological trends proceed along historical patterns

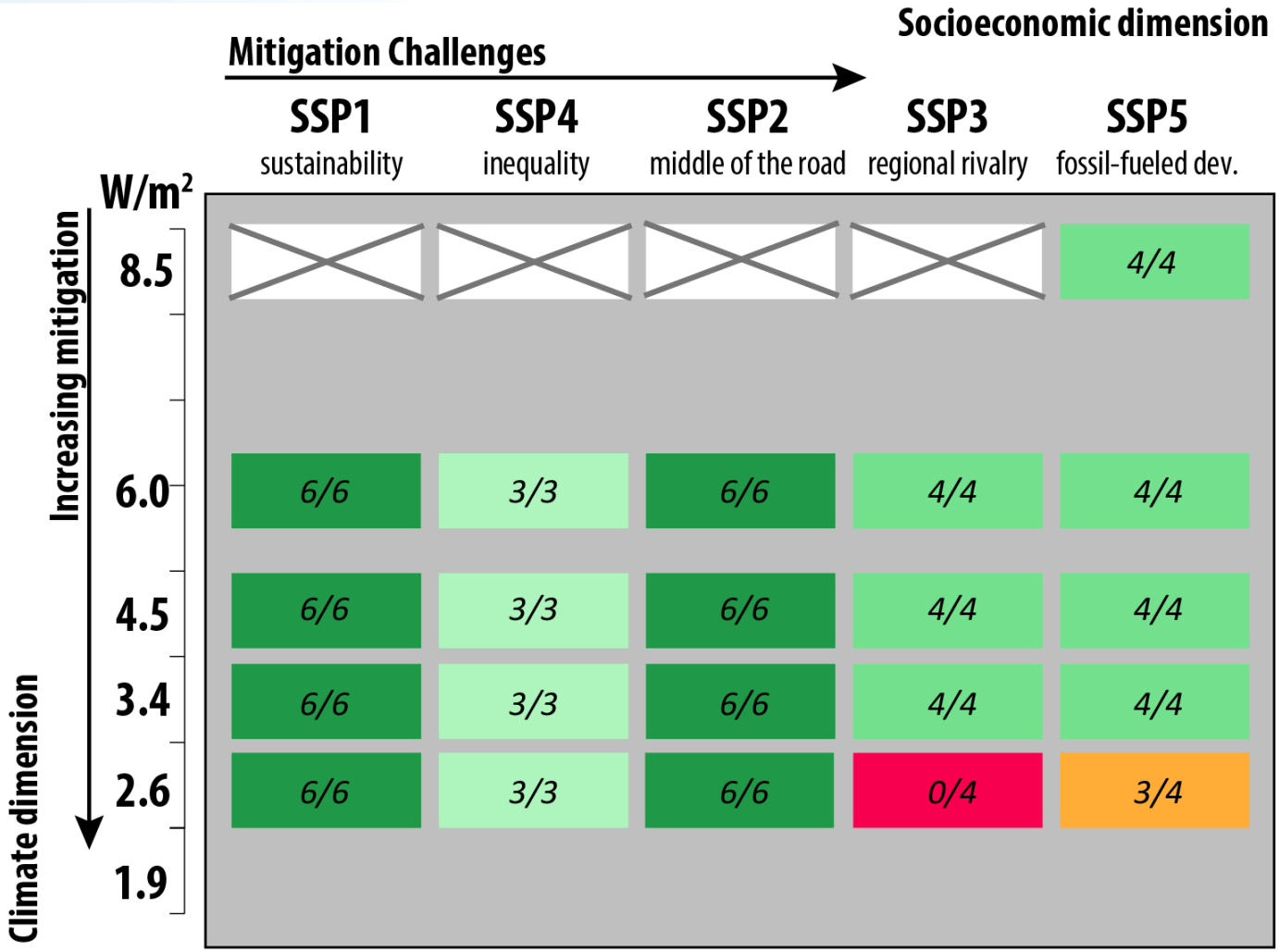
- Development and income growth proceed unevenly
- Slow progress on reaching sustainable development goals
- Technological developments proceed without breakthrough
- Environmental systems experience degradation
- Fossil fuel dependency decreases slowly
  - no reluctance to use unconventional fossil resources
- Moderate population
- Income inequality persists or improves slowly

Source: Adapted from B. van Ruijven (2015); K. Riahi (2017); and O'Neil (2017)

Illustrative SSP ranges



The SSP-RCP scenario Matrix



Riahi et al, 2017

Why integrated assessment?

- Single sector analysis, planning and decision making/policy formulation
- Systems analysis, planning and decision making/policy formulation
- Starting in the early 1970s it became obvious that sector (silo) policy making only is dated:
  - Energy security
  - Local and regional air pollution
  - Climate change (IPCC assessments)
- Coherent framework for organizing and assessing knowledge about climate cha