International Institute for Applied Systems Analysis
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science for global insight

IIASA's Integrated Assessment Framework and its application for the Pathways Project: Modelling approach

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Why integrated assessments?

- It's nothing new that almost everything depends on everything else
- 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 change – requires multi-disciplinary approach
- Uncertainty – which ones are most important
  - Complex interrelationships between natural and social factors driving climate change
  - Interactions between natural and social systems
- Differentiation among policy options
  - Carbon tax
  - Carbon budgets
  - Establishing property rights to pollution through cap and trade systems
- Integrated 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)

To overcome silo-based institutional structures and face the reality of interlinkages between SDGs/sectors

Integrated policy-making:

- Accounting for interdependences between dimensions and sectors

IAMs support integrated approaches to promoting all the dimensions of sustainable development (SDGs) in a balanced manner which is <u>one of the key principles</u> of the 2030 agenda

Integrated assessment models (IAM)

- Cross-sectoral and interdisciplinary
- Integrates different types of information - climate, economics, ecology, health, technology, etc. in a coherent framework
- Highly complex methodological constructs
- IAMs differ in their level of detail and the complexity and interconnections they consider
- Geographical scope is global (aggregate world regions) – temporal scope is long-term (at least decades)
- Highly assumption intensive, especially about consumer preferences or life style changes
- IAMs provide insights not answers
- IAMs are instrumental in facilitating the science-policy interface

Key (energy) challenges

Energy Access

Energy Security

Land & Food

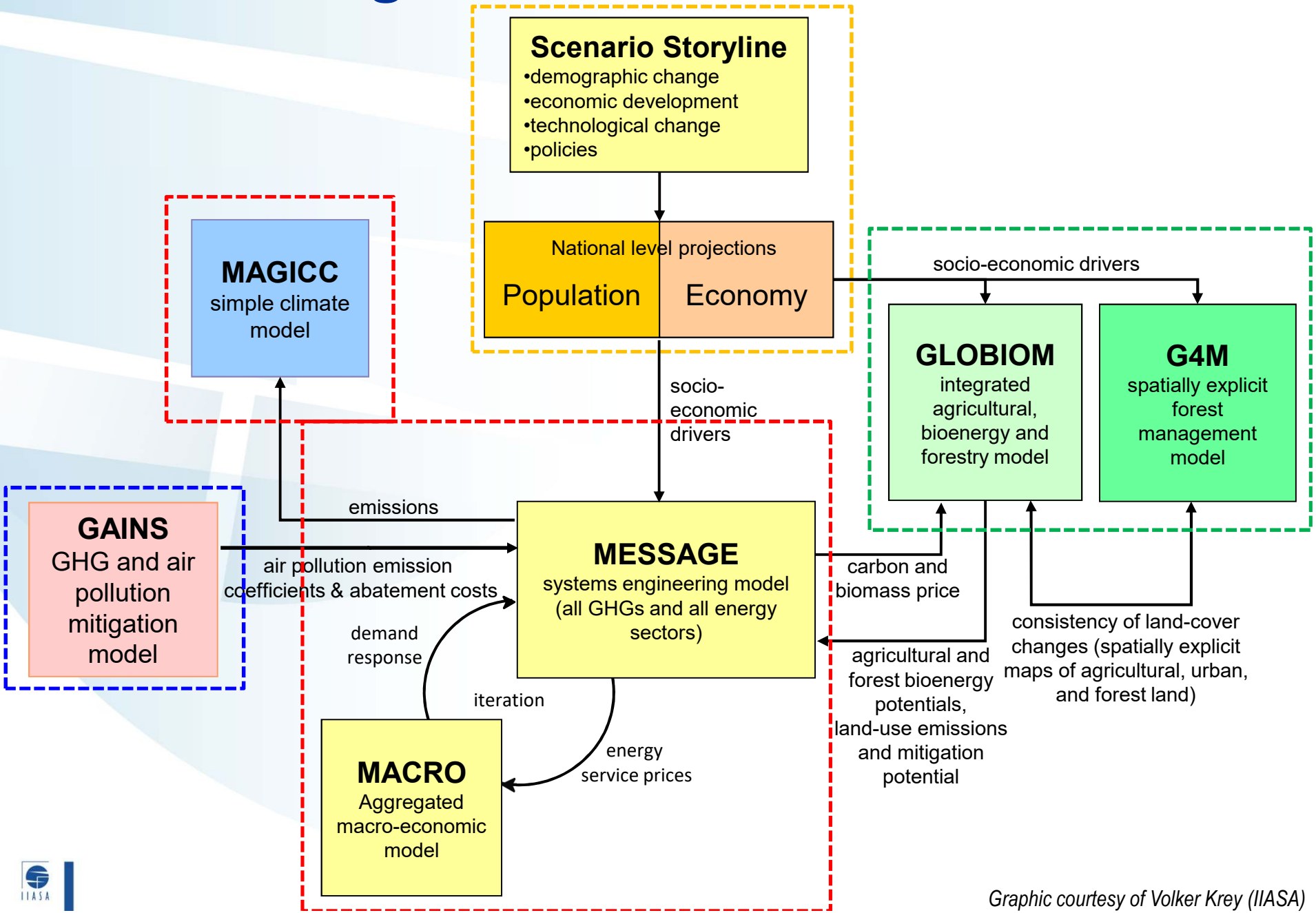
Climate Change

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

IIASA Integrated Assessment Framework



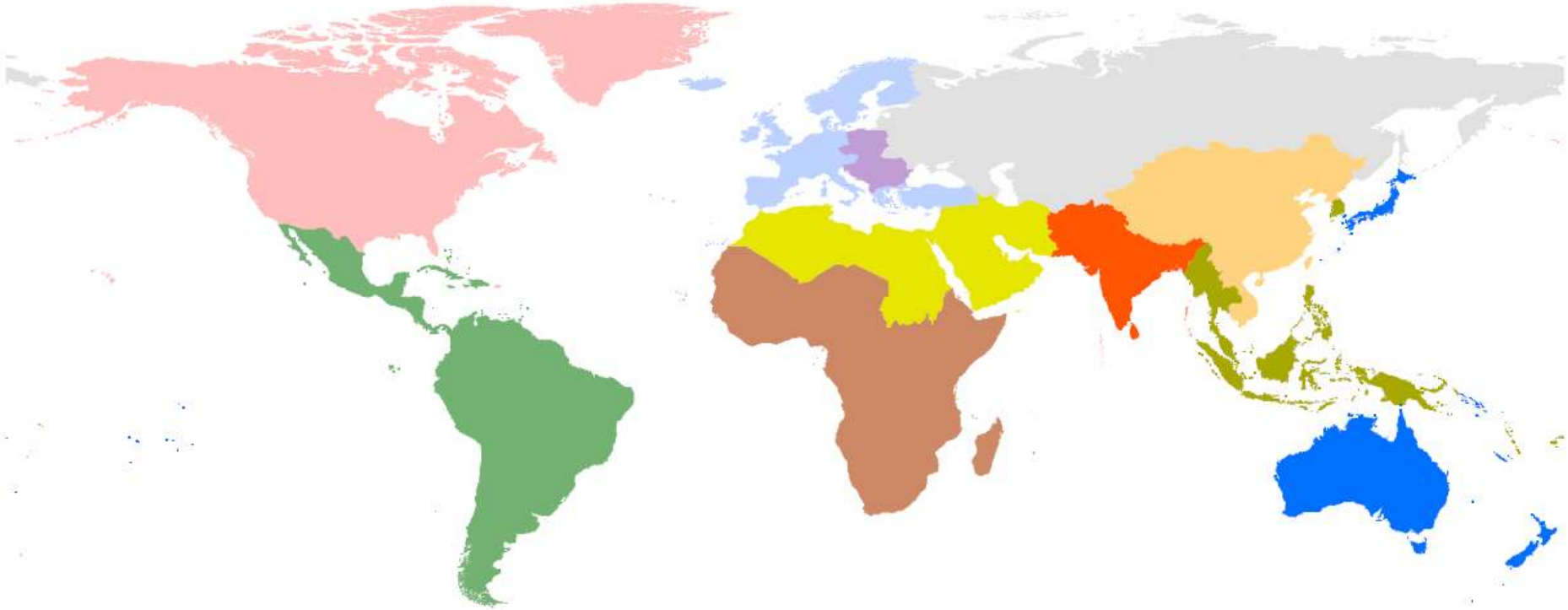
Graphic courtesy of Volker Krey (IIASA)

MESSAGE$_{ix}$

- *Background*: MESSAGE originated at IIASA (Austria) where the model has been continuously advanced – the International Atomic Energy Agency (IAEA) has adapted and distributed the model for capacity building and energy planning applications in IAEA Member States.
- *Purpose:* Policy analysis, electricity sector expansion, optimal supply mix, scenario development, short-medium-and long-term; energy-environment-economy analyses, NDCs, etc.
- *Geographical scope:* User defined
- *Temporal scope:* Used defined
- *Sectors:* All energy relevant economic sectors (supply & demand)
- *Methodology/solution structure:* Combination of dynamic linear programming (LP) energy-engineering model (mixed integer)
- *Level of foresight in decisions:* Perfect foresight; myopic mode possible
- *Complexity:* Flexible – depending on problem formulation
- *Capacity building & training:* IAEA Technical Cooperation (more recently also IIASA, IRENA, ADB and others)

MESSAGE$_{ix}$ Regions

REGION			
NAM	PAO	SAS	AFR
LAM	EEU	PAS	FSU
WEU	MEA	CPA	

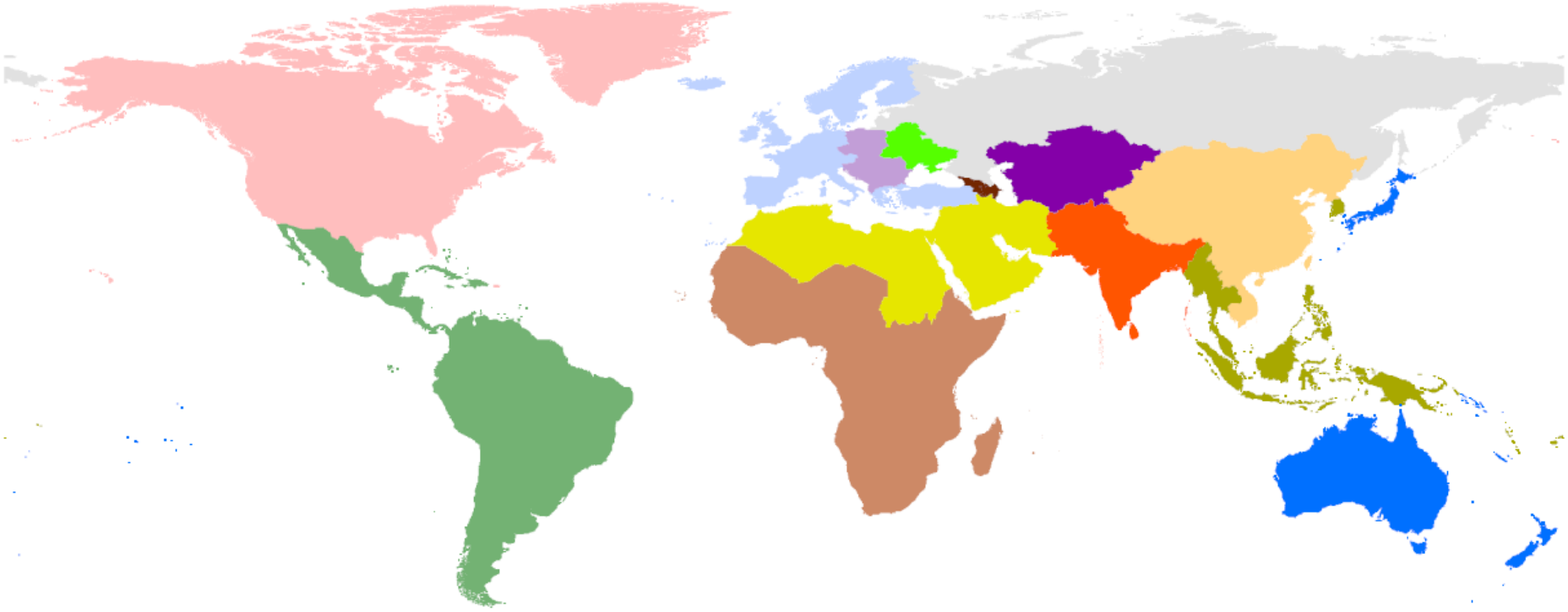


Model adjustments for the Pathways Project

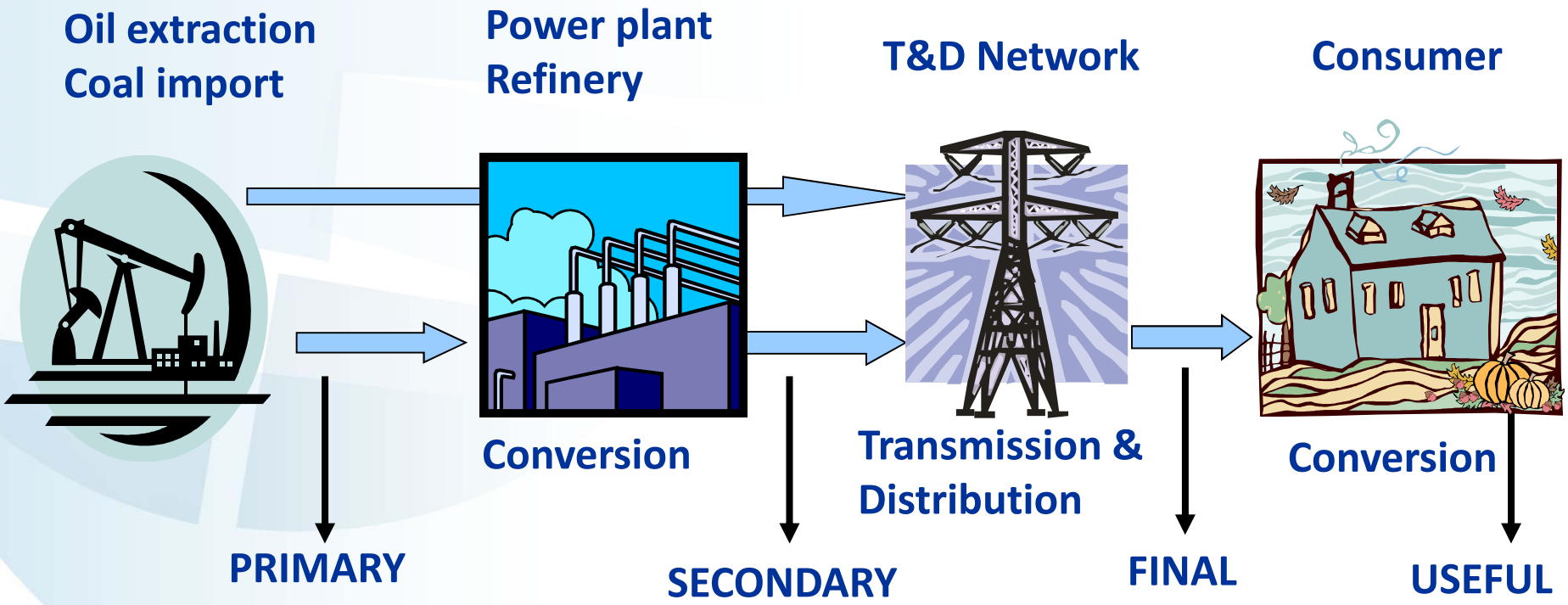
- Regional resolution
- SSP2 trends/philosophy introduced for the new regions (MESSAGE and MACRO)
- Base year updated to 2015
- Introduction of 5 year time steps
- Update of energy resources of UNECE regions (remaining regions to follow)
- Energy trade adjustments
- Introduction of nationally determined 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$_{ix}$ Regions – new 14 regions

REGION				
NAM	PAO	SAS	AFR	CAS
LAM	EEU	PAS	RUS	SCS
WEU	MEA	CPA	UBM	



Modelling with a Quantitative Approach



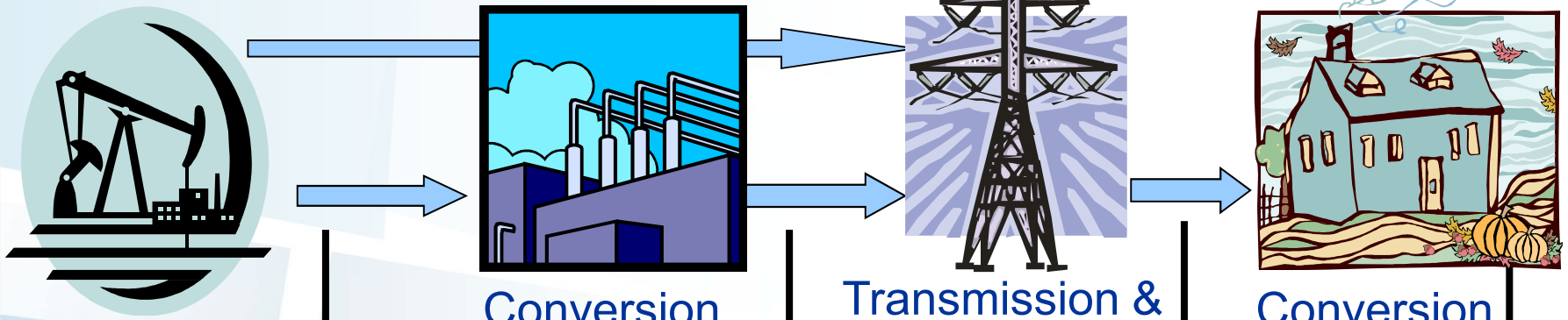
MESSAGE$_{ix}$ Energy System

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
-

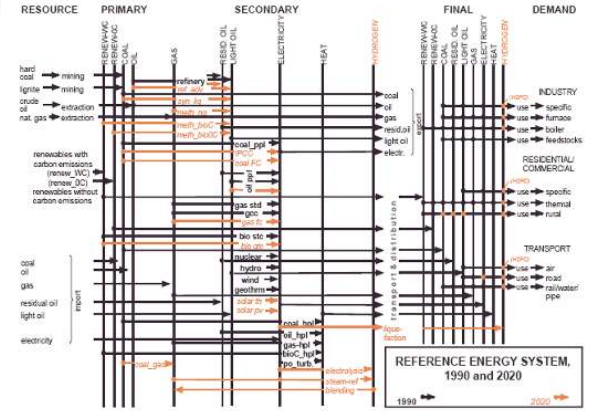
USEFUL

- heat
- light
- mechanical energy

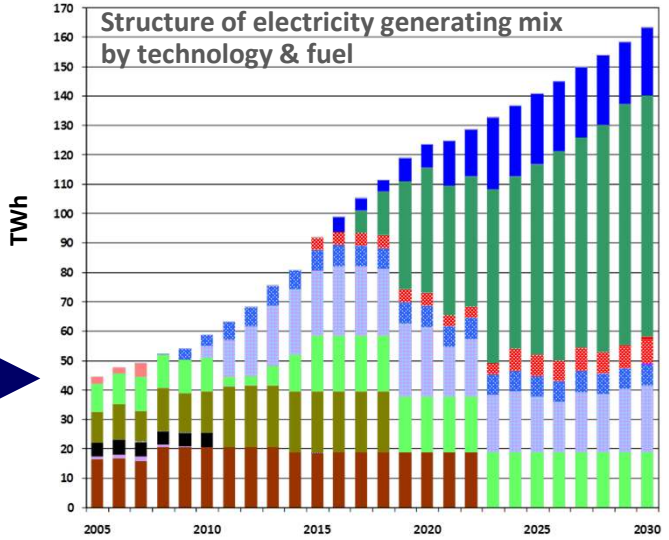
MESSAGE: Model for Energy Supply System Alternatives and their General Environmental Impacts

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

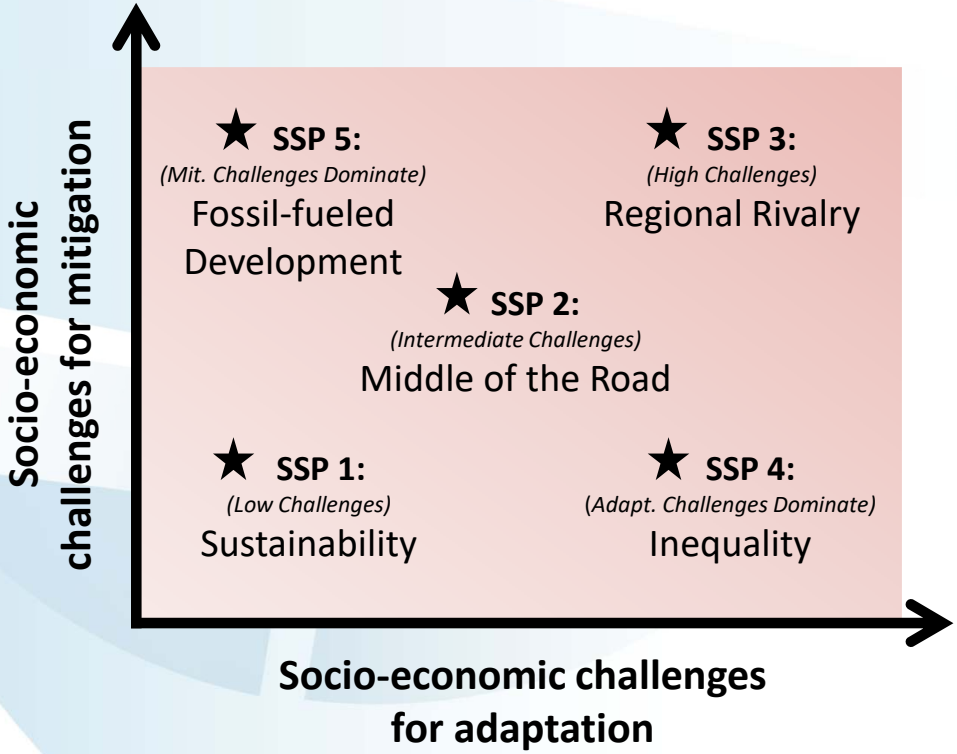


OUTPUT



- 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

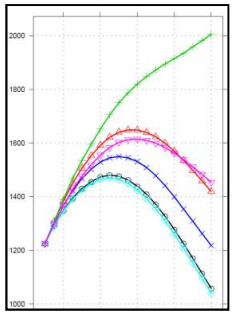
Shared Socioeconomic Pathways (SSPs)



Narrative

Qualitative description of broad patterns of development

Logic relating elements of narrative to each other



Quantitative elements

National:

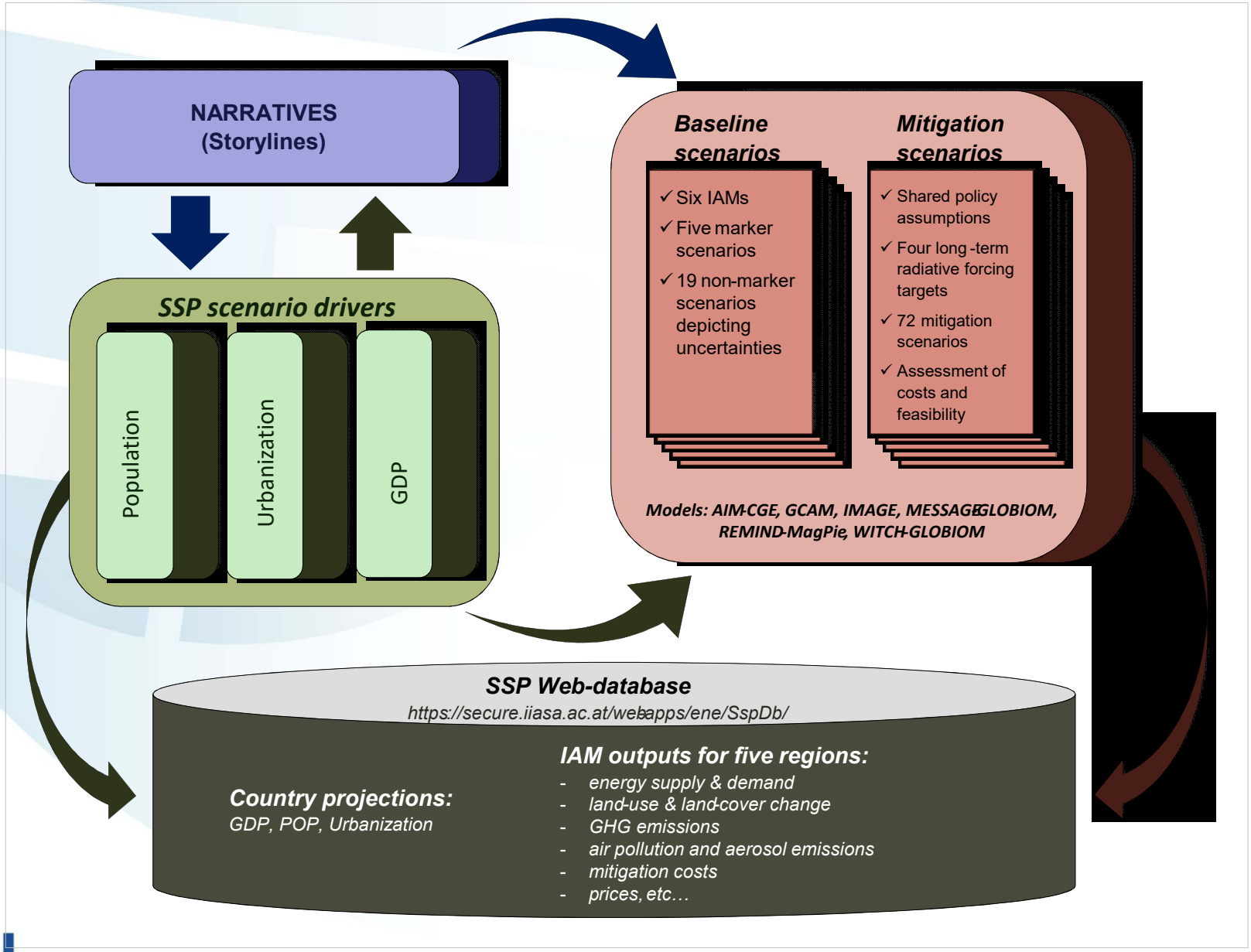
- Population
- Education
- Urbanization
- GDP
- Technology

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 & 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

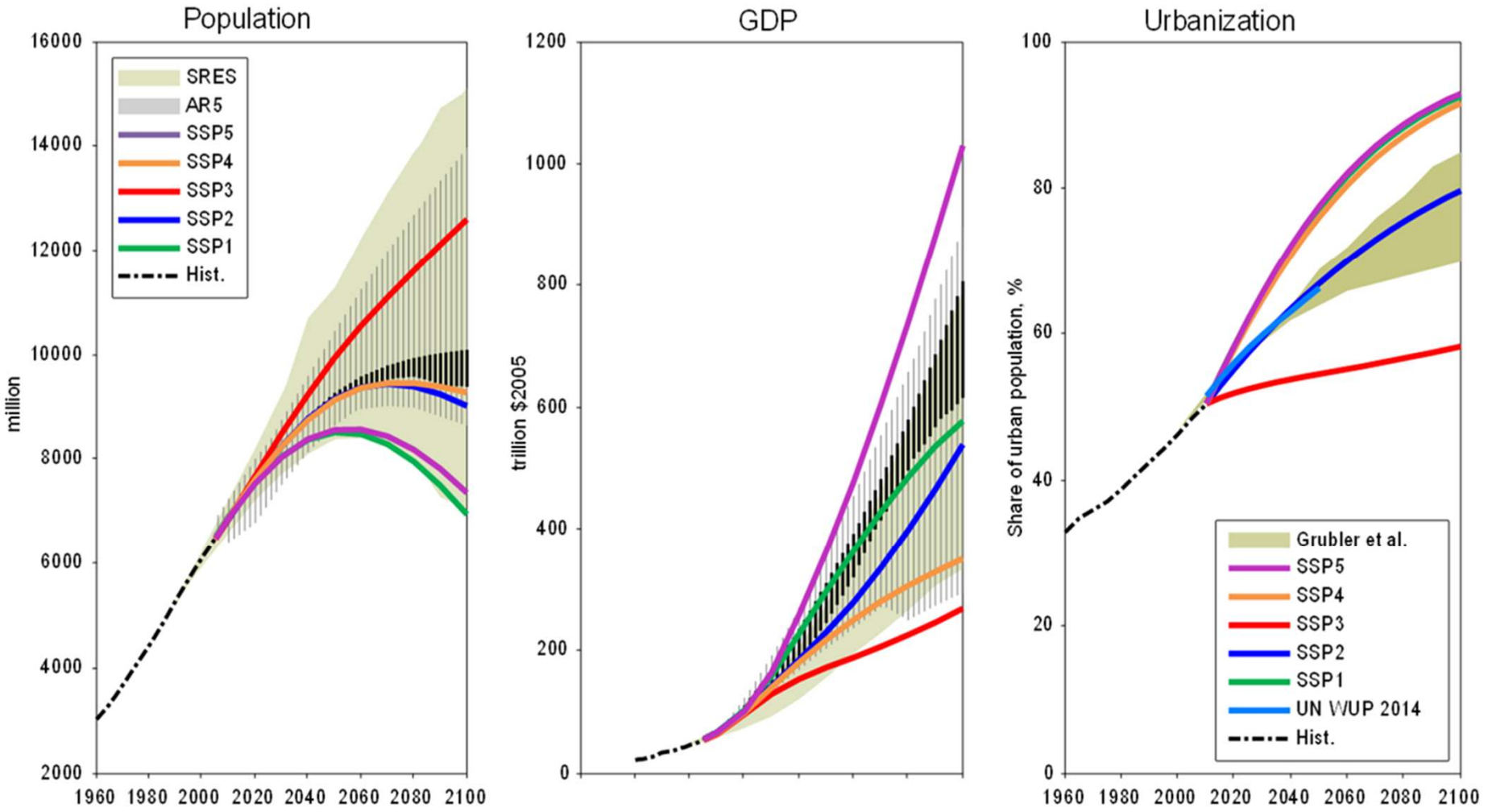
SSP2: Middle of the road

Social, economic, and technological trends proceed along historical patterns

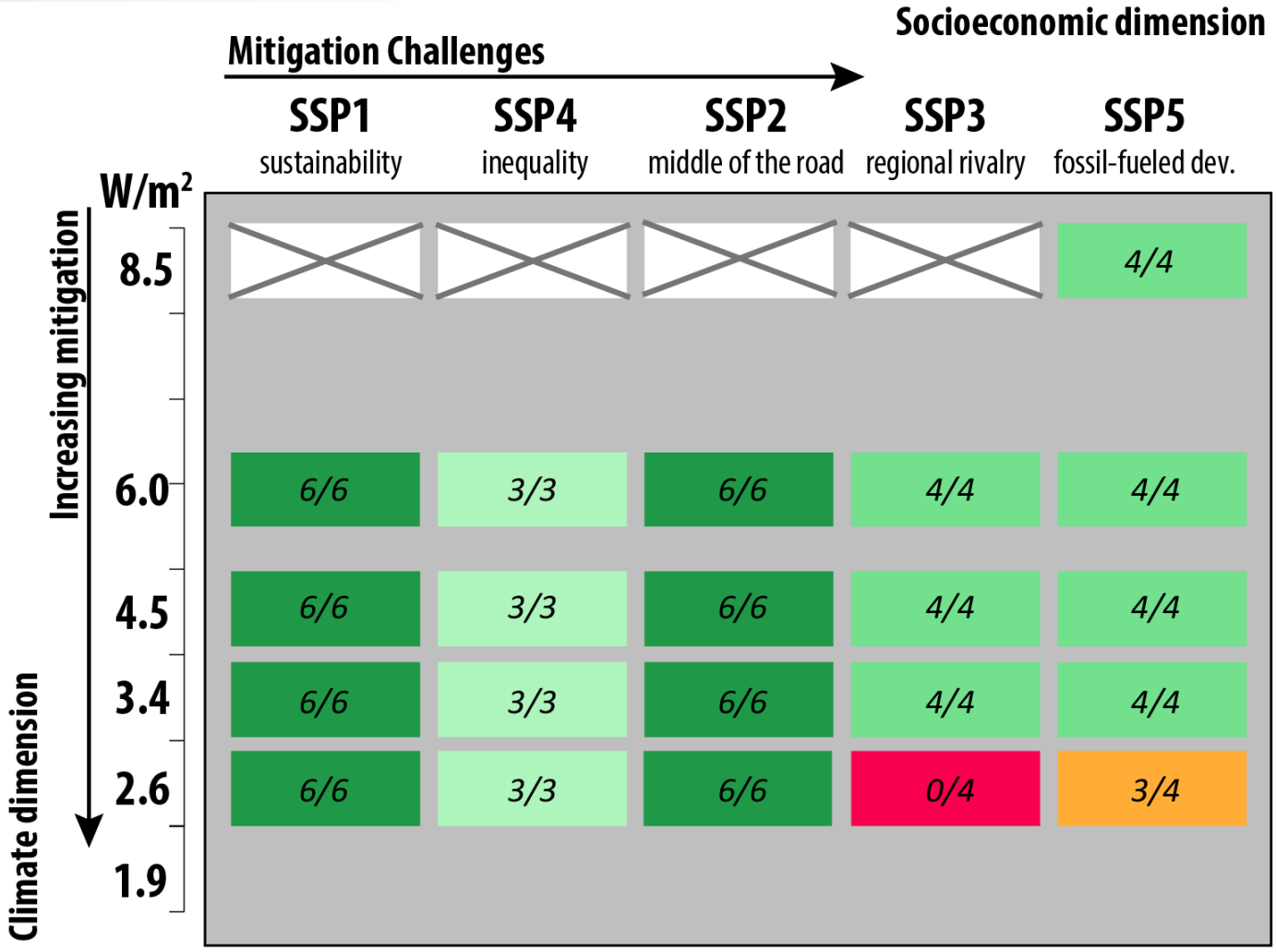
- Development and income growth proceed unevenly
- Slow progress on reaching sustainable development goals
- Technological developments proceed without breakthrough
- Environmental systems experience degradation
- Fossil fuel dependency decreases slowly
  - no reluctance to use unconventional fossil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

Summary

- Good progress – project on time (accounting for the delayed start)
- Now ready to tackle the detailed scenario work
- 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 designed pending availability of resources