

Climate Stabilization Scenarios: New Integrated Assessment Approaches for IPCC AR5 and Recent IIASA Scenarios

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International Institute for Applied Systems Analysis 

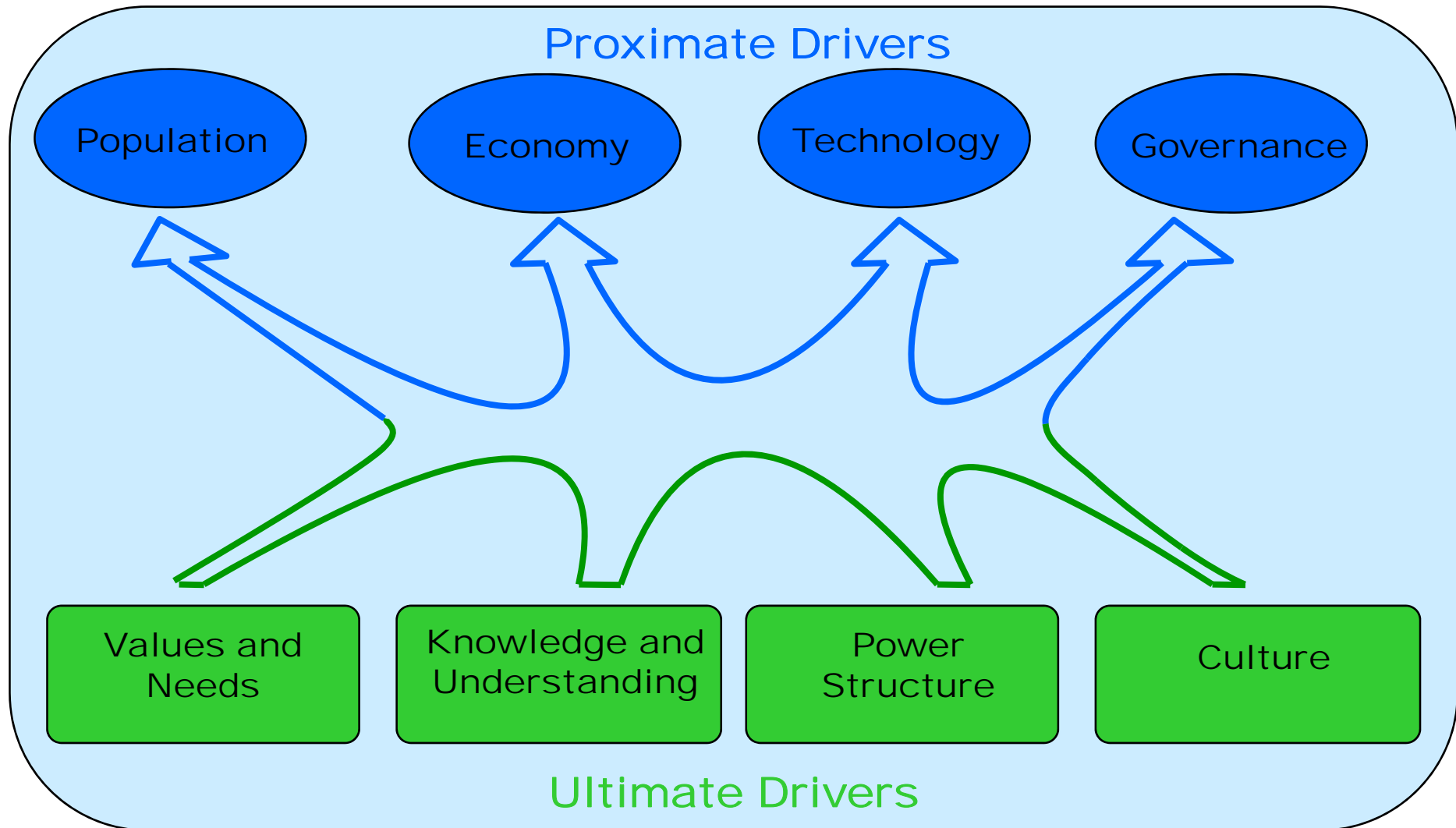
Technische Universität Wien 

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Scenarios:

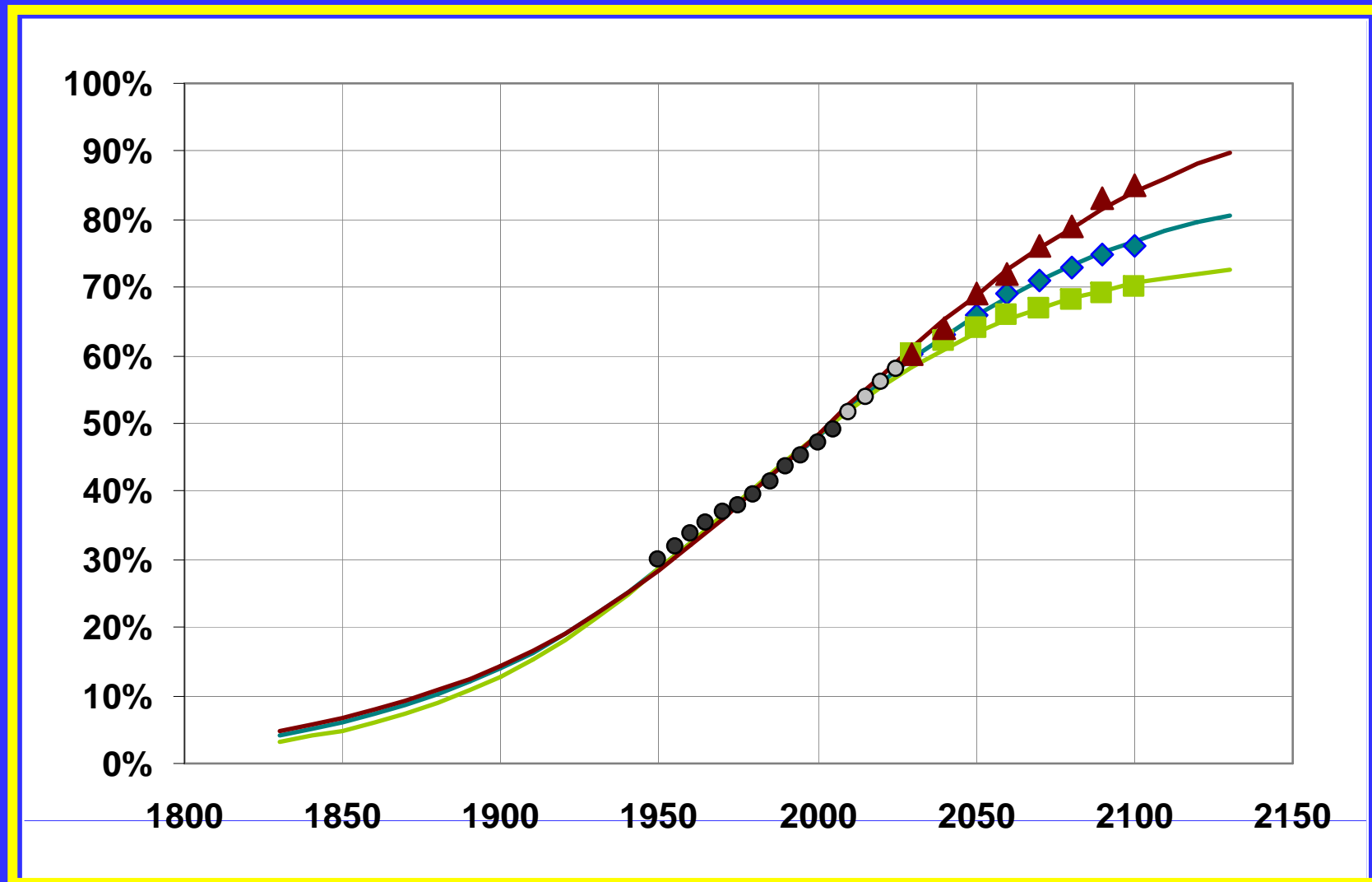
- Provide a framework for decision making which illuminates the impact associated with alternative courses of action
- Facilitate the interpretation of possible future states
- Include elements that cannot be formally modeled
- Aimed at challenging prevailing mind sets

Proximate and Ultimate Drivers

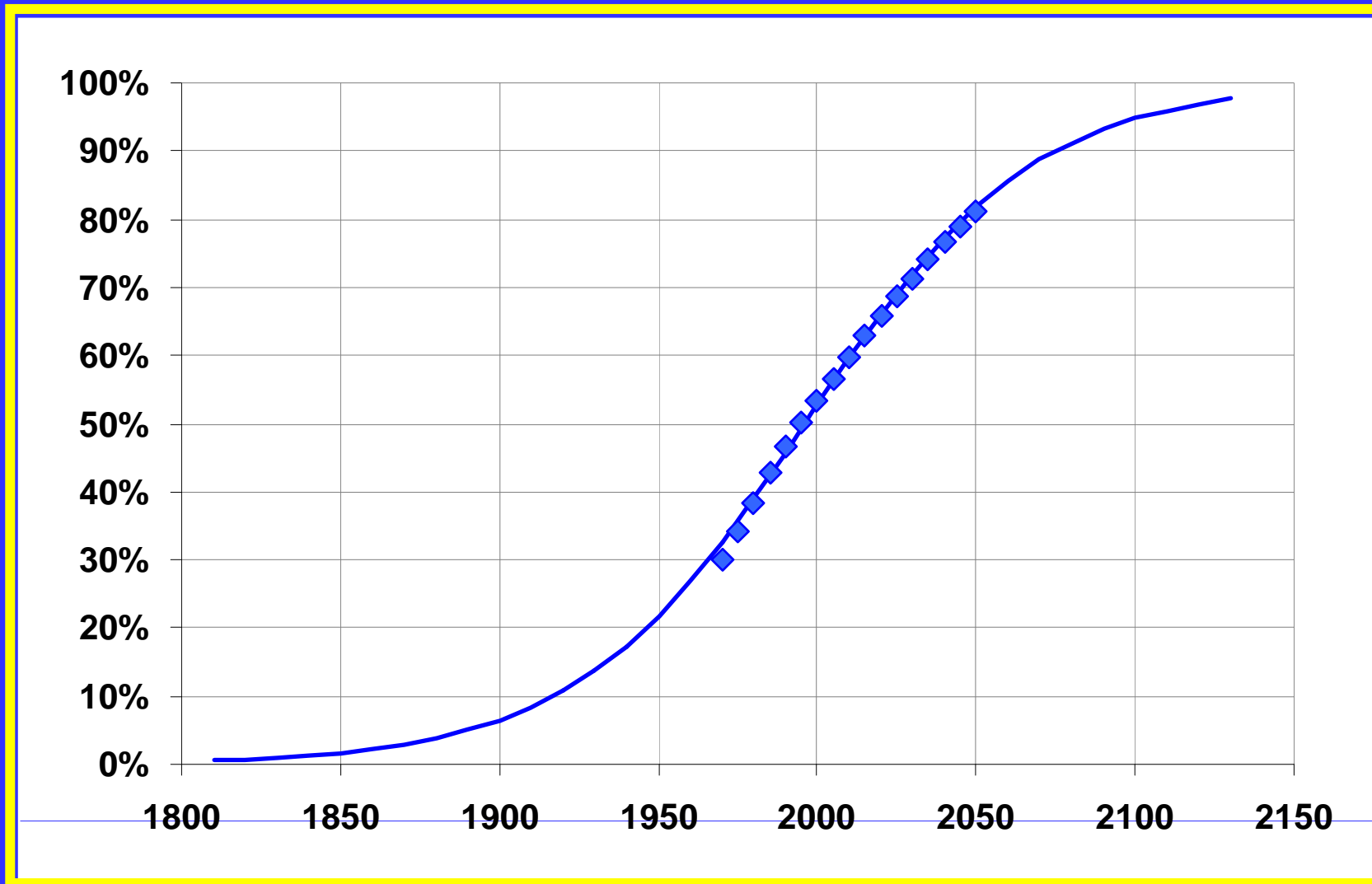


Source: Paul Raskin, 2002

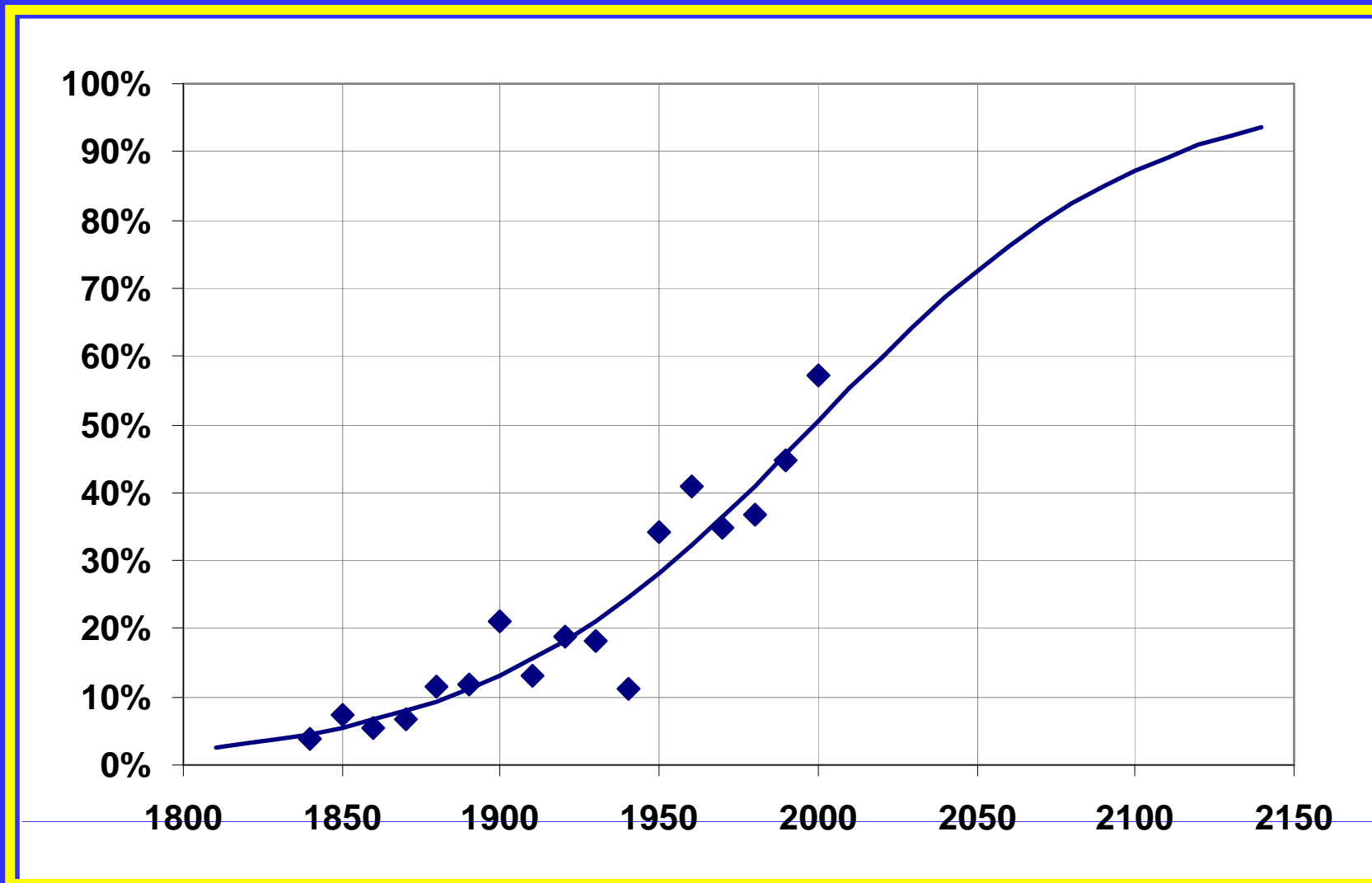
Urbanization



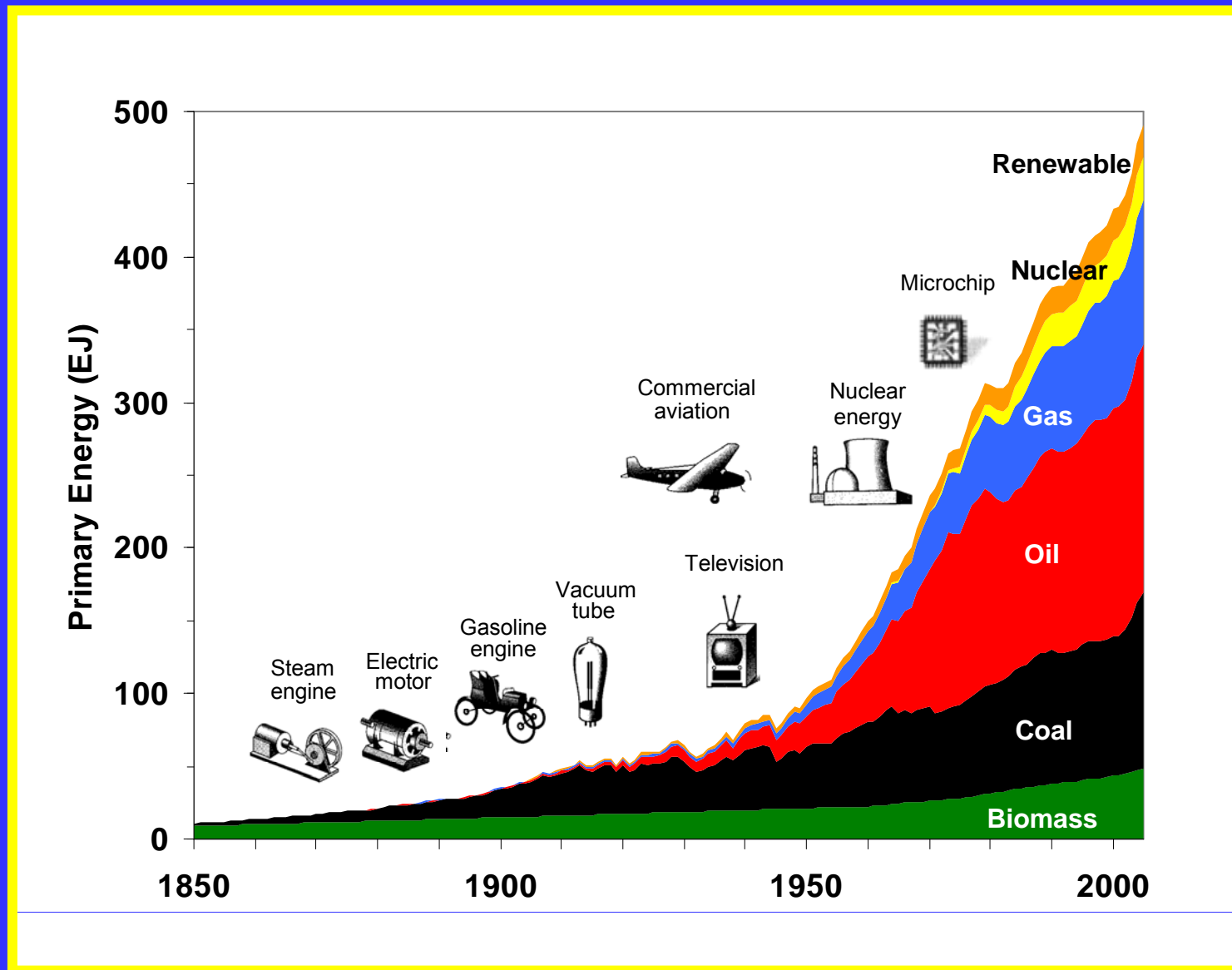
Education



Democratization



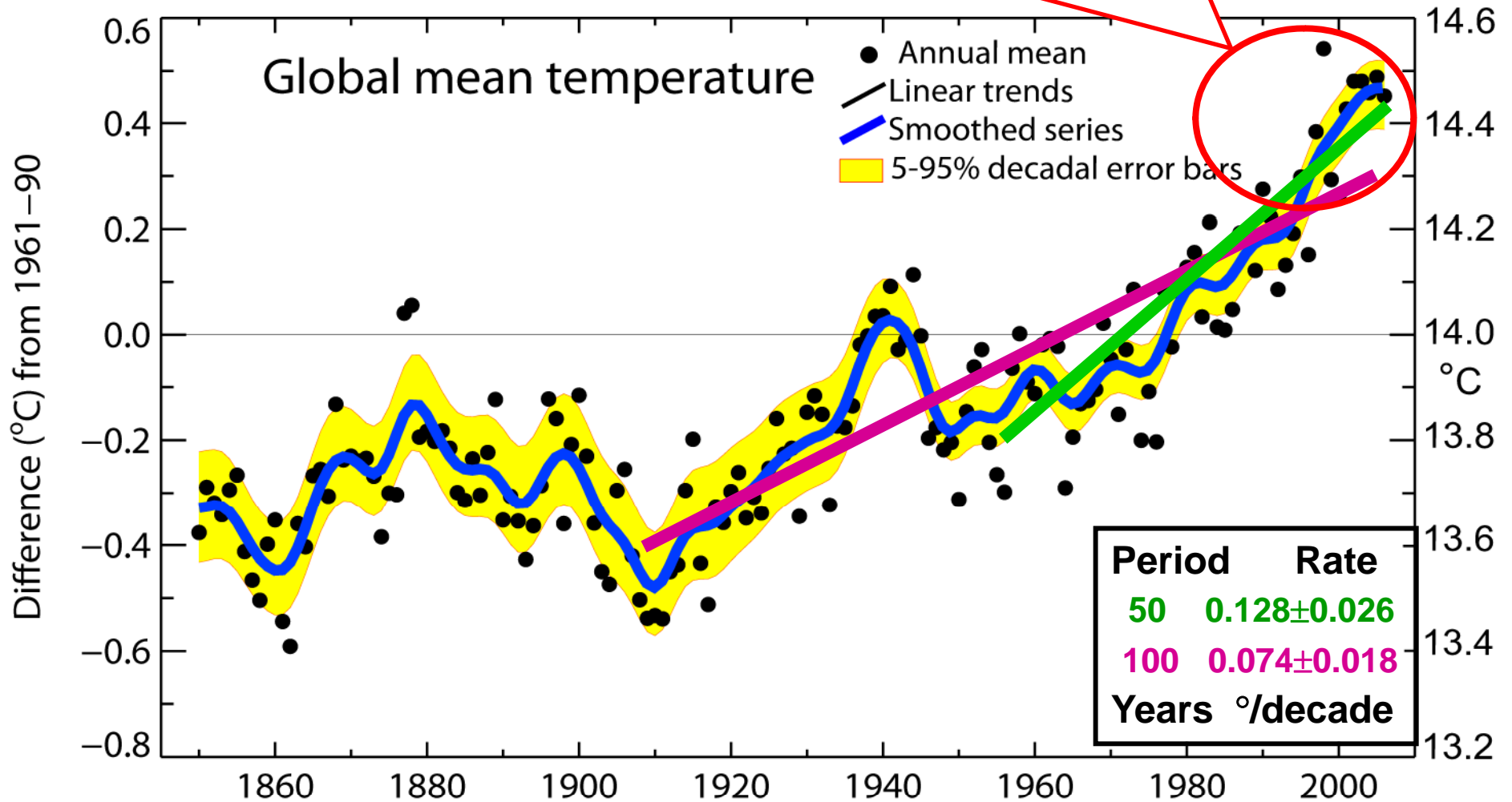
World Primary Energy



Global Mean Temperature

Warmest 12 years:
 1998, 2005, 2003, 2002, 2004, 2006,
 2001, 1997, 1995, 1999, 1990, 2000

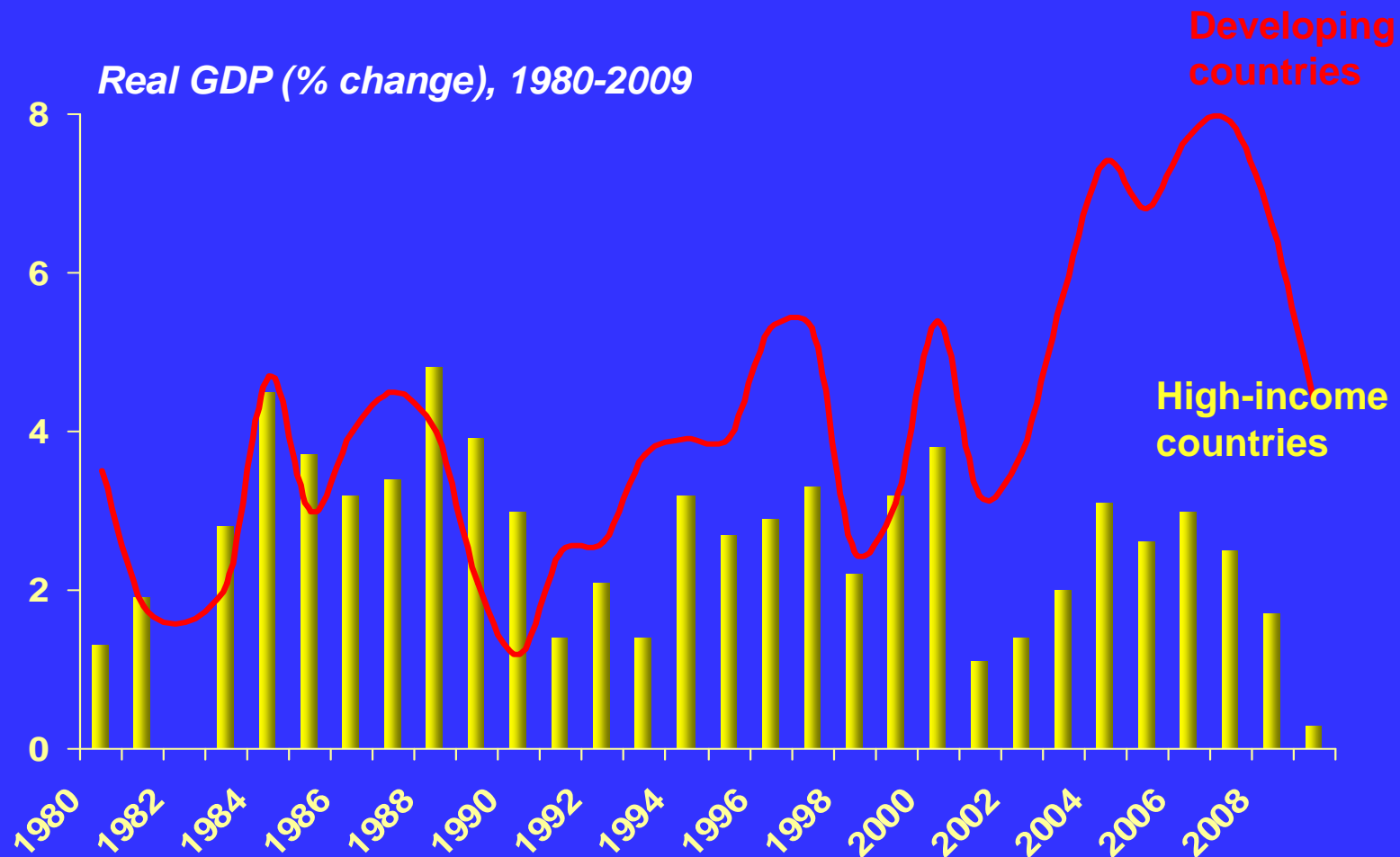
Warming



INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

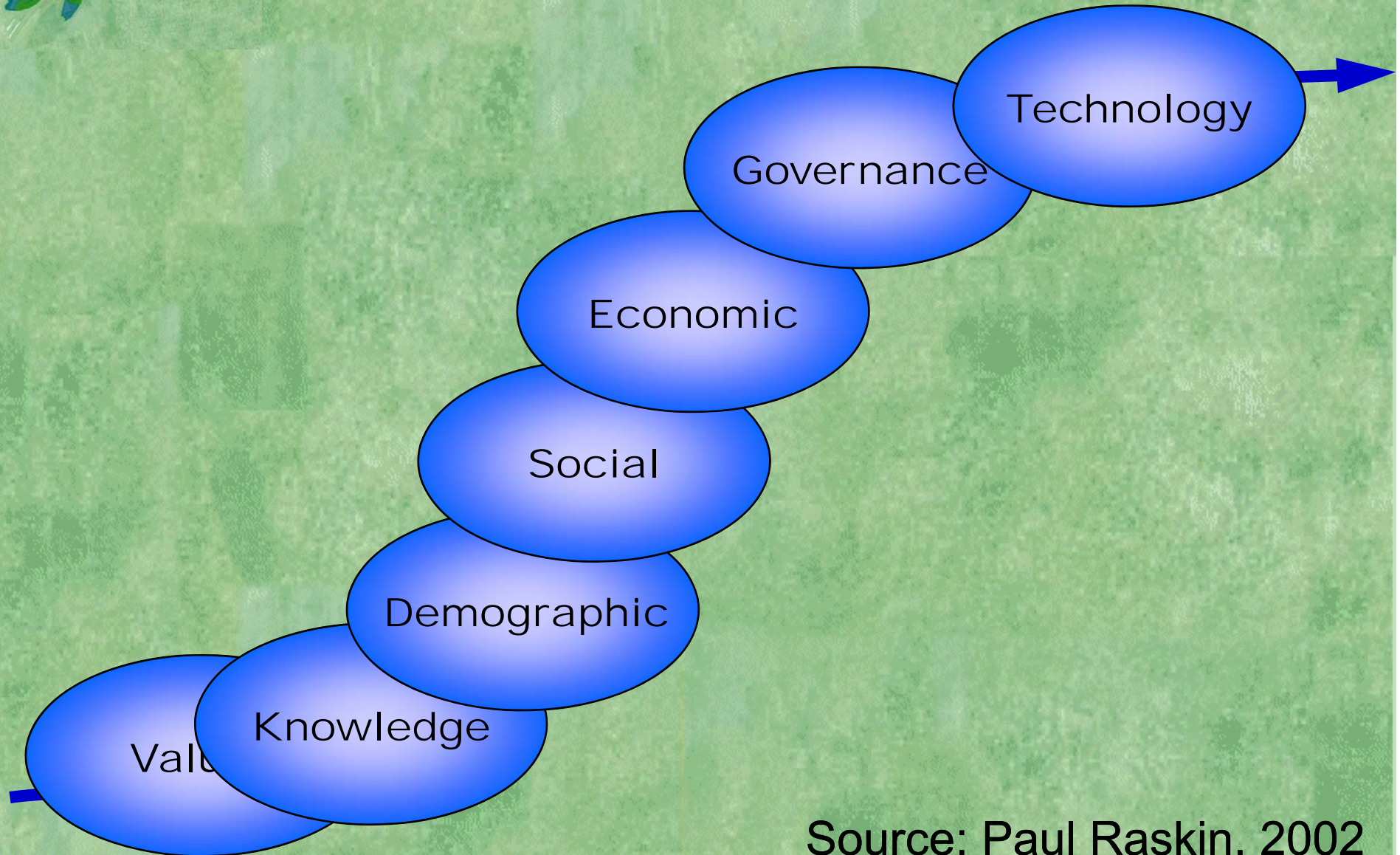


...and with financial woes spreading to the "real economy" ...



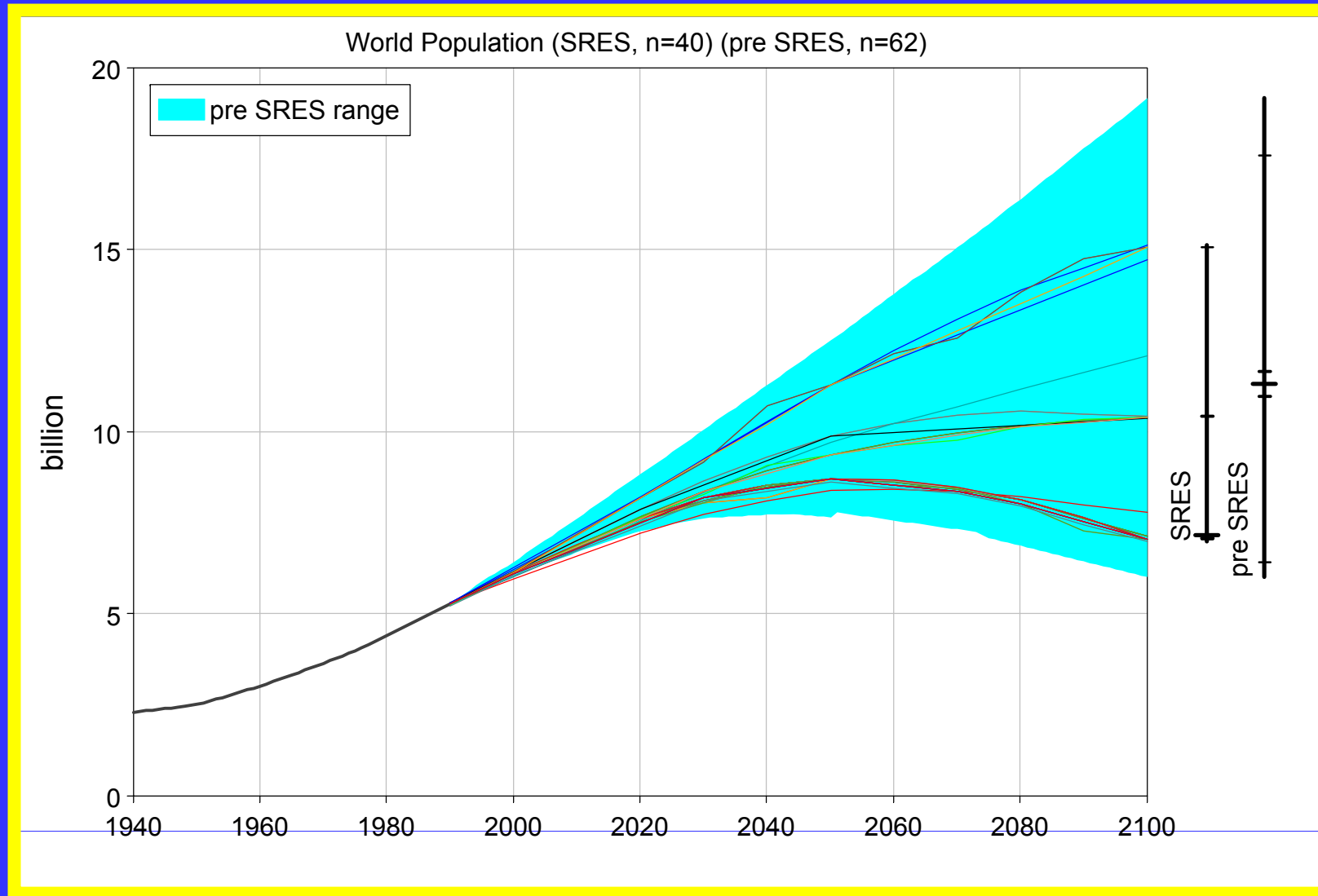


Dimensions of Transition

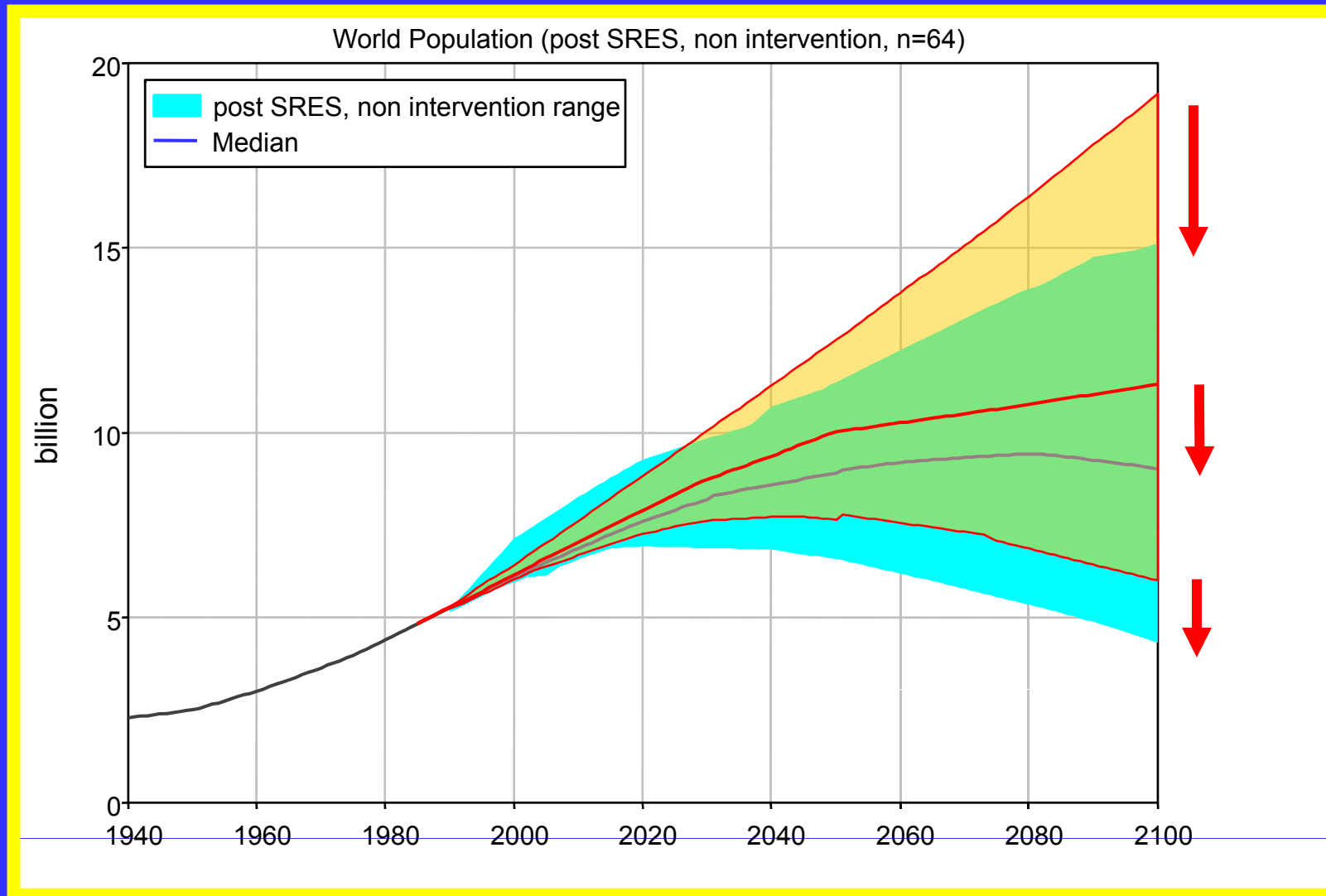


Source: Paul Raskin, 2002

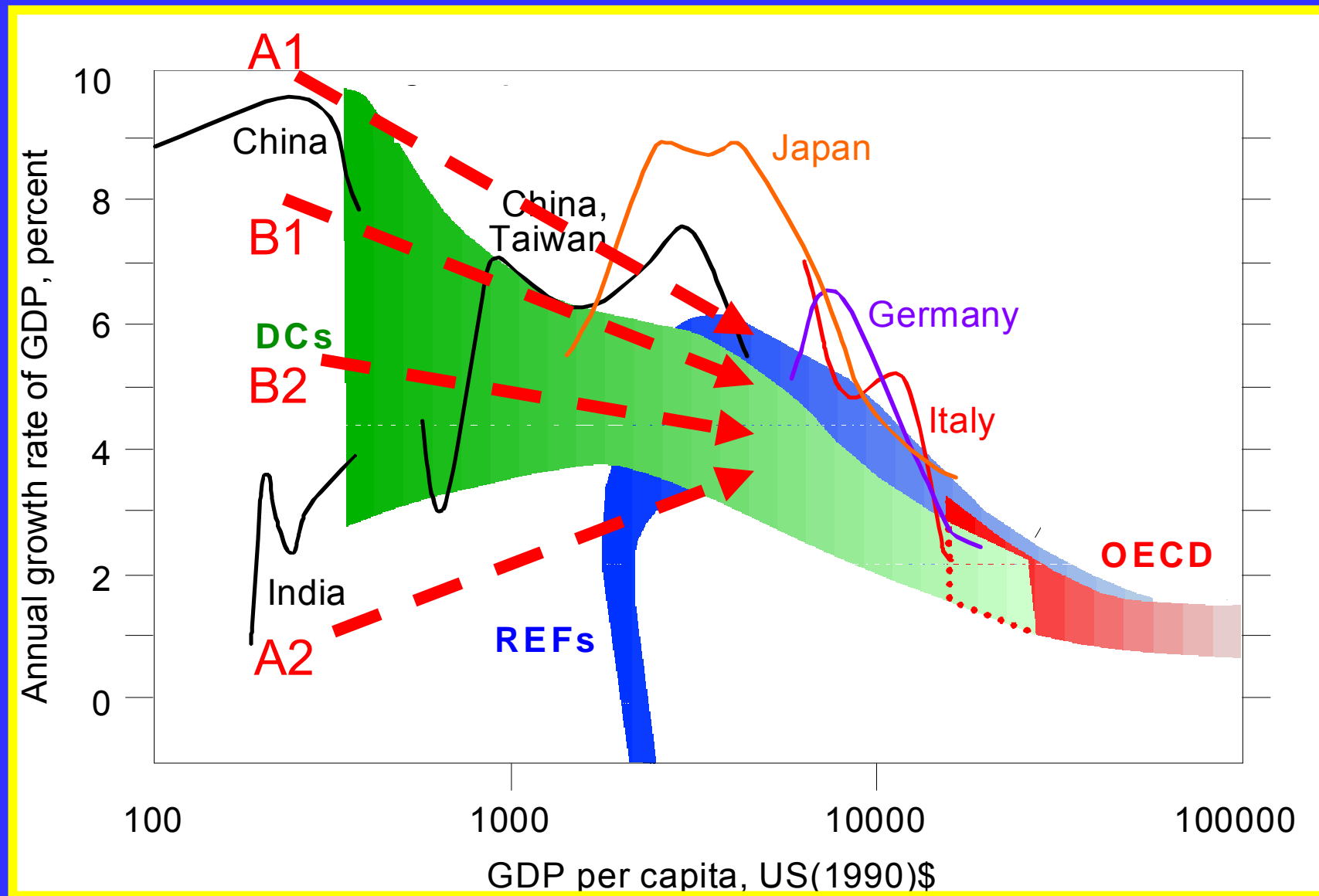
Global Population Projections



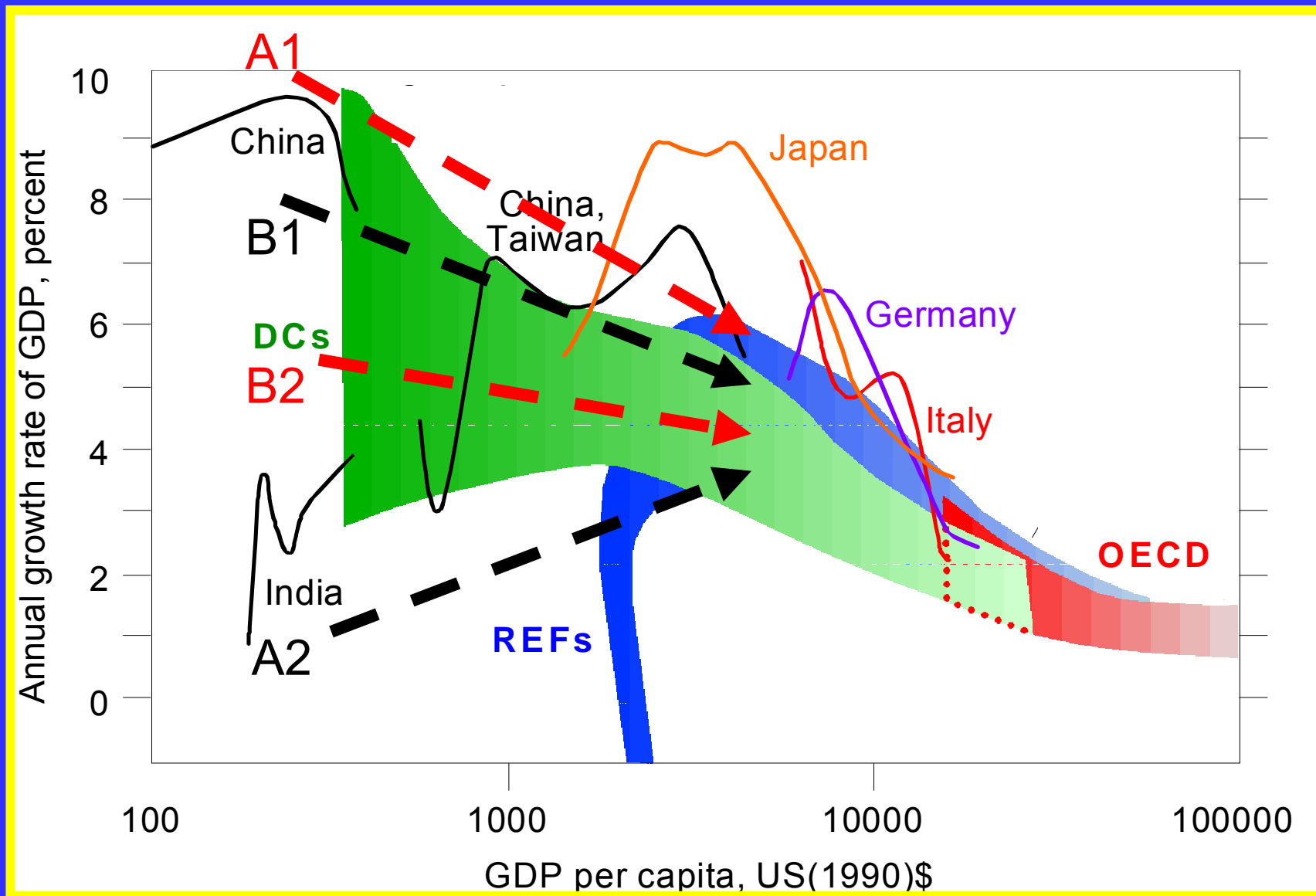
Global Population Projections



GDP Growth Rates and Affluence

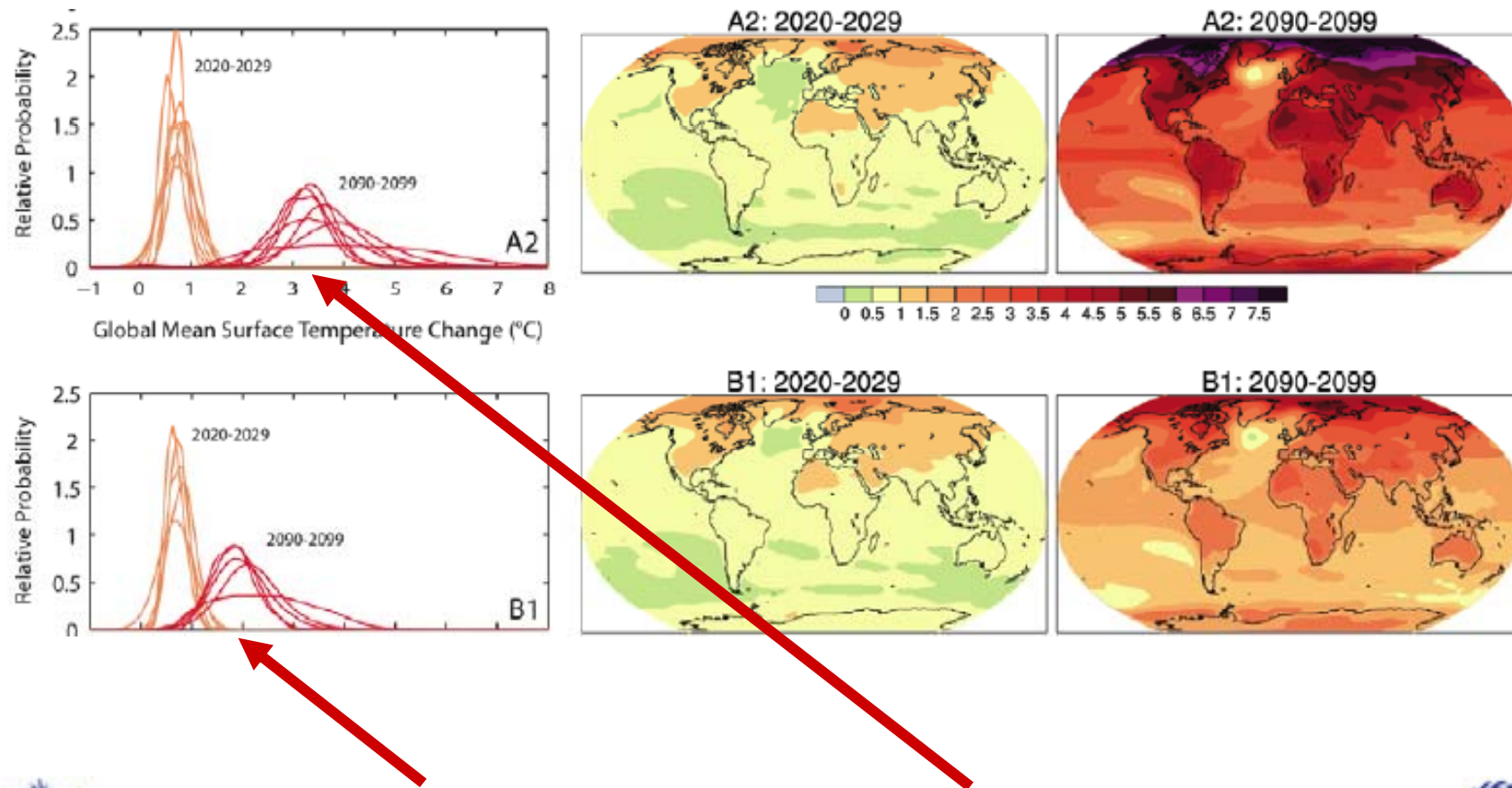


GDP Growth Rates and Affluence

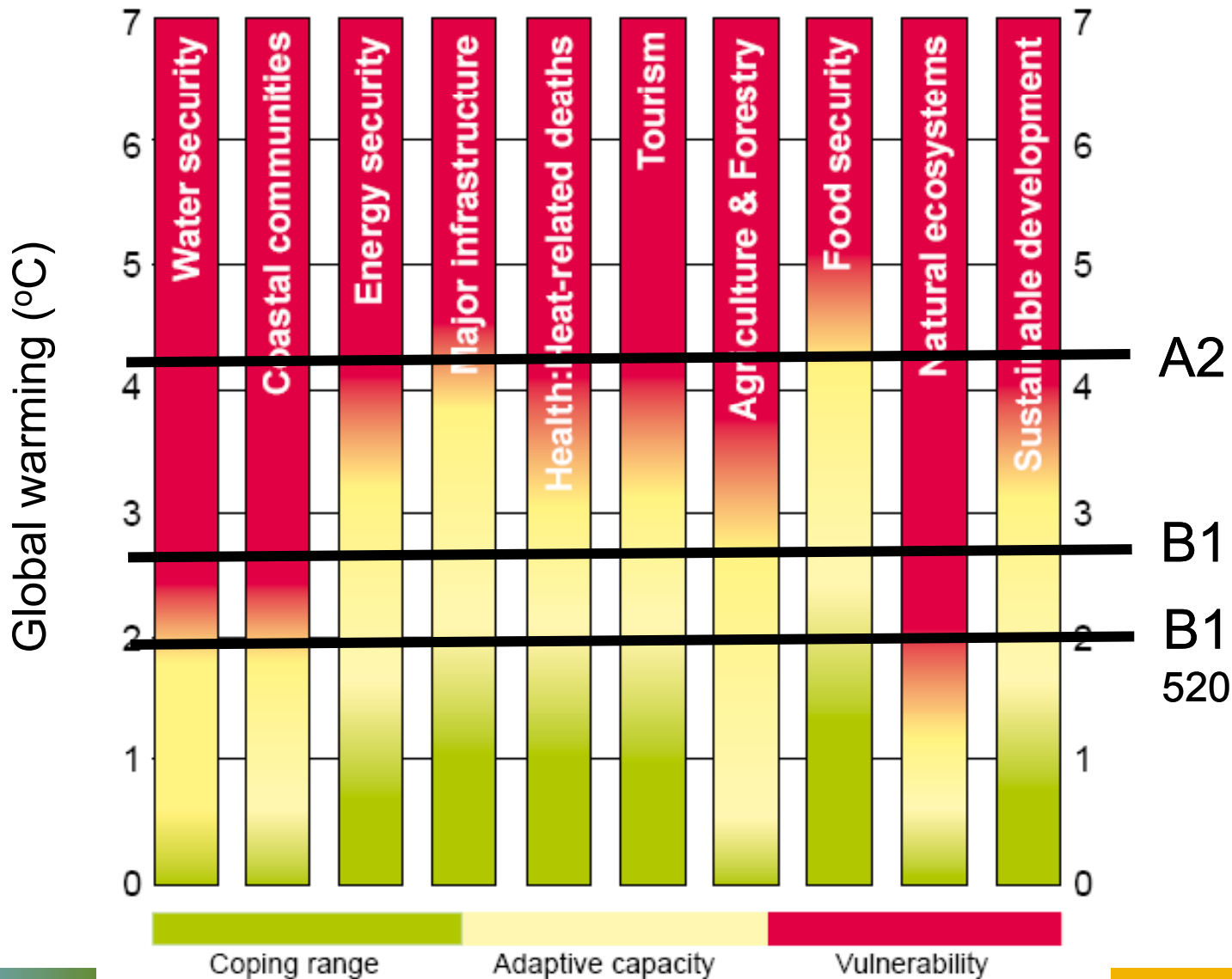


Surface Temperature Change

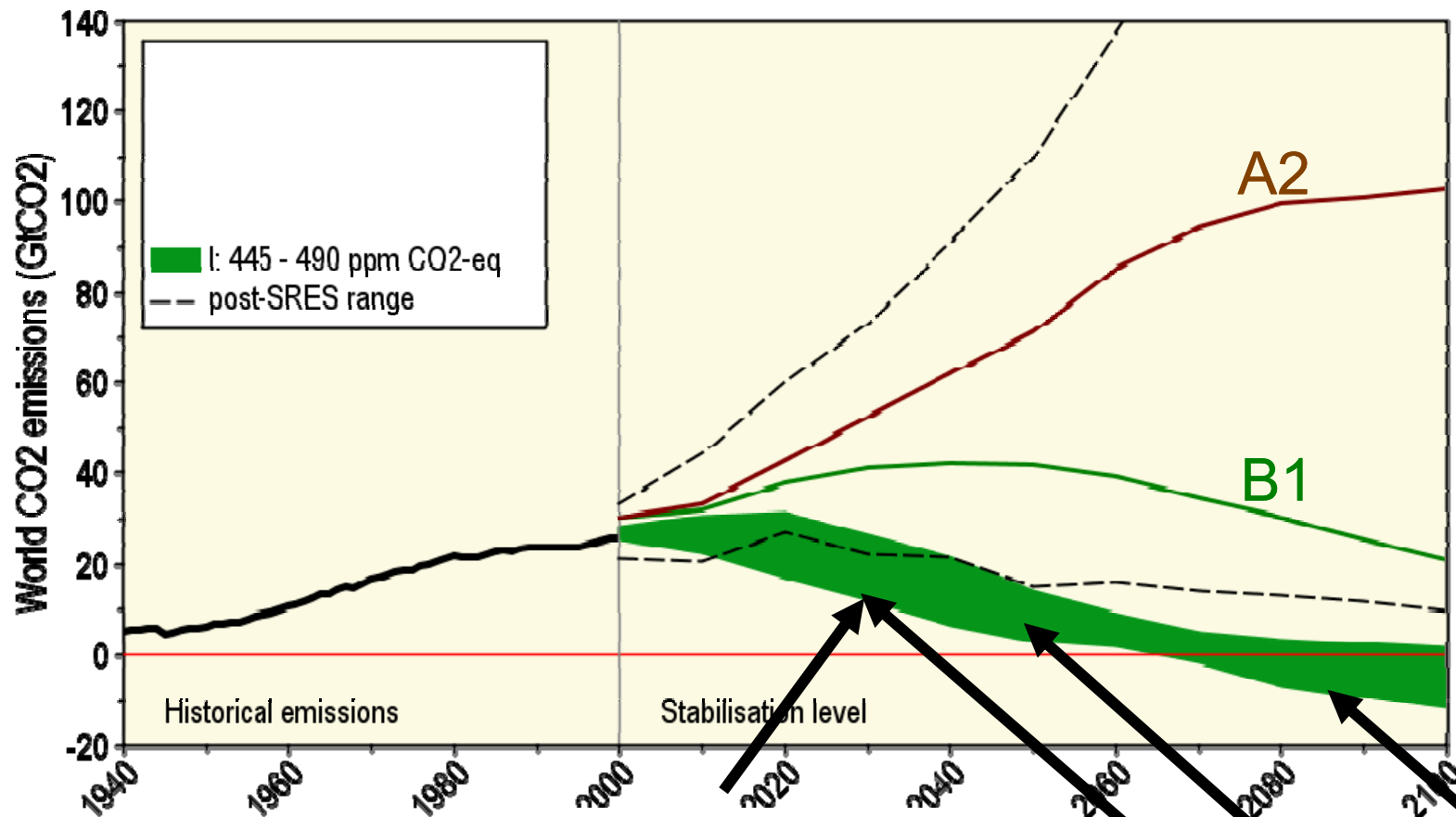
AOGCM projections for illustrative SRES scenarios



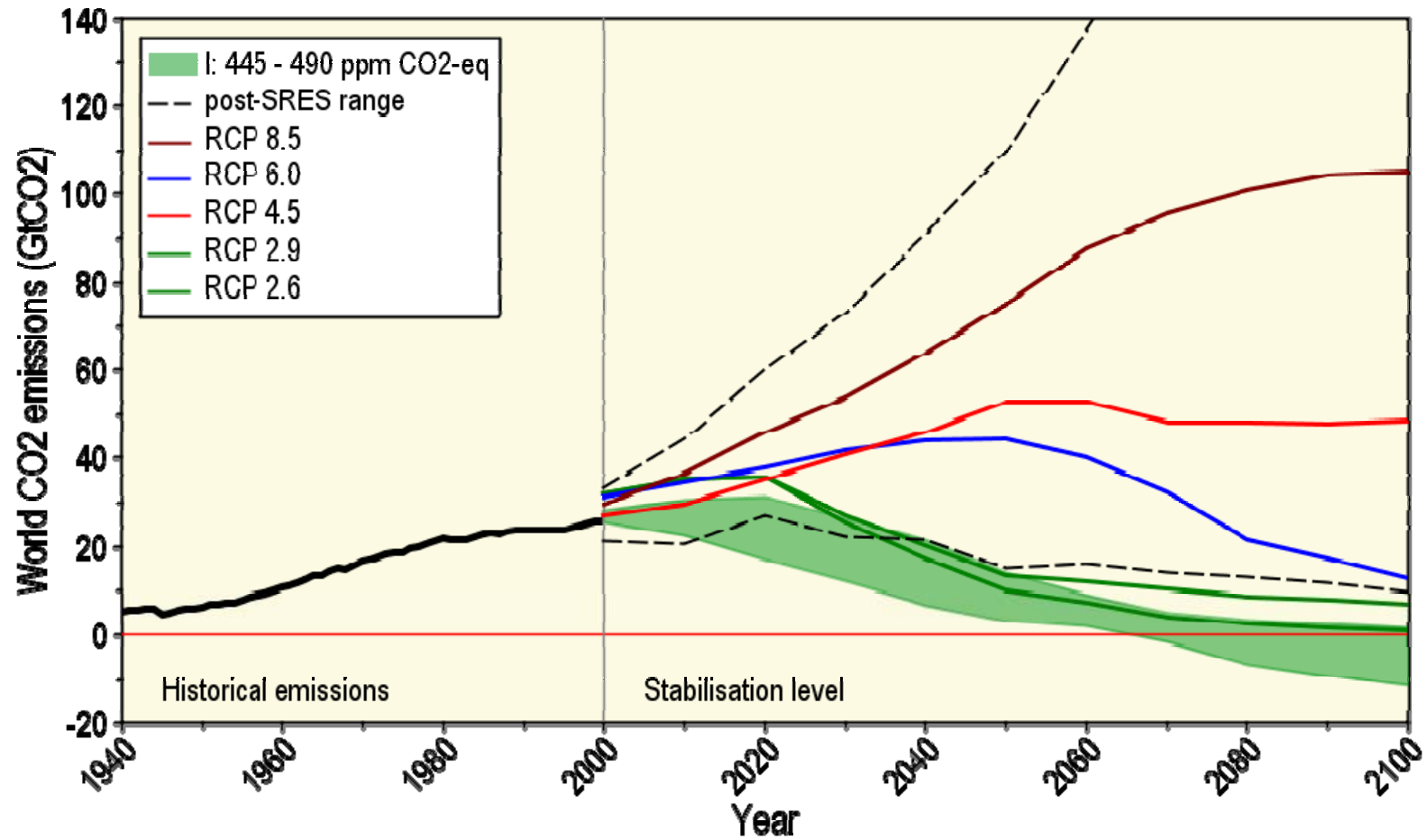
Vulnerability of Key Sectors



Long-Term Stabilization Profiles



RCP Stabilization Profiles



Initial Scenarios

4 RCPs – few stabilization targets (3)
All modeling groups

Sensitivity Scenarios with specific research focus

Selected group of models for each topic

Baseline Uncertainty

Interim-targets and
Overshoot

Limited regional
participation

Technology (e.g.,
limited portfolio)

??...

Climate and ESS Models

Baseline and stabilization climate projections
Carbon fluxes and other feedbacks

Source: After Keywan Riahi, 2006

Intended uses and limits

▶ Intended uses

- Input to CMs
- To facilitate pattern scaling
- To explore ranges of socioeconomic conditions
- To explore climate implications of spatial forcing patterns

▶ Limits

- Not forecasts or absolute bounds
- Not policy prescriptive
- Socioeconomics underlying each RCP are not unique; and, across RCPs, are not a set

REPRESENTATIVE CONCENTRATION PATHWAYS *FORCING AGENTS*

GHG Emissions and Concentrations from IAMs

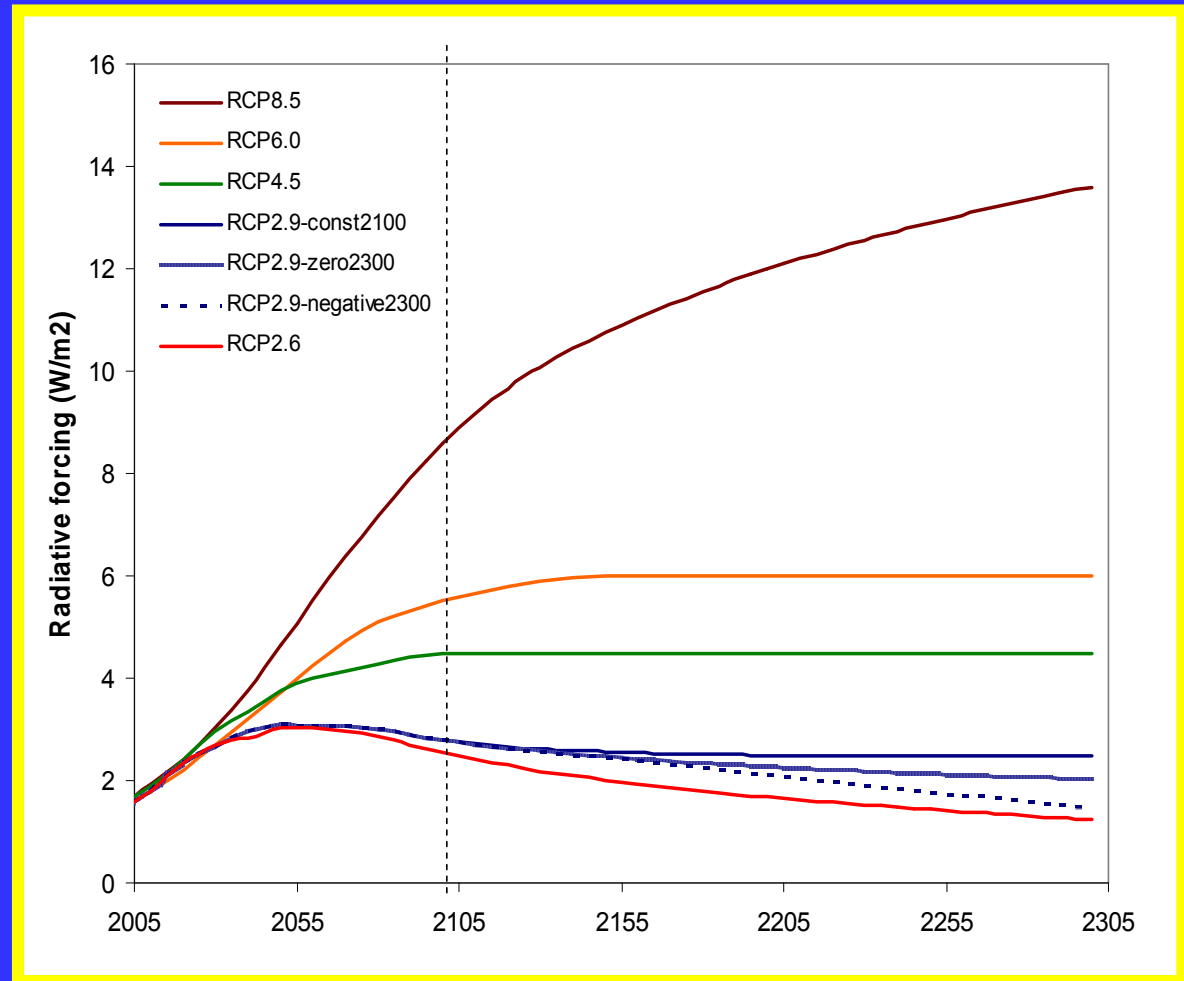
- Greenhouse gases: CO₂, CH₄, N₂O, CFCs, HFC's, PFC's, SF₆
- Emissions of chemically active gases: CO, NO_x, NH₄, VOCs
- Derived GHG's: tropospheric O₃
- Emissions of aerosols: SO₂, BC, OC
- Land use and land cover

2.6 W/m² or 2.9 W/m²?

- ▶ Which scenario for the low (<3W/m²) RCP?
- ▶ Noordwijkerhout debate over what it means to be
 - “compatible with the full range of stabilization, mitigation, and baseline emissions scenarios available in the current literature”

Proposed Extensions to 2300!

- RCP8.5: fix emissions at 2100 levels, derive concentrations
- RCP 4.5 / 6.0: fix concentrations, derive consistent emissions
- RCP2.6/2.9:
 - ◆ Fix emissions at 2100 levels, derive consistent concentrations
 - ◆ Other 2.9 option: allow emissions to fall to zero or negative, and fix
- Land-use: scale cropland and pasture land with population (current proposal); or hold constant (alternative)
- For ESM data, harmonize the unique IAM extended emissions and concentration data with a single climate model (e.g. MAGICC)



International IAM Consortium

Facilitate the coordination of scenario development efforts



International Institute for Applied Systems
Analysis (IIASA)



Energy Modeling Forum (EMF)
Stanford University



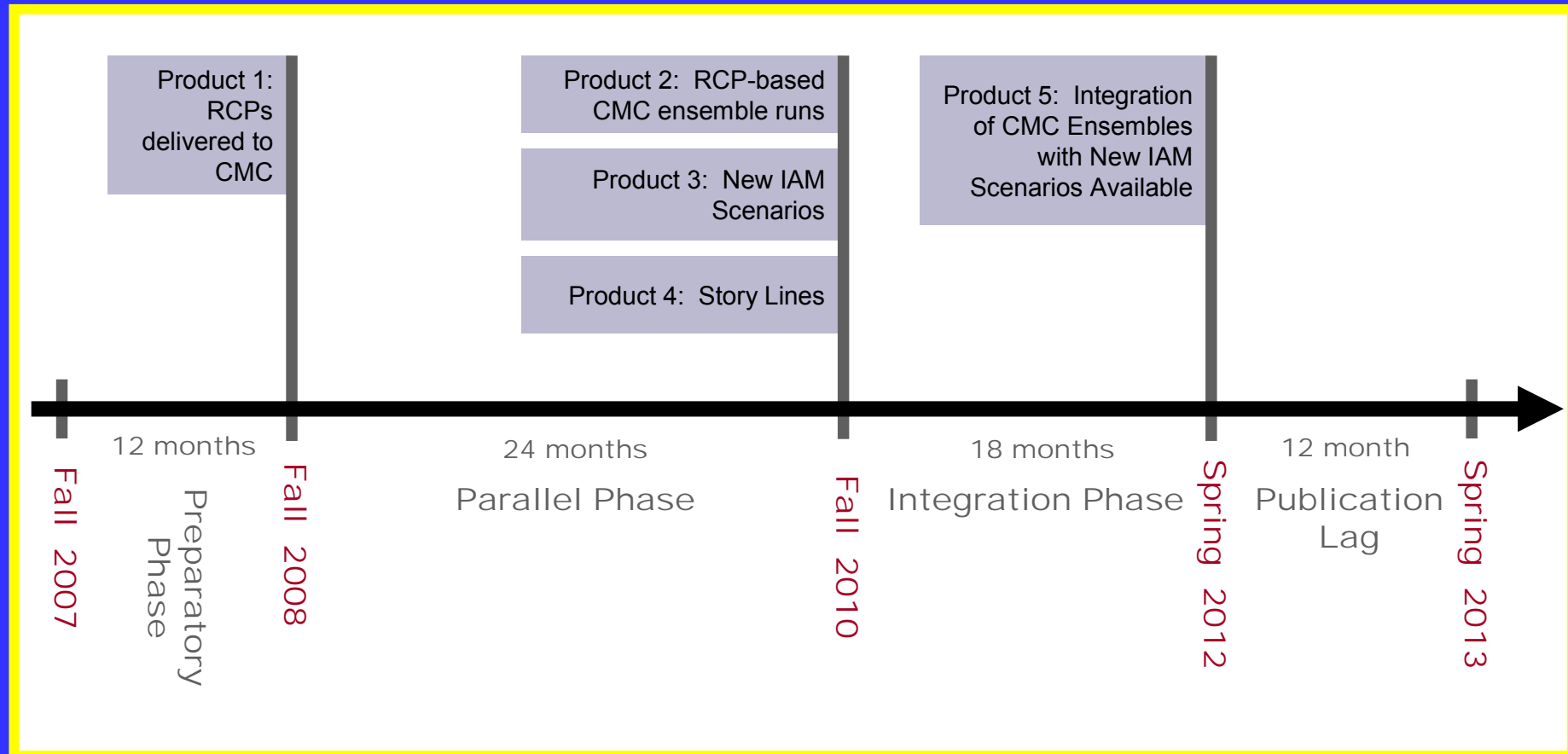
National Institute for Environmental Studies
(NIES)

- > **Australian Bureau of Agricultural and Resource Economics (ABARE)**
- *Hom Pant*
- > **Bundeswehr University, Munich**
- *Stefan Pickl*
- > **Business Council for Sustainable Development – Argentina**
- *Virginia Vilarino*
- > **CEA-LERNA, University of Social Sciences**
- *Marc Vielle*
- > **Centre for International Climate and Energy Research (CICERO), University of Oslo**
- *H.Asbjorn Aaheim*
- > **Argonne National Laboratory**
- *Donald Hanson*
- > **Centre International de Recherche sur l'Environnement et le Developpement, EHESS - U.A. CNRS 940 (CIRED)**
- *Jean-Charles Hourcade*
- > **CRA International**
- *Brian Fischer*
- > **Department of Energy, Transport, Environment, DIW Berlin**
- *Claudia Kemfert*
- > **Electric Power Research Institute (EPRI)**
- *Richard Richels, Francisco de la Chesnaye*
- > **Energy Research Institute, National Development and Reform Commission (NDRC)**
- *Kejun Jiang*
- > **ETH Zurich**
- *Thomas Rutherford*

- > **Hamburg University and Economic and Social Research Institute (ESRI)**
- *Richard Tol*
- > **Indian Institute of Management**
- *Priyadarshi Shukla*
- > **Institut d'Economie et de Politique de l'Energie, IEPE-CNRS**
- *Patrick Criqui*
- > **International Institute for Applied Systems Analysis (IIASA)**
- *Nebojsa Nakicenovic, Keywan Riahi*
- > **San Marcos University**
- *Eduardo Calvo*
- > **National Institute for Environment Studies (NIES)**
- *Mikiko Kainuma*
- > **National Center for Atmospheric Research (NCAR)**
- *Brian O'Neill*
- > **Ohio State University**
- *Brent Sohngen*
- > **Pacific Northwest National Laboratory, Joint Global Change Research Institute at the University of Maryland**
- *Jae Edmonds, Hugh Pitcher, Ronald Sands, Steve Smith*
- > **Potsdam Institute for Climate Impact Research (PIK)**
- *Ottmar Edenhofer, Elmar Kriegler, Brigitte Knopf*
- > **Programa de Planejamento Energético - PPE/COPPE/UFRJ**
- *Emilio Lèbre La Rovere*
- > **Purdue University**
- *Thomas Hertel*
- > **RAND**
- *Rob Lempert*

- > **Research Institute of Innovative Technology for the Earth (RITE)**
- *Keigo Akimoto*
- > **Stanford University**
- *John Weyant*
- > **Tellus Institute**
- *Richard Rosen*
- > **Texas A&M University**
- *Bruce McCarl*
- > **The Institute of Applied Energy**
- *Atsushi Kurosawa*
- > **The Netherlands Environmental Assessment Agency (MNP)**
- *Dettef van Vuuren*
- > **Tyndall Centre for Climate Change Research, The University of East Anglia**
- *Andrew Watkinson, Robert T. Watson*
- > **Universidad de Los Andes / Universidad Nacional de Colombia**
- *Jose Eddy Torres*
- > **Universidad Iberoamericana Puebla**
- *Maria Eugenia Ibararan Viniegra*
- > **University of Cambridge**
- *Andreas Schafer*
- > **University of Oldenburg**
- *Christoph Boehringer*
- > **US Environmental Protection Agency**
- *Allen Fawcett, Steven Rose*
- > **VTT**
- *Sanna Syri*
- > **World Bank**
- *Dominique van der Mensbrugge*

Timeline for New Scenarios



RCP Database

- Central data repository to share information and to provide easy access to the data
- Interactive & web-based “working environment”
 - detailed comparisons between RCPs and base year inventory data
 - quick data visualization
 - help to understand major data differences (eg. identify definitional issues across RCPs)
- At the moment limited access, since all data is preliminary
- Plan to make the database publicly accessible for data dissemination once the data is final

Central IAM Data Repository

IAM working environment & data dissemination

RCP Database - Mozilla Firefox

IAMC-DATABASE

RCP Database Version 0.7.17

About Compare AIM IMAGE MESSAGE MiniCAM

Select region(s), scenario(s), and variable to define your query

(1.) Regions:

- 5 Regions
 - OECD90
 - REF
 - ASIA
 - MAF
 - LAM
- 10 Regions
 - Northern America
 - Western Europe
 - Pacific OECD
 - Reforming Ecomon
 - China +
 - India +
 - Rest of Asia
 - Africa
 - Middle East
 - Latin America

(2.) Scenarios:

- AIM
 - RCP 6.0
- IMAGE
 - RCP 2.6
 - RCP 2.9
- MESSAGE
 - RCP 8.5
- MiniCAM
 - RCP 4.5
- Inventory data
 - EDGAR
 - Eyring et al.
 - IIASA
 - Garg et al.
 - REAS
 - RETRO
 - Smith
 - TRACE-P

(3.) Variables:

- N2O emissions
- HFC emissions
- PFC emissions
- CFC emissions
- SF6 emissions
- Sulfur emissions
 - Total
 - Surface transportation
 - International shipping
 - Aviation
 - Power plants, energy conversion, and distribution
 - Solvents
 - Waste (landfills, waste water, incineration)
 - Industry (combustion and processing)
 - Residential and Commercial
 - Agriculture (waste burning on field)
 - Agriculture (animals, rice, soil)
 - Geothermal business

Query Results - Chart Preview:

missions - Power Plants, Energy Conversion, Extraction, and Distribution

Legend:

- R5OECED - AIM - RCP 6.0
- R5OECED - MiniCAM - RCP 4.5
- R5OECED - IMAGE - RCP 2.6
- R5OECED - IMAGE - RCP 2.9
- R5OECED - MESSAGE - RCP 8.5
- R5OECED - IIASA GAINS CLE
- R5OECED - ID - IIASA
- R5OECED - ID - Smith

generated: 2008-09-20 10:16:08

Query Results:

Region	Scenario	Variable	Unit	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
R5OECED	AIM - RCP 6.0	Sulfur emissions - Power Plants, Energy Conversion, Extraction, and Distribution	TgSO2/yr	20.057	18.967	14.530	11.335	8.489	6.070	4.305	2.998	2.215	1.592	1.144
R5OECED	MiniCAM - RCP 4.5	Sulfur emissions - Power Plants, Energy Conversion, Extraction, and Distribution	TgSO2/yr	18.095	14.057	10.116	8.267	5.770	2.623	1.923	1.204	0.466	0.389	0.312
R5OECED	IMAGE - RCP 2.6	Sulfur emissions - Power Plants, Energy Conversion, Extraction, and Distribution	TgSO2/yr	13.641	8.875	4.302	1.951	0.629	0.268	0.206	0.161	0.112	0.087	0.062
R5OECED	IMAGE - RCP 2.9	Sulfur emissions - Power Plants, Energy Conversion, Extraction, and Distribution	TgSO2/yr	13.641	8.875	4.342	1.954	0.634	0.219	0.176	0.150	0.114	0.094	0.069
R5OECED	MESSAGE - RCP 8.5	Sulfur emissions - Power Plants, Energy Conversion, Extraction, and Distribution	TgSO2/yr	18.750	11.580	5.280	4.730	4.870	4.580	4.060	3.500	3.400	3.440	4.290
R5OECED	IIASA GAINS CLE	Sulfur emissions - Power Plants, Energy Conversion, Extraction, and Distribution	TgSO2/yr	19.864	9.367	6.624	6.523							
Region	Inventory	Variable	Unit	2000	2005									
R5OECED	ID - IIASA	Sulfur emissions - Power Plants, Energy Conversion, Extraction, and Distribution	TgSO2/yr	19.864	17.665									
R5OECED	ID - Smith	Sulfur emissions - Power Plants, Energy Conversion, Extraction, and Distribution	TgSO2/yr	17.098	14.434									

© RCP Database (Version 0.7.17)
generated: 2008-09-20 10:16:08

Output Options:

Microsoft Excel Scalable Vector Graphics Small Web Format (Flash)

Notes:

OECD90 (5 Regions)
AIM: Iceland, Norway, Switzerland, and Turkey are excluded
MESSAGE, MiniCAM: Cyprus and Malta are included
EDGAR, RETRO and UNFCCC inventories exclude Turkey

© 2008 RCP data comparison

IIASA IAM Data Repository

IAM working environment & data dissemination

The screenshot shows the RCP Database web interface. The main content area displays a table of query results for SO2 emissions. The table includes columns for Region, Inventory, Variable, and Unit, followed by a grid of data points for various scenarios and years.

Region	Inventory	Variable	Unit	2000	2005	Other years (values are small and partially obscured)									
Region	Inventory	Variable	Unit	2000	2005	...									
RSOECD ID - IIASA	Sulfur emissions - Power Plants, Energy Conversion, Extraction, and Distribution	TgSO2/yr		19.864	17.665	...									
RSOECD ID - Smith	Sulfur emissions - Power Plants, Energy Conversion, Extraction, and Distribution	TgSO2/yr		17.098	14.434	...									

Output Options: Microsoft Excel, Scalable Vector Graphics, Small Web Format (Flash)

Notes: OECD90 (5 Regions) AIM: Iceland, Norway, Switzerland, and Turkey are excluded MESSAGE, MiniCAM: Cyprus and Malta are included EDGAR, RETRO and UNFCCC inventories exclude Turkey

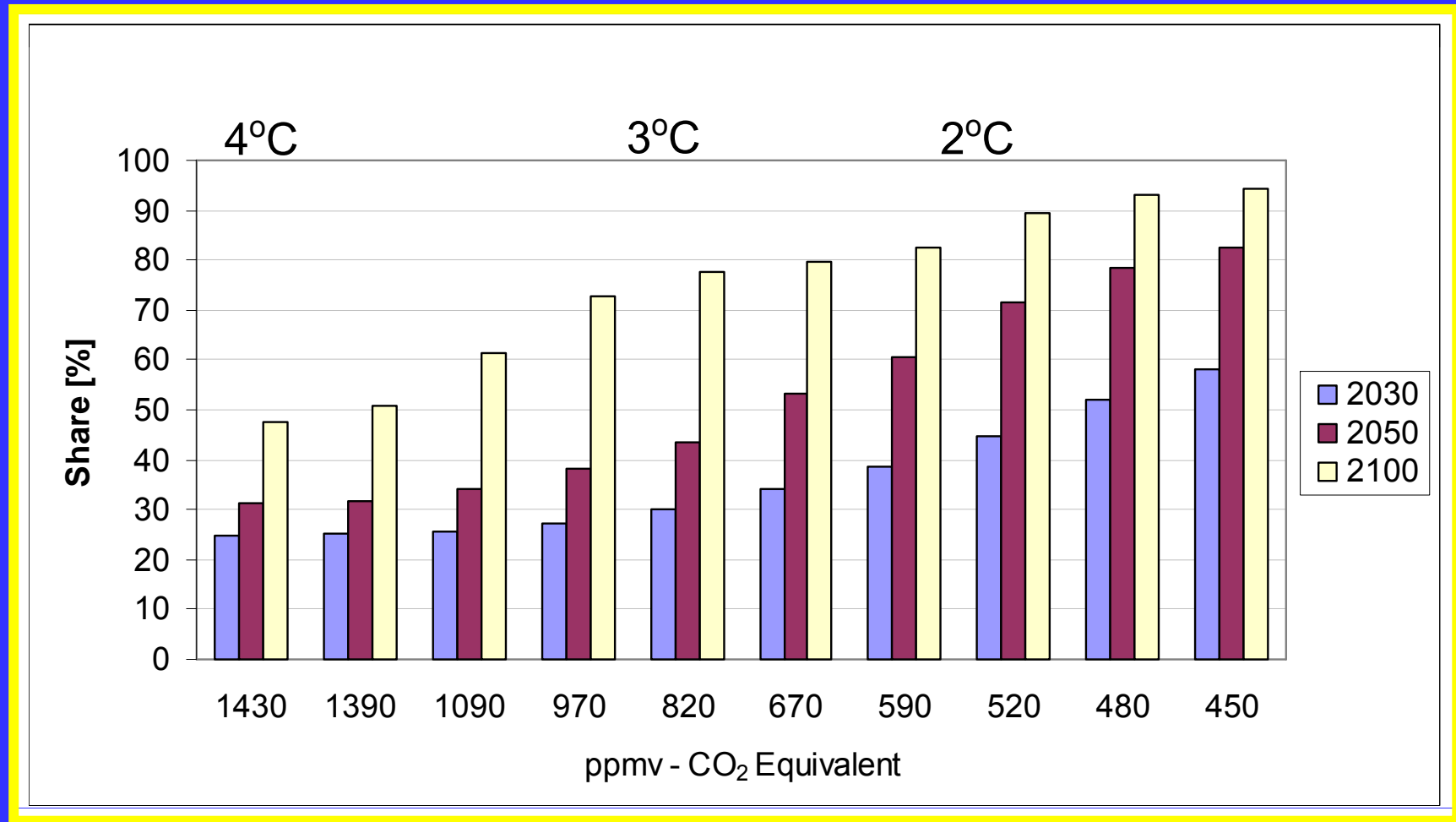
2007 Special Issue of Technological Forecasting and Social Change Journal (Nakicenovic and Riahi, eds., 2007):

<http://www.sciencedirect.com/science/journal/00401625>

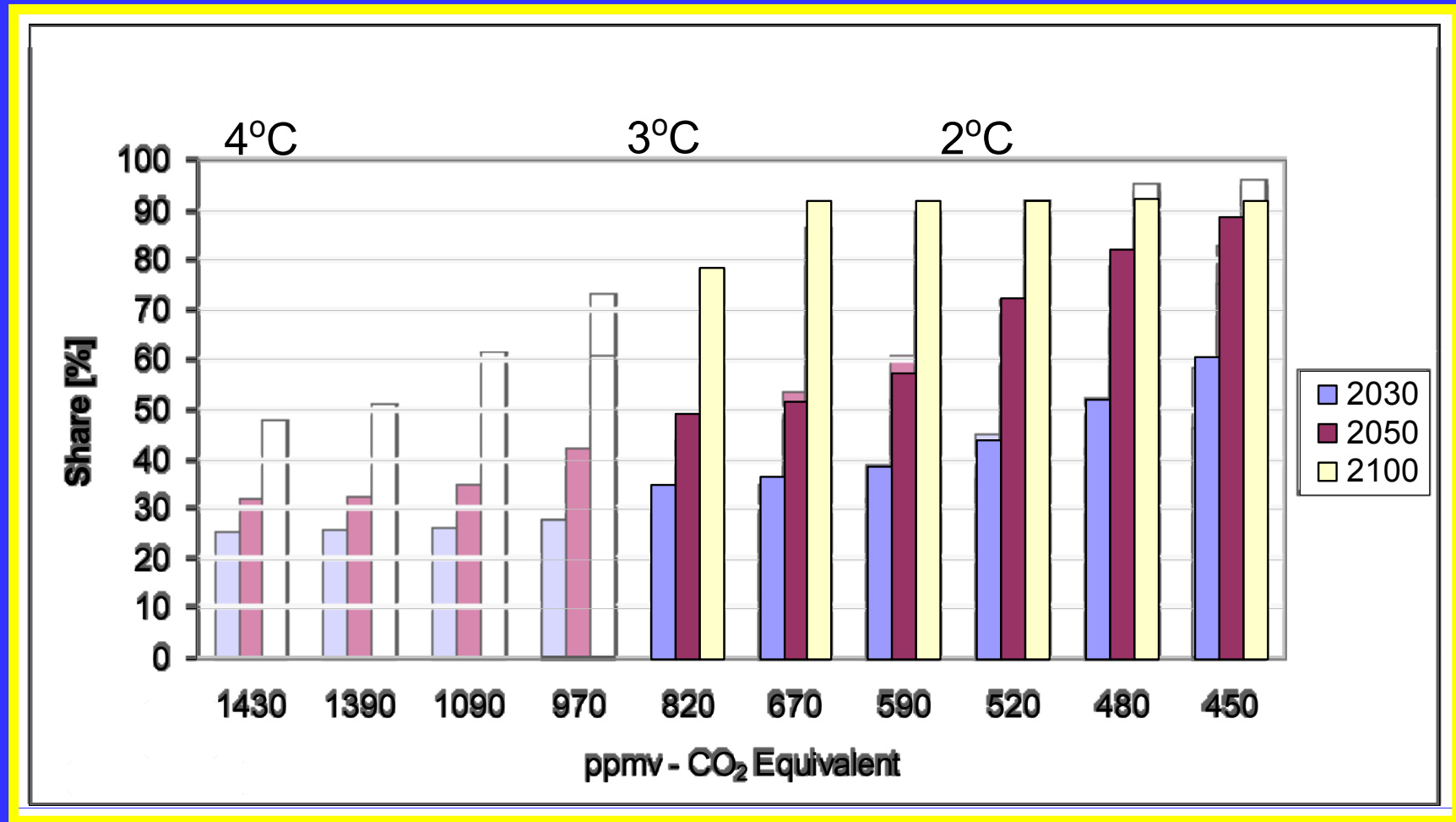
Web-based database:

http://www.iiasa.ac.at/Research/ENE/GGIDB_index.html

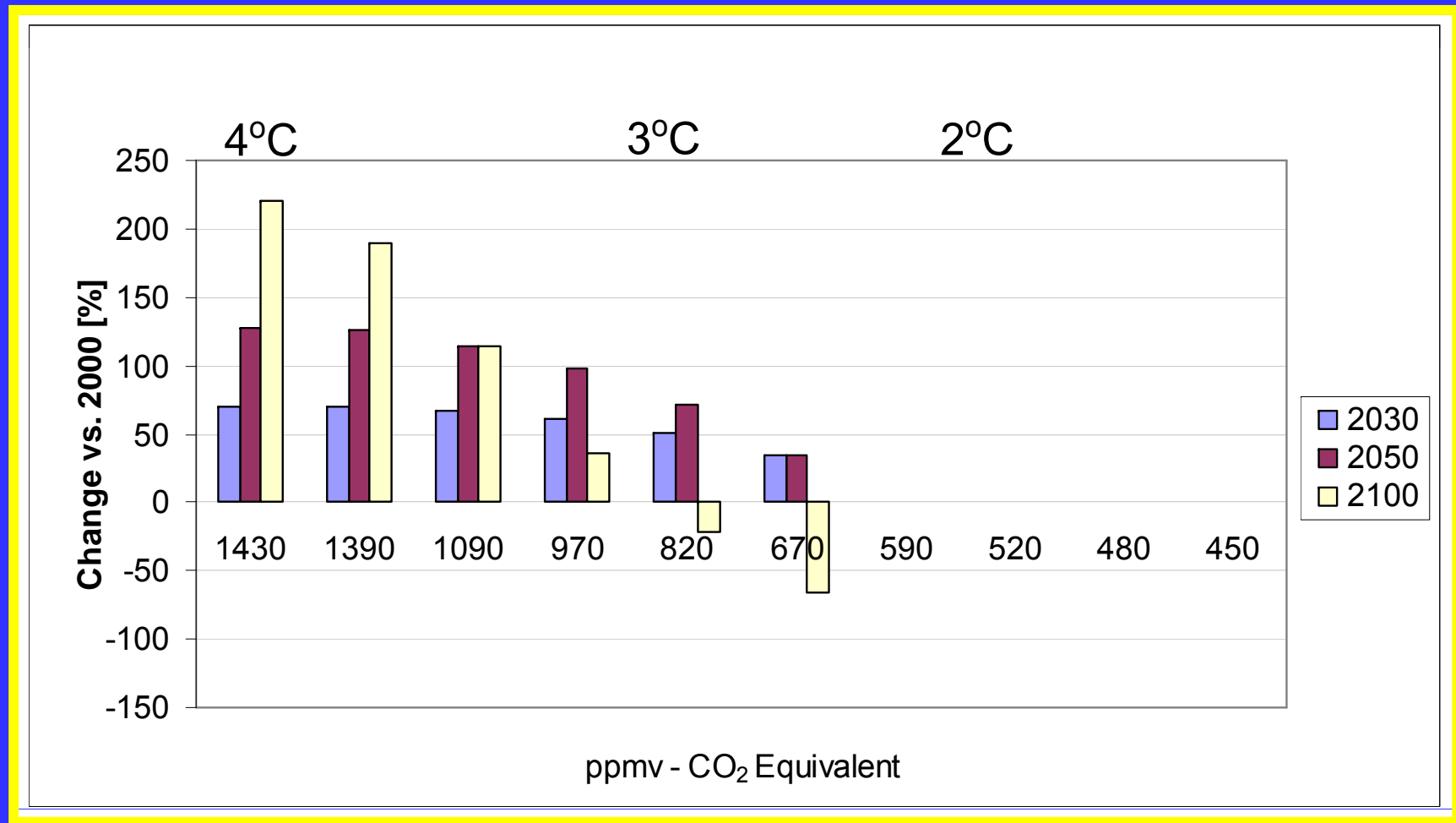
Carbon-Free Energy in A2r



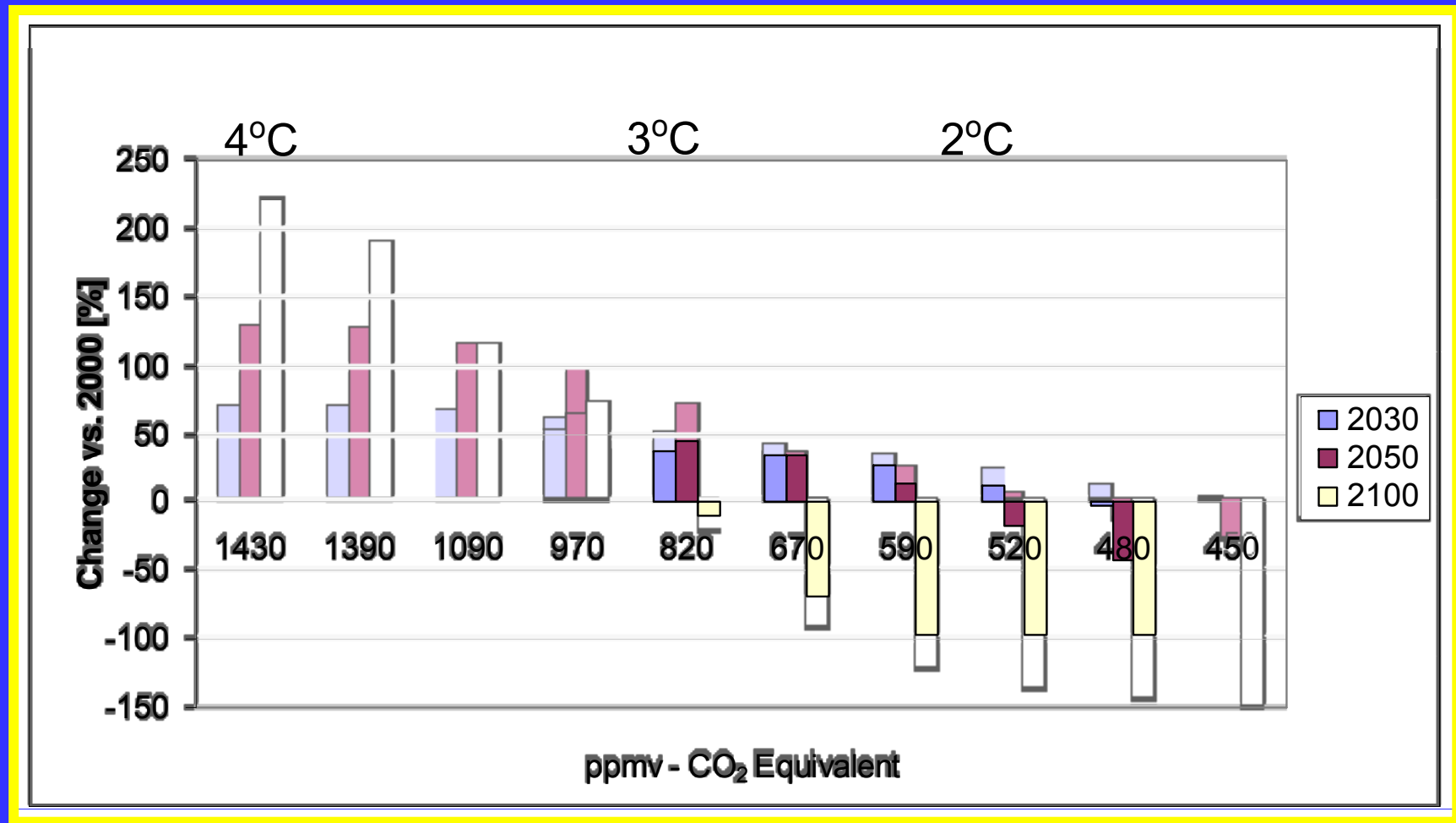
Carbon-Free Energy in B1



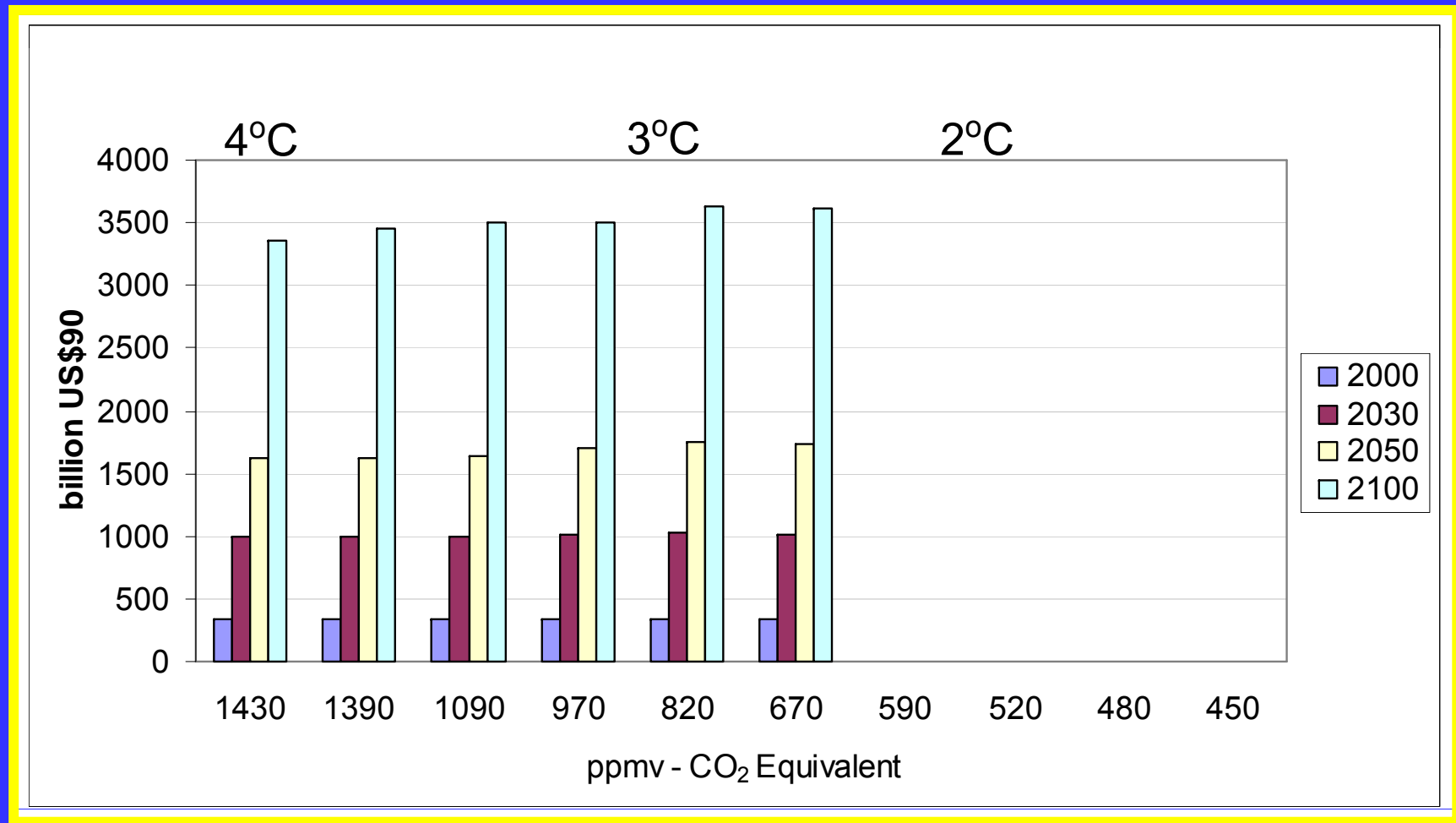
GHG emissions in A2r



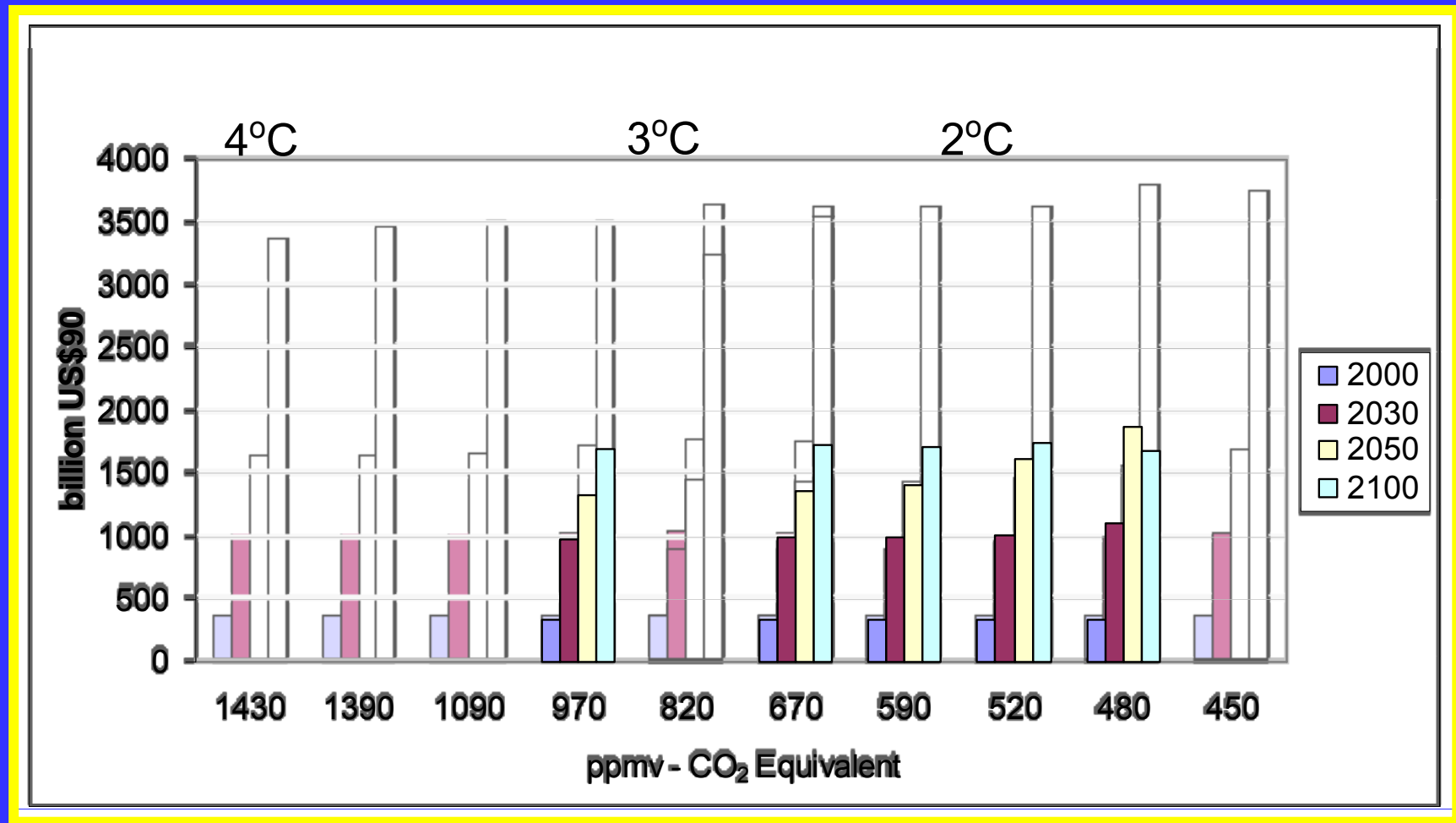
GHG emissions in B1



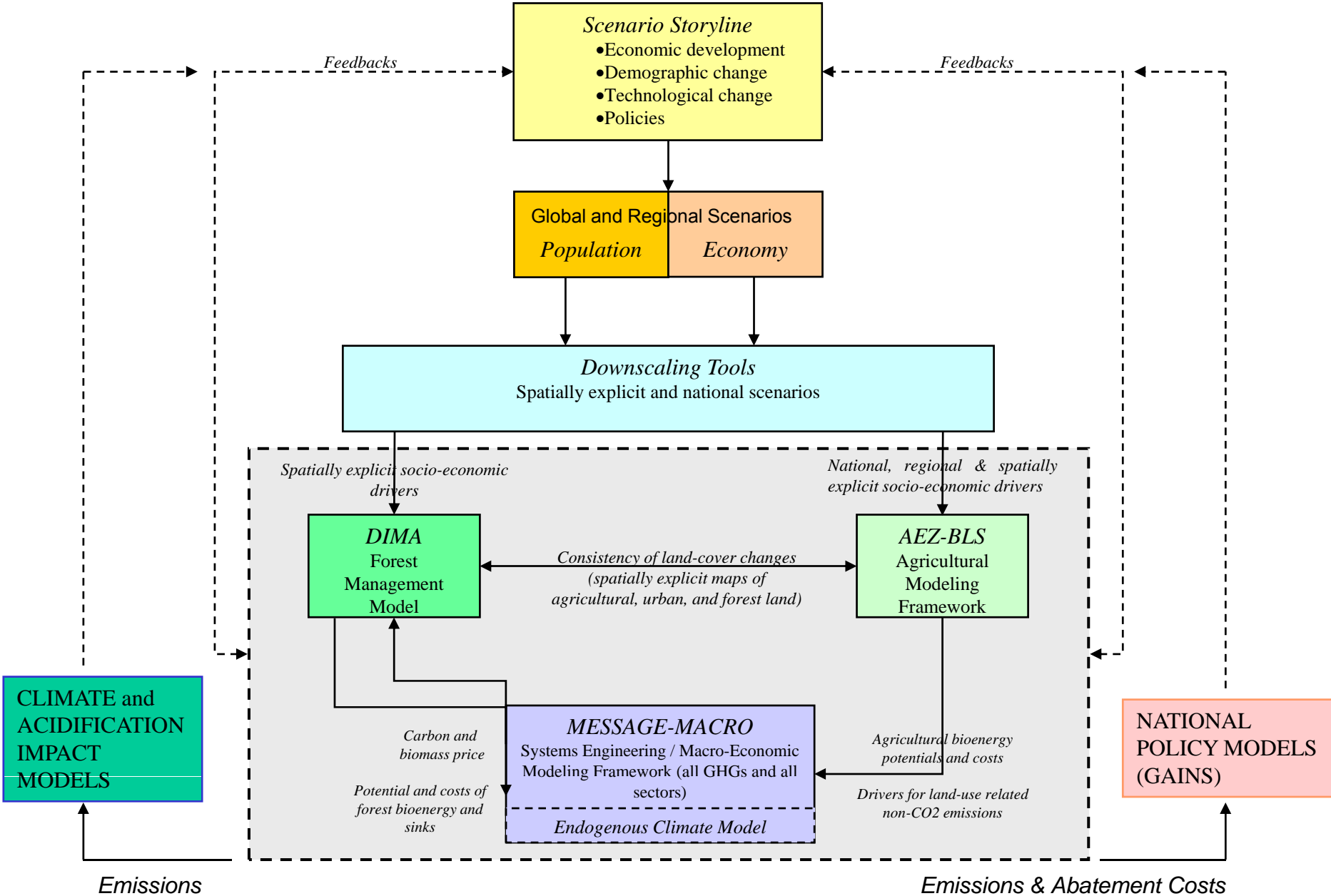
Energy Investments in A2r



Energy Investments in B1



Integrated Assessment Framework



Determinants of Demand

Demographic-Energy Linkages



Scenario Drivers

Scenarios



Scenario Overview

Downscaling

Linkages Energy – Agriculture - Forestry

Forests



Agriculture



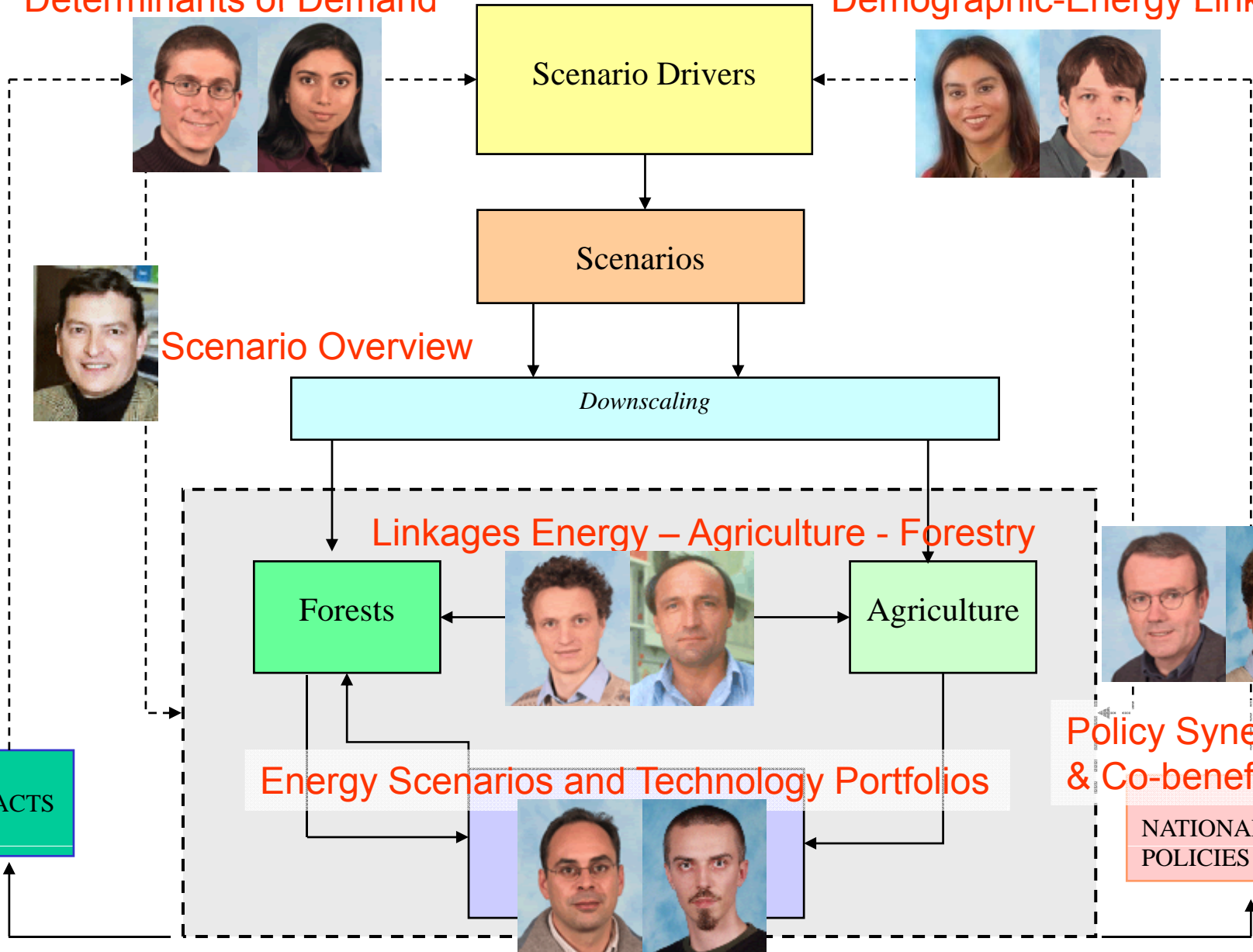
Policy Synergies & Co-benefits

Energy Scenarios and Technology Portfolios

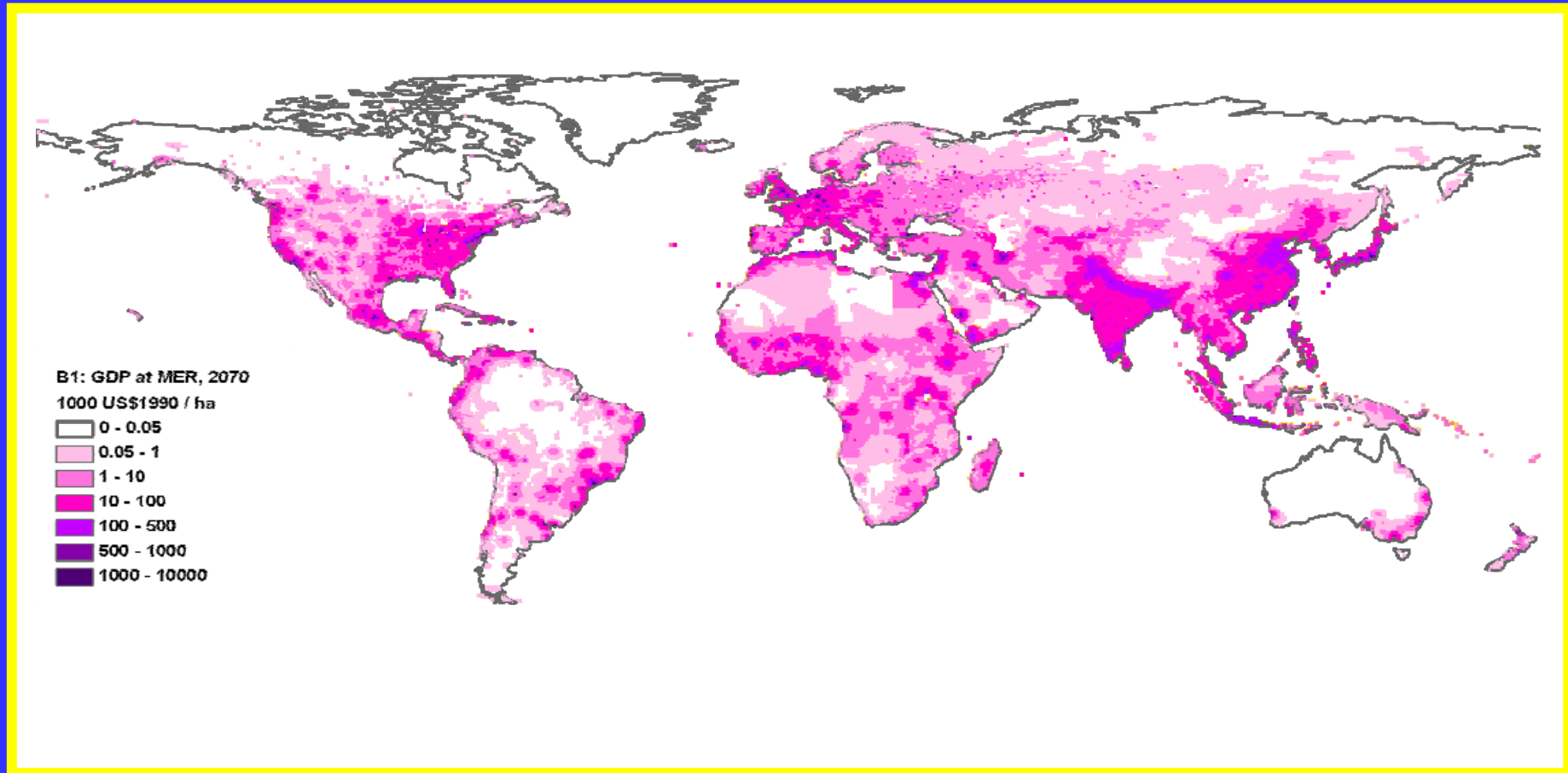


NATIONAL POLICIES

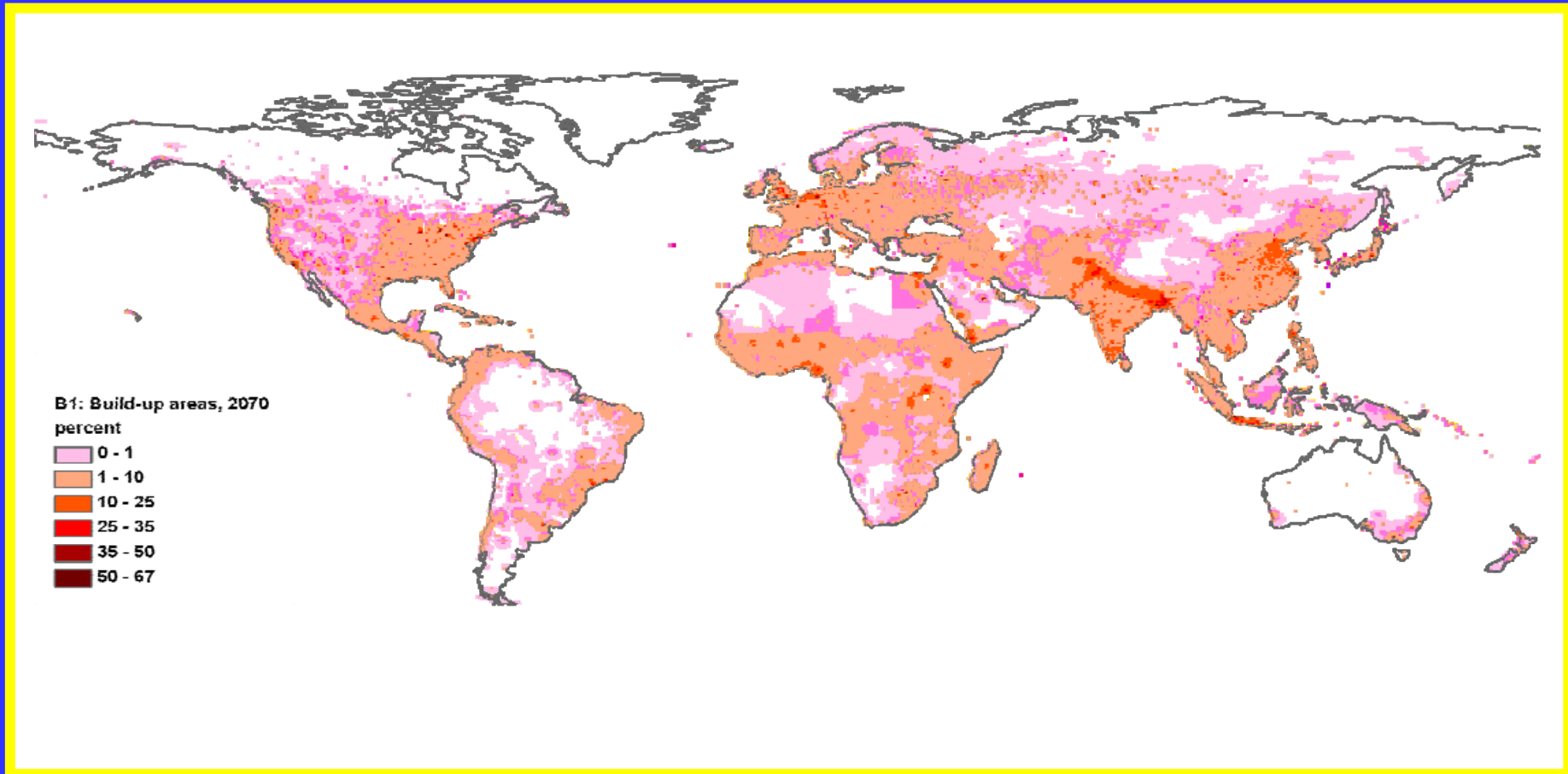
IMPACTS



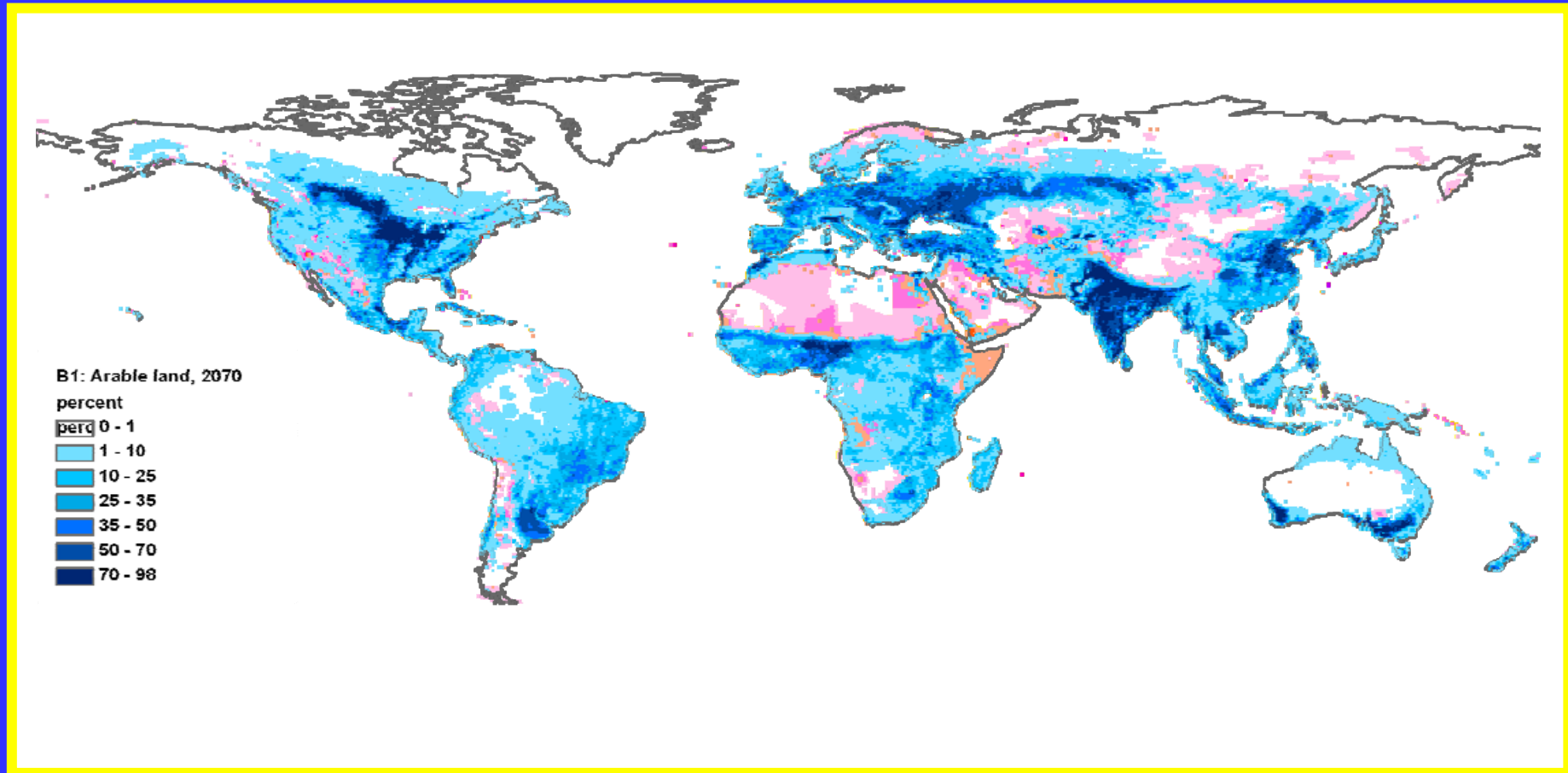
Global GDP Density



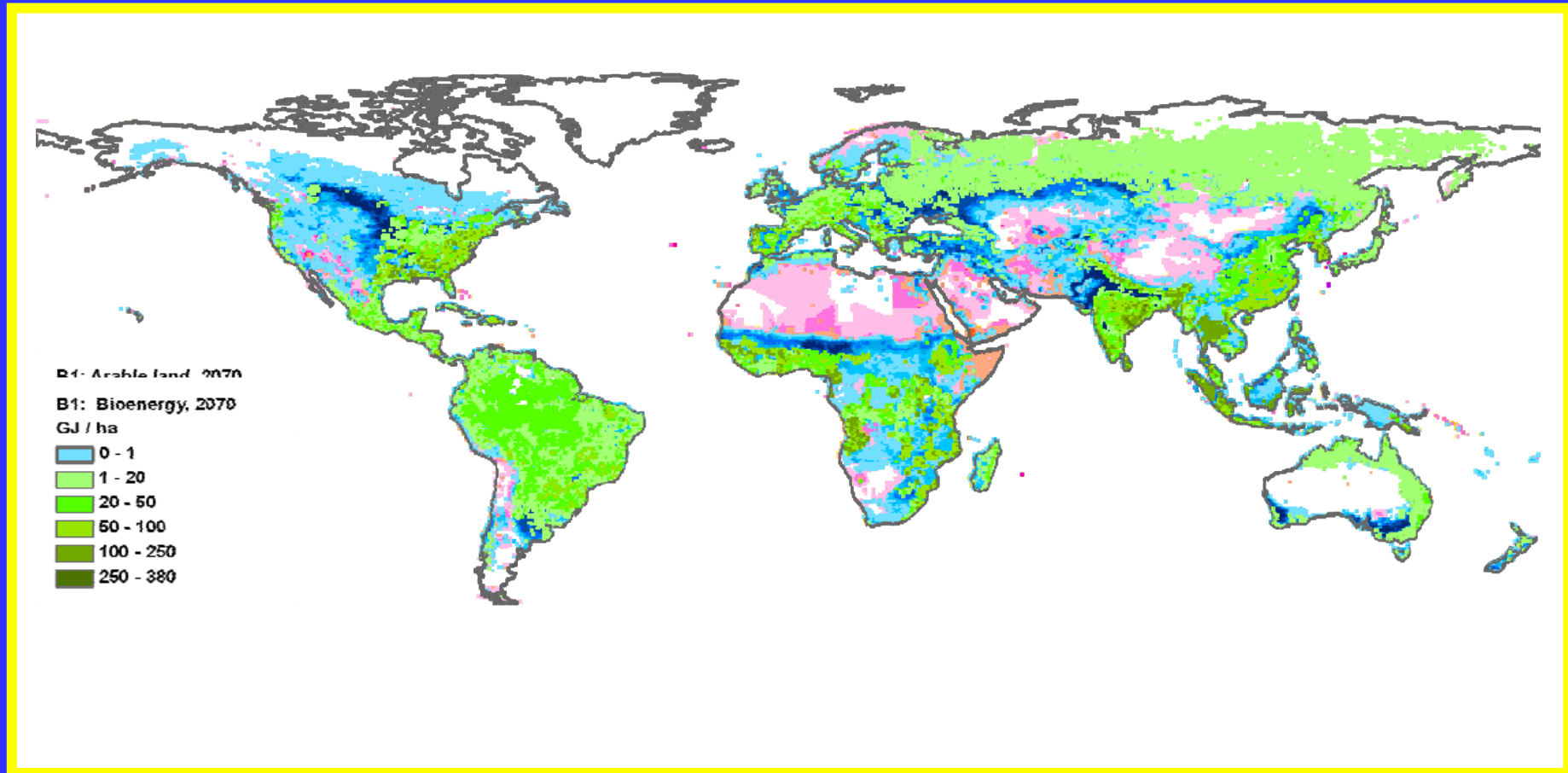
Global Build-Up Area



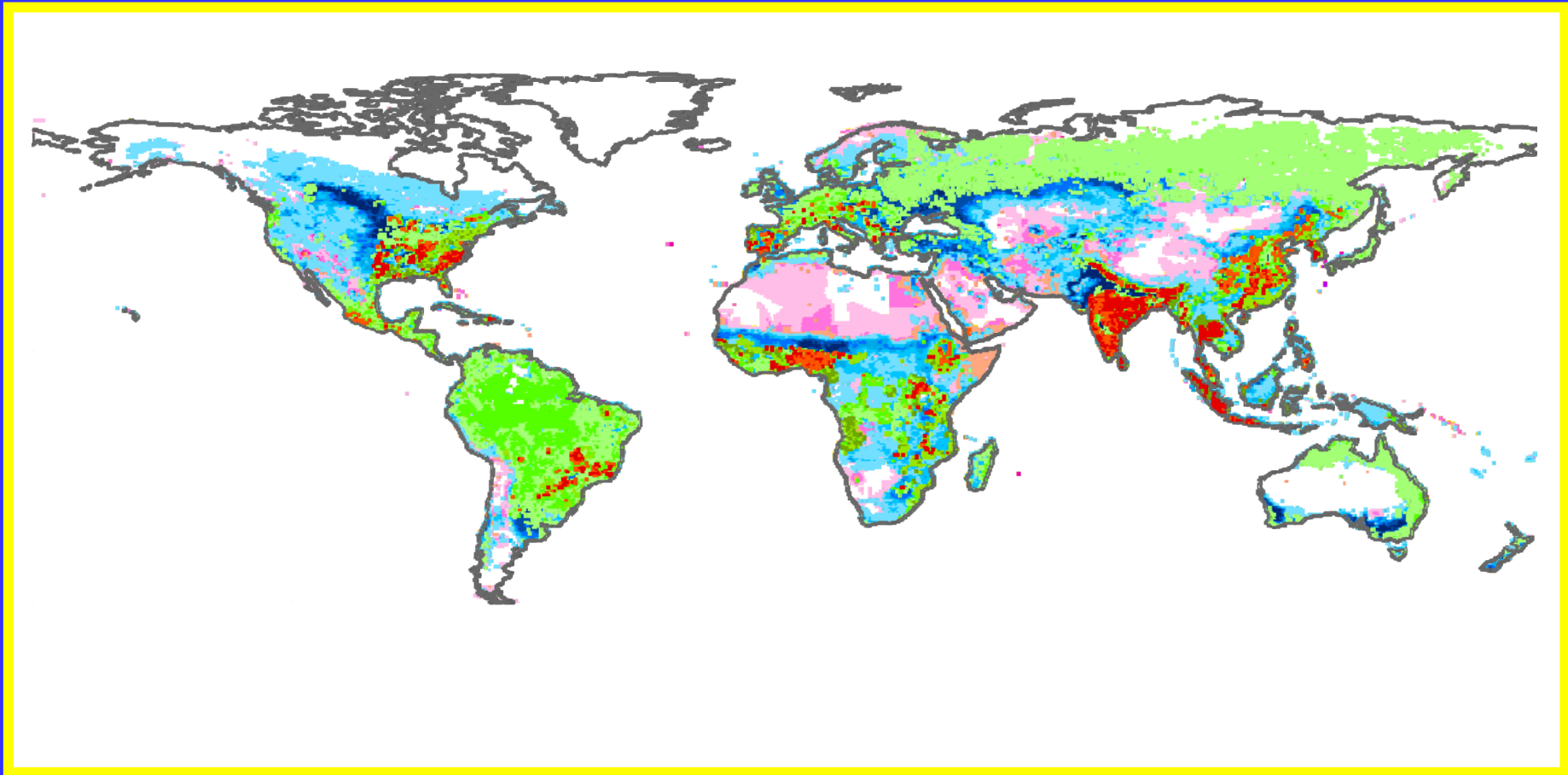
Global Arable Land



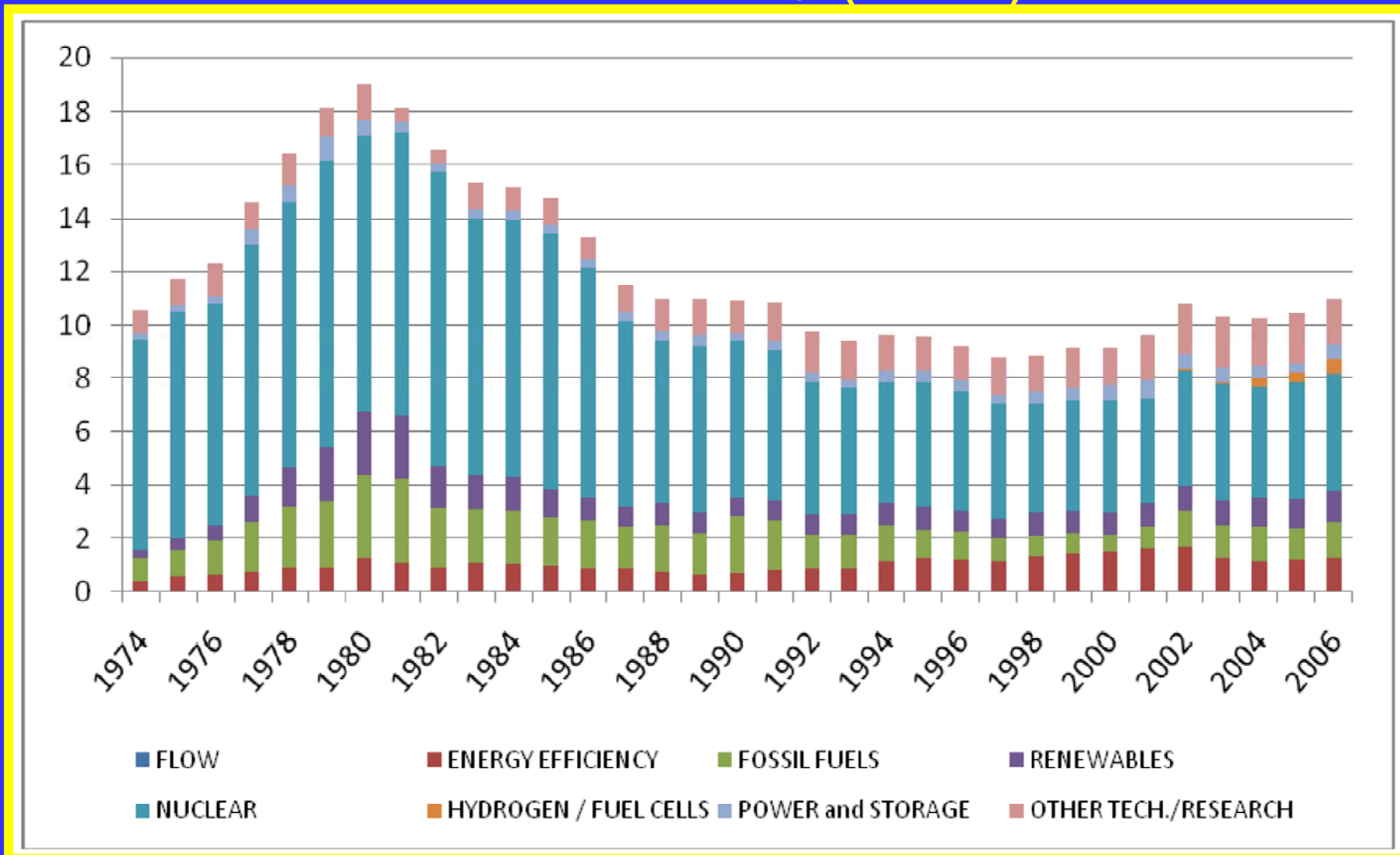
Global Bioenergy Land



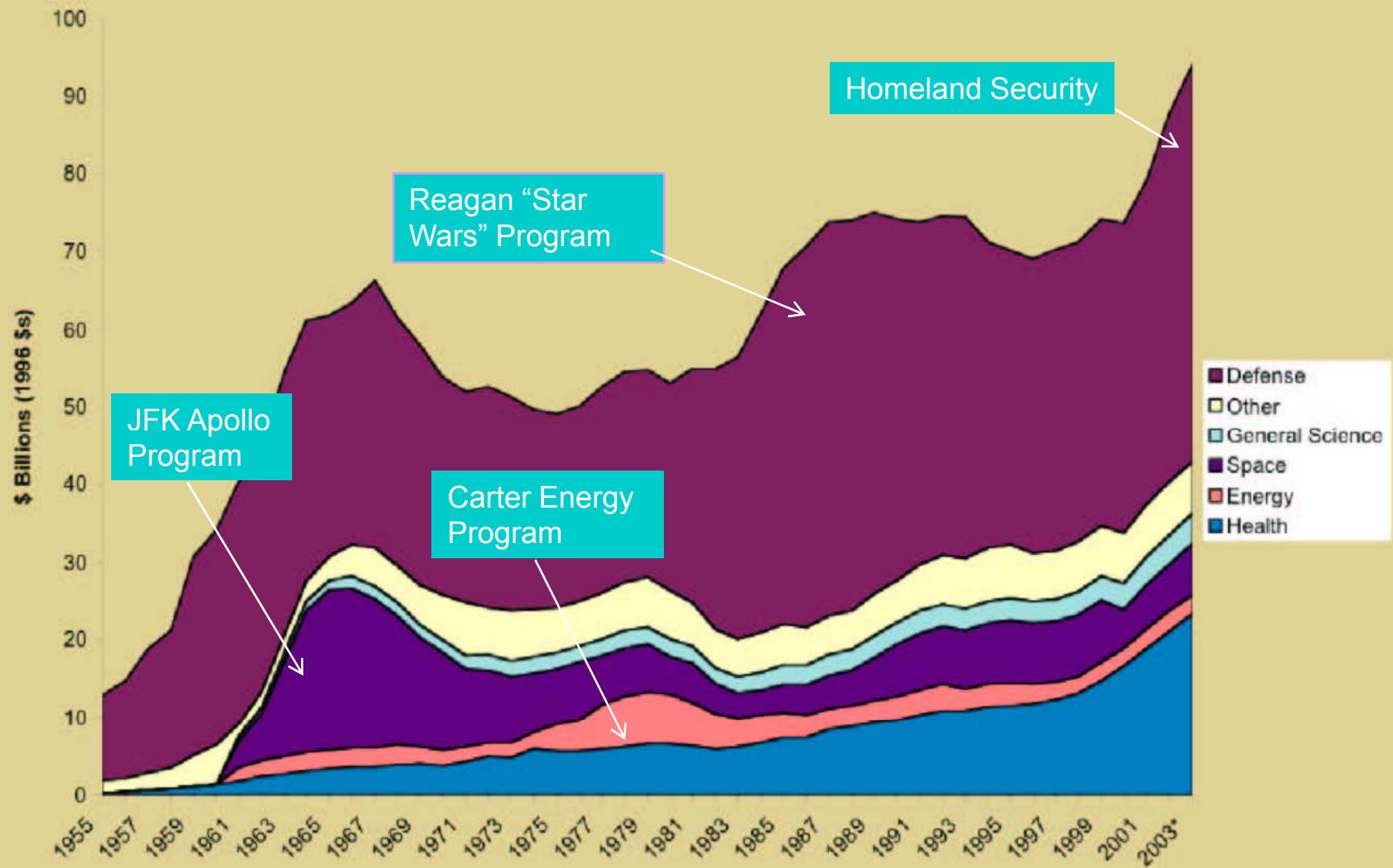
Energy and Food Land Conflicts



Government R&D in IEA countries in billion US\$ (2006)



History of US Federal Government R&D

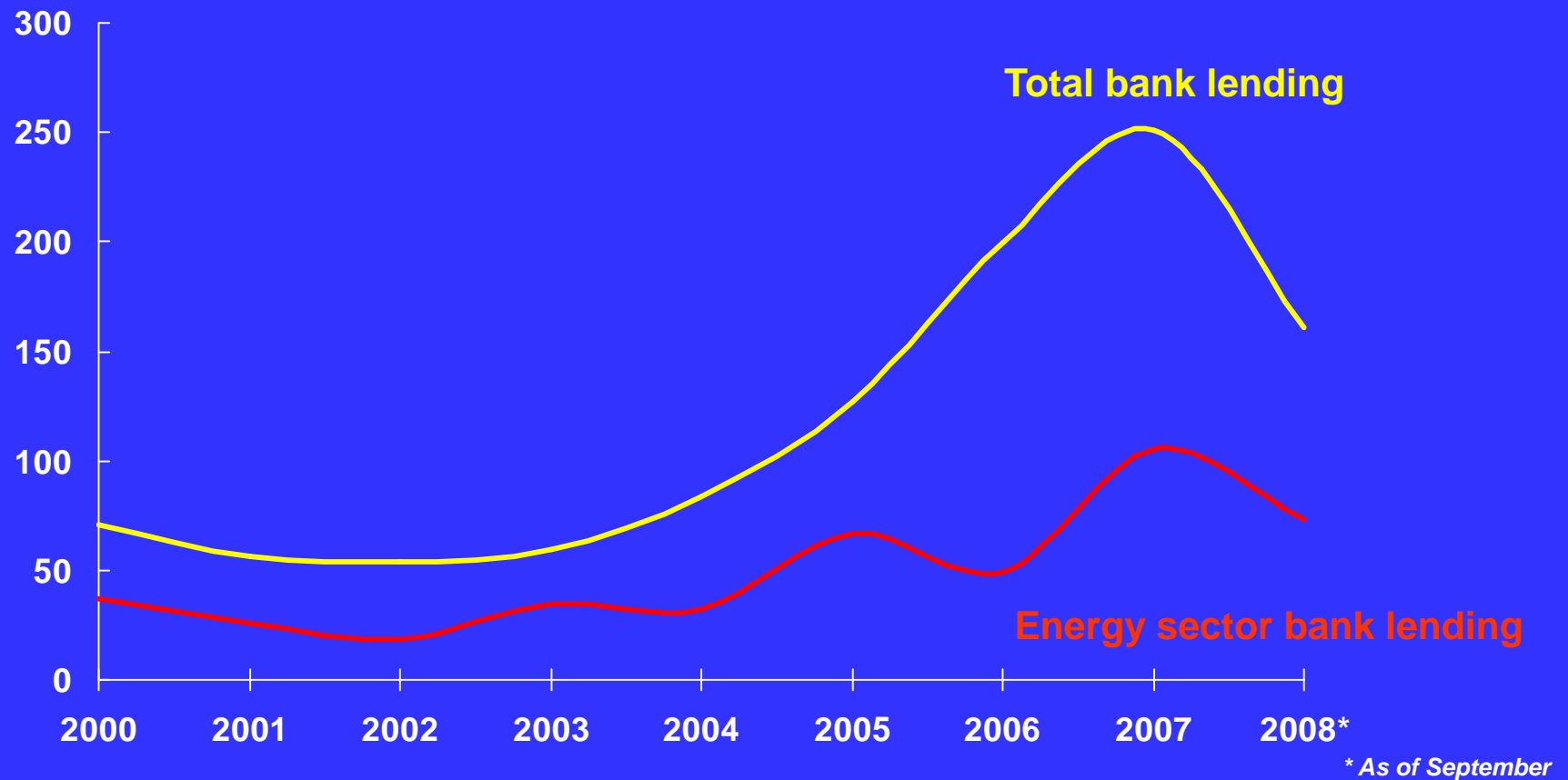


Source: National Science Foundation, Federal R&D Funding by Budget Function, Fiscal Years 2001-03.
* 2002 figures are preliminary, 2003 figures are proposed.

...accounting for one-third of total international bank financing

Bank lending to energy-sector and total bank lending to emerging markets

\$ billions



Towards a more Sustainable Future

- The *magnitude of the change* required in the global energy system will be huge
- The challenge is to find a way forward that addresses *simultaneously* climate change, security and equity issues.
- *Paradigm change is needed*: radical improvements in energy end-use efficiency, new renewables, advanced nuclear and carbon capture and storage.
- Needs to be *globally integrated* but with maximum support of countries and local levels.
- In the best spirit of science: *fact-based and peer-reviewed*



IIASA

International Institute for Applied Systems Analysis
and its international partners present

www.GlobalEnergyAssessment.org

www.GlobalEnergyAssessment.org

Towards a more Sustainable Future

- The *magnitude* of the change required is *huge*.
- The challenge is to find a way forward that addresses all the issues *simultaneously*.
- A paradigm shift is needed: energy end-use efficiency, new renewables, and, if concerns can be resolved, carbon capture and storage and nuclear.