MESSAGE-MACRO (IIASA)

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Tsukuba, Japan

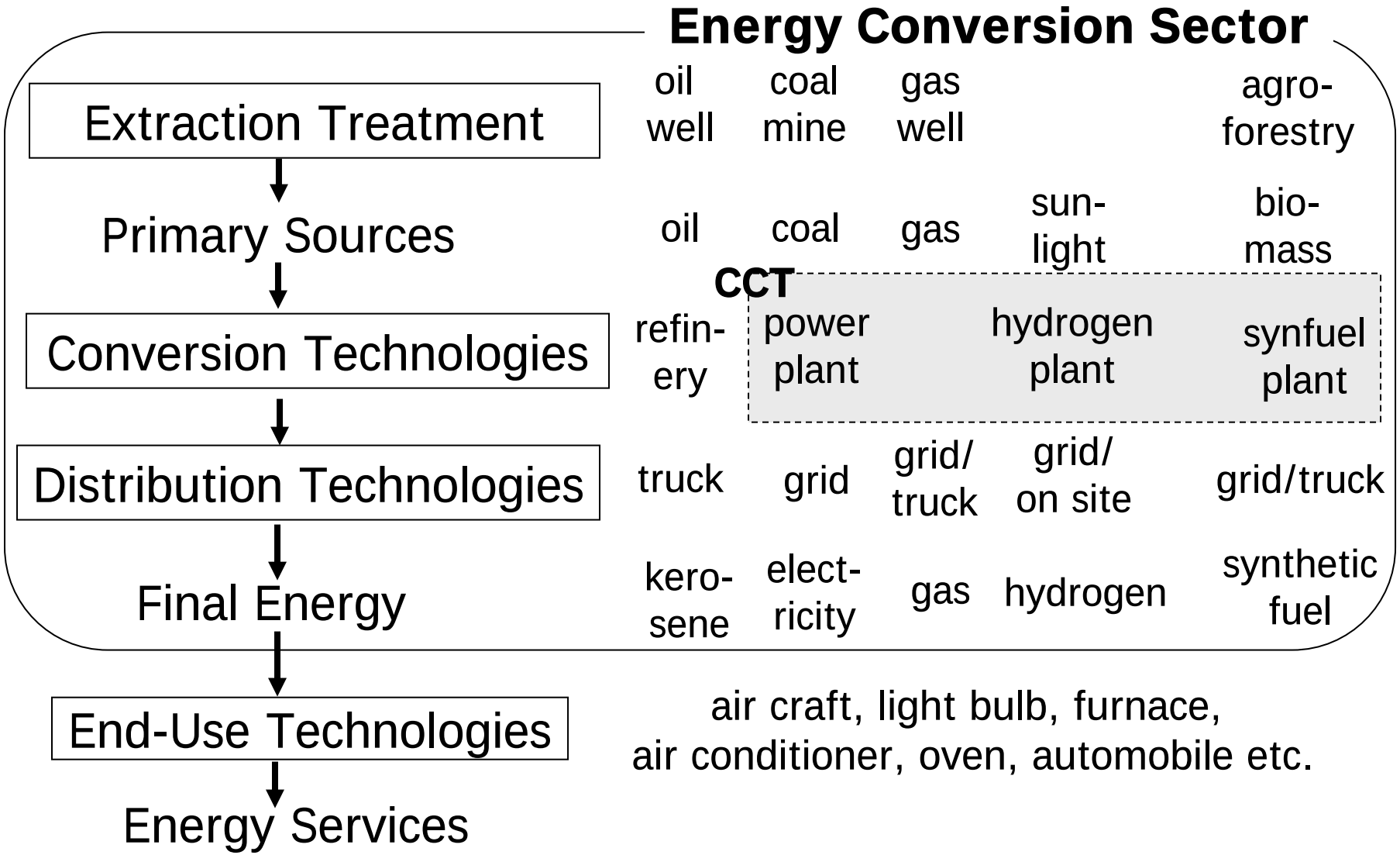
Key Design Characteristics

- ***Participating Model:*** **MESSAGE-MACRO**
- ***Model Type: Coupled Systems Engineering and Macroeconomic model***
- ***Participating Modelers: Volker Krey, Shilpa Rao, Keywan Riahi***
- ***Time Step: 10 years (annual for access modeling)***
- ***Time Frame: 2000-2100***
- ***Solution Type: Inter-temporal optimization (cost minimization)***
- ***Equilibrium Type: Partial Equilibrium***
- ***Underlying Computing Framework: MESSAGE (C, Cplex) and MACRO (GAMS)***

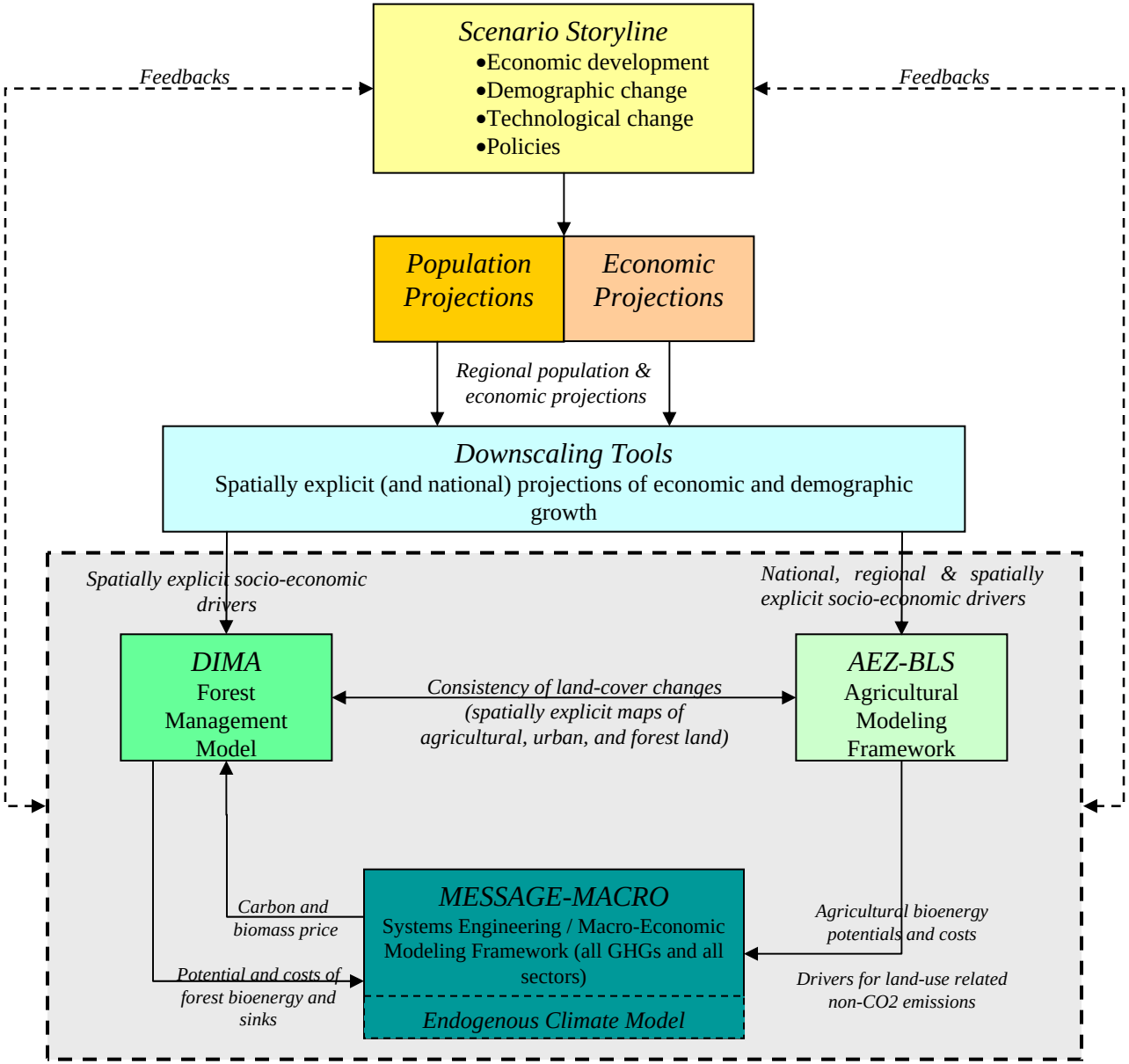
Inputs and Outputs

- **Key inputs**
  - ***Demographics: Population, Income cohorts (access)***
  - ***Economic: reference GDP, household budgets (access)***
  - ***Resources: Conventional & unconventional fossil fuels, renewable potentials (solar, wind, biomass, geothermal)***
  - ***Technology: full energy chain (extraction all the way to consumer services)***
- **Key outputs**
  - ***Economic: GDP, prices (fuels, GHG emissions), investments***
  - ***Energy: technology specific capacity and activity pathways for all sectors***
  - ***Agriculture: commodity, price and land-use change (linked to BLS/AEZ and Dima models)***
  - ***Emissions: All GHGs and raditively active substances***
  - ***Climate: alternative implementations (GHG concentrations, forcings, temperature)***

The Reference Energy System MESSAGE

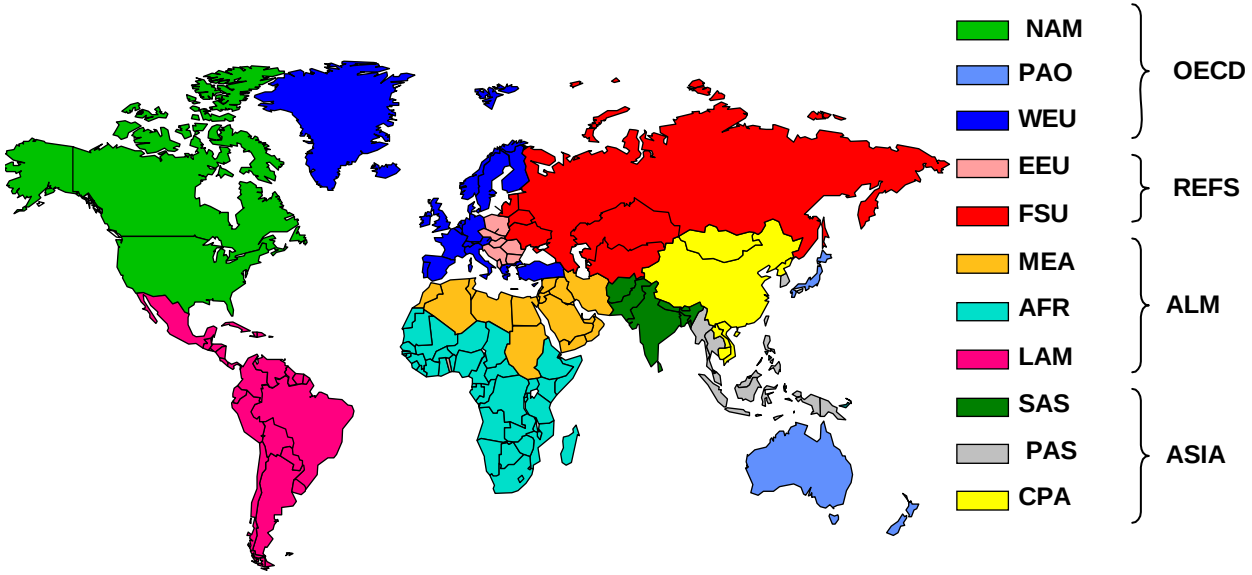


IIASA Modeling Framework



Regional Scope & Other Detail

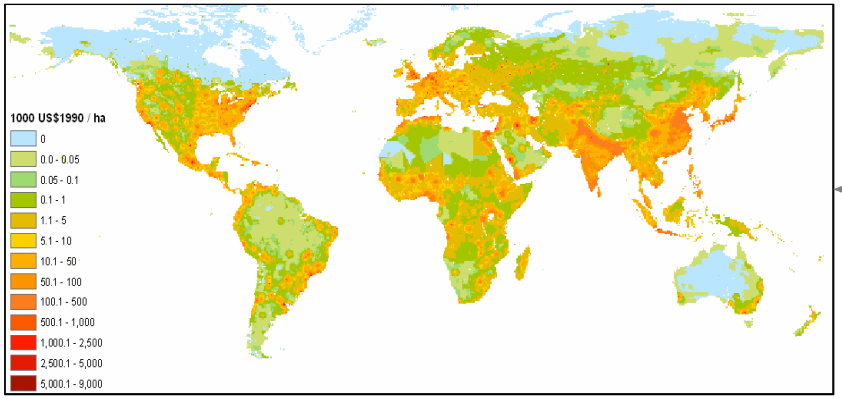
- **Regional Details:**
  - ***Regional Scope: Global***
  - ***Number of Sub-Regions: 11***
  - ***Asian Regions: Pacific OECD (PAO), Centrally Planned Asia (CPA), South Asia (SAS), Pacific Asia (PAS)***



1 NAM North America
2 LAM Latin America & The Caribbean
3 WEU Western Europe
4 EEU Central & Eastern Europe
5 FSU Former Soviet Union
6 MEA Middle East & North Africa
7 AFR Sub-Saharan Africa
8 CPA Centrally Planned Asia & China
9 SAS South Asia
10 PAS Other Pacific Asia
11 PAO Pacific OECD

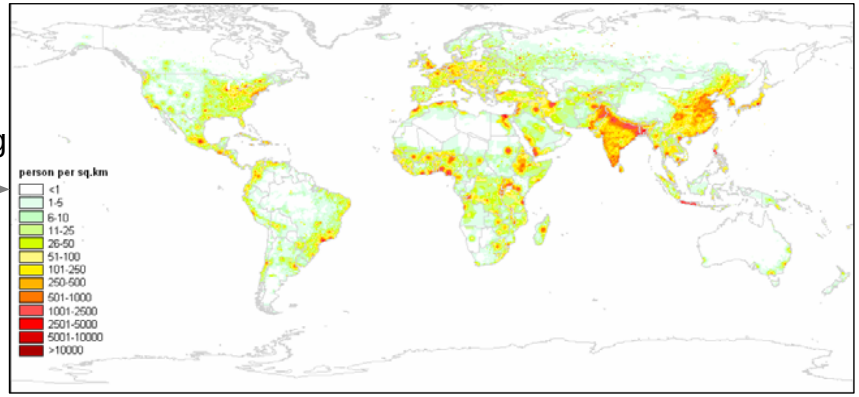
Spatial modeling of Land-use

Dynamic GDP maps (to 2100)

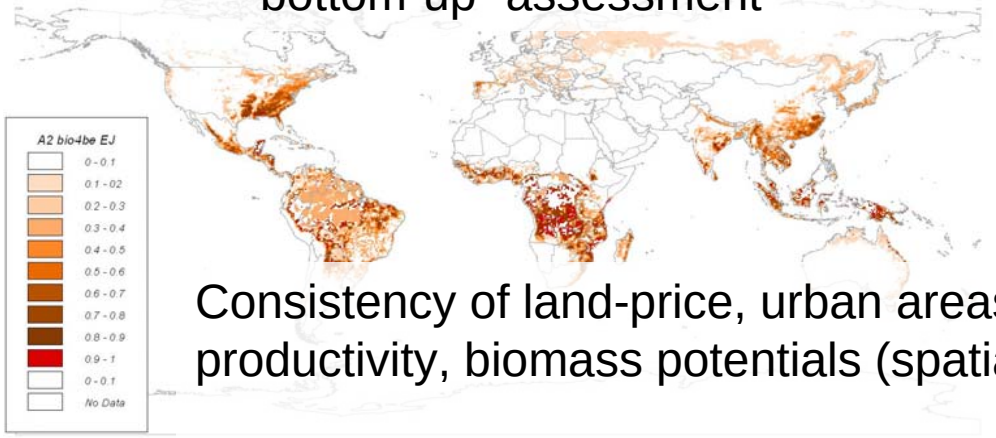


"Top-down"
Downscaling

Dynamic population density (to 2100)

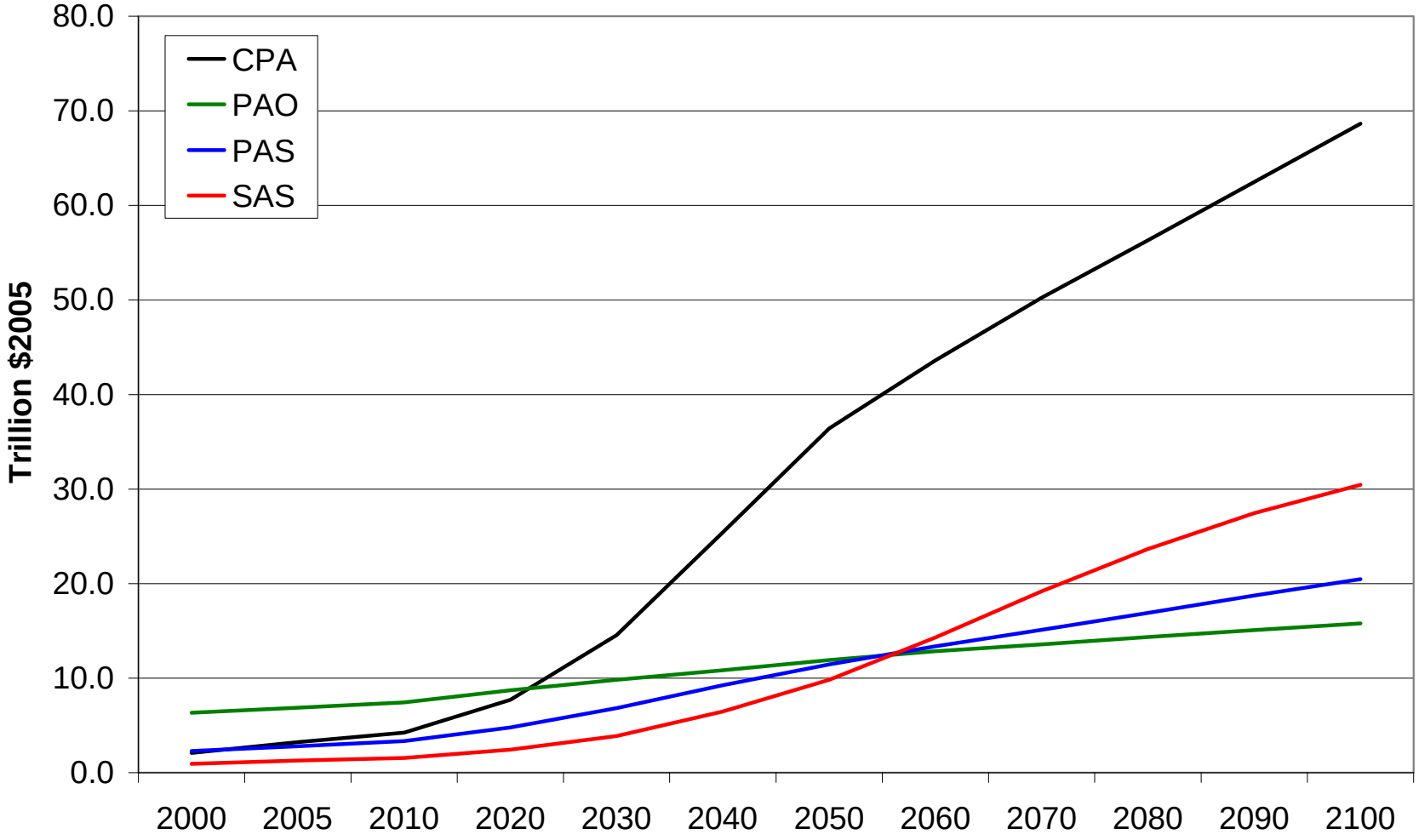


Development of bioenergy potentials
"bottom-up" assessment

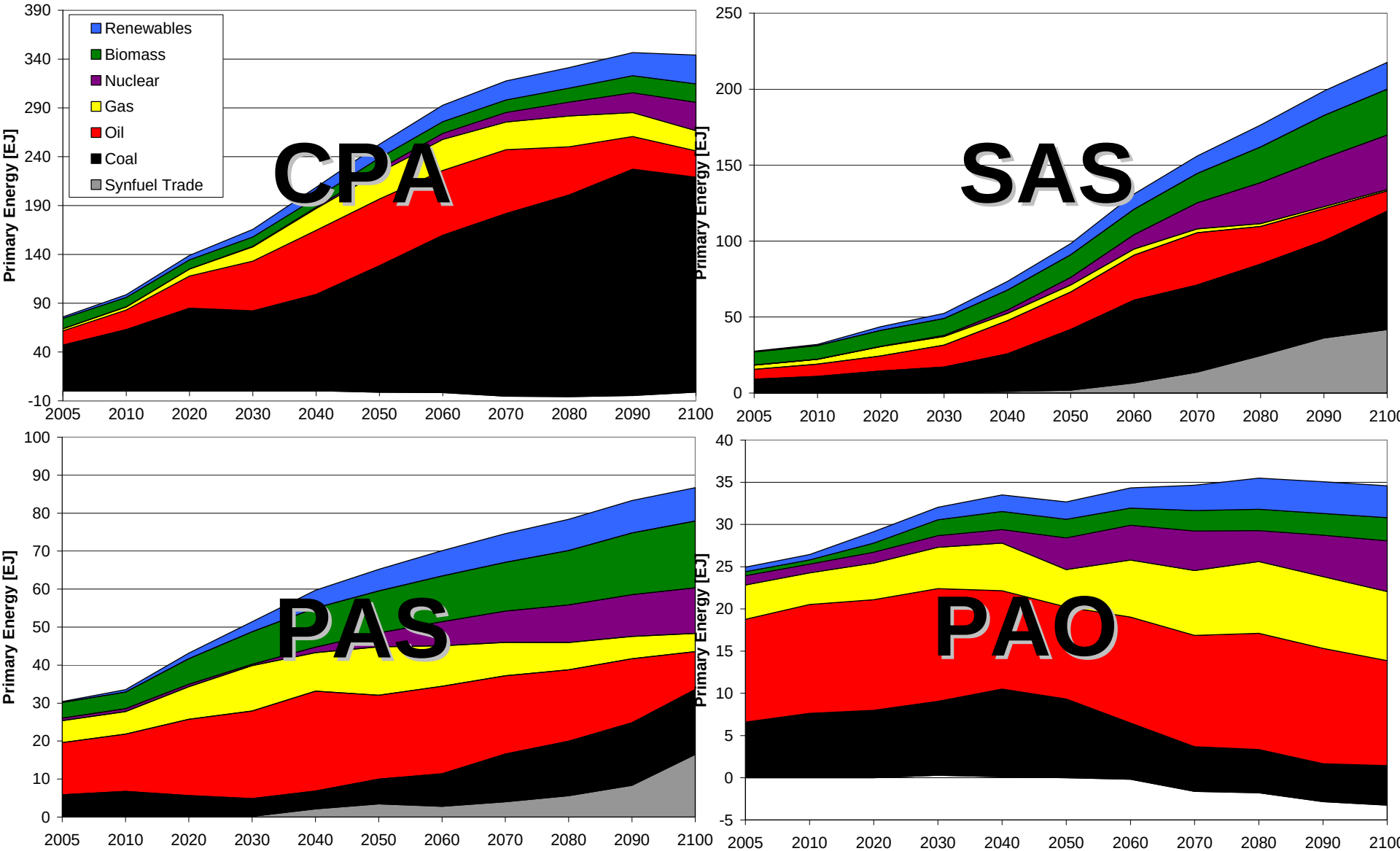


Consistency of land-price, urban areas, net primary productivity, biomass potentials (spatially explicit)

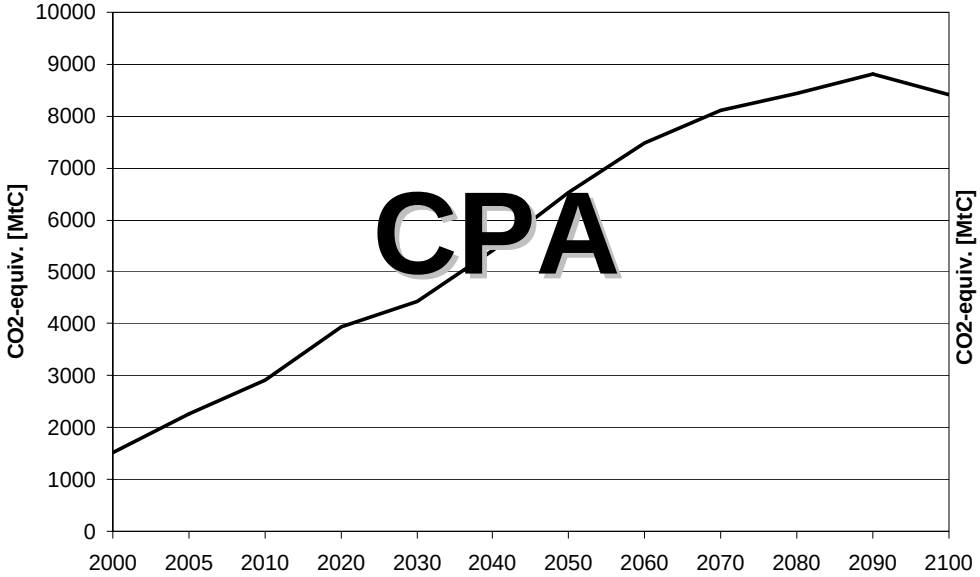
A2 Baseline: Population, Urbanization, GDP

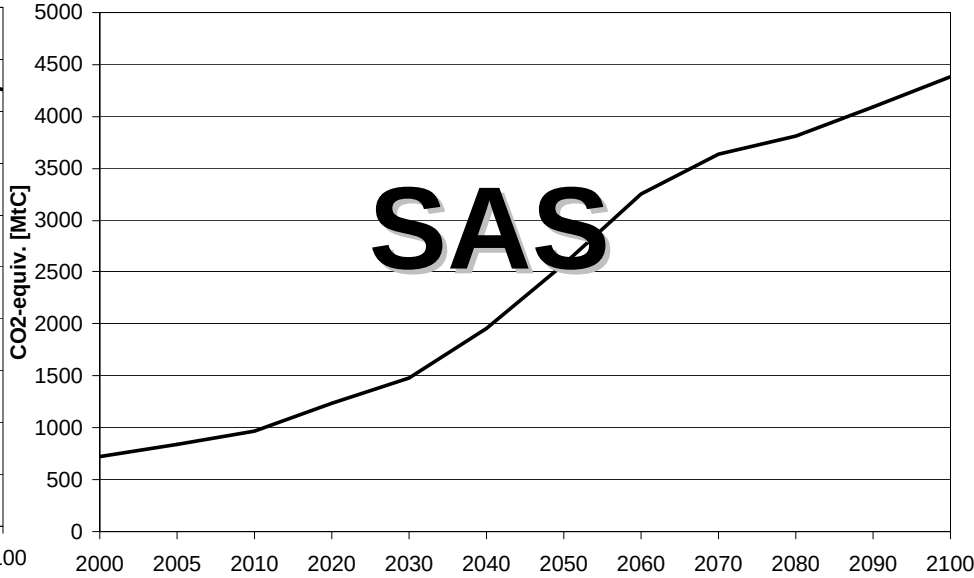


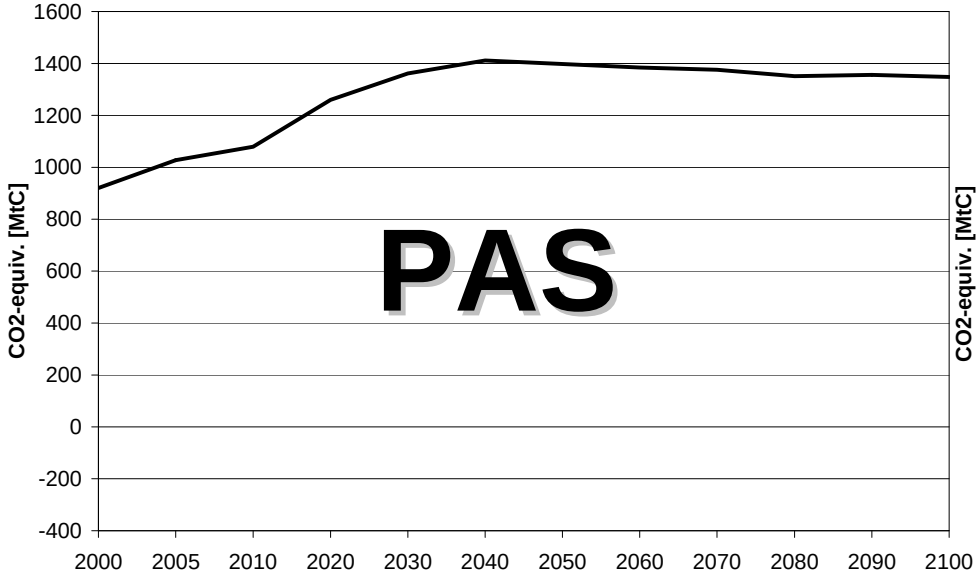
A2 Baseline: Primary Energy

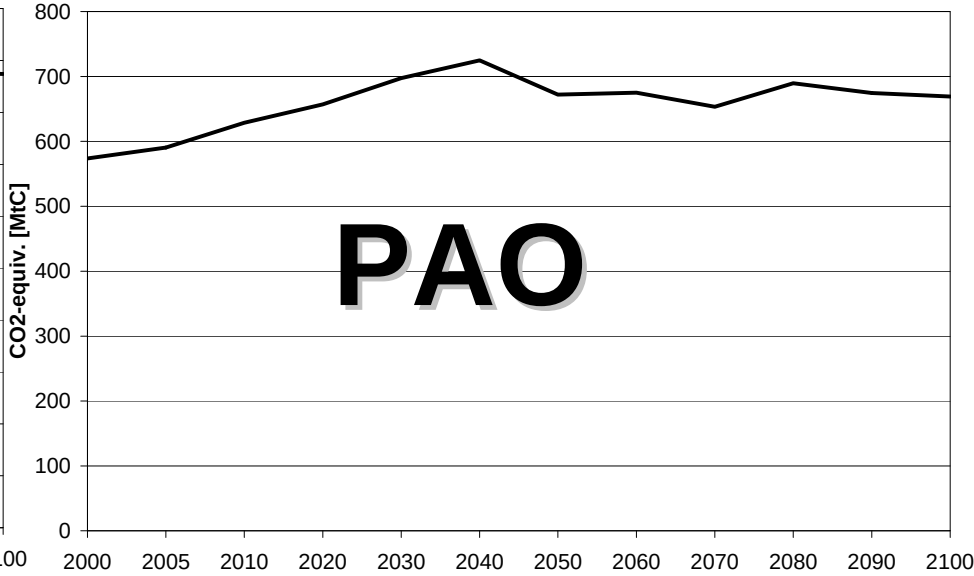


A2 Baseline: GHG Emissions

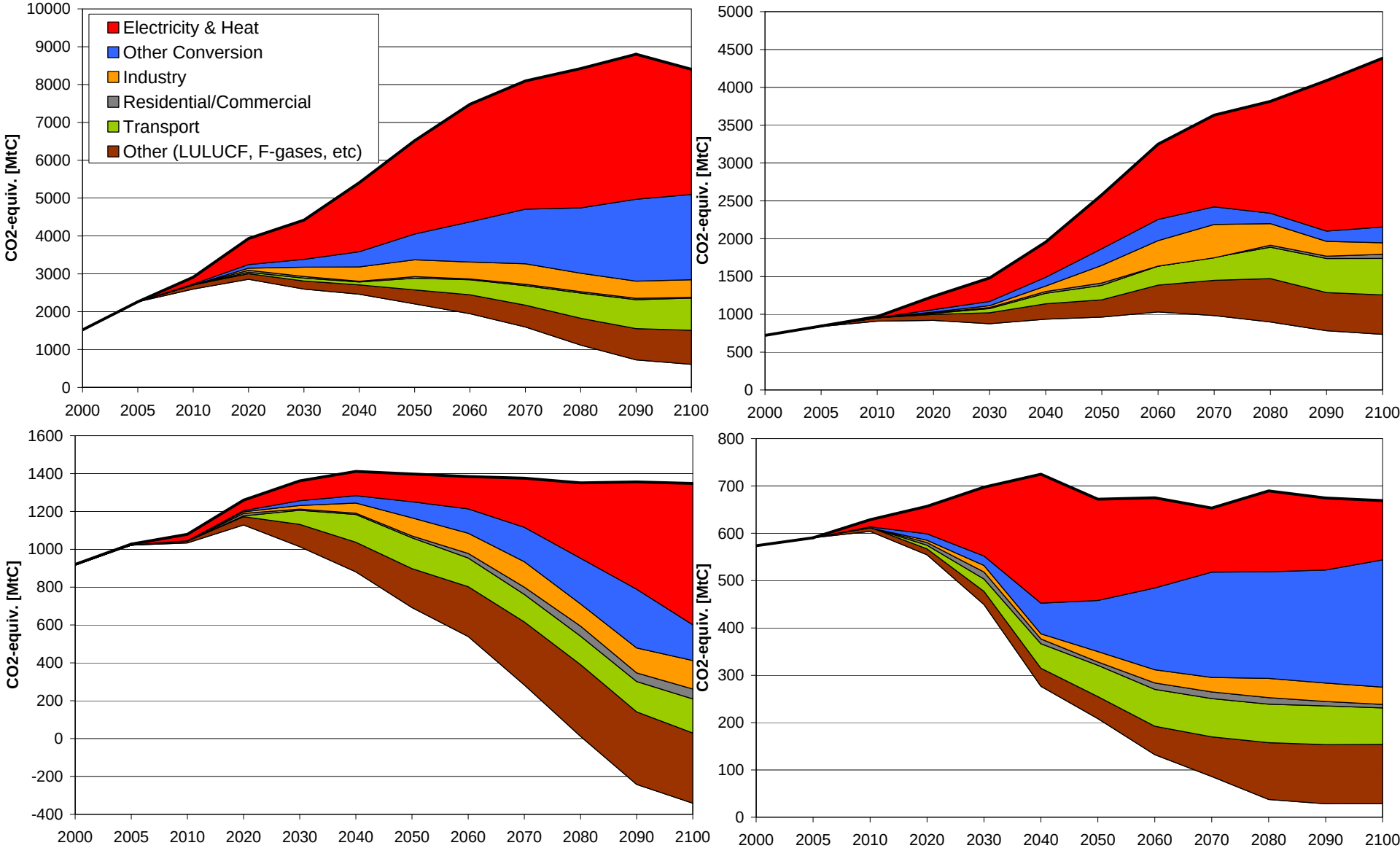








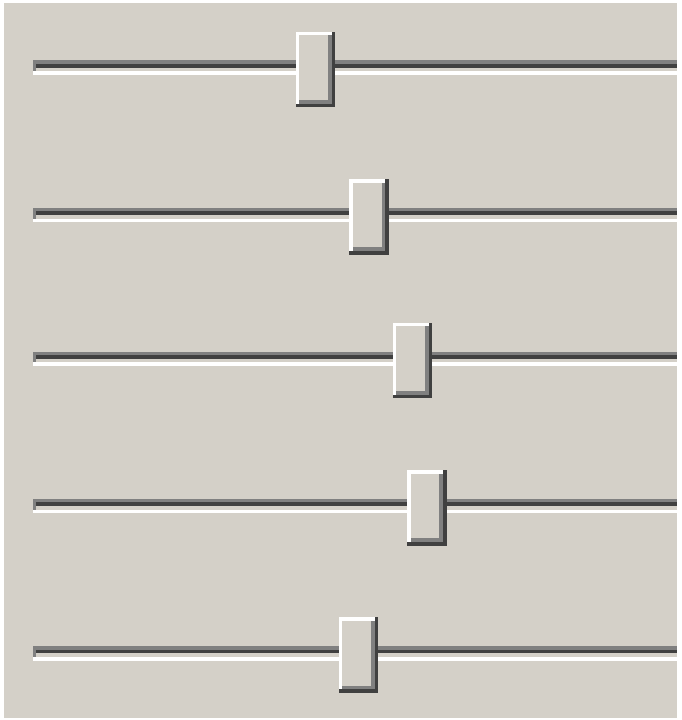
A2 550 ppmv: Sectoral Mitigation

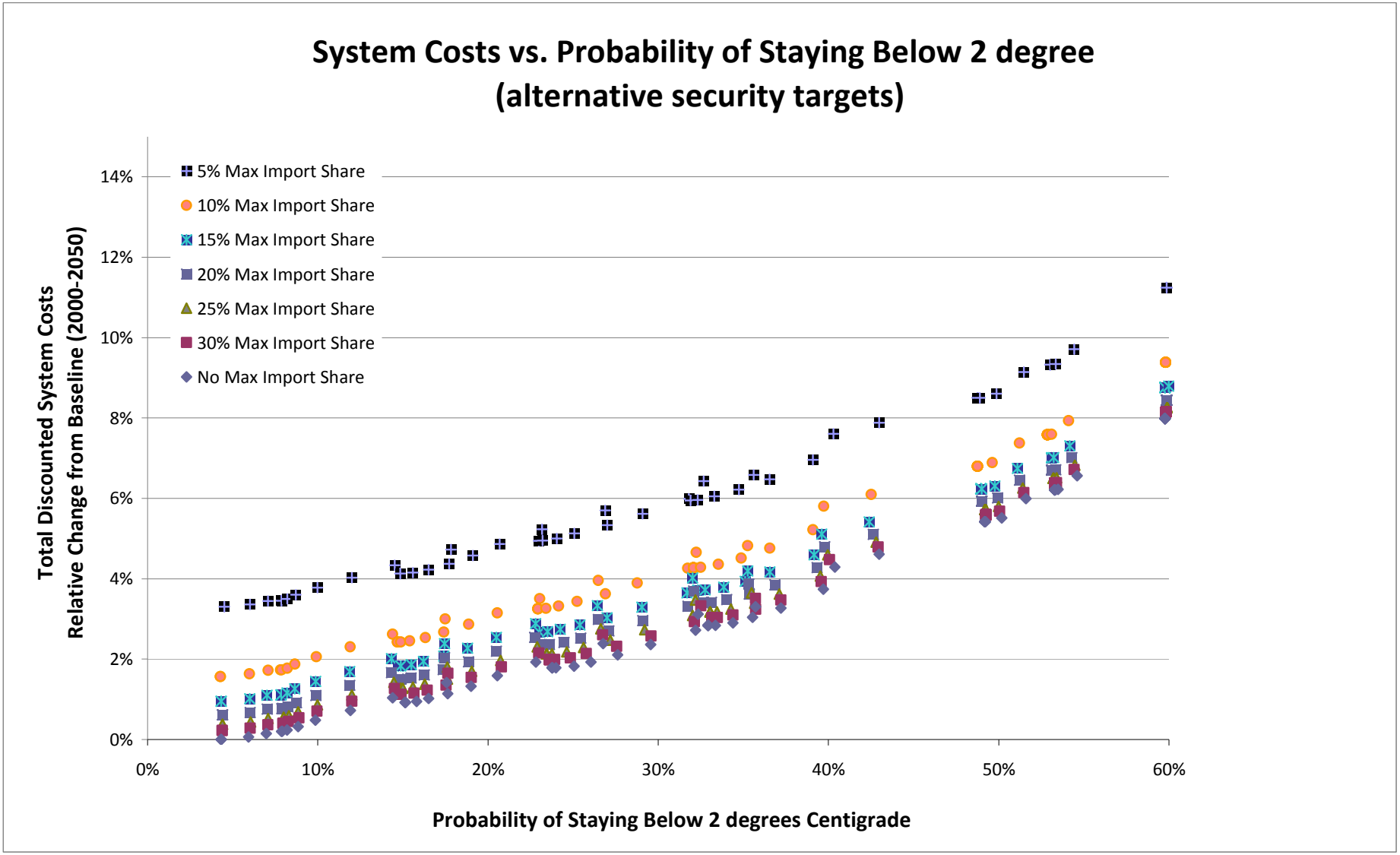


The Nature of the Energy Transition will Depend on the Ranking of (Subjective) Policy Priorities

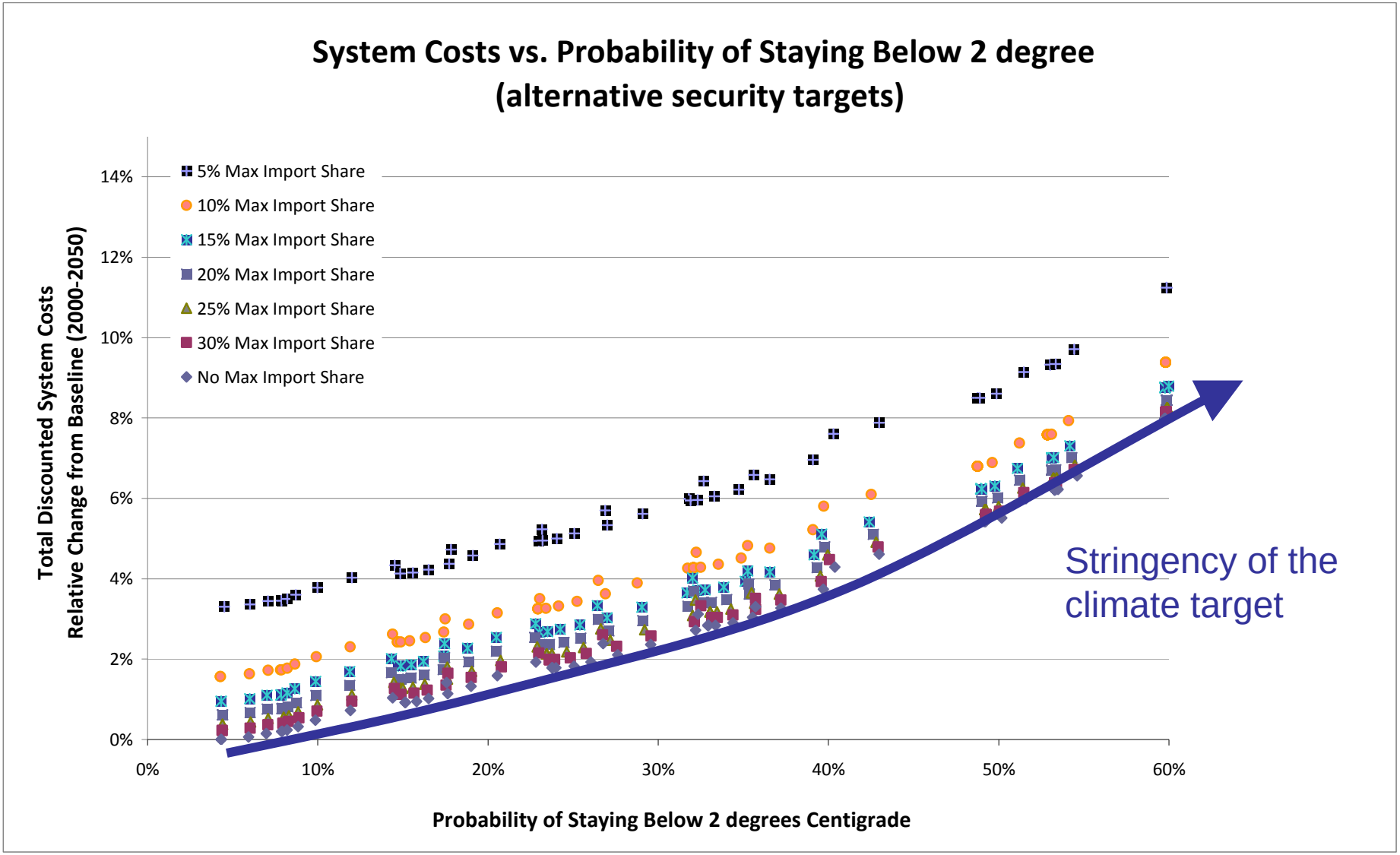
More preferable, but more difficult →

		Reservation Level	Aspiration Level
Environment	Mid-term GHG/pollutant emissions levels (2050)	+80%	-80%
	Long-term climate target (prob. of 2C)	5%	70%
Energy Security	Regional energy trade (share of PE)	100%	5%
	Diversity of trade (index)	0	1
Economy	Energy system cost	X trill	Y trill





More than 600 scenarios!



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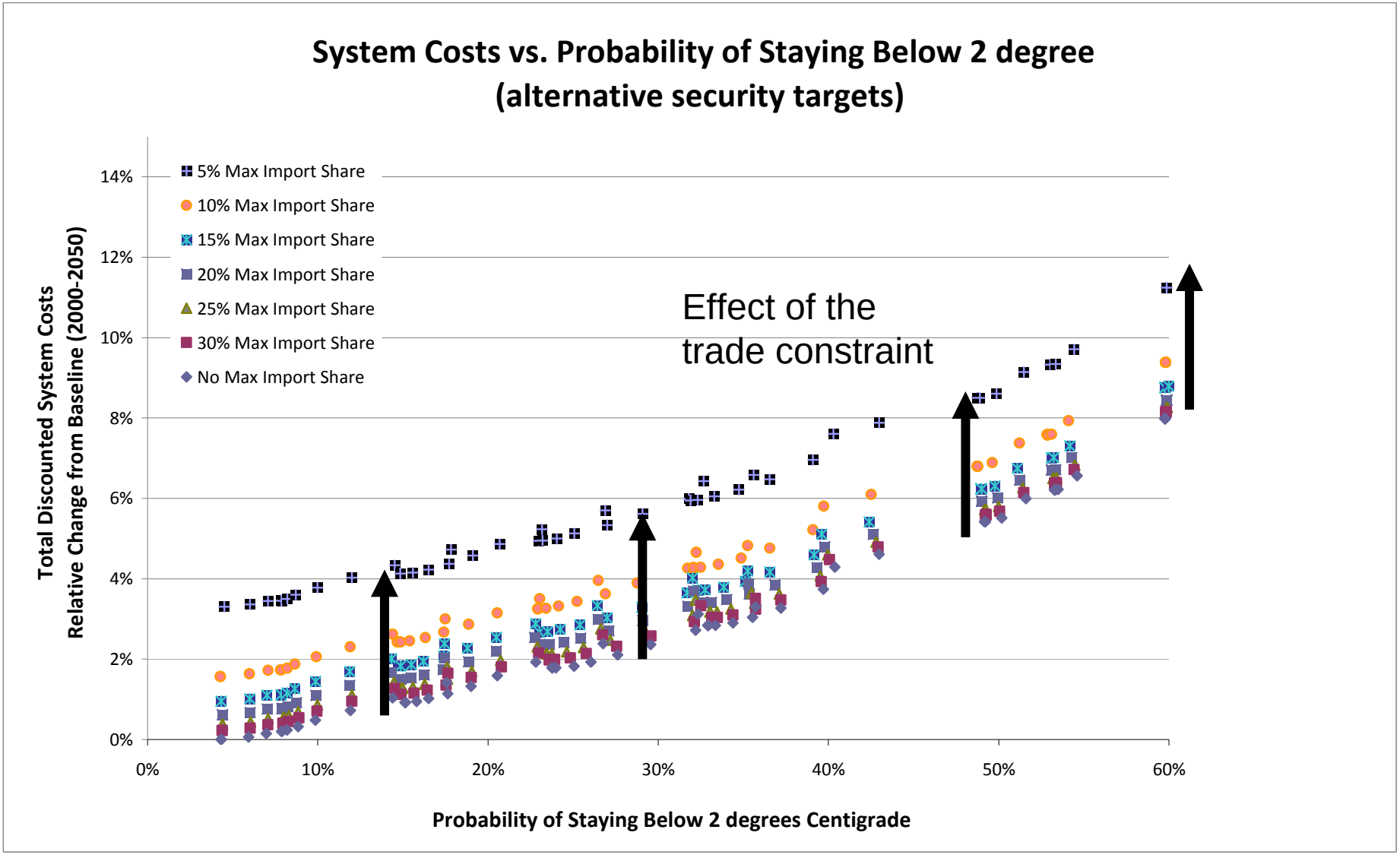

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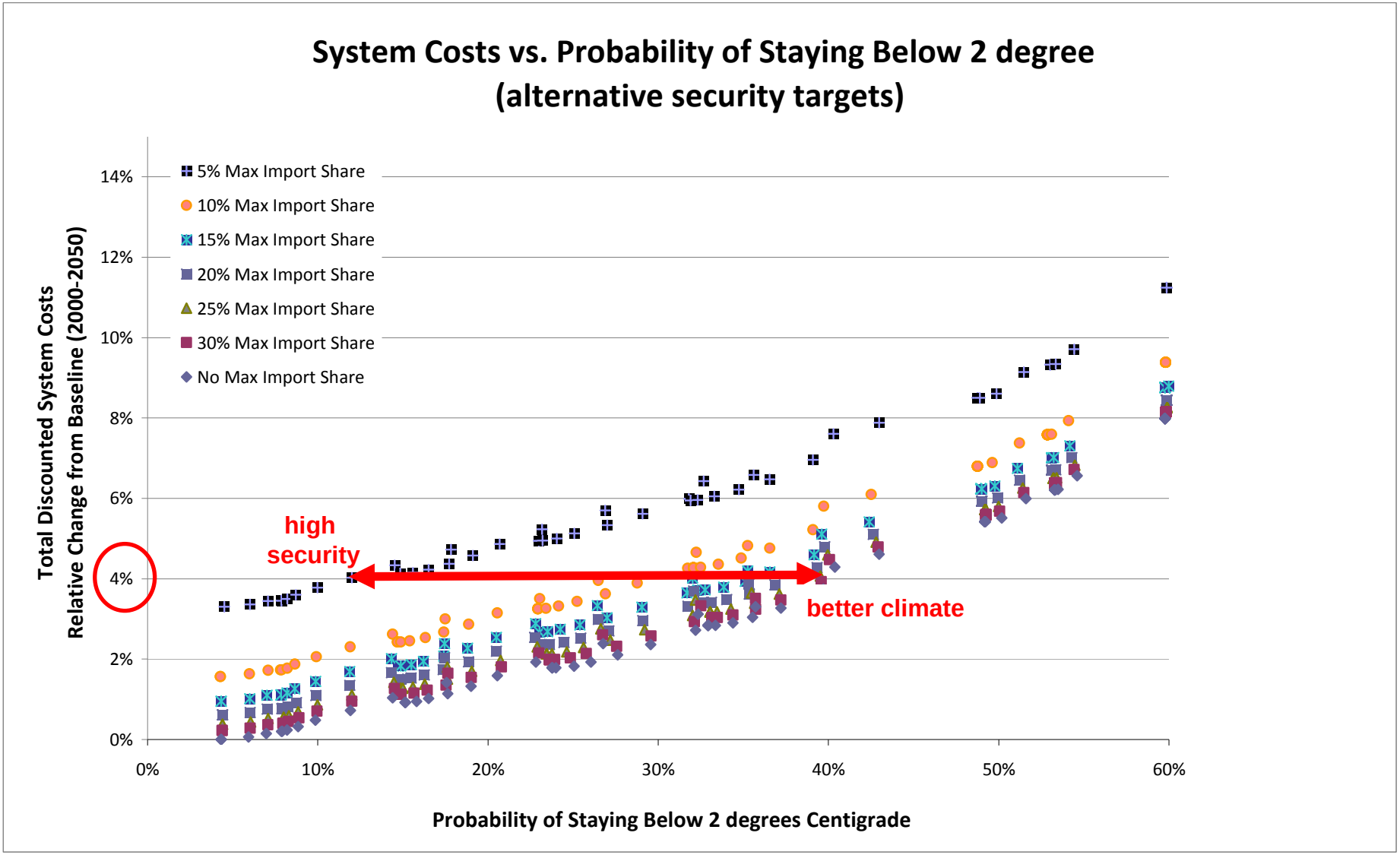
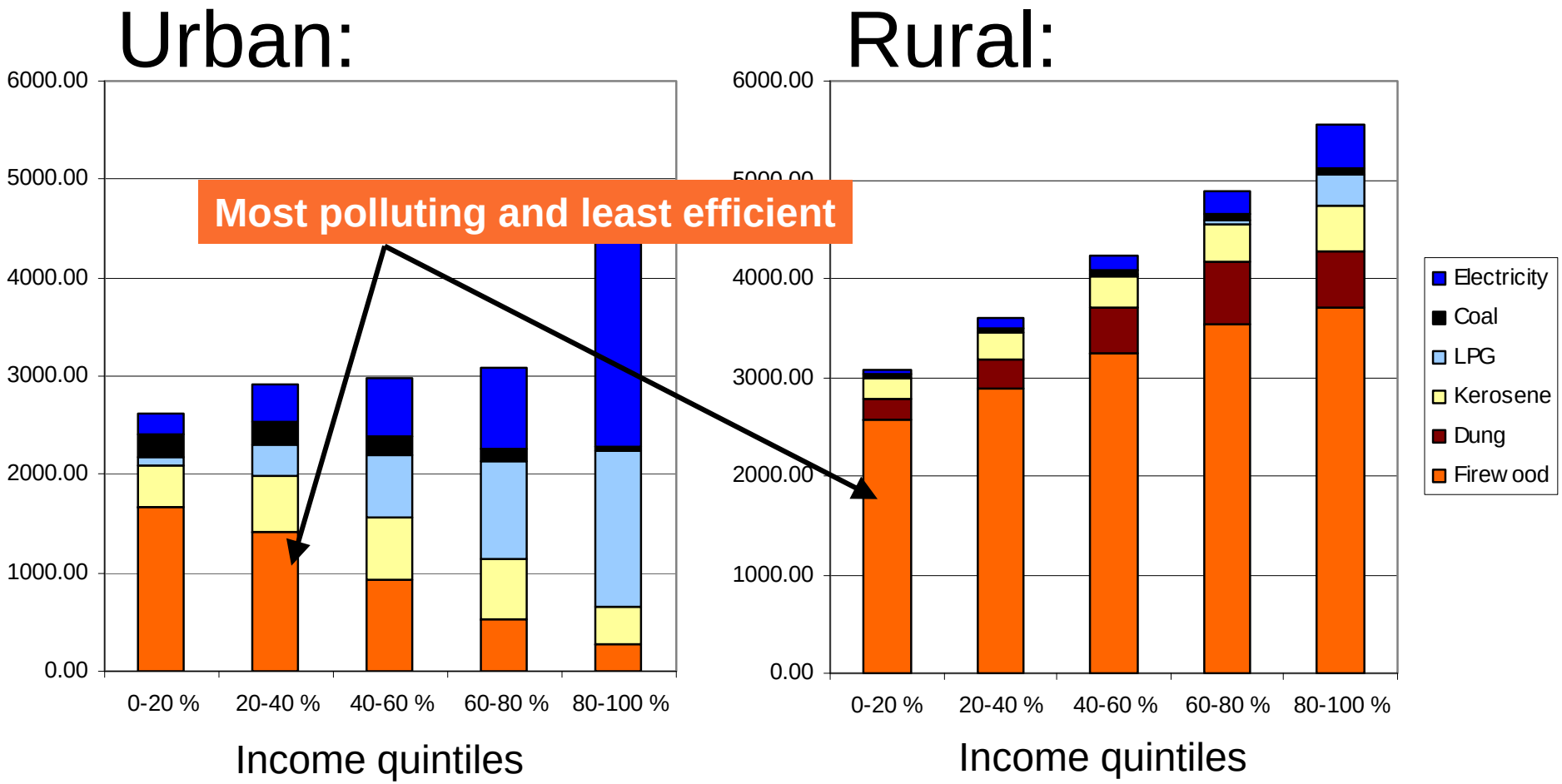


More than 600 scenarios!

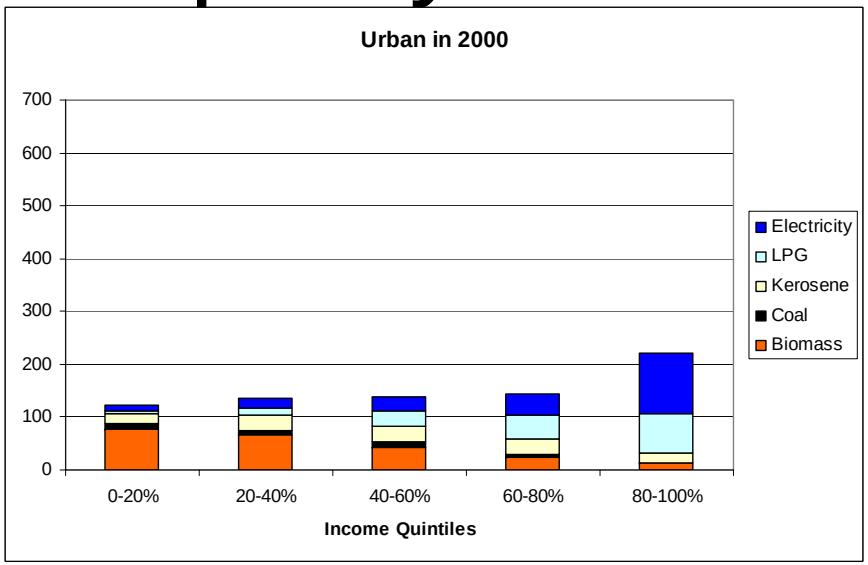
Income vs. energy consumption in India (MJ/cap/a, 2000)

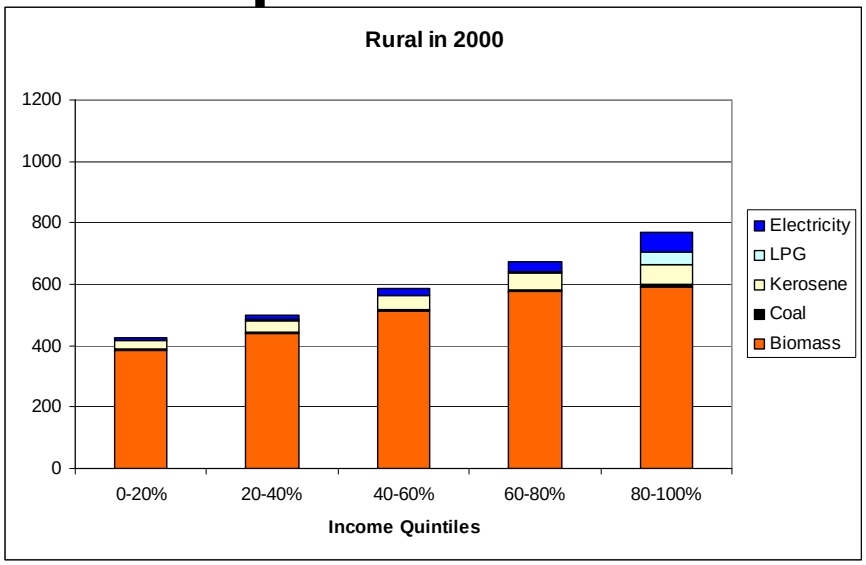


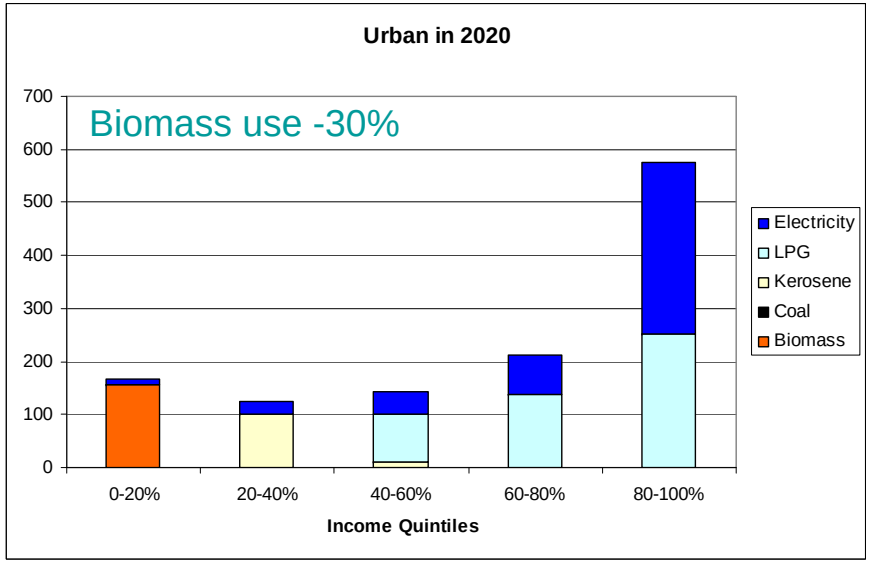
Methodology

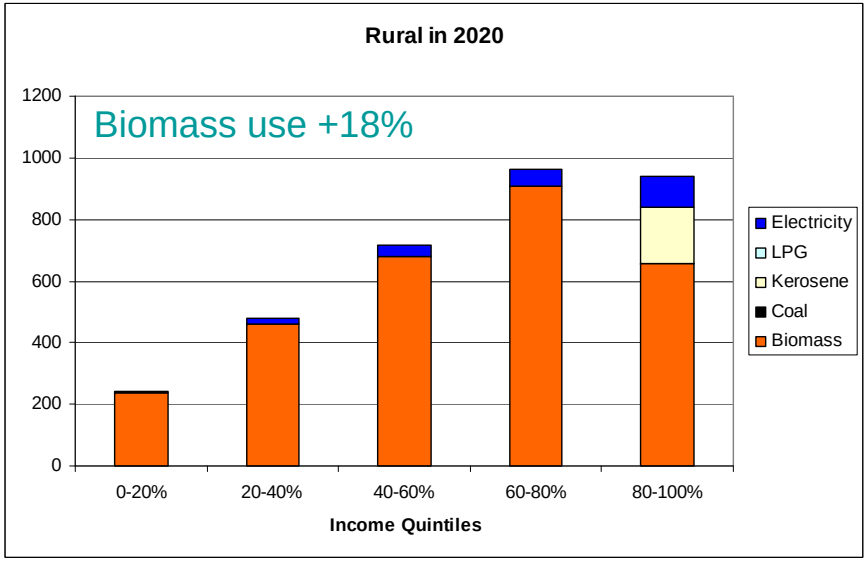
- Simple energy model of the residential/commercial sector of India
  - Linear programming, cost optimization (MESSAGE)
- 10 consumer groups
  - Urban/rural
  - Five income categories
- Main factor affecting fuel choice
  - Price of energy fuels & appliances
  - Financial (budget) constraints
  - Consumer's rate of time preference (planning horizon & implicit discount rate)
  - "Inconvenience costs" of low quality fuels (biomass and coal)
  - Policy instruments: fuel subsidy and/or micro-financing

Urban and rural fuel use (cooking)
No policy in addition to present ones

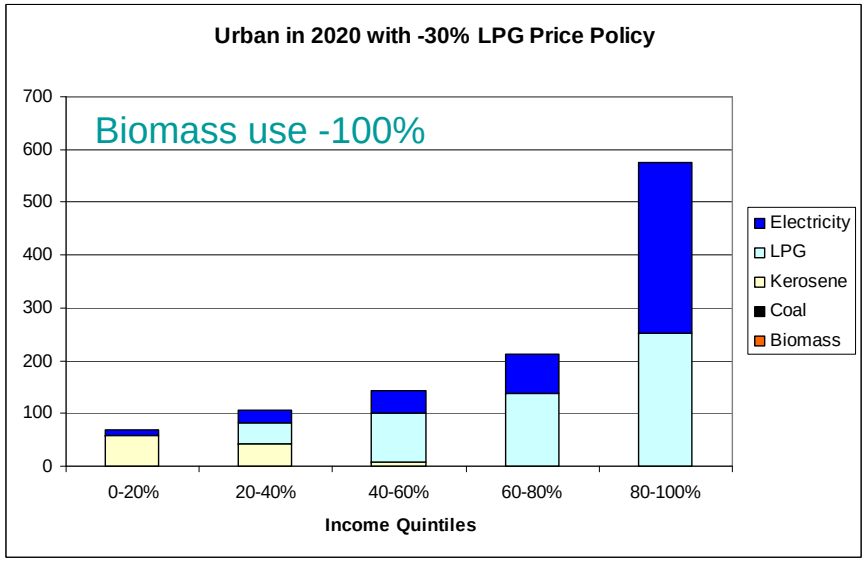


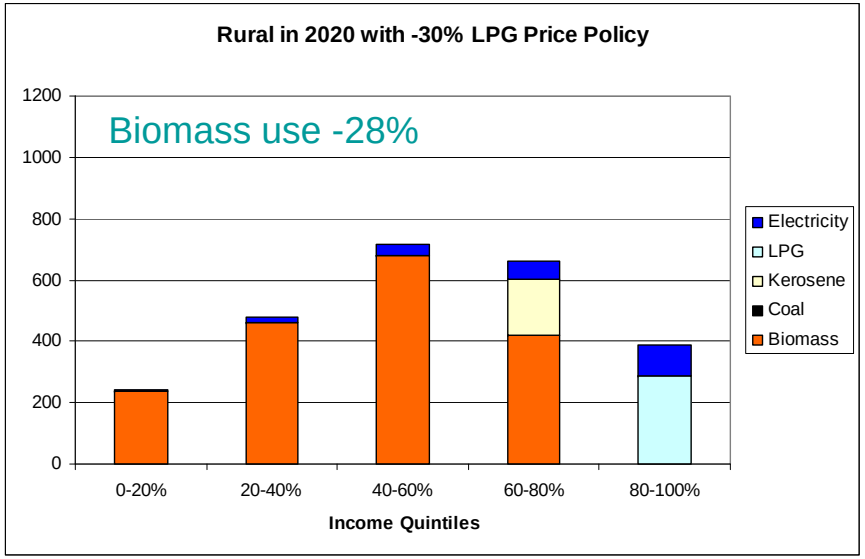


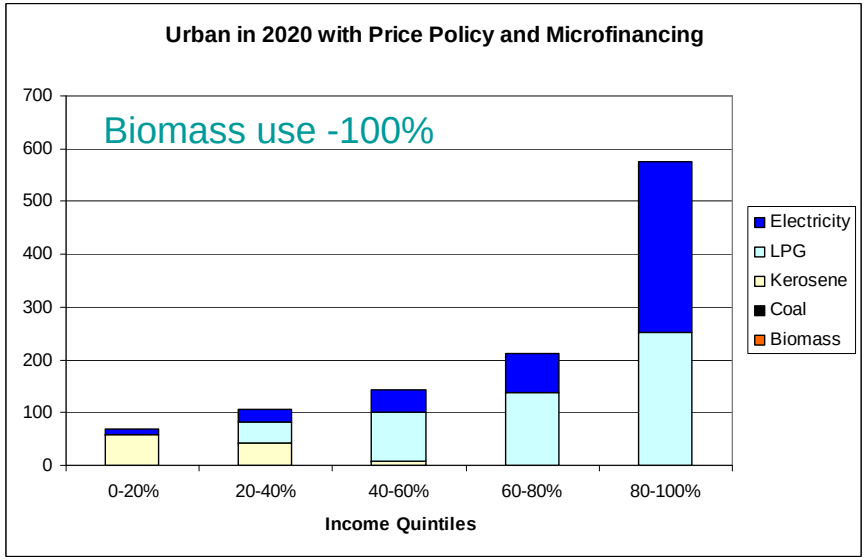


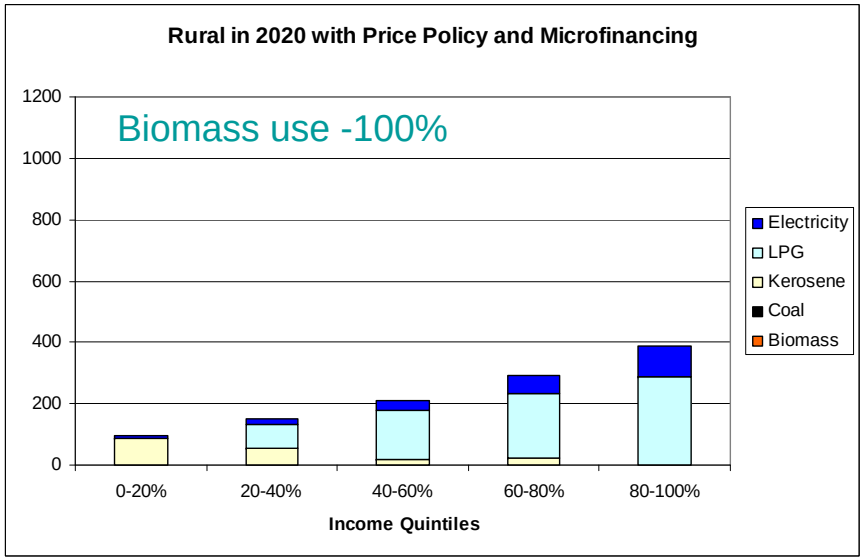


Urban and rural fuel use (cooking)
Two policy cases



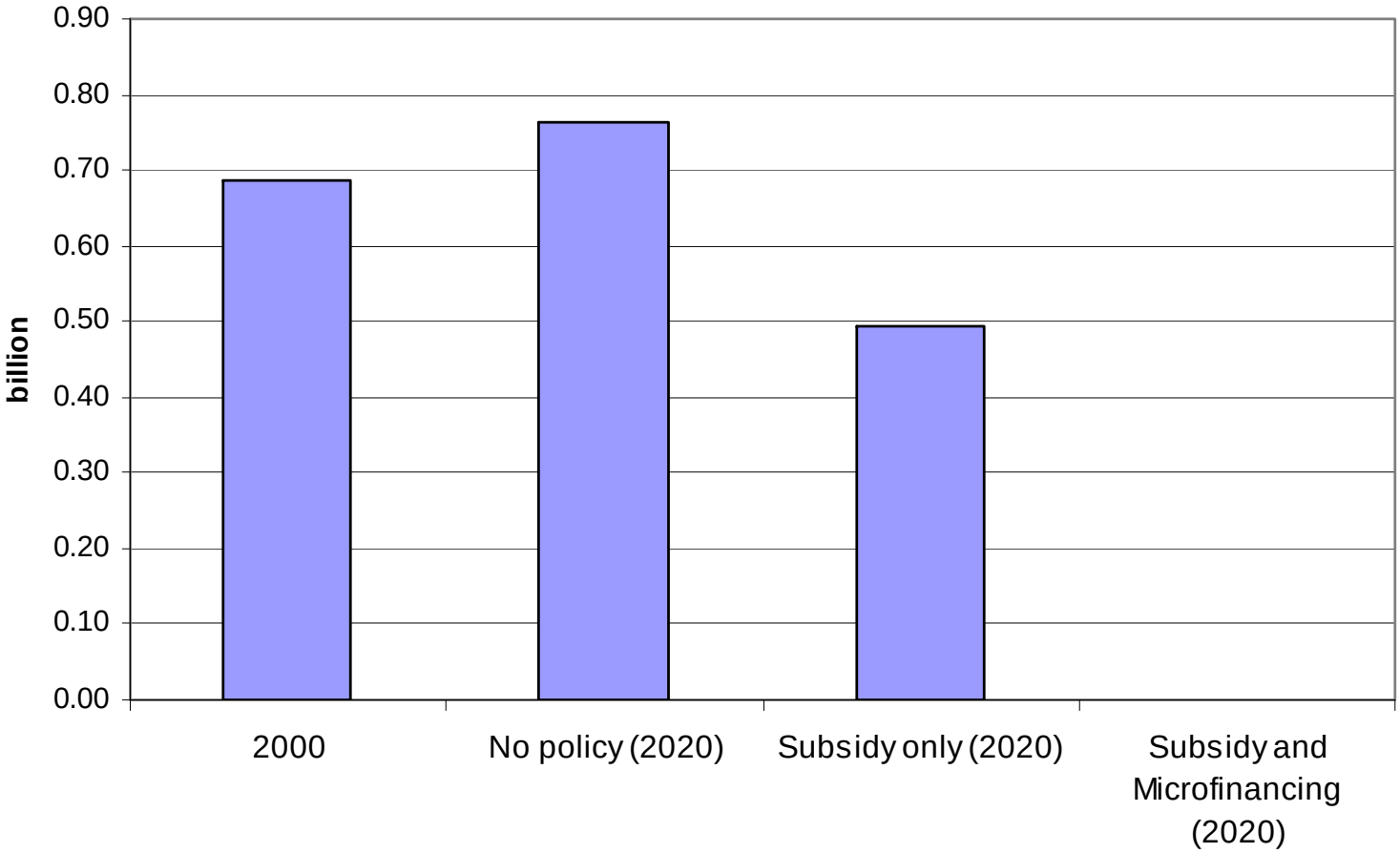






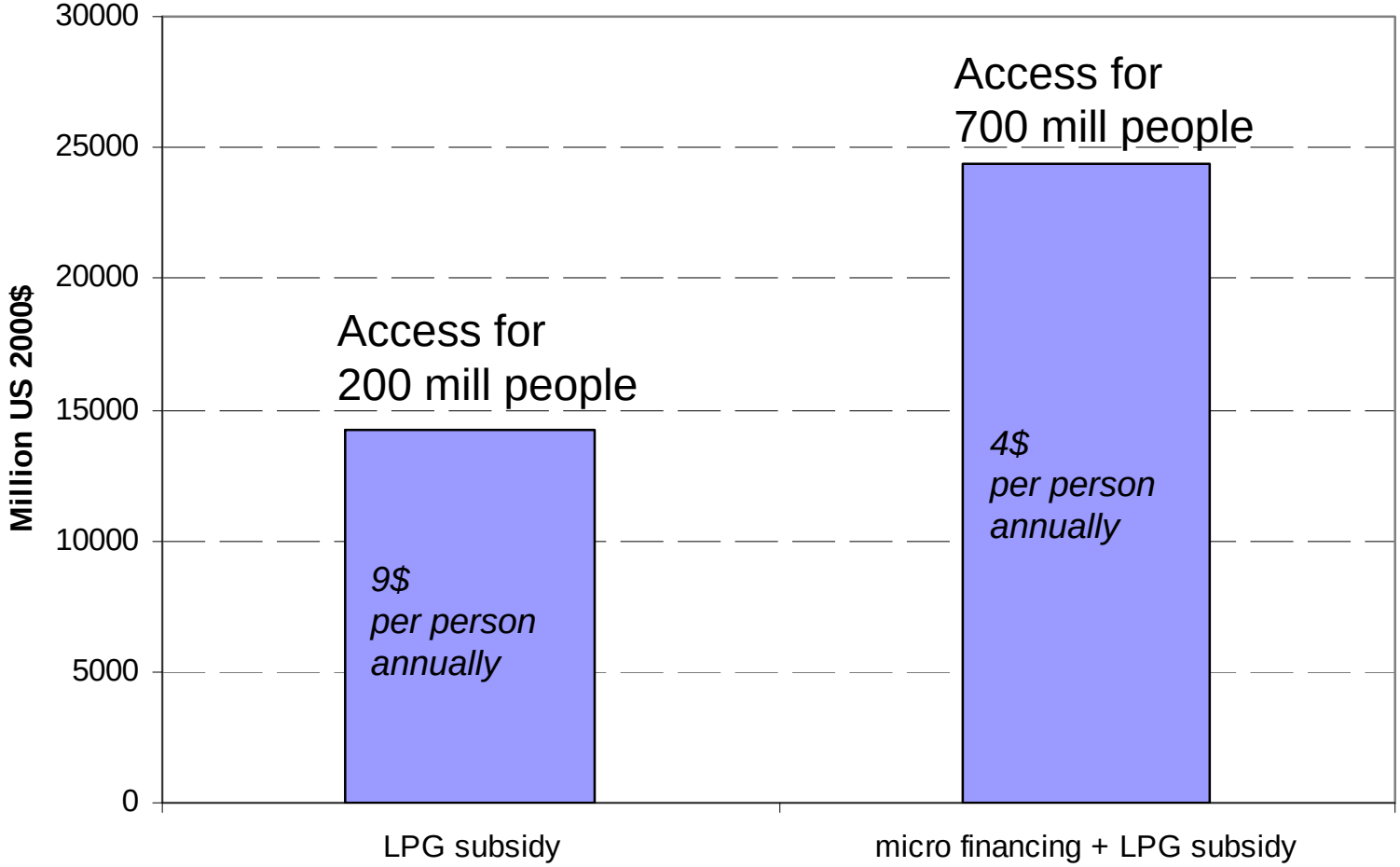
People without Access

(modern cooking fuels only)



Policy Costs and Efficiency

(cumulative 2010-2020)



-33% subsidy assumes reducing LPG prices from 6.4 $/GJ to 4.2 $/GJ
-Values do not include present costs to keep prices at 6.4 $/GJ

CO2 Emissions in India

Effect of cooking fuel policy