Putting Climate Change in Context

Financial Innovations Lab on Energy Independence

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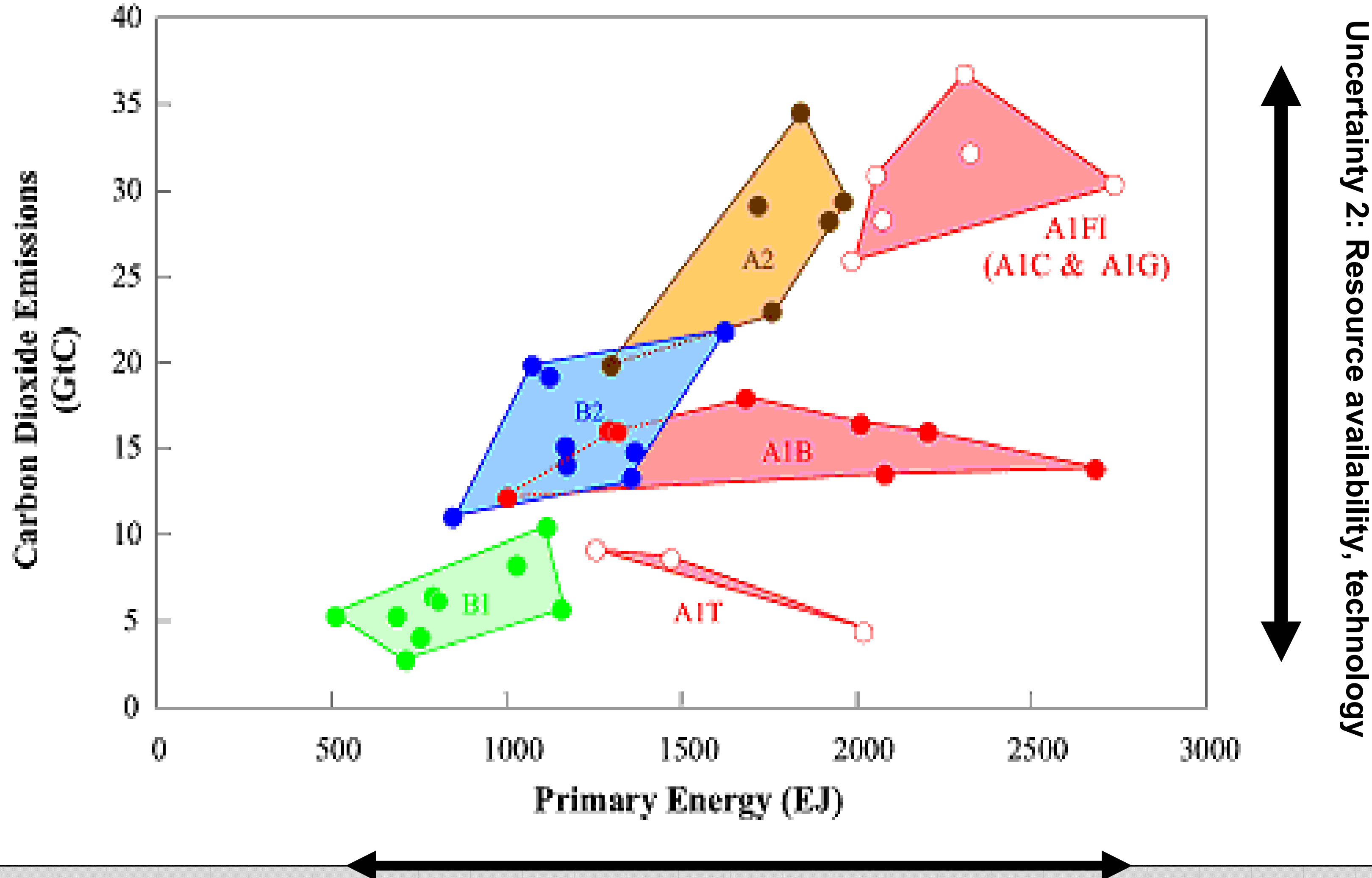
Drivers of the Climate Change Challenge

- Demographic (growth & composition)
- Economic (growth, structure, disparities)
- Social (values, lifestyles, policies)
- Technologic (rates & direction of change)
- Environmental (limits, adaptability)
- Valuation (discounting, non-market damages and benefits)

Drivers can be both source and remedy!

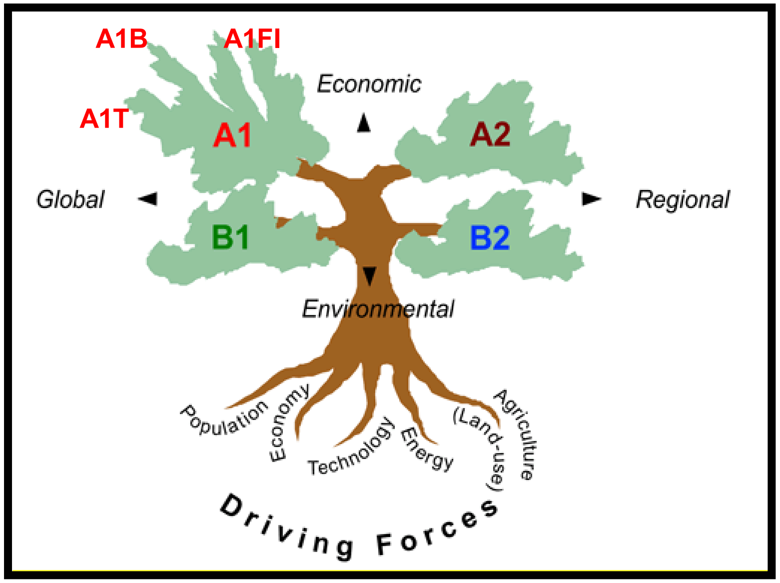
Forecasting impossible! → Scenario Approach

Emissions vs. Energy Use & Technology in IPCC SRES Scenarios



Uncertainty 1: Population and GDP growth, prices, policies

A Taxonomy of Scenarios (ex. IPCC SRES)



Different combination of driving forces can lead to **similar** emissions and climate change outcomes

EMISSIONS:

High: POP: High
GDP: Medium
Efficiency: Low
TECH: Dirty

A1FI
A2
A1B

Medium:

B2
A1T

Low: POP: Low
GDP: High
Efficiency: High
TECH: Clean

B1

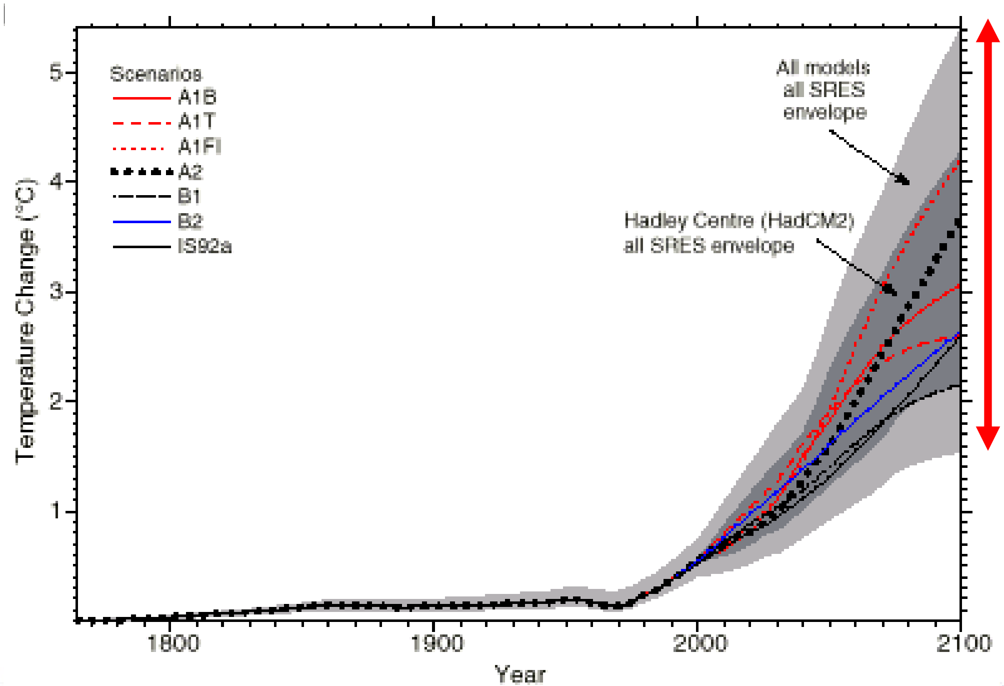
Largest TECH leverage of climate policies:
high GDP (capital turnover) and high efficiency!

Global Carbon & Warming Budgets

GtC					°C warming	*uncertainty*
530	**Emissions 1700-2007**					
245	**Atmospheric increase**				0.8	*0.3 - 1.2*
1000	**Reserves of coal, oil, gas**					
>20,000	**Total carbon fuel endowment**					
	Emissions 2000-2100, <u>no climate policy</u>					
>2000	**High**	A2, A1FI			>4.0	*2.5 - 7.5*
1300-1500	**Medium**	B2			~3.0	*2.0 - 5.0*
1000	**Low**	B1, A1T			~2.7	*1.5 - 4.5*
	Emissions 2000-2100, <u>for stabilization at:</u>					
			ppm CO_2	ppm CO_2-e		
850			500	680	2.5	*1.4 - 4.0*
650			450	600	2.1	*1.2 - 3.5*
<400			380	500	<2.0	*1.0 - 3.0*

Scope for climate stabilization efforts depend on:
(1) Baseline and (2) Climate Target

IPCC Projected Temperature Change in Absence of Climate Policies



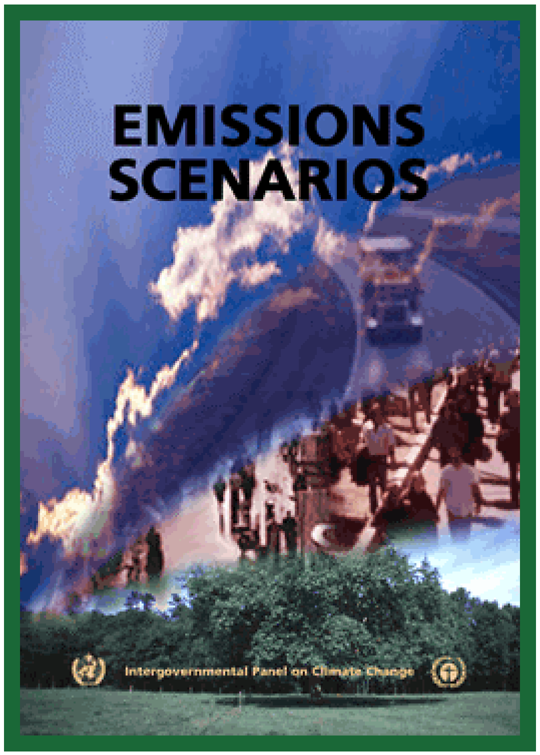
Uncertainty:
50 % climate (sensitivity) modeling
25% emissions (POP+GDP influence)
25% emissions (TECH influence)

WMO INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC) UNEP

Σ: Including mitigation scenarios, technology is the most important variable affecting magnitude of future climate change

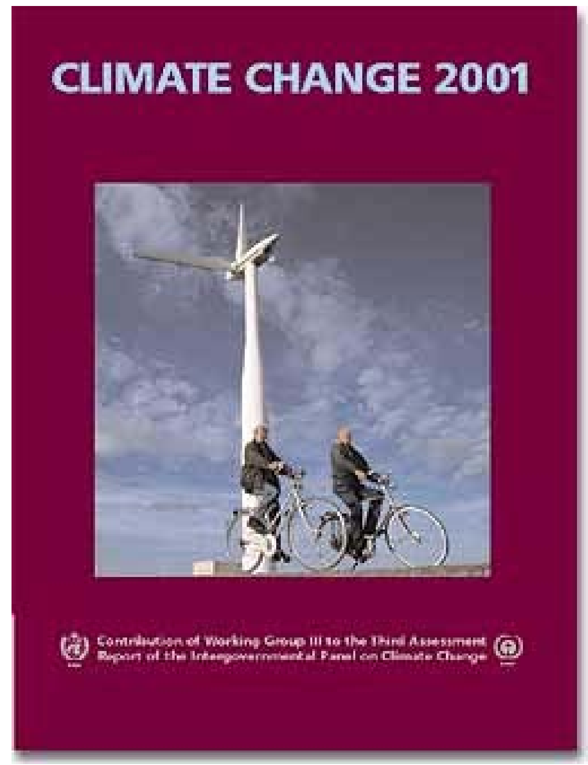
The Importance of Technology

"Unlike resources found in nature, technology is a man-made resource whose abundance can be continuously increased, and whose importance in determining the world's future is also increasing". Starr and Rudman (1973:364):



Technology is at least as important driving force of GHG emissions as population and economic growth (SRES).

Innovative technology is an important driving force of a broad range of GHG atmospheric stabilization levels over the next 100 years or more (TAR).



Drivers of Technology Transitions

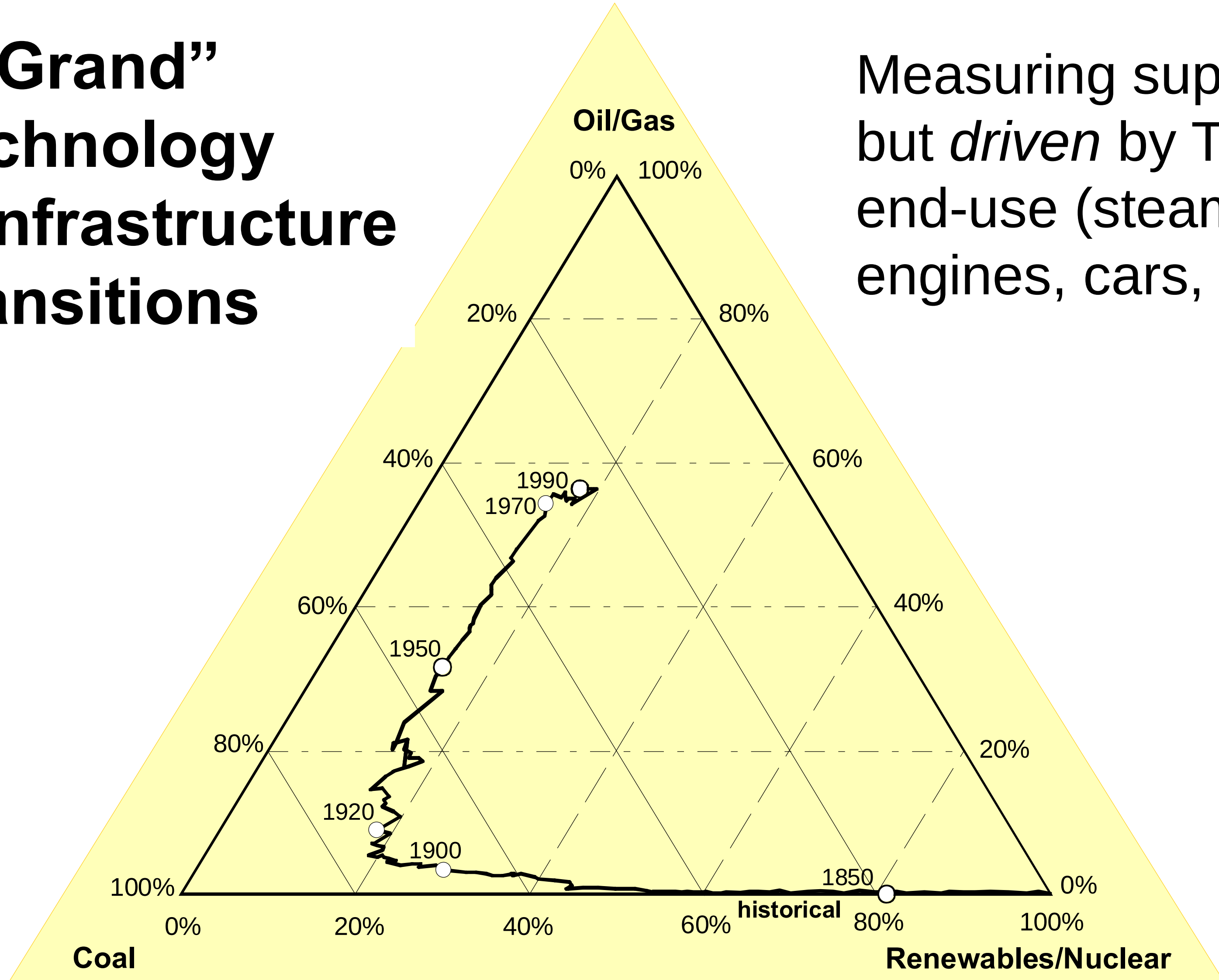
- Innovation & entrepreneurship
- Income and capital turnover
- Investments
- Adoption environment (incl. policies)

- End-use applications (consumers) dominate
- Demand pull AND supply push interact
- Rates of change: 1 - 10 decades!

See bibliography for literature on state-of-art of current understanding

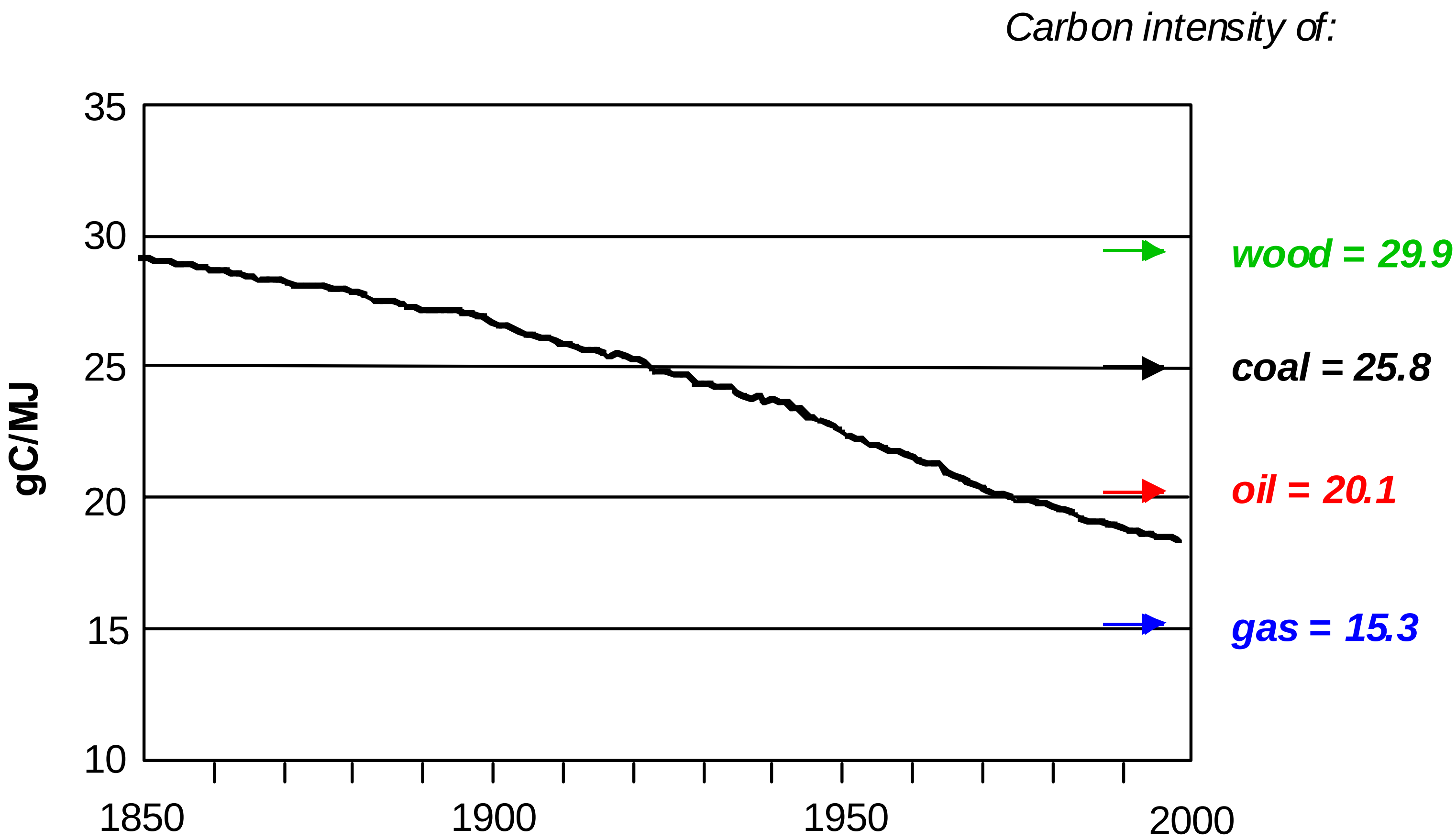
2 “Grand” Technology & Infrastructure Transitions

Measuring supply, but *driven* by TC in end-use (steam engines, cars, aircraft..)



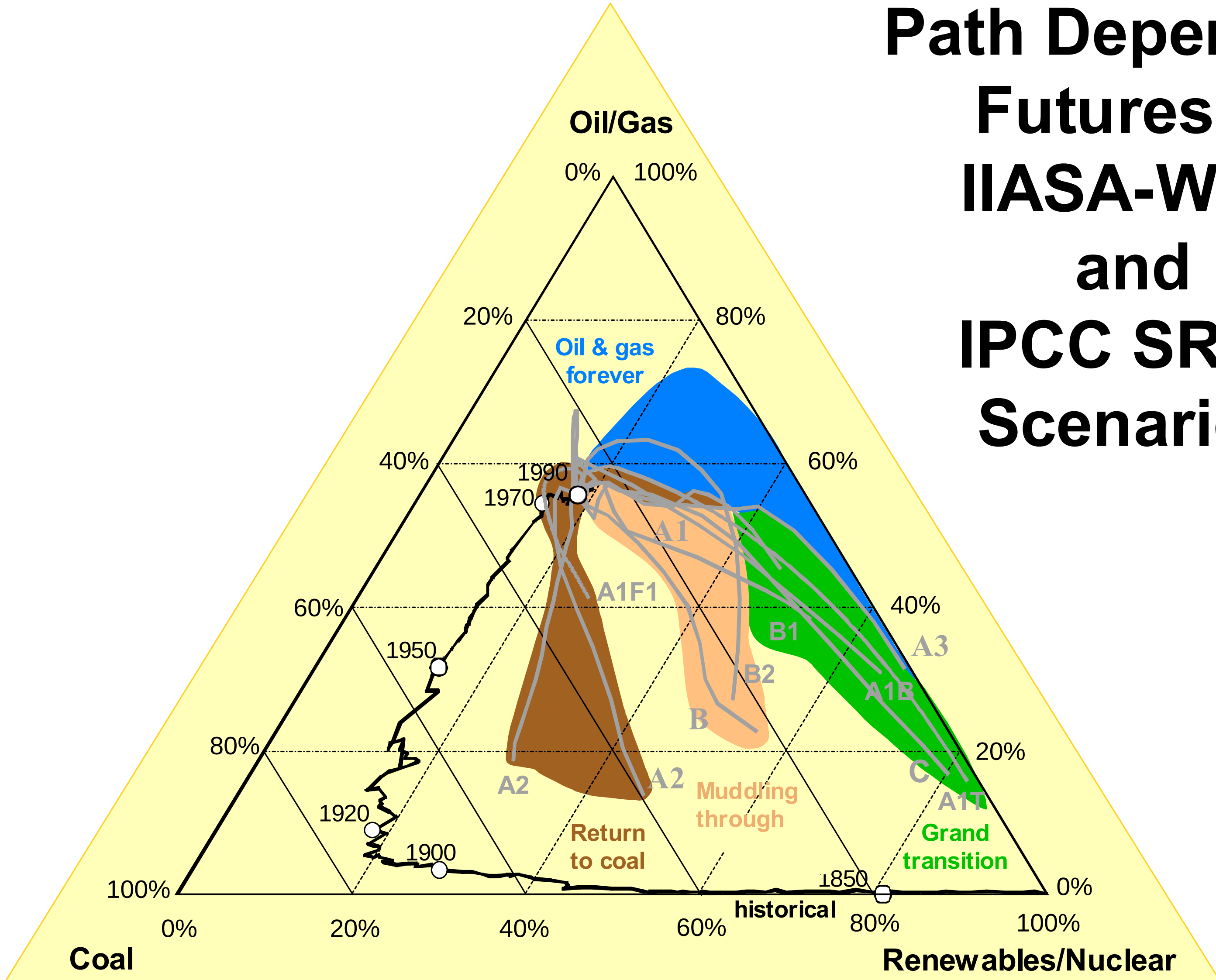
Past: No influence of resource depletion or policy on energy transitions

Decarbonization of Global Energy: Evolutionary Envelope of Multiple Transitions



Getting "cleaner" is deeply engrained in history of technological and societal evolution.
Climate stabilization requires acceleration of historical trends, but not a departure!

Path Dependent Futures in IIASA-WEC and IPCC SRES Scenarios



Only "grand transition" scenarios allow full spectrum of climate stabilization targets.
"Re-fossilization" scenarios need silver bullet technology fixes (CCS, geo-engineering) with unknown feasibility and side effects.

Climate Change: The Bottom Line

- **Vast uncertainties**
  (targets & mitigation feasibility/costs):
  -- impacts (warming plus variability)
  -- technology (which ones when, where, how)
- **Magnitude of challenge depends on:**
  -- future development in "South"
  -- technologies available
  (efficiency AND clean supply)
- **Policy Approach:** Rather than: "wait and do nothing"/ "optimum" path,
  get prepared, hedge risks, adapt
  (develop incentives, institutions, and technology mitigation/adaptation response portfolios)

Private sector and financial community better equipped to deal with uncertainty and in hedging risks, governments can create additional risks via flipping between "denial" or (over-)pre-cautionary principles (US-EU)

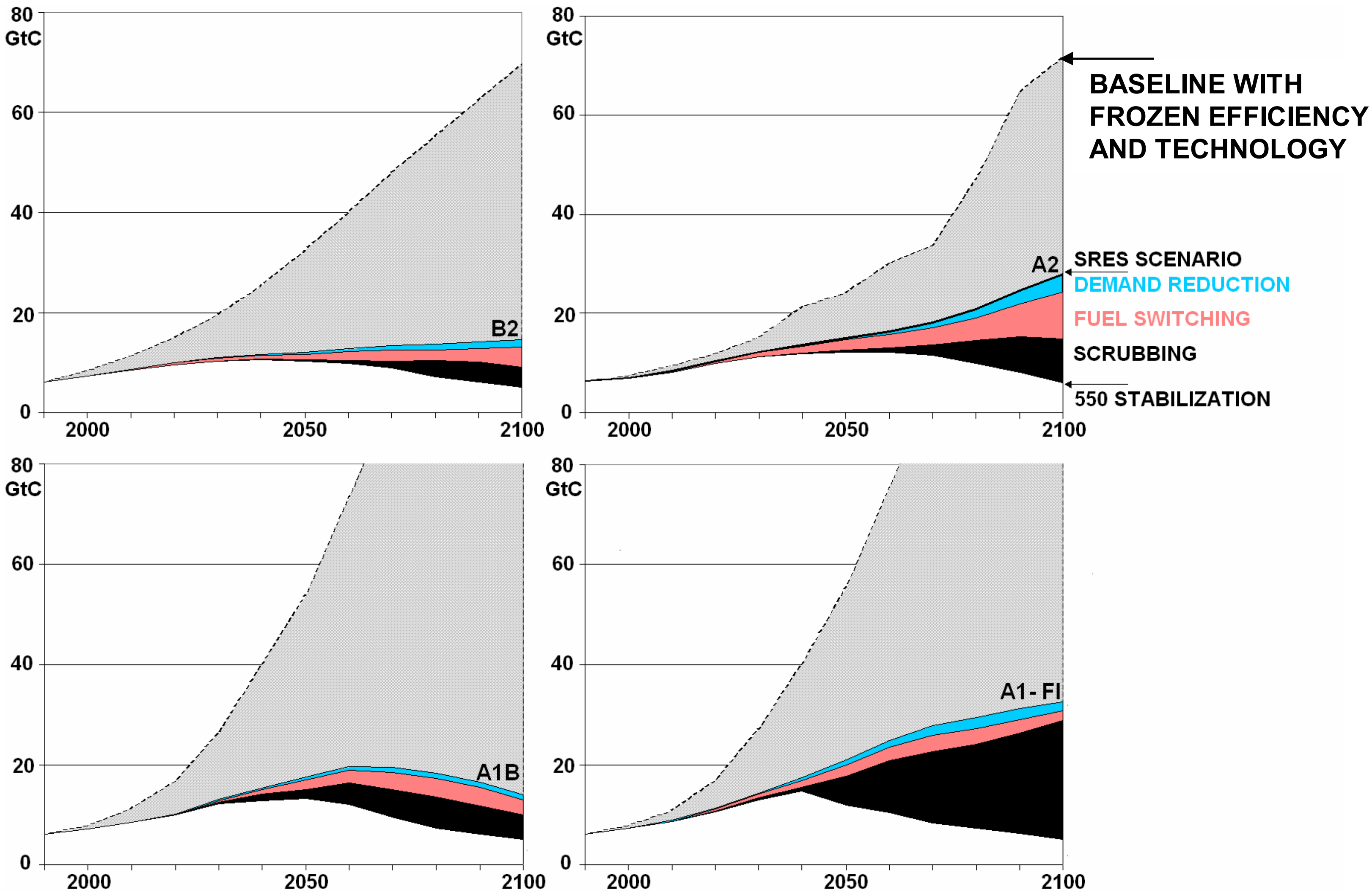
Mitigation Technology Portfolio Analysis

- Paramount importance of Baseline
- Costs matter
- Diffusion time constants matter
- Differences in where technology is developed and where it is deployed
- Technological interdependence and systemic aspects important in “transition” analysis
- Non-energy, non-CO2 can help (lower costs), but cannot solve problem (reduce energy-CO2)
- Multiple drivers, but all channeled via <u>investments</u>

Σ: Popular “wedge” analysis fails on all above accounts!

Technology as Source and Remedy of Climate Change:

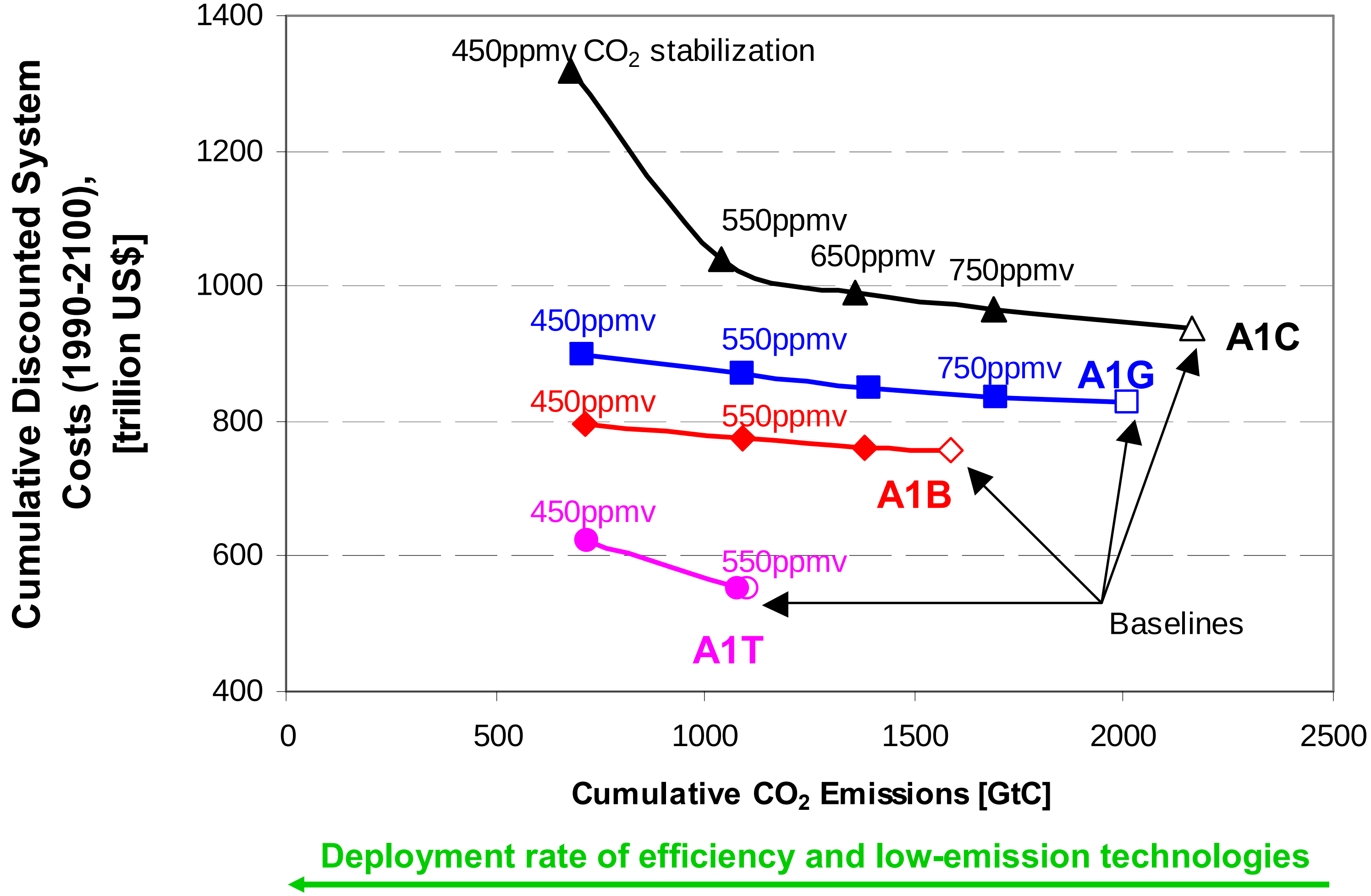
IPCC Baselines and 550 ppmv Stabilization Scenarios (in GtC), Source: IIASA, 2002.



Σ: With “frozen” efficiency and technology improvements emissions grow “through the roof”. Even with continued improvements, additional emission reduction is needed for climate stabilization

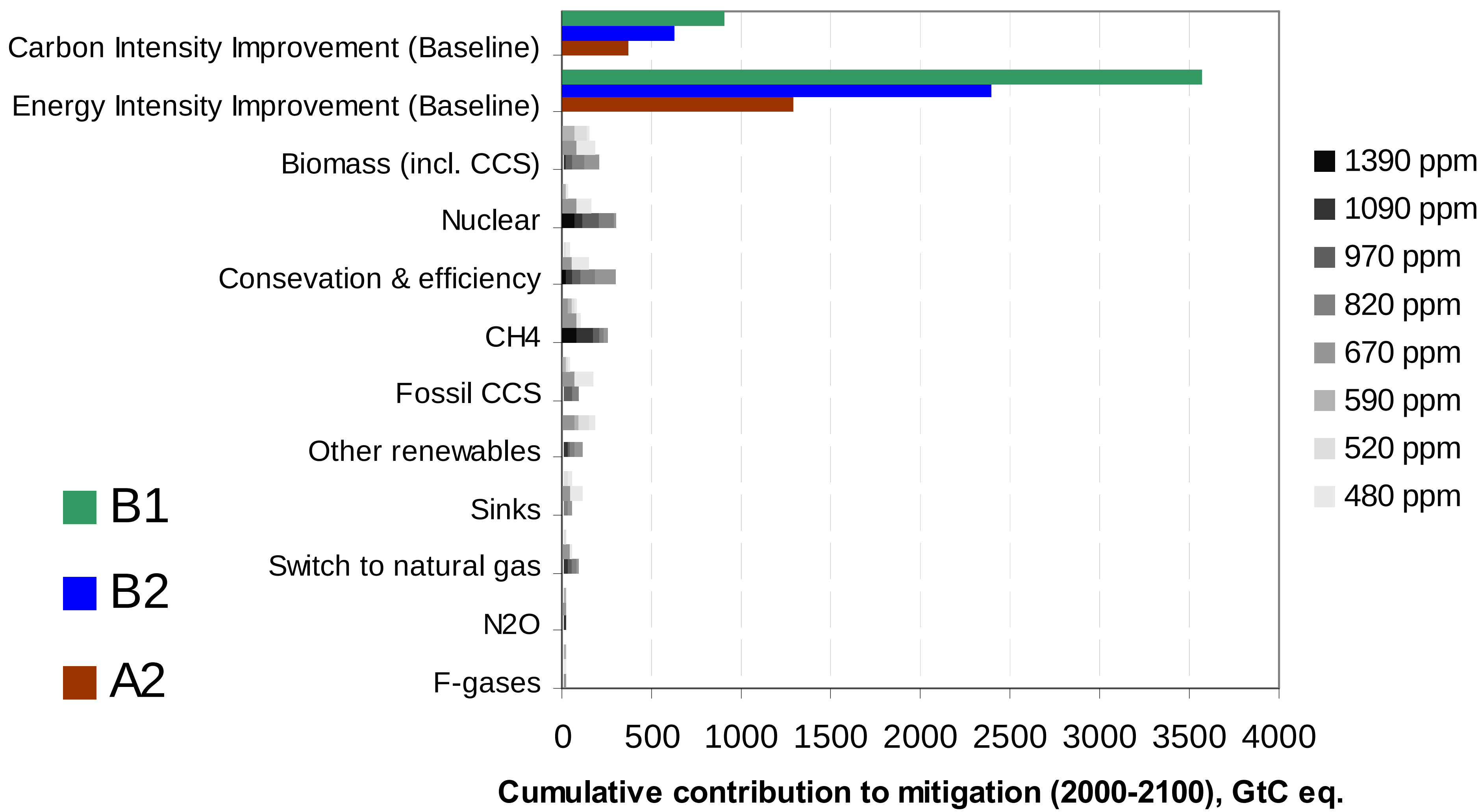
Costs of Different Baselines and Stabilization Scenarios

Source: IIASA, 2000.



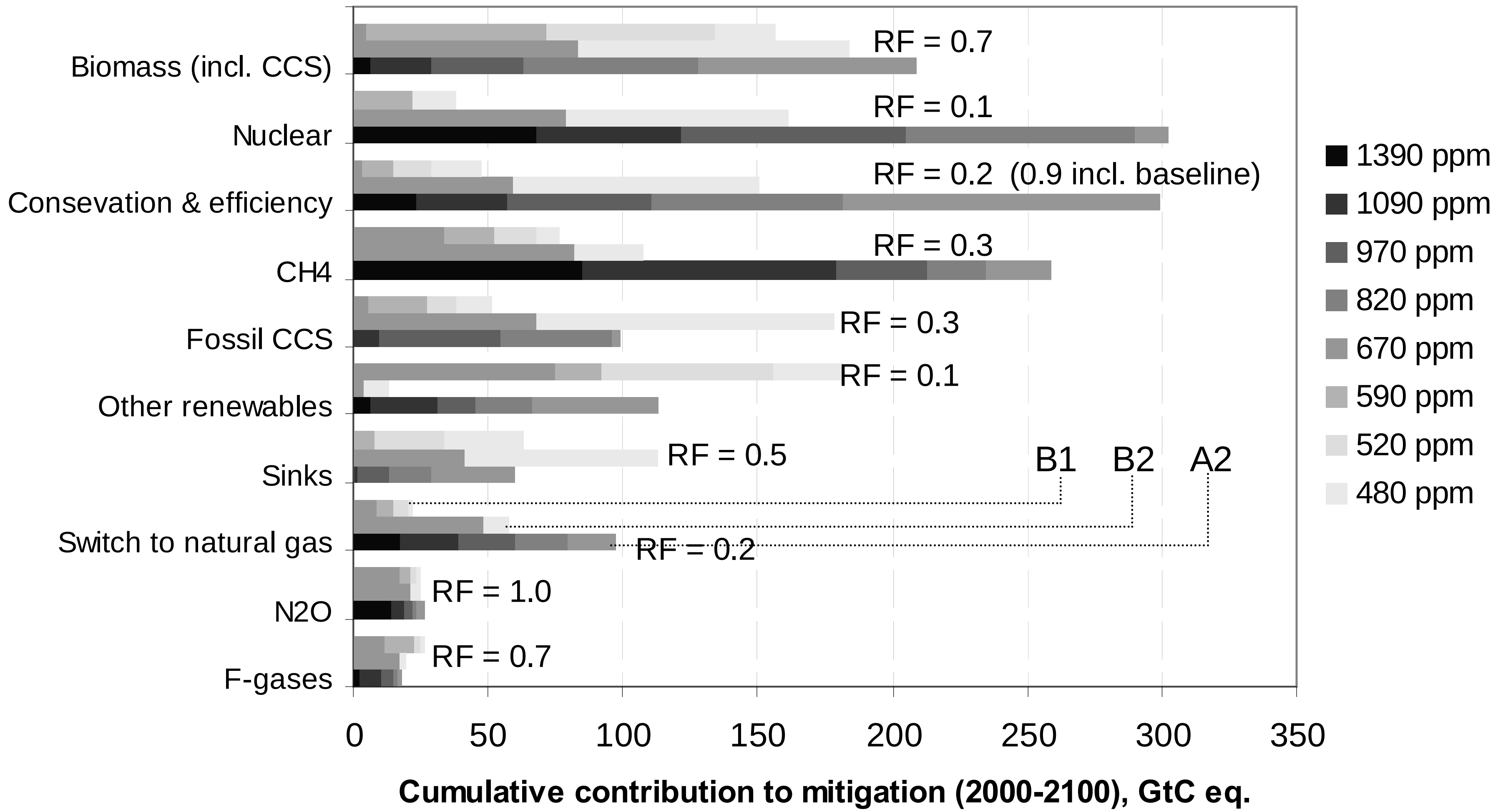
Σ: **The lower baseline emissions (efficiency, clean supply) the easier to achieve (currently unknown) climate targets**

Emission Reduction Measures



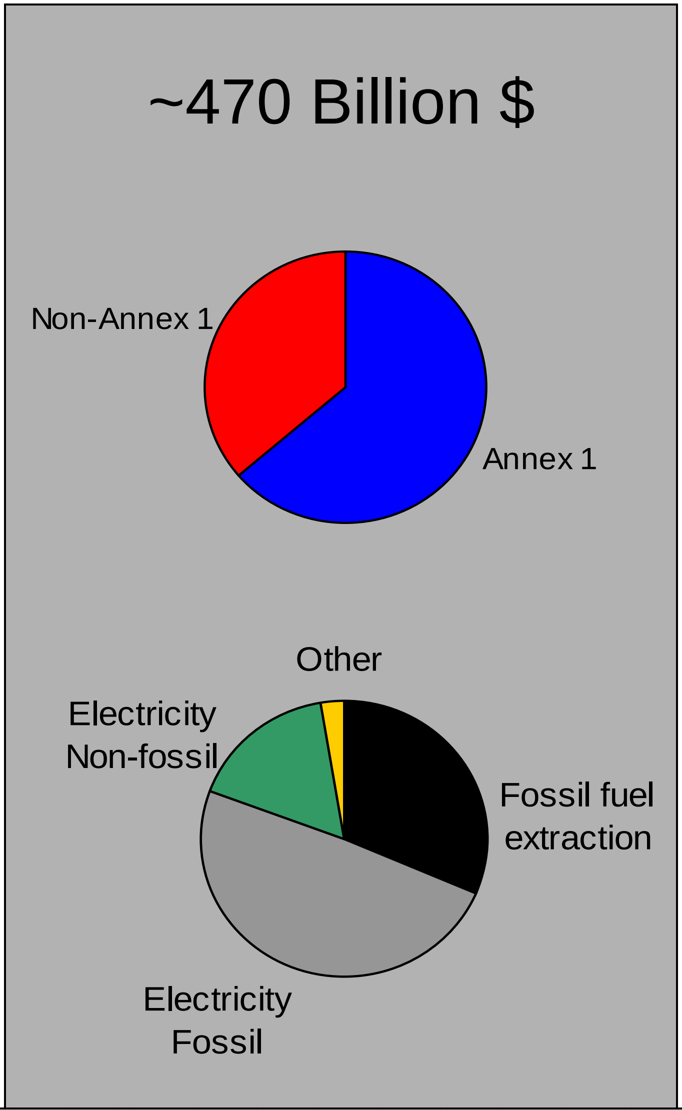
Σ: Technological change in Baseline best hedging against target uncertainty

Emission Reduction Measures



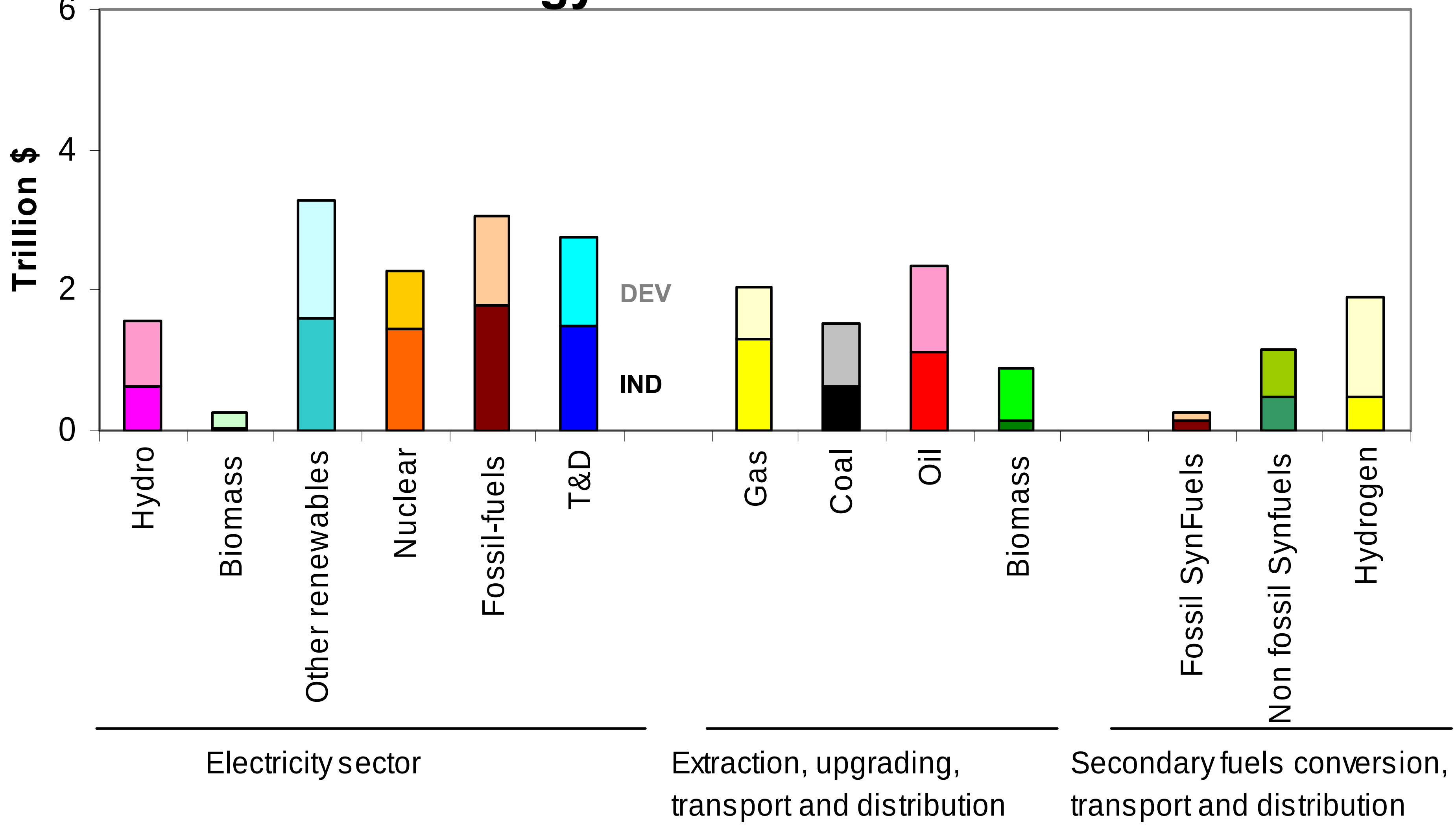
RF = Robustness factor of options across scenario uncertainty is highest for: F-gases and N2O reduction, energy conservation & efficiency, and biomass+CCS “wildcard” (if feasible)

Energy Sector Investments Today



Note Annex-I and fossil fuel bias!

Cumulative Energy Sector Investment 2000-2030



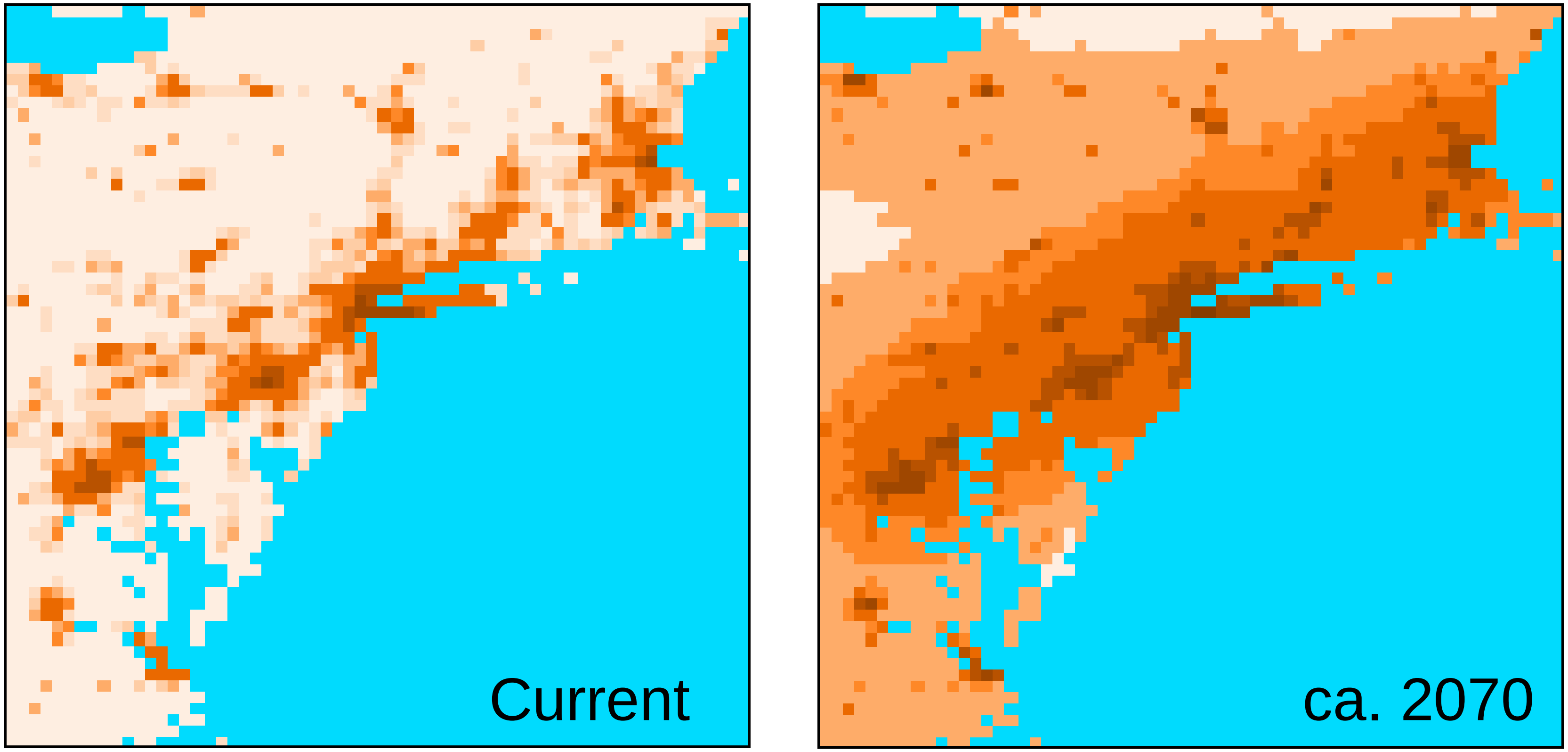
Example of short-term investment leading to a "grand transition" pathway, e.g. along the B1 scenario (dark shades: Industrialized countries, light shades: Developing countries). Largest investment category is in end-use energy efficiency improvements not shown above.

A Final Caveat

The methodological framework used for the illustrative results reported here relies on numerous assumptions and simplifications that are a far-cry away from actual investment environments, ignoring in particular:

-- actor heterogeneity and bounded rationality
-- decision criteria beyond profit maximization
-- irregular/non-rational social planner behavior
-- higher rates of time preference for social decisions as used here (5%)

Thank You!



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Spatial GDP Density Maps for the NE ("high growth" scenario)
Source: TFSC 74:980-1029 (2007)