CLIMATE CHANGE

Nuclear Power and Stabilizing CO_2 Concentrations

Jae Edmonds and Sonny Kim

Nuclear Energy Research Advisory Committee Meeting

April 15 and 16, 2002

Alexandria, VA

Battelle
Pacific Northwest National Laboratory

UNIVERSITY OF MARYLAND
The Joint Global Change Research Institute

preliminary analysis

- **The analysis presented here is preliminary and subject to revision.**

CLIMATE CHANGE

Multiple gases

- CO_2 (fossil fuel, land-use)
- CH_4 (rice paddies, ruminant livestock, landfills, coal mining, oil and gas production, incomplete combustion)
- N_2O (nitrogen fertilizers, industrial processes, other??)
- Manufactured gases (CFCs, HFCs, SF_6, etc.)
- Aerosols and dark particles

Global emissions—all human emissions, everywhere.

Many long-lived species.

CLIMATE CHANGE

background

1992 United Nations Framework Convention on Climate Change (FCCC)

GOAL—"…stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." (Article 2)

CLIMATE CHANGE

miscellaneous useful information about CO_2

- Pre-industrial concentration 280 ppmv
- Current concentration 370 ppmv
- Fossil fuels 6.9 PgC/year
- Land-use change 1.6± 1.3 PgC/year

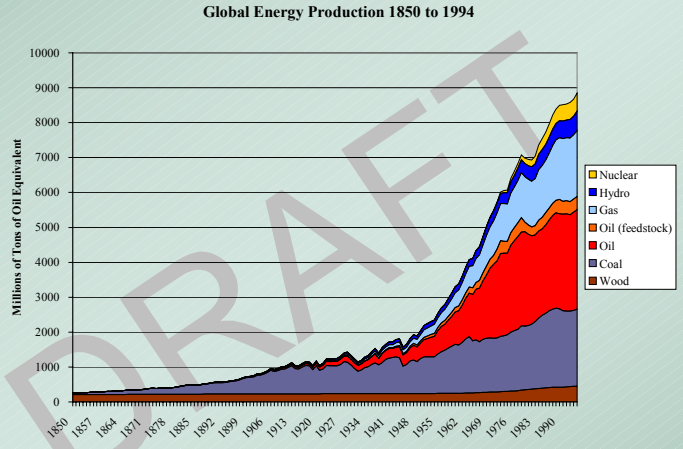
CLIMATE CHANGE

miscellaneous useful information about CO_2 –*carbon stocks*

- atmosphere 750 Pg
- above ground plants 610 Pg
- soils and roots 1,200 Pg
- upper ocean 1,200 Pg
- deep ocean 40,000 Pg

CLIMATE CHANGE

The problem may go away on its own—BUT, don't count on it. There are plenty of fossil fuels available to fuel the global economy for hundreds of years.

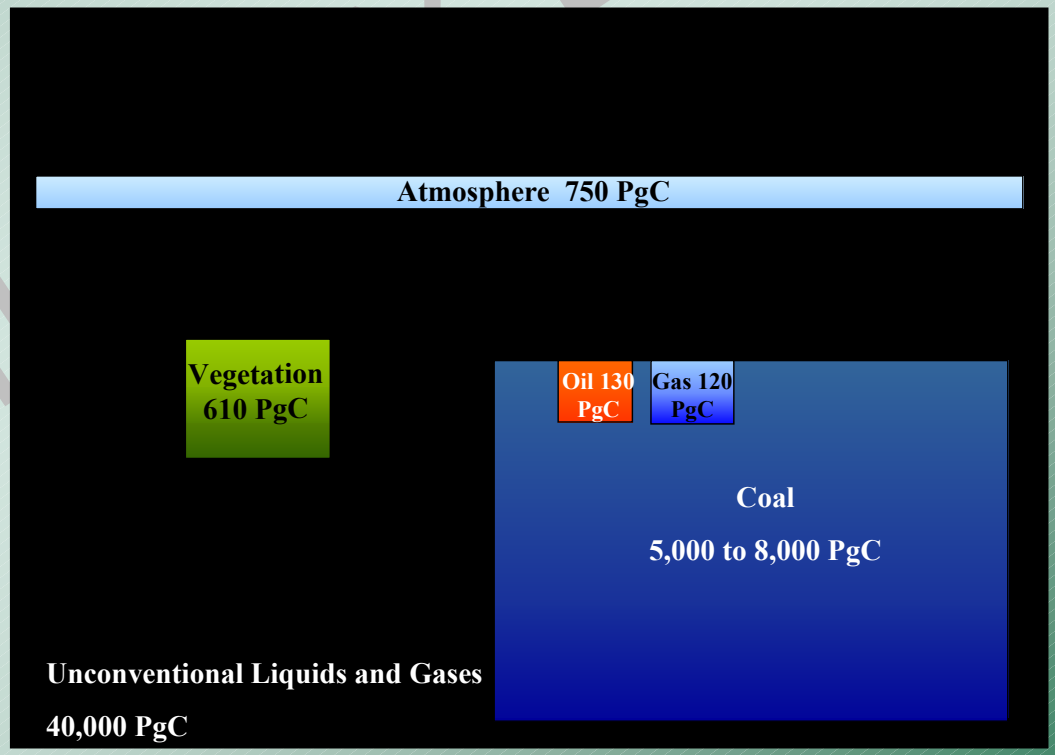


Fossil fuels are abundant,

Large relative to the stock in the atmosphere,

The backbone of the present global energy system, and

May continue to be used.



Battelle

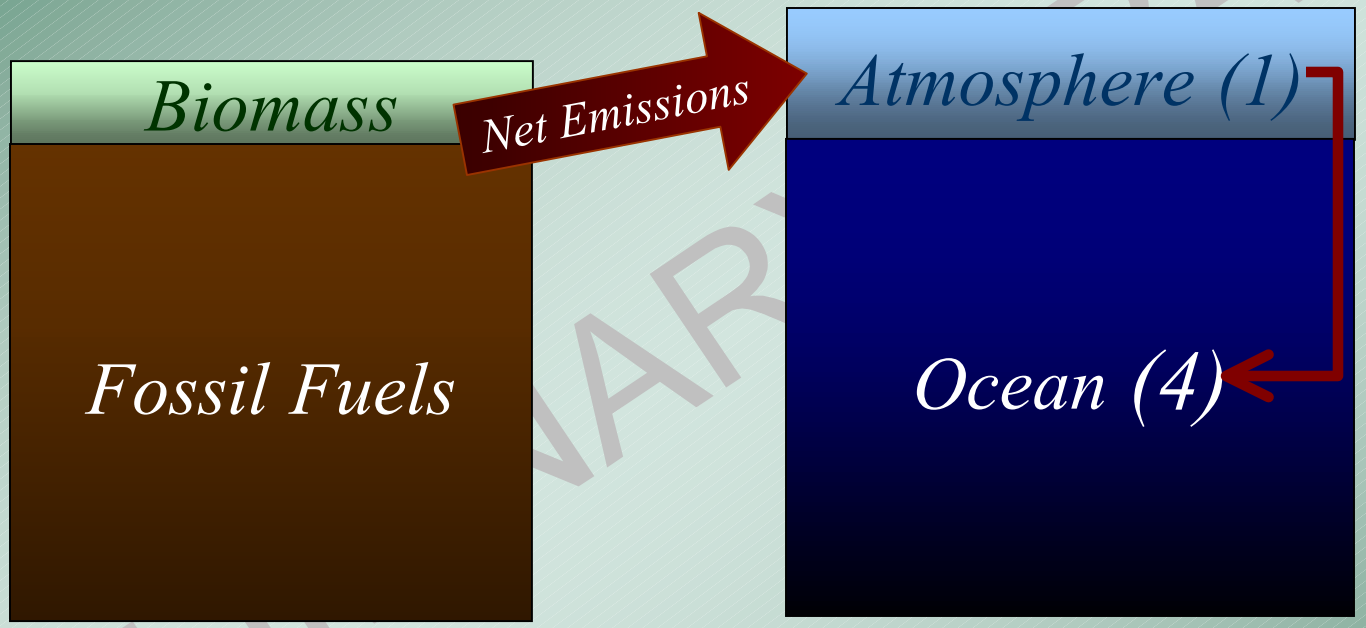
Pacific Northwest National Laboratory

UNIVERSITY OF MARYLAND

The Joint Global Change Research Institute

CLIMATE CHANGE

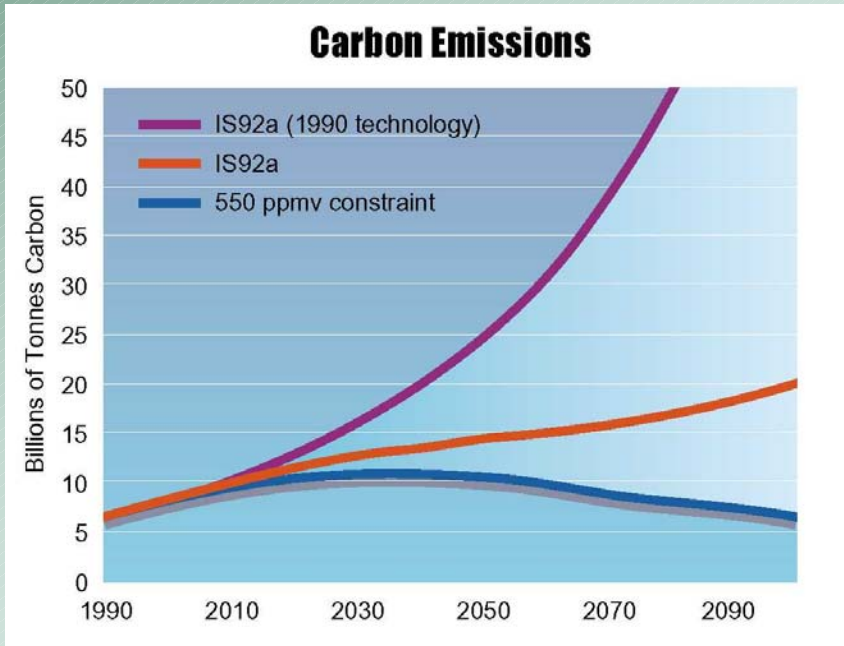
Background

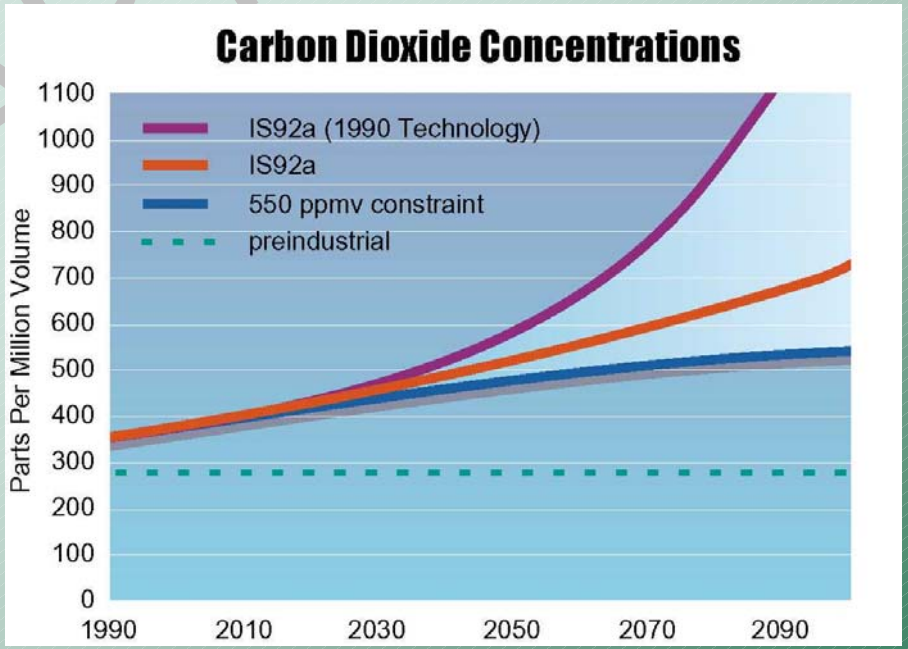


Long Term Distribution between ocean and atmosphere ~4:1

CLIMATE CHANGE

CO_2 emissions & concentrations



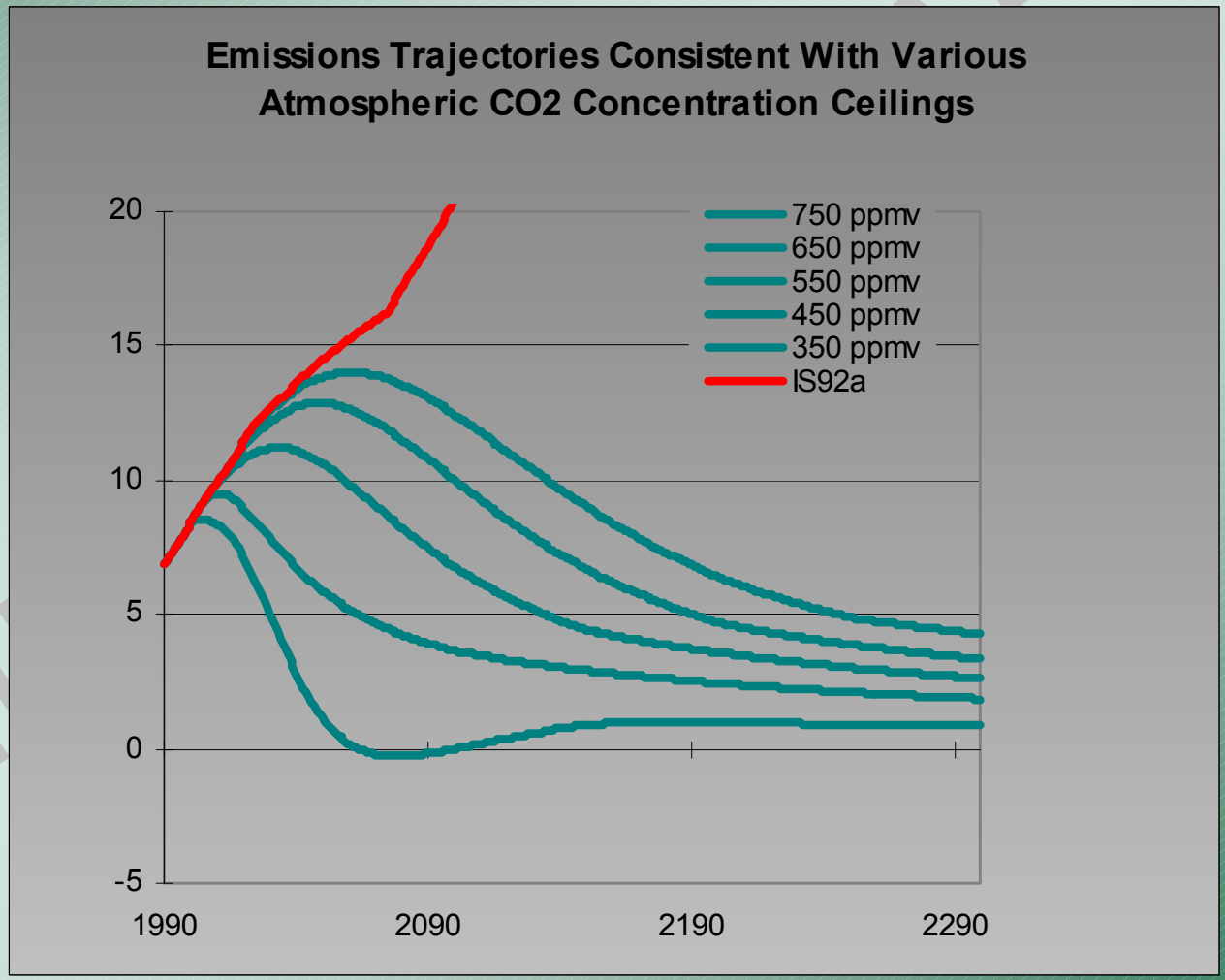


CLIMATE CHANGE

Stabilizing the Concentration

Emissions Must Peak & Decline

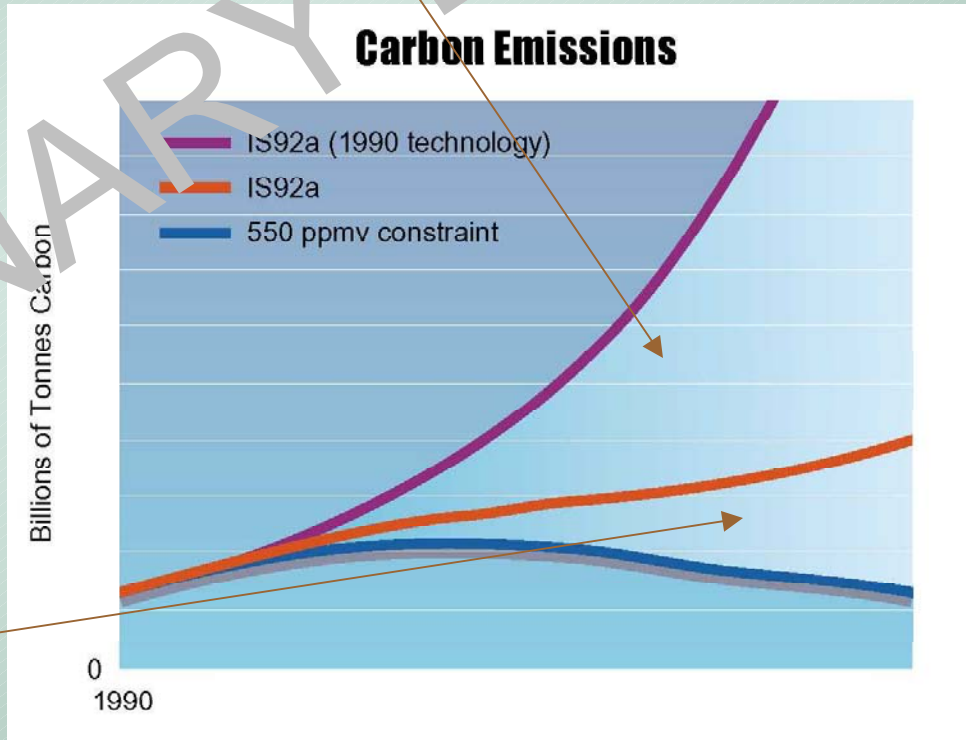
Cumulative emissions determine the concentration.



CLIMATE CHANGE

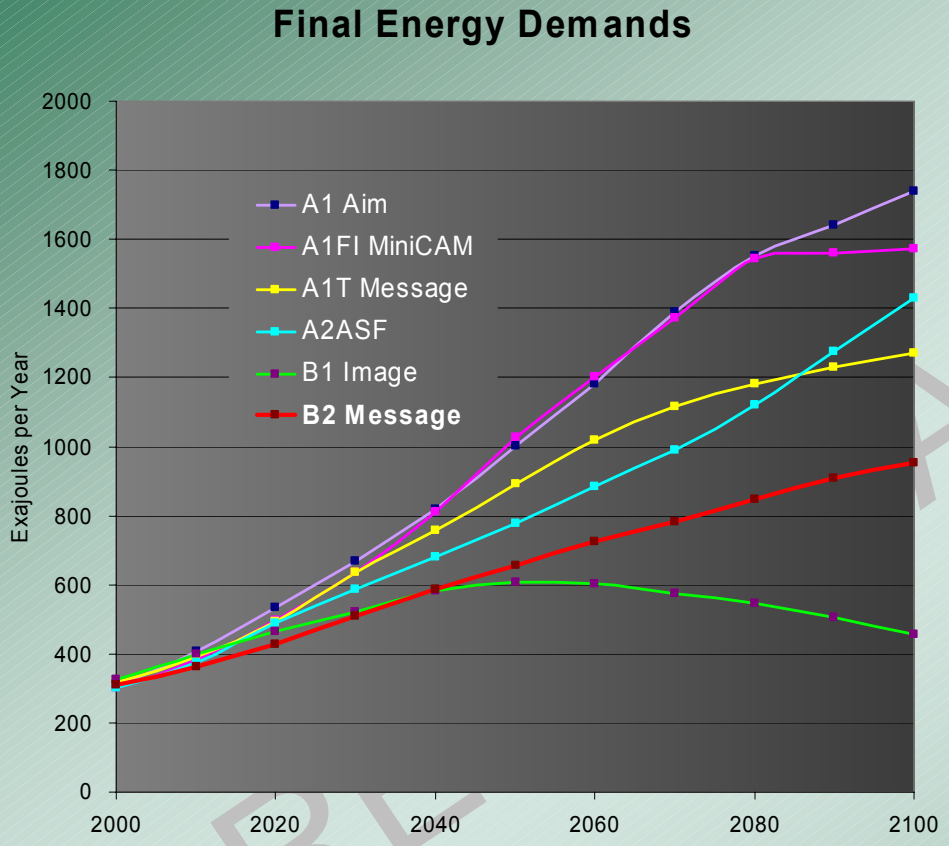
Significant technological change is assumed in reference cases such as IPCC.

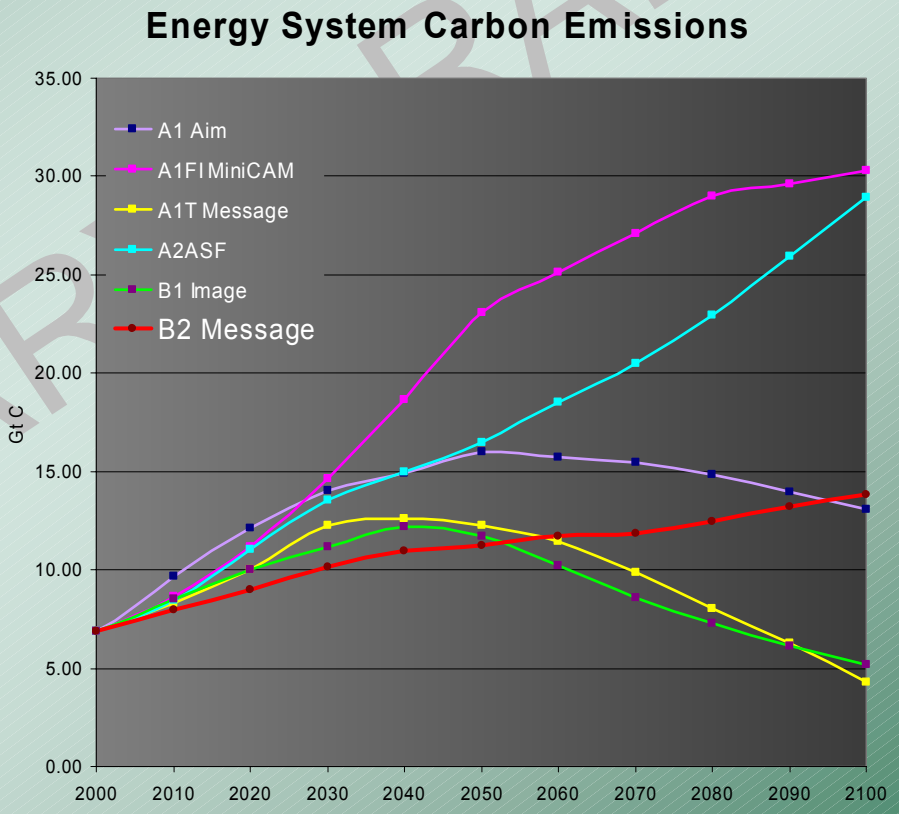
Cost effective stabilization of CO_2 concentrations results in additional technology deployment.



CLIMATE CHANGE

SRES





Battelle

Pacific Northwest National Laboratory

UNIVERSITY OF MARYLAND

The Joint Global Change Research Institute

CLIMATE CHANGE

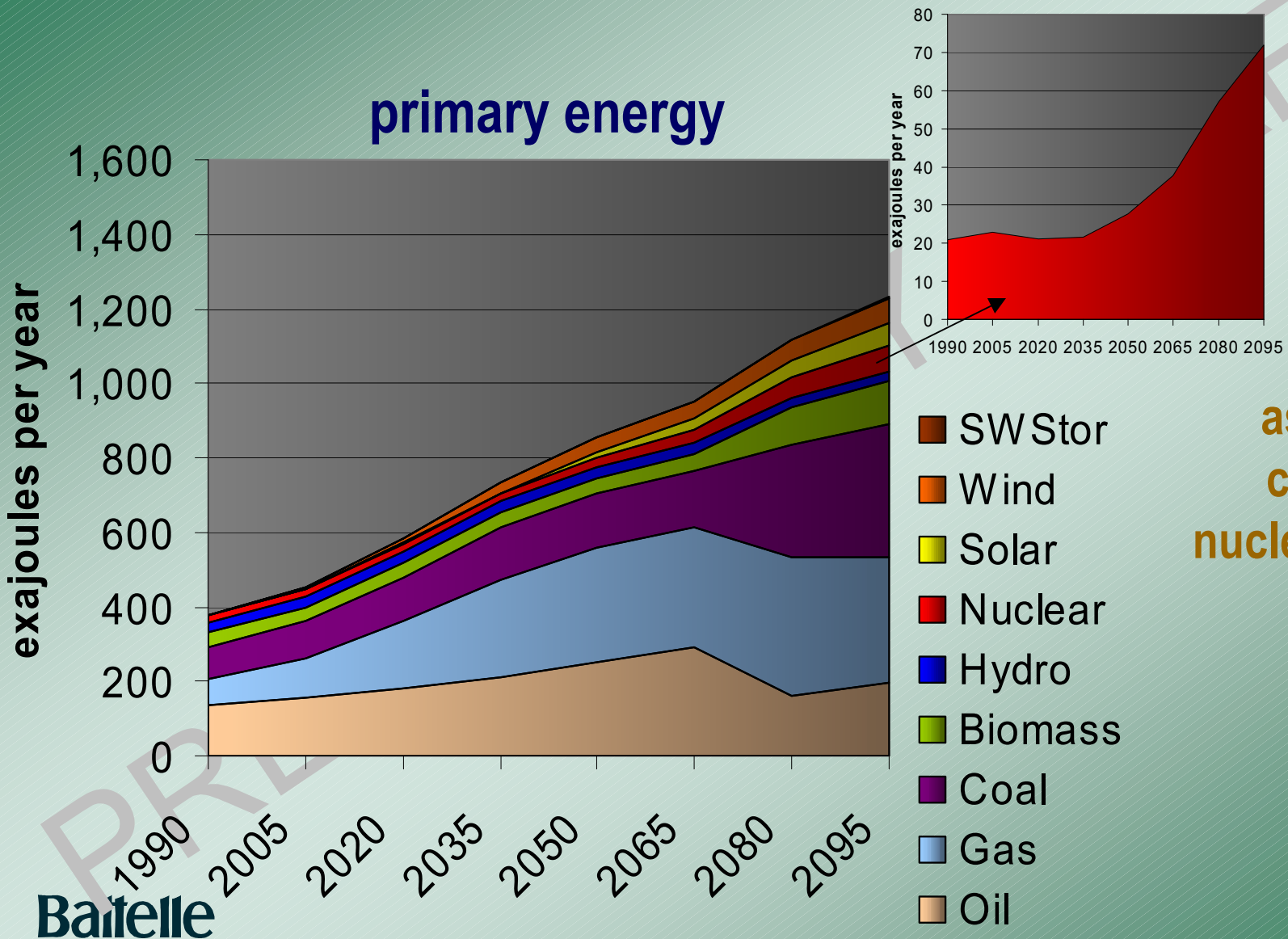
B2

the B2 scenario

- Population→9.4 billion people in 2100.
- Income per capita disparities shrink between regions, but don't close—average GDP/capita growth = 1.85%/yr.
- Gross World Product increases by an order of magnitude $23T/yr→$200T/yr.
- Technologies improve dramatically.

CLIMATE CHANGE

B2



assumes constant nuclear cost

Battelle

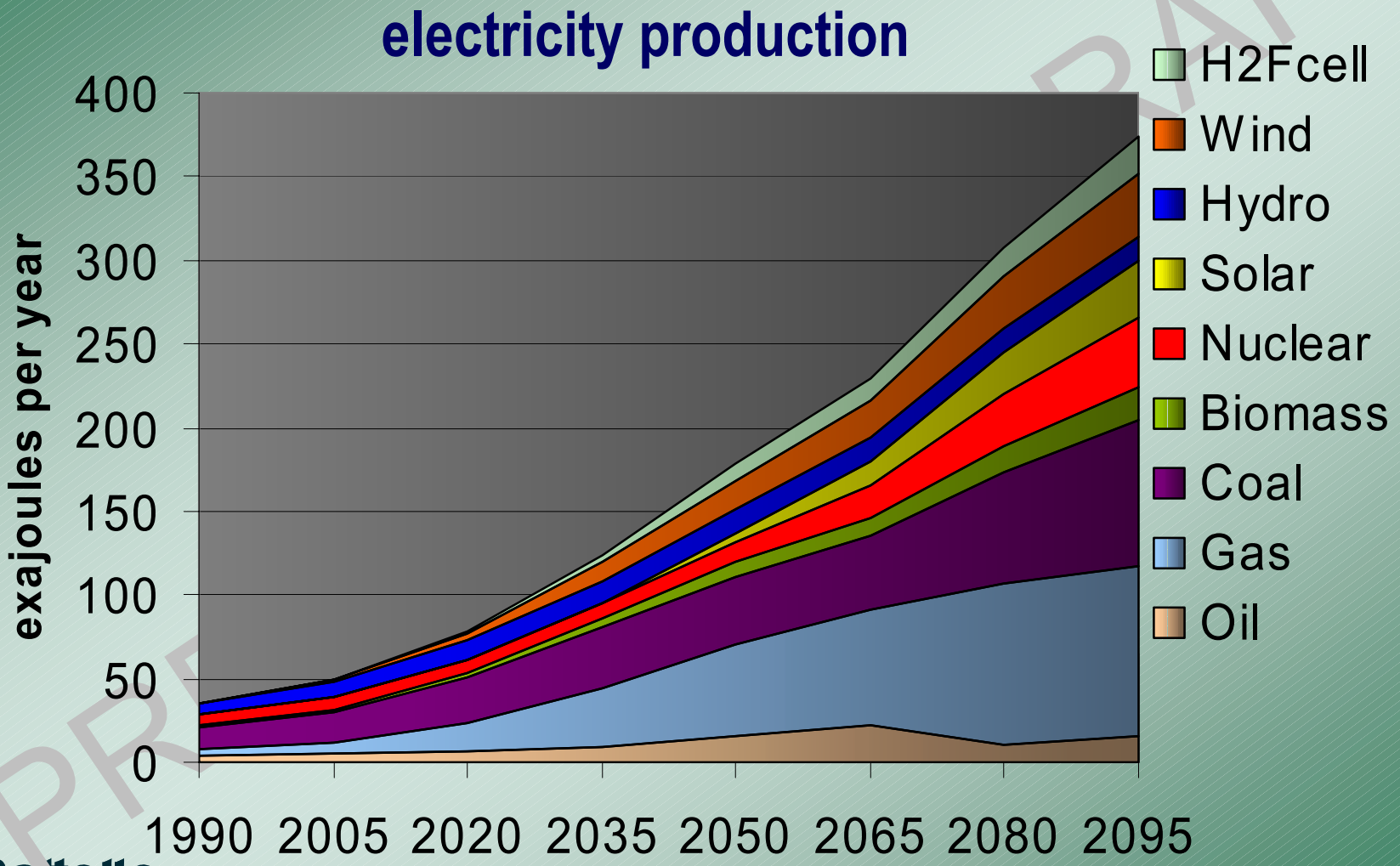
Pacific Northwest National Laboratory

UNIVERSITY OF MARYLAND

The Joint Global Change Research Institute

CLIMATE CHANGE

B2



CLIMATE CHANGE

some cases

Four different nuclear technologies

- *Nuclear moratorium*
- *Current cost power*
- *Advanced technology*
- *Goal technology*

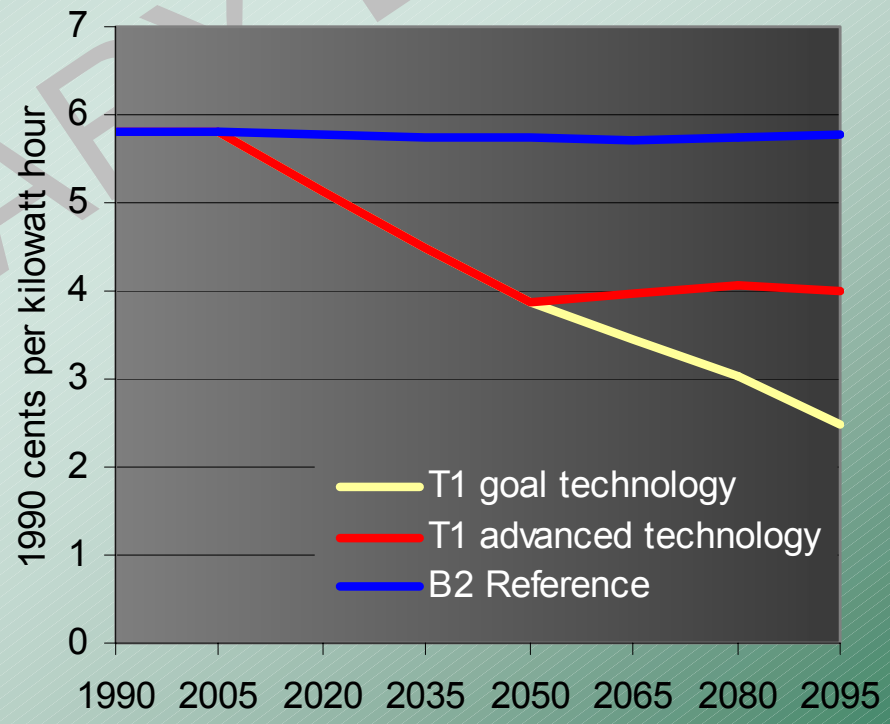
Five different climate policy regimes

- *No climate policy intervention*
- *Four different concentration limits: 450, 550, 650, 750 ppmv*

CLIMATE CHANGE

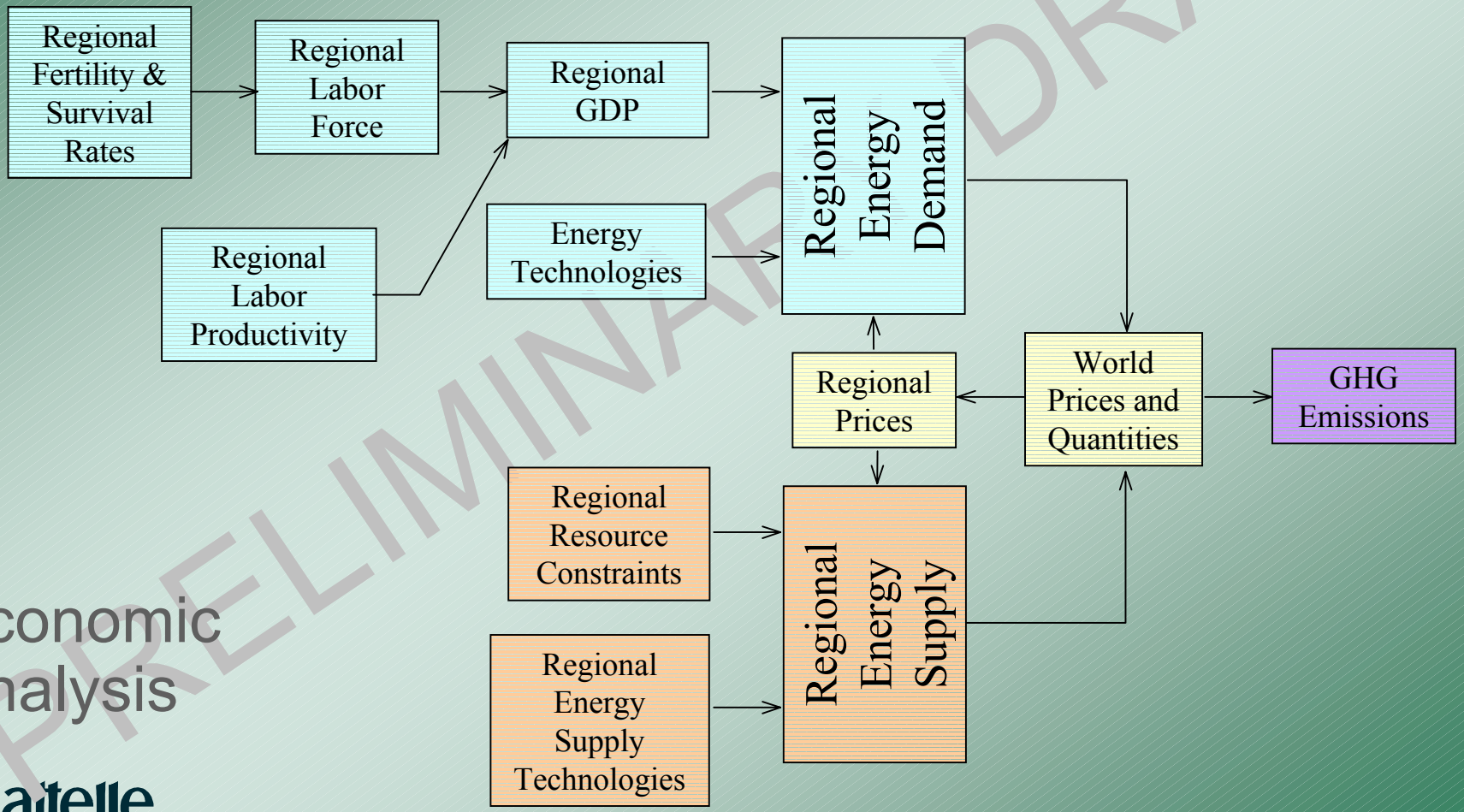
Reactor Technology

- *B2 Reference technology*
- *T1 Advanced Technology (0.9%/yr to 2050)*
- *T2 Goal Technology (0.9%/yr to 2095)*



CLIMATE CHANGE

the MiniCAM



Economic Analysis

Battelle

Pacific Northwest National Laboratory

UNIVERSITY OF MARYLAND

The Joint Global Change Research Institute

CLIMATE CHANGE

MiniCAM Regions

- US
- Canada
- W. Europe
- Australia & New Zealand
- Japan
- Eastern Europe
- Former Soviet Union
- China
- Mid-East
- Africa
- Latin America
- Korea
- Southeast Asia
- India
- *Mexico*
- *Argentina*
- *Brazil*

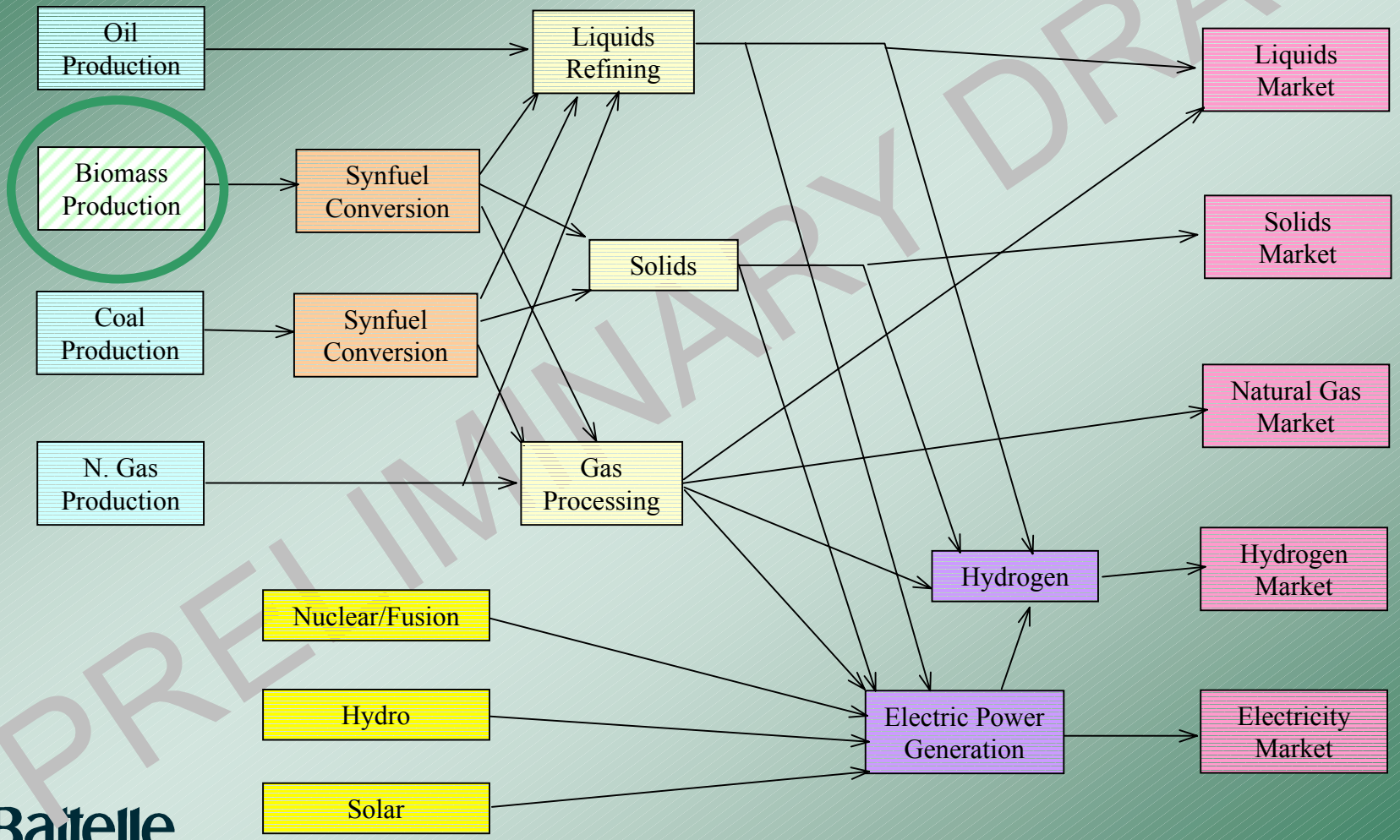
CLIMATE CHANGE

the competition

- *Fossil fuels—oil, gas, coal*
- *Renewables—solar, wind, hydro, biomass*
- *Derived fuels—H_2, electricity*

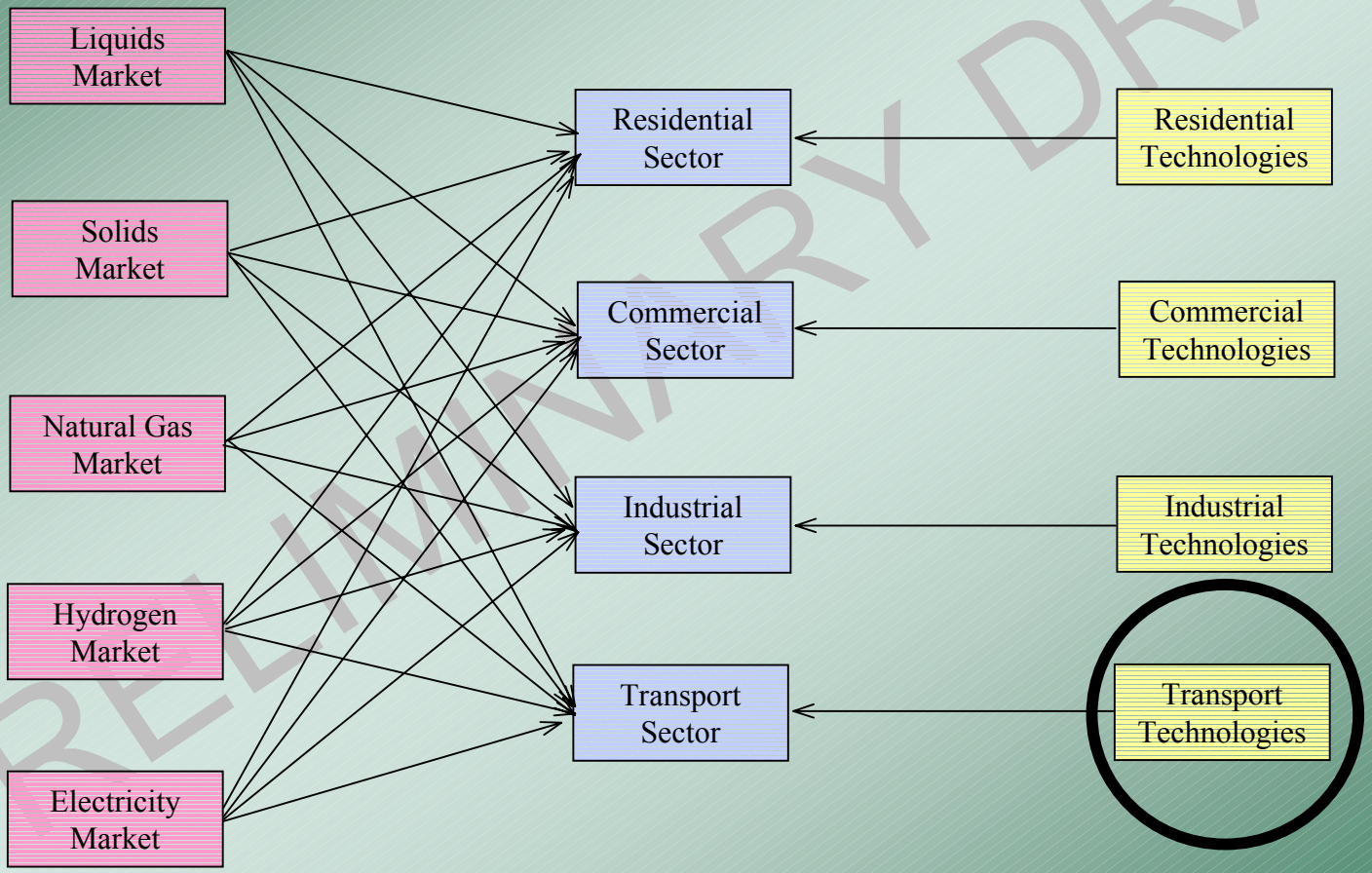
CLIMATE CHANGE

MiniCAM Energy Markets



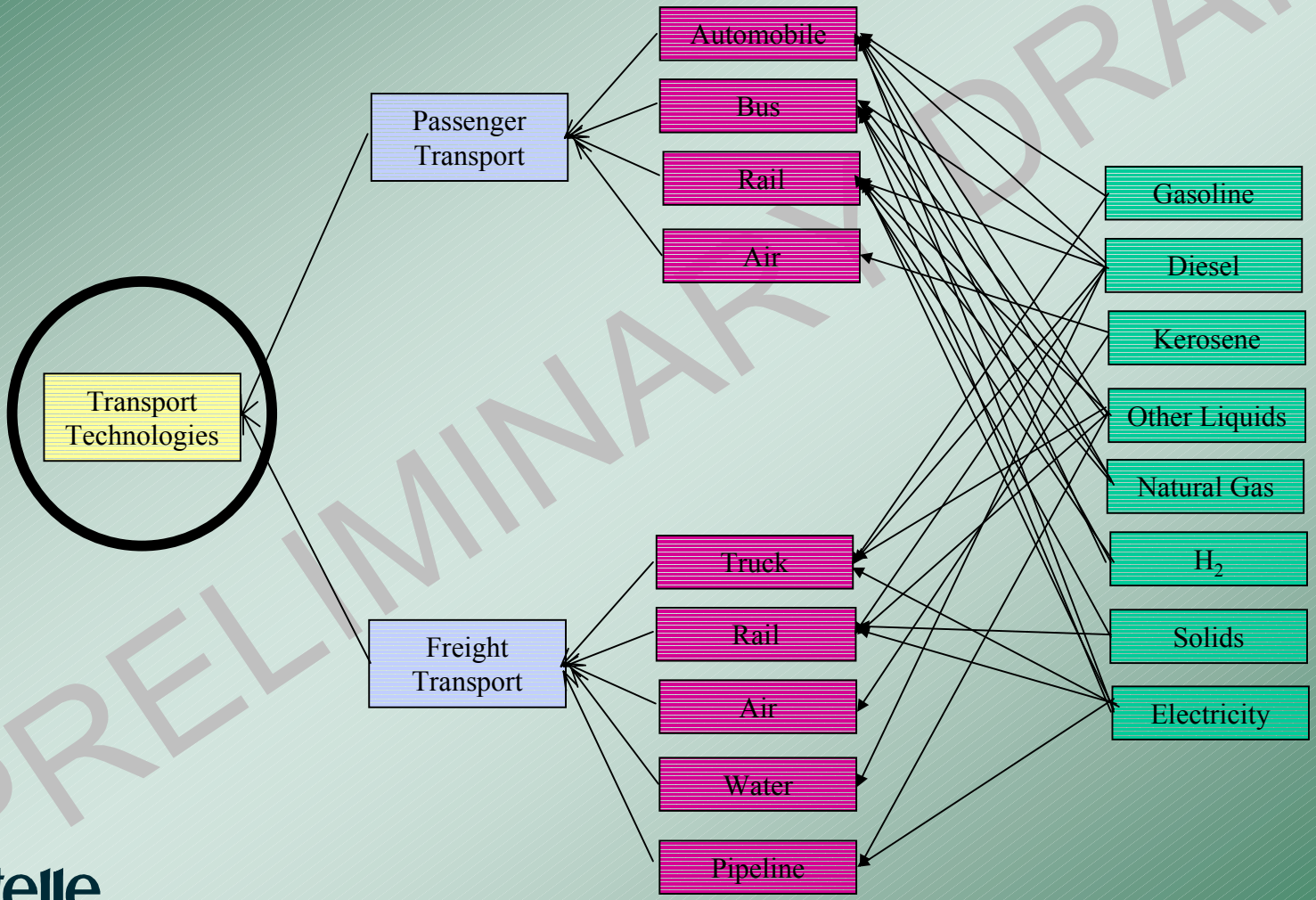
CLIMATE CHANGE

MiniCAM Energy Markets



CLIMATE CHANGE

MiniCAM Energy Markets



CLIMATE CHANGE

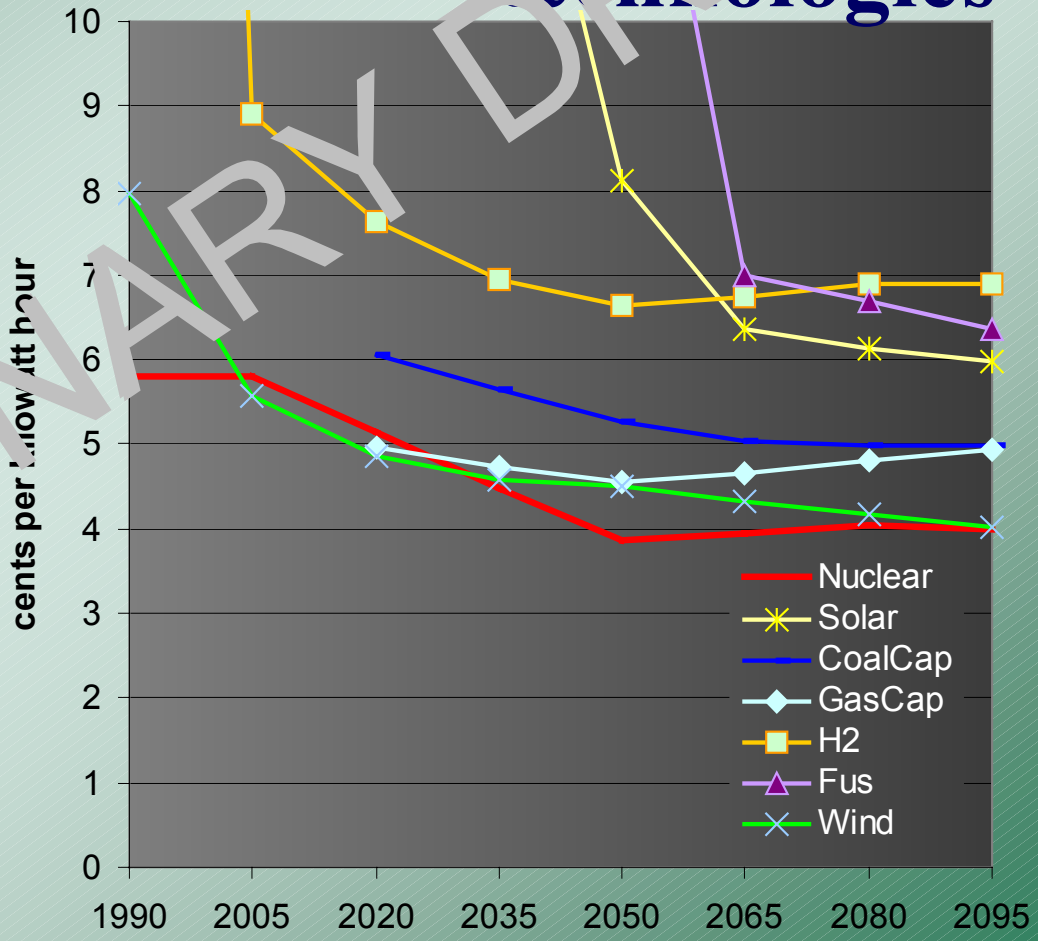
missing from the current analysis

- *Specification of reactor designs*
- *Interactions with resource limitations*
- *Option to produce combined power and hydrogen*
- *Safety*
- *Weapons proliferation*
- *Waste*

CLIMATE CHANGE

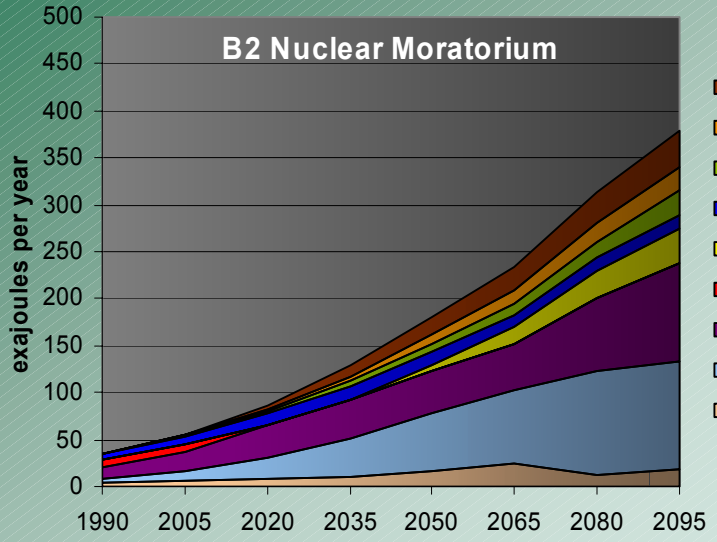
competition among power generation technologies

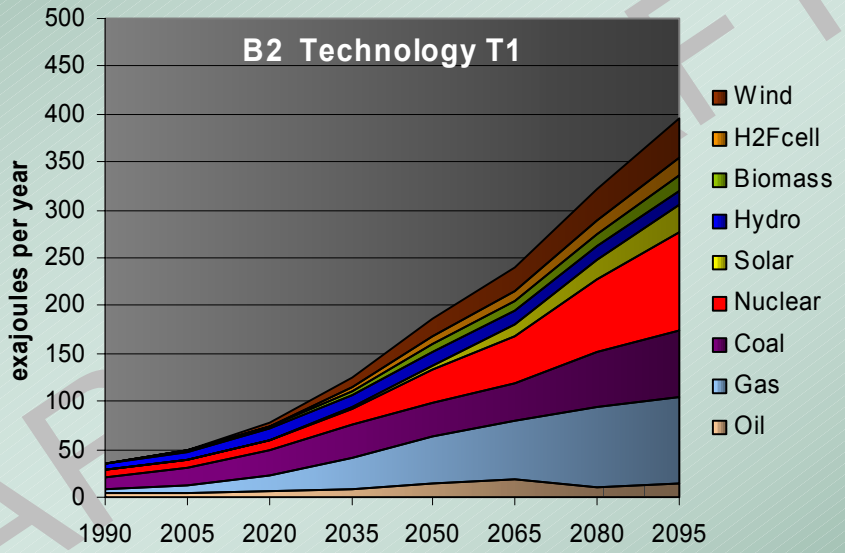
Other technology options improve with time.

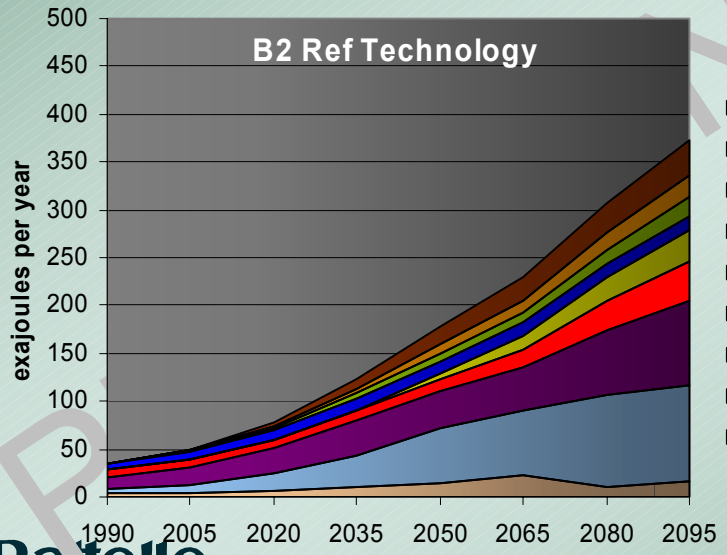


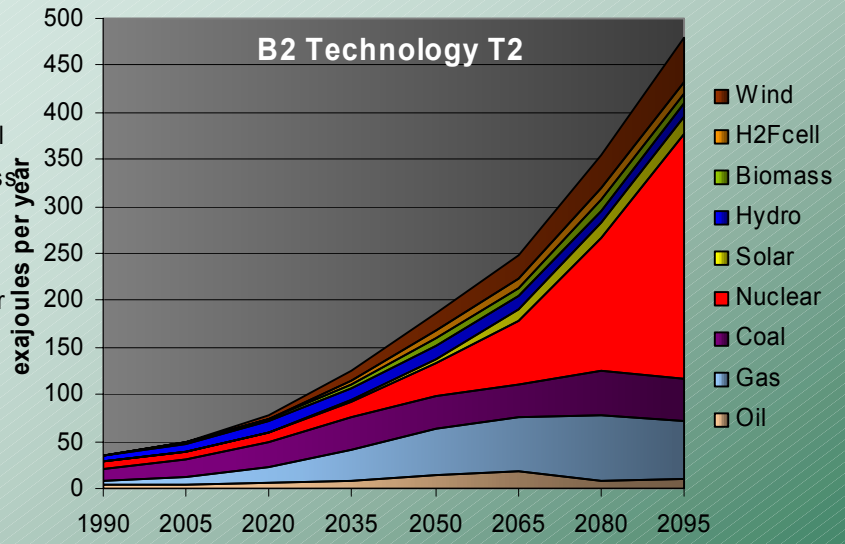
CLIMATE CHANGE

technology & mkt









Battelle

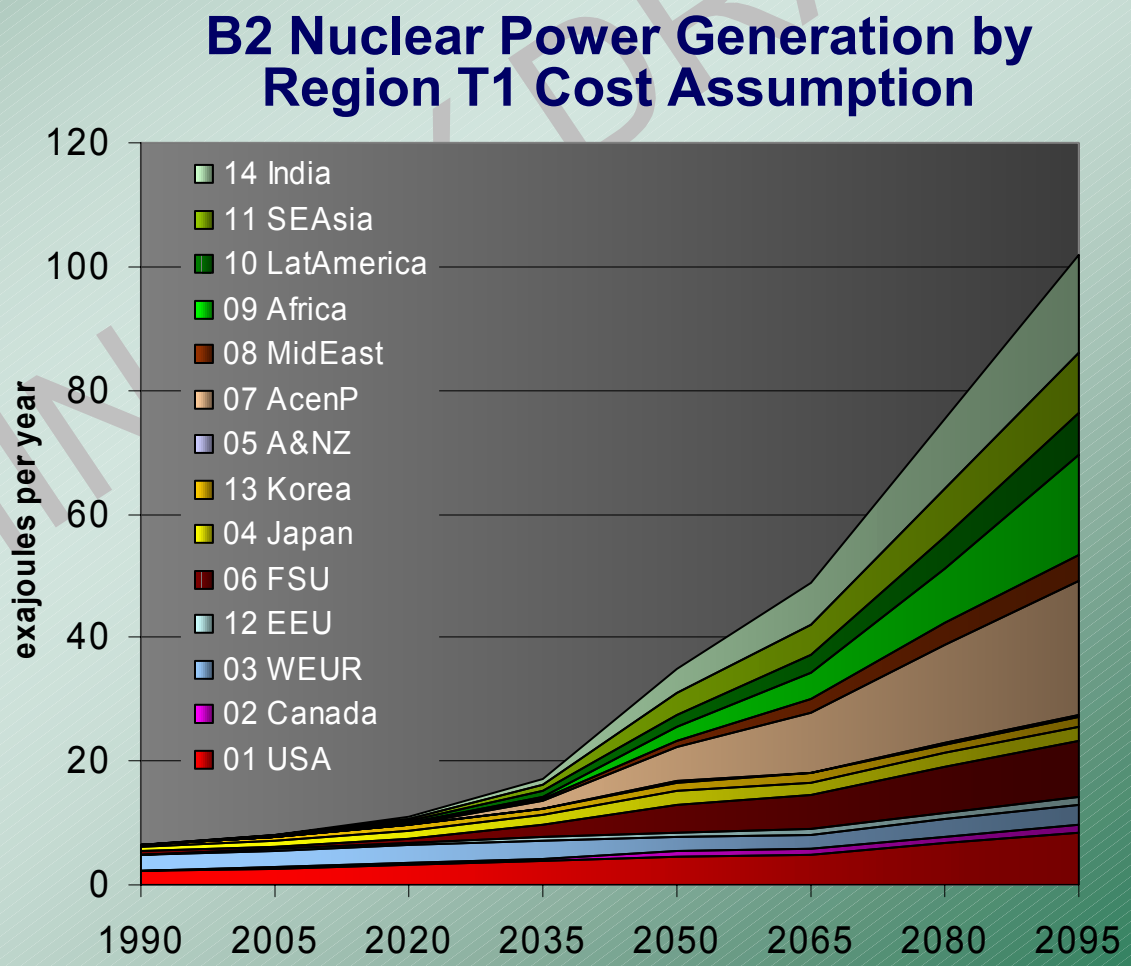
Pacific Northwest National Laboratory

UNIVERSITY OF MARYLAND

The Joint Global Change Research Institute

CLIMATE CHANGE regional deployment

The non-OECD market is BIG.



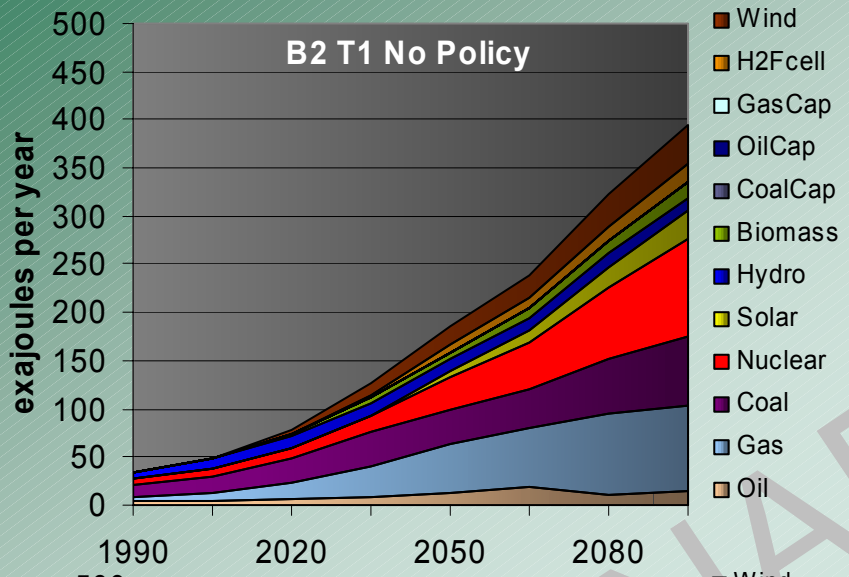
CLIMATE CHANGE

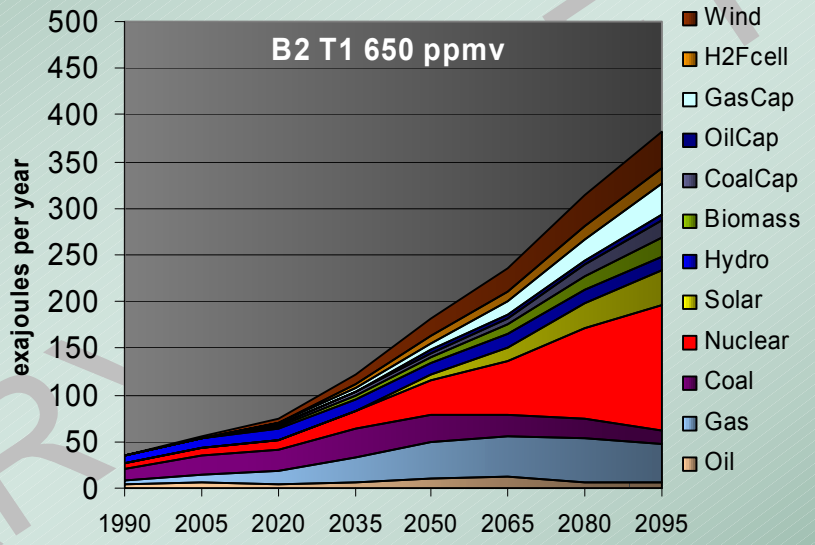
Stabilizing the concentration of CO_2

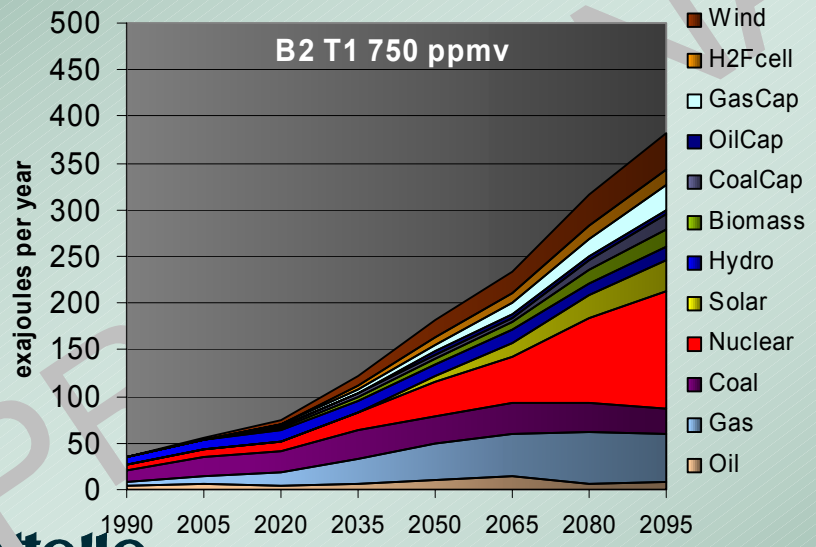
- *Goal of the UNFCCC*
- *No consensus as to the "right" concentration.*
- *We examine four options: 450, 550, 650 & 750 ppmv*

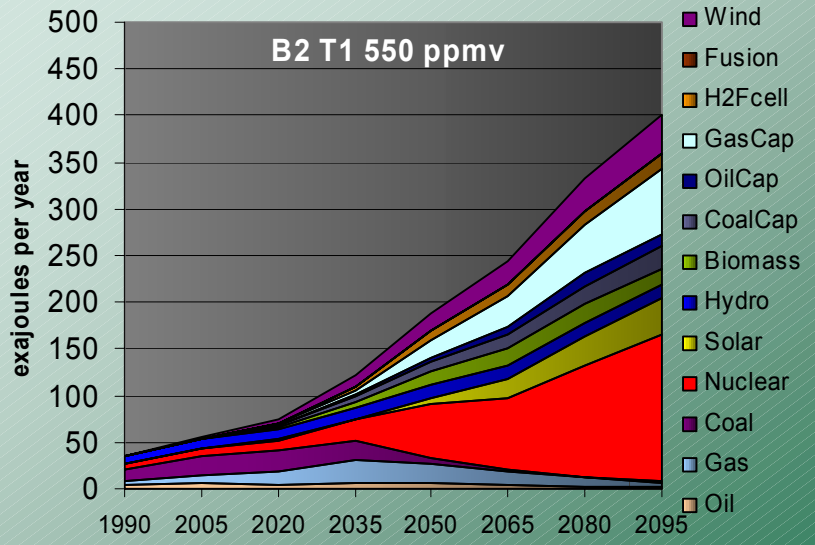
CLIMATE CHANGE

policy & power









Battelle

Pacific Northwest National Laboratory

UNIVERSITY OF MARYLAND

The Joint Global Change Research Institute

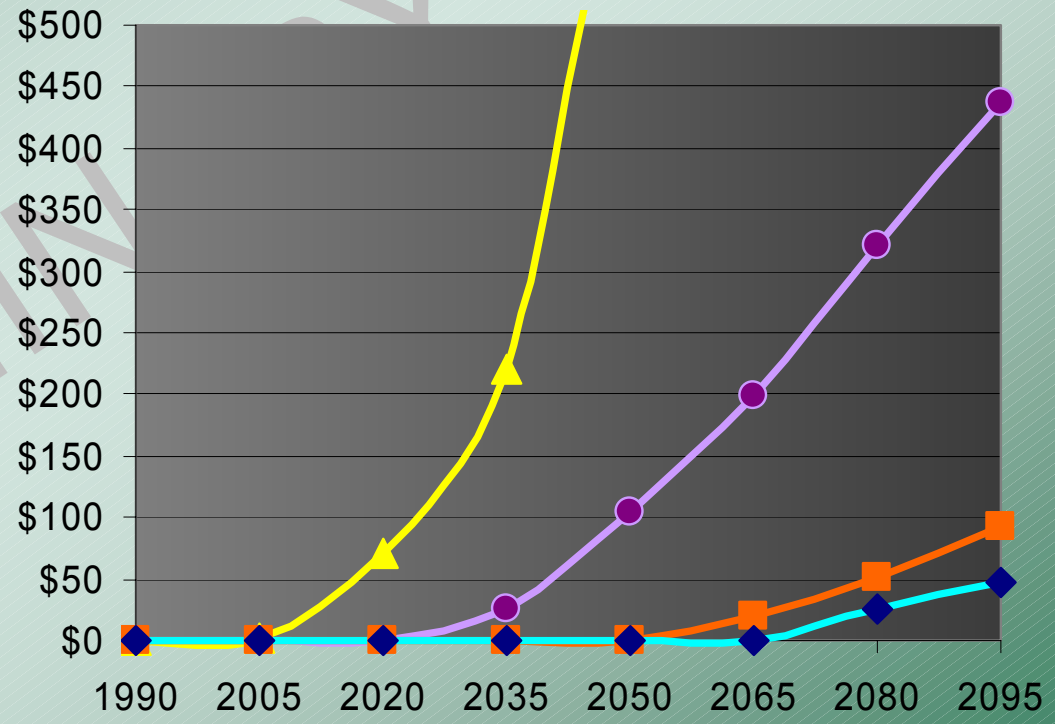
CLIMATE CHANGE

carbon tax

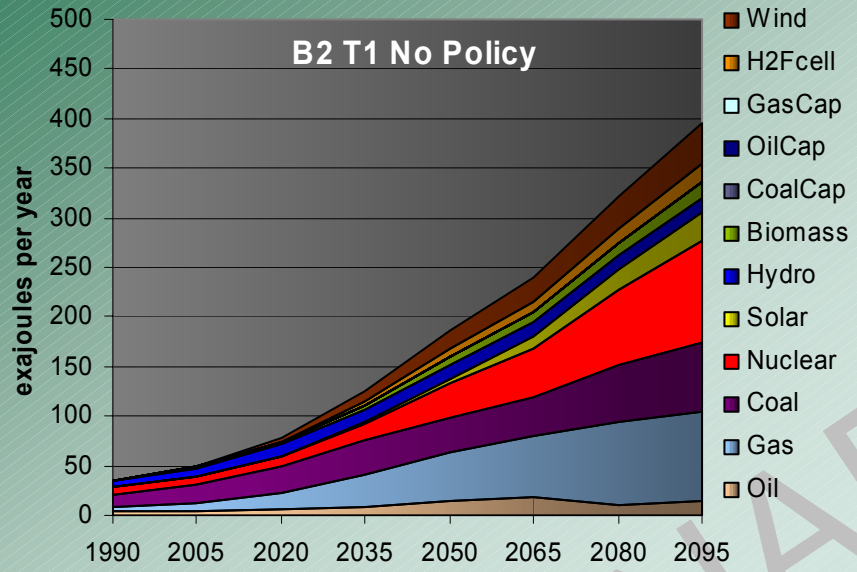
- *Cost advantage of $105/ton C in 2050 is*

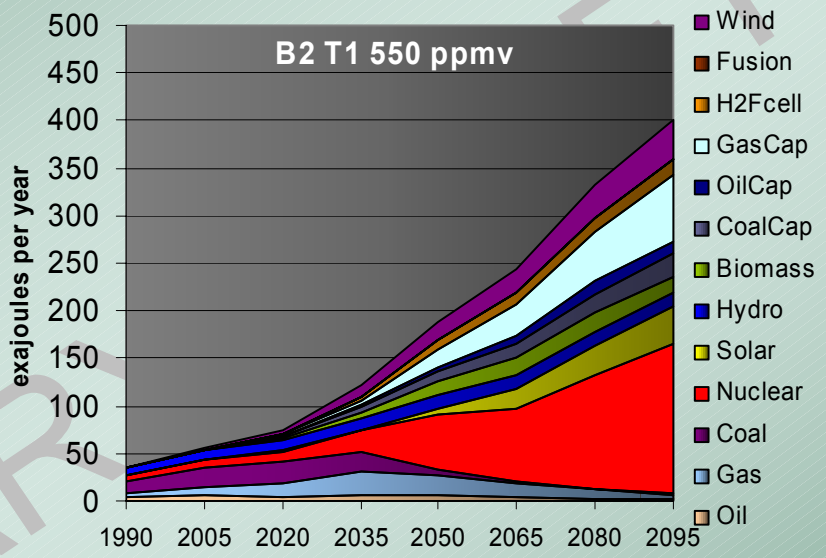
Gas=0.94 cents/KWh

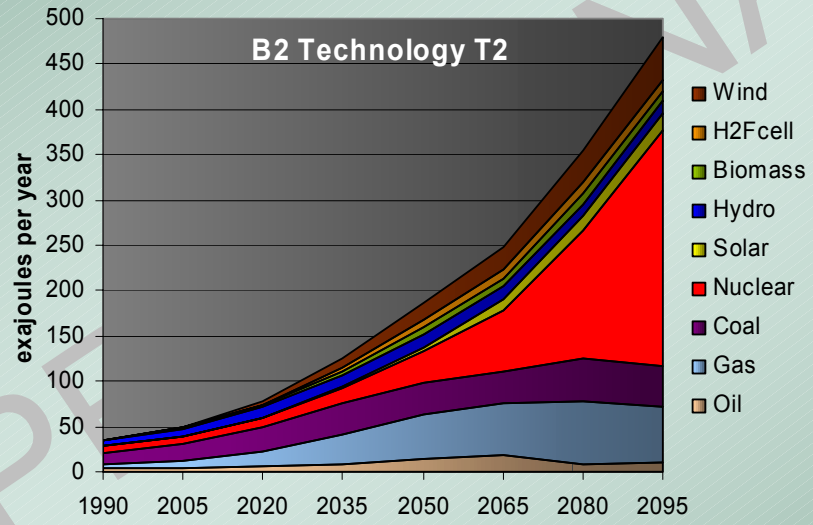
Coal=2.25 cents/KWh

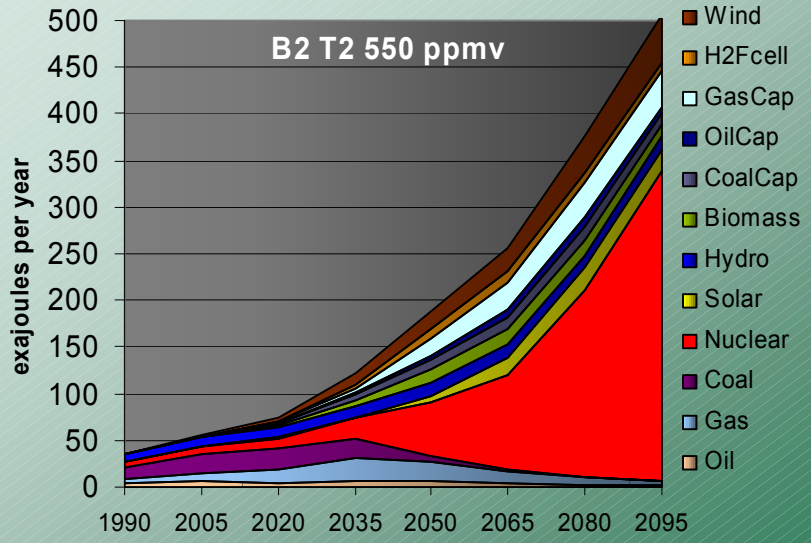


CLIMATE CHANGE technology or policy









Battelle

Pacific Northwest National Laboratory

UNIVERSITY OF MARYLAND

The Joint Global Change Research Institute

CLIMATE CHANGE

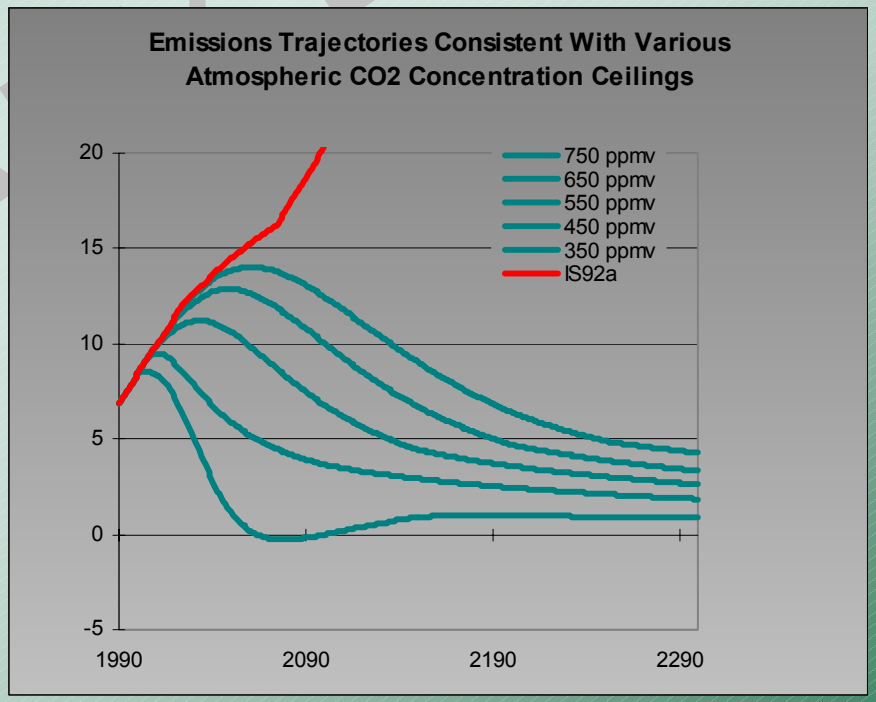
economic cost of stabilizing the concentration of CO_2

- *Minimum cost*
  - *All nations participate from the beginning*
  - *Common carbon value*
  - *Gradual transition*
- *Real policy can never be this efficient.*

CLIMATE CHANGE

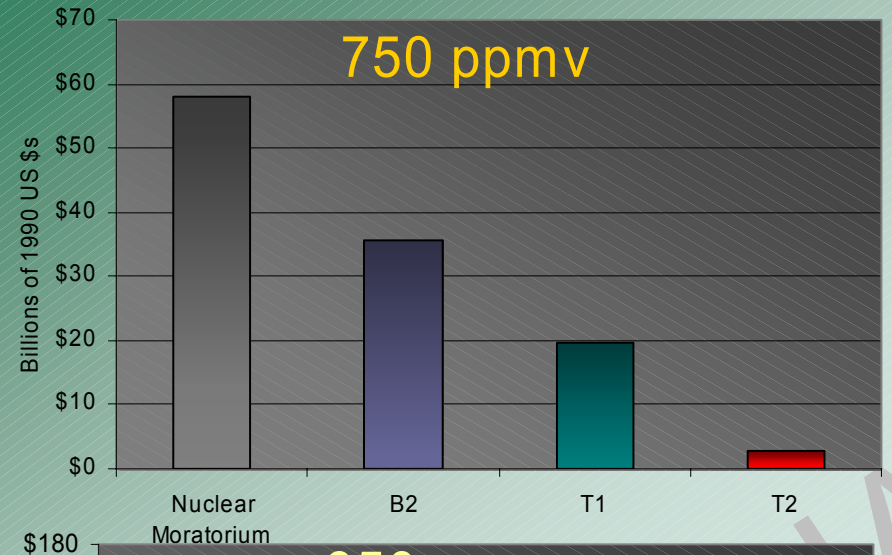
economic cost of stabilizing the concentration of CO_2

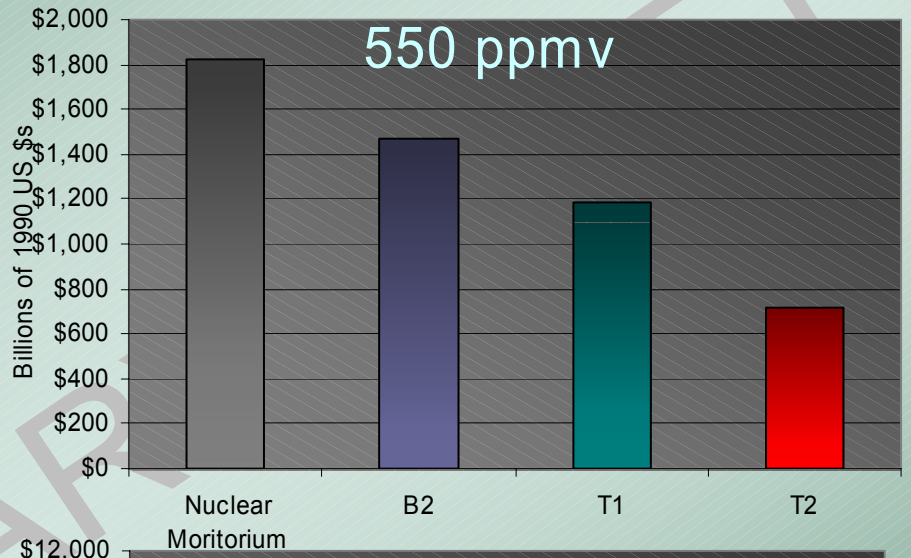
- *Present discounted cost at 5%.*
- *Follow the WRE trajectories.*

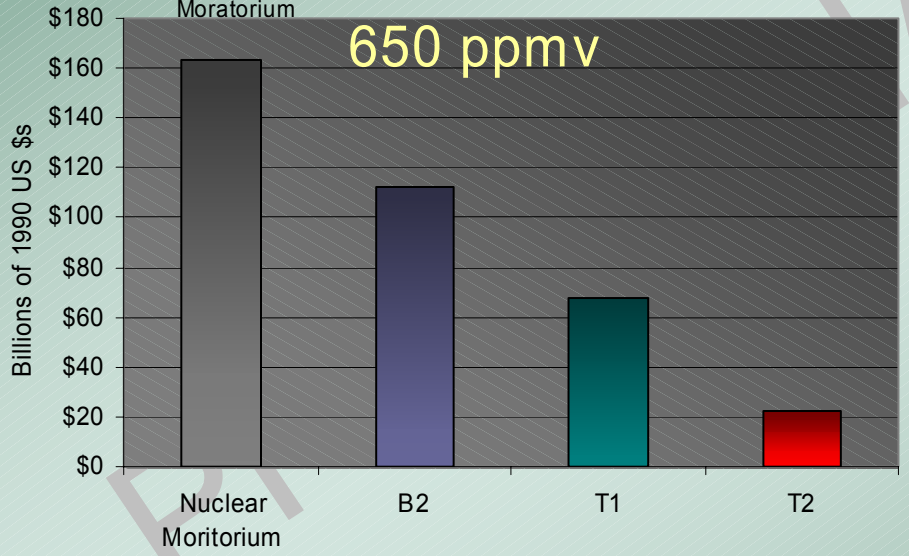


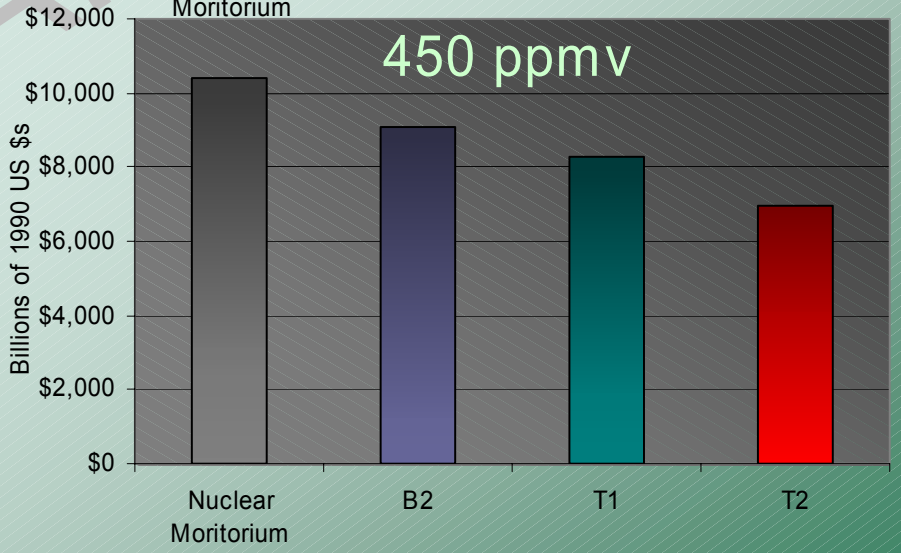
CLIMATE CHANGE

technology & cost









Battelle

Pacific Northwest National Laboratory

UNIVERSITY OF MARYLAND

The Joint Global Change Research Institute

CLIMATE CHANGE

some final thoughts

- *The greenhouse problem is not likely to disappear on its own, but the greenhouse problem does not necessarily mean that nuclear will be reborn.*
- *It's a competitive world and cost and performance matter big time.*
- *Competing technologies cannot be assumed to stand still. They too can be expected to improve and evolve over time.*
- *Nuclear power could be a major component of the global energy system with or without climate change, if cost and performance is right, and if other issues can be resolved.*