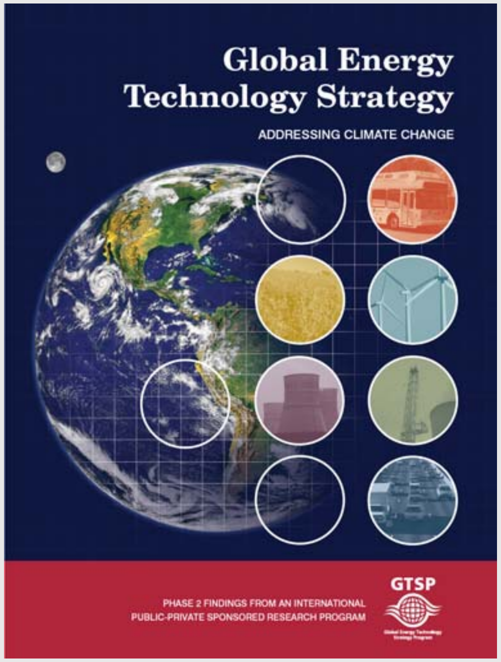
The Role of Technology in a Low-carbon Society



Selected Key Findings from the Global Energy Technology Strategy Program

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Pacific Northwest National Laboratory
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Acknowledgements

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- Thanks to the sponsors of the Global Energy Technology Strategy Program (GTSP) for research support.

GTSP Sponsors – Phases 1,2, & 3

A Note on Units
CO_2 Versus C

- 1 ton C = 44/12 tons of CO_2
  = $3^2/_3$ tons of CO_2
  = ~4 tons of CO_2

- \$1/ton CO_2= \$$3^2/_3$ tons of C
  = ~\$4 tons of C

Both appear in the literature.

This presentation used tons of carbon.

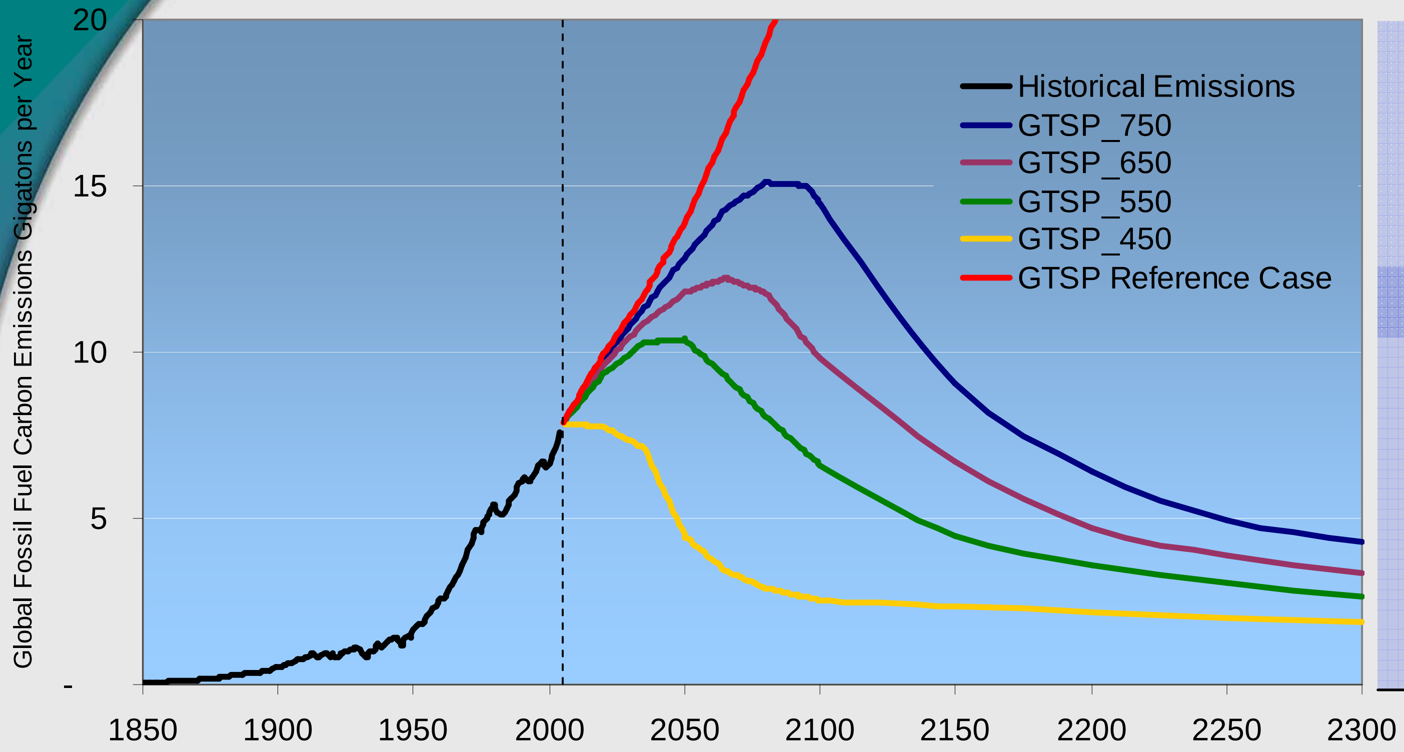
Key Findings of the GTSP

- Climate is a long-term problem, with implications for actions today.
- Stabilizing the concentration of CO_2 means fundamental change to the global energy system.
- Technology will play a central role in addressing a growing mitigation challenge in the near-, mid- and long-term.
- Six technology systems could play dramatically greater roles in a climate constrained world.

  CO_2 capture and storage, Biotechnology, Hydrogen systems, Nuclear energy, Wind and solar, and End-use energy technologies, though none is a “silver bullet.”

- A strategy to develop and deploy technology should be part of a larger program—including scientific research, emissions limitation, and adaptation to climate change.

Climate change is a long-term strategic problem with implications for today

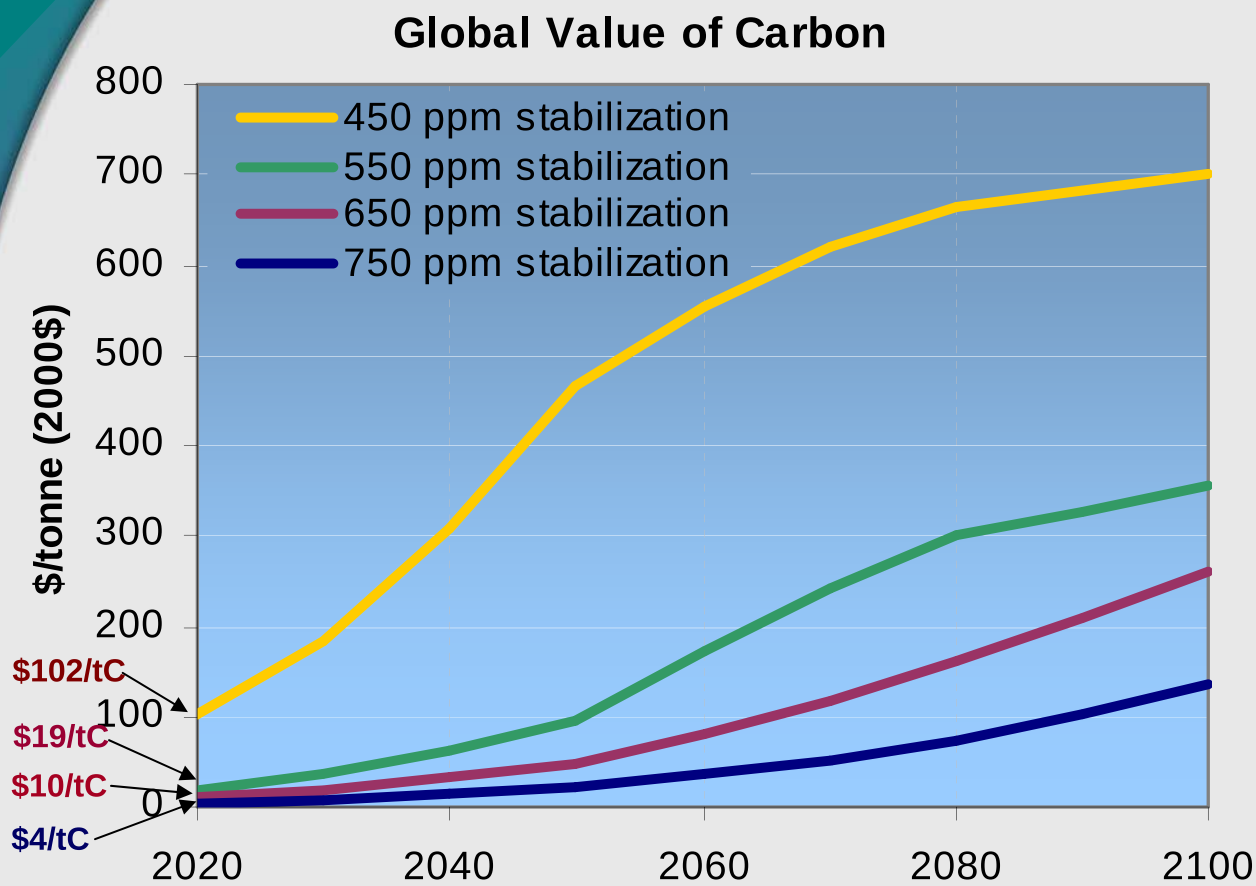


Fossil Fuel Carbon Emissions
Historic & 2005 to 2100

1750-2005	300 GtC
GTSP Ref	**1430 GtC**
750 ppm	**1200 GtC**
650 ppm	**1040 GtC**
550 ppm	**862 GtC**
450 ppm	**480 GtC**

- Stabilization of greenhouse gas **concentrations** is the goal of the Framework Convention on Climate Change.
- Stabilizing CO_2 **concentrations** at any level means that **global**, CO_2 emissions must peak and then decline forever.

A global commitment to stabilizing CO_2 concentrations requires a carbon price that escalates over time



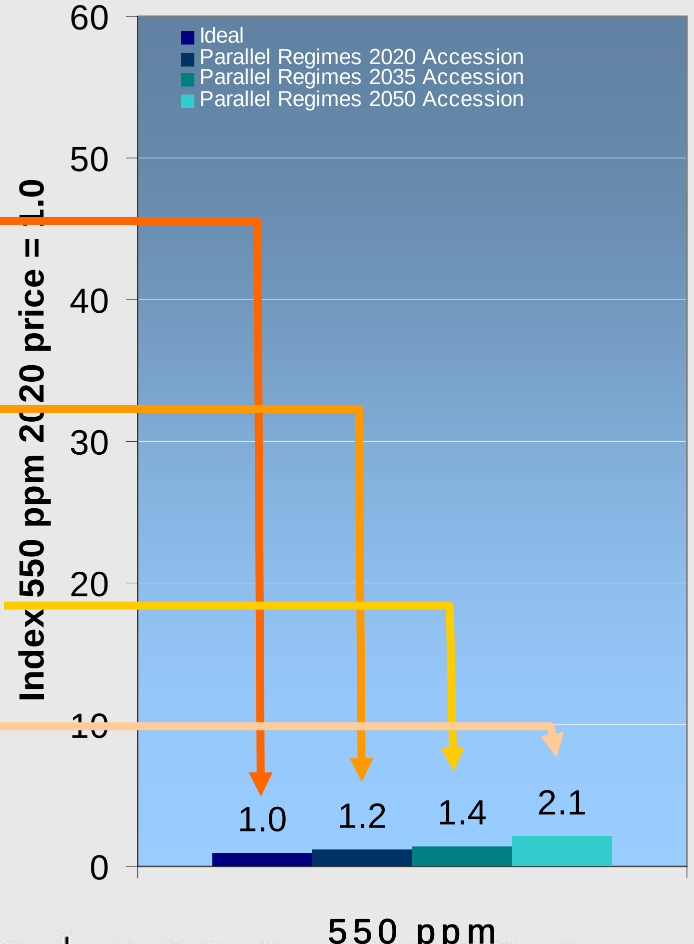
- Price of carbon should start low and rise steadily to minimize society's costs.
- Eventually all nations and economic sectors need to be covered as the atmosphere is indifferent as to the source of CO_2 emissions.
- The response to this escalating price of carbon will vary across economic sectors and regions.

Year 2020 Annex I carbon prices for different accession assumptions: 550 ppm

Near-term carbon prices depend on both the concentration at which CO_2 is stabilized and the degree and timing of Non-Annex I accession.

Four alternative assumptions:

1. The whole world starts emissions mitigations **immediately** with perfect “where” and “when” flexibility.
2. Annex I starts emissions mitigation immediately, but most non-Annex I starts in **2020** in a parallel regime.
3. Annex I starts emissions mitigation immediately, but most non-Annex I starts in **2035** in a parallel regime.
4. Annex I starts emissions mitigation immediately, but most non-Annex I start in **2050** in a parallel regime.



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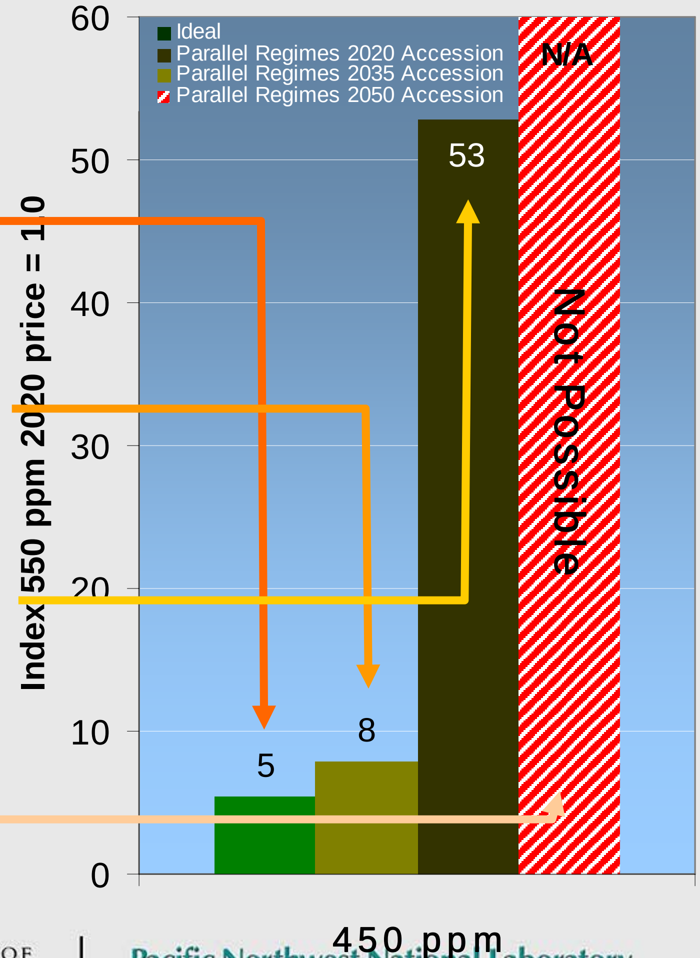
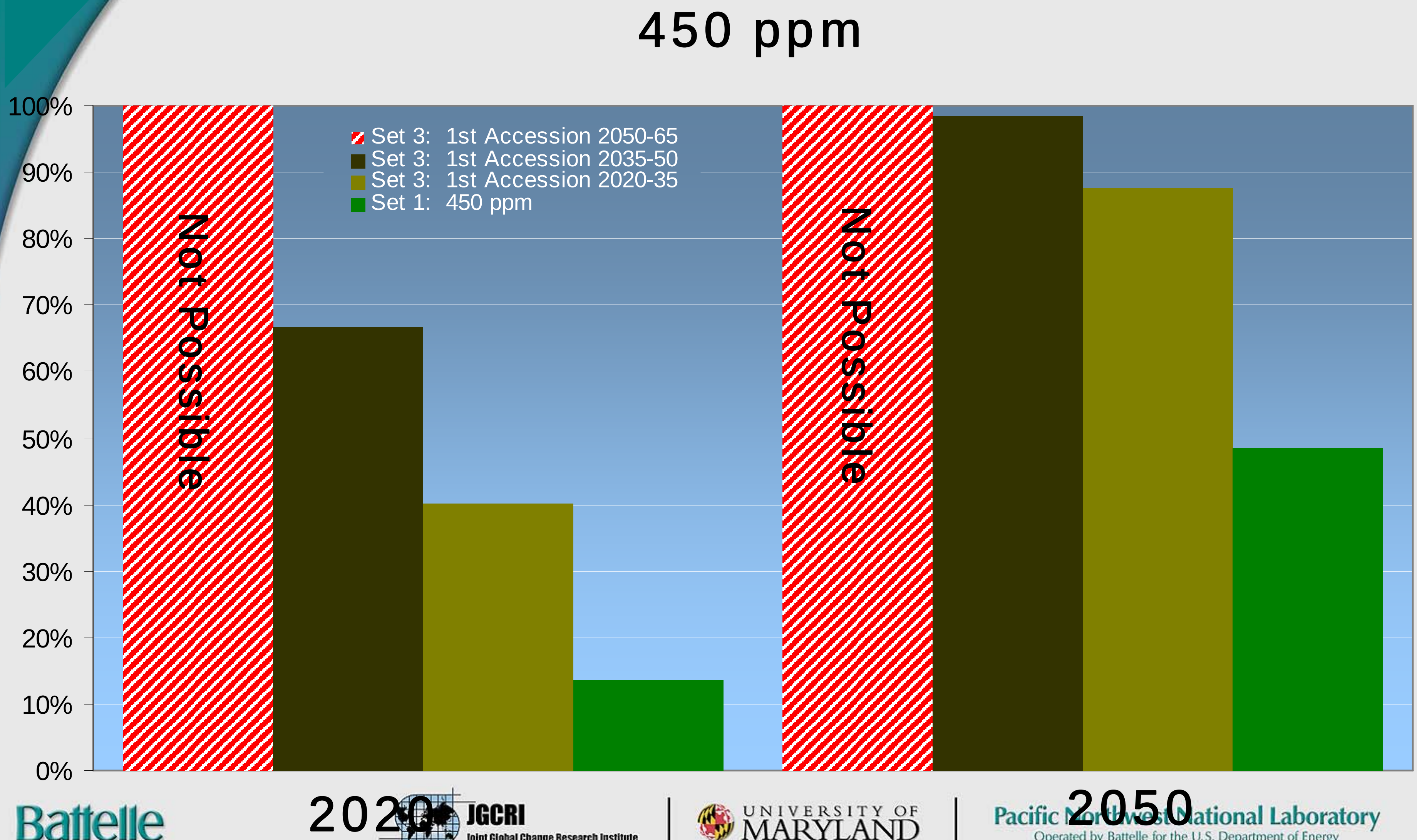
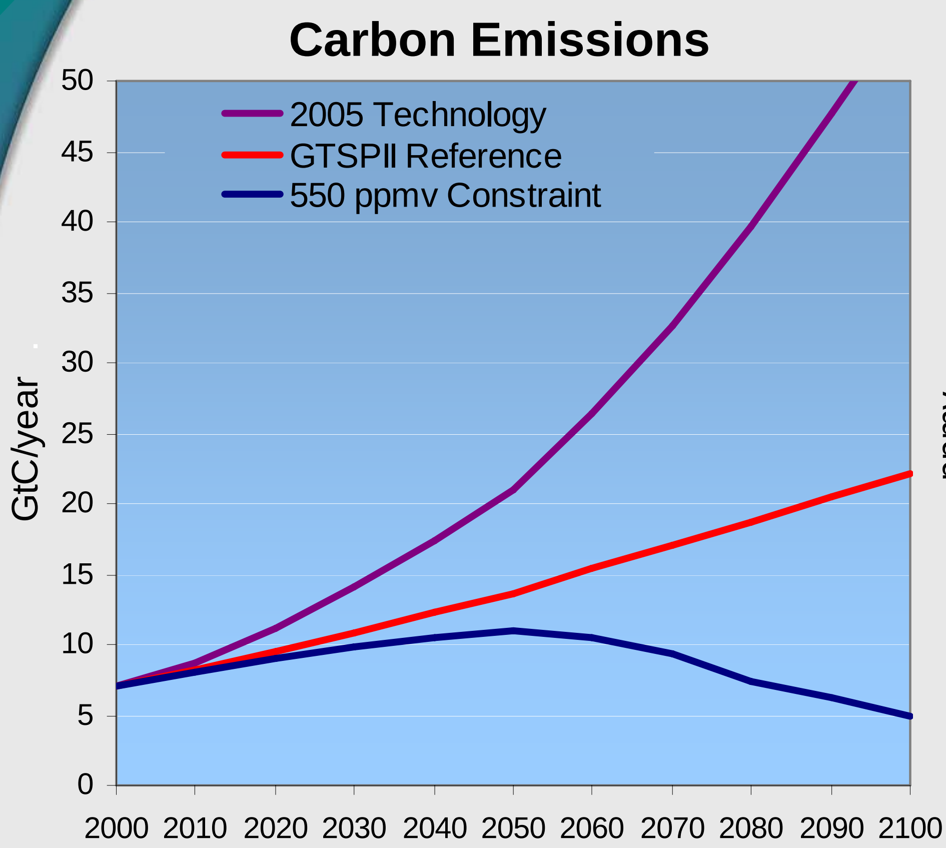


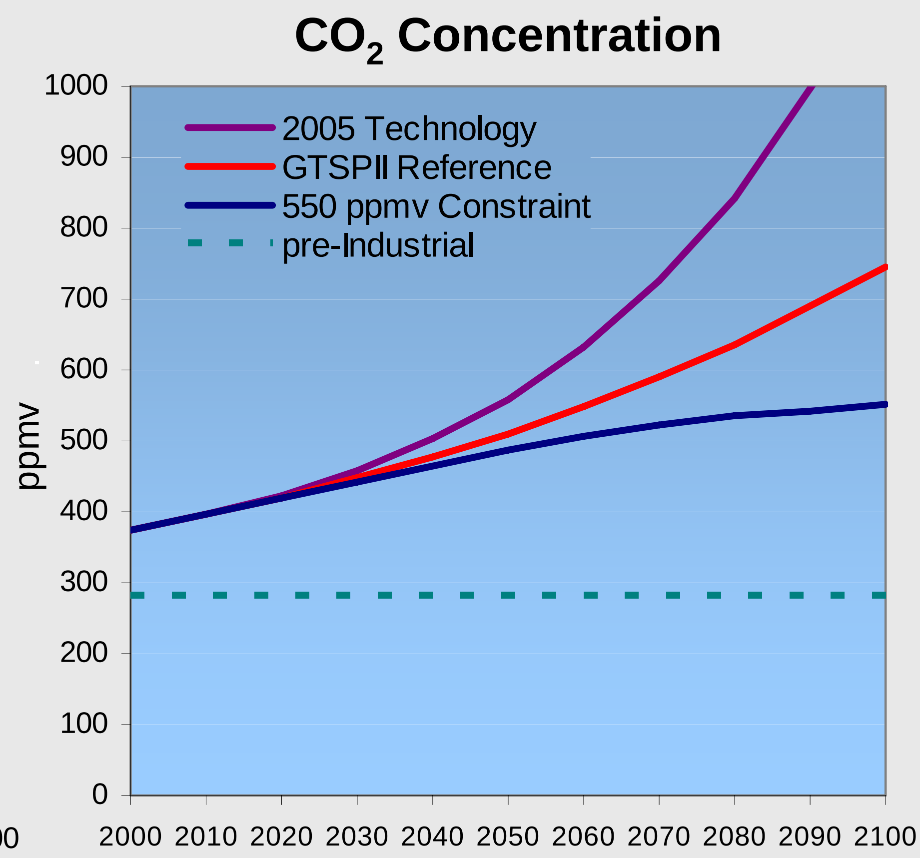
Year 2020 Annex I emissions mitigation, relative to 2005, for different accession assumptions: 450 ppm



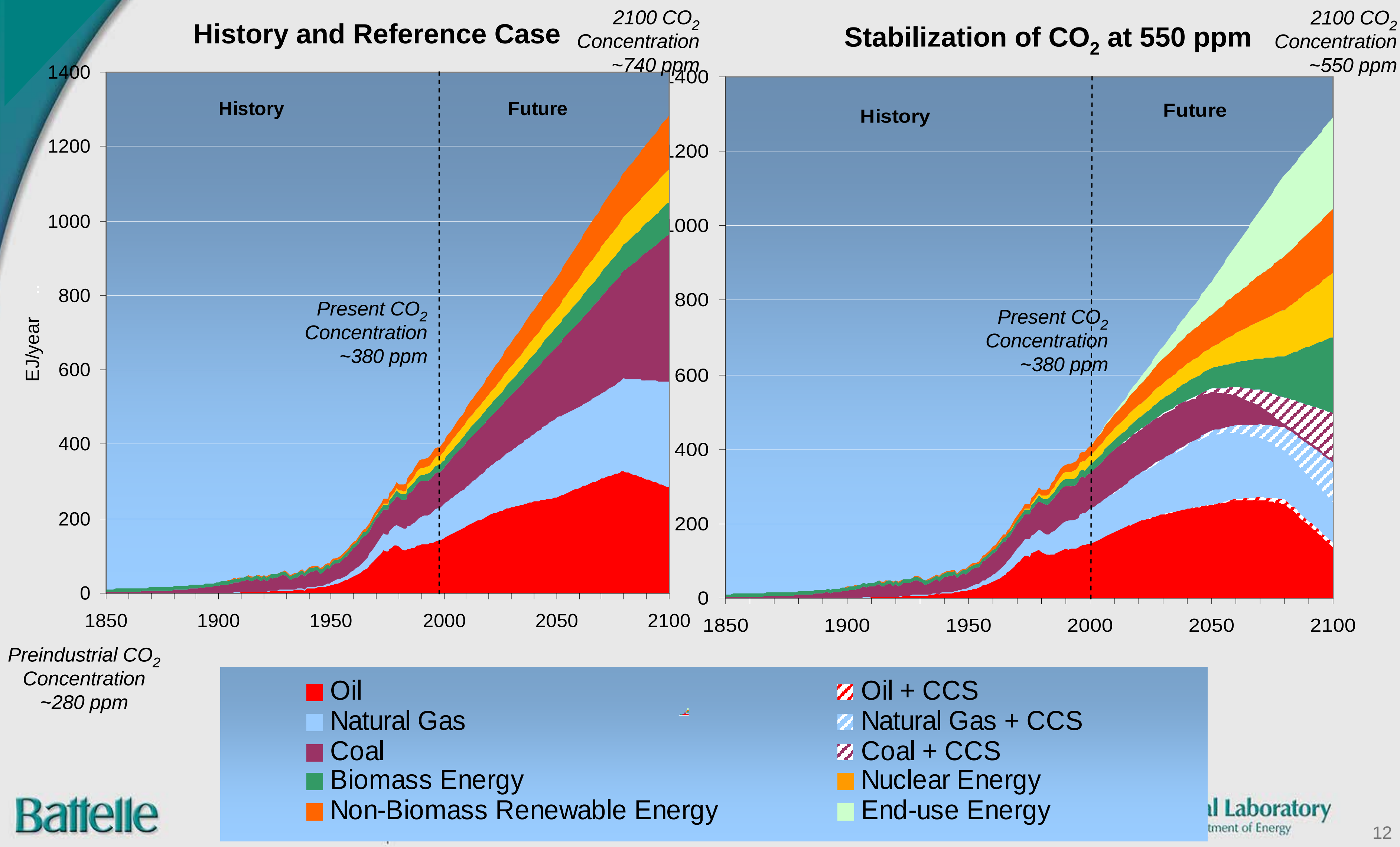
The role of technology

Future projections of energy use and CO_2 emissions assume significant technological progress in their no-climate-policy, business-as-usual cases





Stabilizing CO_2 concentrations means fundamental change to the global energy system



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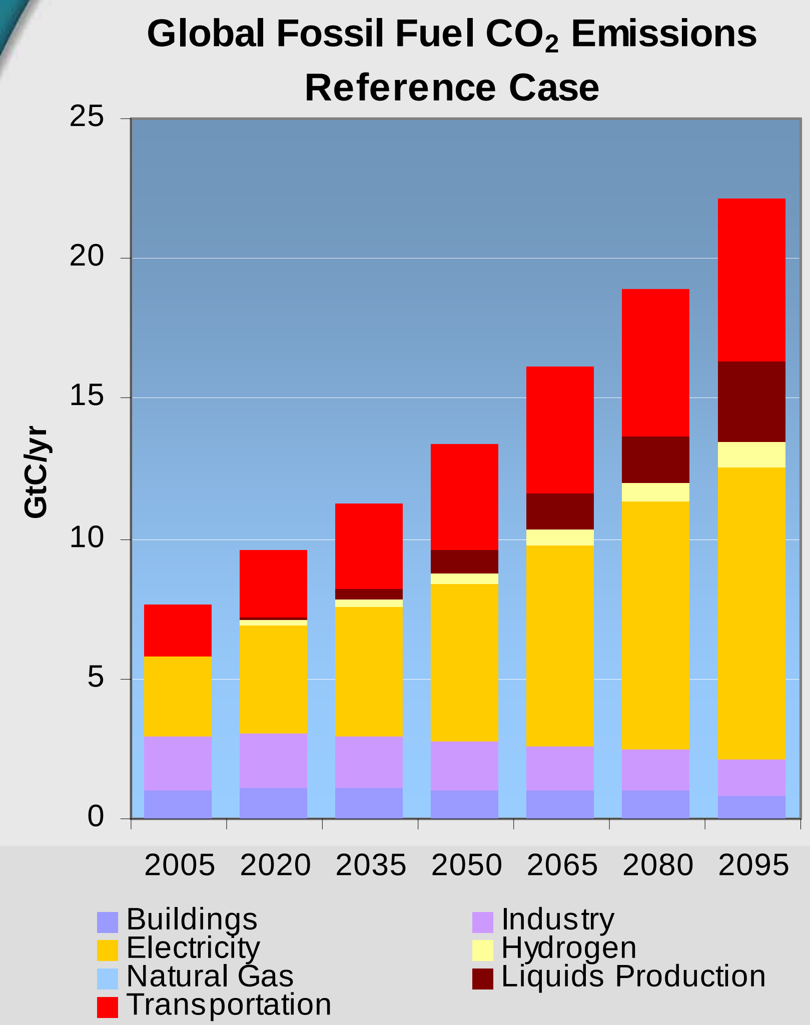
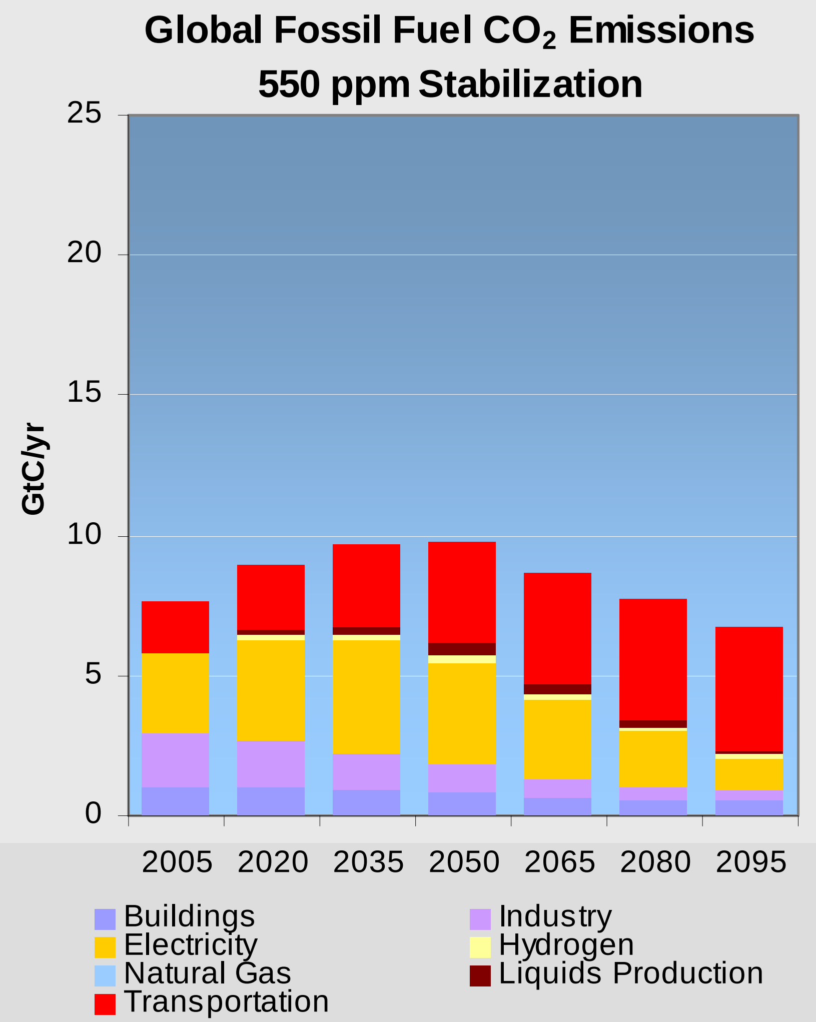
The response to this escalating price of carbon will vary across economic sectors and regions.

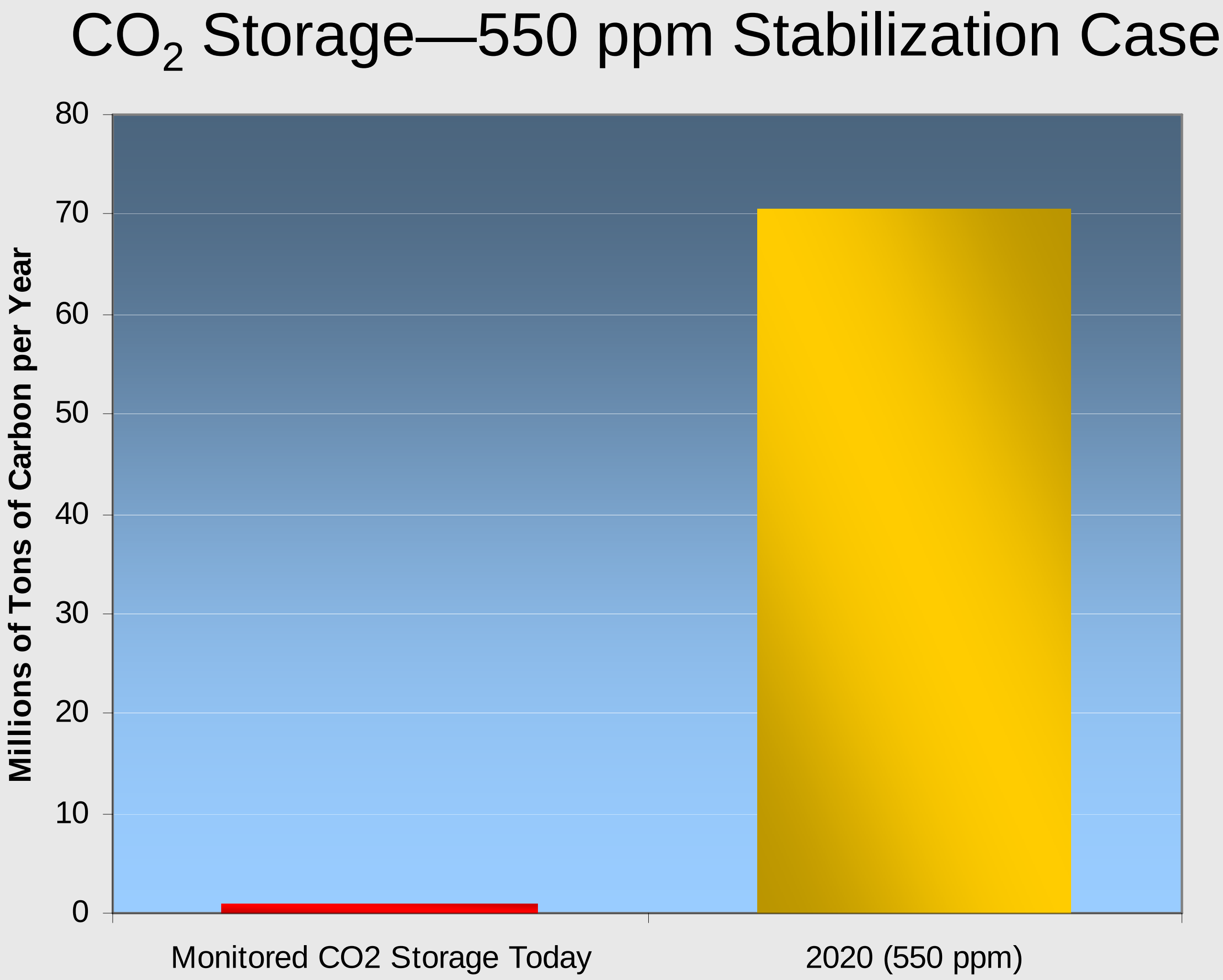
Stabilization changes the sources of fossil CO_2 emissions. Utility emissions drop to virtually zero. Transportation emissions dominate.



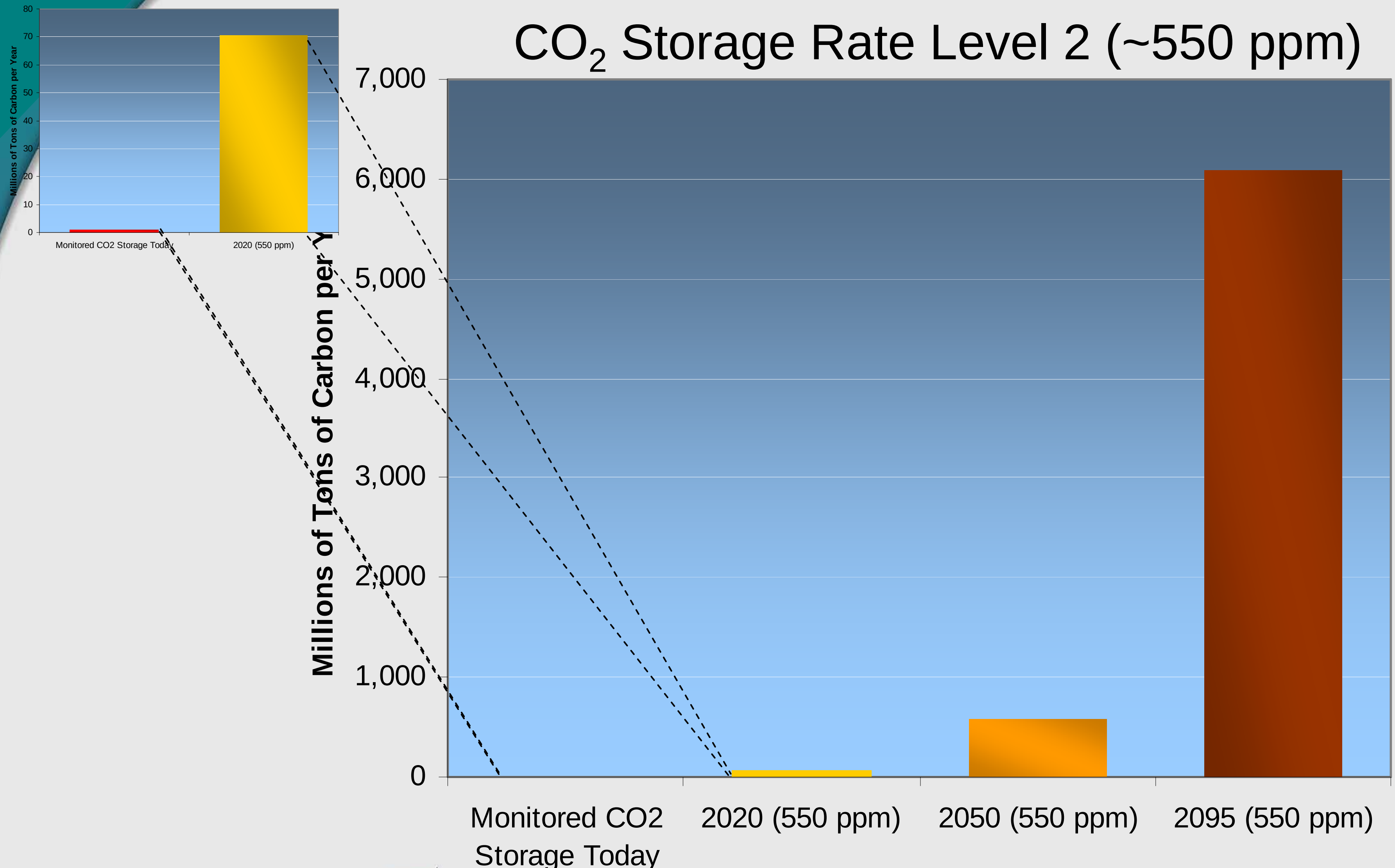


The challenge of scale

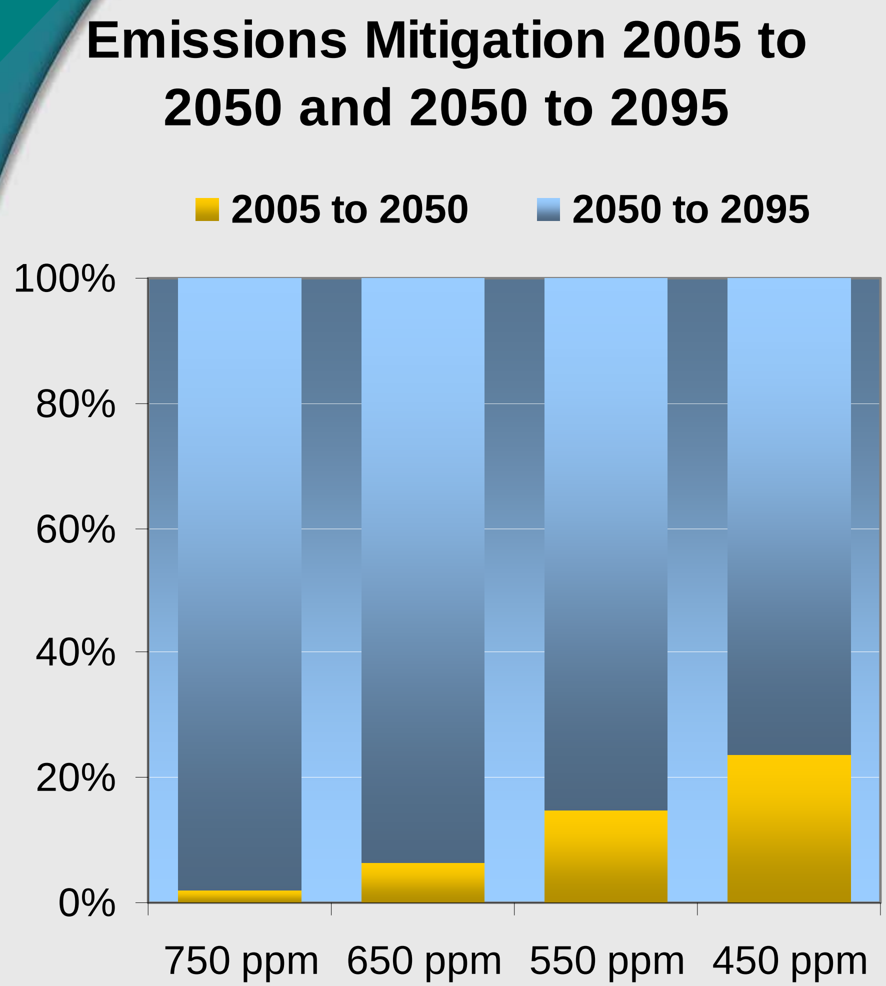
The Challenge of Scale—near term



In the mid- and long-term the challenge grows



CO_2 emissions mitigation during 2005 to 2050 is just the start



- The time scale of emissions mitigation is a century or more.
- Energy technology will be needed to help control emissions in the NEAR-, MID-, and Long-term to address climate change.
- Investments in basic scientific research in the first half of the 21st century can be transformed into energy technologies that can become a major part of the global energy system in the second half of the century.

Bioenergy and Land use

Biotechnology—One of the 6 Key Technologies that Could Deploy Dramatically in a Climate-Constrained World

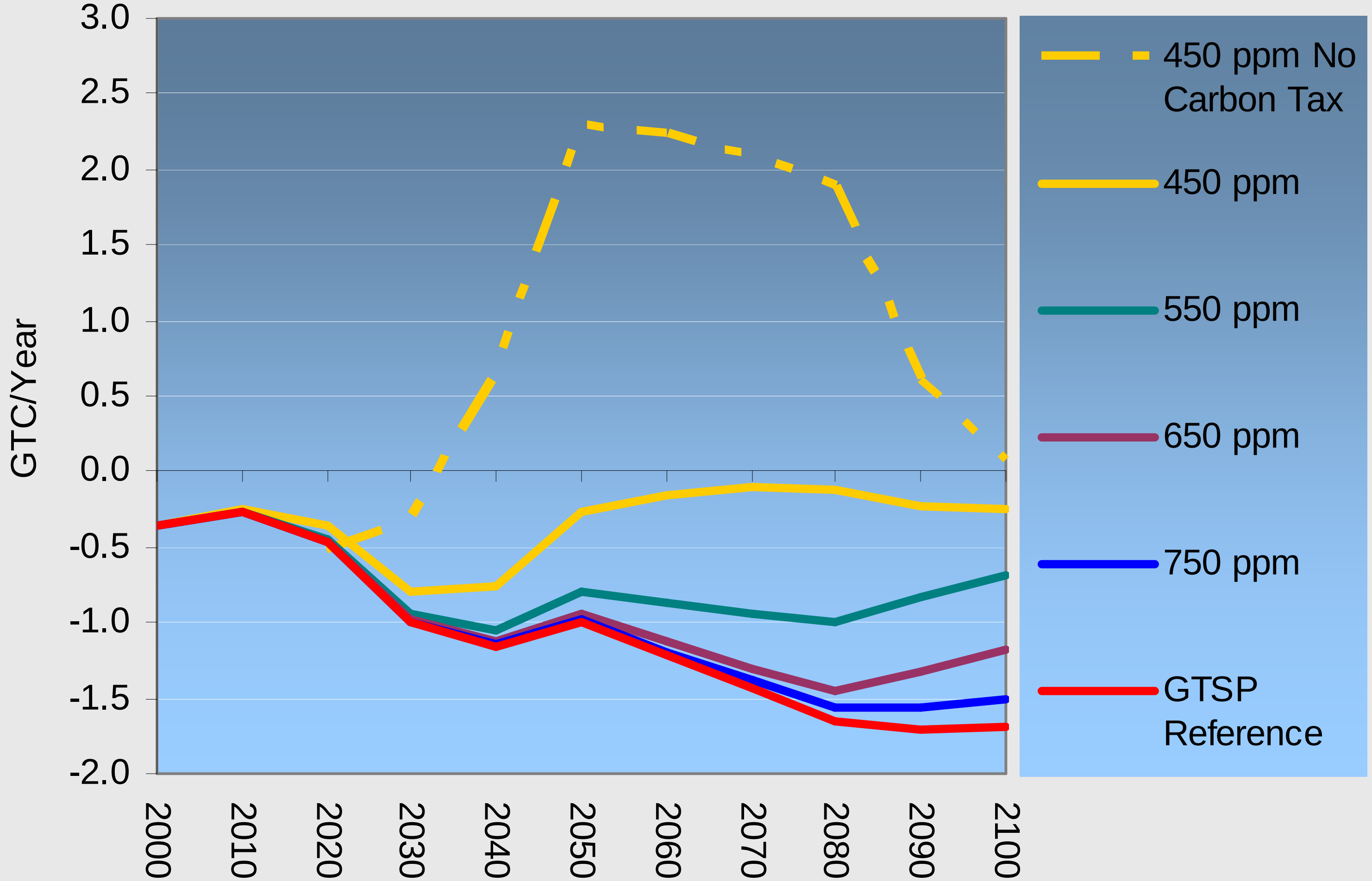
- Biotechnology is itself a portfolio of technologies
  - Soil carbon
  - Sequestration via reforestation and afforestation
  - Growth of crops for their energy content
  - Potential advances from the biological revolution in science.

- Bioenergy crops are particularly interesting because they potentially offer a way to produce energy without producing any net CO_2 emissions.

Some Insights from Our Research on Biotechnology

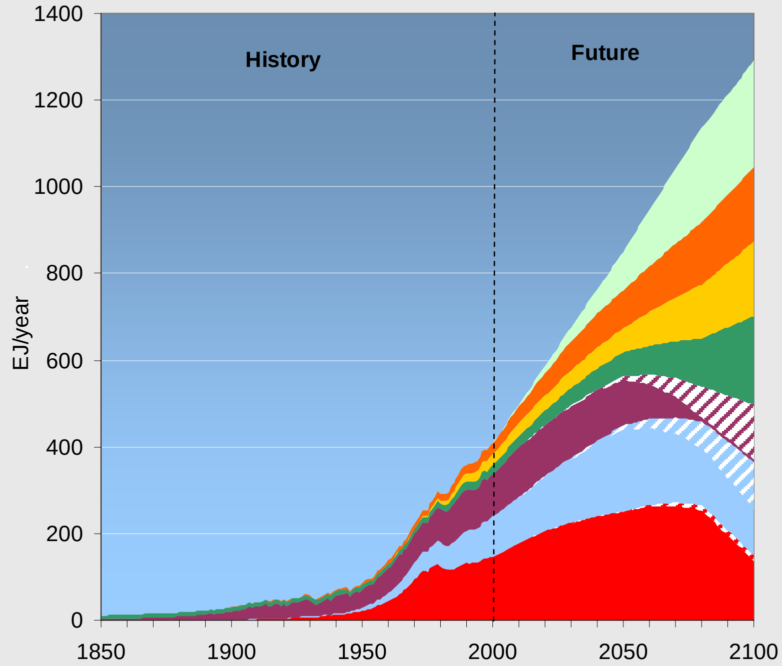
- In a climate-constrained world bioenergy crops could become the largest single crop grown by humans on the planet.
- The development of a bioenergy industry fueled by purpose-grown bioenergy crops depends on continued growth in non-biomass crop productivity as well as progress in bioenergy crop productivity.
- Technologies can work in combinations. Combining bioenergy with CO_2 capture and storage could provide a way to produce energy and produce **NEGATIVE** emissions of CO_2.

To the atmosphere all carbon counts the same. Carbon cycle implications of valuing terrestrial carbon emissions



Stabilization of CO_2 concentrations means fundamental change to the global energy system

… but the character of the global energy system will depend on technology developments:



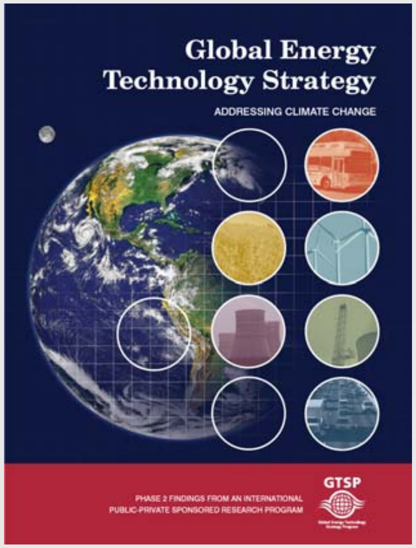
- CO_2 capture and storage (CCS) plays a potentially large role assuming that the institutions make adequate provision for its use.
- Biotechnology has dramatic potential, but important land-use implications.
- Hydrogen could be a major new energy carrier, but requires important technology advances in fuel cells and storage.
- Nuclear energy could deploy extensively throughout the world but public acceptance, institutional constraints, waste, safety and proliferation issues remain.
- Wind & solar could accelerate their expansion particularly if energy storage improves.
- End-use energy technologies that improve efficiency and/or use energy carriers with low emissions, e.g. electricity deploy more extensively.`

Technology in the Near, Mid, and Long Term

- The challenge of scale grows exponentially over the century
- The role of technology is to help manage the cost of stabilizing greenhouse gas concentrations.
  - Emissions mitigation starts with the existing suite of technologies.
  - Improving the existing suite of technologies will help to lower the cost of stabilization.
  - In the long term that suite of improving technology options can be augmented by new technology options, some of which do not yet have names. Those technologies will emerge out of near-term investments in basic and applied science across a broad range of research domains.

The GTSP Report

Copies of the Report are Available upon request



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