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BIOENERGY, CAPTURE, AND LAND USE

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EPRI

Energy and Climate Change Research Seminar

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Acknowledgements

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- The GCAM team

OVERVIEW

Why are we interested in bioenergy with CCS?

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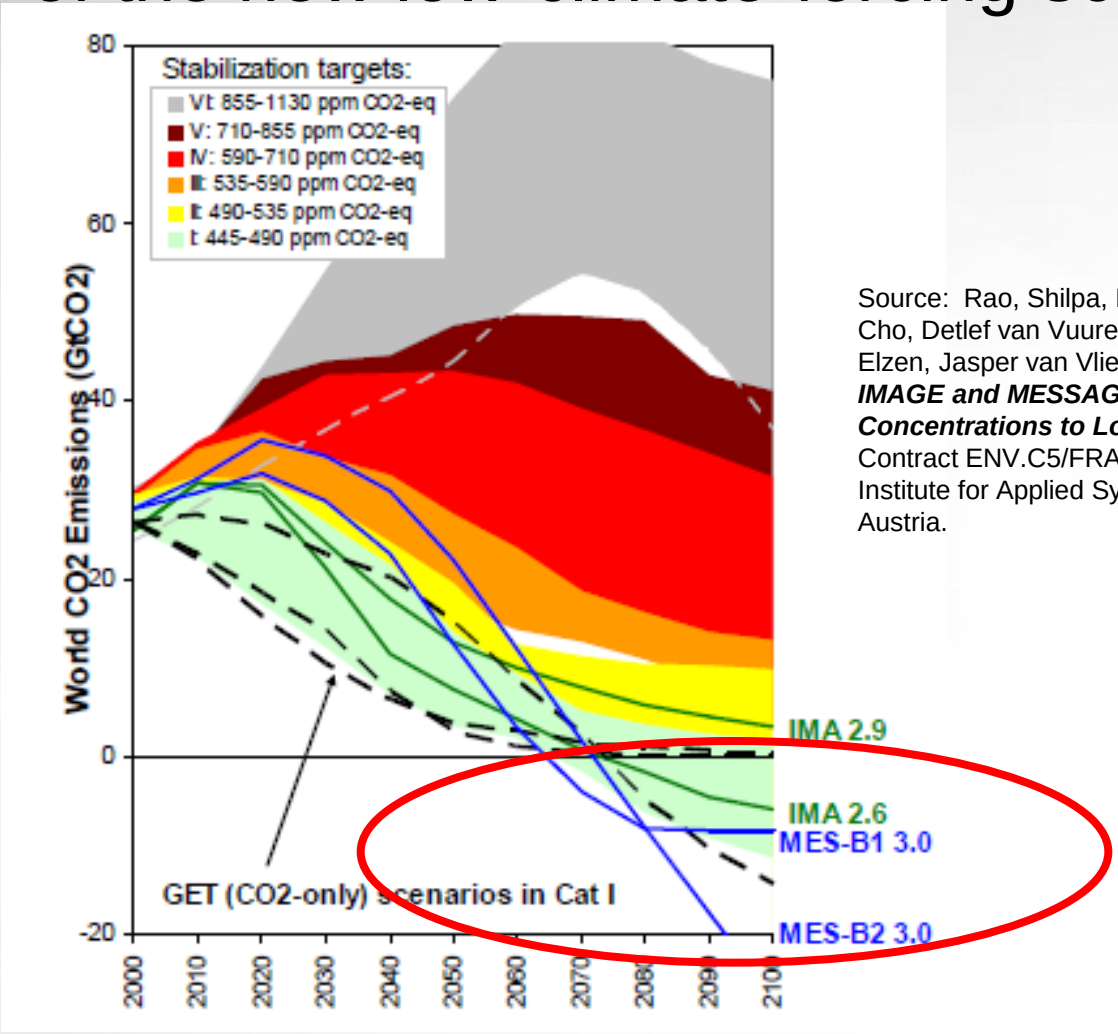
- ENERGY with NEGATIVE emissions are a major feature of the new low-climate-forcing scenarios.



Source: Rao, Shilpa, Keywan Riahi and Cheolhung Cho, Detlef van Vuuren, Elke Stehfest, Michel den Elzen, Jasper van Vliet and Morna Isaac. 2008. ***IMAGE and MESSAGE Scenarios Limiting GHG Concentrations to Low Levels***. Framework Contract ENV.C5/FRA/2006/0071. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Bioenergy and CCS

- Both bioenergy and CCS are technologies that exist today.
  - The combination of both is also being explored.
- CCS is not deployed at scale.
- Deployment of each depends on the institutional environment.
  - Carbon price
  - Institutional framework that facilitates a business model for deployment.

Two Key Questions

- **Is it possible to limit radiative forcing to 2.6 Wm^{-2} in 2100 without bioenergy and CCS?**
- **Do resource limits preclude successful deployment of either bioenergy or CCS or both?**
  - **Bioenergy is constrained by competition for land.**
  - **CCS is constrained by storage reservoirs.**

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THE PNNL GLOBAL CHANGE ASSESSMENT MODEL—GCAM

GCAM is an integrated assessment model

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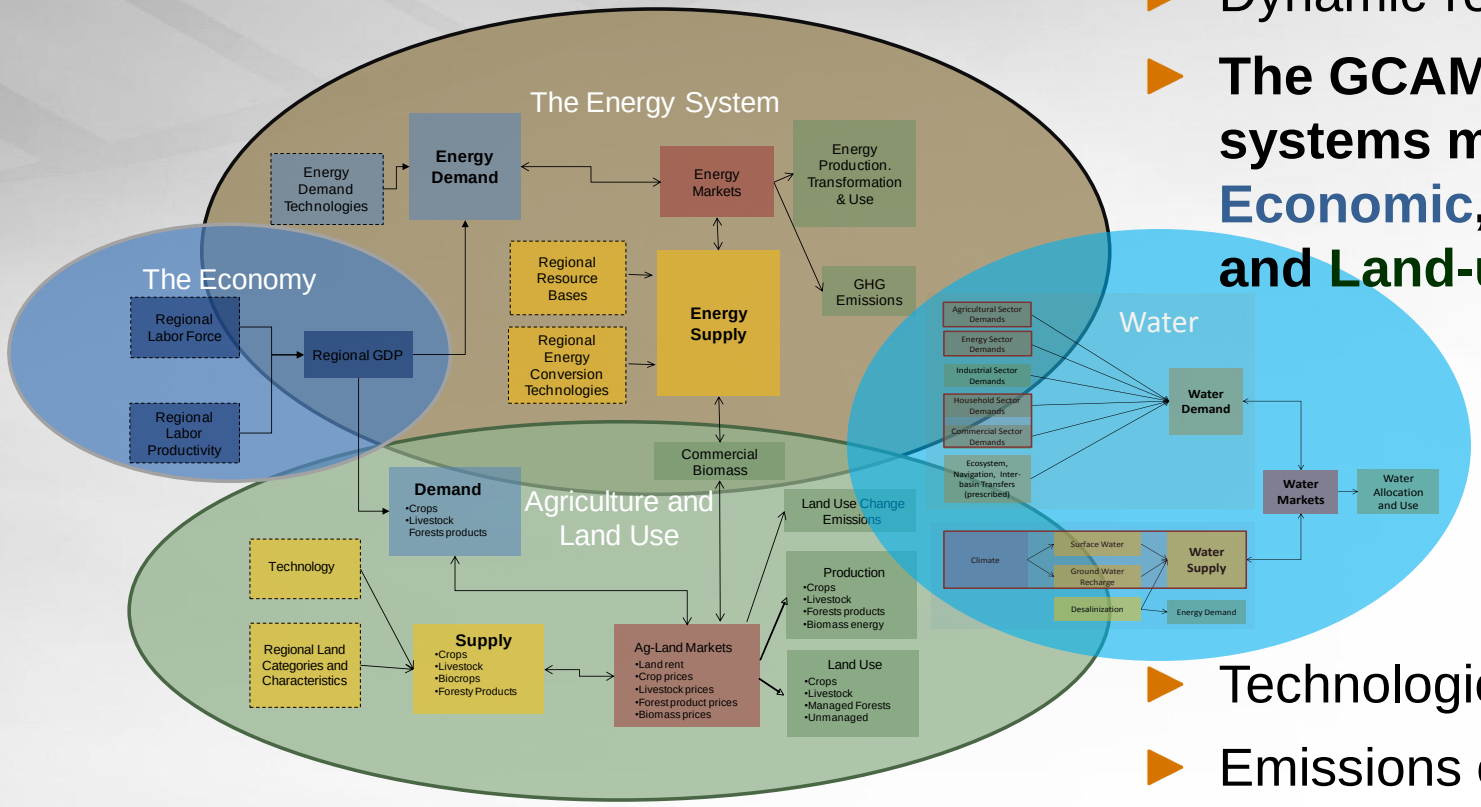
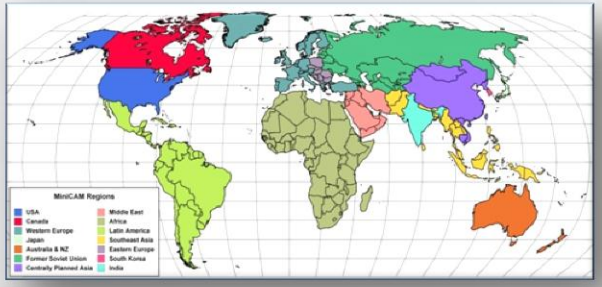
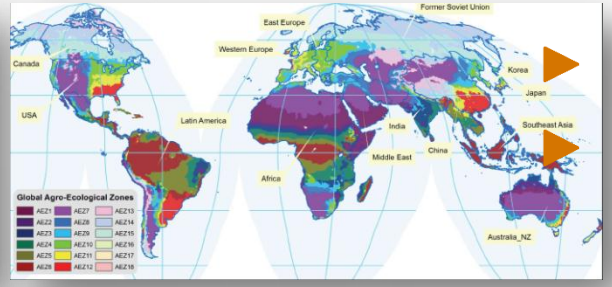
GCAM human Earth systems



- **Open source model.**
- Dynamic-recursive model.
- **The GCAM human Earth systems model has Economic, Energy, Water and Land-use systems.**





- Technologically detail.
- Emissions of 16 greenhouse gases & short-lived species
- 151 region land-use model.
- Runs through 2095 in 5-year time-steps (time step is variable).

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CO_2 CAPTURE AND GEOLOGIC STORAGE

Maximum Practical Potential Geologic Storage Capacity

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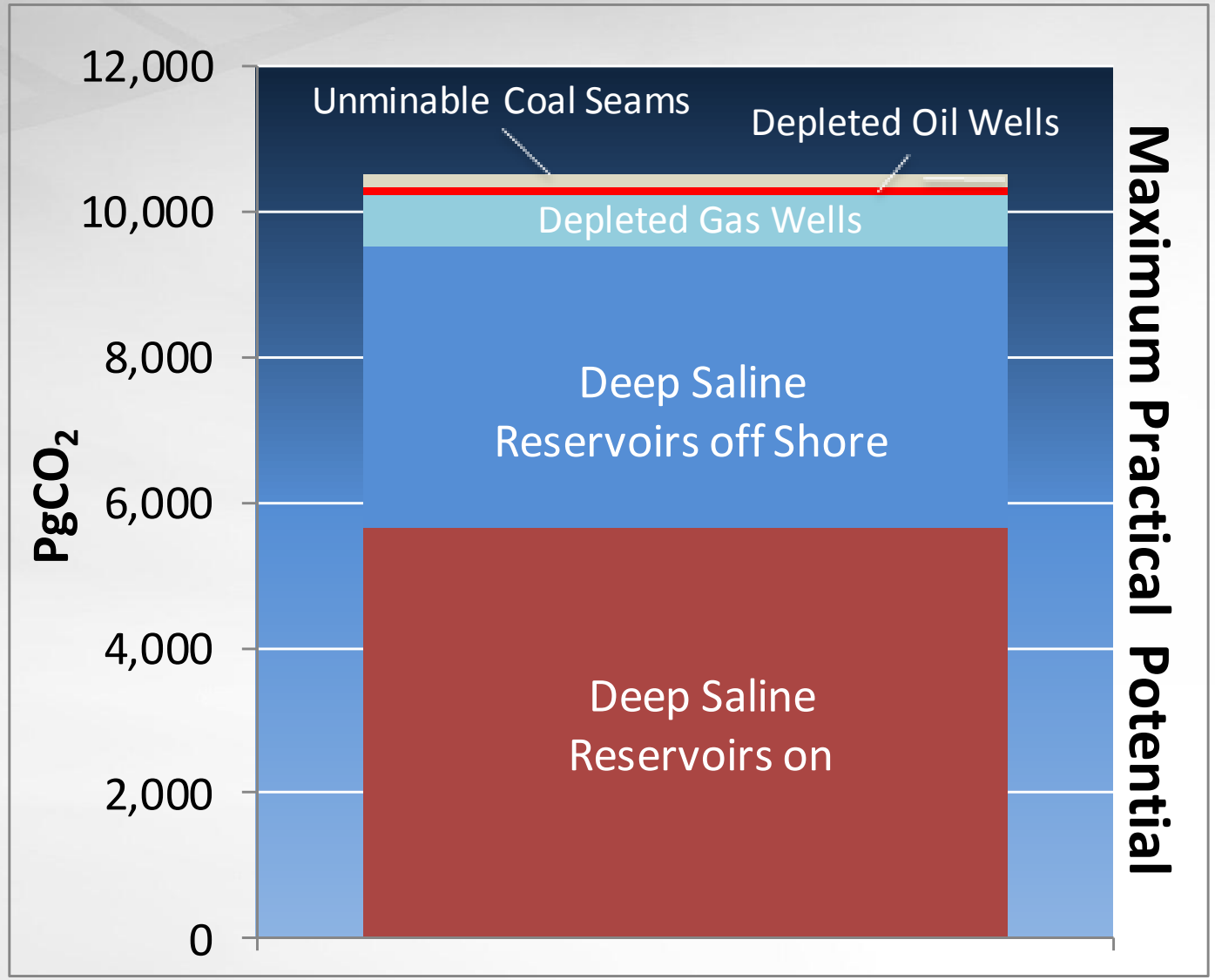
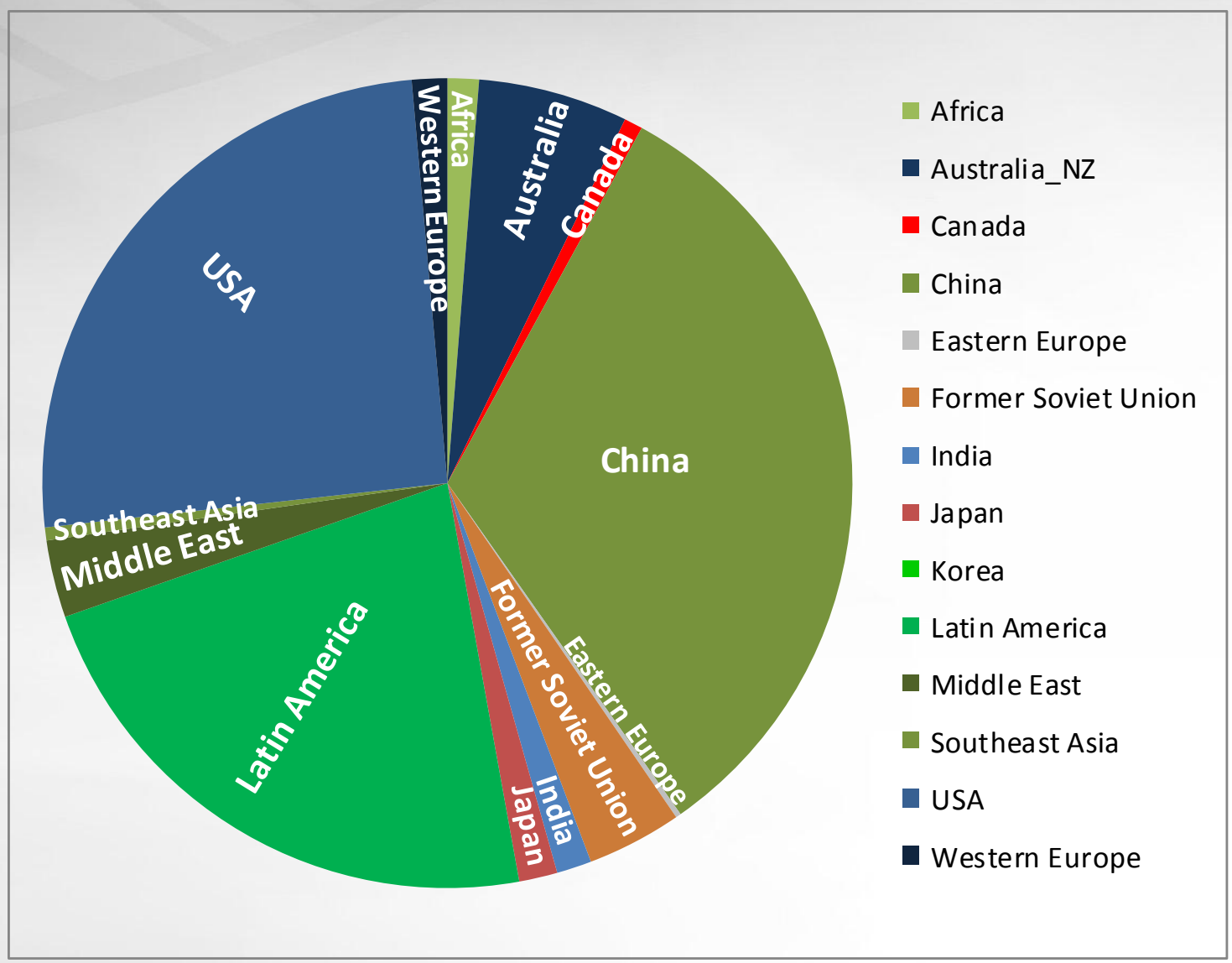


Regional Distribution of Practical Geologic Storage Potential



Geographic and storage media distribution of potential practical geologic storage capacity

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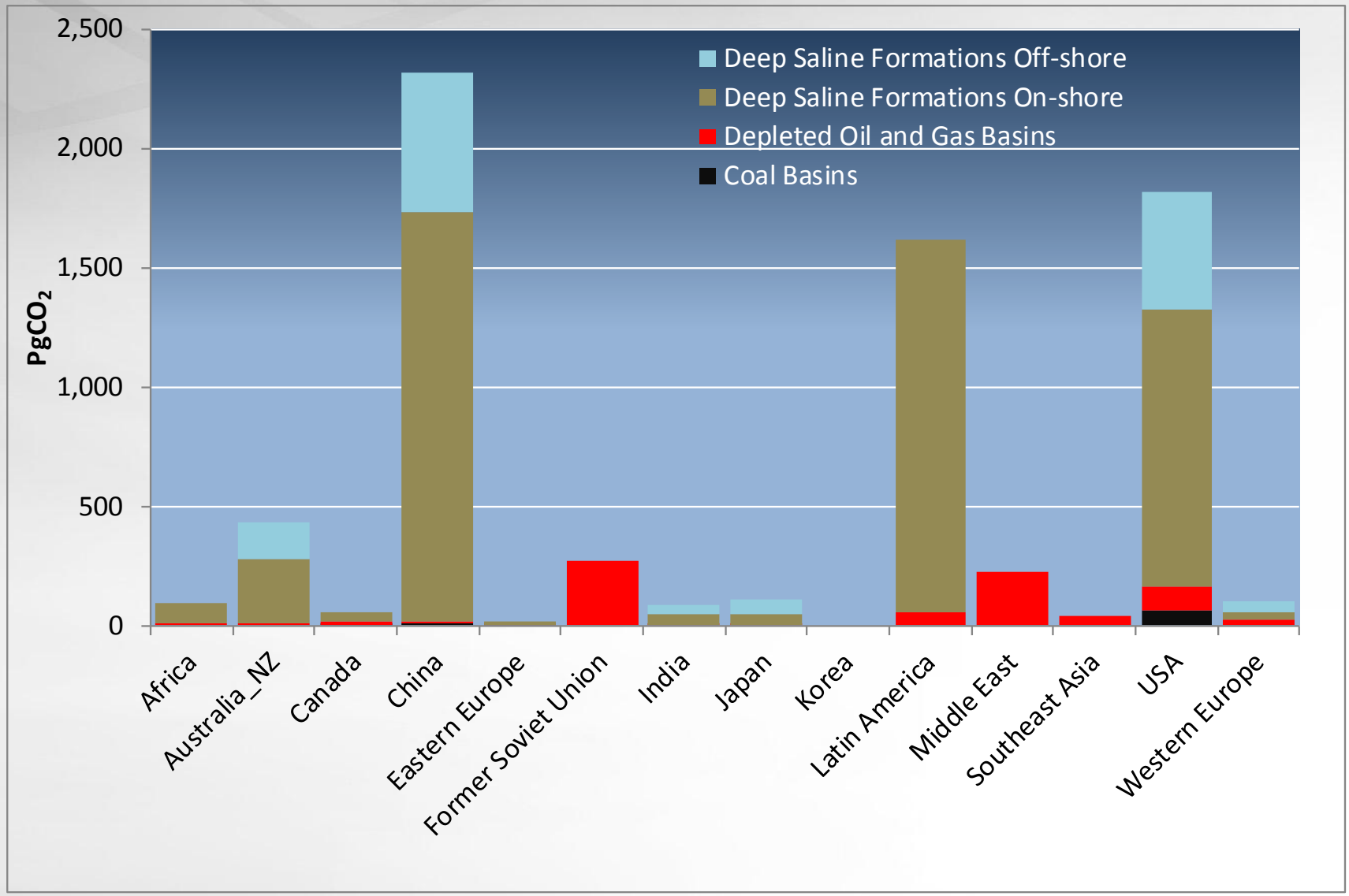

EXPERIMENTAL DESIGN

Policy regimes

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Idealized Accession

- All regions initiate emissions mitigation simultaneously in the year 2020;
- The price of carbon emissions, both from industrial activities and land-use change, is equal in all regions and across all sectors in every period;
- The price of carbon rises at the rate of interest plus the average rate of removal of carbon by oceans, the Hotelling-Peck-Wan path (Hotelling, 1931; Peck and Wan, 1996).

Delayed Accession

Year	Regions Joining Mitigation Regime	Years Between Joining & Common Carbon Price
2015	Western Europe, Eastern Europe, Japan	NA
2030	Australia/NZ, Canada, China, Korea, USA	10
2050	India, L. America, Other South & East Asia	20
2070	Africa, FSU, Middle East	30

An Additional Delay Scenario

Delayed Accession 2

- We created an additional scenario in which two regions never undertake emissions mitigation.

Year	Regions Joining Mitigation Regime	Years Between Joining & Common Carbon Price
2015	Western Europe, Eastern Europe, Japan	NA
2030	Australia/NZ, Canada, China, Korea, USA	10
2050	India, L. America, Other South & East Asia	20
2070	Africa	30
Never	FSU, Middle East	NA

Technology Regimes

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Technology Set	CCS	Bioenergy	Nuclear Power	Other Technology
Ref	Yes	Yes	Ref	Ref
NoCCS	No	Yes	Ref	Ref
NoBio	Yes	No	Ref	Ref
NoBioNoCCS	No	No	Ref	Ref
LowTech	No	No	Phased out	Ref

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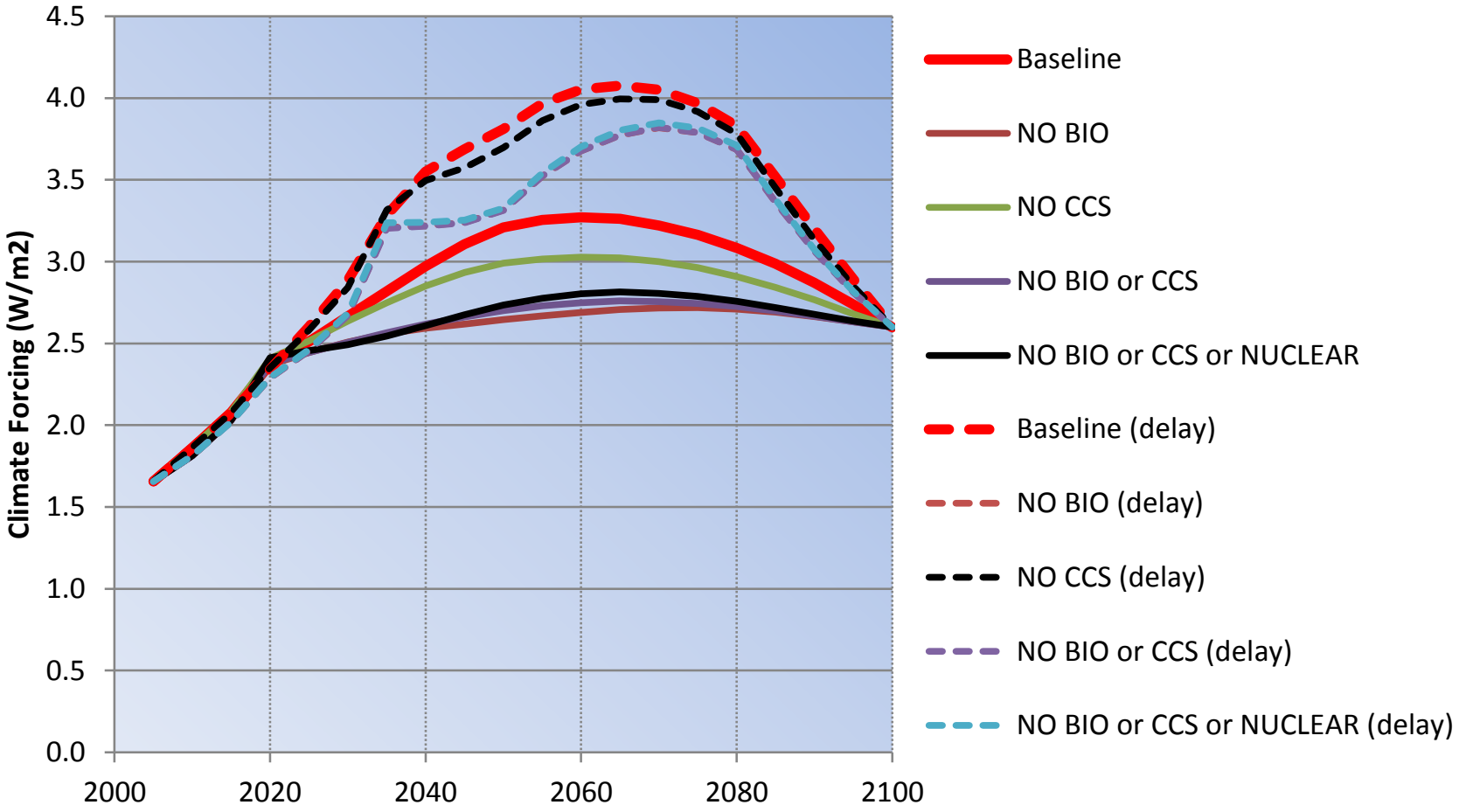
FEASIBILITY AND COST OF LIMITING RADIATIVE FORCING TO 2.6 WM^{-2}

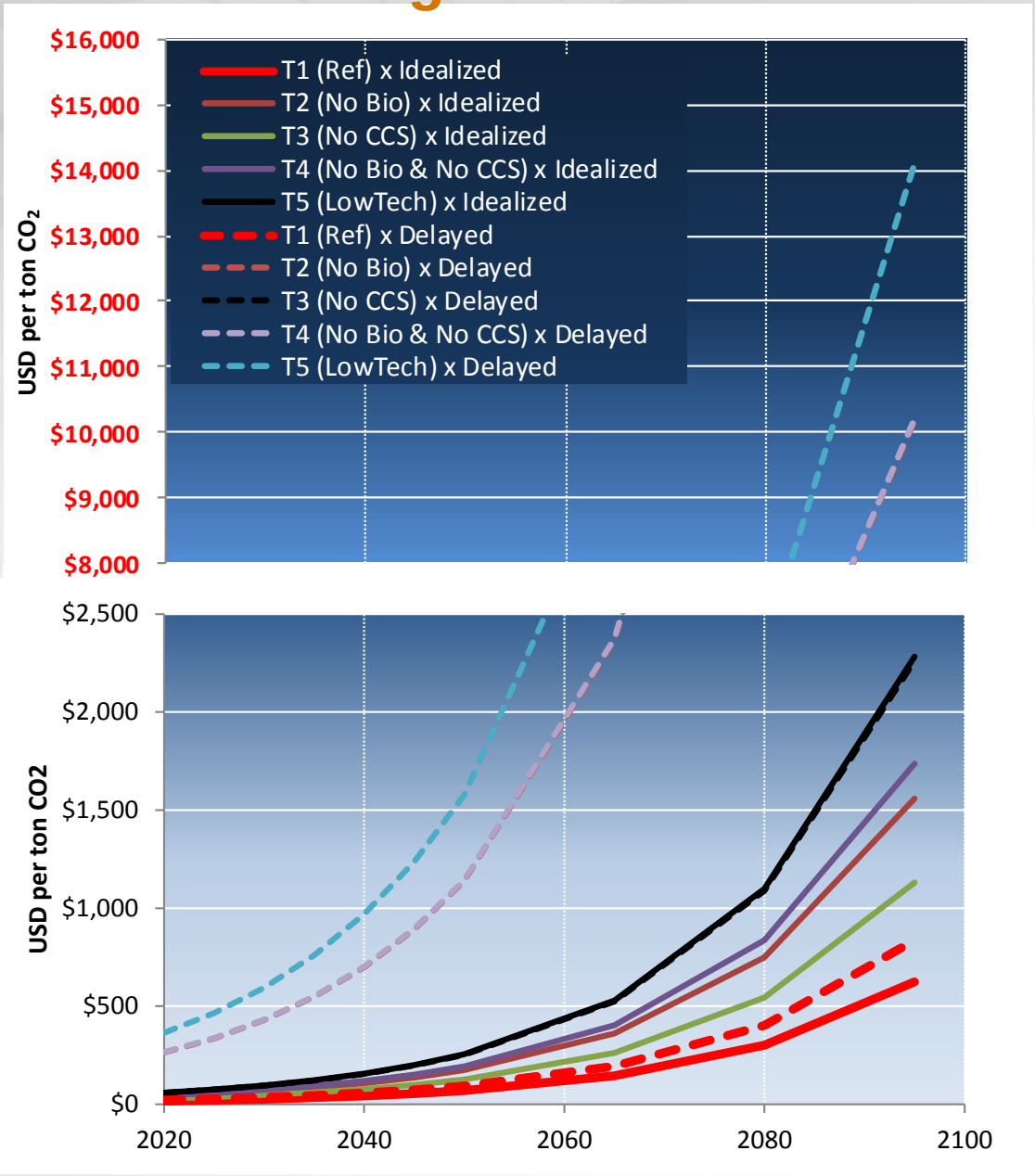
Radiative Forcing Paths: All technologies and all policy regimes can reach 2.6 Wm^{-2}



Delayed Accession 2

- **When two regions never participated in emissions mitigation it was not possible to limit radiative forcing to 2.6 Wm^{-2} for any technology suite.**

Carbon Price in the Mitigation Coalition



Fossil Fuel Emissions

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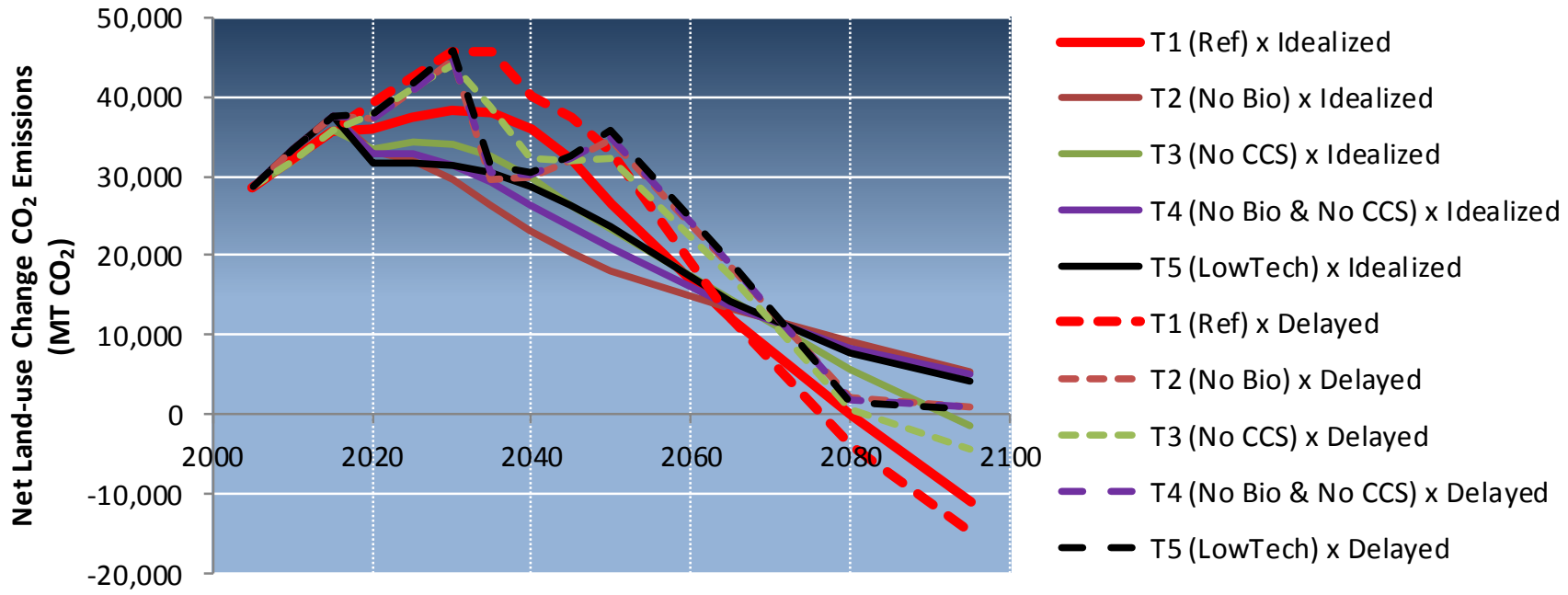

Land Use Change Emissions

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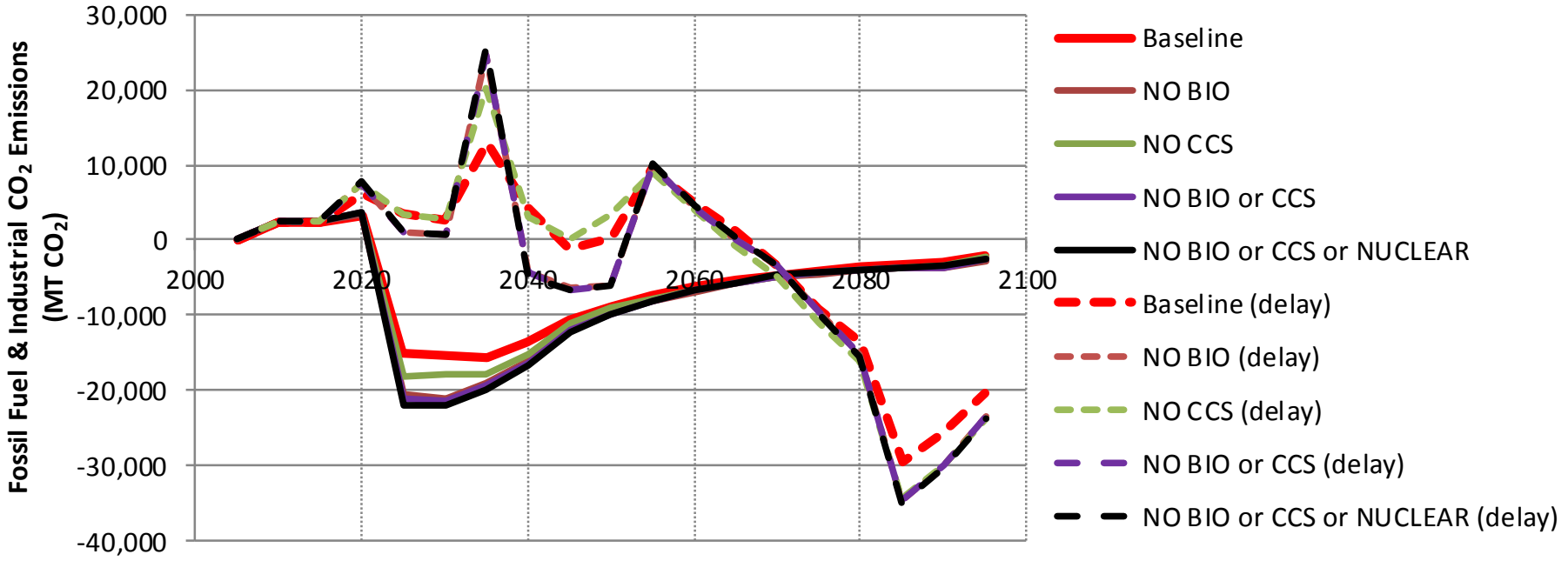

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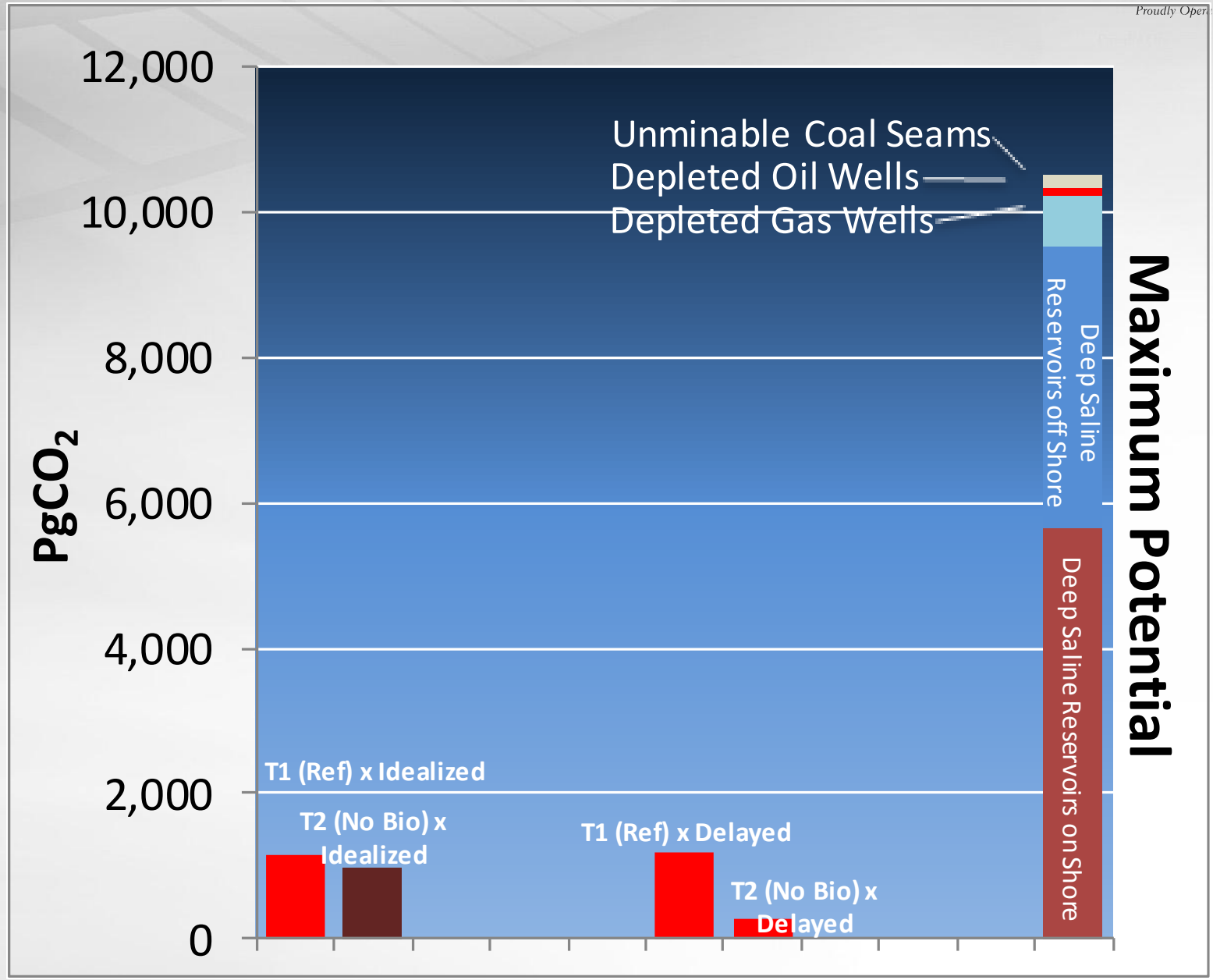
CARBON STORAGE

Cumulative Geologic Storage through 2100



Land use Change—Net Cumulative Sequestration 2020 through 2100

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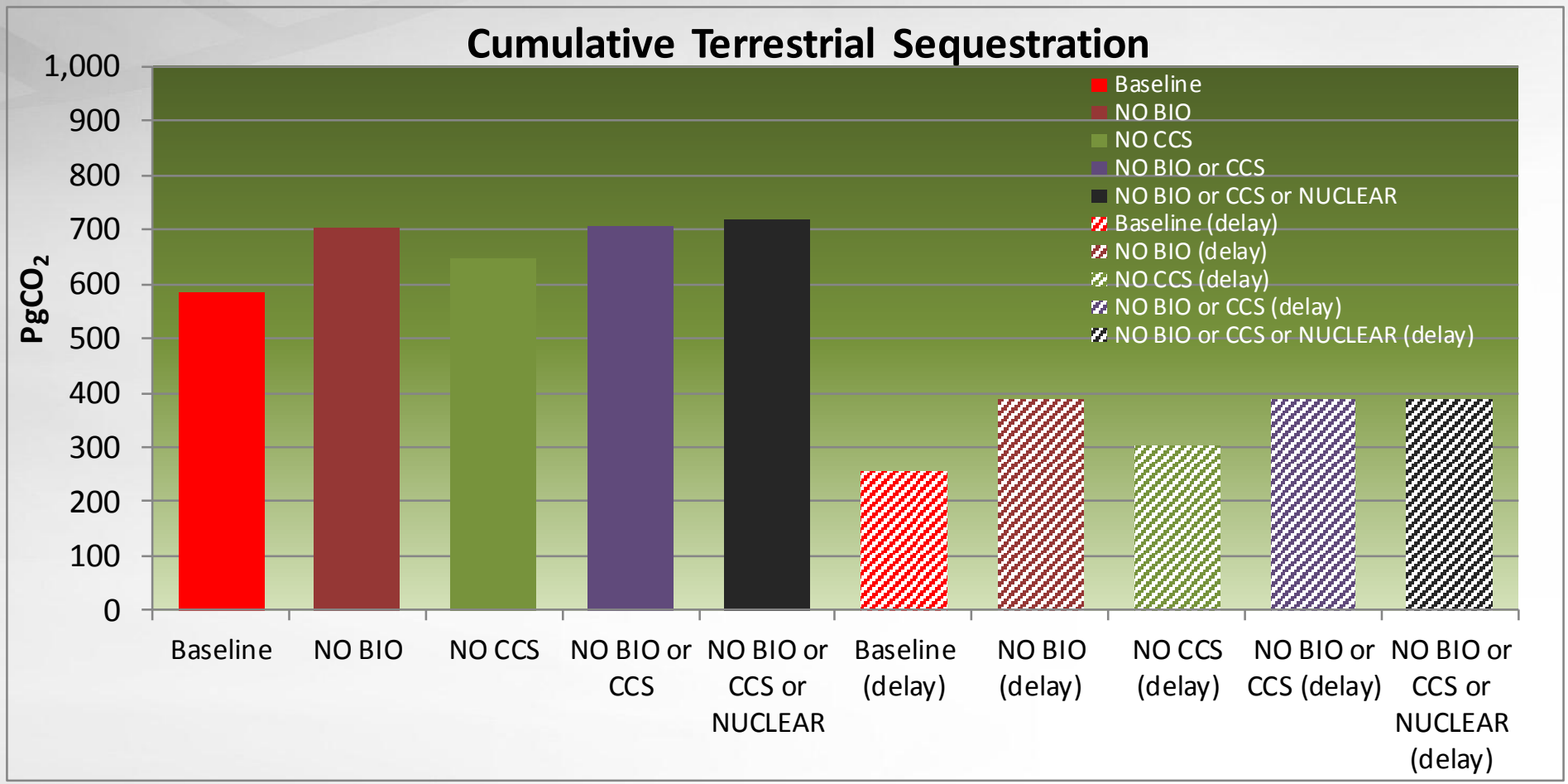

CCS Geologic Storage and Land use Sequestration: Cumulative 2020 through 2100

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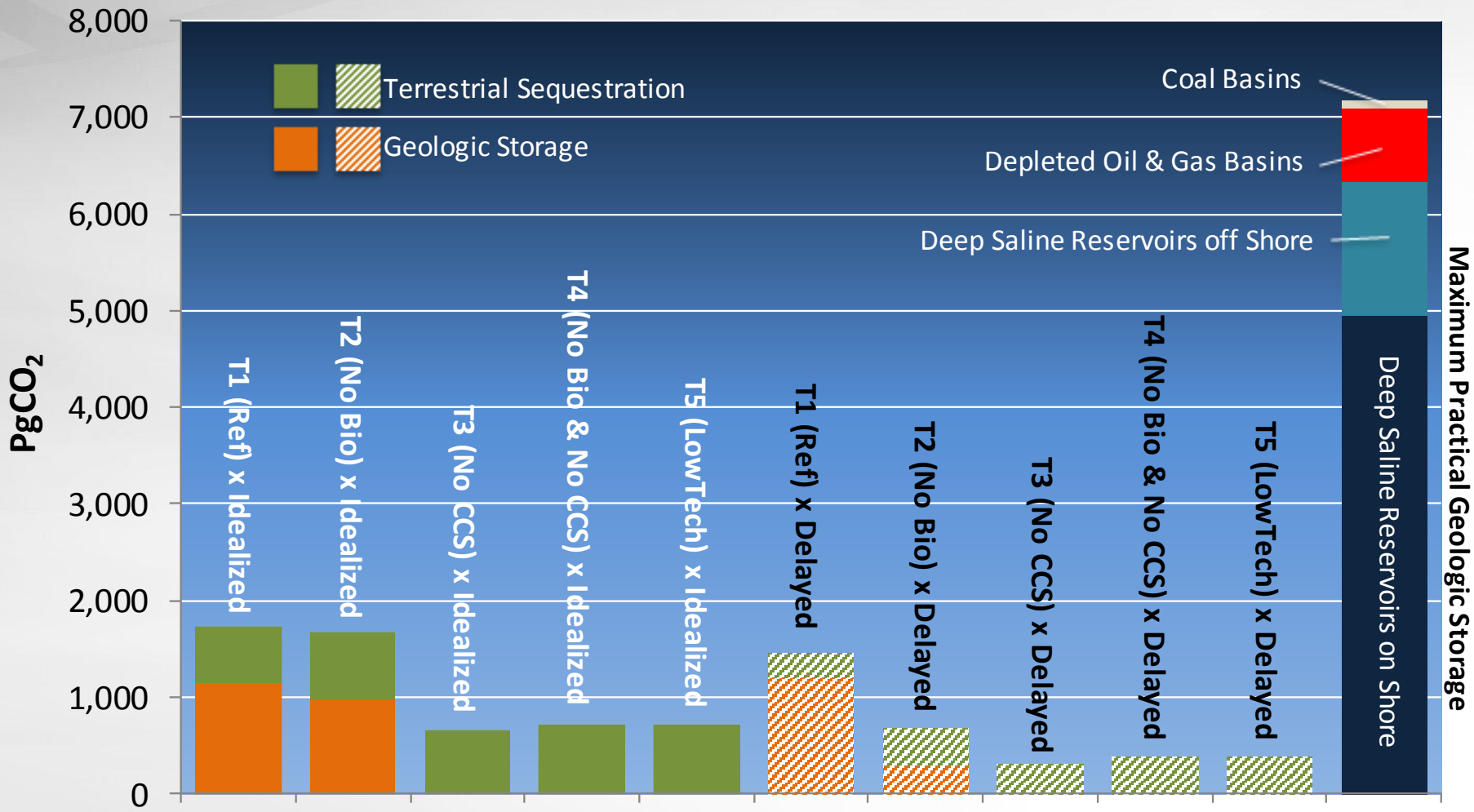

CCS Geologic Storage and Land use Sequestration: Cumulative 2020 through 2100

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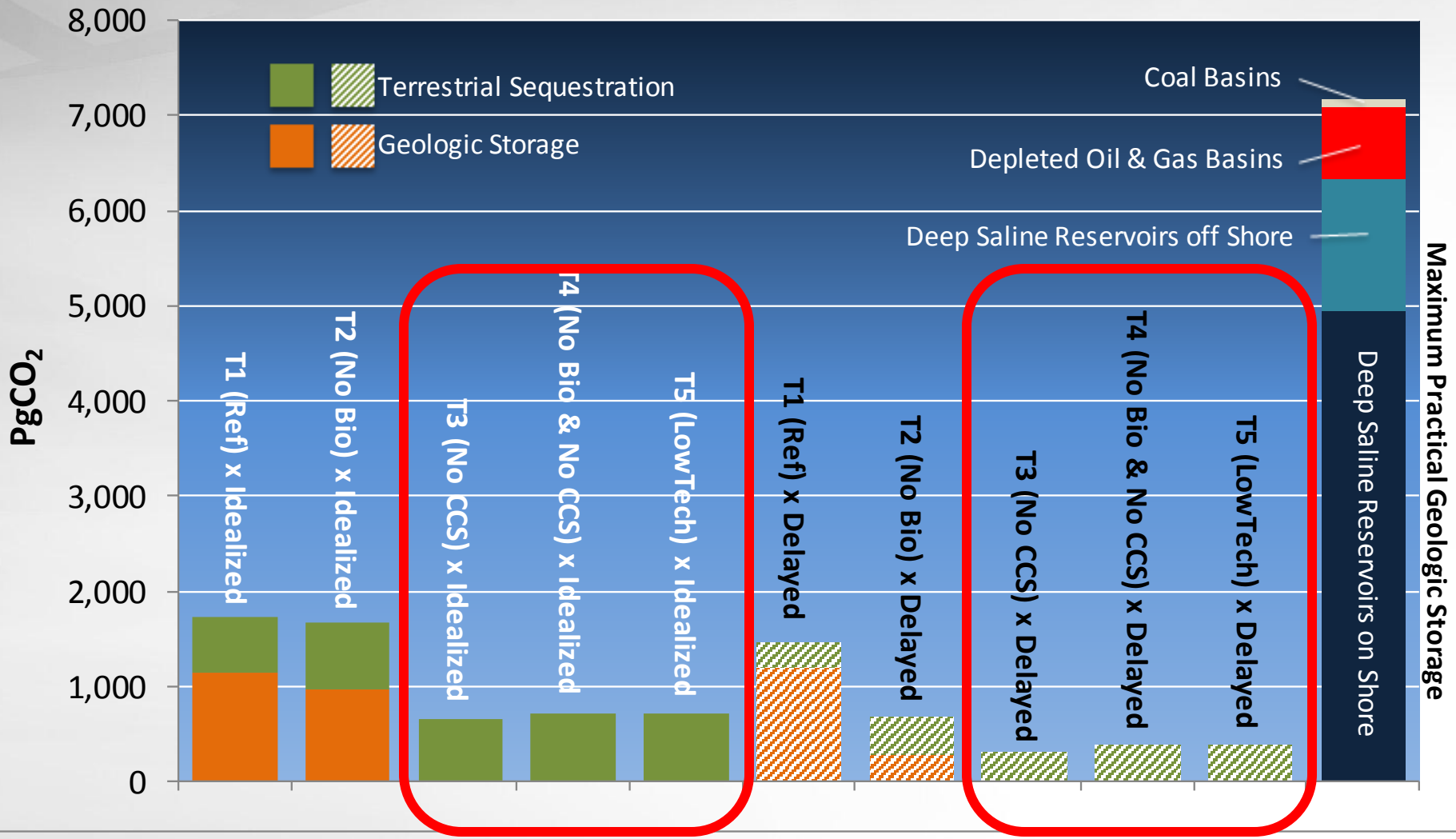

SUMMARY

Final remarks

- We used the GCAM integrated assessment model to assess two questions:
  - Is it possible to limit radiative forcing to 2.6 Wm^{-2} in 2100 without bioenergy and CCS?
  - Do resource limits preclude successful deployment of either bioenergy or CCS or both?
- We find the following:
  - A variety of technology regimes including technology portfolios that have neither Bioenergy, CCS, or nuclear power are feasible.
  - However, the lowest costs are found when bioenergy with CCS is available.
  - Delays in mitigation participation can raise costs substantially.
  - If two key regions never joined, then it was impossible to limit radiative forcing to 2.6 Wm^{-2} in 2100.
  - Neither limits to geologic storage or available land provided a meaningful constraint to limiting radiative forcing to 2.6 Wm^{-2} in 2100.

DISCUSSION