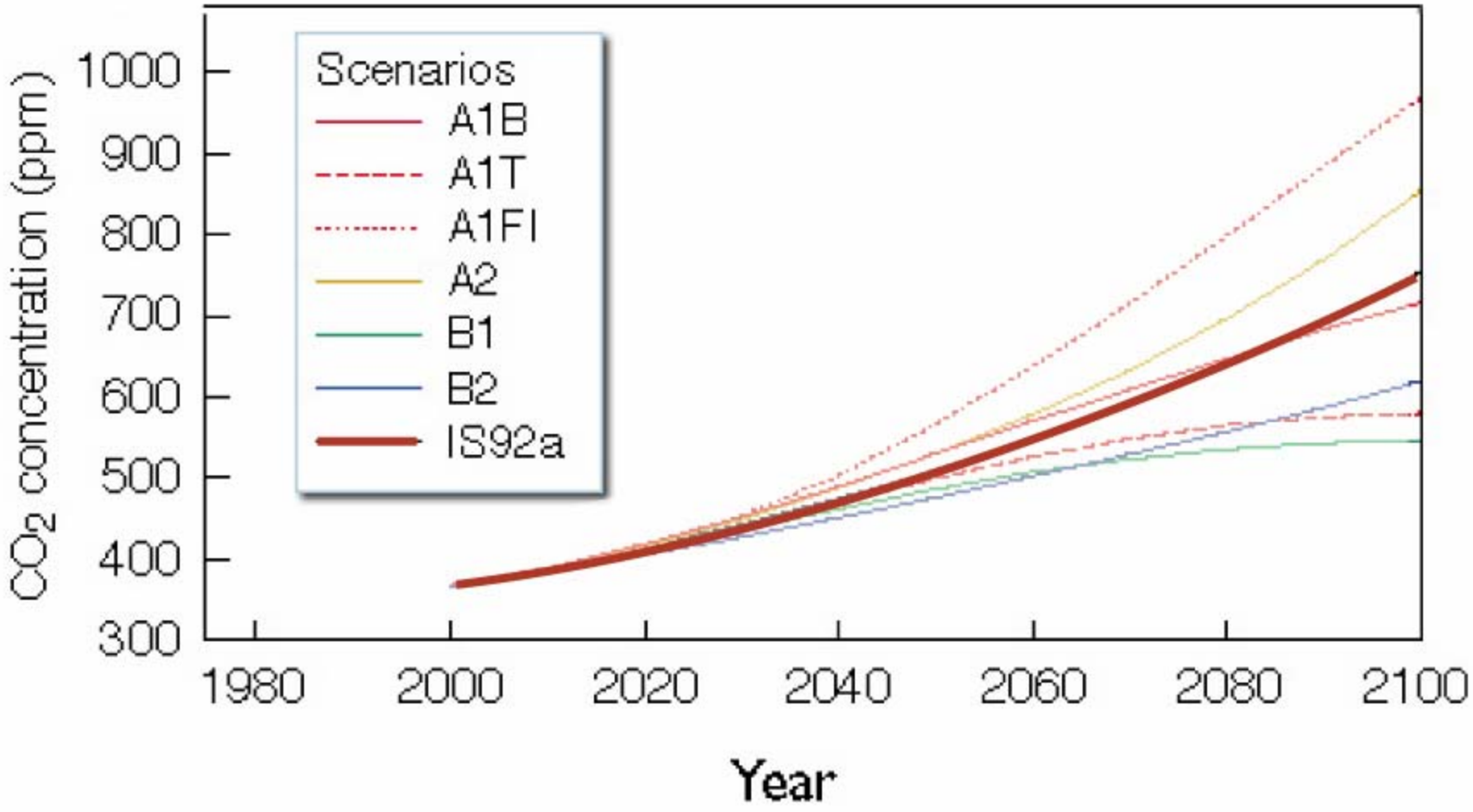
Carbon Sequestration Leadership Forum

Melbourne Meeting, 13-15 Sept 04

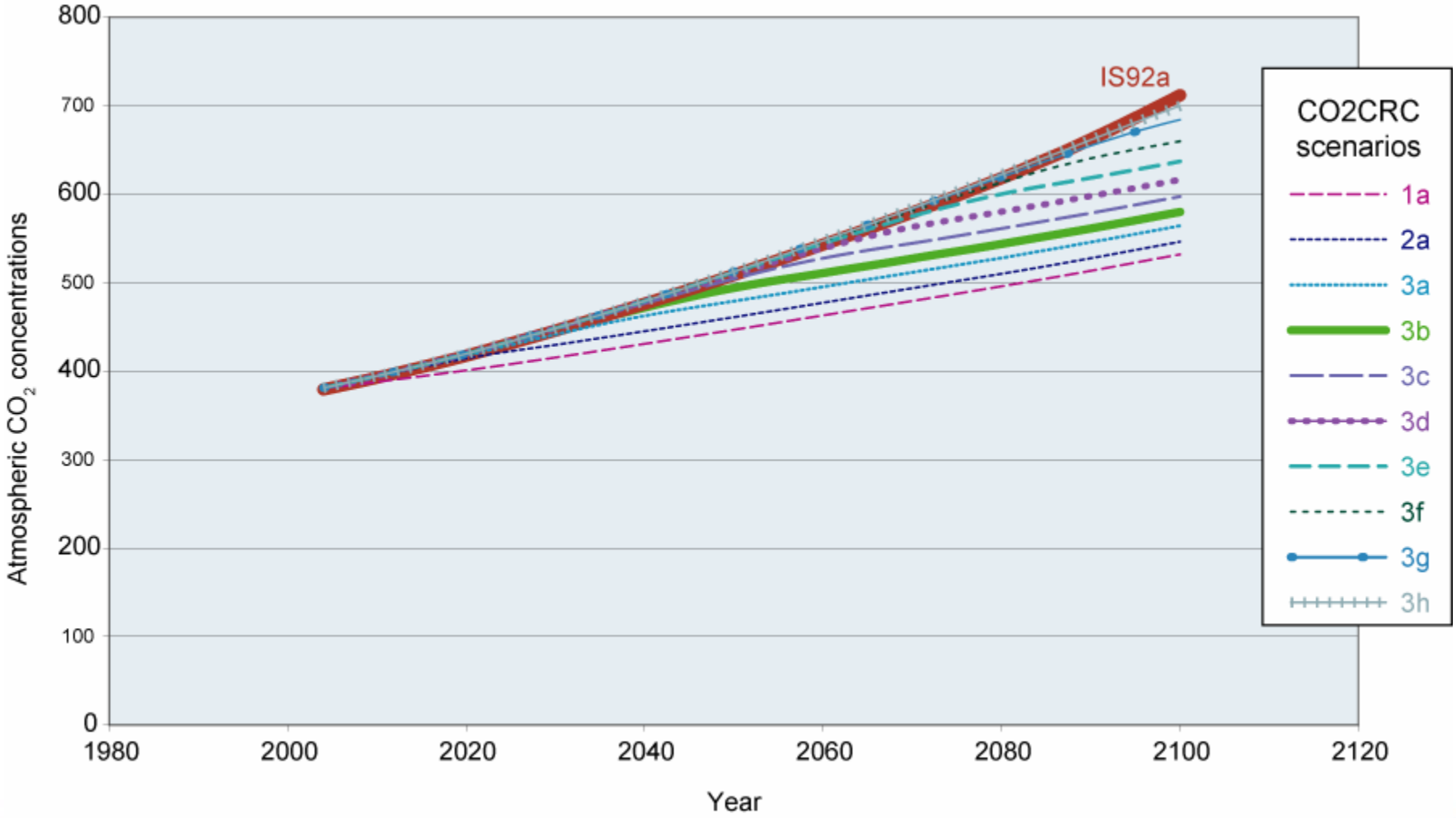
Technology Roadmap

Dr Peter Cook
Australia

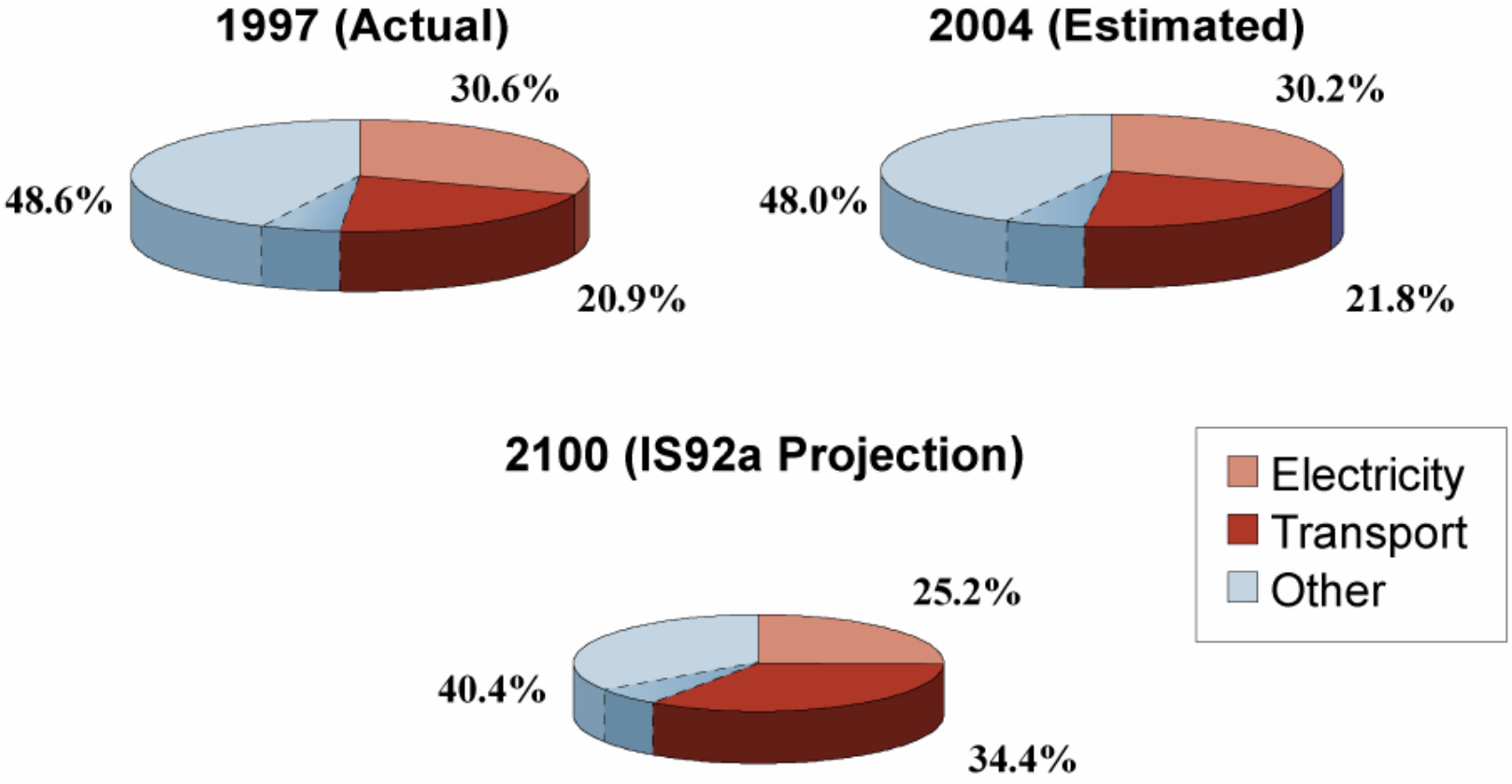
IPCC Scenarios: Anthropogenic emissions of CO_2 for the six illustrative SRES scenarios



Atmospheric CO_2 concentrations from CO2CRC Scenario 1a through 3h

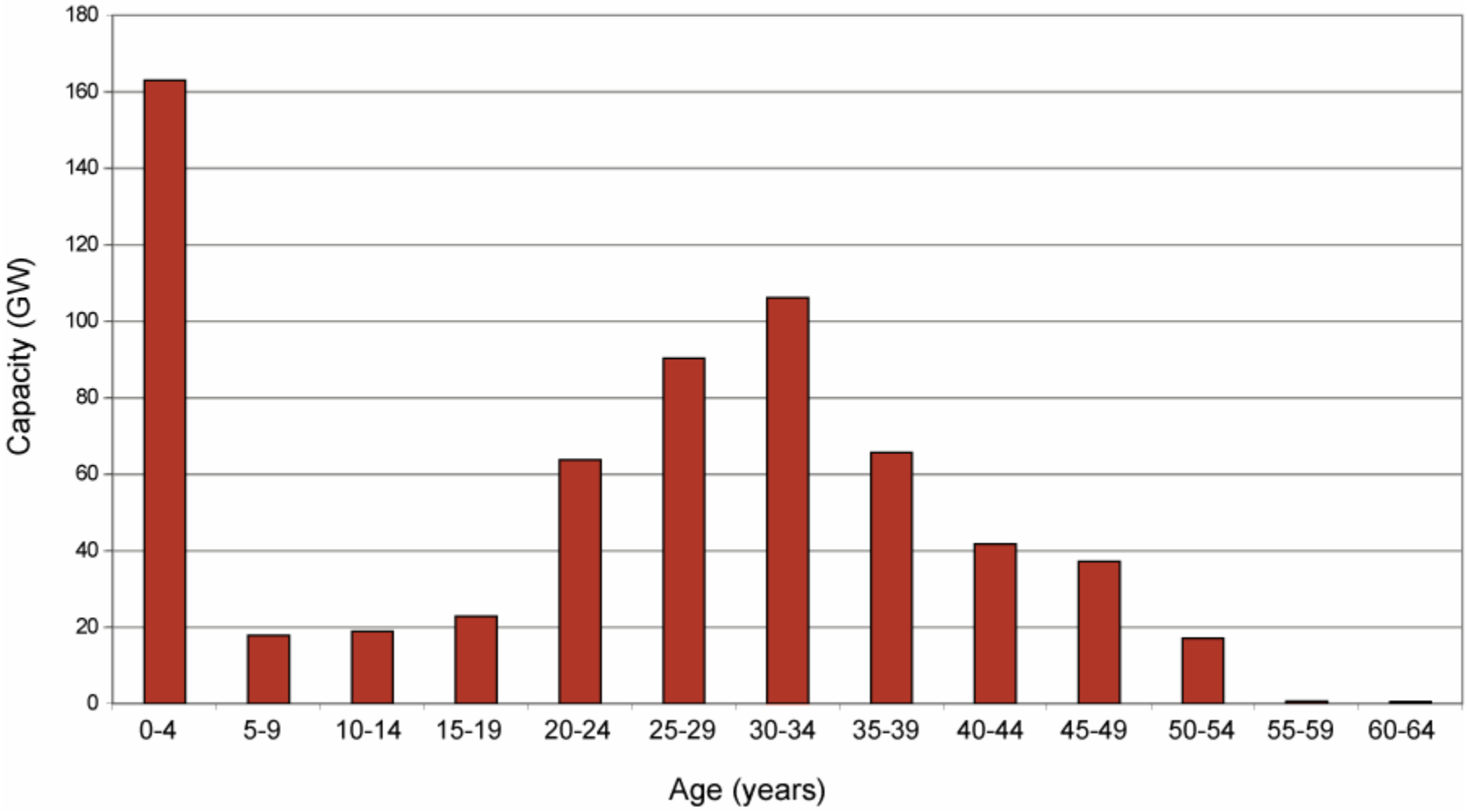


CO_2 emissions from fossil fuels source breakdown

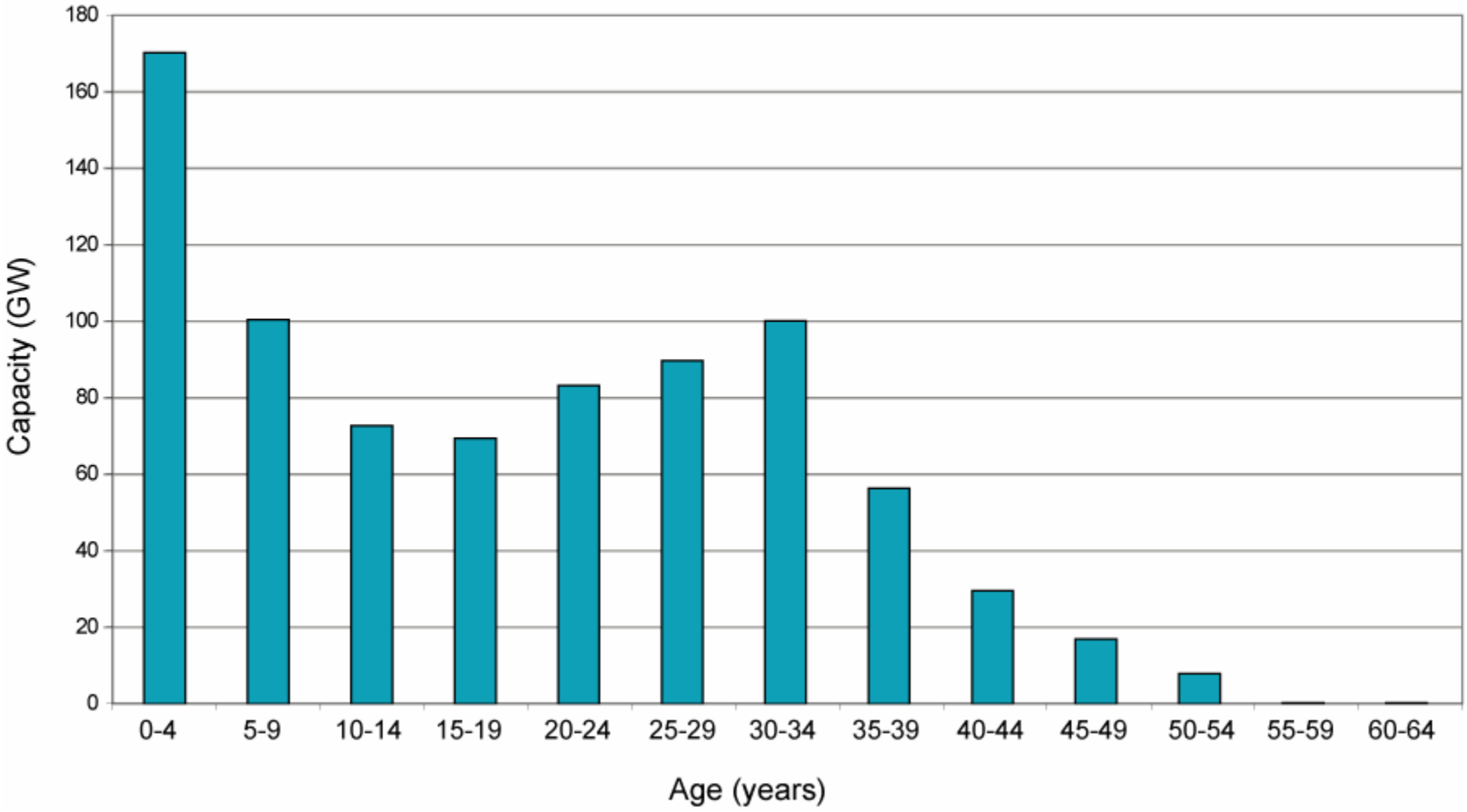


"Other" includes CO_2 emissions from industrial and manufacturing facilities, commercial/residential heating etc., but also potentially suitable for CCS as steel and cement plants.

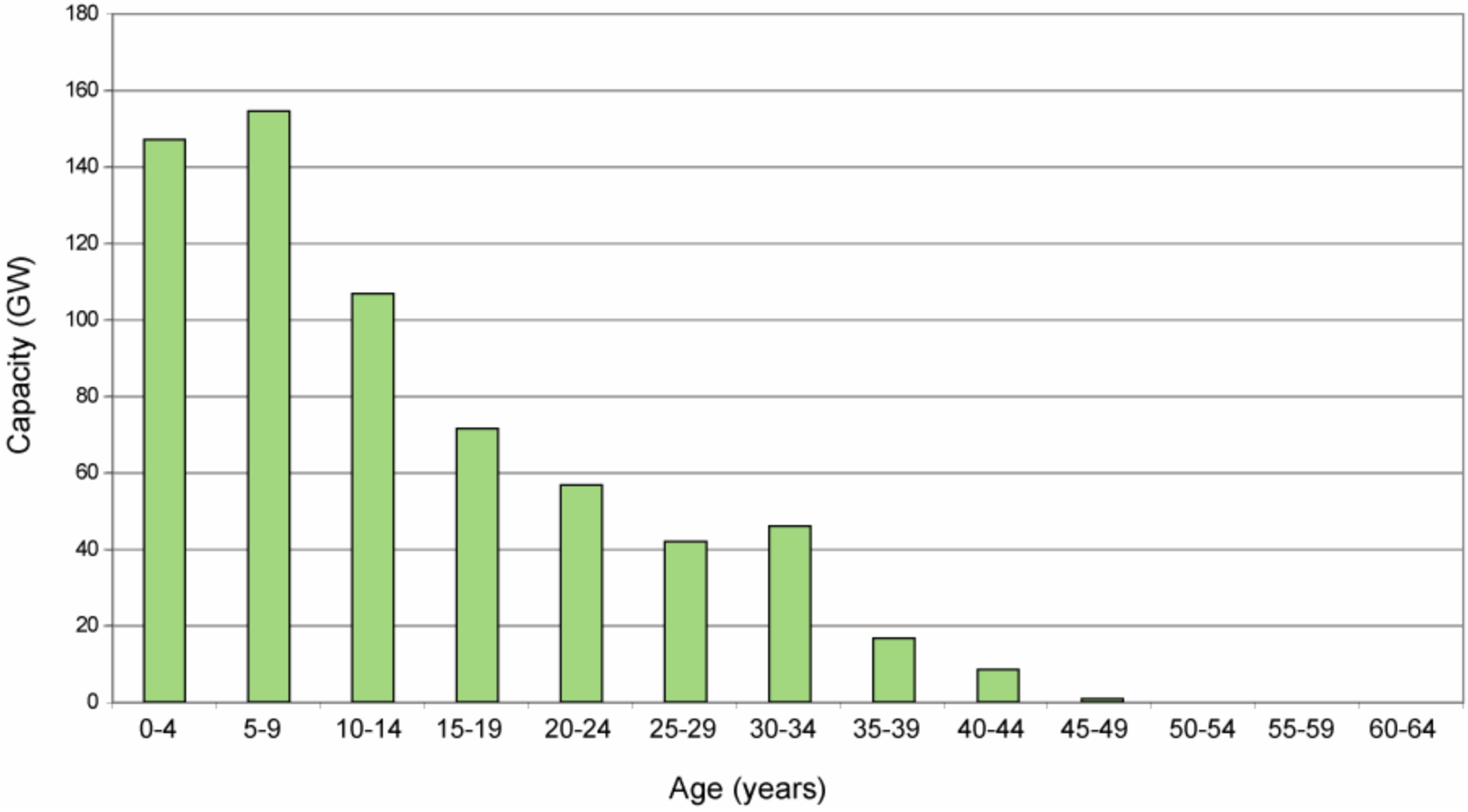
Age distribution of fossil-based electric power plants - NORTH AMERICA



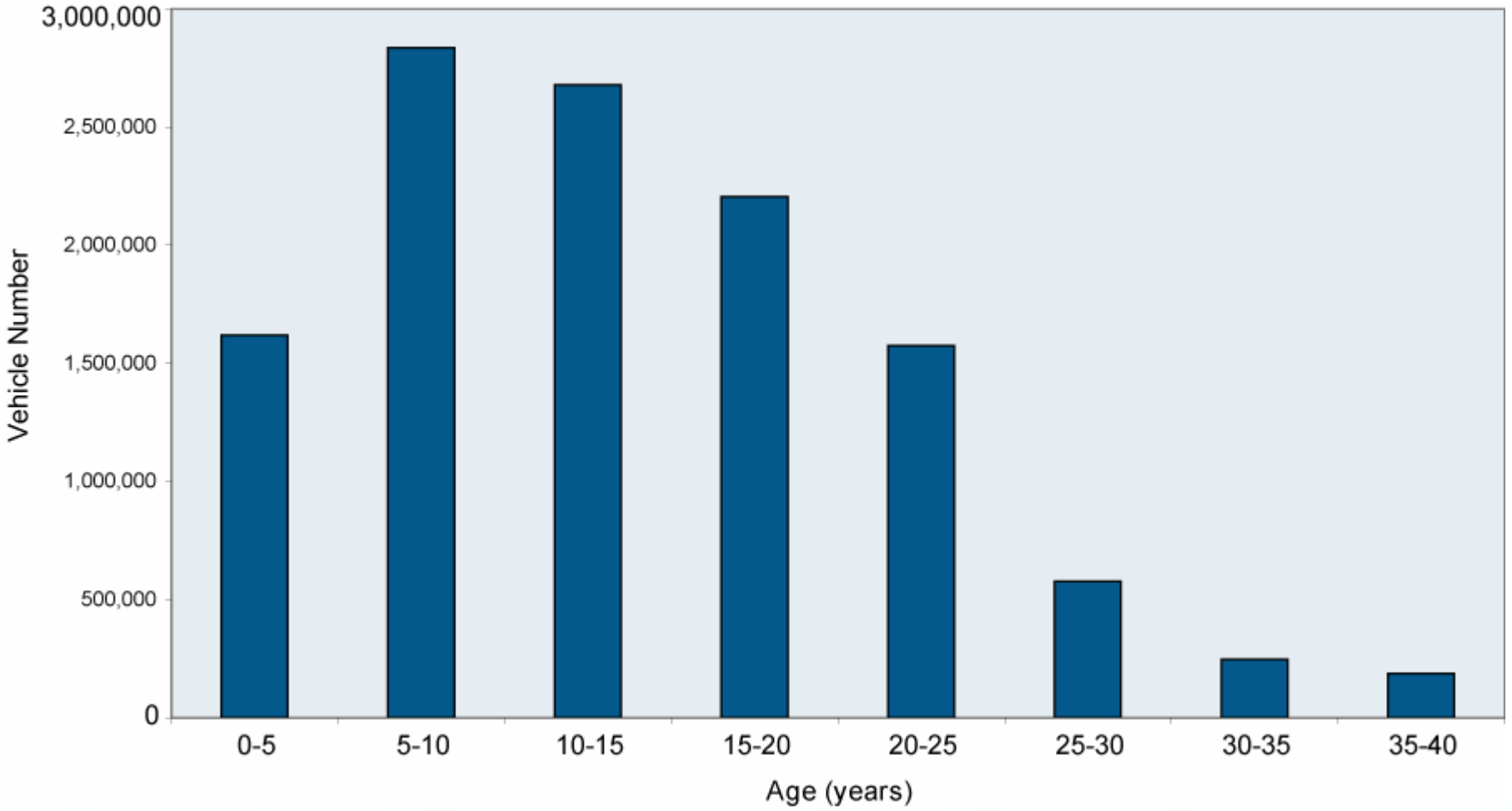
Age distribution of fossil-based electric power plants - WORLD



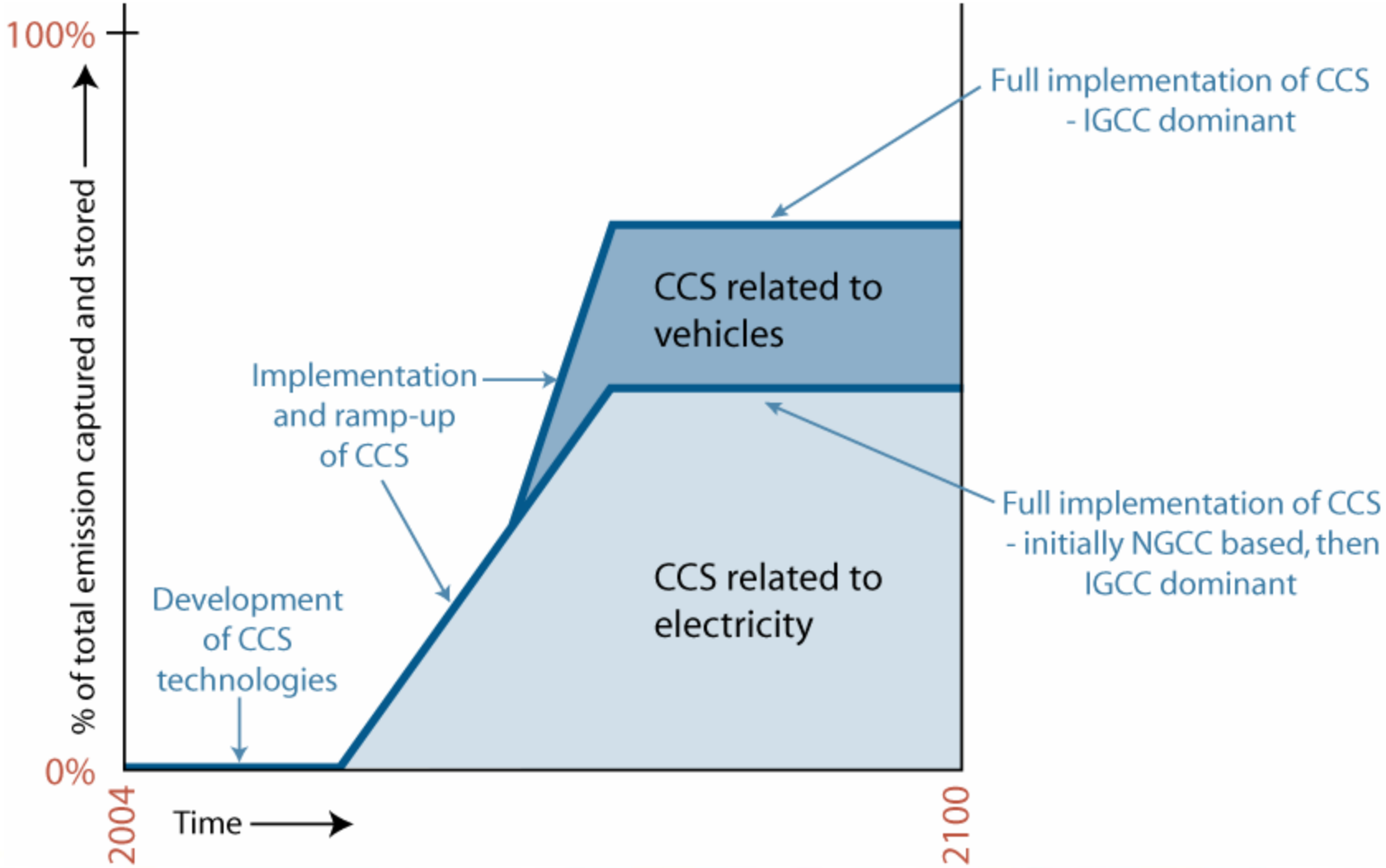
Age distribution of fossil-based electric power plants - ASIA



Age distribution of vehicle fleet - Australia



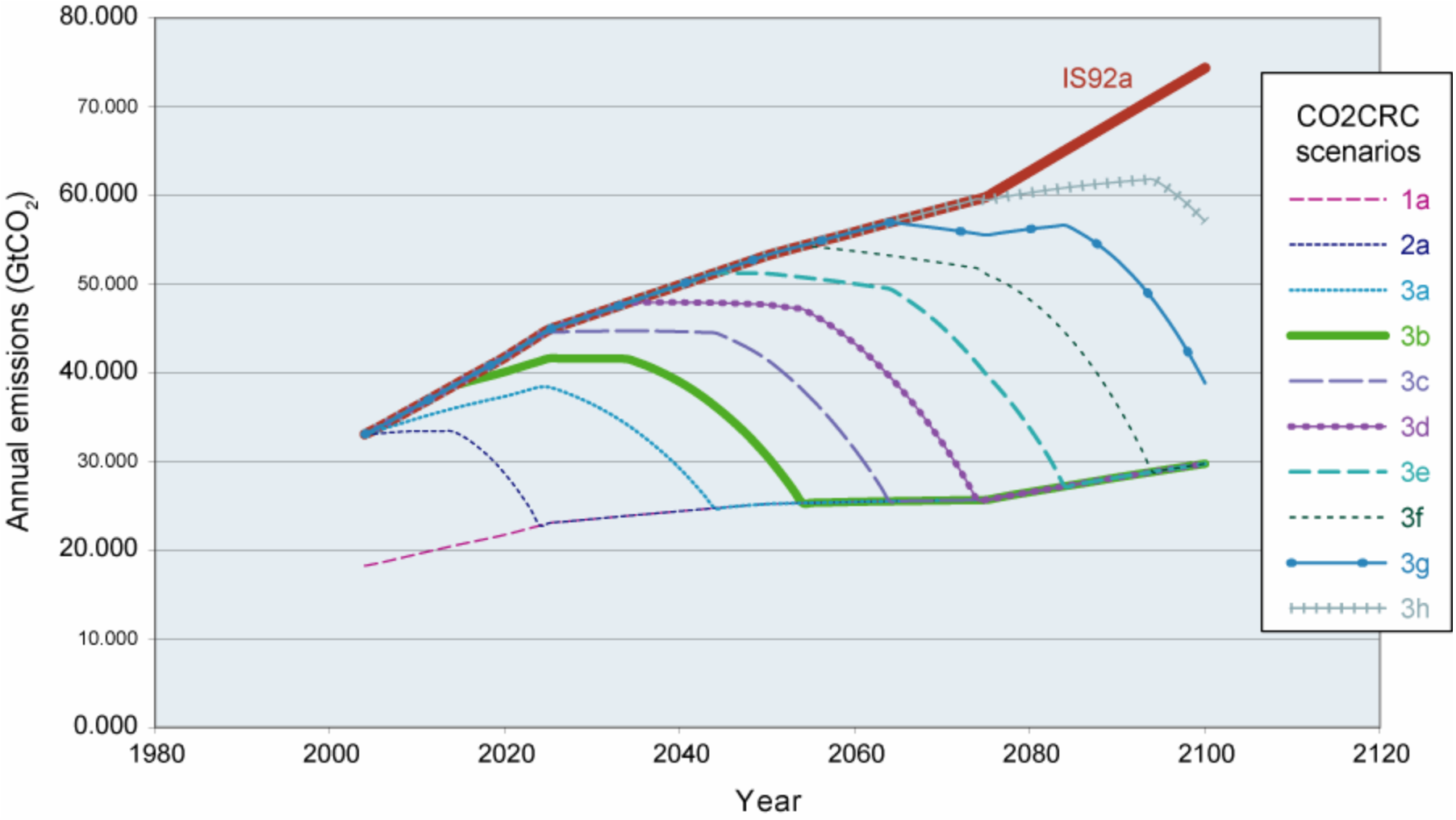
Approach taken to CO2CRC Scenarios



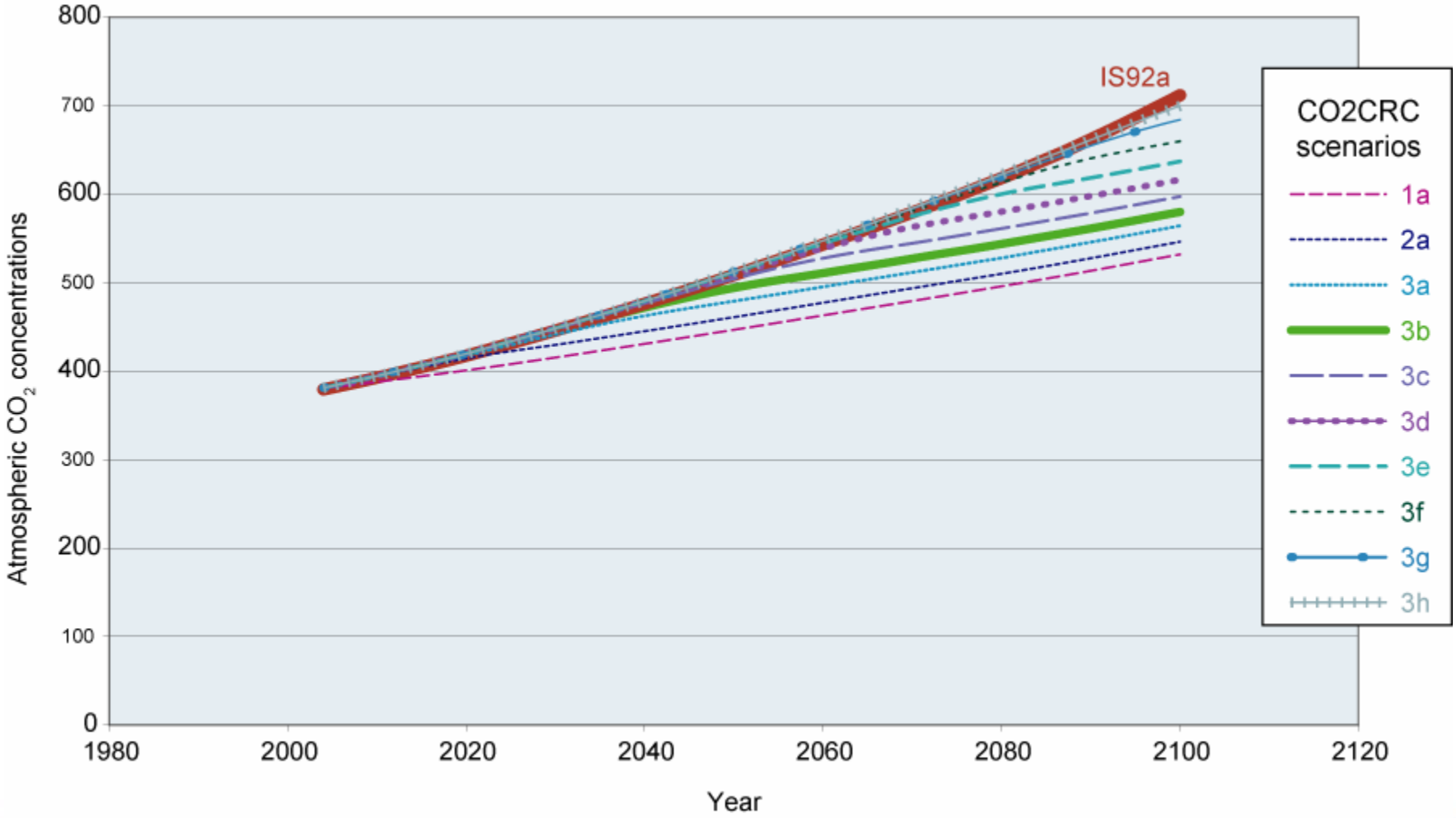
CO2CRC emissions scenarios

		2004	2014	2024	2034	2044	2054	2064	2074	2084	2094
1a	Electricity	100%	-	-	-	-	-	-	-	-	-
	Vehicles	100%	-	-	-	-	-	-	-	-	-
2a	Electricity	0%	50%	100%	-	-	-	-	-	-	-
	Vehicles	0%	0%	100%	-	-	-	-	-	-	-
3a	Electricity	0%	25%	50%	75%	100%	-	-	-	-	-
	Vehicles	0%	0%	0%	50%	100%	-	-	-	-	-
3b	Electricity	0%	0%	25%	50%	75%	100%	-	-	-	-
	Vehicles	0%	0%	0%	0%	50%	100%	-	-	-	-
3c	Electricity	0%	0%	0%	25%	50%	75%	100%	-	-	-
	Vehicles	0%	0%	0%	0%	0%	50%	100%	-	-	-
3d	Electricity	0%	0%	0%	0%	25%	50%	75%	100%	-	-
	Vehicles	0%	0%	0%	0%	0%	0%	50%	100%	-	-
3e	Electricity	0%	0%	0%	0%	0%	25%	50%	75%	100%	-
	Vehicles	0%	0%	0%	0%	0%	0%	0%	50%	100%	-
3f	Electricity	0%	0%	0%	0%	0%	0%	25%	50%	75%	100%
	Vehicles	0%	0%	0%	0%	0%	0%	0%	0%	50%	100%
3g	Electricity	0%	0%	0%	0%	0%	0%	0%	25%	50%	75%
	Vehicles	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%
3h	Electricity	0%	0%	0%	0%	0%	0%	0%	0%	25%	50%
	Vehicles	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

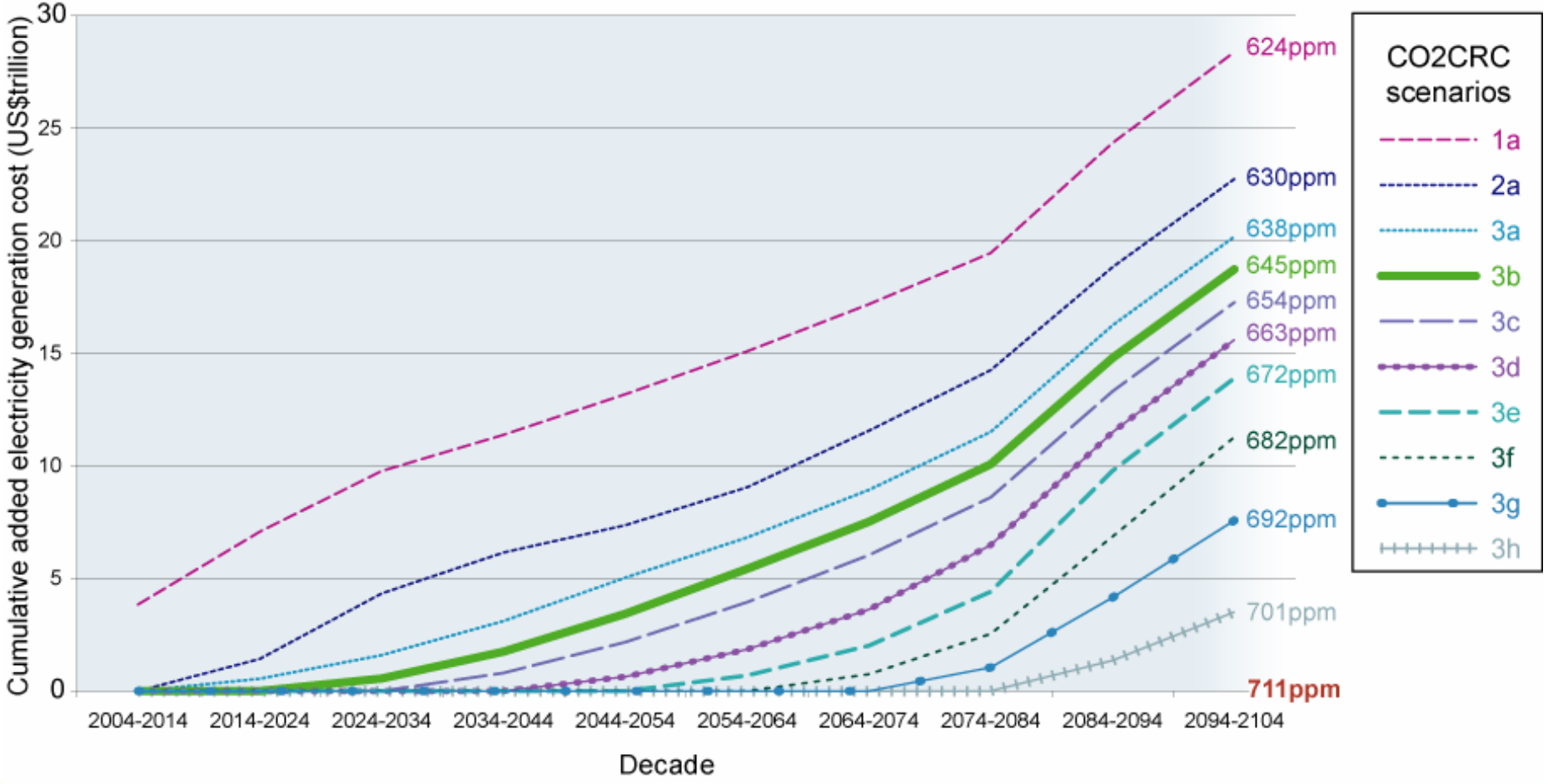
Annual emissions for CO2CRC Scenarios 1a through 3h



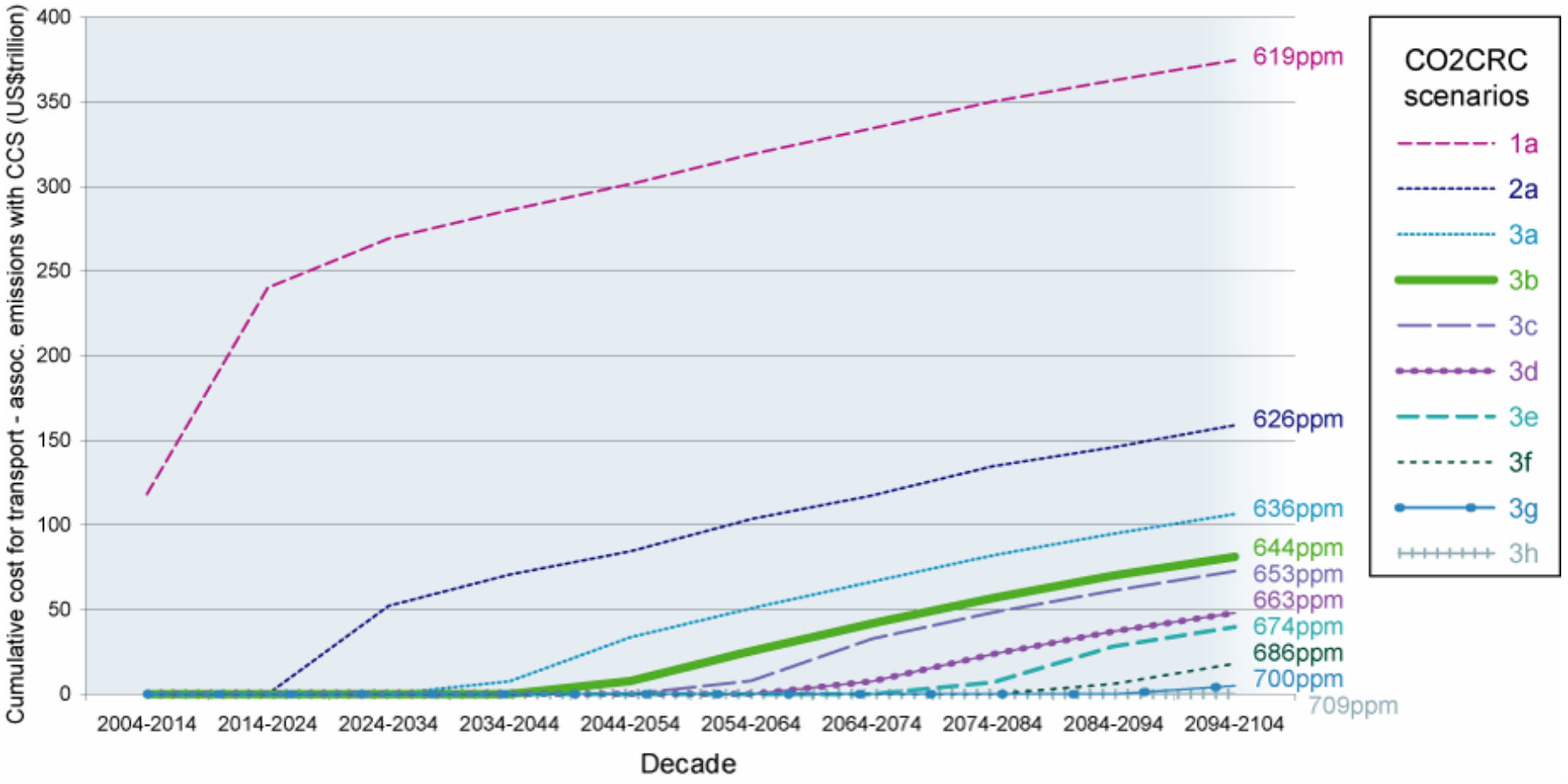
Atmospheric CO_2 concentrations from CO2CRC Scenario 1a through 3h



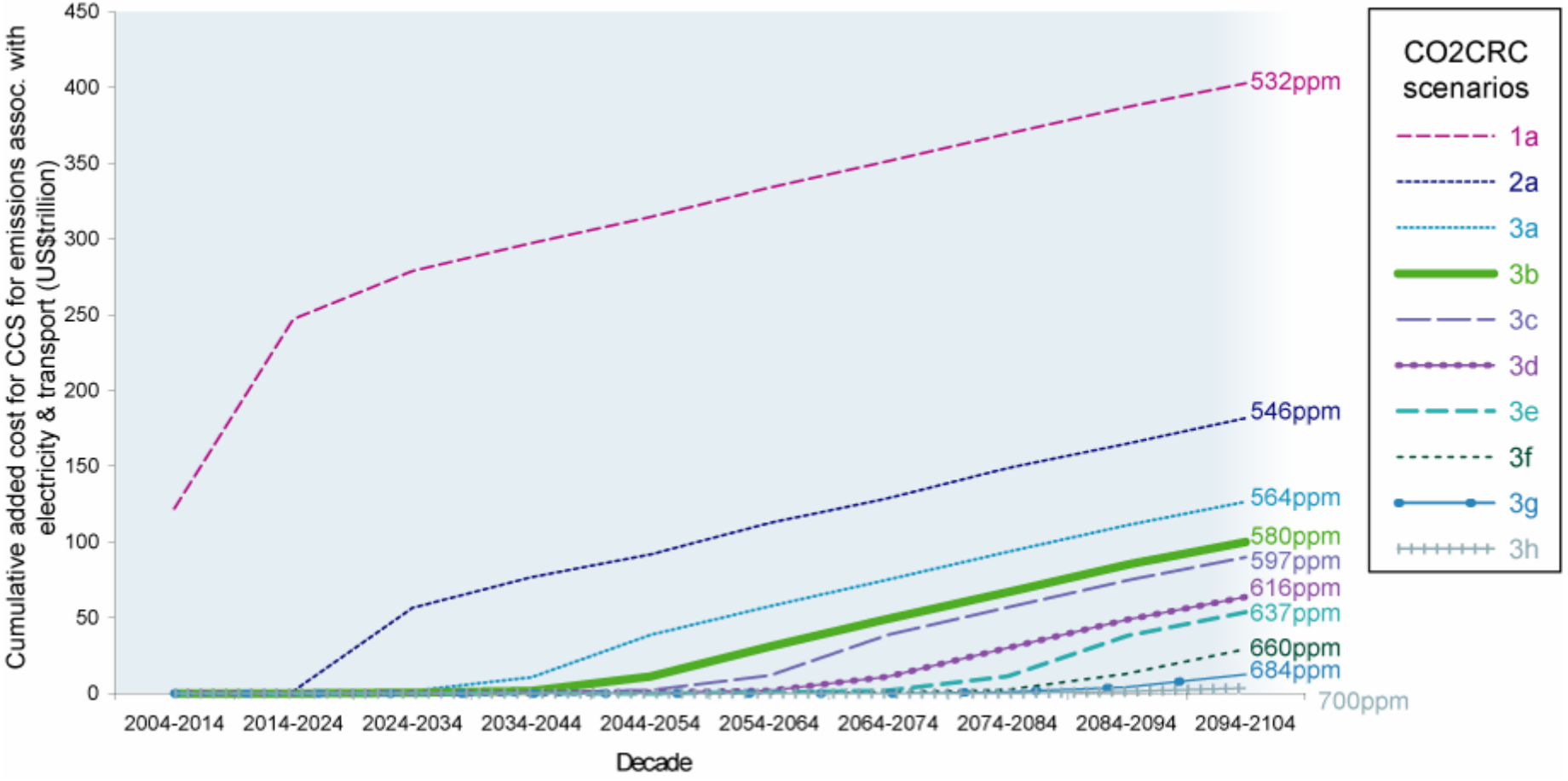
Cumulative cost of sequestering emissions associated with electricity generation power plants to achieve target 2100 atmospheric CO_2 concentrations



Cumulative cost of sequestering emissions associated with transport to achieve target 2100 atmospheric CO_2 concentrations



Cumulative added cost of sequestering emissions associated with both electricity generation and transport emissions to achieve target 2100 atmospheric CO_2 concentrations



Parameters for CO2CRC scenario 3b

Electricity Generation

2004 – 2014	Development of CCS technologies (10 years)
2014 – 2054	Progressive implementation of CCS for all new/retiring power stations (40 year ramp-up)
2054 – 2100	All power stations zero emission through application of CCS

Transport

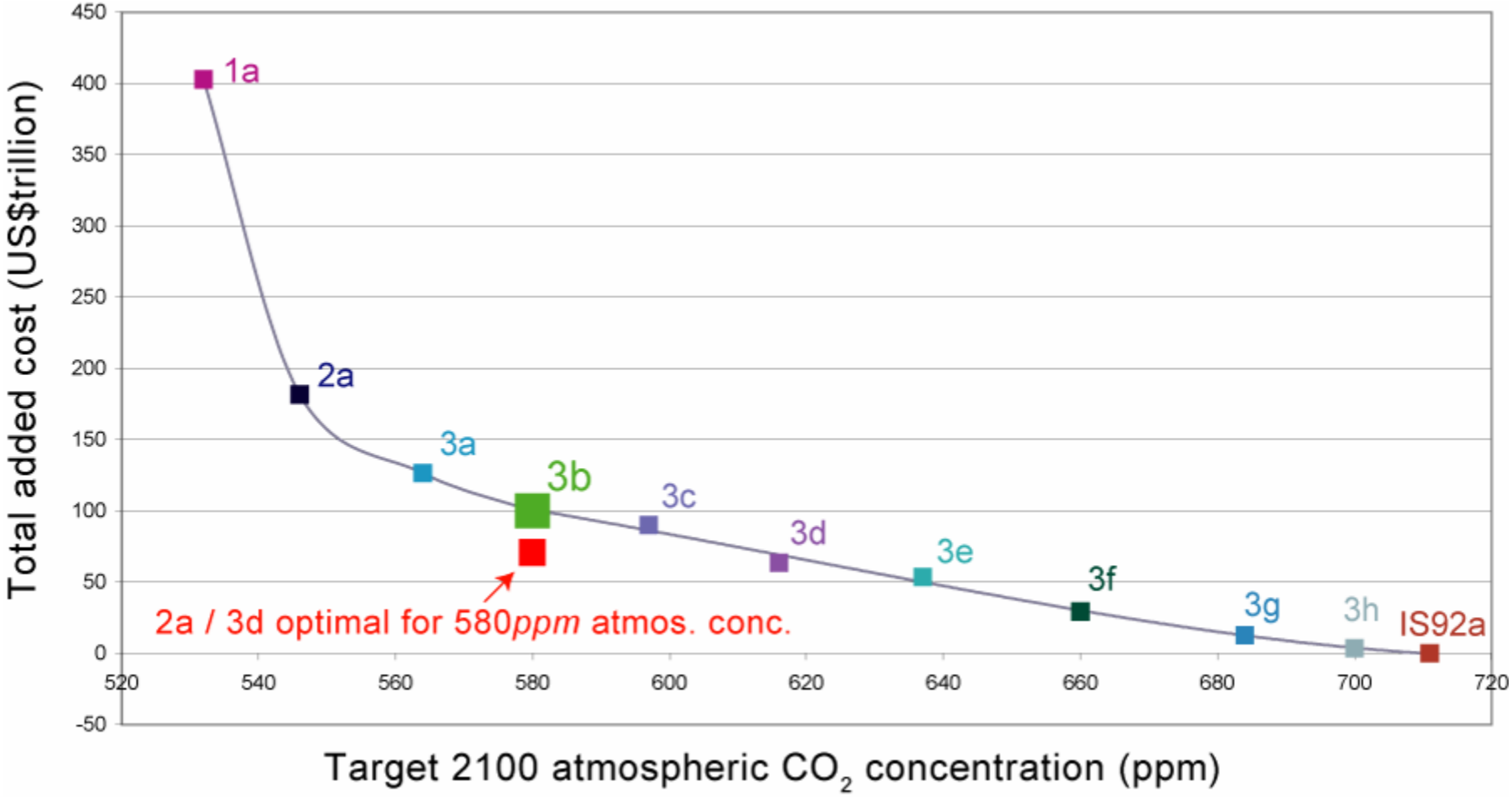
2004 – 2034	Development of viable hydrogen and electric vehicles (30 years)
2034 – 2054	Progressive introduction of H_2/electric for all new/retiring vehicles (20 year ramp-up)
2054 – 2100	All vehicles zero-emission through application of CCS to H_2/electricity generation.

Other

Not addressed in modeling to date, but need to take account of cement plants, gas separation, steel manufacture and chemical plants that provide early opportunities for CCS.

Added (upfront) cost over 21st century of sequestering

- both power plant & vehicle emissions to achieve target 2100 atmospheric CO_2 concentrations



References for calculating economics of sequestering electricity CO_2 emissions

- **CO_2 Emissions from Fossil Fuel Consumption by Activity**
  - Williams, R., "Decarbonization of Fossil Fuels for the Production of Fuels and Electricity," presented at the *1st Workshop for the Clean Coal Technology Roadmap*, Alberta, Canada, 20 March, 2003.
- **IS92a Projected Annual Fossil Fuel-Based Electricity Generation**
  - Leggett, Jane, personal communication, July, 2004.
- **Age Distribution of Power Plants**
  - Platts, "World Electric Power Plant Database," 2004.
- **Cost of Electricity for Reference and Capture Plants**
  - Herzog, H.J. and D. Golomb, "Carbon Capture and Storage from Fossil Fuel Use," *Encyclopedia of Energy*, to be published 2004.
  - Herzog, H., "The Economics of CO_2 Separation and Capture," *Technology*, vol. 7, suppl. 1, pp. 13-23, 2000.
- **Cost of CO_2 Storage**
  - Allinson, G. and V. Nguyen, "CO_2 Geological Storage Economics," Proceedings of the *6th International Conference on Greenhouse Gas Control Technologies*, 1-4 October 2003, Kyoto, Japan, pp. 615-620, 2003.
  - Heddle, G., H. Herzog and M. Klett, "The Economics of CO_2 Storage," MIT LFEE Report, 2003.

CO2CRC

References for calculating economics of zero emissions vehicles

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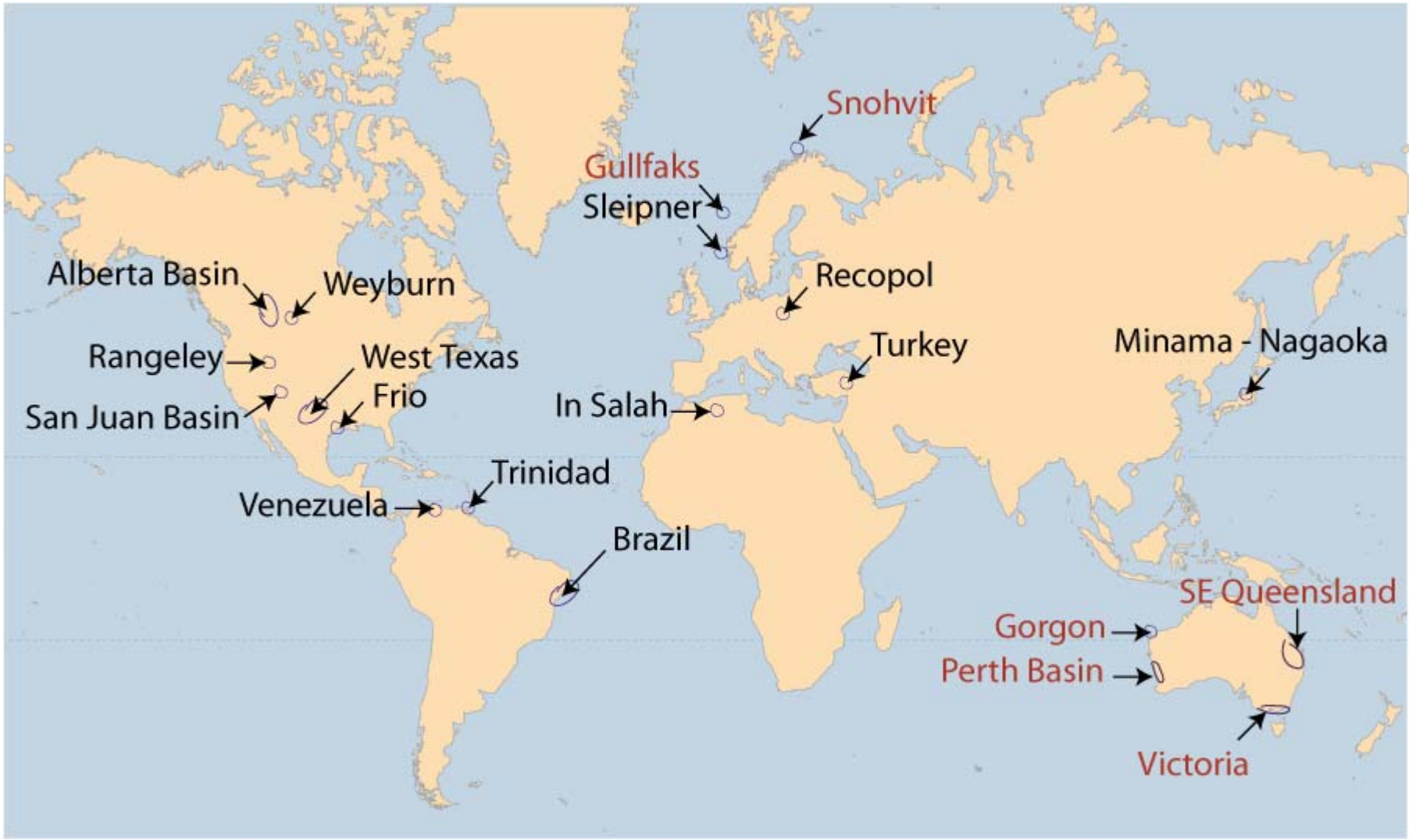
  - Ward's Communication, "Ward's World Motor Vehicle Data," 2002.
- **Projected Vehicle Demand**
  - Schipper, L., "People on the Move and Goods on the Go," LBNL Report, 1997.
  - IPCC Data Distribution Centre, "The IS92a Scenario - Key Assumptions," 1992.
- **Age Distribution of Vehicles**
  - Australian Bureau of Statistics (ABS), "Motor Vehicle Census 9309.0", 31 March, 2002.
- **Cost of Reference and Hydrogen Fuel Cell Vehicles**
  - Weiss, M.A., J.B. Heywood, E.M. Drake, A. Schafer and F.F. AuYeung, "On the Road in 2020: A Life-cycle Analysis of New Automobile Technologies," MIT Report, 2000.
  - Lachlan McIntosh, personal communication, August, 2004.
- **Gasoline/Hydrogen Demand of Reference/Hydrogen Fuel Cell Vehicles**
  - Weiss, M.A., J.B. Heywood, E.M. Drake, A. Schafer and F.F. AuYeung, "On the Road in 2020: A Life-cycle Analysis of New Automobile Technologies," MIT Report, 2000.
  - National Research Council and National Academy of Engineering – Committee on Alternatives and Strategies for Future Hydrogen Production and Use, "The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs," 2004.
- **Projected Gasoline Price**
  - Intergovernmental Panel on Climate Change (IPCC), "Climate Change 1992: Supplementary Report to The IPCC Scientific Assessment," 1992.
- **Cost of Hydrogen Production and Distribution**
  - National Research Council and National Academy of Engineering – Committee on Alternatives and Strategies for Future Hydrogen Production and Use, "The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs," 2004.

Geosequestration related activities underway or proposed



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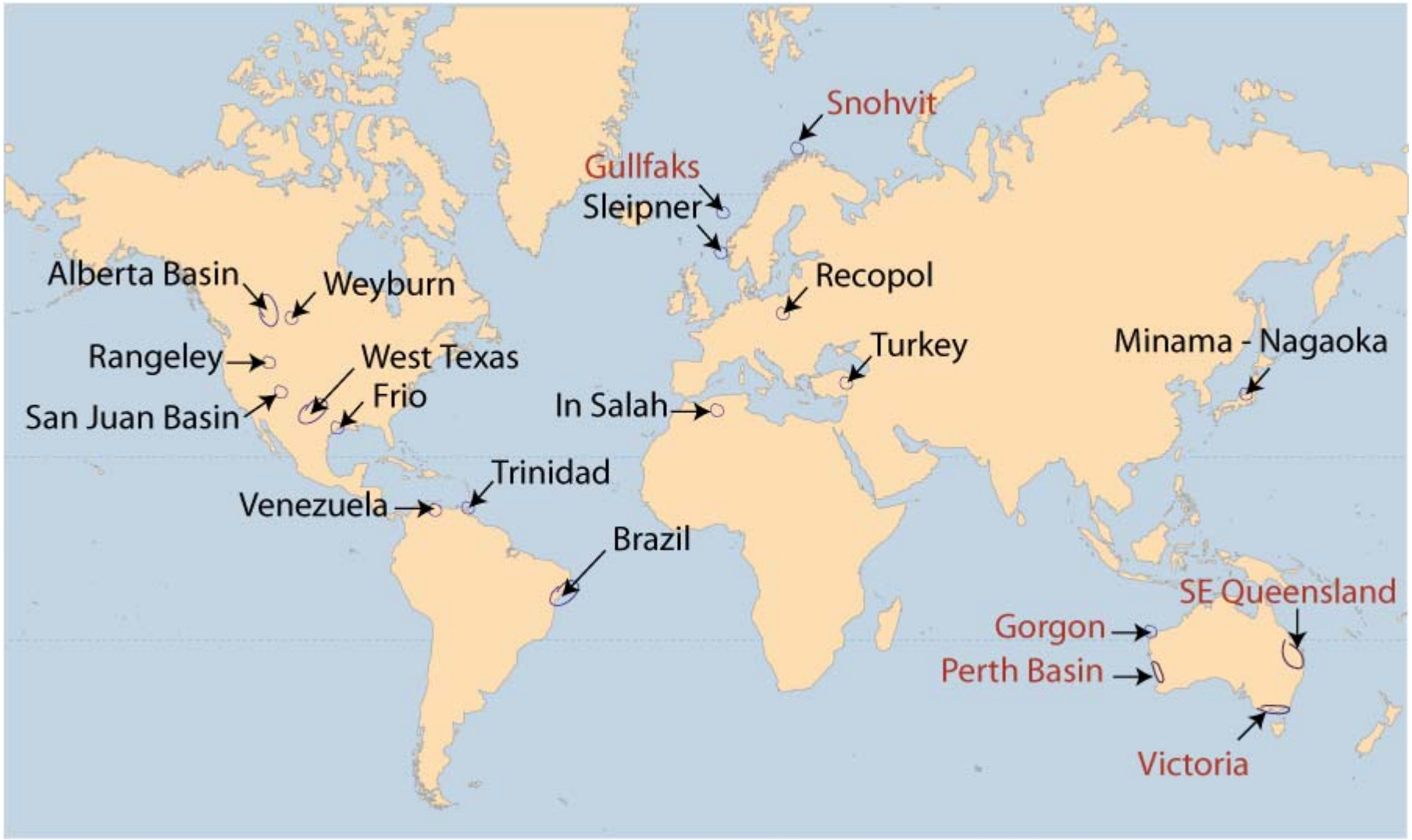
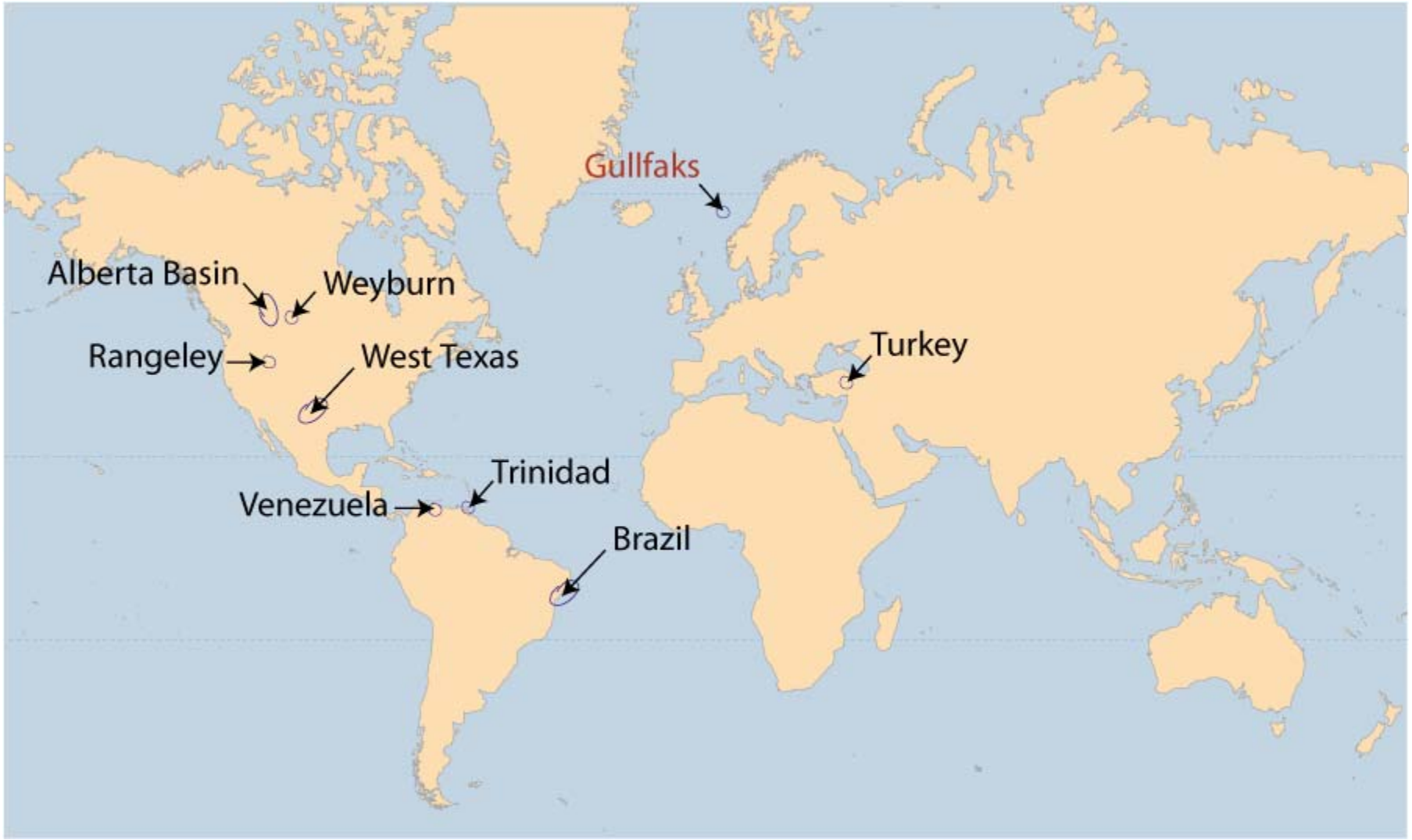
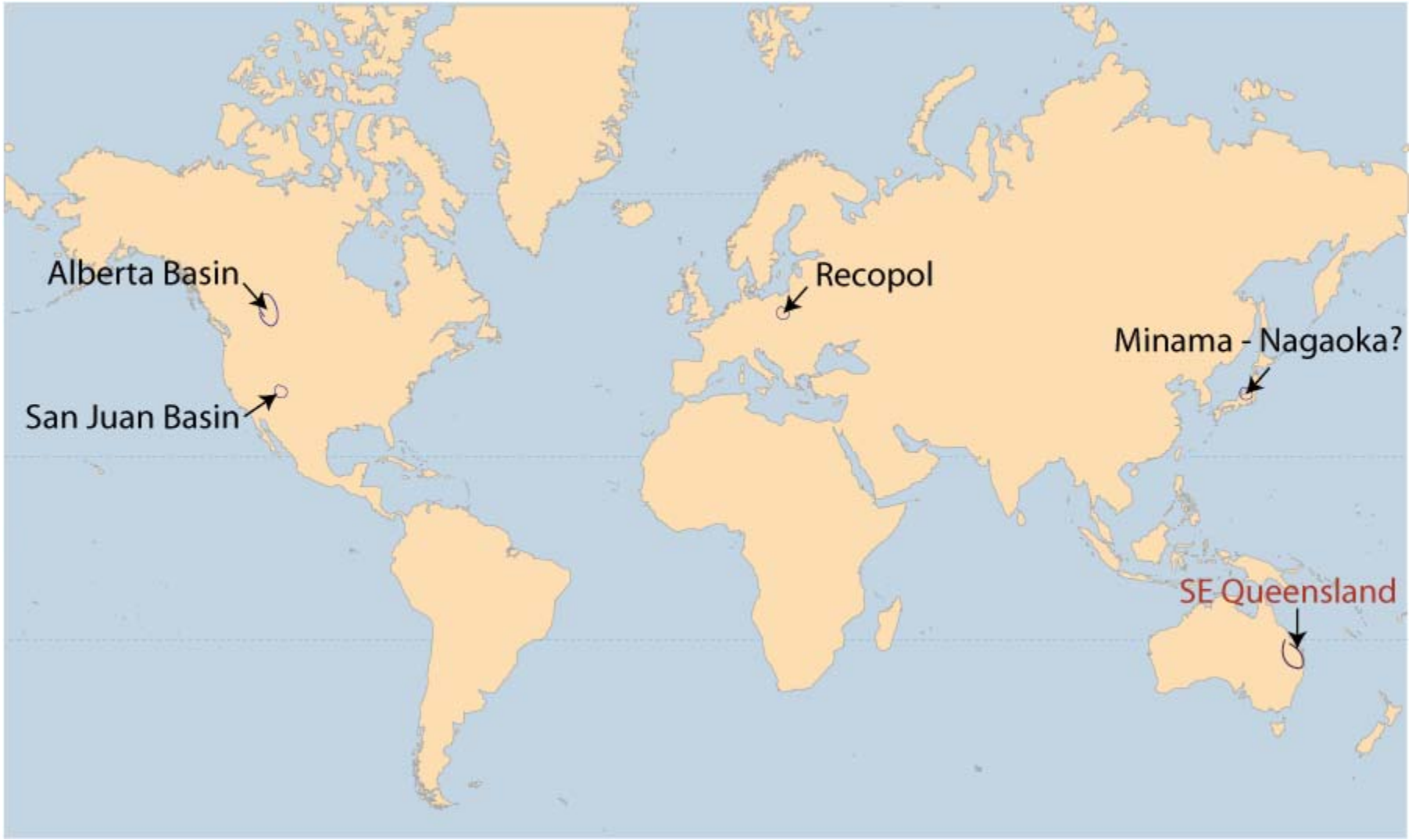


CO_2 enhanced oil recovery underway or proposed

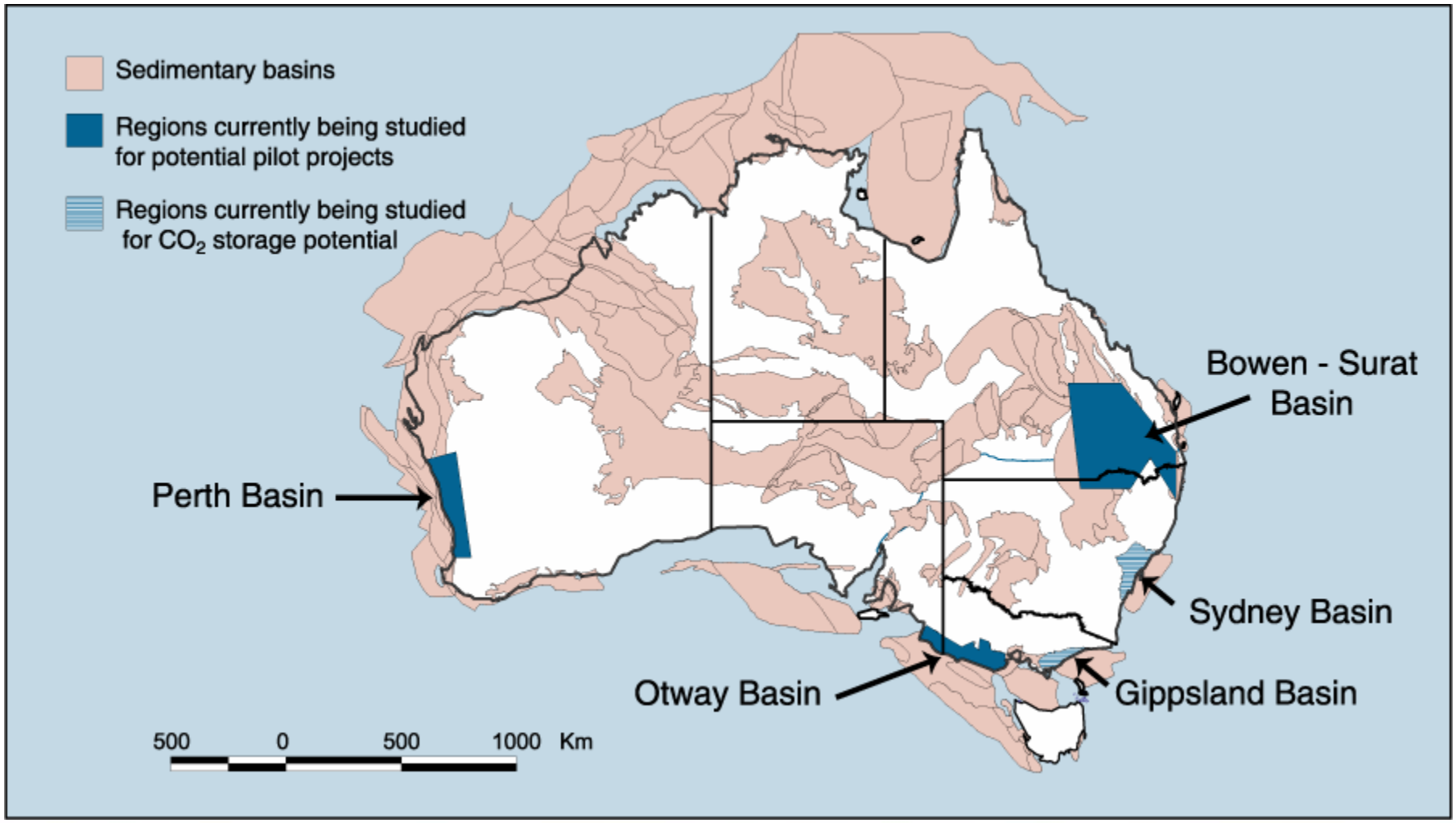


CO_2 enhanced coal bed methane pilots undertaken or proposed



Comprehensive CO_2 monitoring & verification underway or proposed

Regions being studied for potential pilot projects



CO2CRC participants:

Australian Government

Geoscience Australia
Australian Greenhouse Office
Department of Industry, Tourism and Resources

RIO TINTO

xstrata coal

NZ RESOURCE CONSORTIUM

STANWELL CORPORATION LIMITED

THE UNIVERSITY OF ADELAIDE AUSTRALIA

MONASH University

ACARP
Australian Coal Association Research Program

curtin
University of Technology
Western Australia

THE UNIVERSITY OF MELBOURNE

ChevronTexaco

Schlumberger

UNSW

PRIMARY INDUSTRIES AND RESOURCES SA

CO2CRC

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Carbon Sequestration Leadership Forum

STAKEHOLDER WORKSHOPS

TECHNICAL PERSPECTIVES

Chairs

John Hartwell ITR

Peter Cook CO2CRC

Stakeholders Dialogue Technical Perspective

- World storage capacity appears to be large and widespread but, with pressure for global capacity figures, need more standardised methodologies for assessment; taskforce?
- Saline aquifers provide main capacity; depleted oil/gas fields important locally; EOR useful in places; ECBM and coal storage uncertain
- Storage technology is largely available; good experience with oil reservoirs; not much experience to date with gas reservoirs; less information about flow properties for deep saline formations; deep, unmineable coal least well understood
- Potential for geologic storage to be very safe; evidence of effective storage; site dependant; storage security should increase over time; biggest risks have been identified and have means to prevent such risks

Stakeholders Dialogue Technical Perspective

- Public acceptance is key; the technical community has confidence in CCS but the broader community has yet to be convinced
- Inform public about the impact (costs) of climate change; focus communication at a local, project specific level; get endorsement from broad range of stakeholders; encourage open, transparent communication; educate public on various GHG mitigation technologies to allow for informed debate
- Comprehensive monitoring and verification is a key component of developing stakeholder confidence in the sustainability of CCS, particularly in providing reassurance on the the issue of leakage

CCS technologies will be a very important part of the

Stakeholders Dialogue Technical Perspective

- There is a need for much better costings for CCS; costs, especially capture component, need to be brought down; express costs on common basis in terms of $ per tonne CO2 avoided; recognise costs for same technology will vary by geographic region
- Retrofit an issue
- Commercialisatin requires stronger market signals through greater recognition of the need for deep emissions reduction; reduce financial risk
- Collaborative, cross-disciplinary arrangements are crucial for taking CCS forward
- Involvement of developing countries critical; technology transfer is important but costs are involved
- Need to act more quickly; more demonstration projects needed now; must not be unreasonably burdened with

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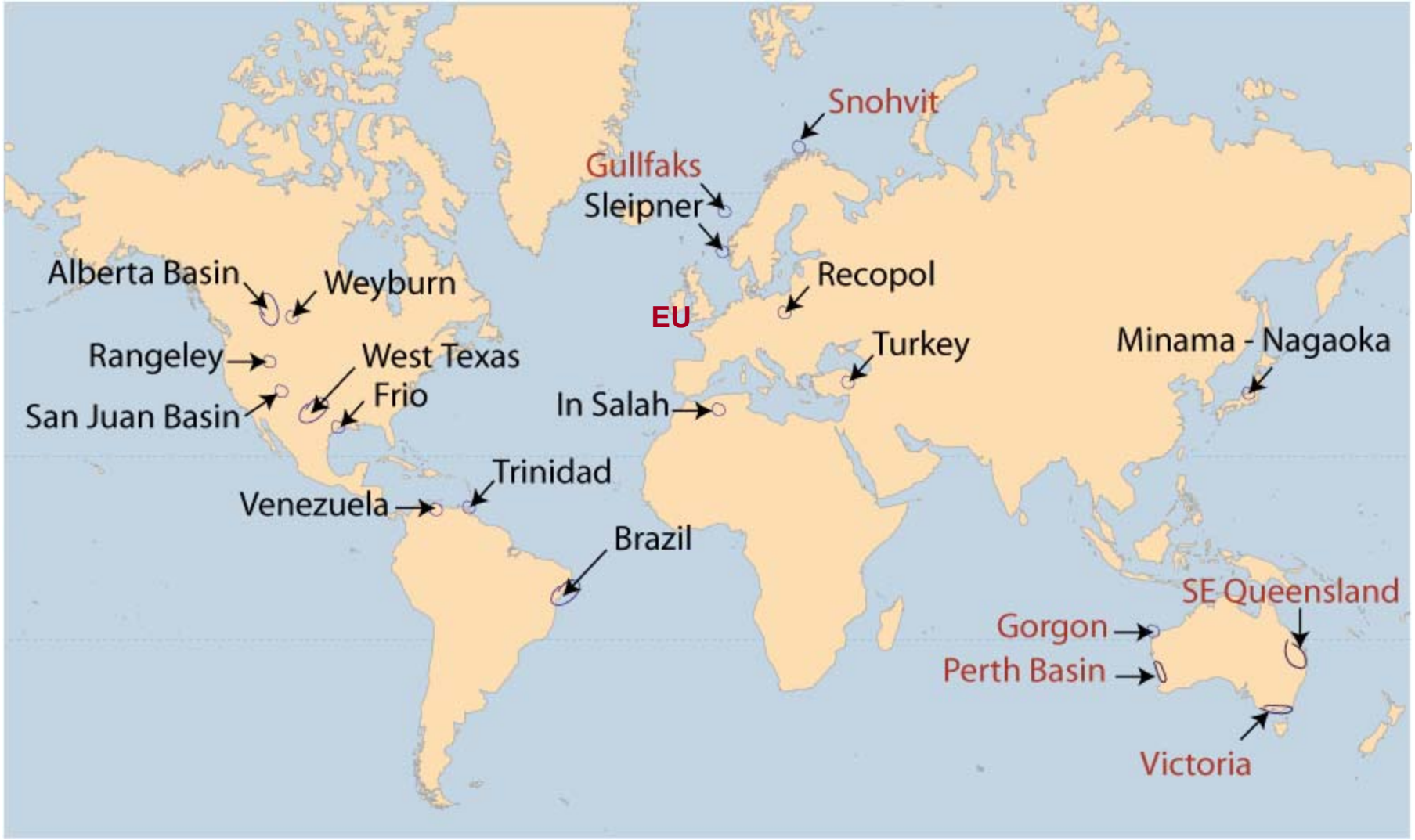

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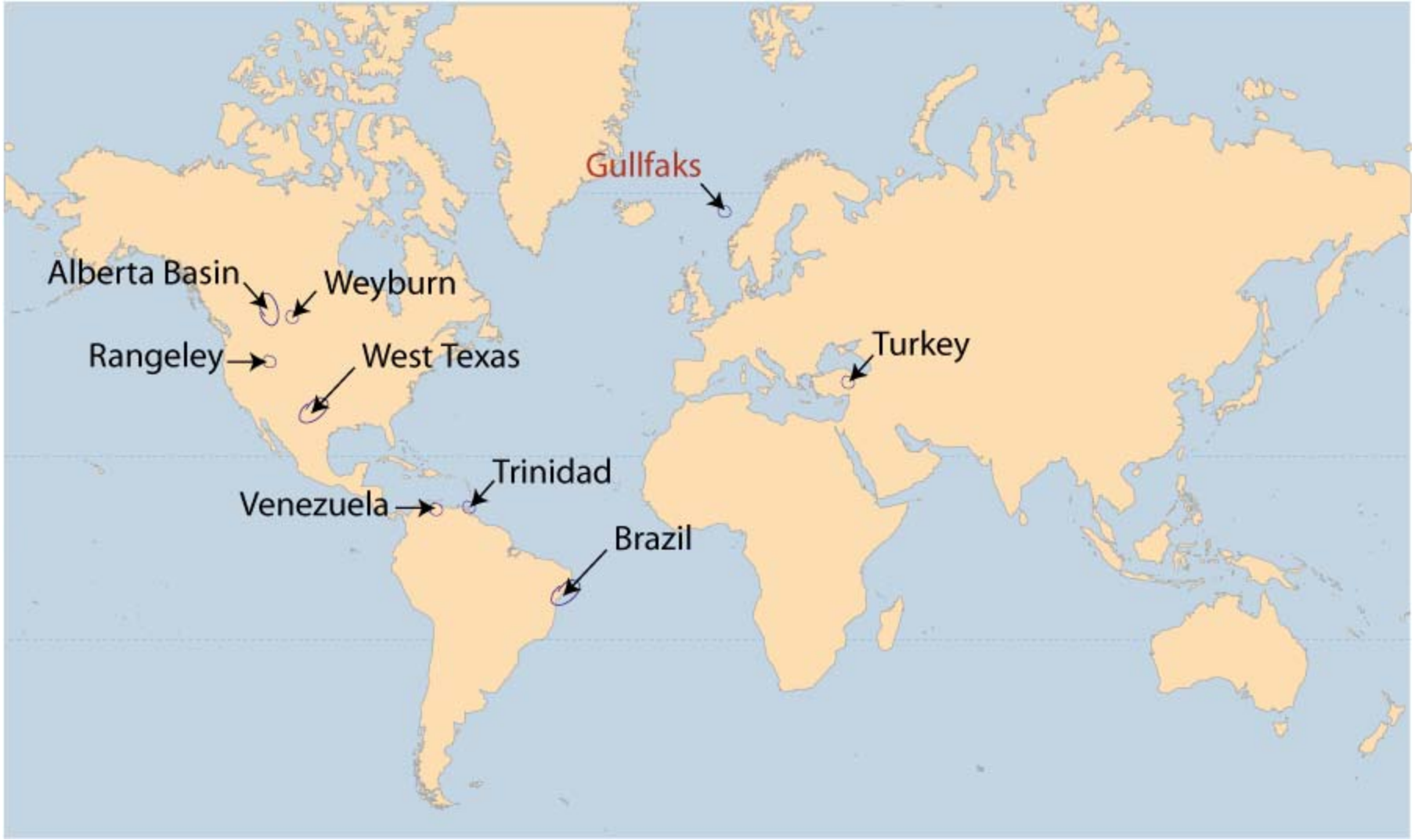

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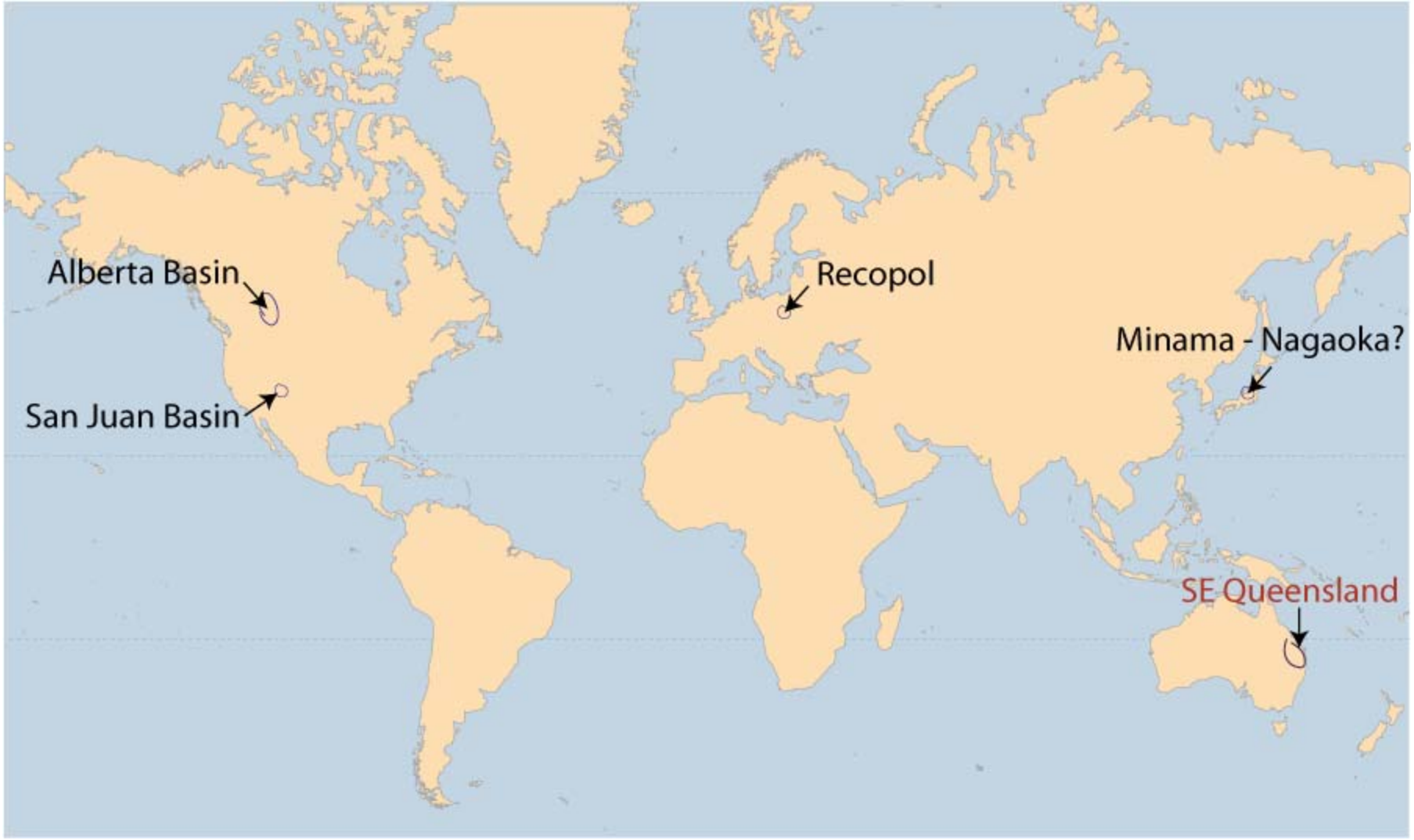

Comprehensive CO_2 monitoring & verification underway or proposed

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Summary

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