Clean Coal Technology Roadmap

Cartes routières technologiques du charbon écologique

CCTRM / CRTCÉ

Technology Roadmap

Network Meeting
Ottawa, Ontario
June 2, 2006

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Natural Resources Canada
CANMET Energy Technology Centre - Ottawa
Canada's Clean Coal Technology Roadmap
http://www.cleancoaltrm.gc.ca

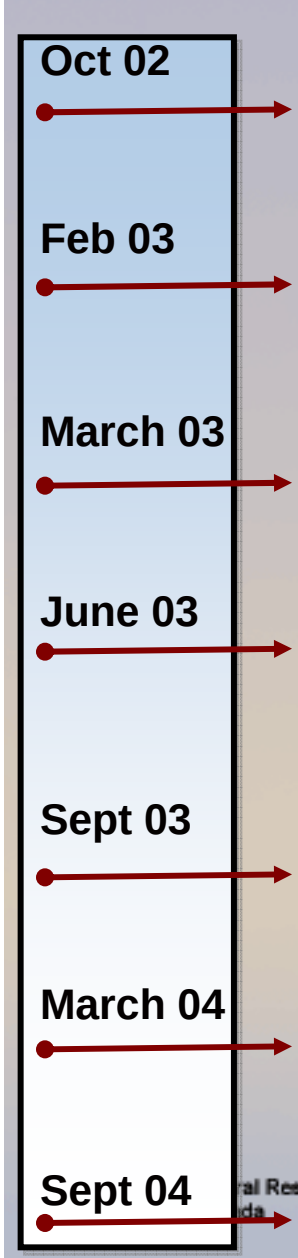
Roadmap Objectives

The Roadmaps were developed in cooperation with about 250 industry and government stakeholders.

Some of the questions addressed included:

- What will tomorrow's clean coal/CO2 capture and storage industry look like?
- What technologies will be required to support that vision?
- When should they be ready?
- What actions are required?

Pathway



Industry Steering Committee

Survey of roadmaps & technologies

Set up interactive website — Feb 03

Launching workshop: Info dissemination, strategy, A/group

Survey of energy strategies, issues & needs — Mar 03

Activity of advisory group : detailed technology pathways

Industry Lead: Bob Stobbs, Sask Power
Govt Lead: Kelly Thambimuthu, CETC

Supporting analysis: technology pathways

Workshop on technology pathways, key issues and needs

Activity of subgroups on analysis of key technology pathways

Special Studies

Input from CCPC near term technology map

Assemble draft report & review workshop

Final clean coal roadmap & translation — Nov 04

Natural Resources Canada / Ressources naturelle Canada

CTRM / CRTCÉ

Strategic Steps Comprising the Development of the Roadmaps

Step1: Roadmap Proposal presented to a inter-department DG Committee to obtain CCAP funding.

Benefits: Although several iterations were needed to gain approval, the exercise provided all concern valuable high level information on the Roadmap needs expectations, issues, concerns, and challenges.

Outcome: Received budgets of approximately $280,000/Roadmap and a 2.5 year time frame to completed the Roadmaps.

Observations: Developing Roadmaps are important undertakings for Canada and they should be granted the resources and time to get them done effectively. The benefits far outweigh the Roadmap process cost. The initial Roadmap comprises the starting off a long marathon race in the right direction.

Roadmap Steps

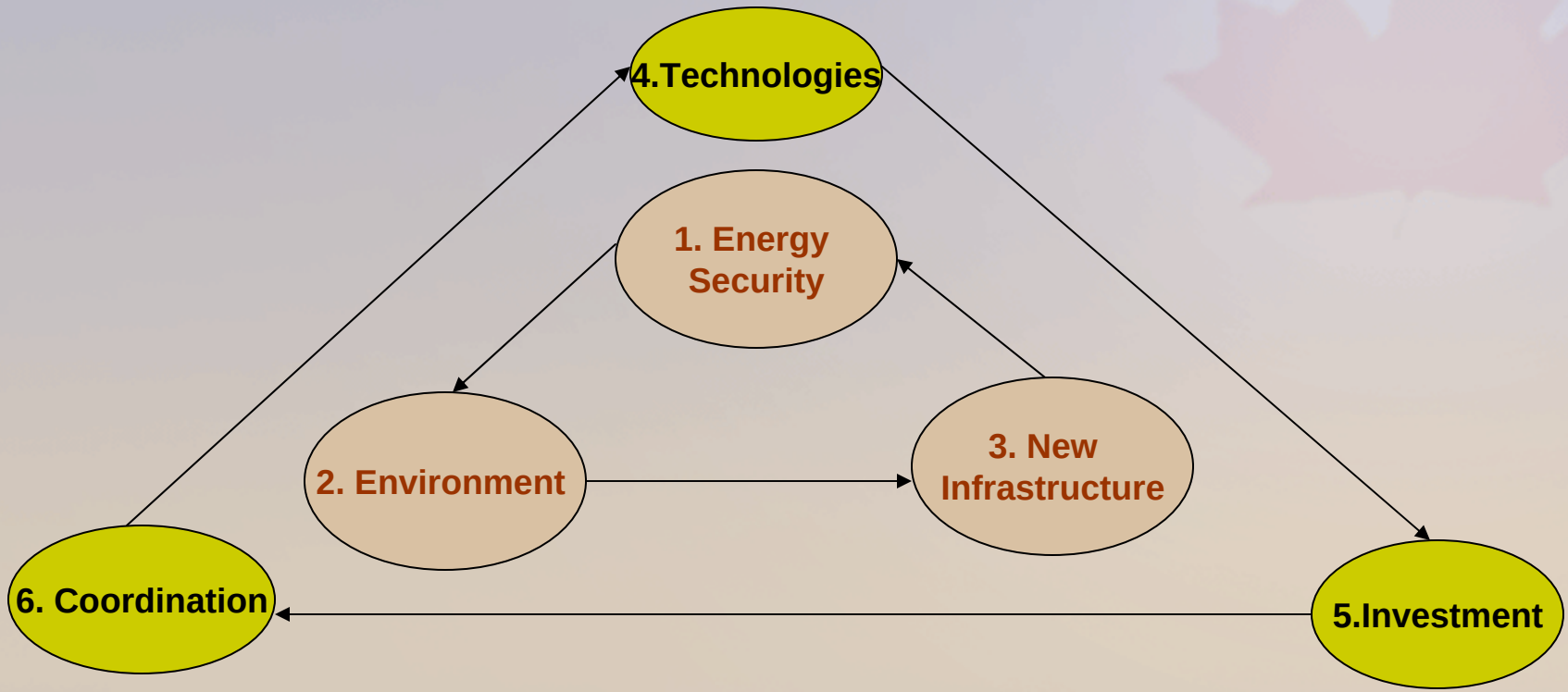
Step 2: Prepare "Terms of Reference" (ToR) for the Roadmap and the Management Steering committee.

Benefits: The (ToR) document played a critical role in attracting key industry executive and senior government provincial stakeholders.

Outcome: Both "Roadmaps" had buy in and serious commitment on the part of a few but influential stakeholders from the start.

Observations: The terms of reference comprised a preliminary assessment of future trends and provided a compelling case for Roadmap as a needed exercise to help industry and governments map their way forward.

Canadian Challenges and Needs



1. Energy Security

IEA's Energy Outlook for North America

Gas

Conventional gas supplies are on the decline and prices will remain volatile. North American LNG imports are predicted to grow to 30% by 2030.

Oil

North American oil imports may reach 57% by 2030.

Nuclear

The nuclear option will move slowly while dealing with reliability, availability, maintainability, public acceptance, waste disposal and long term liabilities issues.

Renewables

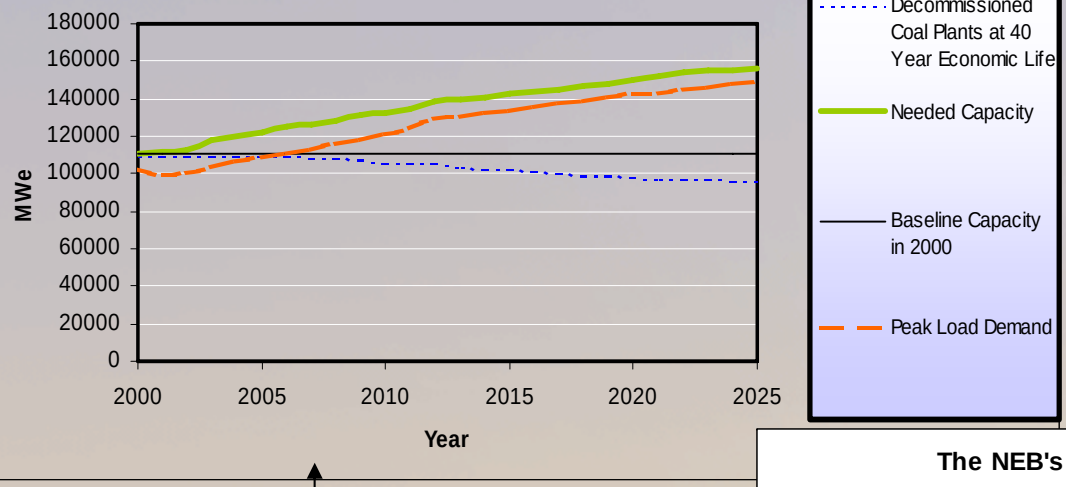
Will grow rapidly but will not keep pace with the energy demand.

Coal

Power-sector coal demand will grow with the expected increase in gas prices.

3. New Infrastructure

Canada's Electricity Generation Gap



2025

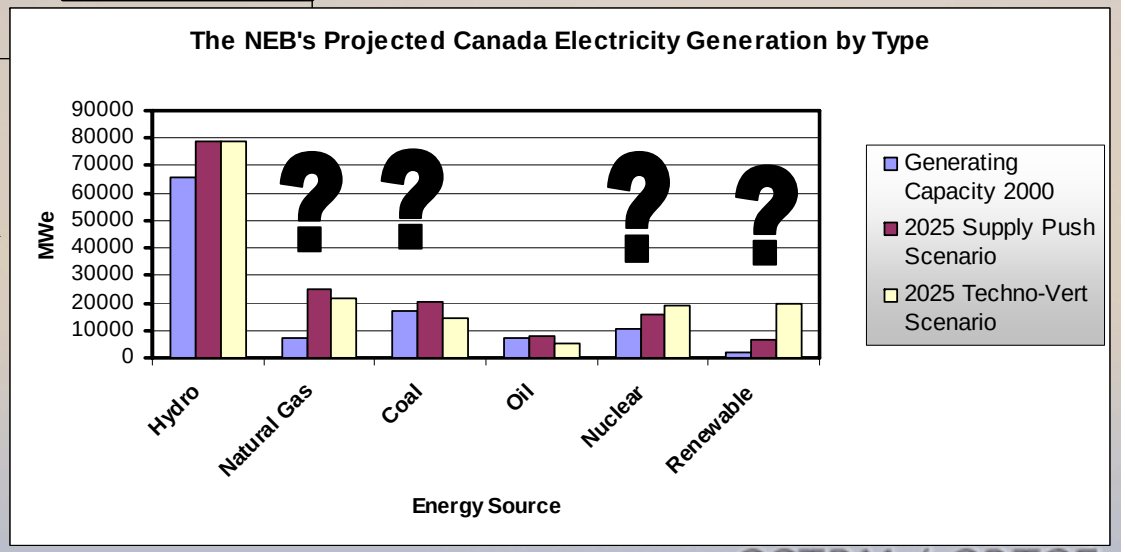
New Demand Capacity: 46,000 MWe

Decommissioned coal: 14,000 MWe

Total New Capacity: 60,000 MWe

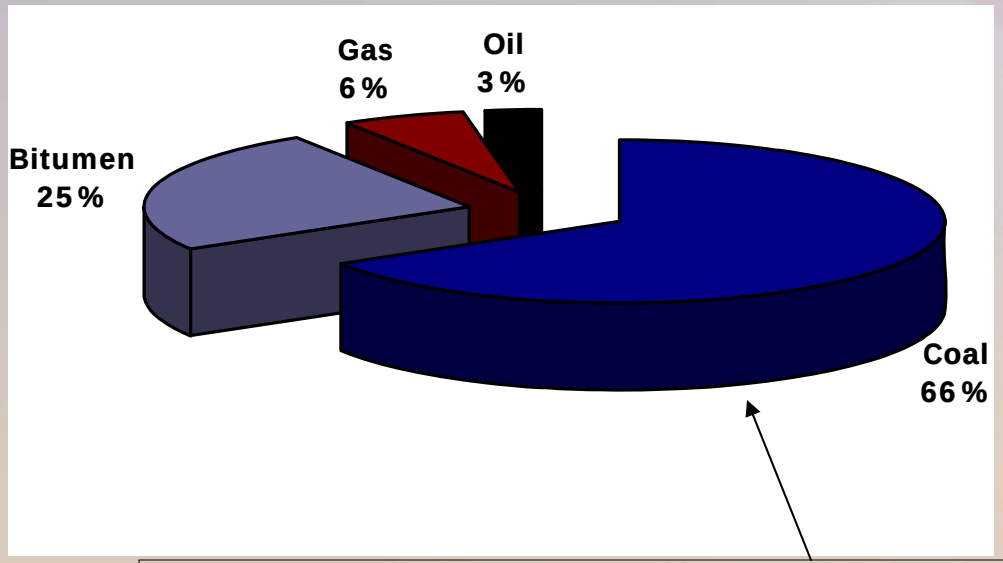
Will clean coal be part of this mix? Absolutely

Source: National Energy Board



1. Energy Security

Canadian's Proven Energy Reserves



Based on today's production rate, Canada has over 224 years of proven coal reserves and about 1000 years when considering measured reserves.
Western Canadian Coal: $1.00 GJ
Ontario Coal Imports: $2.00 GJ
Natural Gas: 2006 - $6.00 to $1400 /GJ - very volatile

2. Environment

Coal Related Emissions

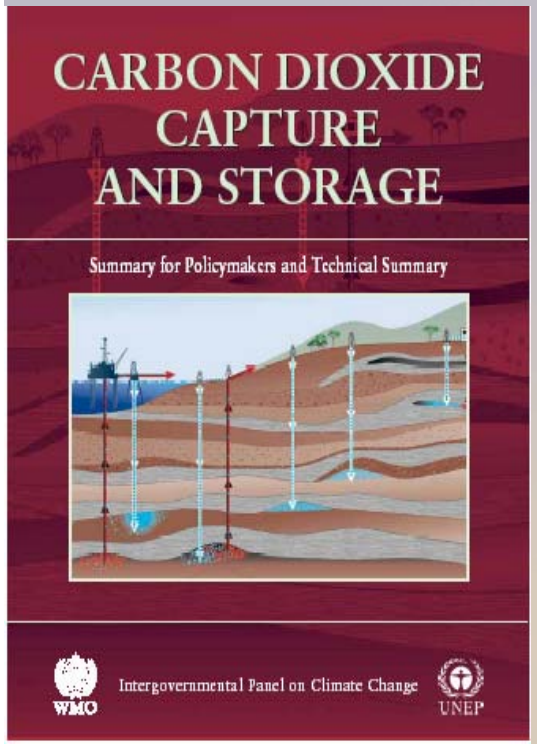
Issues	Emissions	Fossil Electricity Generation's Share (%)
Acid Rain	SO_2	20
Smog	NO_x	11
	Particulates	13
Air Toxics	Hg	26
Climate Change	CO_2	15

Today's Best Available **Retrofit** Technologies (% Reduction)
98%
98 to 99.9 %
84 to 90%
96%
Next generation power plant technology

3. New Infrastructure

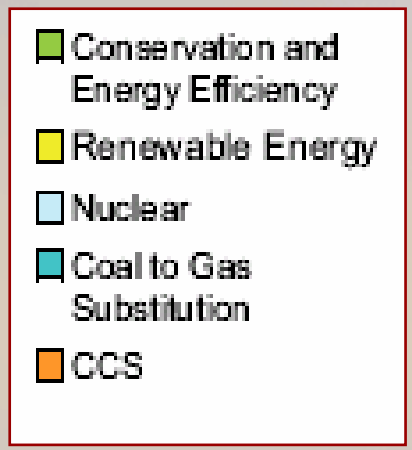
IPCC Special Report

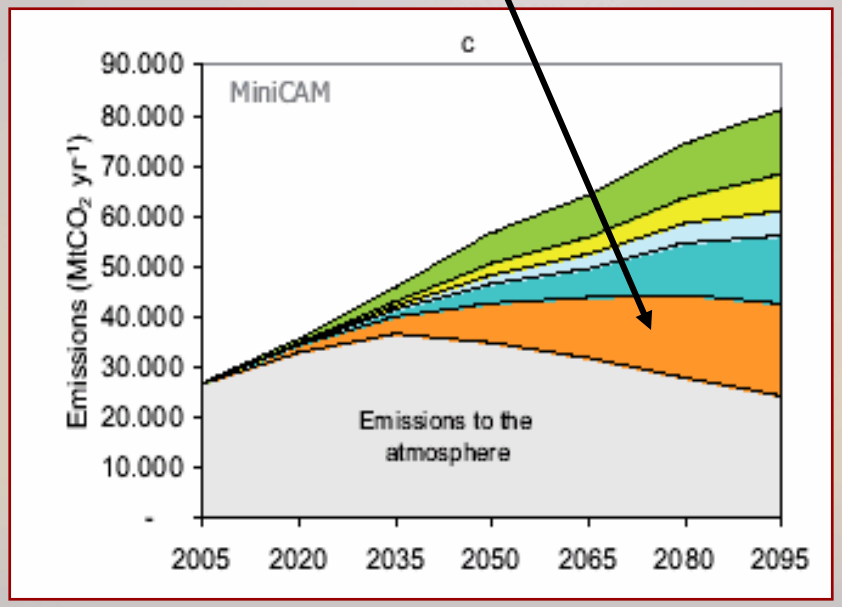
http://www.ipcc.ch/activity/ccsspm.pdf



Highlights:

- Carbon Capture and Storage (CCS) will plays a significant role in GHG mitigation.





3. New Infrastructure

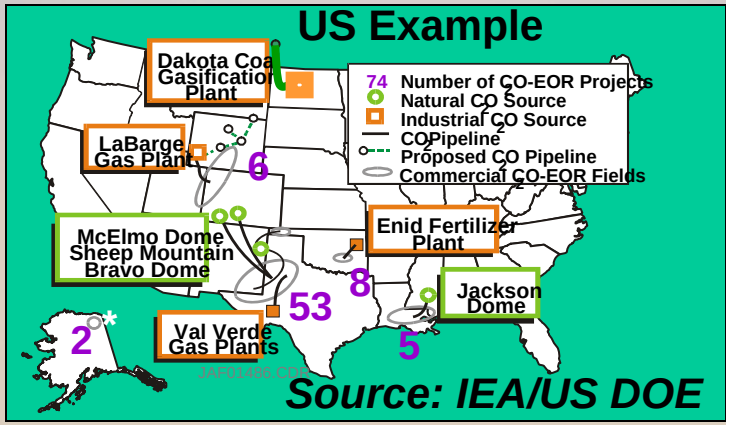
Synergistic Clean Coal Technology Opportunities with the Oil and Gas Industry

Oil Sands – Need low cost hydrogen

Production and upgrading facilities are expected to grow by a factor of 5 over the next 25 years.

Aggregate Production Forecast:

2003 – 1.1 million b/d 2012 – 2.0 million b/d 2030 – 5.0 million b/d



EOR/EGR/ECBM - Need CO_2

There is a need for a new CO_2 capture & transport infrastructure to support EOR, EGR and ECBM.

I.e. Weyburn is injecting about 2MT/yr of CO_2 and will likely continue to do so for the next 20 years.

EOR alone in Canada can store up to 450 Mt.

The 74 EOR projects in the US inject 30Mt of CO2/yr but only 3 MT of that CO2 is industrial sourced. The remaining comes from underground sources.

Roadmap Steps

Step 3: Formed a small technical advisory committee comprising of key Canadian well known experts in the technology area.

Benefits: Content of material in the Roadmap workshops and reports on solid ground. Advisory panel members were effective at engaging stakeholder participation. Working with a smaller group expedited decisions making.

Outcome: Workshops were well organized and in general there was a strong sense of accomplishment.

Note: The Roadmaps experienced some turn over in both the technical and management committees. This does cause difficulties.

Roadmap Steps

Step 4: Developed a web site to communicating and offer an opportunity for feedback with all stakeholders throughout all elements of the Roadmap process.

Benefits: The web site offers transparent, informative, interesting, open, and consistent communications with all stakeholders. Very effective at providing a inexpensive market outreach to both national and international interest groups and stakeholders.

Outcome: Both Roadmaps were very well profiled in the market place.

Roadmap Steps

Step 5: Three Workshop 6 to 12 month intervals.

- 1st Workshop - information dissemination aimed at bring everyone up to speed. Straw man position paper. .
- 2nd Workshop – Roadmap strategy document.
- 3rd Workshop – present draft roadmap report.

Note: Via breakout groups, all Workshops solicit feedback and advice on key issues pre-selected by the technical advisory panel.

Benefits: Participants are informed of the Roadmap developments that took place between the workshops and were given an opportunity to discuss and provide advice on key issues.

Outcome: Workshop stakeholders had a sense of accomplishment.

Roadmap Steps

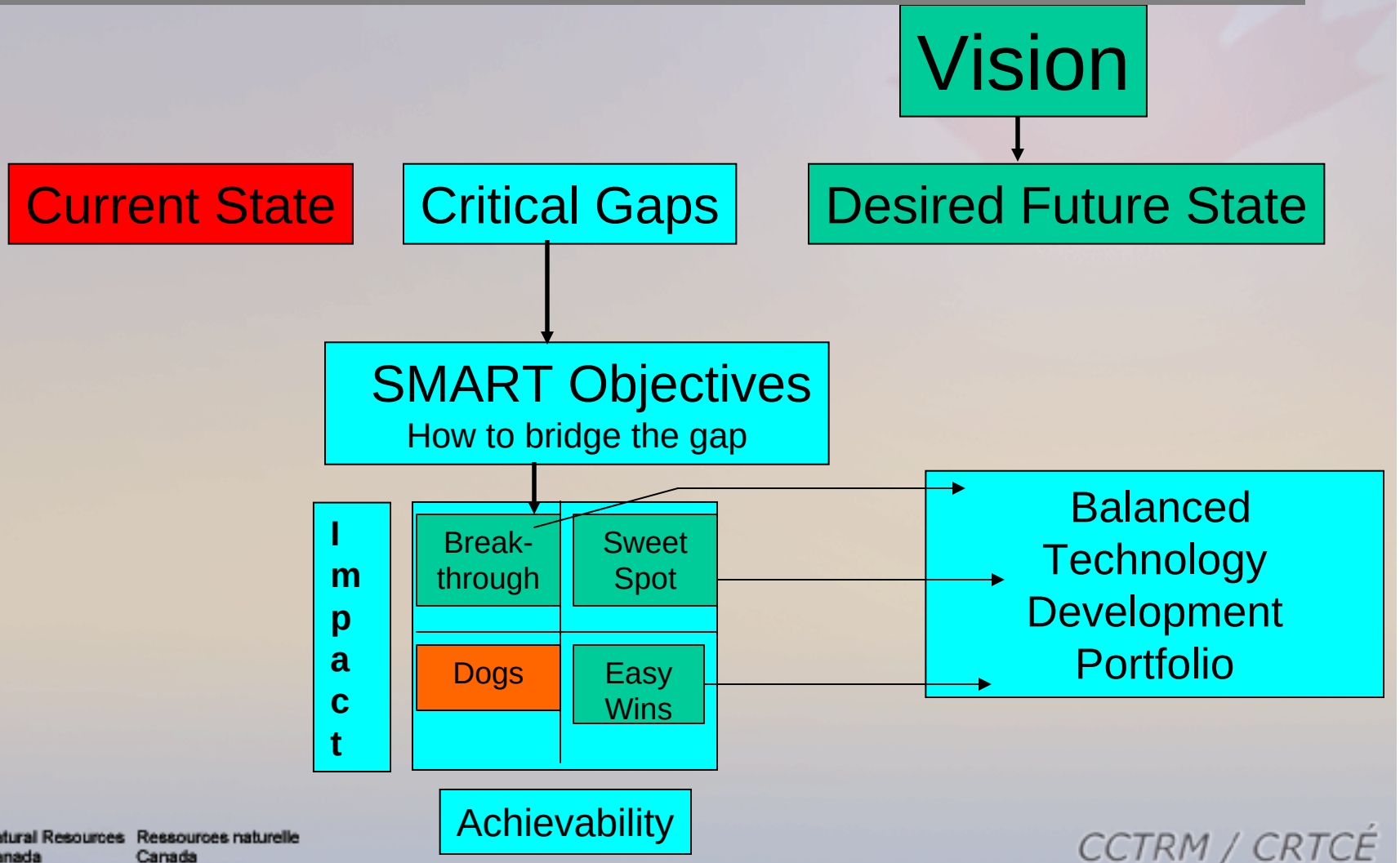
Step 6: Had to get professional writer to prepare the final Roadmap report and sought senior executive approval before releasing the Roadmap.

Benefits: The Roadmap findings are presented professionally.

Outcome: Stakeholders had a sense of pride in the outcome of their efforts. The Roadmap Report is used to influence decision makers

4.Technologies

Roadmap Gap Analysis



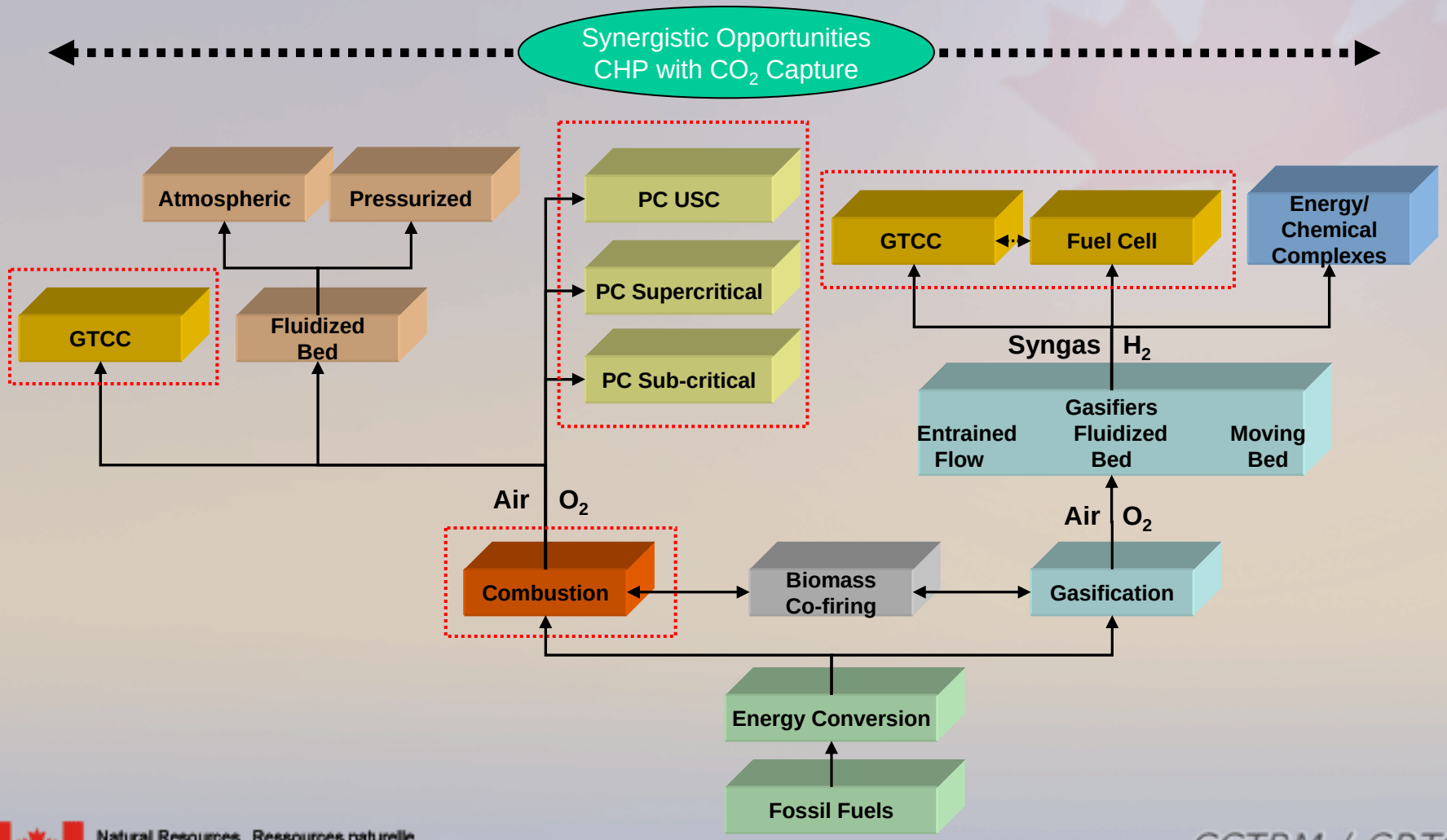
4.Technologies

Roadmap Outputs

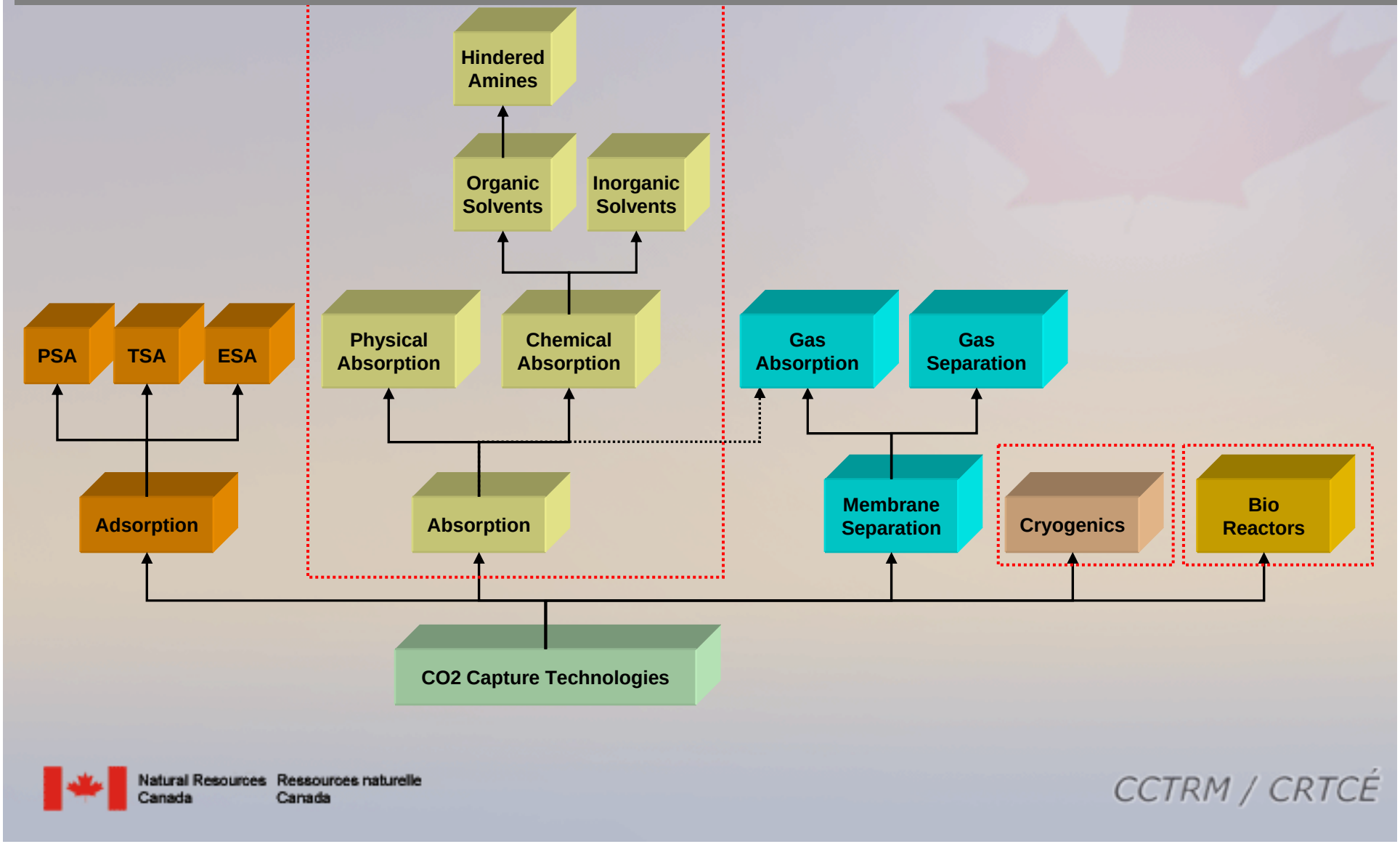
- Emissions, efficiency and cost performance targets
- Likely placements of the technologies across Canada
- R&D strategy
  -Up stream coal cleaning for down stream use
  -Air combustion with and without CO_2 capture
  -Near zero emission oxy-fuel combustion
  -Near zero emission gasification poly-generation
- Technology demonstrations targets
- Recommendations for public outreach and collaboration with other national and international stakeholders.

Note: Key stakeholders were identified as a lead agencies to implement the high level Roadmap objectives.

Roadmap Output: Clean Coal Pathways



Roadmap Output: Capture Technology Pathways



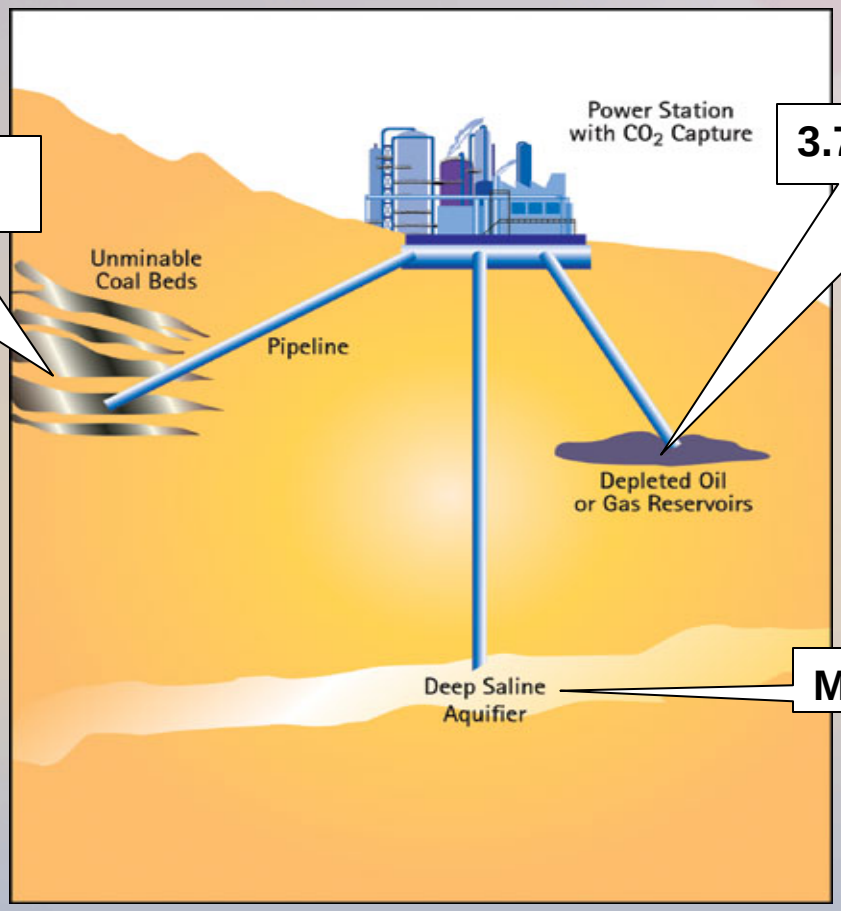
4.Technologies

Technology Performance Target Summary

Near zero emissions Performance Targets by 2020	Pre-combustion	Post combustion	Oxy-fuel combustion
Efficiency with capture (HHV)	← 40 to 42% range →		
Capital cost, $/kW	← 1200 to 1300 →		
Cost of electricity , c/kWh	← 4.4 to 4.7 →		

4.Technologies

CO_2 Storage Capacity



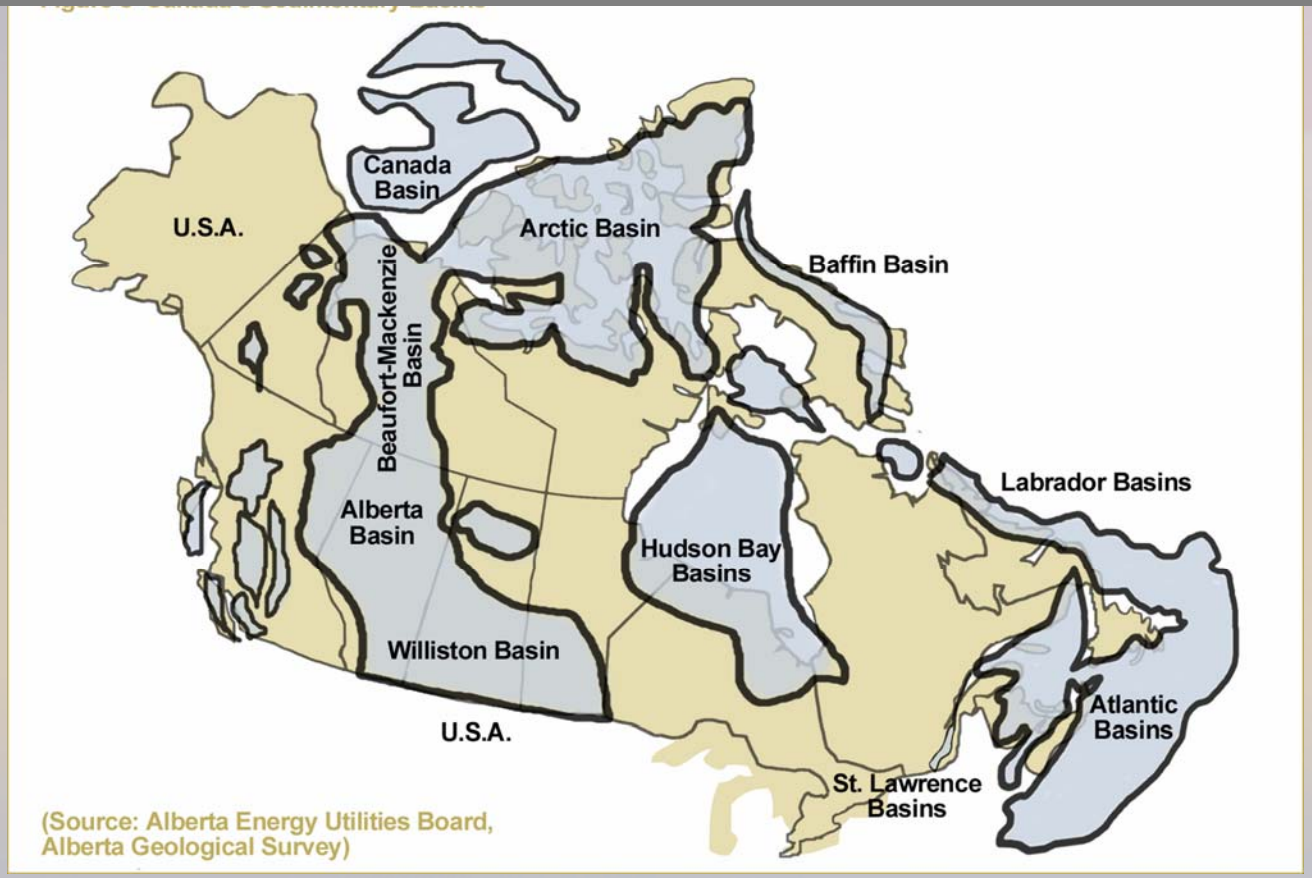
Notionally 2 Gt CO_2

3.7 Gt CO_2

More than 100 Gt

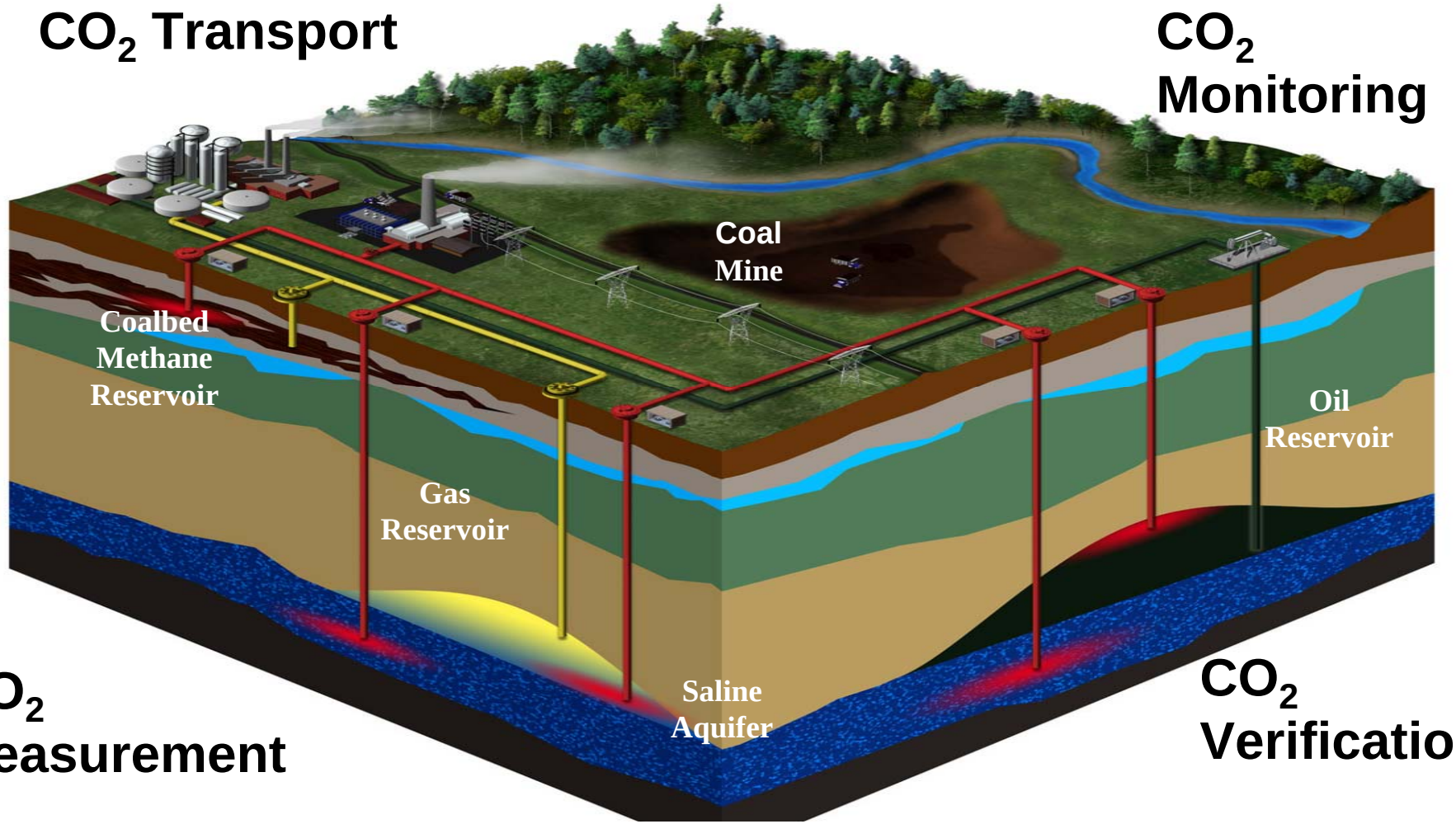
4.Technologies

Other Canadian Basins for CO_2 Storage



4.Technologies

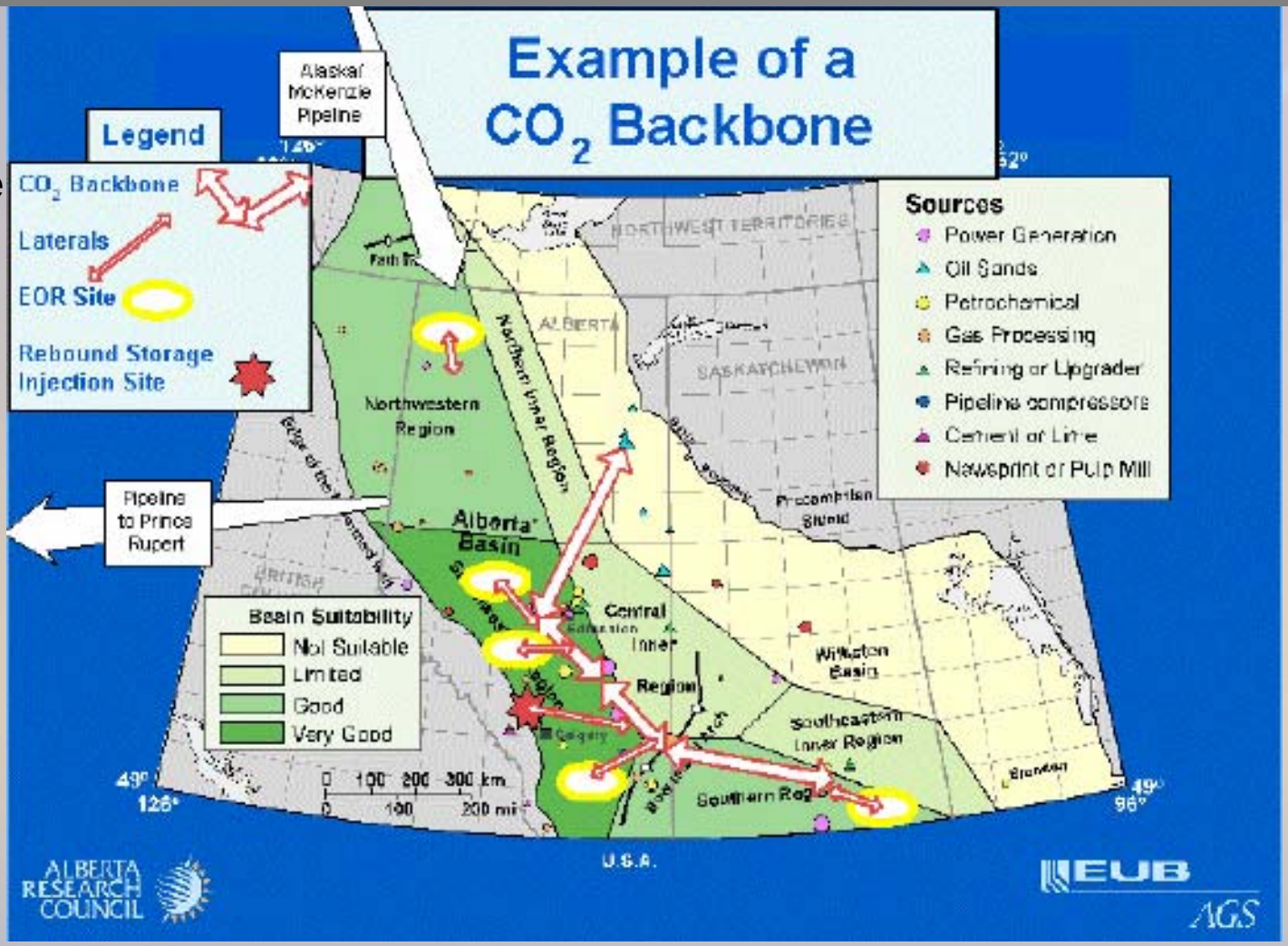
Development of Standards and Protocols



5.Investment

CO_2 Hubs and Pipeline Backbone Infrastructure

"CO2 Capture and Storage Roadmap" investigates matching CO_2 sources, with users and storage

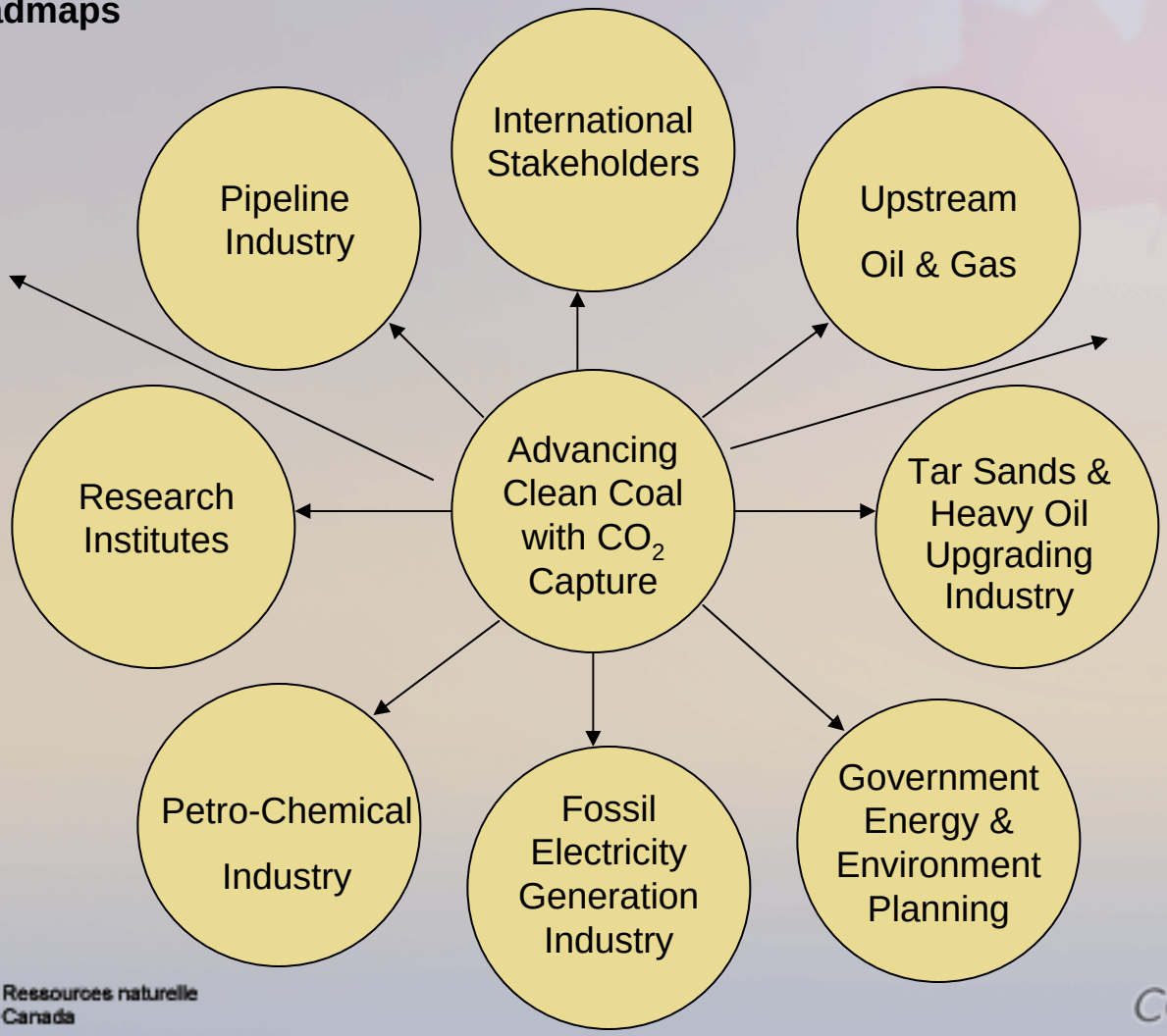


6. Coordination

Coordination & Planning

Cross Cutting Roadmaps

- CANiCAP
- CANiSTORE
- H_2 Economy TRM
- Oil Sand'sTRM
- Clean Coal TRM
- International TRM



Coordinating Networks

- Energy *i* Net
- CSLF
- CCP
- IEA
- IPCC

Conclusion

Ultimately, the Roadmap outcome is a resounding call for coordinated action today, to enable industries and government stakeholders to share a common vision and build the capacity for an economically competitive and environmentally sound energy future.