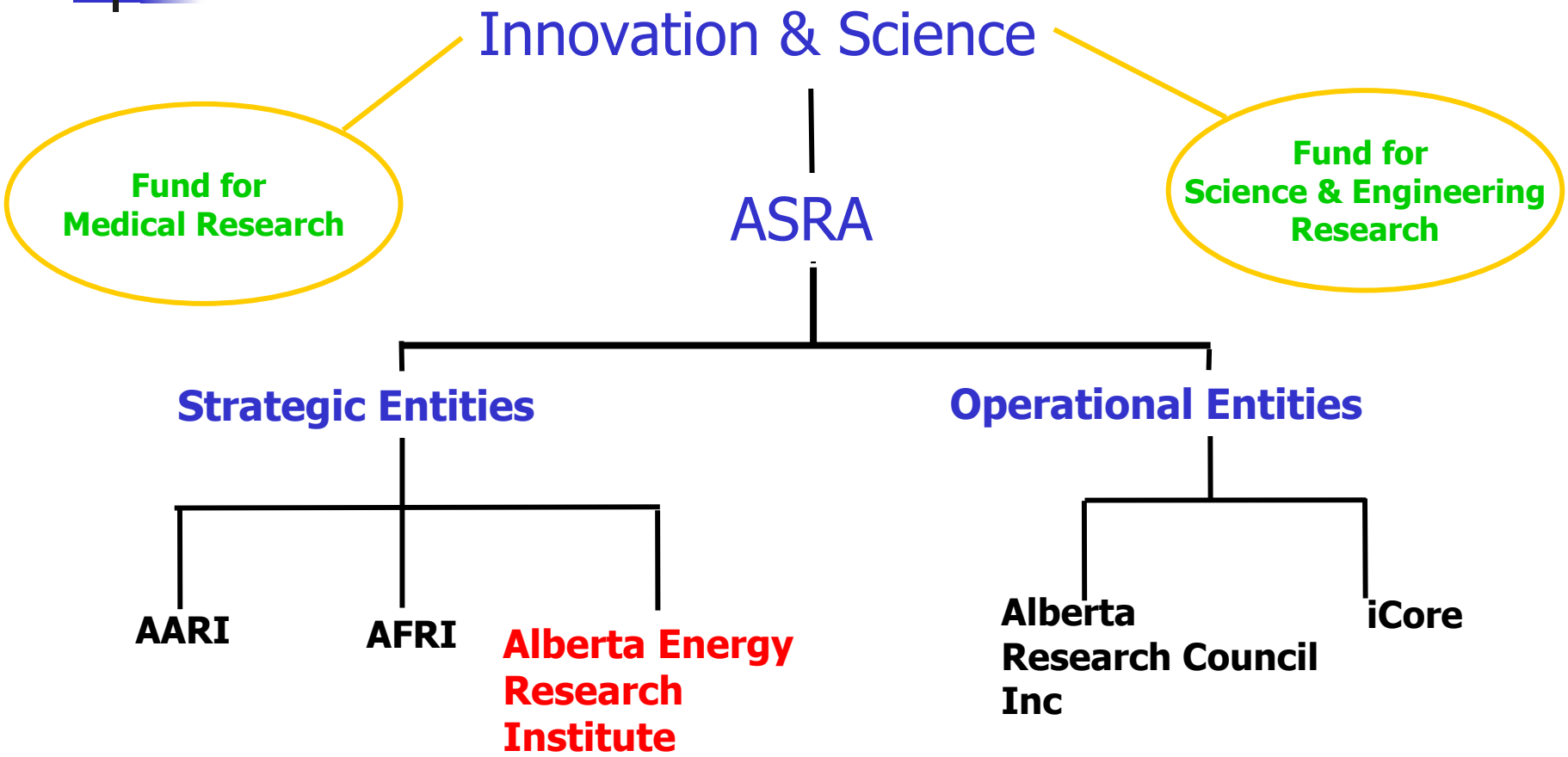
Update on Alberta Energy Research Strategy

Prepared for CONRAD NCC

September 18th, 2002

Eddy Isaacs

Ministry of Innovation & Science



Alberta Energy Research Institute (AERI)

Mission: Enhance the development of energy resources in the Province through research and technology.

Mandate: Position Alberta for the future in energy

Provide advice to the Government

Recommend science & research policy in energy

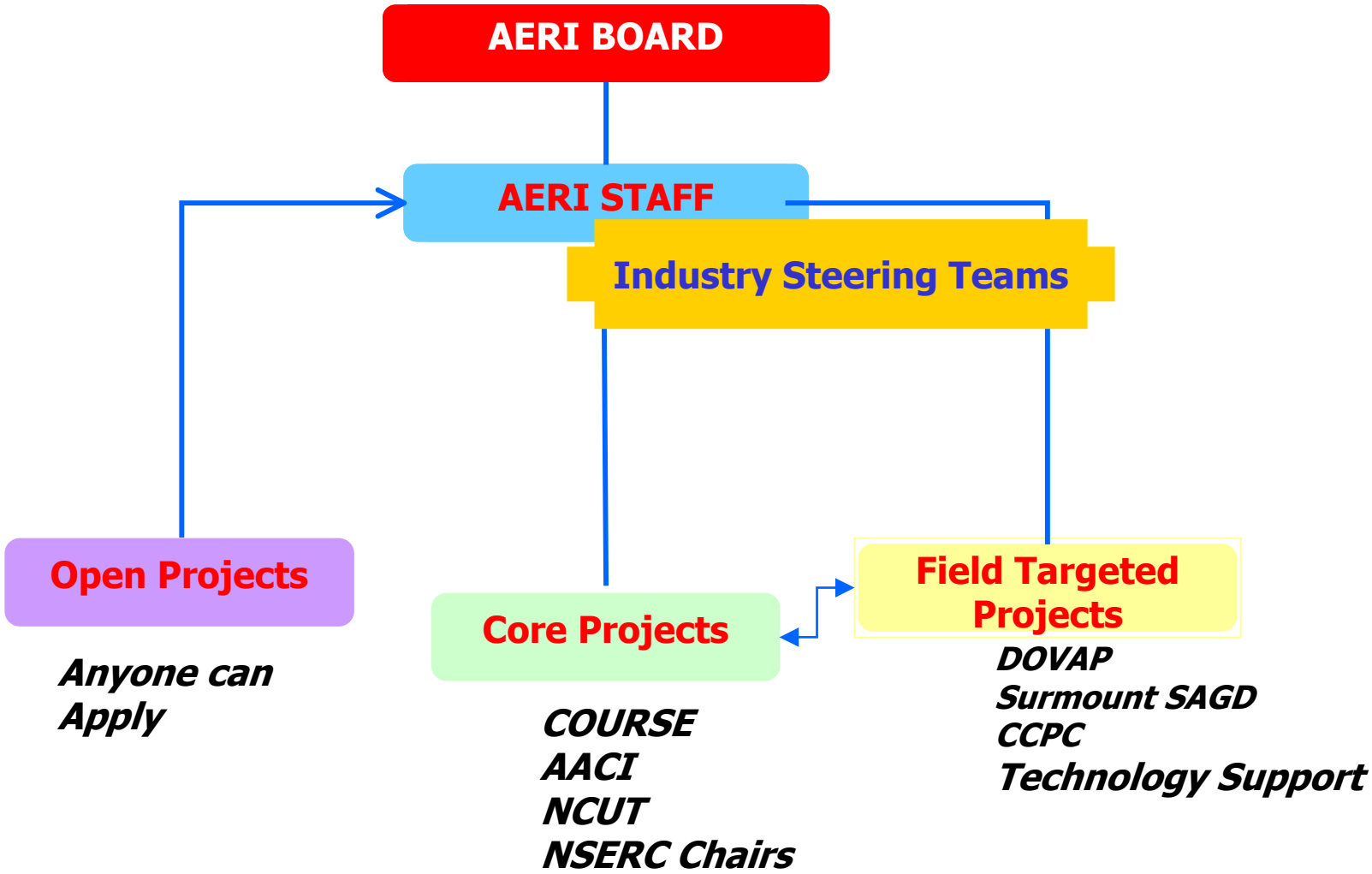
Strategic Intent: Stimulate R&D of new technology and assist the energy sector to play a dominant role in the new economy by:

- reducing the cost of development and increasing reserves
- developing value-added products and processes including alternate energy sources
- promoting environmental sustainability

AERI Board

- Board Co-Chairs:
  - Len Bolger & Denis Ducharme
- Board Members:
  - Dan Bader, Jim Dinning, John Donner, Paul Galachiuk, David Lynch, Robert Mansell, Bob Taylor, Murray Todd

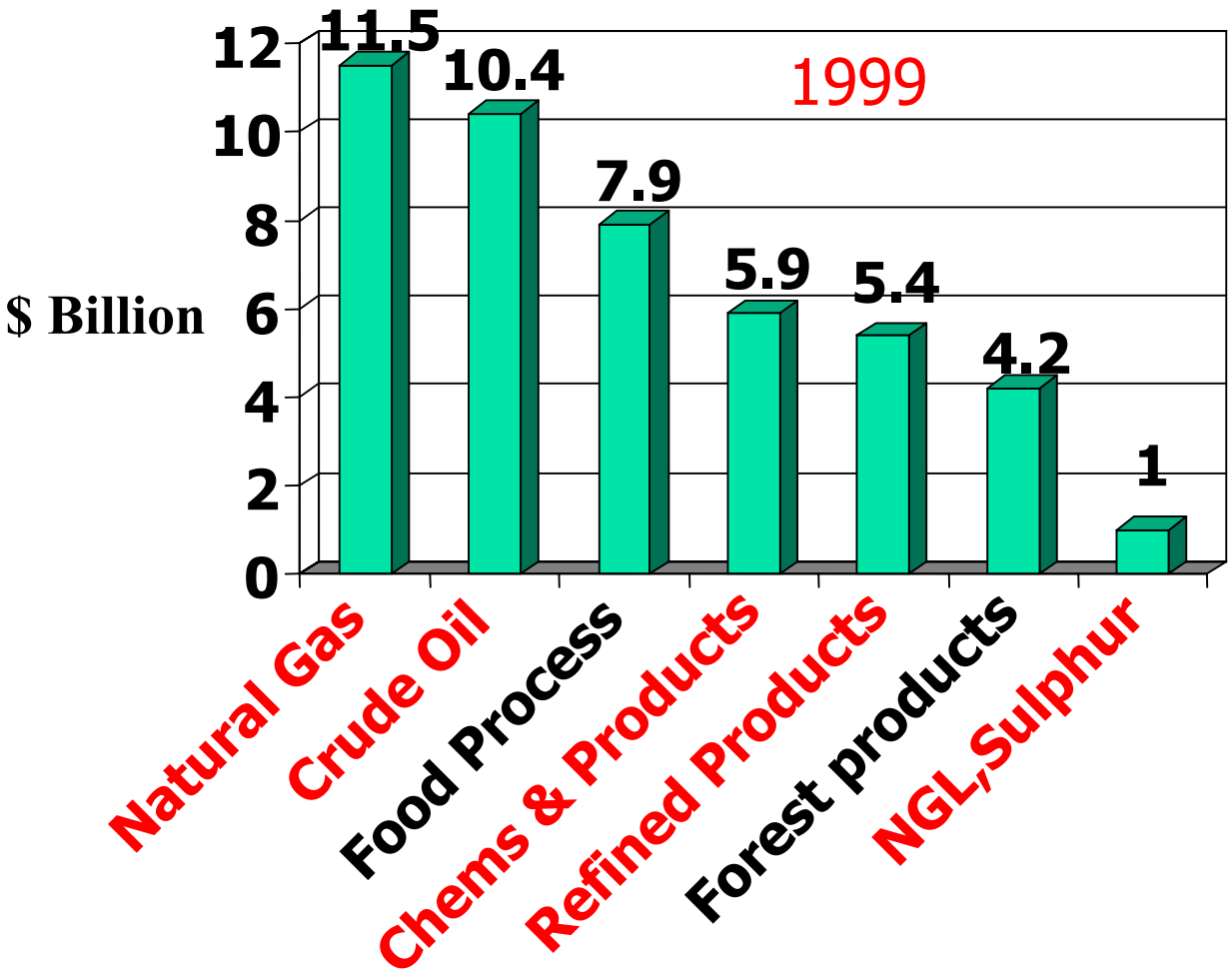
The AERI model to stimulate competitiveness



Current Major AERI Projects

- AERI/ARC Core Industry Research Program ($ 3 M/y)
- National Center for Upgrading Technology ($ 9 M/y)
- COURSE (University Energy Research Program) ($3 M/y)
- Dover VAPEX (DOVAP) Pilot ($30 M)
- Gulf Surmont Pilot ($25 M)
- Weyburn CO_2 EOR Monitoring Project ($20 M)
- Enhanced Coal Bed Methane ($4.7 M)
- Canadian Clean Power Coalition ($5 M phase 1)
- CANMET CO_2/O_2 Consortium
- North American CO_2 Test Center

Alberta Production & Manufacturing Exports



Energy Exports in 2000

Alberta

- **Natural gas - $17.4 b**
- **Crude oil - $16.2 b**

Canada

- **$55 b/year**
  (7% of GDP)

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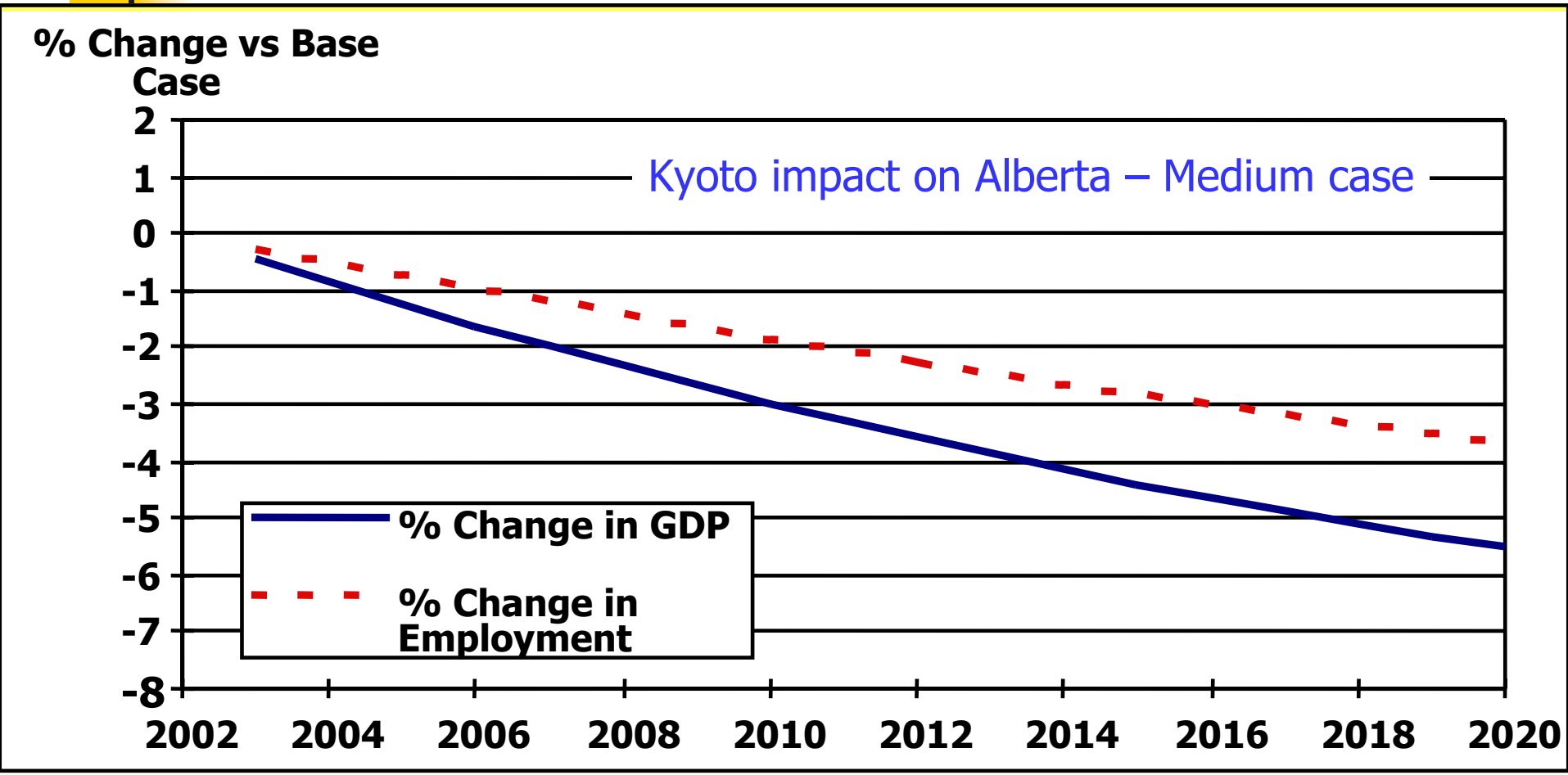
Today's resource revenue to the treasury is not guaranteed for the future

- Maturing Western Canadian Sedimentary Basin
  - Conventional crude production decline
  - Conventional natural gas production near peak
- Energy costs are rising
- Emission control costs high
  - SOx, NOx , PM, Hg, CO_2

Serious threats to Alberta's future resource revenue continued

- Volatile electricity and gas prices
- High gas prices and tight supplies threaten
  - Oil sands upgrading
  - Thermal recovery
  - Petrochemical manufacturing
- Bitumen and synthetic crude market limitations
- GHG emissions – additional business risks

Kyoto impact difficult to predict



Robert Mansell, ASRA Retreat on Energy R&D, June 2002

"The impacts of Kyoto on investment are almost certainly underestimated, particularly in the near term"

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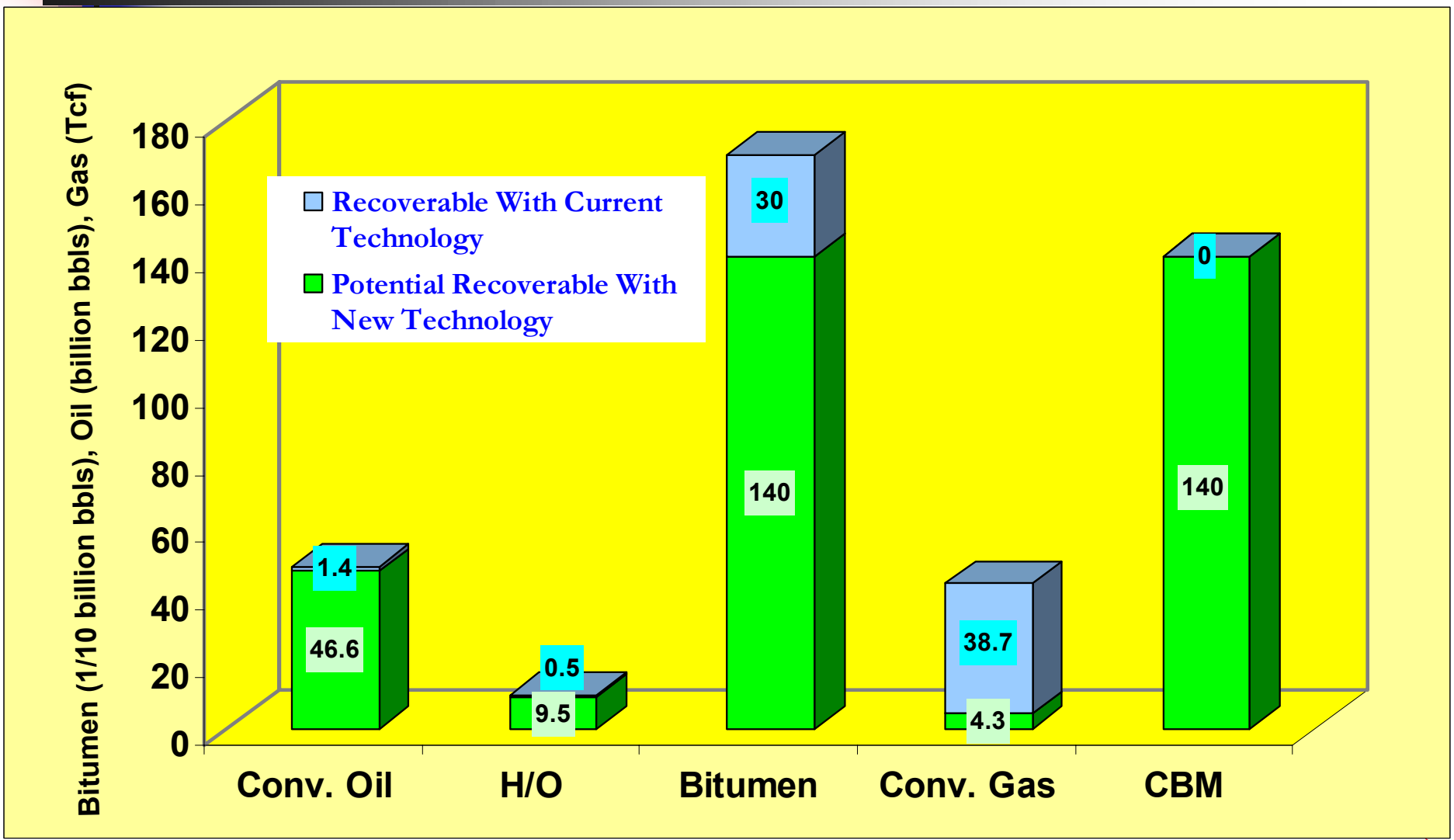
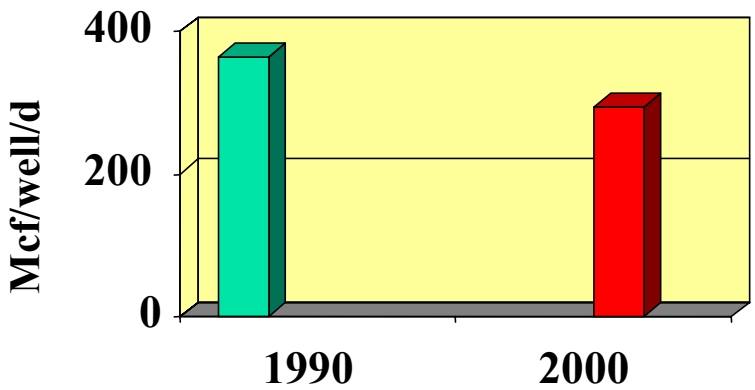
Alberta's Petroleum Outlook



AEUB Data (2001)

Alberta's Natural Gas: Status

- **Maturing (< 9 years)**
  - Reserves – 44.8 trillion cubic feet (TCF)
  - Production – 5 TCF/y
    - 73% exported
  - Wells drilled – 7,353 (2000)
- Declining well productivity



- **Technologies:** Well established; need new technologies for coal bed methane, deep and tight gas
- **Infrastructure:** 600 Gas plants & pipelines
- **Intellectual Capacity:** Top-of-the-Class but aging

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Natural Gas: Future

- Cradle to grave emissions will increase
  - Leaner, sourer gas, gas high in CO_2
- Costs will increase
  - More difficult extraction
  - Higher costs of gas processing
- Emissions similar to coal in the long-term
  - Federal "clean energy exports" jeopardy
- Long-term coal bed methane – 3 x more gas in CBM but potential unproven

Average Energy Intensity, GJ/m^3 of production	
Sweet Gas – 1.4	**Sour Gas – 2.2 (with flaring)** **Sour Gas – 3.7 (with sulfur recovery)**

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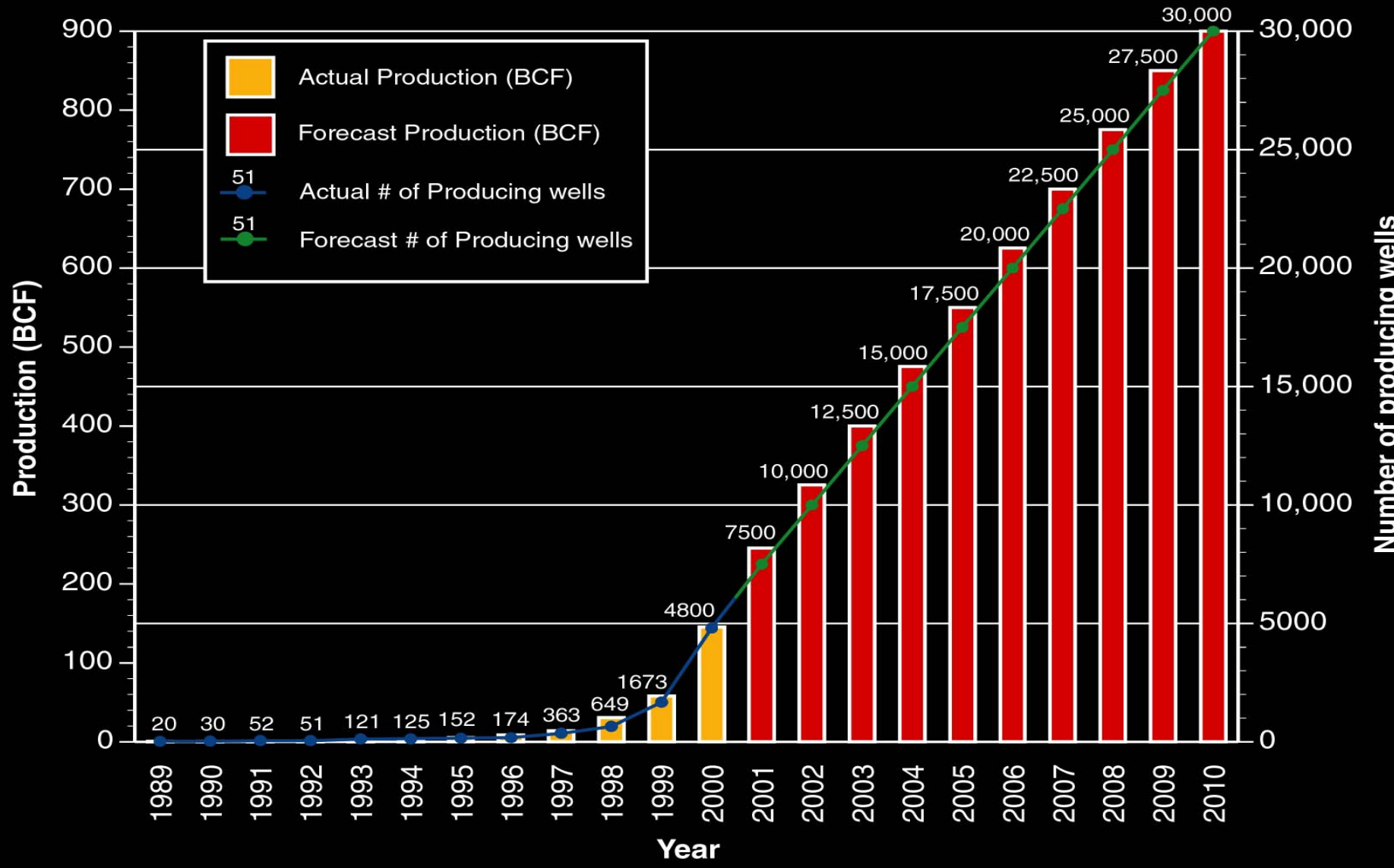

Yearly production and number of producing wells for coalbed methane in the Powder River Basin, Wyoming, 1989 through 2000, with forecasts to 2010.

The Probable Future (to 2020)

- **Natural Gas - Maintaining the supply**
  - **Natural gas from coal beds**
    - Characterization of unique Alberta coal beds for gas
    - Adapting and developing new production technologies for coal bed methane (CBM)
    - *In situ* gas separation
    - CBM produced water for agriculture use
  - **Carbon capture**
    - From oil sands, petrochemical, fertilizer plants and power plants for enhanced coal bed methane (ECBM)

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Alberta's Conventional Oil : Status

- **Maturing (< 8 years)**
  - Reserves – 2,079 million bbls
  - Production – 270 million bbls/y
    - 73% exported
  - Wells drilled (2000) – 3,198

- **Technologies:** New seismic, horizontal drilling indigenous and adapted
- **Infrastructure:** Refineries & pipelines; capital investment $12.9 billion/year (incl. Gas)
- **Intellectual Capacity:** Top-of-the-Class but aging

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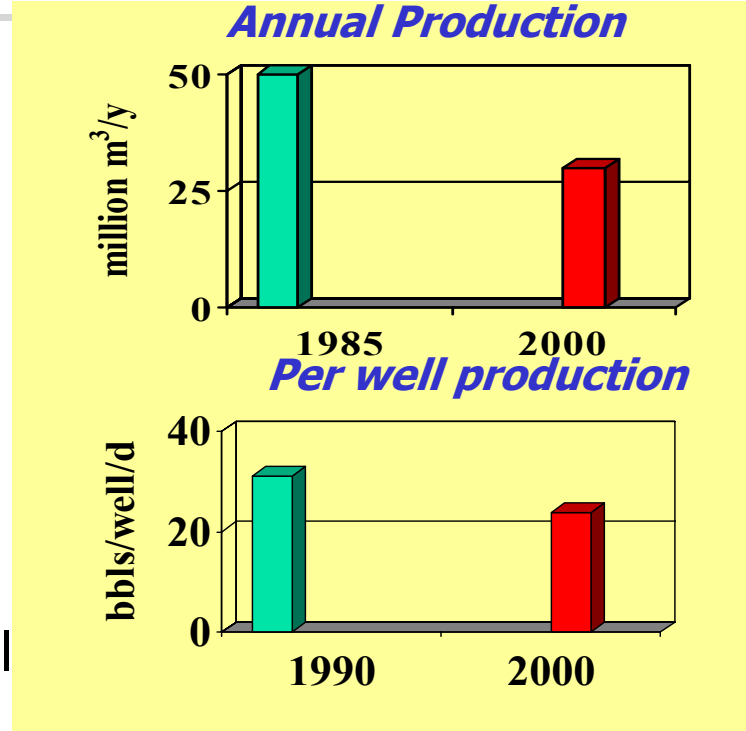
Conventional Oil: Future

- **Challenge**
  - Depleting Resource
    - Peak production – 1973
    - Extensive use of horizontal wells and infill drilling
  - Investments shifted to oil sands, offshore and international
- **Opportunity**
  - 70% still in the ground
  - Enhanced oil recovery (EOR) potential is high
  - Basin ideally suited for CO_2 storage

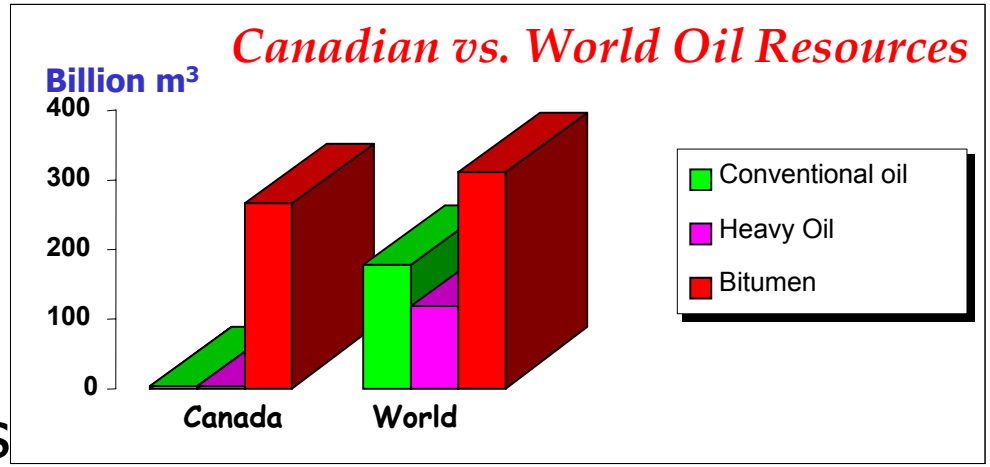


- **Technologies:** CO_2 EOR and other
- **Infrastructure:** Missing pipelines for CO_2
- **Intellectual Capacity:** Needs experience with EOR

The Probable Future (to 2020)

- **Conventional Oil - Maintaining the supply**
  - **Enhanced oil recovery (EOR)**
    - CO_2
    - Solvent
    - Advanced seismic
  - **Carbon capture**
    - Characterization of basin suitability
    - Monitoring and verification for storage of CO_2
    - Safety and reliability

Alberta's Oil Sands: Status



- **World's Largest Deposit**
  - Reserves – 6.8 billion bbls
  - Production – 0.222 billion bbls/year (85% exported)

- **Technologies:** World Class – Surface Mining, SAGD, VAPEX, Horizontal Drilling, Cold Production
- **Infrastructure:** $25 billion spent or committed; $60 billion proposed over next 7-10 years
- **Intellectual Capacity:** Unique, top-of-the-Class

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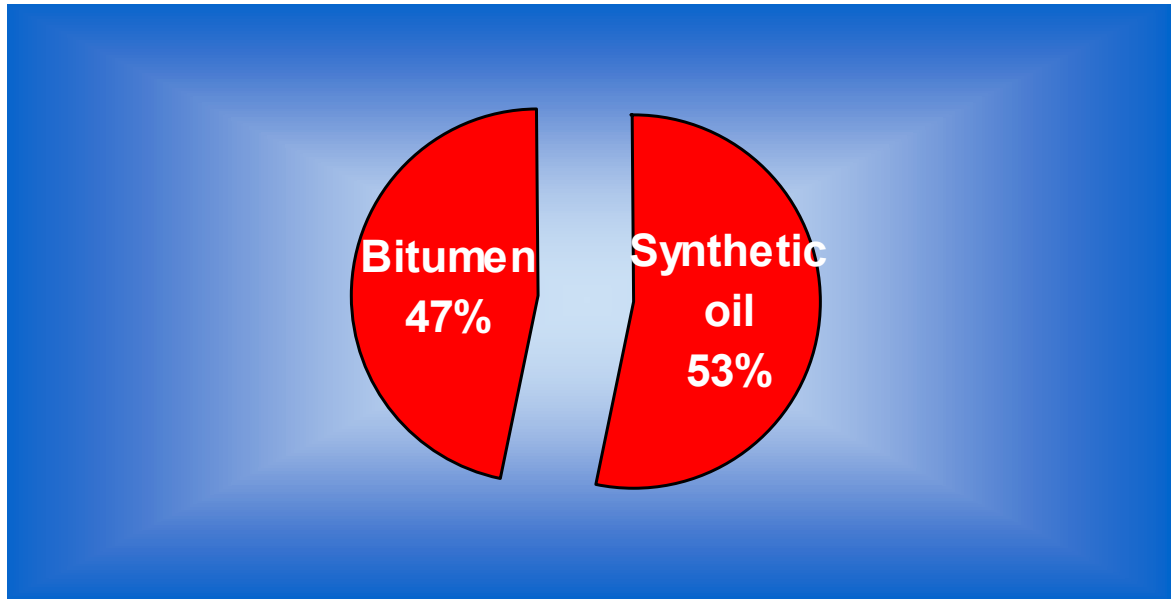
Oil Sands: Key Challenges

Estimated Gross Revenue Loss by Not Upgrading - $1.6 billion/year

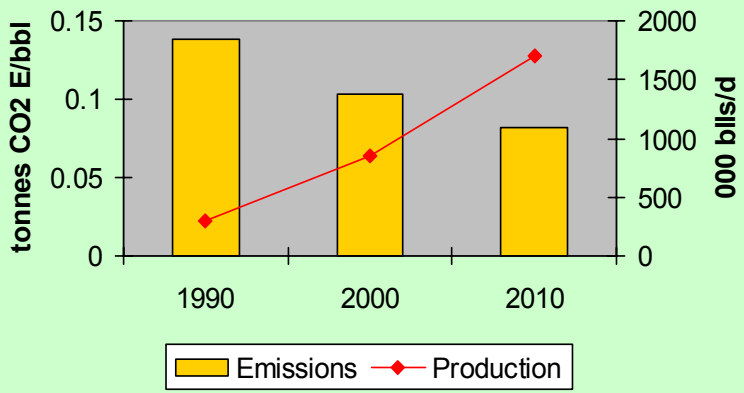


Kyoto Targets might stifle expansion plans

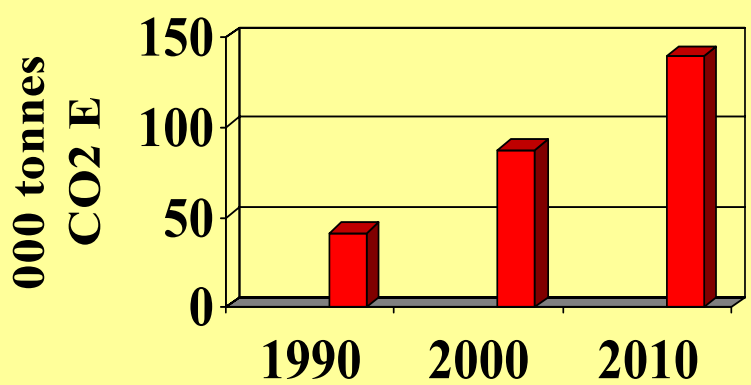
Oil Sands: Future

- Staggering capital costs – high risks
  - Major projects all experiencing cost overruns
- Synthetic crude and bitumen refinery limitations
- Heavily dependent on natural gas
  - Hydrogen production
  - Steam generation
- Water issues
- Energy intensity – GHG Emissions

Oil sands energy efficiency gains



Total emissions increase



The Probable Future (to 2020)

- **OIL SANDS – 3 x increase in production**
  - **Upgrading**
    - Customized synthetic products
    - Less intensity processes
  - **Recovery**
    - Lower temperature processes (e.g. VAPEX)
    - Water management
  - **Integrated operations**
    - Bitumen bottoms (with coal and biomass) feedstock for gasification providing hydrogen, power and steam
  - **Carbon capture**
    - From hydrogen plants for enhanced recovery operations

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Alberta's Coal: Status

- **Source: Unlimited**
  - Ultimate Potential: 620 billion tonnes
  - Production (2000): 0.035 billion tonnes

- **Alberta's coal reserves**
  - **70% of Canada's**
  - **50% of coal produced in Canada**
  - **2x the energy of all other natural resources (oil sands, oil and natural gas)**
  - **7 Major mines**
    - **80% electricity generation**
      - **Sub-bituminous (low S, clean burning)**
    - **20% exported – valued at $380 million**
      - **Metallurgical**

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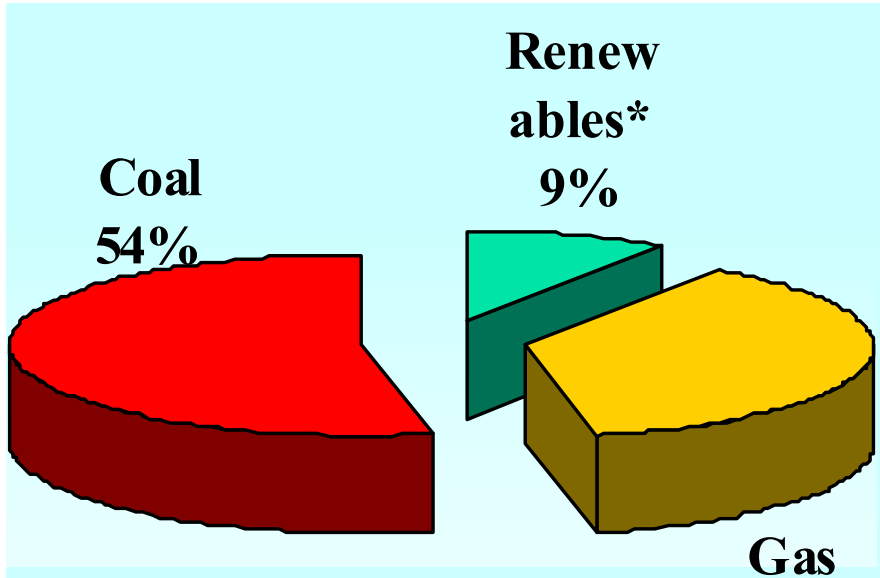
Coal: Challenge

- In a "carbon constrained world" - coal most vulnerable
  - 25% of Alberta's emission
  - High cost of CO_2 capture in existing coal plants
- Emission control costs high
  - SOx, NOx , PM, Hg
- Technology threats
  - Distributed generation cost reductions



*Includes hydro, wind and biomass

Total Installed = 10,640 MW
(year end 2001 data)

DOE Web site May 2002

The Probable Future (to 2020)

- **COAL – Technology Evolution**
  - Advanced emissions control, efficiency improvements, and waste utilization
  - Existing coal plants retrofitted with integrated gas combined cycle (IGCC) or Pressurized Fluidized Bed Combustion
  - IGCC plants flexible feed and multi-products
  - Anaerobic hydro-gasification technology (ZECA concept)
  - Synthesis gas (coal gas) direct to fuel cell → high efficiency
  - Near zero emission power plant

Alberta niche -

- adapt and demonstrate unique Alberta opportunities
  - integrate with oil sands
  - integrate with petrochemicals
  - utilize CO_2
  - coal to fuel cells
- **Pay-to-play**

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CO_2 Management

- **Alberta CO_2 Source Inventory**
  - Currently available (7260 tonnes/d equivalent to 15,000 bbls EOR project)
    - Fertilizer plants, gas plants, petrochemical facilities, ethane processing
    - Purity (30 to 99%)
  - Market dependent (54,000 tonnes/d)
    - + hydrogen plants, gas pipelines, power plants
- **Potential CO2 Markets**
  - Enhanced oil recovery
  - Enhanced coalbed methane
  - Hydrocarbon solvent recovery
  - Gas-over-bitumen

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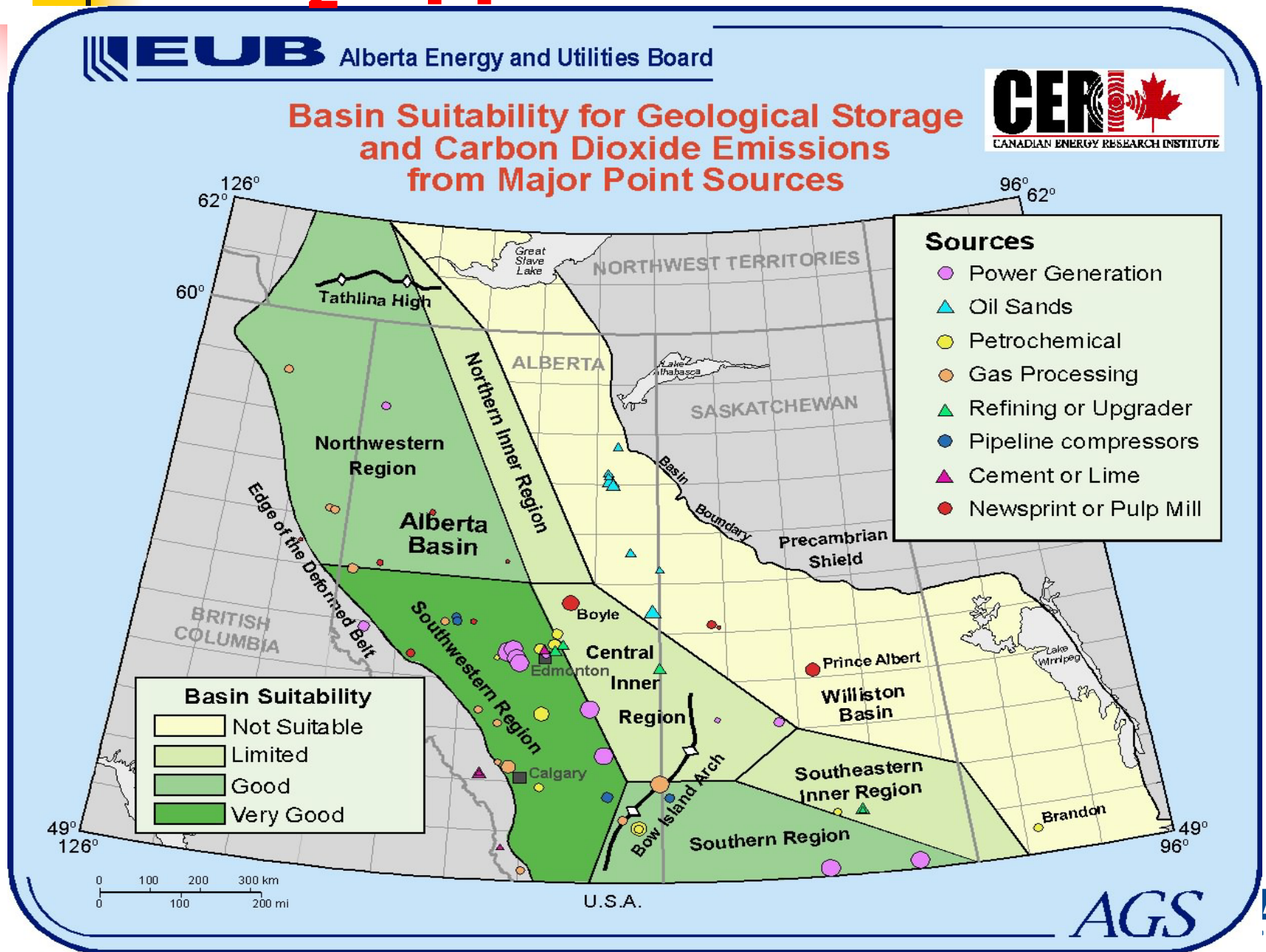
CO_2 Opportunities



Hydrogen: Challenge

- **Source:** Alberta is the world's largest repository of hydrocarbon-based Hydrogen
- **Technologies**: Steam reforming of natural gas; coal gasification. Need storage & distribution and fuel cell technologies
- **Infrastructure:** Minimal; need to develop new technologies & build infrastructure
- **Intellectual Capacity:** Minimal but Growing

The Probable Future (to 2020)

- **Hydrogen: Fuel of the Future**
  - Hydrogen storage
  - Efficiency of hydrogen production
  - Fuel cells designed to use excess hydrogen supply
    - Edmonton refinery hub
    - Fort Saskatchewan hub
    - Red Deer petrochemical hub
  - Demonstration of "Green Corridor" concept

Biofuels: Challenge

- **Source:**
  - Agriculture waste
- bio-mass (wood waste)
  - wheat, barely, corn, canola oil
- **Technologies** (Renewable and clean)
  - ethanol
  - bio-diesel additive to diesel
- **Infrastructure:** Minimal
- **Intellectual Capacity:** Minimal

Life-cycle analysis – greenhouse gas reduction dependent on feedstock

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Alberta's Energy Resources

- Natural Gas
- Conventional Oil
- Oil Sands
- Heavy Oil
- Coal
- Coal Bed Methane
- CO2
- H2S
- biomass

Leading us to a C, H, N and S strategy

From oil, gas, coal & power

To Multi-product pollution-free energy

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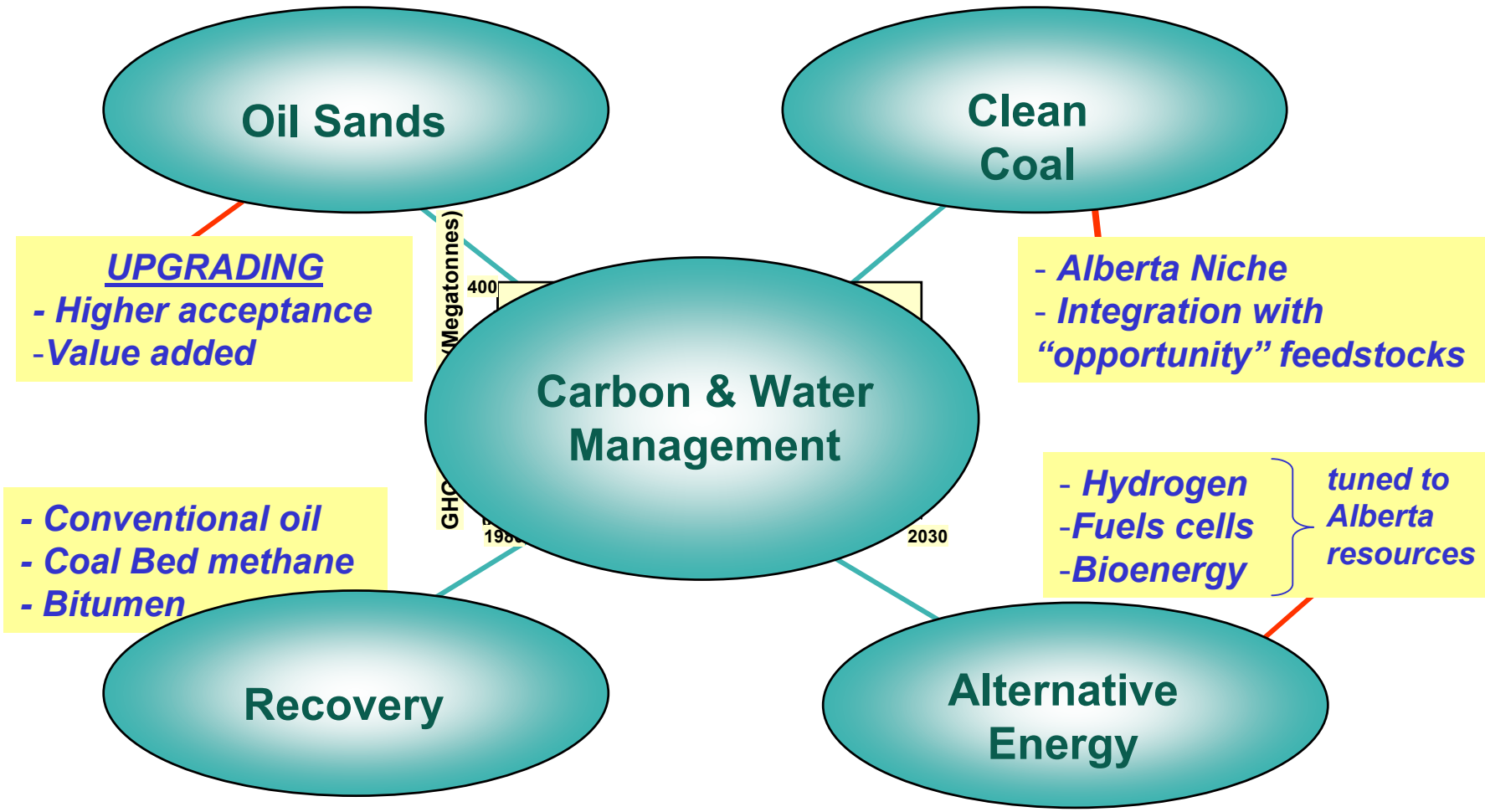
AERI's Strategic Business Plan

- Outline
- The Urgency
- The Intent
- The Vision
- The Mission
- The Role
- The Strategic Plan
- The Process
- The Prize

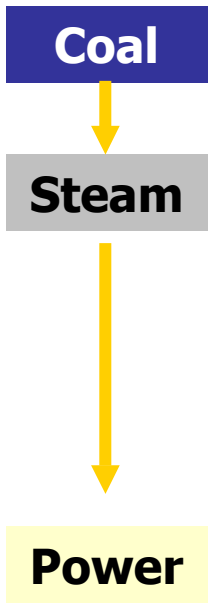
www. AERI.ab.ca

The priority areas



Example of what we mean by an integration strategy

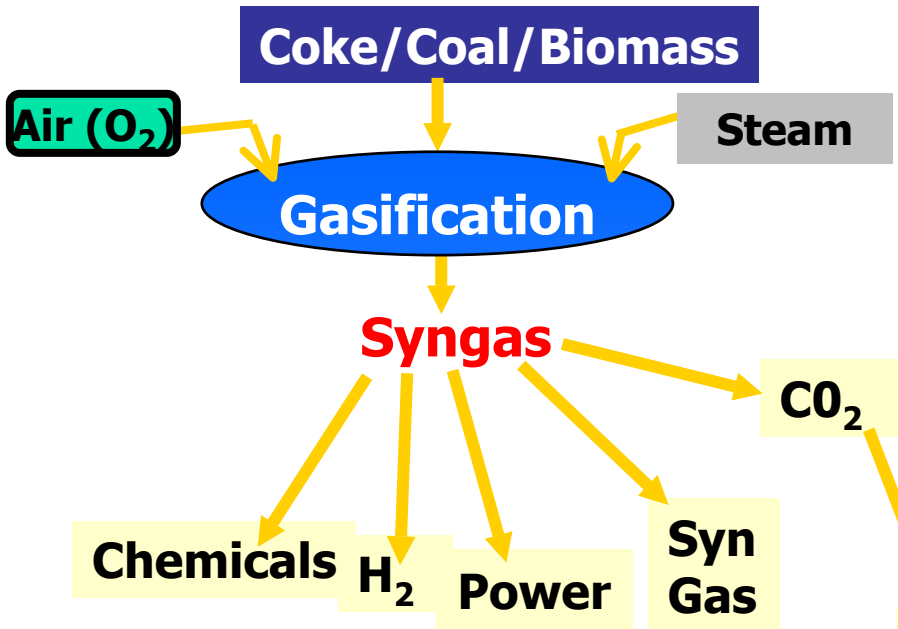
Traditional Coal Stovepipe



40% efficient, NOx, SOx, GHG, PM

Reducing emissions is largely uneconomic

Multi Fuel / Multi Product = Flexibility & Commercial Viability



55% efficient, ~~NOx, SOx, GHG~~, PM

Integral emissions control & favorable economics at healthy natural gases prices

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Concept Moving Forward

- R&D focused on resources and niche Alberta opportunities
- An eye on the future – bridging from hydrocarbon to hydrogen economy
- Forward and integrated thinking on technology innovation, knowledge and environment
- Industry leadership is crucial

Investments in energy research?

- 1% of average royalties = $55 million per annum

Concept Moving Forward

- Energy Research Strategy endorsed by ASRA and the Alberta Government
  - Technology component of Alberta's Climate Change Plan
  - Basis of "Alberta's sustainable energy economy"
- Building to a significant investment over 20 years
  - 1/3 Federal, 1/3 Industry and 1/3 Alberta

- CONRAD NCC can help!