The Role of EOR in CO_2 Capture and Storage Lessons and Opportunities

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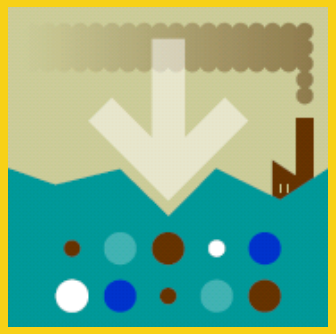

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Resources: Our use of the term "resources" in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves or SEC proven mining reserves. Resources are consistent with the Society of Petroleum Engineers 2P and 2C definitions.

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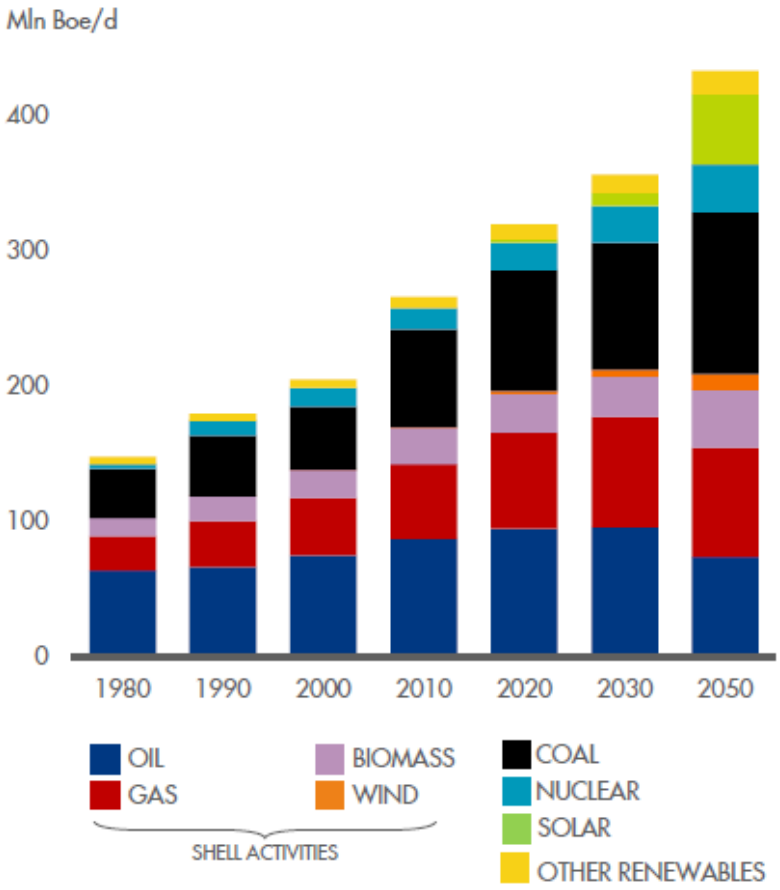
ENERGY OUTLOOK

GLOBAL ENERGY MIX



SHELL ESTIMATES

SHELL STRATEGY

1. Upstream
2. Downstream
3. Climate change
   - CCS and energy efficiency
   - Grow gas and biofuels
4. Financial

SHELL'S RESPONSE TO THE CO_2 CHALLENGE

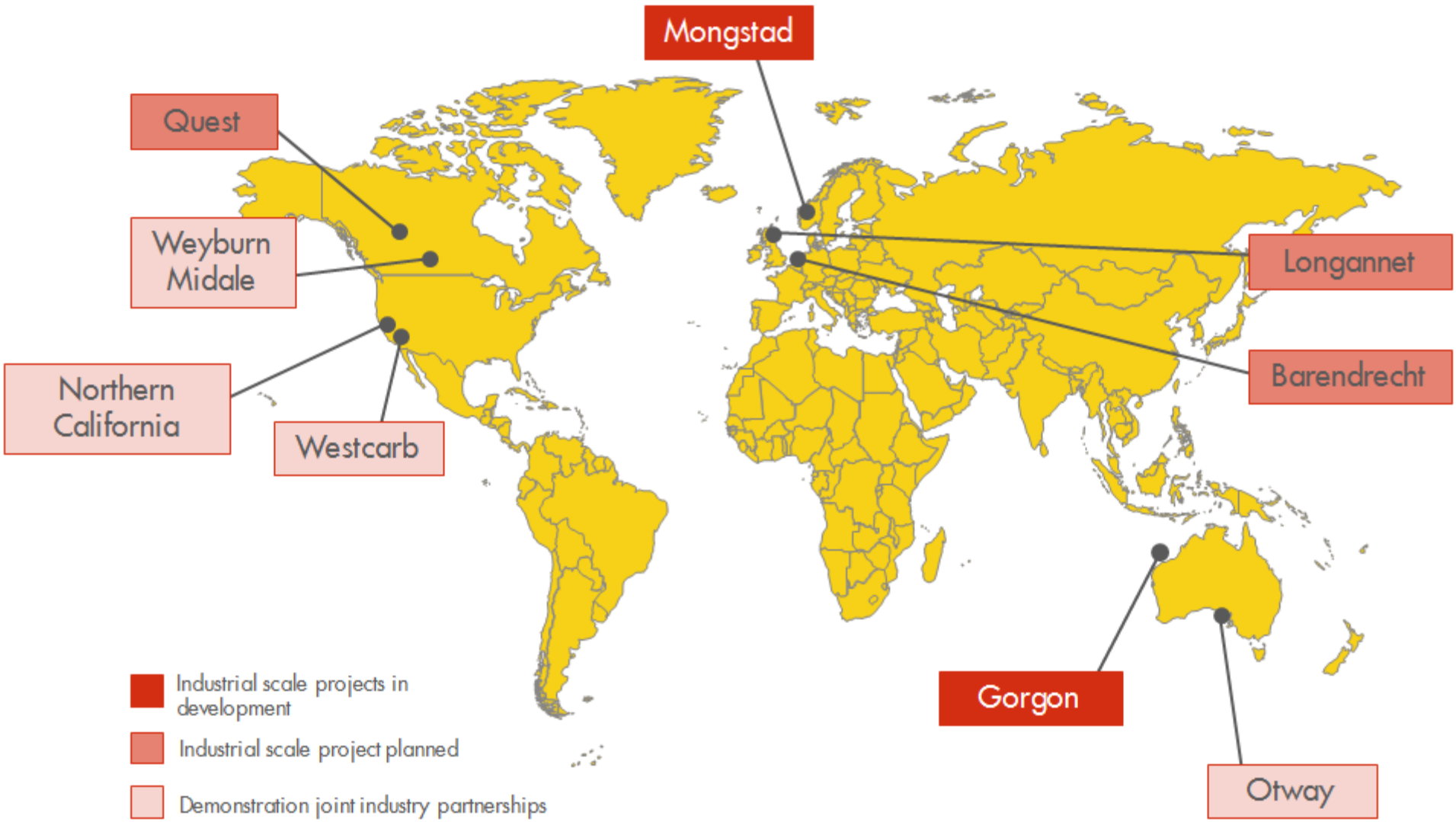
Supplying More Natural Gas

Supplying More Biofuels

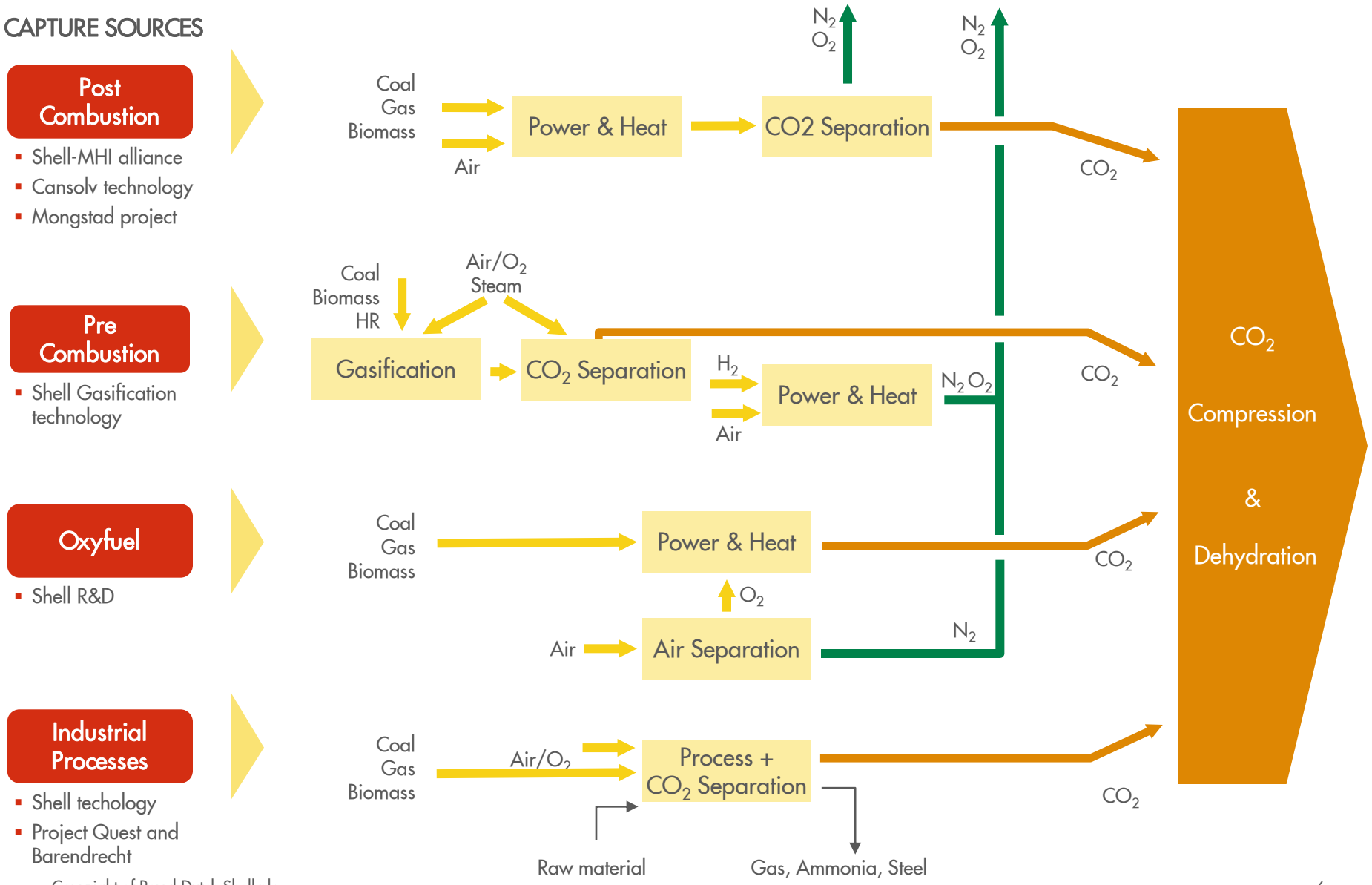
Progressing CCS

Energy Efficiency In Our Operations and in Helping Others

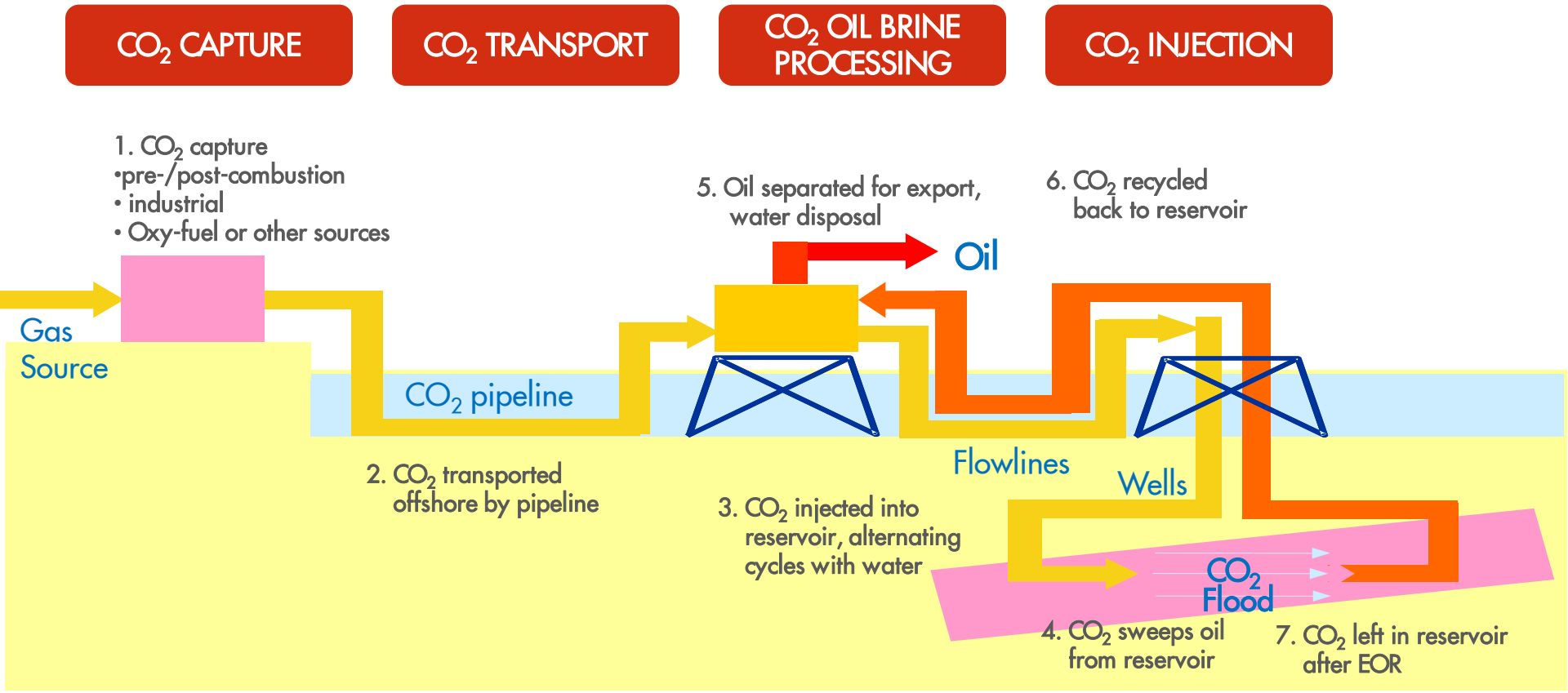
SHELL DEVELOPING CCS TECHNOLOGIES FOR THE FUTURE



SHELL INVESTING IN THE CARBON CAPTURE VALUE CHAIN



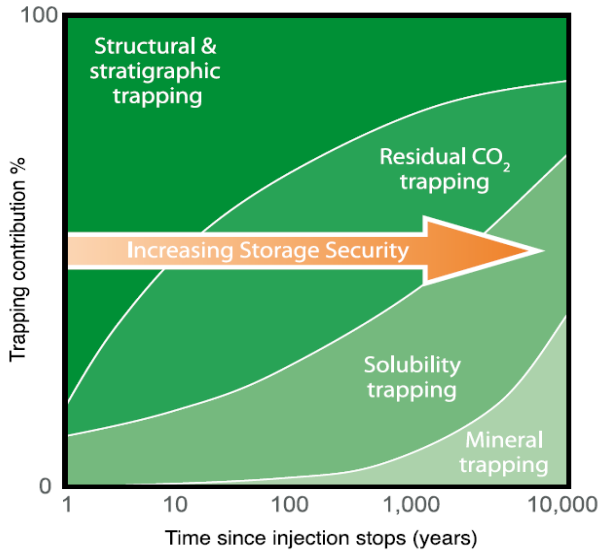
CO_2 EOR STORAGE, HOW IT WORKS



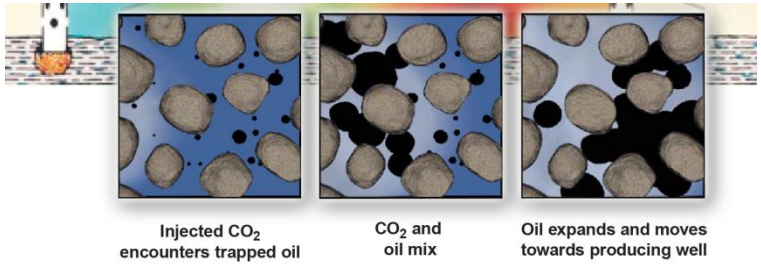
- Large investment typically required for CO_2 EOR projects
- Complex with specialized capabilities needed

CO_2 EOR STORAGE, HOW IS DIFFERENT FROM CCS

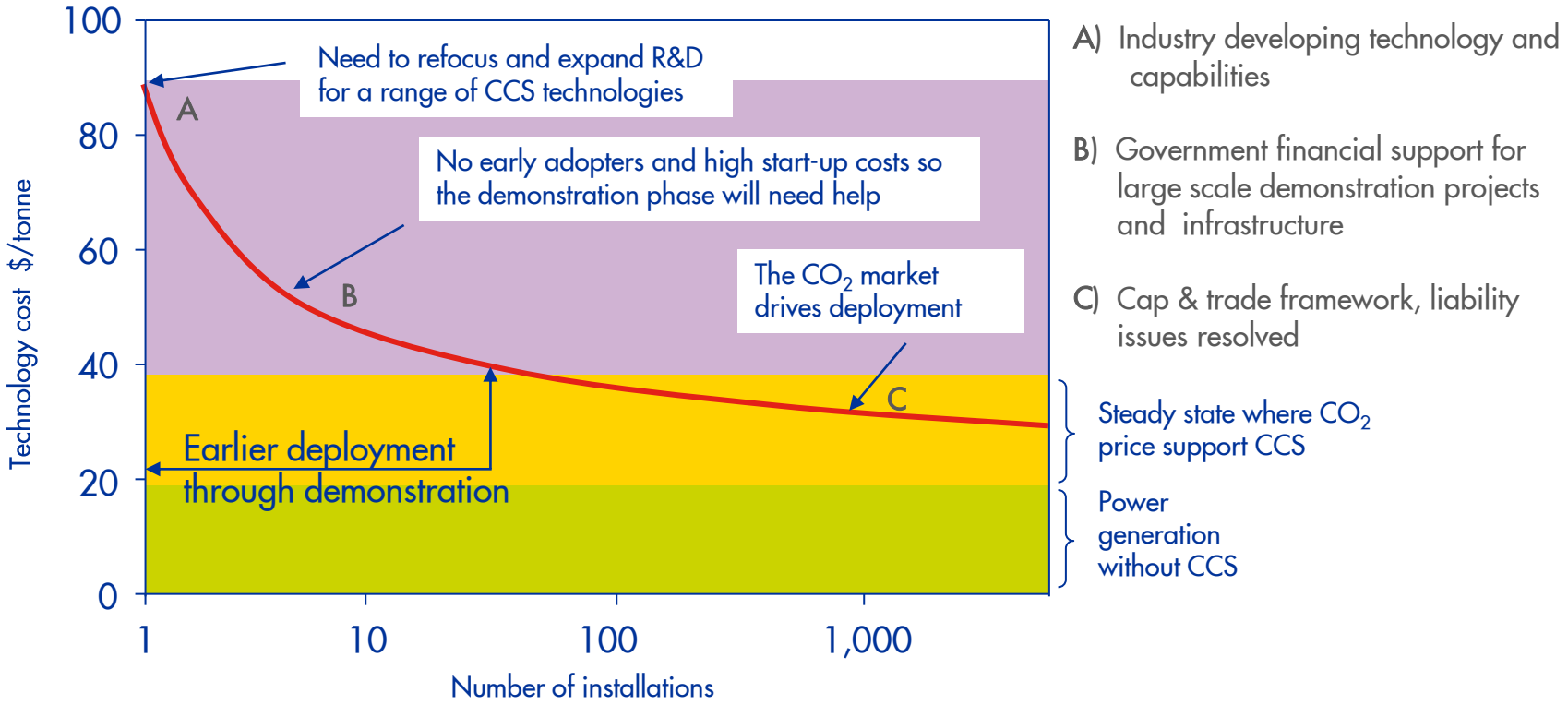
- After injection stops in CCS aquifer storage, most CO_2 is trapped structurally or stratigraphically, but is still a mobile phase
- CO_2 progressively becomes locally immobilized through residual, solubility and mineral trapping



- During the EOR operation some CO_2 is trapped by capillarity – residual trapping and dissolution. Therefore, more or less contained.
- After injection stops in conventional WAG EOR project, most CO_2 left in reservoir is already present as an immobile trapped saturation or dissolved in brine
- Much reduced scope for lateral or vertical migration



BRIDGE COMMERCIAL GAP TO MARKET DRIVEN CCS



- Capital costs for new CCS technologies will drop with repetition, economy of scale and infrastructure planning
- EOR projects can help enable early capture demonstrators
- Government support will be required to close the commercial gap for earlier deployment projects

EXAMPLE OF ACTIVE GOVERNMNET SUPPORT: Alberta

- Canada's investment in CCS demo projects (>11MTpa)
  - $3bln in public funding
  - $7bln total investment
- CO_2 is sourced from different locations, transported by pipelines to suitable oil or gas reservoirs for EOR
- After the depletion of the reservoir, the CO_2 remains permanently stored in the depleted field.
- 4800 oil pools are technically suitable. 110 pools have > 1MT CO_2 capacity. 988 MT CO_2 stored *(Bachu, 2004)*

- Alberta Carbon Trunk Line an analog for a transnational Middle East CO_2 infrastructure

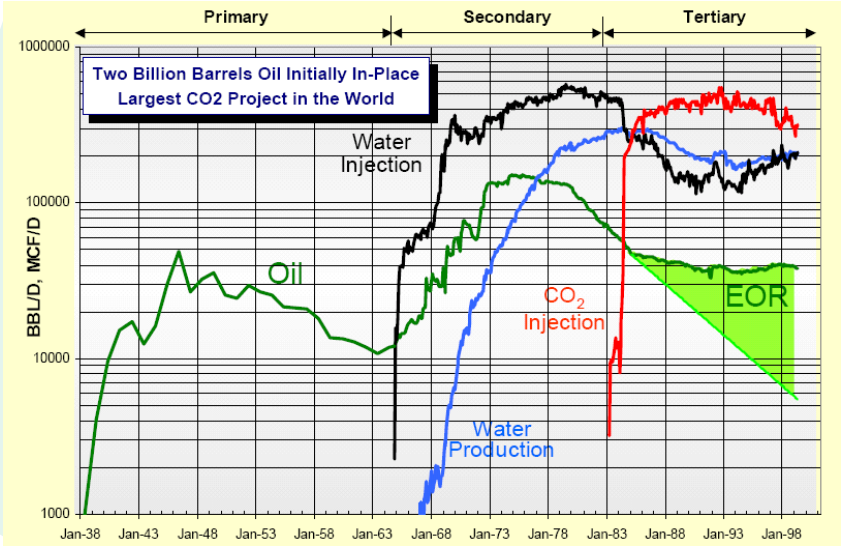
CO_2–EOR TAKING A GAME WE KNOW INTO THE FUTURE

SHELL INTO THE FUTURE OF CO_2 EOR

- Proven Technology
  - 30+ years experience
- Difference for the Future
  - Anthropogenic CO_2
  - Carbon Capture and Storage alternatives
- Next Wave Integration
  - Source-Sink frameworks
  - Cost reductions
  - Recovery improvements

DENVER UNIT CO_2 PROJECT

- Developed by Shell
- Largest CO_2 project in the world
  - more than 400 MMscf/d sustained CO_2 injection in >100 patterns
  - over 200 MMscf/d gas processing/recycling on site
  - surveillance and management of CO_2 EOR in various areas



CO_2 - EOR CAN'T PAY FOR CCS BUT HAVE ADVANTAGES

CO_2 EOR (Pros ▲ / Cons ▼)

- ▲ Cost and revenue
- ▼ CO_2 injection (WAG) > oil and CO_2 production > recycling
- ▲ CO_2 highly soluble in oil and brine
- ▲ Trapping mechanism proven
- ▲ Pressure maintenance
- ▲ No public un-acceptance
- ▲ Historic framework for permitting and monitoring (reservoir surveillance)
- ▲ Immobile nature of CO_2 after EOR projects should reduce the need for long term MMV
- ▼ Many wells
  oil fields have significantly more potential leak paths from abandoned E&A wells and production wells, which may not have been abandoned with CO_2 storage in mind
- ▼ Conventional EOR projects are optimized to maximize oil recovery and minimize CO_2 usage

CCS (Pros ▲ / Cons ▼)

- ▼ Cost only
- ▲ CO_2 injection
- ▼ Weak CO_2 dissolution in brine
- ▼ Assumed trapping
- ▼ Extensive areas of pressure increase in target reservoir
- ▼ Poor public acceptance
- ▼ Strict regulatory requirements for permitting and monitoring
- ▼ Significant uncertainty on who should be responsible for long-term liability for pure CCS (requirement for MMV)
- ▲ Few wells

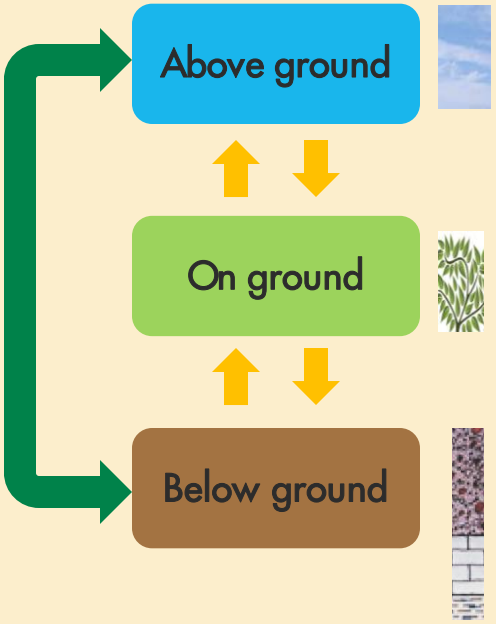
CCS – REQUIREMENT TO ACCELERATE DEPLOYMENT

- ▶ Close commercial gap for early CCS projects
- ▶ Enable deployment of CCS in emerging economies
- ▶ Progress CCS regulatory framework to implementation
- ▶ Achieve Public awareness and support for CCS
- ▶ Build on proven CO_2-EOR industry where possible
- ▶ Assess available pore space, develop CO_2 transport/hubs
- ▶ Global knowledge sharing to maximize learning from early projects

IT'S ALL ABOUT THE BALANCE…

MATERIAL BALANCE

CARBON ROUTES



FINANCIAL BALANCE

REVENUE
- Oil / gas
- CDM
- Public fund

-

COSTS
- Capture
- Transportation
- Processing
- Storage

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BALANCE > 0
- To be determined by market forces

STAKEHOLDERS BALANCE

Regulator

Public

Industry

- Make carbon tradable leads to efficiency
- Shell believes that a market-based approach is most appropriate to achieve a credible and sustainable CO_2 price

Q&A