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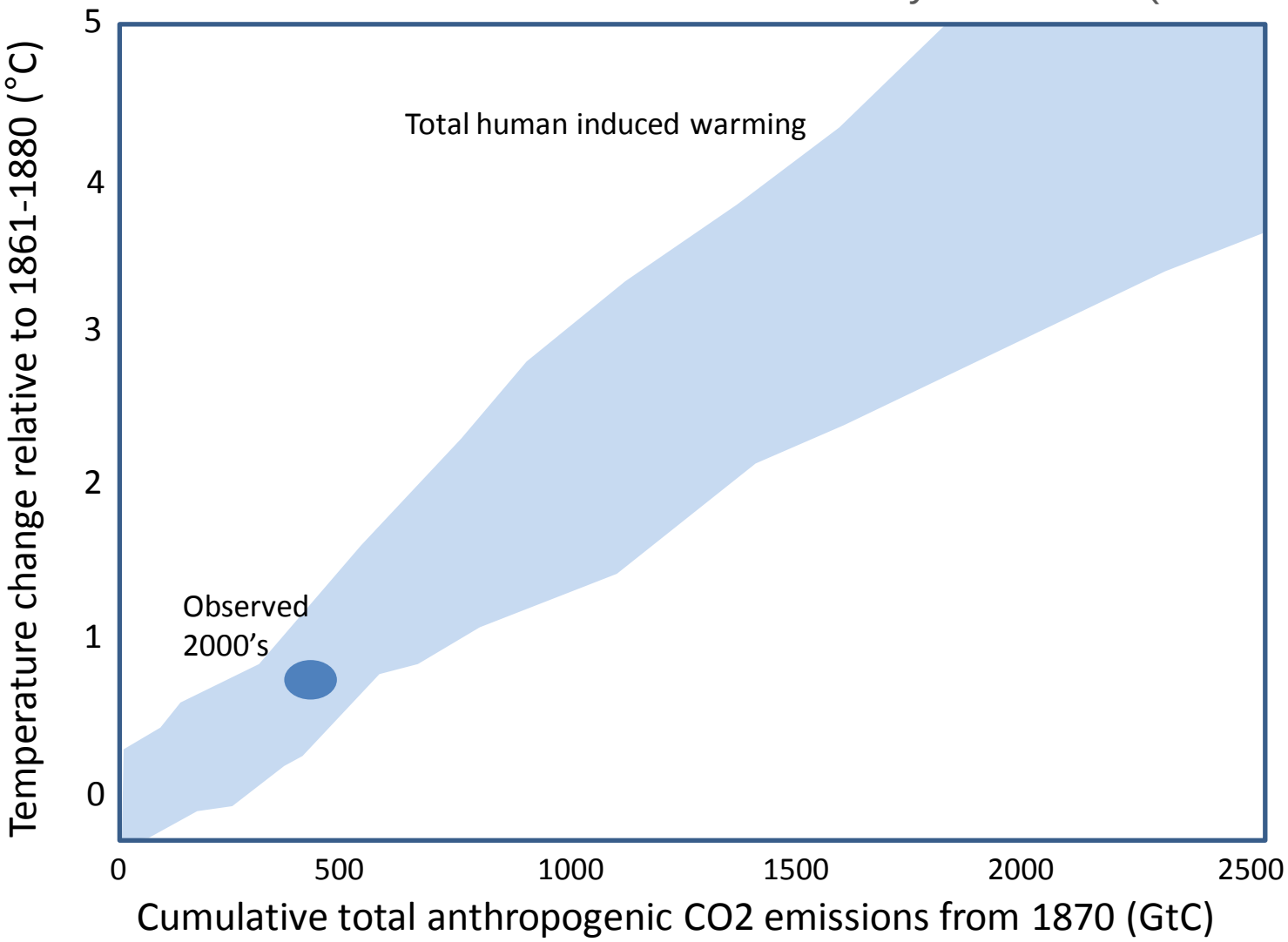
Temperature rise is driven by cumulative carbon (but with considerable uncertainty)

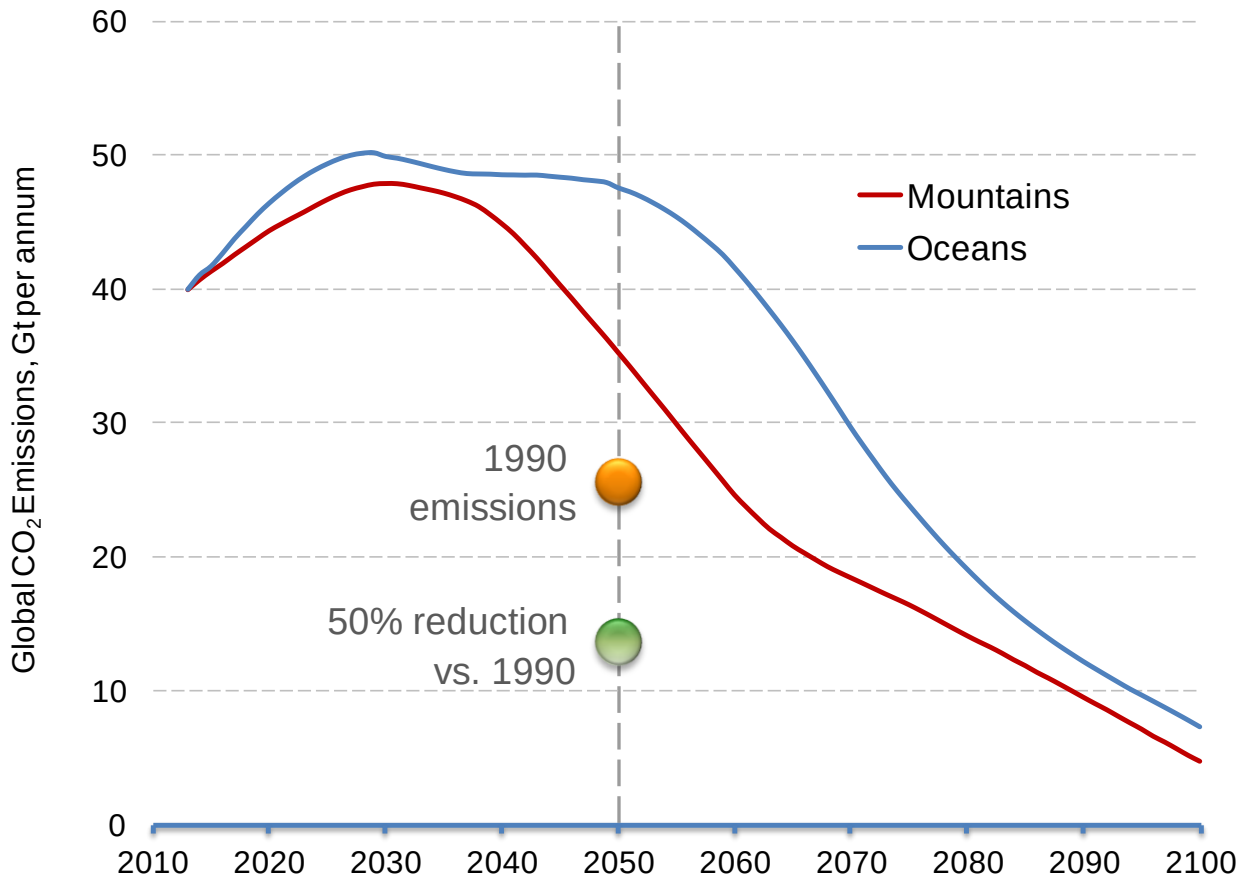
Need to avoid the trillionth tonne of carbon to stay below 2°C (50% chance) . . .



Source: Adapted from IPCC 5th Assessment Report

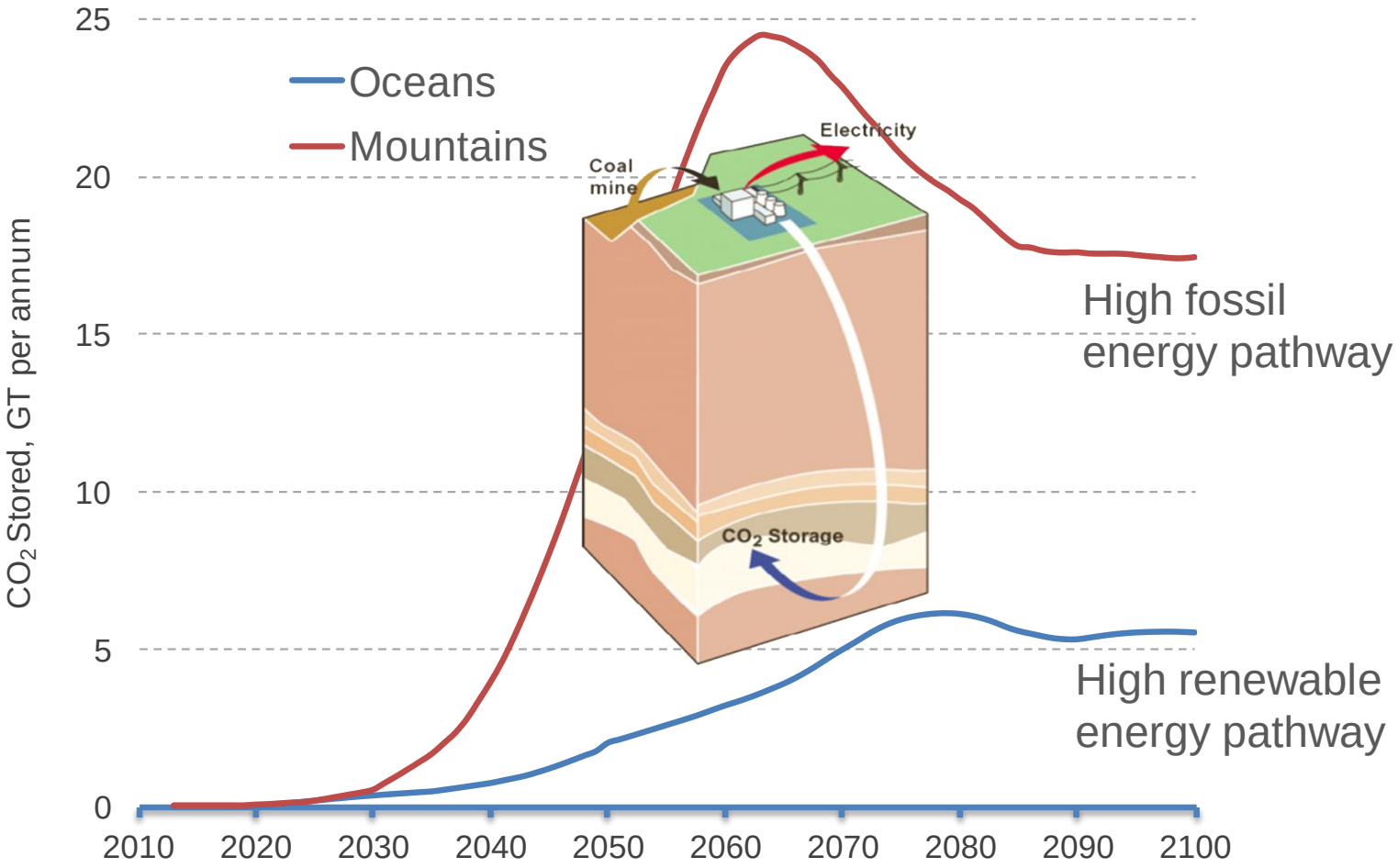
Shell scenarios show that cumulative carbon can be managed within this century

2°C is an elusive goal, but both scenarios see emissions head to net-zero within this century, i.e. cumulative carbon managed.



Source: Shell New Lens Scenarios

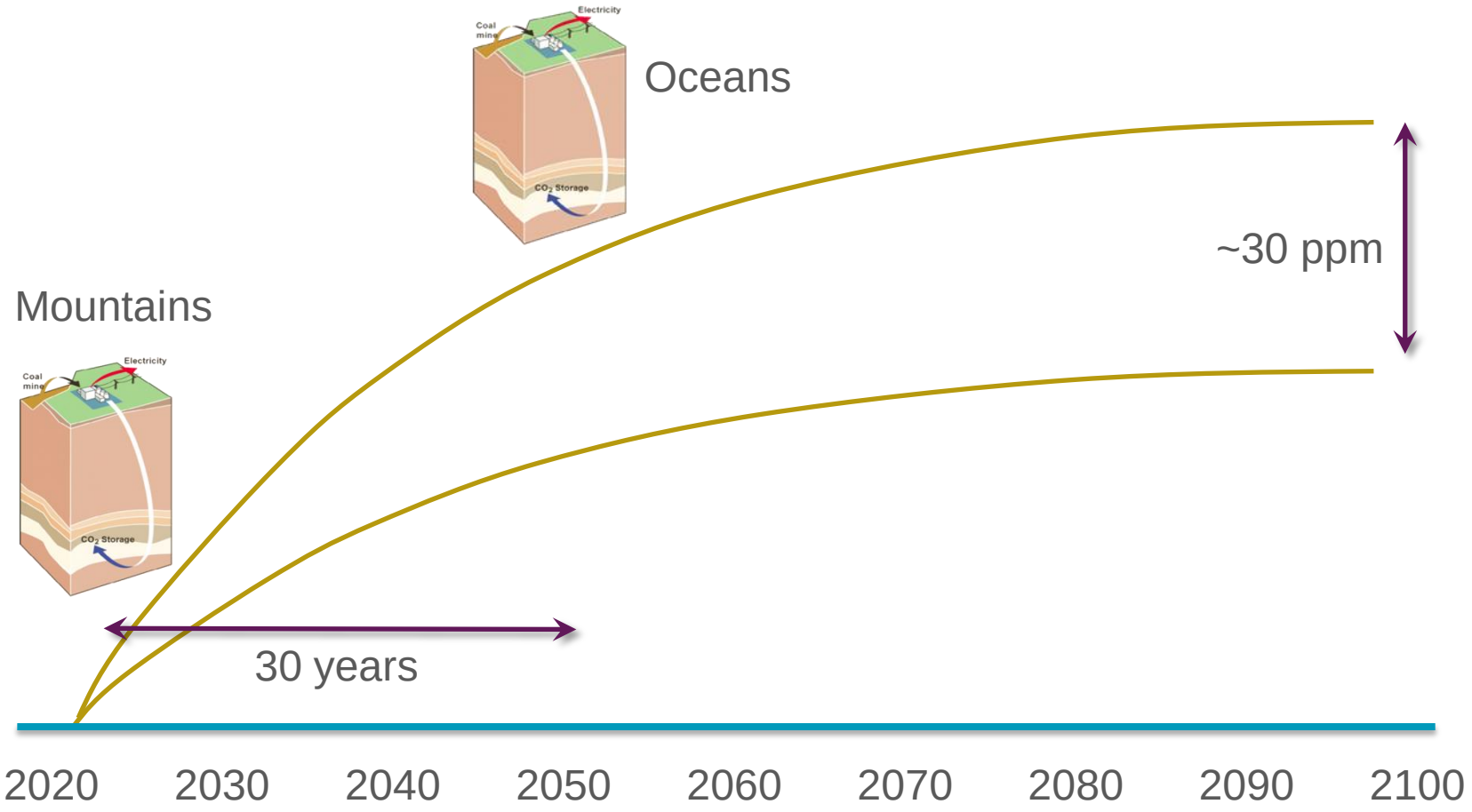
CCS must be deployed on a very large scale, irrespective of the energy pathway



Source: Shell New Lens Scenarios

A key lesson from the scenarios . . . . . .

Every year we delay the large scale rollout of CCS we commit to another ~1 ppm in long term CO_2 stabilization.

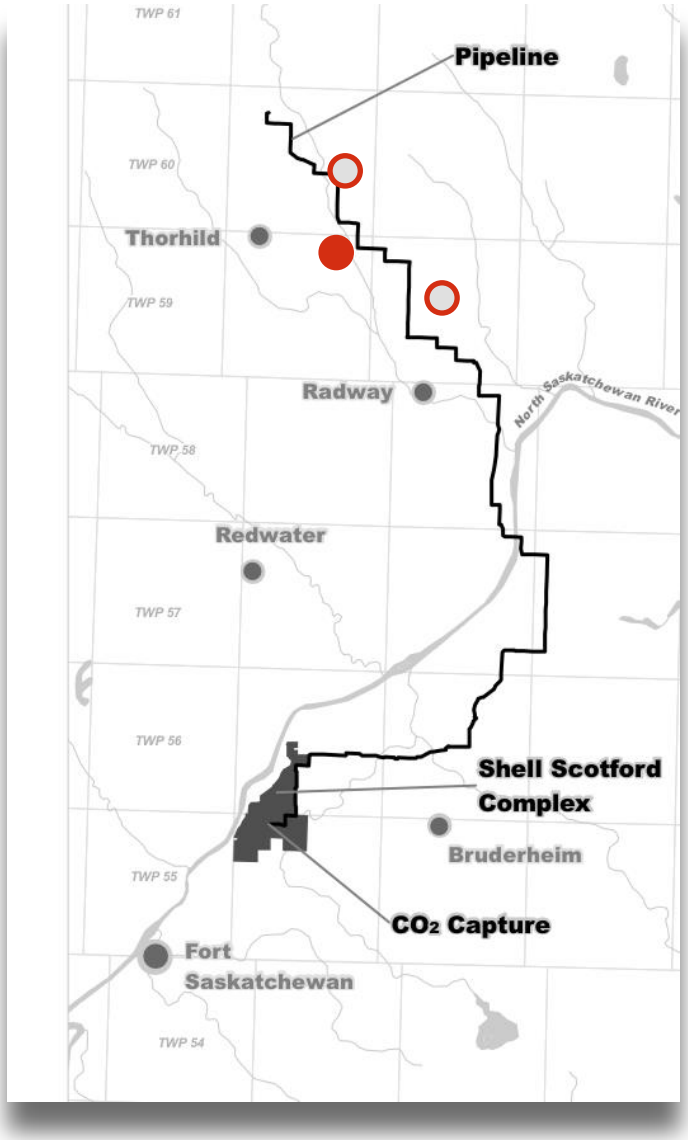


Source: Derived from Shell New Lens Scenarios

The issue with CCS is not the technology, it's the lack of real projects to bring maturity and economy of scale

The Quest CCS Project in Alberta, Canada

- ✓ Fully integrated with capture, transport & storage; starting up in 2015.
- ✓ Located at Scotford Upgrader, will capture CO_2 from Hydrogen Manufacturing Units.
- ✓ Will use existing technology with amine separation.
- ✓ Capacity to capture over one million tonnes of CO_2 per year for 25 years.
- ✓ CO_2 will be transported by 12 inch pipeline to storage, approx. 65 km north of the Upgrader.
- ✓ Route selected to meet stakeholder requirements.
- ✓ 3 injection wells, ~2 km depth.



Three key challenges

1. The Business Case
   - First generation CCS > US$100 per tonne CO_2
   - Alberta carbon price ~C$15 per tonne CO_2

     (but at least they had one)
2. Storage Regulations and Liability
   - Pore space tenure
   - Long term liability
   - Post closure stewardship fund
3. Safe operational procedures designed for CCS
4. No . . . . . it wasn't the technology!

A funding & revenue model of many parts

1. **Government Funding Support – C$865 million**
   - C$120 million Canadian Federal Government (Pre FID)
   - C$745 million Alberta Province (Construction, Startup and 10 years operation)
   - NPV Zero commitment
   - Conditional on extensive knowledge sharing and stringent monitoring (MMV) plan
2. **Revenues – GHG Credits**
   - Lower emissions in Alberta Specified Gas Emitters Regulation (SGER), baseline & credit system, ~C$15 per tonne
   - An additional set of serialized offset credits under SGER; maximum 10 years or 10.8 million credits (whichever is first)

Key Regulatory Challenges and Legislation

1. **Pore Space Tenure**
   - In Alberta, it was initially unclear who “owns” the porosity
   - Government had no legal ability to grant proponents tenure
2. **Long-Term Liability**
   - Alberta decision to assume liability for stable sequestered CO2
   - There was no legal ability for Government to assume liabilities and indemnify former operator
3. **Post-Closure Stewardship Fund**
   - Government wished ability to collect funds to cover the post-closure costs (after assume liability)
   - Proponents wished clarity on what costs would be included

CCS Statutes Amendment Act and Carbon Sequestration Tenure Regulation

- Clarity that the Crown owned geological porosity
- Ability for Government to grant pore space tenure
- Ability for Government to assume long-term liability and collect funds to cover associated specific costs

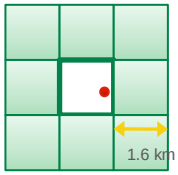
“Gaps” in Regulation Encountered (I)

1. **CCS “Scheme” Application**
   - O&G approach - drill numerous wells to prove geology and then convert some wells to disposal = containment risk!!
   - Shell “scheme” approach- utilize non-invasive technique to prove geology, apply for all wells and facilities, and then develop injection wells only as needed
2. **Consultation and Notification**
   - CCS project could impact stakeholders that would not have even been notified under O&G consult/notify requirements
   - Shell- notification of surface occupants and mineral rights in relation to proposed subsurface activity

Mineral Notification

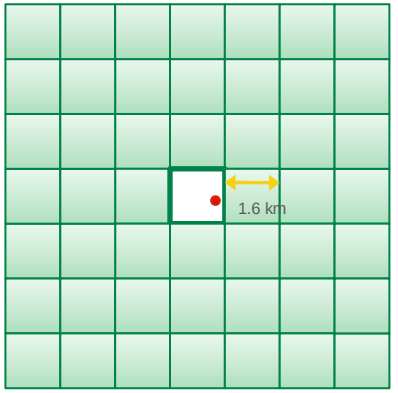
O&G Requirement

3x3 sections surrounding well



Shell Quest

Notification of stakeholders to modeled extent of CO2 plume



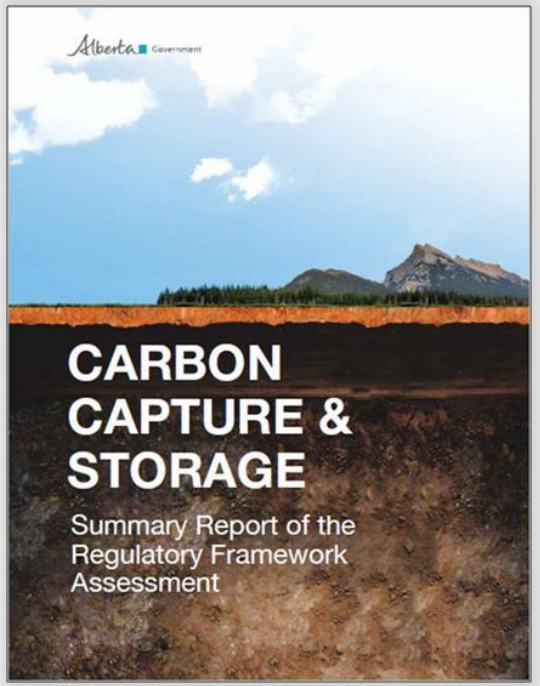
“Gaps” in Regulation Encountered (II)

3. **Emergency Response Plan**
    - Alberta regulation does not require CO2 projects to have ERP to ensure safety of landowner/occupants in emergency
    - Shell- prepared a full ERP to address CO2 release from wells, pipelines, and leaks to surface within tenure area
4. **MMV Plan**
    - Not required for O&G production
    - Shell - submission of comprehensive MMV Plan as part of Tenure Application and “Scheme” Injection Application

Alberta- Regulatory Framework Assessment

- A multi-stakeholder process convened by the Government of Alberta
- Mandate to examine the regulatory framework for CCS in Alberta and make recommendations on how the regulatory framework could be enhanced to accommodate CCS
- Steering Committee forwarded 70+ recommendations to Government of Alberta
- Majority of Shell best practice with Quest taken as recommendations
- Most recommendations are technology rather than jurisdictionally specific
- Full document available at:

  http://www.energy.alberta.ca/Initiatives/3544.asp



Key takeaways

- CCS is the only technology that deals directly with the “stock” emissions issue, but this isn’t widely recognised.
- Net zero emissions is an eventual “must have”. Only CCS can deliver this.
- CCS needs to come early and be rapidly deployed, but will need robust and widespread carbon pricing.
- There need not be regulatory barriers, but a multi-stakeholder step-by-step process is required.
- There is much to learn from Alberta.

Thank you