

Asset Integrity Management Underpinning Safe & Secure Geological CO₂ Storage & Reducing Risk & Liability

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New drivers in the CCS/CCUS Market

Infrastructure Investment and Jobs Act – IIJA (aka Bipartisan Infrastructure Bill)

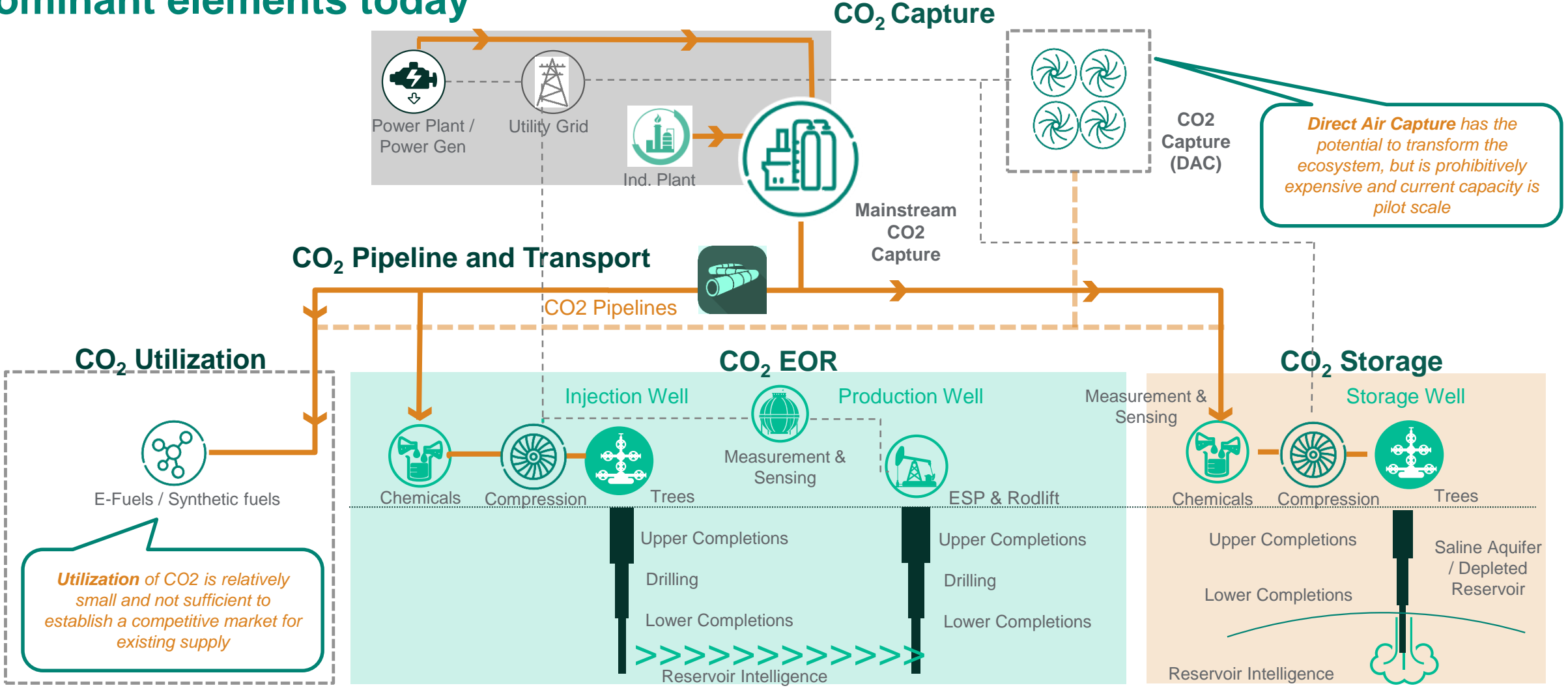
- \$1.2 trillion dollar investment in “traditional” infrastructure – transportation, energy, broadband, etc.
- Signed into law by President Biden Nov. 15, 2021
- Key CCUS provisions – SCALE Act, transportation, storage, permitting
- Key Hydrogen provisions – ‘Clean’ standardization

Build Back Better Act 2021 - BBBA (aka Budget Reconciliation Bill)

- \$1.75 trillion dollar investment in social safety net and climate change
- Can be passed with only Democratic support but requires 100% of Senate Dems
- **Outlook: Uncertain**
- Key CCUS provision – 45Q enhancements
- Key Hydrogen provisions -

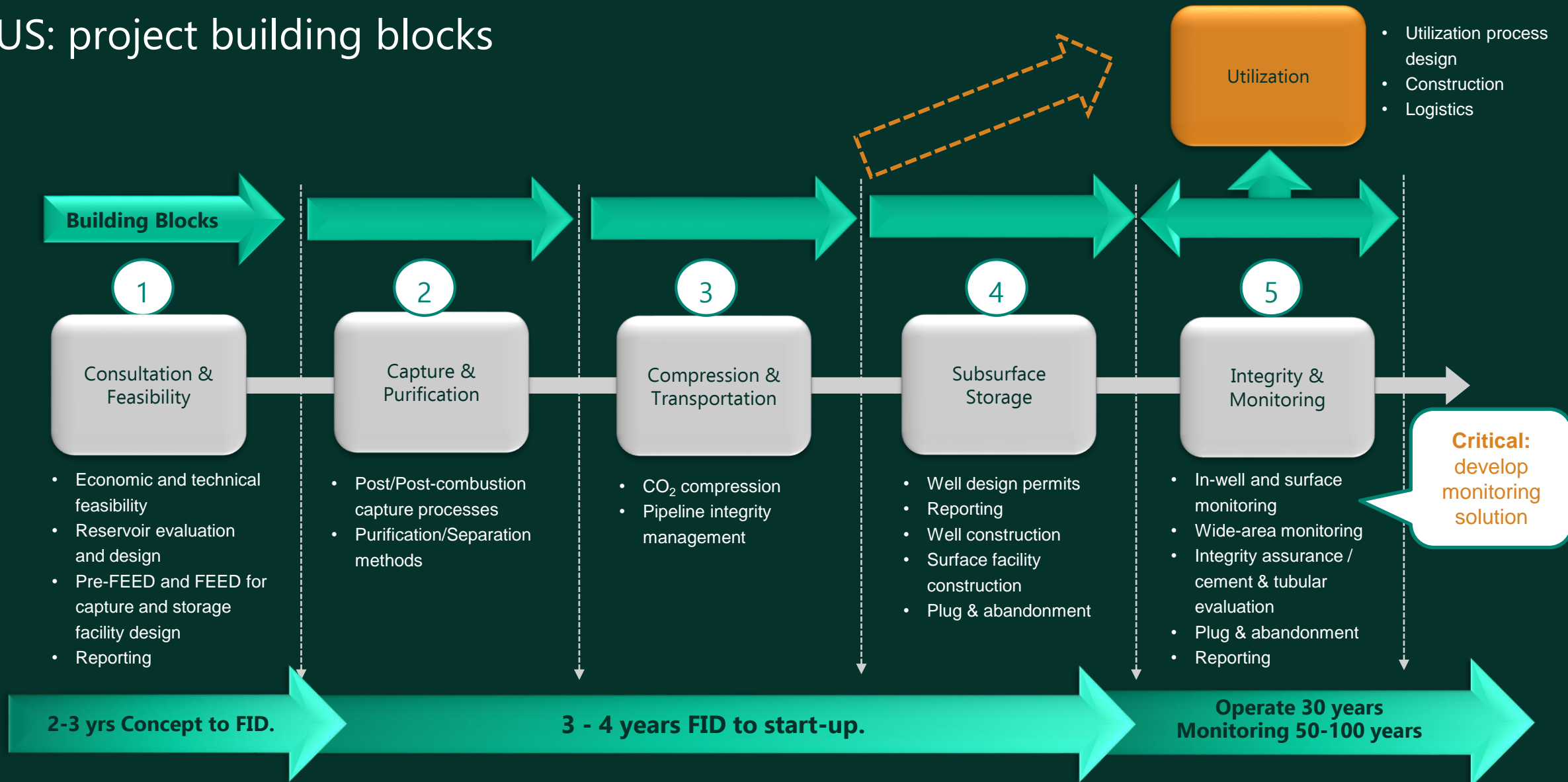
Recovering oil prices

CCUS ecosystem: Capture, Transportation, Utilization and Storage are the dominant elements today

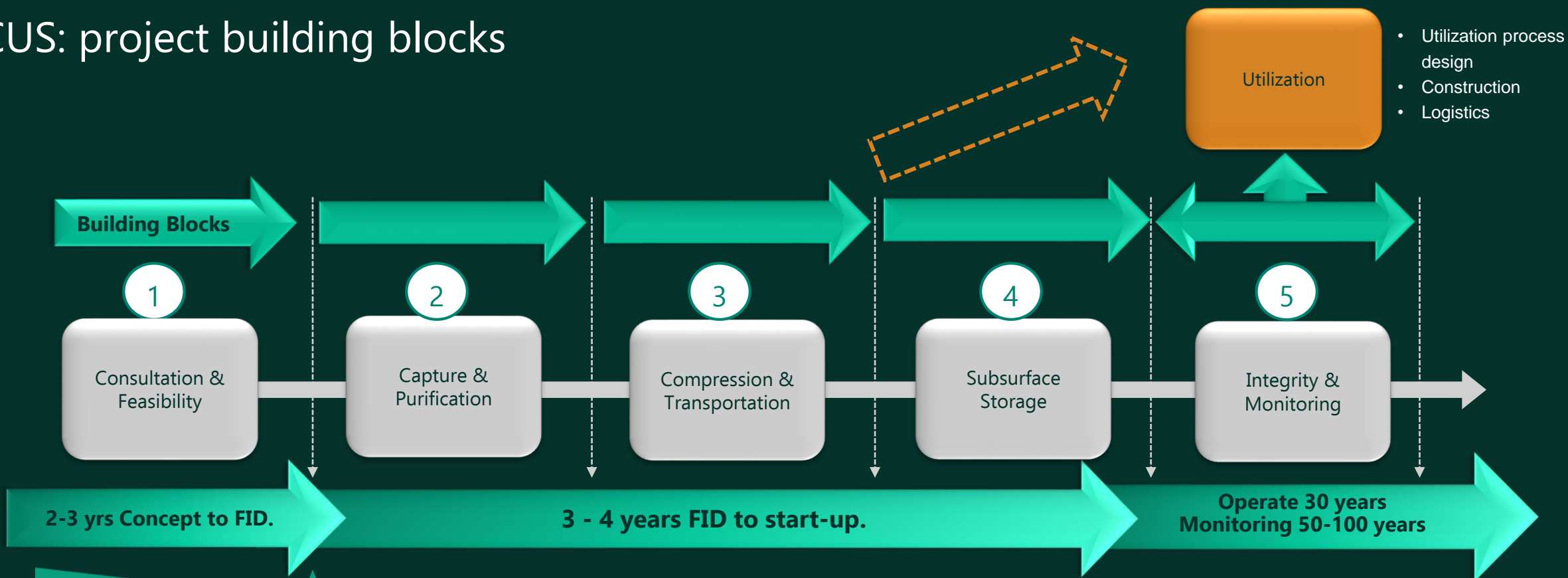


A complex ecosystem where multiple stakeholders are at play.

CCUS: project building blocks



CCUS: project building blocks



Risk & Liability

Why focus on risk and liability? Why now?

- Global ramp-up in CO₂ capture
- Understanding R&L will help to construct business models
- Properly vetted business models will showcase where along the operational chain insurance is most needed
- Defined models help to define best business practices & industry standards

Different Business Models Unfolding



A complex ecosystem with different levels of risk and insurance needs.

Potential Insurance Models



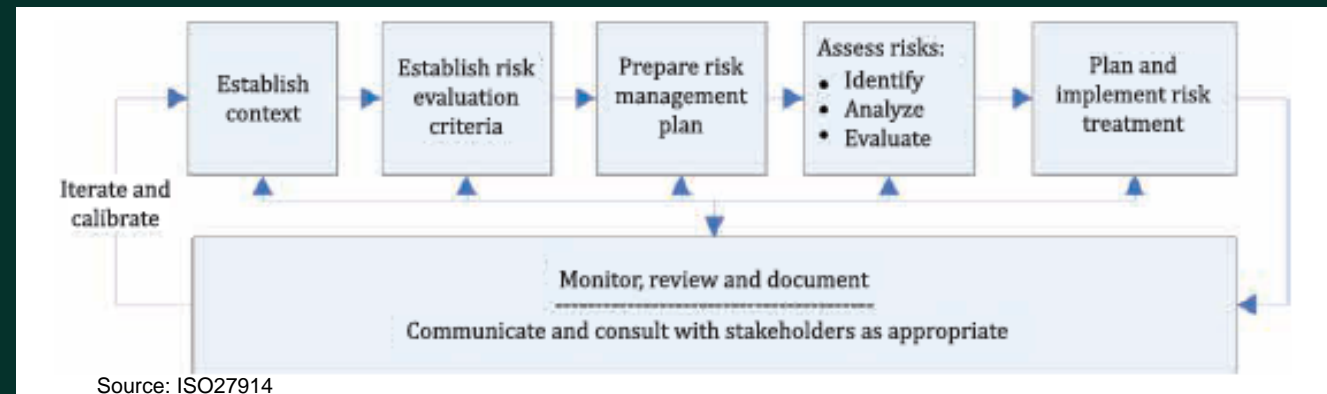
Multiple considerations for insurance backing.

Asset Integrity Management (AIM)

Underpinning insurance policy is the assurance that unacceptable outcomes will be mitigated, managed or prevented by proper management of the CO₂ injection asset.

Process of Asset Integrity Management:

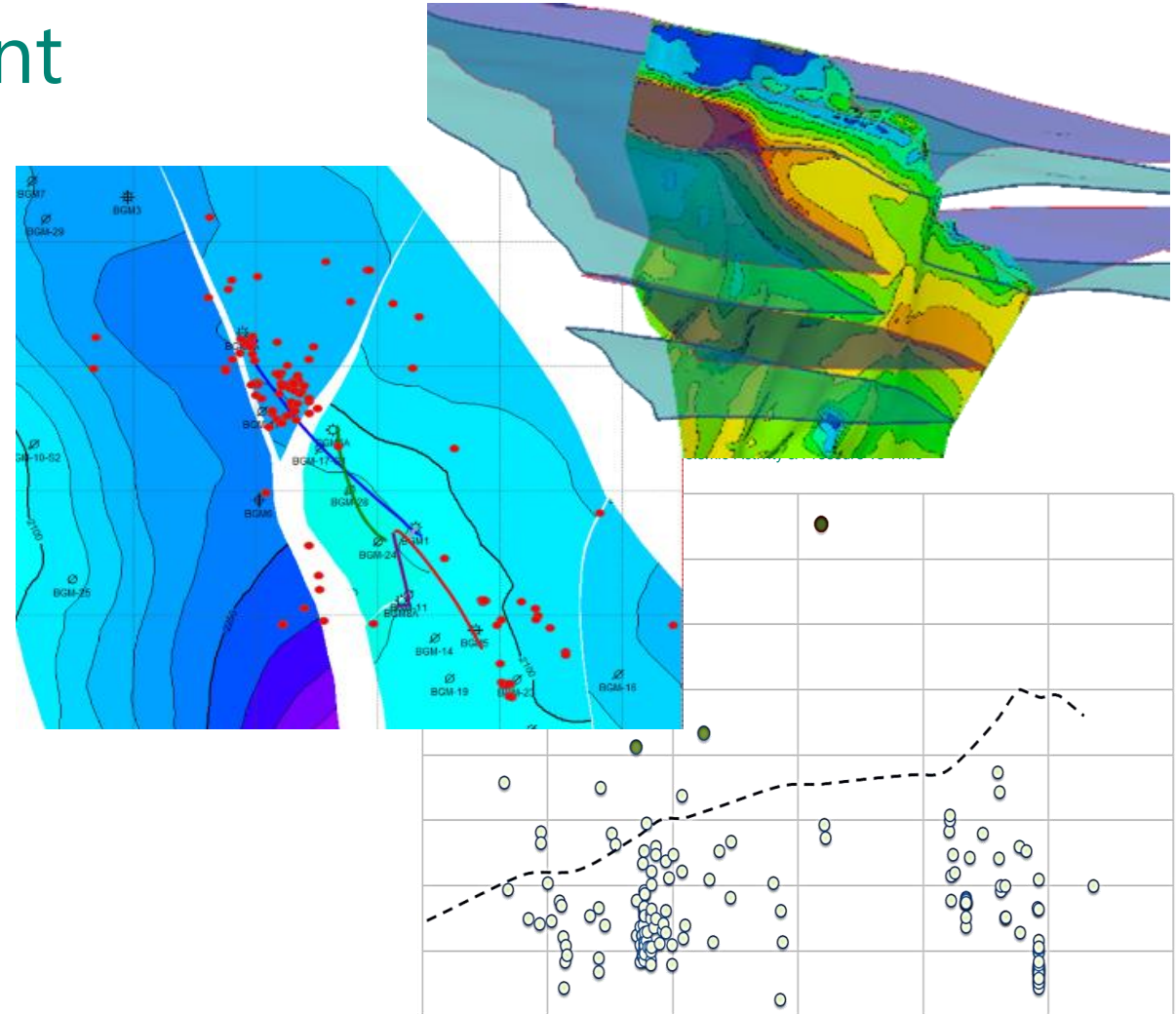
- Assessment of topside risk and management strategy
- Subsurface asset identification
- Assurance of secure geological storage
- Risk assessment and monitoring plan
- Measurement, verification and reporting



Source: ISO27914

Why Asset Integrity Management

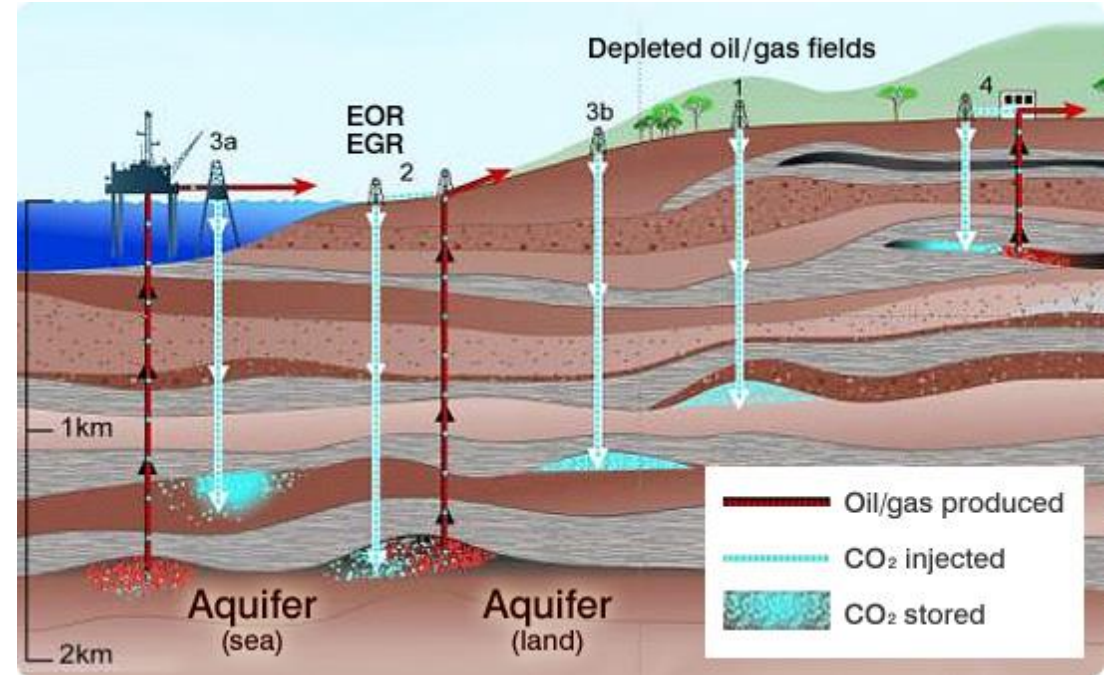
- Required by UIC & GHGR programs
- Gain public acceptance
- Required for 45Q or CA LCFS
- Manage and track risk of unacceptable outcomes
- Develop a consistent and repeatable approach
- Ensures industry longevity



Details of the complications around AIM - Subsurface

What are the storage options?

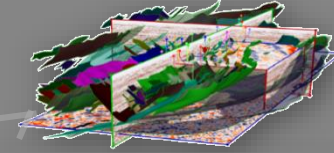
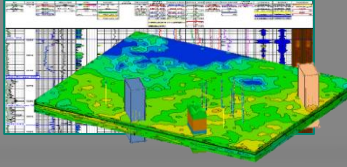
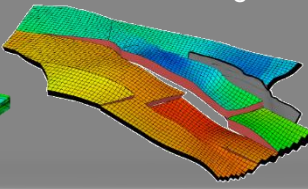
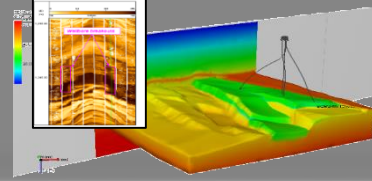
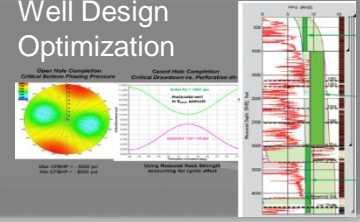
- Storage options in Conventional Geologic Formations
- Storage options in Unconventional Geologic Formations
- Storage in Offshore Geologic Formations
- Storage in Depleted Hydrocarbon Reservoirs
- Other Geologic Storage Options




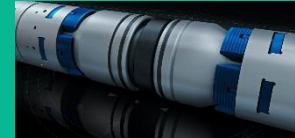



NPC CCUS Study

Sequestration Iterative Workflow

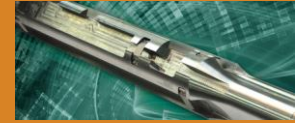


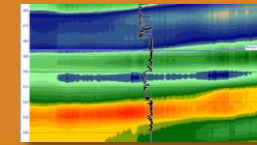

Subsurface Engineering

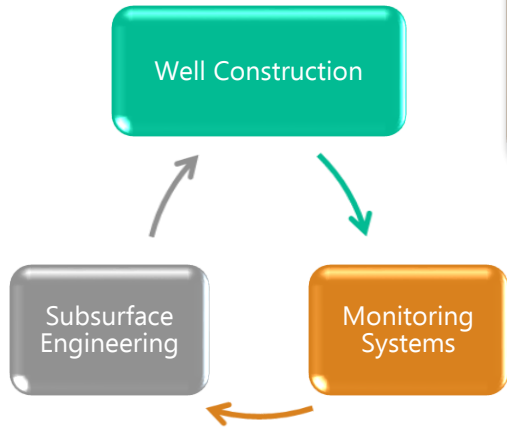
Seismic Interpretation  Petrophysics  Reservoir Modeling  Geomechanics  Well Design Optimization 

Well Construction

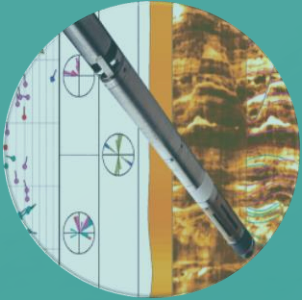
Integrated Well Services  Completions  Wireline  Cement Systems  Drilling Services 

Monitoring Systems

Well Monitoring  Well Integrity  Cement Integrity  Plume Growth  Microseismic 

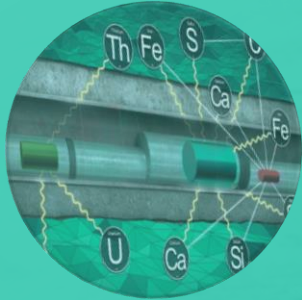


AIM Site Characterization



Fractures

- Resistivity Imager
- Ultrasonic Imager
- Distribution and Orientation
- Fracture stability



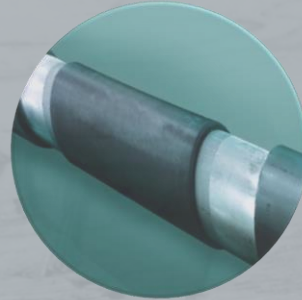
Lithology

- In-situ Mineralogy
- Elemental Spectroscopy
- Coring Services
- Petrophysical Logging



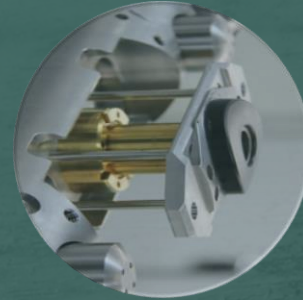
Permeability

- Whole Core
- Rotary Sidewall Core
- XLOT / Injection Testing



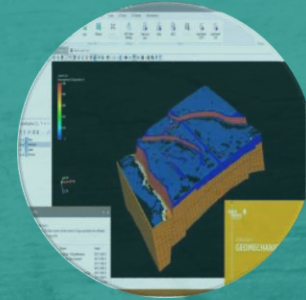
In-situ Stress

- RCI/RCX Microfrac
- XMAC Cross Dipole acoustic



Reservoir Fluids

- Formation fluid Sampling
- Magnetic Resonance
- Volatile Analysis – Mudlogging



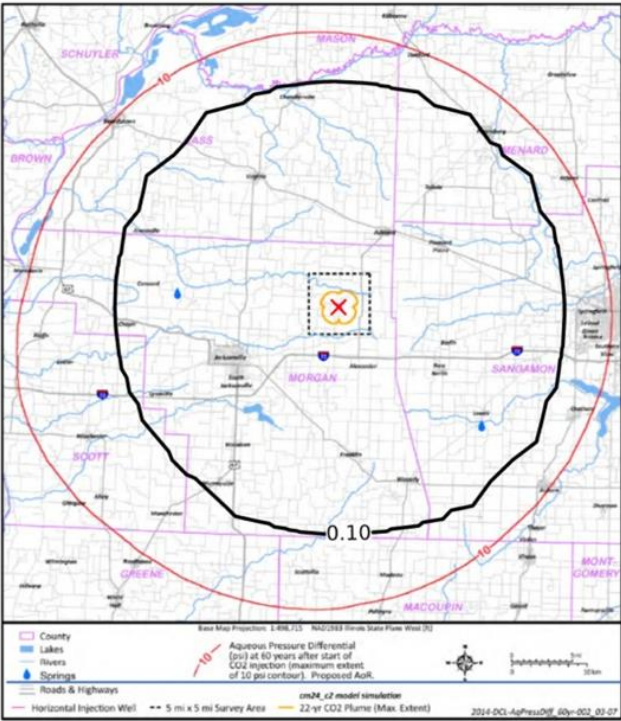
Fault Stability

- 2D/3D Seismic Interpretation
- Fault Stability Analysis
- 1D and 3D Geomechanics

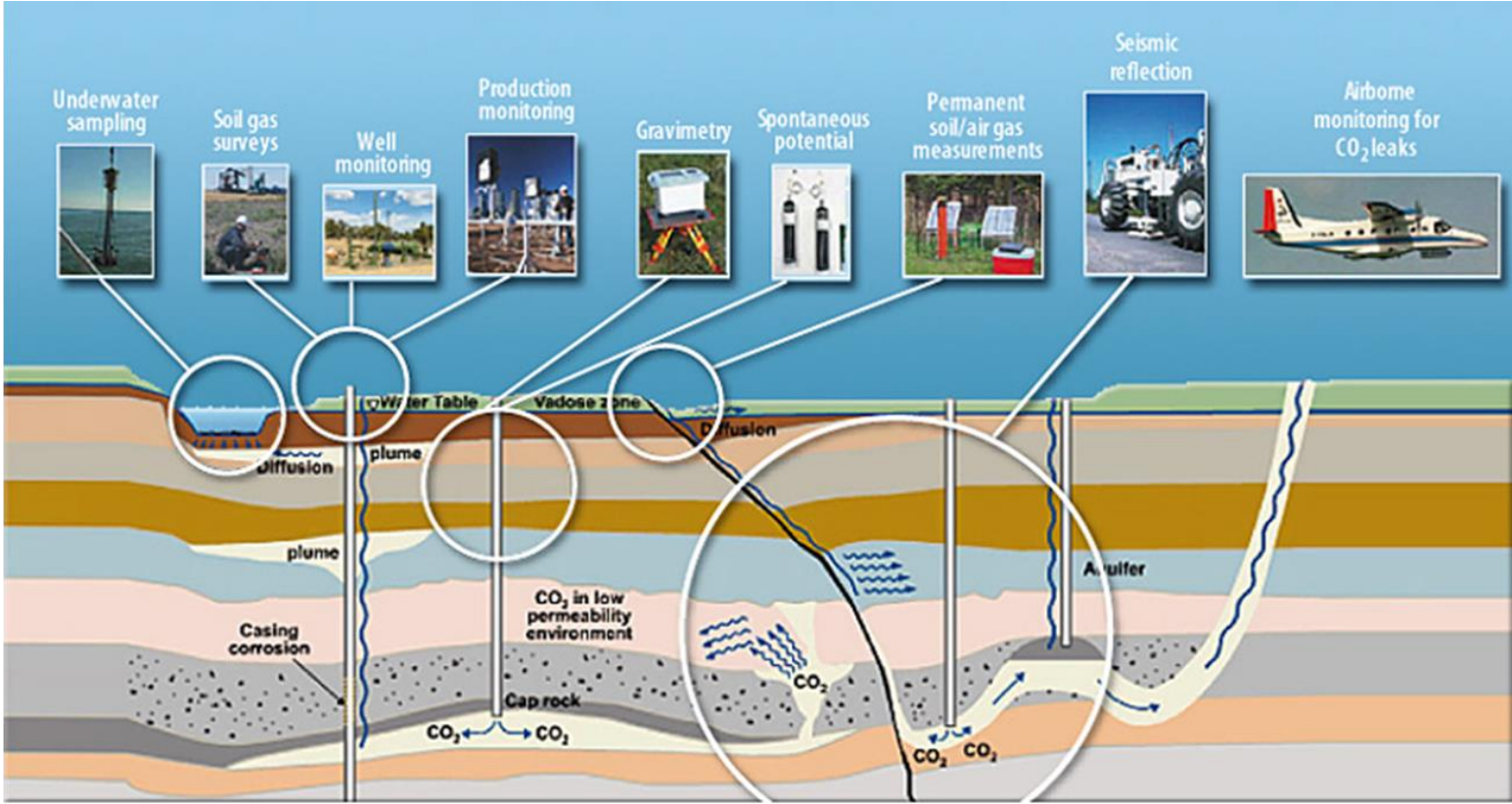
Secure Geologic Storage

CO₂ storage monitoring requires a range of solutions over a large area

Risk-Based AoR (0.1 MPa/14.5 psi (black)
 Class VI Permit AoR 0.69 MPa/10 psi (red)



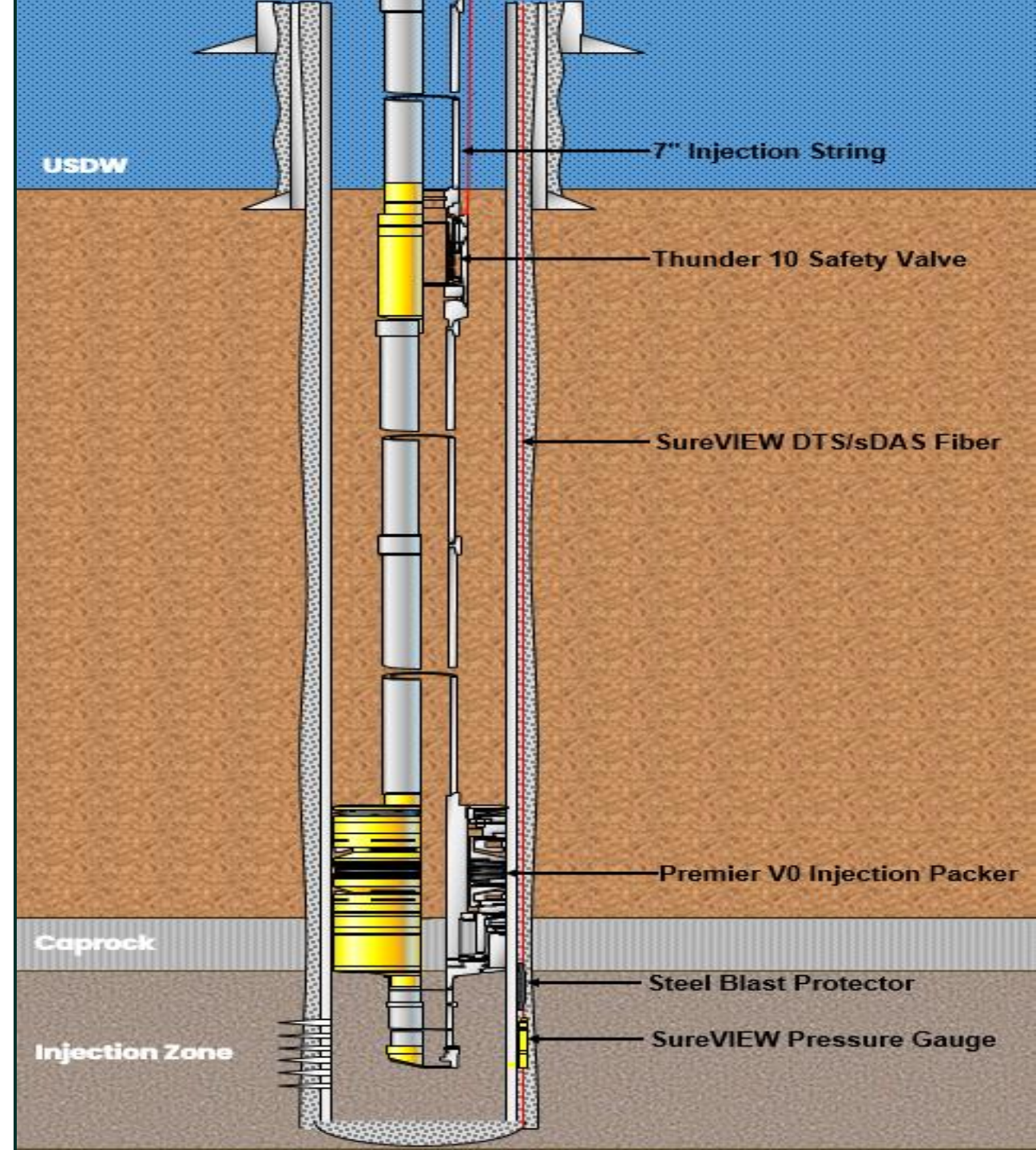
Courtesy: PNNL



Courtesy: CO2 Capture Project

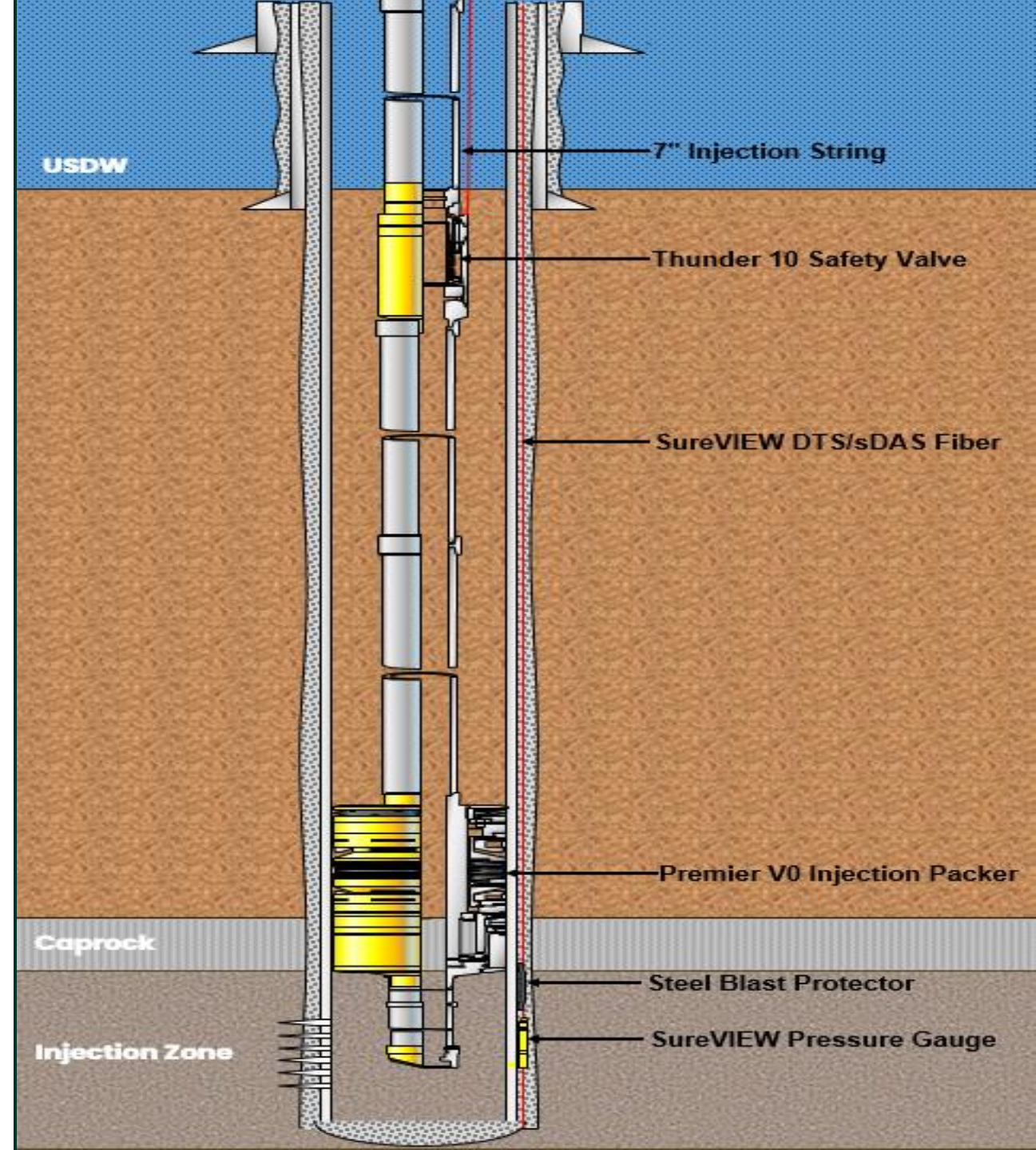
CO₂ Field Completion Design

- CO₂ Injection Well Design
- Class II to Class VI
- Proper P&A
- Monitoring System Installation



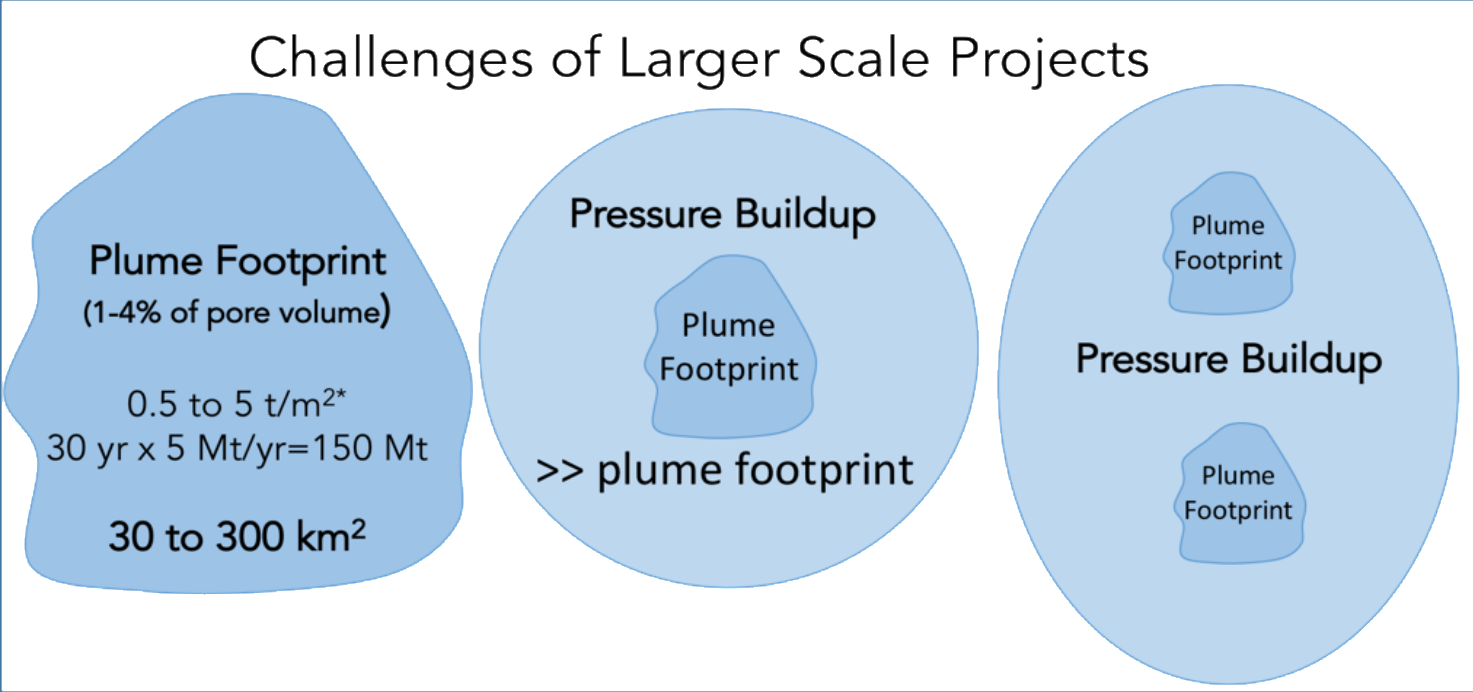
Conversions to Monitoring Well

- Accurate CBL
- Packer selection and placement
- Monitoring systems

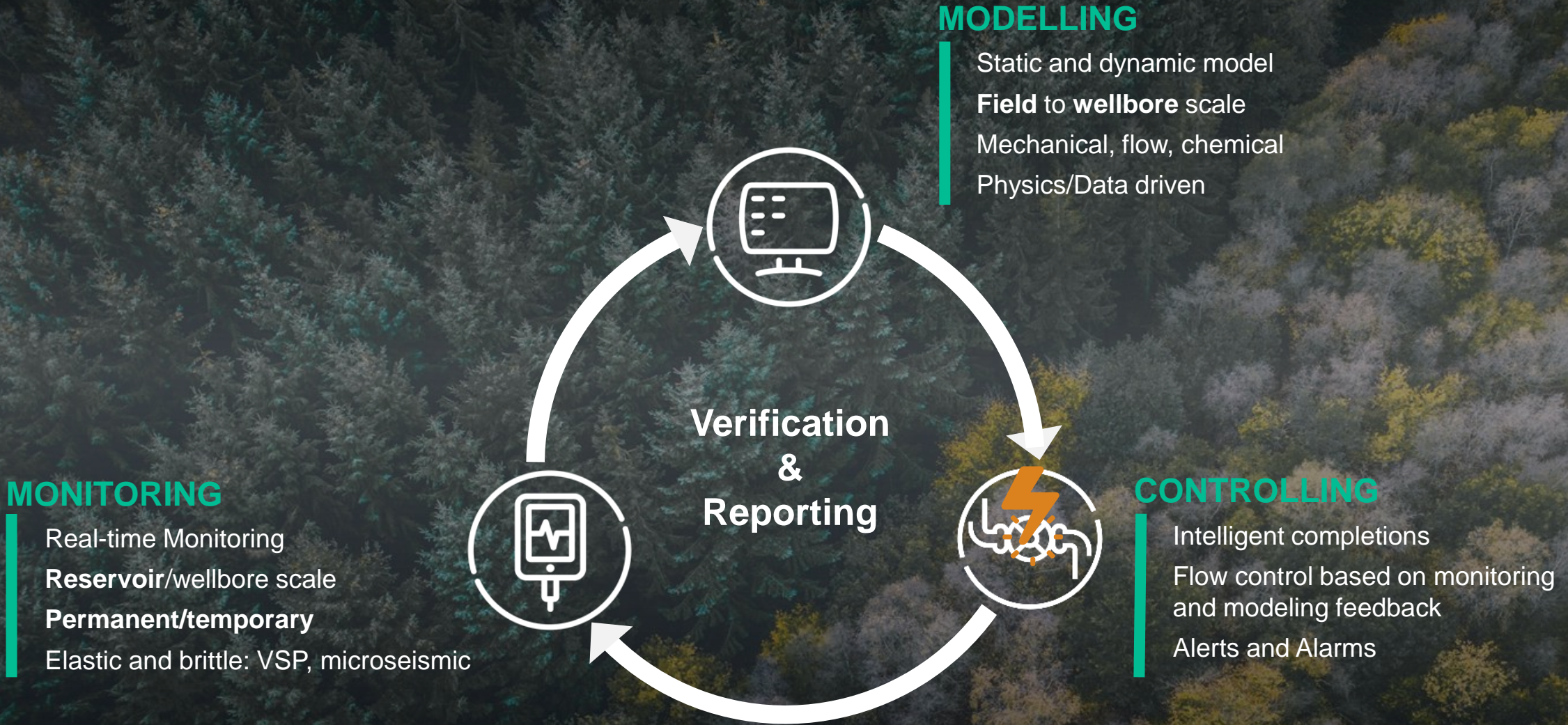


Challenges of large-scale projects include inefficient use of pore space as well as AOR overlap

Leases of underground pore space and surface access
Monitoring requirements over large area are expensive



AIM Strategy



Conclusions

- Market growth continuing a positive trend
- The CCS/CCUS ecosystem is complex with multiple levels of risk
- New business models are presenting themselves
- Risk and Liability must be understood to address and insure these business models
- The market is becoming increasingly complicated
- The time for consideration is now.

Thank You