Update on Carbon Capture and Sequestration Activities

California Air Resources Board

Sacramento, California

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Overview

- Background
- Potential of Carbon Capture and Sequestration (CCS) in California
- Lessons Learned
- Design Principles
- Next Steps and Timeline

California's Climate Leadership

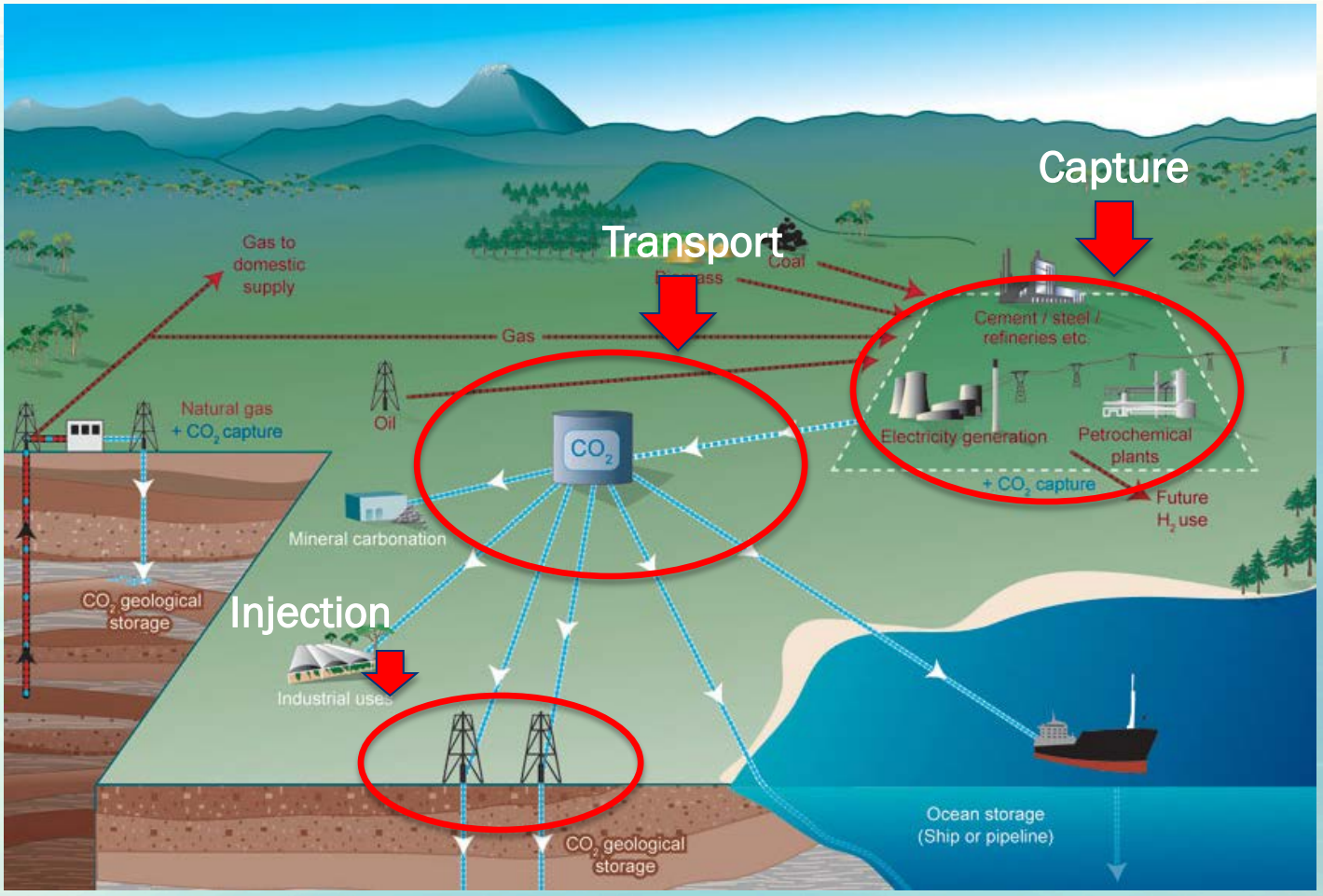
- Climate Goals
  - 40% greenhouse gas (GHG) reduction below 1990 levels by 2030
  - 80% reduction below 1990 levels by 2050
- California Council on Science and Technology found almost all solutions to 2050 goal require CCS
  - Consistent with IPCC studies for other regions
  - International Energy Agency emphasizes CCS not optional in meeting Paris climate agreement
  - Net negative carbon emission opportunities if combined with bioenergy

California CCS Background

- In 2010, ARB, CEC, and PUC created a Review Panel on CCS that issued recommendations*
- Legislative appropriation and Board direction to develop CCS quantification methodology (QM):
  - Forms basis of future CCS regulatory effort
  - Proper accounting of CO_2 reductions
  - Board approval needed for CCS QM and protocols
- CCS included in all ARB Scoping Plans
- Coordinating with multiple state and federal agencies serving critical roles in CCS

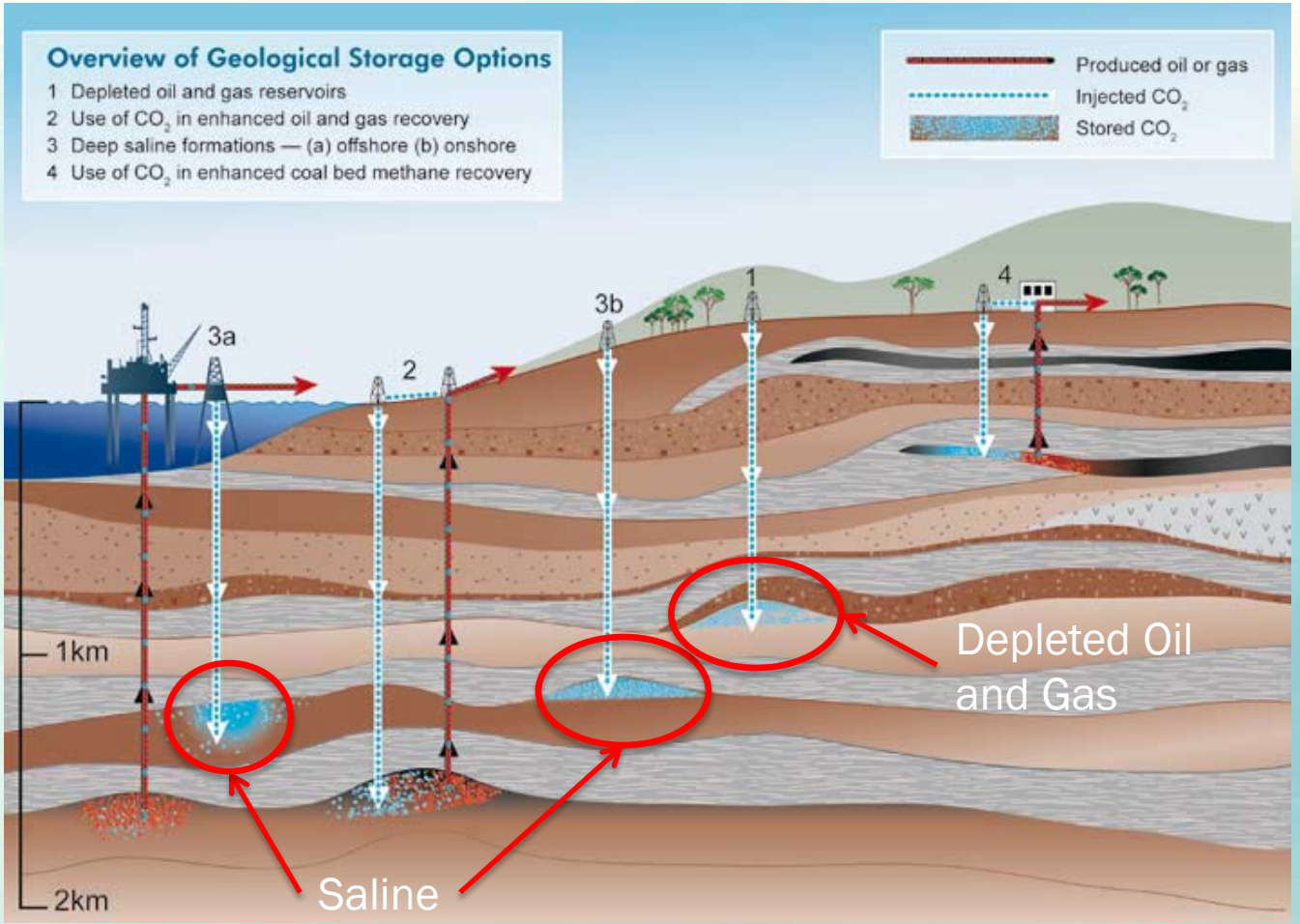
* https://www.arb.ca.gov/cc/ccs/ccs.htm

Carbon Capture & Sequestration (CCS) or Utilization



Source: CO_2CRC

CO_2 Geologic Sequestration Options



Source: CO_2CRC

Status of CCS Technology

- 20 commercial-scale CCS projects either under construction or in operation
  - Potential injection rate of 40 MMT CO_2/yr
  - 5 saline and 15 CO_2-EOR
  - None in California but some may serve CA fuel market

Status of CCS Regulations and Barriers

- Federal regulation governs current projects
  - US EPA underground injection control permits to protect drinking water sources (Safe Drinking Water Act). In CA:
    - Class VI (Sequestration) – USEPA
    - Class II (Enhanced Oil Recovery) – DOGGR
  - US EPA GHG reporting dependent on UIC permit
  - Included in US EPA Clean Power Plan
- Barriers: long term liability, pore space ownership, landowner considerations, costs and financing

Relevant Federal and State Agencies

- U.S. Department of Energy
- U.S. Environmental Protection Agency
- California Division of Oil, Gas and Geothermal Resources (DOGGR)
- California Geologic Survey
- California Energy Commission
- California Public Utilities Commission
- State Water Resources Control Board

Input from Environmental Organizations and EJ Community

- Several environmental organizations have expressed general support of CCS
  - Support strong standards to ensure permanence
- EJAC members have commented on CCS
  - Raised concerns on impact on land owners, appropriate life-cycle, increasing oil production (CO_2-EOR), and co-pollutants/sustainability

Potential for CCS in California

- CO_2 storage potential in CA
  - 30–420 Gigatonne onshore formation capacity (California Geological Survey, 2011)
  - Offshore sub-seabed offers additional capacity
- Potential use in California's climate programs
  - Standalone strategy (e.g. refineries)
  - Compliance tool for market programs and standards:
    - Low Carbon Fuel Standard
    - Cap-and-Trade Program
    - Emission Performance Standard for Power Plants

Potential Sectors for Applying CCS

- Fuel production
  - Ethanol plants
  - Refineries
  - Gas processing
  - Hydrogen production
- Electricity generation
- Cement
- Other large stationary CO_2 sources
- Costs vary by source
  - The purer the CO_2 stream, the less expensive
  - Fuel production, including H_2 production, tend to have less expensive options amenable to near term projects.

Lessons Learned from Underground Natural Gas Storage Leaks

- Site selection is key
- Well integrity requirements need to be strong
- Rigorous monitoring is necessary
- Best practices need to be followed. DOE's National Energy Technology Lab's best practice manuals:
  - Site Characterization
  - Geologic Storage Formation Classification
  - Monitoring, Verification and Accounting
  - Simulation and Risk Assessment
  - Carbon Storage Systems and Well Management Activities
  - Public Outreach and Education

Storage Permanence and Risks

- Leak prevention to achieve maximum benefits and avoid environmental impacts
- Focus on avoiding or mitigating: water/soil impacts, CO_2 accumulation in enclosed/low lying areas, human-induced seismicity.
- Process: address concerns through comprehensive agency consultation, public process
- Lower risk: proper site selection, site and risk management, and regulatory standards
  - No CCS leaks recorded to date

Design Principles for CCS Program

- Protection of public health and the environment
- Robust GHG monitoring, reporting, and verification that ensure reductions are:
  - Real, permanent, quantifiable, and enforceable
- Focus on leak prevention
- Based on sound science
- Inclusion of expert state and federal agencies
- Transparent public process
- Serve as a model for other jurisdictions

Process for CCS Projects

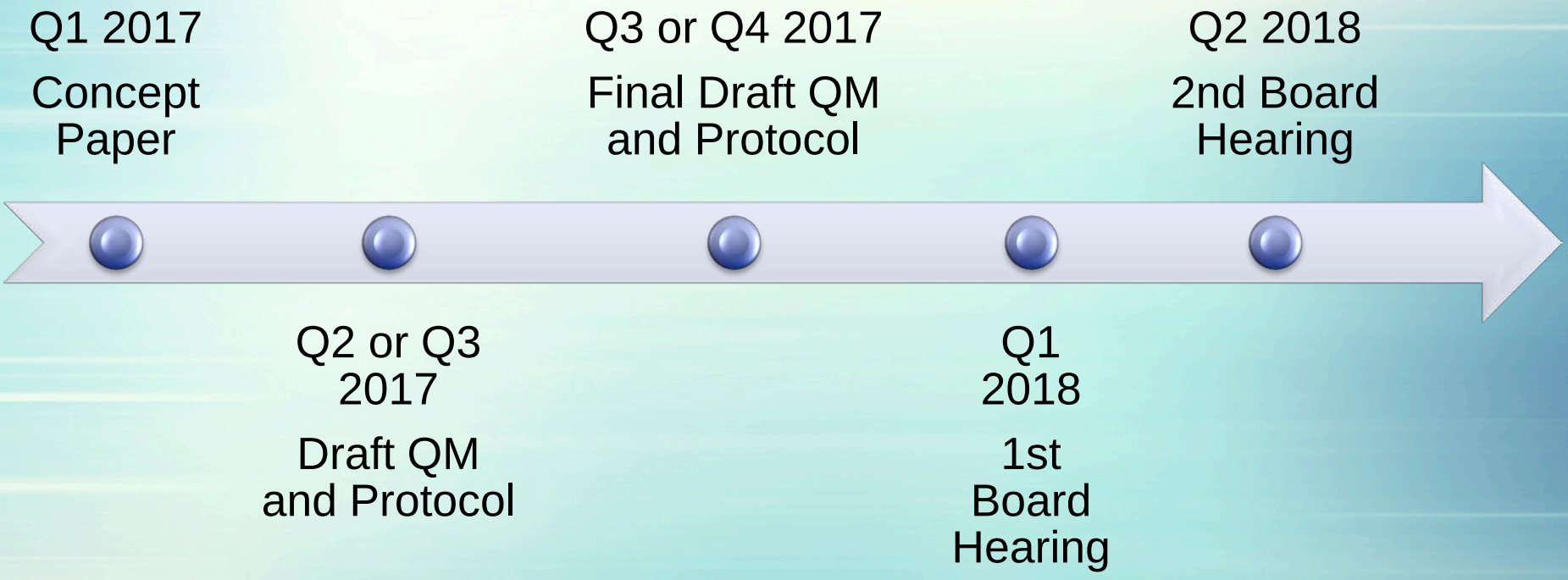
- USEPA: Underground injection control permit to protect drinking water
  - In CA: either USEPA for Class VI (Sequestration) or DOGGR for Class II (Enhanced Oil Recovery)
- ARB: Develop standards with expert input, build upon existing requirements
  - Evaluate project proposals with expert agencies
  - Transparent public process
  - Board approval of QM and protocols

ARB'S CCS Quantification Methodology and Protocol

- CCS Quantification Methodology (QM)
  - Accounting only
- Geologic Carbon Storage Permanence Protocol
  - A single procedure for CCS permanence analysis
  - Non-regulatory: incorporated by reference as appropriate into climate regulation/programs
  - Will be developed in consultation with state and federal agencies with robust stakeholder process

Timeline

- QM and protocol development



Longer-term Activities

- Explore actions that could help ensure CCS is able to contribute to long term goals
  - Targeted mid-term adoption strategies to enable widespread long-term adoption
  - Enabling carbon negative technologies
- Investigate potential CCS direct measures and consider incorporation of utilization into QM and protocol