Public Workshop
Carbon Capture and Sequestration

California Air Resources Board

Sacramento, California

February 12, 2016

Agenda

- Introductory presentation on CCS - *ARB*
- Overview of CCS related activities in California - *California Energy Commission*
- CCS in California regulations and Quantification Methodology development - *ARB*
- Overview of U.S. Department of Energy's CCS program – *U.S. Department of Energy*
- Next steps - *ARB*

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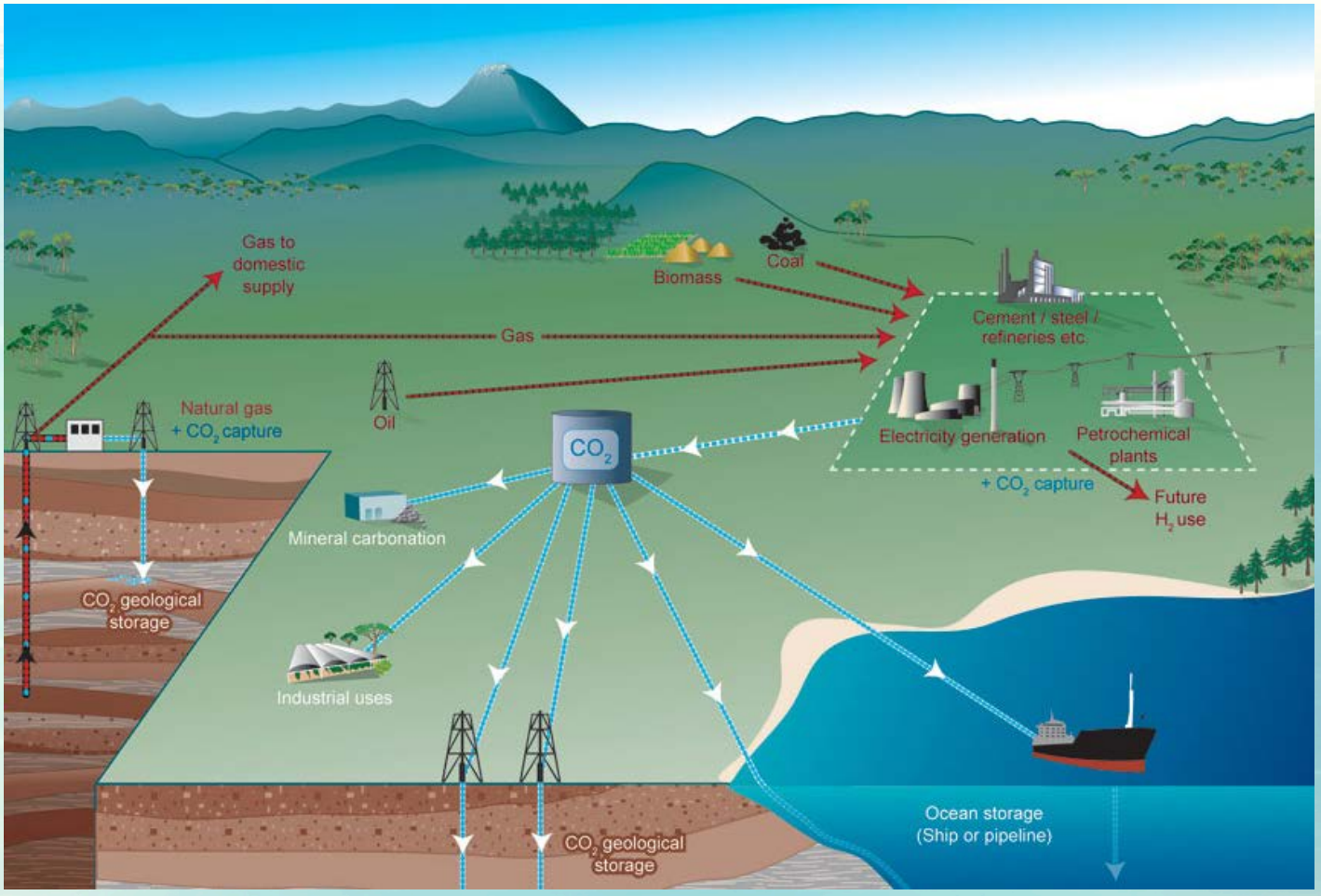
INTRODUCTORY PRESENTATION

WHAT IS CARBON CAPTURE AND SEQUESTRATION?

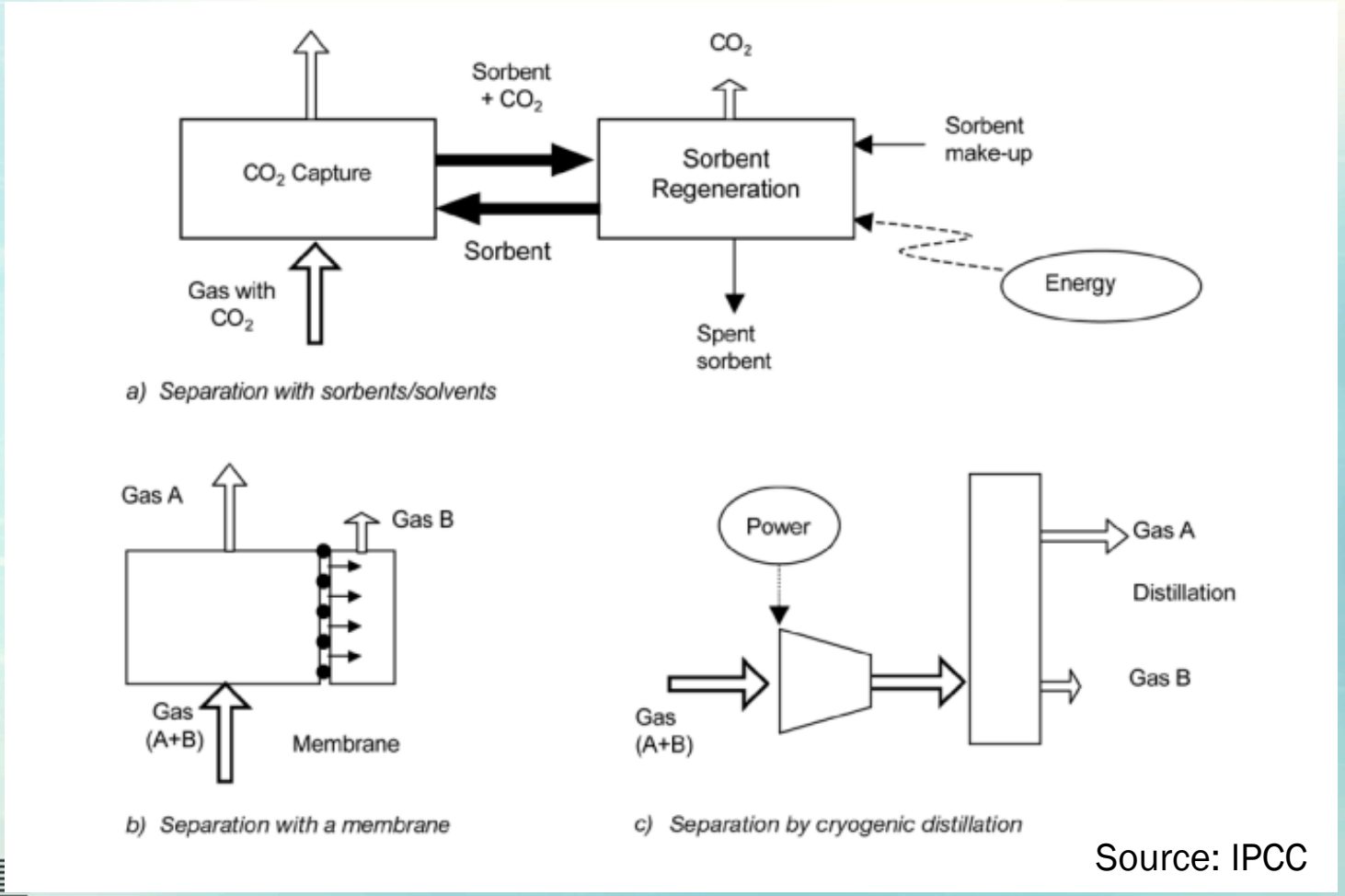
Carbon Capture and Sequestration



Source: CO_2CRC

CO_2 Capture Technologies

Current capture technologies are well understood but relatively expensive

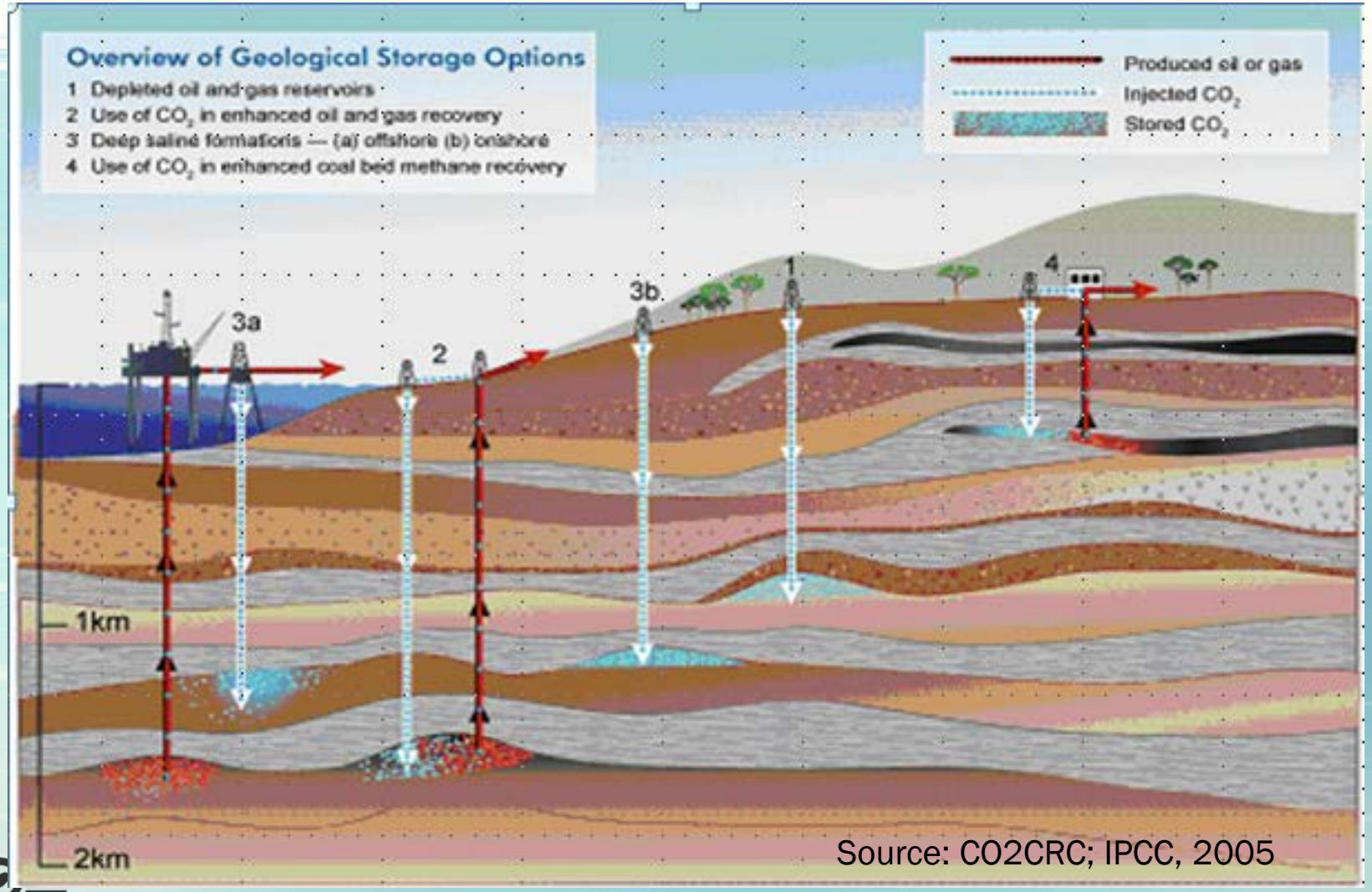


Source: IPCC

CO_2 Transport

- Movement of CO_2 by pipeline, truck, rail, ship, or barge to a storage facility
- Transport is the most technically mature step in CCS
- Currently no CO_2 pipeline in California
- U.S. has 50 individual CO_2 pipelines and with a combined length over 4,500 miles, primarily dedicated to enhanced oil recovery

CO_2 Geologic Sequestration Options



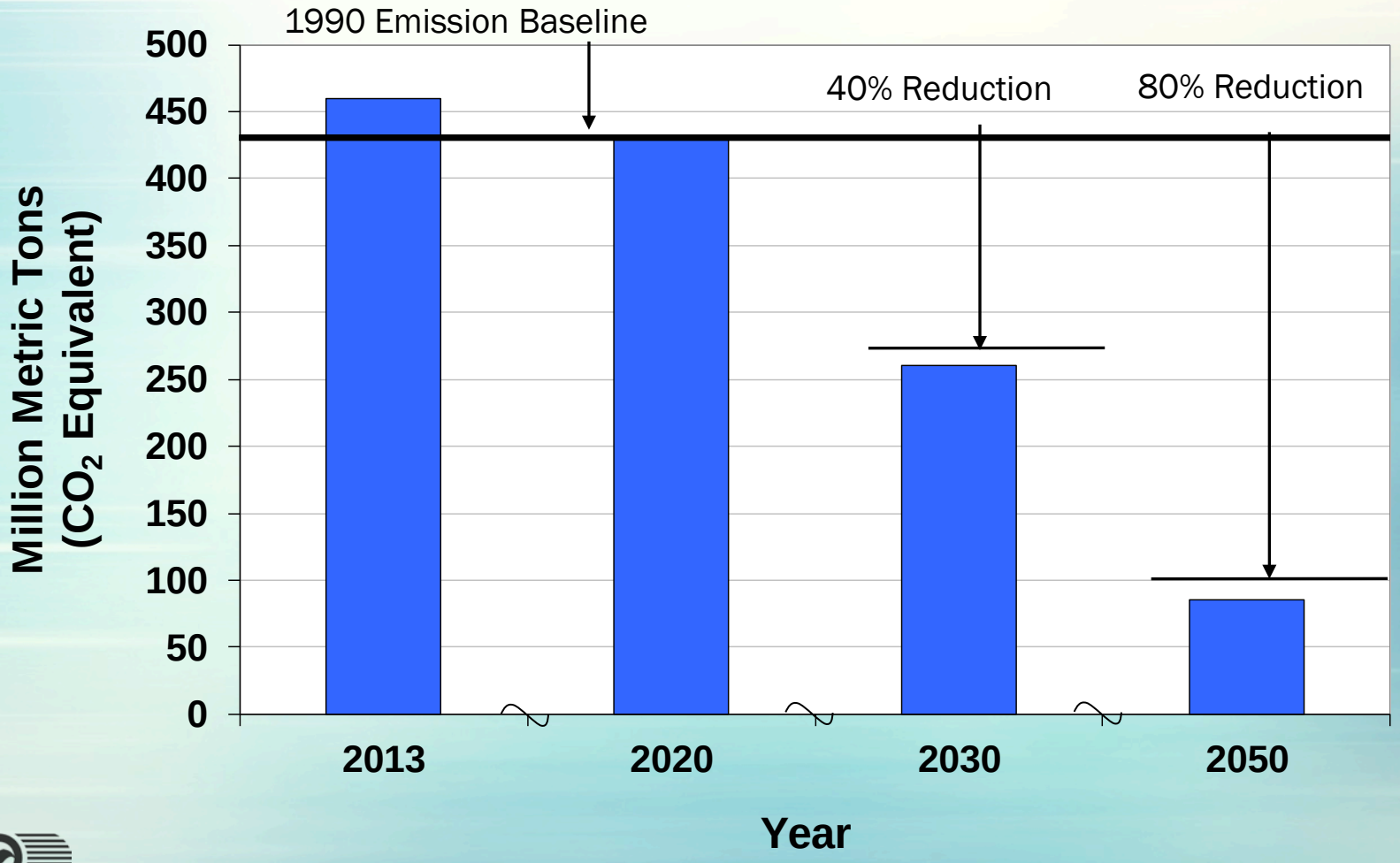
Source: CO2CRC; IPCC, 2005

CO_2 Utilization

- Use captured CO_2 or convert it to useful products such as chemicals, cements, or plastics.
- Life-cycle approach is necessary
- Most uses are currently small scale, need to understand the market potential
- Potential supply of anthropogenic CO_2 is very much larger than potential demand

WHY IS CARBON CAPTURE AND SEQUESTRATION IMPORTANT?

California's GHG Challenge



Long-term Targets

- IPCC (2014) found that models could not limit likely warming to below 2° C if bioenergy, CCS and their combination (BECCS) are limited
- Capable of achieving large CO_2 emission reductions
- Can be used in combination with other GHG reduction strategies
- Applicable to both the power and industrial sectors
- 2050 and 2100 scenarios without CCS have increased overall costs
- CCS combined with bioenergy may offer “negative emissions”

California Studies

- California's Energy Future – The View to 2050 (CCST, 2011) Findings:
  - CCS is an important technology for electricity generation
  - CCS is a key strategy for achieving economywide low-carbon fuels
  - California will require substantial CO_2 in-state storage capacity in 2050, with saline aquifers required by end of century
- California PATHWAYS: GHG Scenario Results (2015)
  - CCS scenario showed potential cost savings when compared to the straight line scenario
  - CCS scenario was a relatively higher risk strategy when compared to the straight line scenario

Policy Challenges for California

- Infrastructure investment is a pre-requisite for CCS being a large scale climate mitigation option
- Who is taking long-term liability and responsibility for injected CO_2
- Interaction with policy goals of achieving a larger renewables portfolio
- Further understanding geologic storage assets is needed
- Public trust and education- test and demonstrate technologies

POTENTIAL RISKS OF GEOLOGIC STORAGE OF CO_2

CO_2 Leakage - Potential Risk Factors

- Aliso Canyon leak provides a cautionary lesson- need to identify, minimize, and mitigate risks
- Existing wells in the injection area
  - Includes active, closed, and orphaned wells
  - Well depth
  - Well integrity, casing and condition of well abandonment
- Transmissive faults or fractures in the surrounding rock formations
- Lateral and upward movement into connected reservoirs
- Quality of the cap rock, or other seals
- Permeability characteristics of the rock layers overlying or adjacent to the reservoir

CO_2 Leakage - Potential Impacts

- Impacts dependent on:
  - How much, at what concentration, and over what time?
  - What are the current conditions of the surface and subsurface environment? Underground sources of drinking water?
- Health - effected at:
  - Acute exposures to concentrations > 3%
  - Prolonged exposures to concentrations > 1%
- Groundwater
  - Potential for increased heavy metals, acidity, turbidity, organics, changes in groundwater flow, brine displacement
- Environment
  - Impact vegetation due to high root-zone CO2
  - Impact burrowing animals, basements, vaults

Induced Seismicity

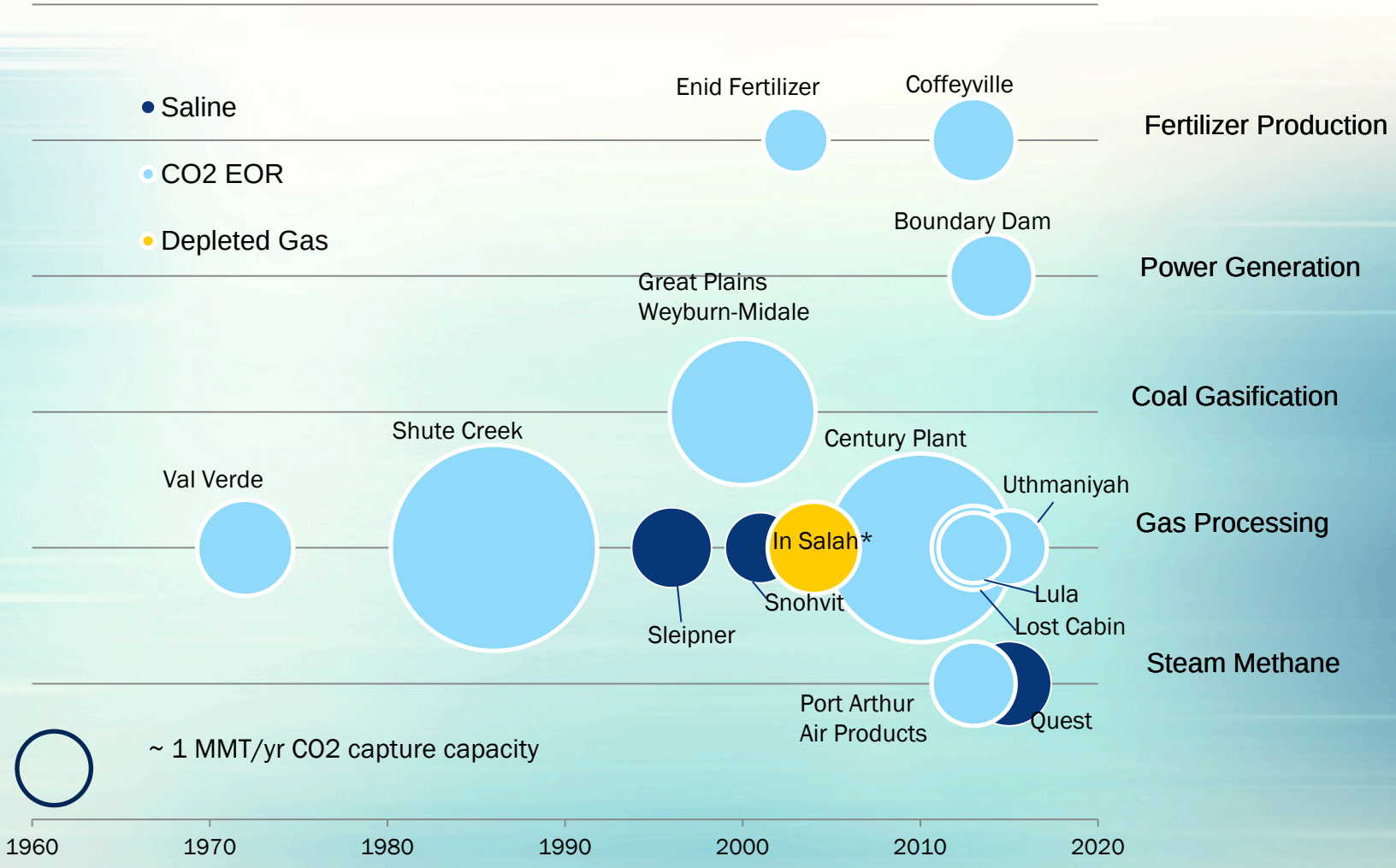
- Caused by human activities and is commonly related to the injection or extraction of fluids into or out of the subsurface.
- Induced seismicity associated with wastewater disposal, geothermal operations
- Existing CCS projects provide limited direct data on induced seismicity
- Factors to consider:
  - Pressure changes to critically stressed faults
  - Injection proximity to basement rock
  - Reservoir permeability
  - Injection rate

Risk Management

- Site Characterization
  - Identifying risks helps define proper management
  - Reservoir characteristics
  - Identify pressure limits for the surrounding geology
- Active injection site and pressure management
- Corrective Action and Remediation Plans
- Monitoring
  - In conjunction with modeling
  - Small leaks are a challenge due to plume size and detection limits
  - Monitoring prior to injection useful to establish a baseline

OVERVIEW OF LARGE-SCALE ONGOING CCS PROJECTS

Current Large-Scale CCS Projects



* Injection suspended

North American CCS Projects

Project Name	Location	Operational date	CO_2 source	Capture type	Capture capacity (MMT CO_2/yr)	Sequestration type
Century Plant	Texas	2010	Gas Processing	Pre-combustion	8.4*	CO_2-EOR
Shute Creek/La Barge	Wyoming	1986	Gas Processing	Pre-combustion	6	CO_2-EOR
Val Verde	Texas	1972	Gas Processing	Pre-combustion	1.3	CO_2-EOR
Boundary Dam	Saskatchewan	2014	Power Generation	Post-combustion	1**	CO_2-EOR
Quest	Alberta	2015	Steam Methane	Industrial Separation	1	Saline
Port Arthur/Air Products	Texas	2013	Steam Methane	Industrial Separation	1	CO_2-EOR
Lost Cabin	Wyoming	2013	Gas Processing	Pre-combustion	1	CO_2-EOR
Coffeyville	Kansas	2013	Fertilizer Production	Industrial Separation	1	CO_2-EOR

* 5 MMT CO_2/yr currently being captured
** 0.4 MMT captured in first year of operation

Projects Anticipated in 2016

- Illinois Industrial CCS Project- ADM corn-to-ethanol production facility, with saline injection (capture capacity of ~1 MMT/yr)
- Full commercial operation at the Kemper County Energy Facility, Mississippi (capture capacity of ~3 MMT/yr)
- Petra Nova Carbon Capture Project at the W.A. Parish power plant, Texas, CO_2 capture anticipated by the end of 2016 (capture capacity of ~1.4 MMT/yr)

ROLE OF FEDERAL AND STATE GOVERNMENT IN CCS

U.S. Department of Energy

- Research funding (ARRA, CCPI)
  - Industrial capture and storage projects, including innovative usage
- Seven Regional Carbon Sequestration Partnerships
- Lessons learned during the validation phase small-scale field tests generated a series of Best Practices Manuals:
  - Monitoring, Verification and Accounting (2012)
  - Public Outreach and Education (2009)
  - Site Characterization (2010)
  - Geologic Storage Formation Classification (2010)
  - Simulation and Risk Assessment (2012)
  - Carbon Storage Systems and Well Management Activities (2011)

U.S. Environmental Protection Agency

- Underground Injection Control (UIC)
  - Class II - oil and gas
  - Class VI - geologic sequestration of CO_2
- GHG Reporting Program (40 CFR Part 98)
  - Subpart UU - injection of CO_2
  - Subpart RR - geologic sequestration of CO_2
- New Source Performance Standards- Carbon Pollution Standards
  - Sets carbon pollution emission performance rates for new, modified and reconstructed power plants
  - New coal power plants can emit no more than 1,400 lbs CO_2/MWh, compliance possible with partial CCS

State Agencies

- California Air Resources Board
  - Cap and Trade, GHG Mandatory Reporting
  - Low Carbon Fuel Standard
- California Energy Commission
  - SB 1386- Emission Performance Standards
  - WESTCARB
- California Department of Conservation Division of Oil, Gas and Geothermal Resources
  - Oil and gas well permitting
- State Water Resources Control Board
- California Public Utilities Commission
  - SB 1386- Emission Performance Standards
  - Could potentially consider CCS when establishing electricity rates

California Energy Commission
Mike Gravely

OVERVIEW OF CCS RELATED ACTIVITIES IN CALIFORNIA

California Air Resources Board

CCS IN CALIFORNIA REGULATIONS AND QUANTIFICATION METHODOLOGY DEVELOPMENT

Cap and Trade Program

- Covers ~450 entities that emit more than 25,000 MTCO2e per year, including:
  - large industrial sources,
  - electricity generation and imports,
  - transportation fuels, and
  - residential and commercial use of natural gas
- Regulates direct emissions from facilities and upstream for fuels/some uses of NG
- Annual emissions reporting and third-party verification by ARB-approved verifiers
- Linked with Québec's Cap-and-Trade System

Potential Role of CCS in Cap and Trade

	Cap and Trade Requirements
CO_2 capture location	onsite at regulated facility
CO_2 storage location	not currently specified
Quantification methodology	must be adopted into the Regulation
Results in…	reduction in Cap and Trade compliance obligation at covered entities
Benefits to…	source of CO_2 captured emissions
Other	not eligible to generate offsets; consideration of reversals, enforceability, and long term liability in market program

Low Carbon Fuel Standard

- Nearly 160 active entities have registered for reporting in the LCFS Reporting Tool (LRT)
- Compliance tracked through a system of "credits" and "deficits."
  - Credits are generated from fuels with lower CI than the standard
  - Credits may be banked and traded within the LCFS market to meet obligations; do not expire
- Uses a life cycle assessment (LCA) approach for determining fuel CI, includes direct and indirect emissions

CCS in the Low Carbon Fuel Standard

	Tier 2 Fuel Pathway	Innovative Crude Provision
CO_2 capture location	anywhere along the fuel production pathway	onsite at the crude oil production facilities
CO_2 storage location	not specified	not specified; if third-party storage, must be joint applicant
Quantification methodology	required by ARB policy	required in regulation
Results in…	carbon intensity (CI) determination	credits, prorated on amount to California
Benefits to…	fuel pathway applicant(s)	crude oil producer opt-in as a regulated party or by the California refinery(ies) that purchase the crude
Other	consideration of reversals, enforceability, and long term liability in market program	

California's Emission Performance Standard

- Administered by the California Energy Commission and the California Public Utilities Commission
- Establishes a facility based standard for baseload generation of 1,100 lbs/MWhr CO_2
- Regulatory requirements for CCS project:
  - Includes capture, transport, and geologic injection of CO_2 emissions
  - Complies with all applicable laws and regulations
  - Includes plan that will result in permanent sequestration of CO_2
- Compliance based on projections of net emissions over the life of the power plant.

ARB'S REGULATORY ADOPTION PROCESS

ARB's Regulatory Adoption Process

- Informal development process
  - Public workshops; technical and policy discussions
  - Stakeholder outreach
  - Draft proposals
  - Process can take several years
- Rulemaking proceedings
  - 45-day public notice and comment period on proposed regulation
  - Public hearing(s)
  - Responses to relevant comments
  - Submit rulemaking action to the Office of Administrative Law

Post- Board Adoption

- Integrate newly adopted Regulation or Program into existing ARB or other entities' programs
  - Coordinate existing programs' needs
  - Possible regulatory updates to existing regulations
- Program Implementation
  - Stakeholder outreach, education
  - Develop reporting tools, other guidance documents
  - Establish contracts or MOU/MOA's, if necessary
- Program Review/Expansion
  - Evaluate implementation of program
  - Make necessary program updates to reflect new technologies

DEVELOPMENT OF ARB'S QUANTIFICATION METHODOLOGY FOR CCS

ARB's Quantification Methodology

- Mechanism for CO_2 reductions from CCS to be recognized in CARB regulations
- Ensure CO_2 reductions are:
  - Real
  - Permanent
  - Quantifiable
  - Verifiable
  - Enforceable
- Could potentially be used for both Low Carbon Fuel Standard and Cap-and-Trade, and possibly for Emission Performance Standard

ARB's Quantification Methodology

- Initial focus on geologic sequestration
  - Saline reservoirs
  - Depleted oil and gas reservoirs
  - CO2- enhanced oil recovery
- Future efforts will include:
  - Conversion to building products (e.g., cement, plastics)
  - Conversion to fuels
  - Direct air capture

Guiding Principles

Provisions of the QM should strive for:

- Protection of human health and the environment, safety
- Accurate accounting
- Permanent storage
- Leak prevention over mitigation
- Rigor and comprehensiveness with flexibility
- Robust scientific basis
- Verifiability and enforceability
- Exportability

ARB's Quantification Methodology

- Accounting and reporting protocols
  - Currently evaluating existing frameworks
  - LCFS requires a LCA approach - define project boundaries
  - Data verification requirements
- Site selection and characterization
  - Identify and assess long-and short-term risks
  - Define area of review
  - Requirements for remedial actions
  - Define requirements for monitoring and contingency plans

ARB's Quantification Methodology

- Site and injection operations
  - Injection well design- Class II vs. Class VI
  - Injection quantity and pressure limits
  - Monitoring, reporting and active site management
- Site Closure/Post Closure
  - Decommissioning
  - Monitoring
    - How long?
    - How often?
    - How comprehensive?

ARB's Quantification Methodology

- Long-Term Stewardship
  - Responsibility
    - Ensure emission reductions remain whole
    - Ownership transfer requirements
  - Financial liability

CO_2 Enhanced Oil Recovery

- Additional challenges
  - Potential for overall increased oil production, conflict with California's petroleum reduction goals
  - Uncertainty with site closure, unclear responsibilities for permanent CO_2 sequestration
  - Maximize for CO_2 storage vs. oil production
- Potential benefits
  - Additional revenue to offset costs of CCS
  - Potentially large storage potential
  - Reservoir pressure controlled by production
  - Historical knowledge of the storage reservoir
- ARB plans to include requirements more strict than Class II or similar

U.S. Department of Energy
Sarah Forbes

OVERVIEW OF U.S. DEPARTMENT OF ENERGY'S CCS PROGRAM

California Air Resources Board

NEXT STEPS

Public Process

- Public workshops-
  - Will cover QM development, Environmental Analysis of the QM, CCS policy development
  - Multiple locations in California
- ARB hosted technical and policy discussions- winter through summer 2016
- Ongoing stakeholder meetings
- Written comments will be posted online

Development Timeline *(tentative)*

Technical and Policy Discussions

- ARB hosted discussions on a variety of topics; receive feedback on concepts
- Format:
  - ARB established topics, identify specific questions for discussion
  - Webinar, conference call, and in-person
  - Provide advance notice of date/time~ 30 days
  - Presentations by stakeholders and open discussion
- April 5, 2016 - Accounting protocols
- April 28, 2016 - Well integrity, construction
- Contact person: Sara King, (916) 323-1009 or Sara.King@arb.ca.gov

Contact Info

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COMMENTS AND DISCUSSION