CCUS Capacity Building and Technology Adoption in Mexico

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ABSTRACT

Mexico has committed in the Paris Agreement to ambitious greenhouse gas reductions by 2030. Their plan to meet these goals, summarized in their CCUS Technology Roadmap in Mexico, includes widespread deployment of CCUS technologies in power and other industries and includes utilization applications, particularly enhanced oil recovery (EOR). One of the main objectives is to set commitments for CFE, the power company, and PEMEX, the oil and gas company, to develop integrated CCUS projects, using CO_2 from power for EOR.

Mexico recognizes that facilitating CCUS requires policy commitments, regulatory development, and technology advancement from pilot-scale to commercialization, but also workforce training. The Engineering School at the Autonomous University of Mexico (UNAM) and University of California's Berkeley Energy and Climate Institute (BECI) are collaborating to establish a Master's degree in engineering with specialization in CCUS and to explore international opportunities for joint research.

Keywords: carbon storage, carbon capture, Mexico, EOR, CCS, capacity development

1 INTRODUCTION

The Paris Agreement at the Conference of Parties (COP 21) of the United Nations Framework Convention on Climate Change provides a framework for countries to voluntarily undertake Intended Nationally Determined Contributions (INDCs) to reduce greenhouse gas (GHG) emissions and adapt to climate change. Mexico submitted its INDC document to the UN on September 21, 2016, pledging by 2030 to reduce its GHG emissions by 22 percent below business-as-usual baseline projections [1].

Mexico has identified CCUS as an important technology for meeting its greenhouse gas reduction goals. In Mexico, 60 percent of emissions are from energy, with power generation and transportation each accounting for about one-third of energy-related emissions. To implement CCUS technology in Mexico, the Secretary of Energy (SENER), with assistance from other agencies, completed a Roadmap for CCUS Technolgy in Mexico [2]. As part of the Roadmap, SENER has sponsored a collaboration between the Universidad Nacional Autónoma de México (UNAM) and the University of California Berkeley's Energy and Climate Institute (BECI) to create a workforce trained in all aspects of CCUS. Training covers the four areas critical to CCUS deployment: capture, transport and utilization technologies; geological storage and monitoring; legal and regulatory issues; and social and economic issues. The program is designed to provide a workforce to support CCUS technology development.

2 CCUS TECHNOLOGY ROADMAP

Several stages of CCUS technology development and deployment were identified in the Roadmap:

- Incubation
- Public Policy
- Planning
- Pilot tests-Enhanced Oil Recovery, Power Plant Capture
- Commercial-scale demonstration-Enhanced Oil Recovery, Power Plants
- Commercial adoption

These stages, which began in 2014, may overlap in time, however any foundational activities for the next stage must be completed to assure sequential and uninterrupted development.

During the three-year Incubation stage, analysis of carbon markets and regulatory frameworks were performed, and national and international collaborations and funding mechanisms were identified. During the Public Policy stage, which has a 10-year time-span, four main elements are underway:

- Capacity Building, of which the UNAM-BECI collaboration is a major element;
- Regulatory Framework Adjustments to facilitate pilot, demonstration, and commercial-scale projects;
- Legally Binding Observation for Permanent Monitoring, which defines obligations and responsibilities of project developers; and
- Dissemination of the Technology Implementation Plan, which will provide CCUS outreach and

- education to stakeholders, such as the public, local governments, and institutions with interests in sustainability.

The Planning Stage will establish specific strategies within the first two years, with reviews every three years, for Mexico's two largest CO_2 emissions industry sectors (power generation and oil and gas) with the goal of integrating planning activities for the pilot, demonstration, and commericial stages.

Planning strategies will include:

- CCUS applications to power plants, including opportunities for CO_2-EOR;
- Estimation of saline storage capacity;
- Analysis of fields suitable for CO_2-EOR, with down-selection and prioritization;
- CO_2-EOR strategy and planning specific to PEMEX and CFE facilities for pilot and demonstration projects; and
- Strategy for ensuring supply and demand of captured CO_2 for EOR at medium- and large-scale over the long term, to be updated every three years.

Two Pilot Projects will be undertaken over a two-year period, one in the oil industry, involving CO_2-EOR, with an emphasis on understanding the storage reservoir, and one in the power industry, focused on the technical and economic feasiblity of capture. The EOR pilot will:

- Evaluate the feasibility of injection, considering adjustments of well and surface infrastructure to accommodate CO_2 handling and injection;
- Include laboratory tests under reservoir conditions to study miscibility, oil swelling, and viscosity reduction;
- Perform numerical reservoir simulations to estimate the additional oil recovery due to CO_2 injection and to provide a basis for other technical and economic assessments; and.
- Perform a field injection, monitoring and assessment of simulations compared to field data on CO_2 breakthrough, degree of trapping, and additional oil recovery.

The power pilot goal is to capture CO_2 from a 2MW power plant to achieve a flow rate of 10 tonnes/day (<20 kt CO_2/year). The pilot will:

- Select a coal- or natural gas-fired power plant suitable for future integrated PEMEX-CFE CCUS projects;
- Perform an assessment and cost-benefit analysis of capture technologies for the selected plant;
- Establish the design, technical specifications and project costs for a tender to construct the pilot plant;
- Commission and construct a capture plant at the selected power plant; and
- Acquire scalable data during operations such as capture efficiency and energy penalty.

Following the pilot stage, a medium-scale Demonstration project (20MW plant, <500 kt CO_2/year) will be developed, storing CO_2 in a saline reservoir. The demonstration project will:

- Use geological characterization and simulation to determine the saline reservoir conditions for injectivity and caprock security and to assess leakage risk;
- Apply scale-up of pilot project results to determine technical and economic specifications for a tender;
- Issue a tender for construction;
- Apply for environmental permits and perform environmental assessments, including right-of-ways for pipelines;
- Engage the public and communities located near the plant;
- Implement a monitoring plan, including baseline data collection, based on modeling of the CO_2 migration extent over time, including well and seismic data;
- Commission and construct the project facilities; and
- Perform injection and monitoring.

The Commercial stage will begin after the results of the pilot and demonstration projects are analyzed to resolve technical risks and socio-economic issues. At this point, CCUS technology may expand to other CO_2-emitting industries, assuming implementation costs and policy incentives promote widespread project development. By this point, CCUS should be handling significant volumes of emissions. The first commercial-scale CCUS-EOR project(s) will be field-scale, scaled up based on pilot and demonstration project data. A nationwide assessment of the proximity and economics of capture for large-scale CO_2 point sources should have been completed to plan and prioritize the development of a CCUS capture-pipeline transport-storage national network, based on source locations (Figure 1) and storage resources (Figure 2). Also, Mexico's CCUS industry should be participating in international carbon markets and adhering to international standards for monitoring, verification, and accounting to assure permanent CO_2 storage.

3 CAPACITY BUILDING

The CCUS capacity building program includes a strong element of workforce development. This element includes providing training and international knowledge exchange for faculty and professionals in Mexico who will be instrumental in training the next generation of CCUS professionals and in executing the stages of the Roadmap. It also includes developing undergraduate and graduate education programs and international research collaborations.

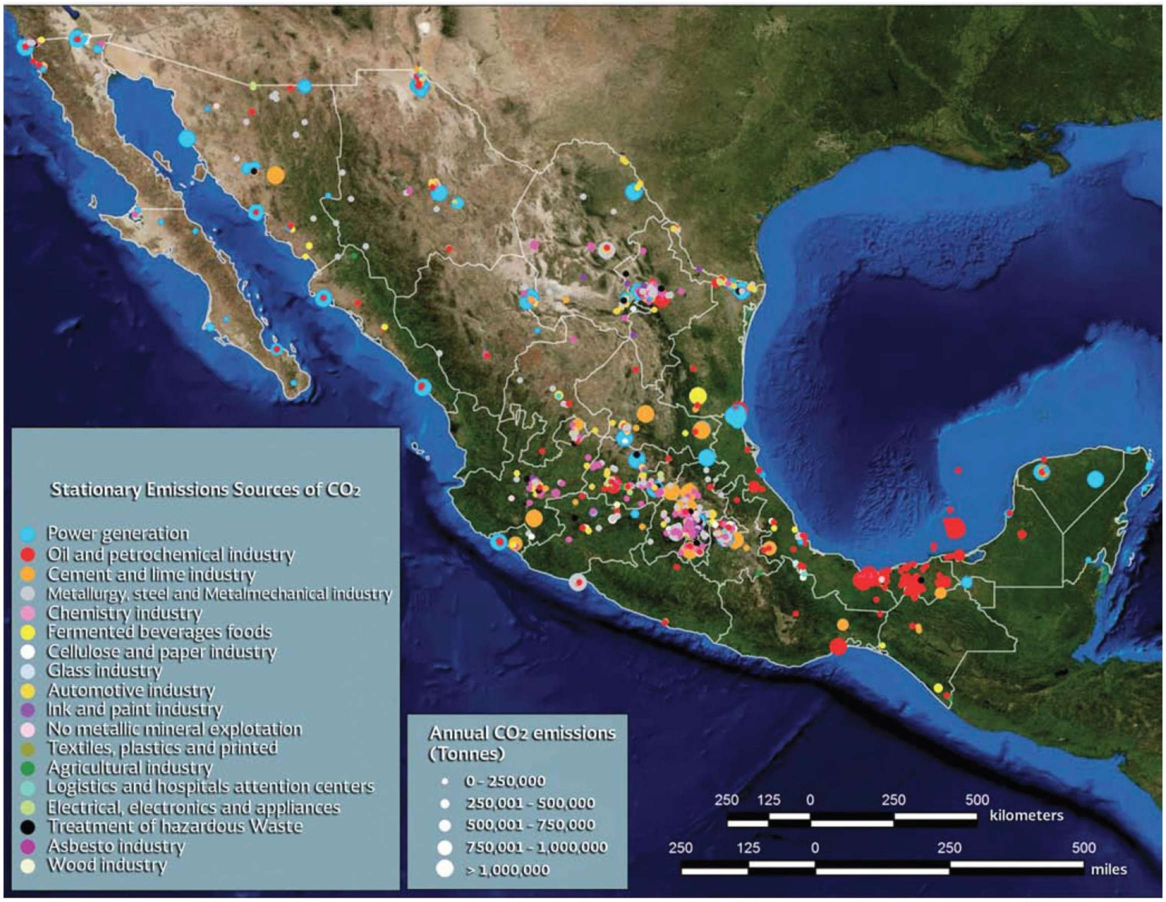

Figure 1: Stationary Emissions Sources of CO_2 in Mexico [2].

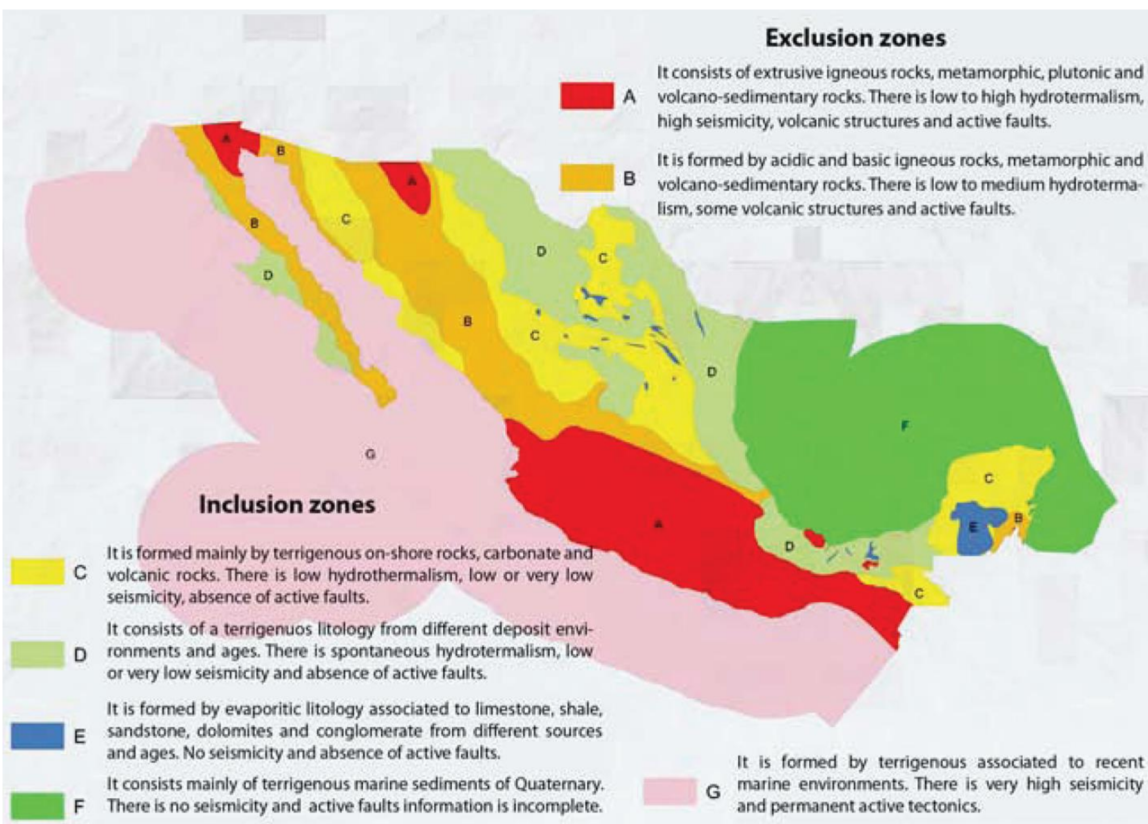

Figure 2: Storage assessment of Mexico's eleven geologic provinces [2].

In 2014, the Asia-Pacific Economic Cooperation (APEC) funded the Global CCS Institute to hold several workshops aimed at professionals and undergraduate students. These workshops, in Mexico City and Hermosillo, provided a basic overview of CCUS technology.

The first stage of capacity development through graduate education began in 2016 as a joint collaboration between the UNAM and BECI at the University of California. This collaboration will develop graduate courses leading to a specialization in CCUS for Masters in Engineering students. Students and faculty will also have opportunities to participate in international CCUS education programs, take internship assignments at CCUS projects, and perform CCUS thesis research.

Capacity development will also include joint research activities on CCUS technology between Mexican and international researchers. Mexico is in the process of establishing a multi-institutional CCUS Research Center for the purpose of facilitating these research collaborations.

A review of CCUS education programs and textbooks shows that most emphasize the technical aspects of capture, transport, and storage—e.g., CCUS applications within disciplines such as mechanical or chemical engineering, materials science, geology, or petroleum engineering [e.g., 3,4,5]. However, the worldwide experience in CCUS projects to date shows that projects typically fail due to nontechnical reasons, such as lack of a business case, lack of policy support, or because of perception issues or stakeholder opposition [6, 7].

Consequently, the graduate CCUS courses at UNAM will not only train engineers across technical disciplines, but also provide coursework in legal, regulatory, economic, and sociopolitical issues. Generally, engineering students are unlikely to be exposed to this training. For successful CCUS technology adoption, or for that matter, adoption of any new technology by the public and policymakers, engineers should understand they have an important role in integrating technical knowledge into policy development, accommodating nontechnical considerations into technical designs, and in making technology understandable and acceptable to a wide audience of stakeholders.

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