

CCS IN MEXICO AND ASSOCIATED COSTS

Rodolfo Lacy
Mario Molina Center

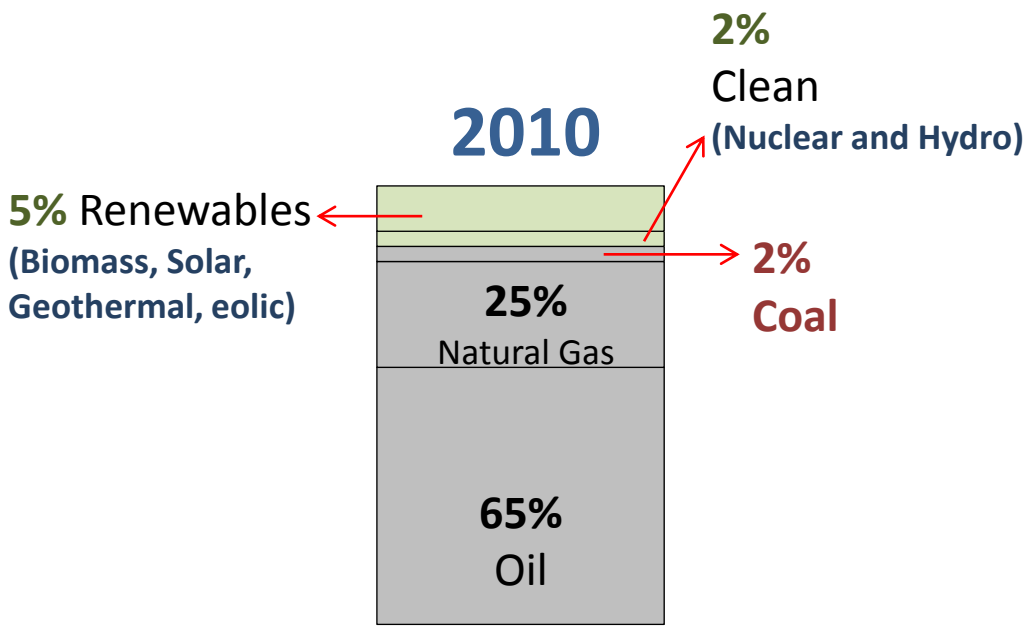
Centro Mario Molina
INSTITUTO DE INVESTIGACIONES ELECTRICAS
PEMEX
CFE
IMP
INSTITUTO MEXICANO DEL PETRÓLEO

IEA-SENER Joint Workshop
CCS in Mexico: Policy Strategy Options for CCS
March 2012

National Energy Strategy







…by 2026 fossil fuels will account for almost 65%

*Estrategia Nacional de Energía, 2012

Demonstrative Project CCS+EOR status



IEA workshop

CSLF workshop

Energy National Strategy presentation

National Strategy for **CCUS**

Mexican Atlas for CO_2 Geological Storage

EOR/EGR incorporation

Demonstration Project

2012 FEB MAR JUN AUG OCT 2013 2014 2015-2019

COST STUDY, World Bank (1.2 MUSDlls)

Basic Engineering, IIE (325 mil USDlls)

PILOT PLANT CONSTRUCTION AND OPERATION

Announcement **Sustentability Fund**

CONTRACT consortium Integral Project (Pilot Plant+EOR)

Integral Project

Pilot Plant + EOR



As part of the National Energy Strategy, a CCS+EOR demonstration project is being considered in order to reduce CO_2 emissions from CFE power plants and use that CO_2 for EOR operations within PEMEX fields.

The CCS Mexican Group* decided to pursue the design and construction of a Pilot Plant for capturing CO_2 emissions. The plant will added to a CFE Power Plant in Poza Rica, Veracruz, in the Gulf of Mexico region**.

The Integral Project will also include the transportation of CO_2 to near production sites where PEMEX will use for EOR activities.



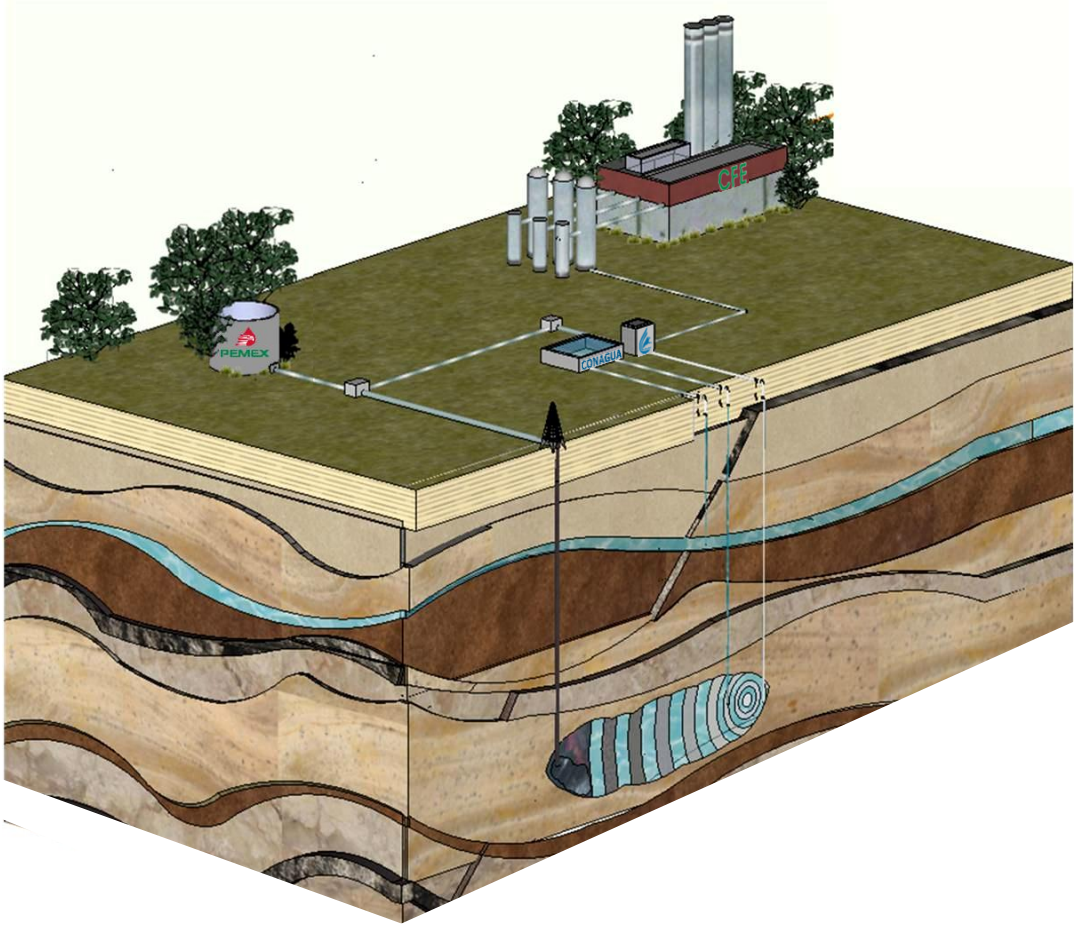
2 MW Pilot Plant
Charleston, West Virginia, USA

* Members: PEMEX, CFE, Ministry of Energy, Electrical Research Institute, Mexican Petroleum, Institute, Mario Molina Center, among others

**The experience and experience obtained from the Pilot Plant will be an important source of information for the design of a large scale CO_2 capture system for the demonstration project.

CCS+EOR Proposal





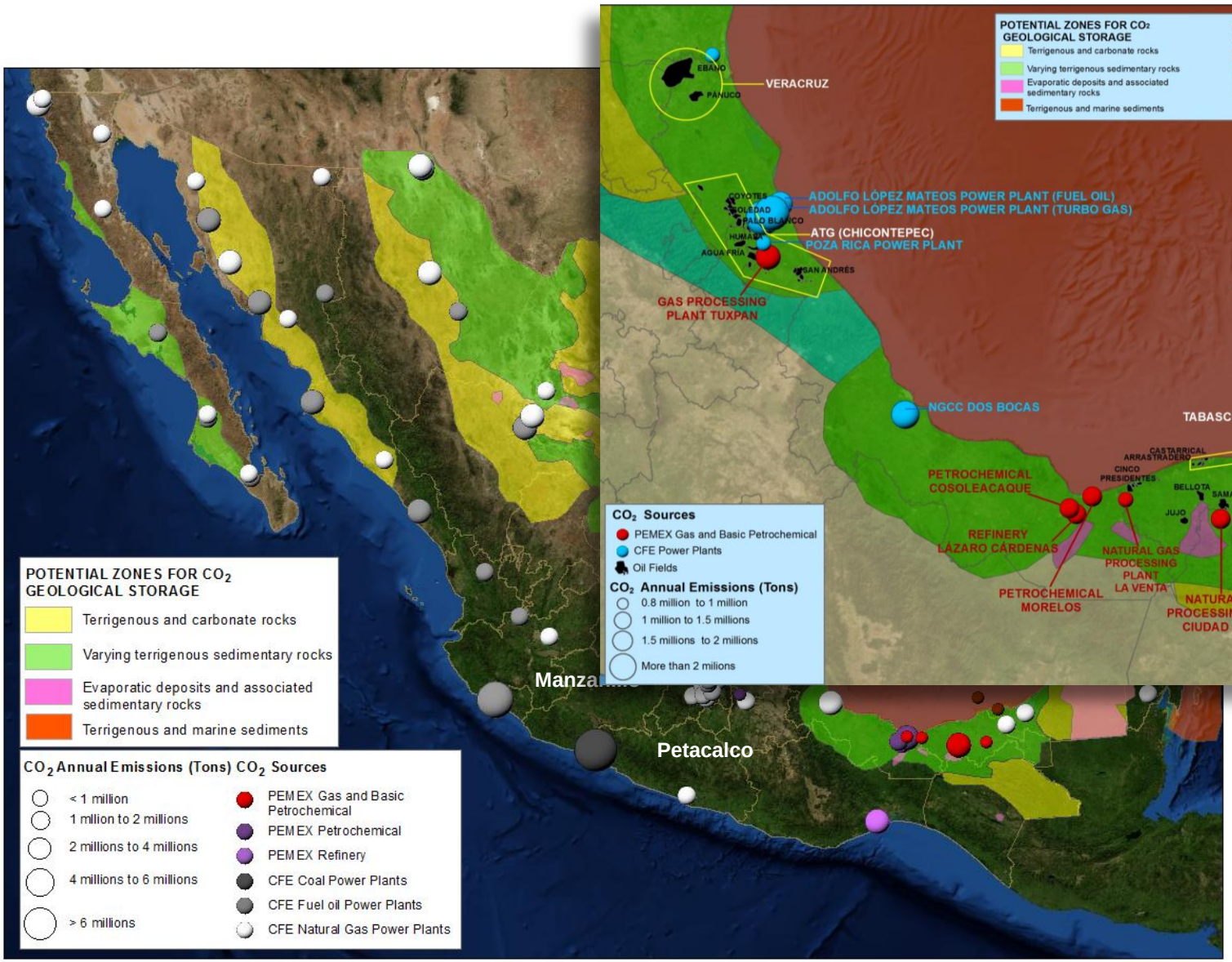
It is planned that the first carbon capture project that will take place in Mexico must be a **CCS+EOR** form. This strategy will enable Mexico to start utilizing this low-carbon emission technology

One of the main factors that support such a project is that the CFE, PEMEX, and geological reservoirs are state-own enterprises and assets

*CCS+EOR. *Carbon Capture and Storage + Enhance Oil Recovery*

CO_2 Sources in Mexico
2009

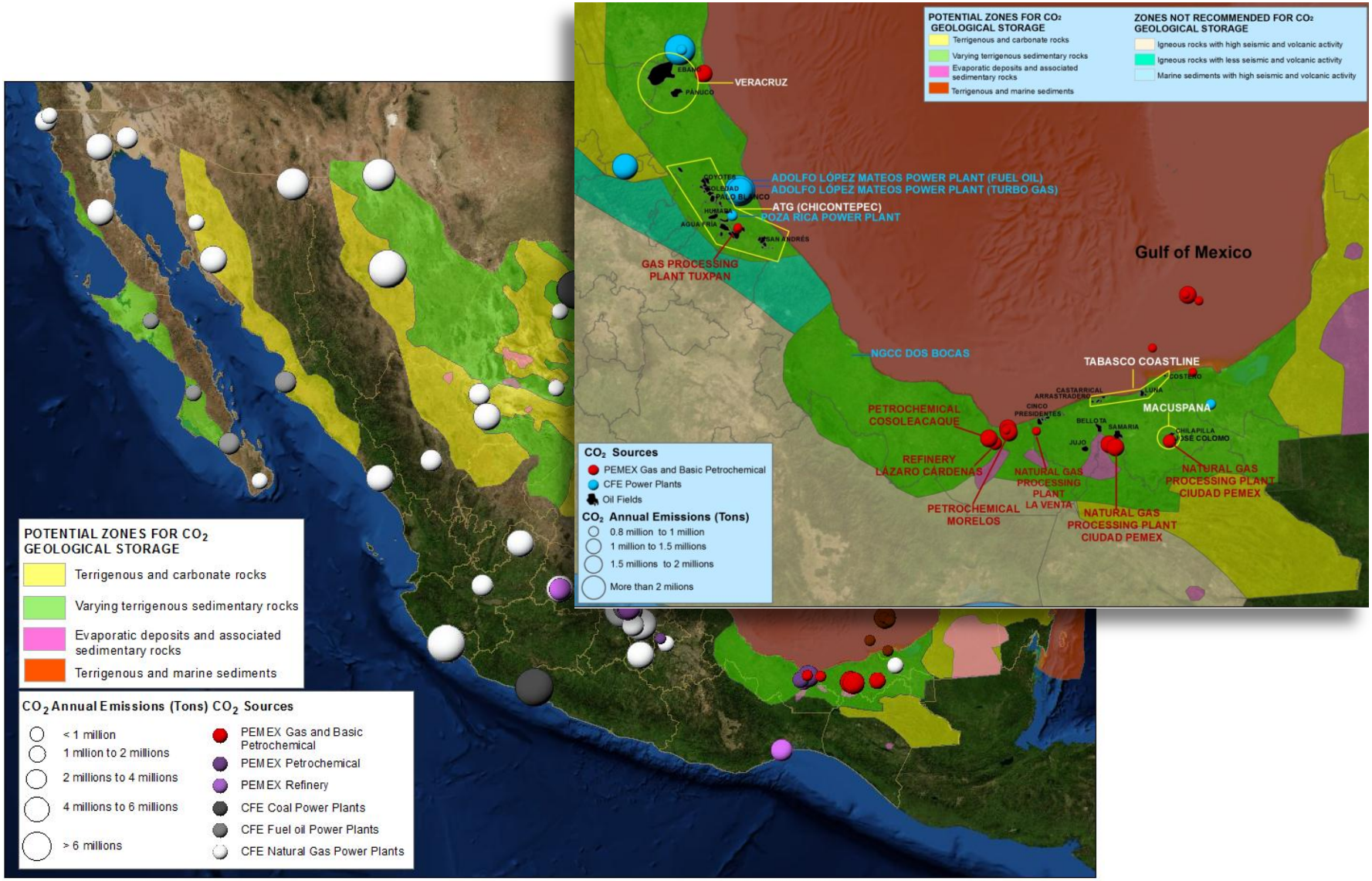




CO_2 Sources in Mexico

Projections to 2025





CO_2 emission sources



CO_2 emission sources (>500,000 ton/year) in Veracruz state

Company Name	Sector	Town	CO_2eq (2008)	CO_2eq (projection to 2025)
CFE Central Termoeléctrica Adolfo López Mateos	Energy Generation	Tuxpan	4,364,184	4,318,360
Fuerza y Energía de Tuxpan S.A: de C.V.	Energy Generation	Tuxpan	2,662,755	2,634,796
PEMEX Complejo Petroquímico Morelos	Oil and Petrochemical Industry	Coatzacoalcos	1,792,074.0	2,240,093
PEMEX Complejo Petroquímico Cosoleacaque	Oil and Petrochemical Industry	Cosoleacaque	1,714,444.6	2,143,056
PEMEX Refinería Lázaro Cárdenas	Oil and Petrochemical Industry	Minatitlán	1,540,040	1,955,851
Central Ciclo Combinado, Dos Bocas	Energy Generation	Medellín	1,287,484	1,314,650
Central Turbo Gas, Adolfo López Mateos	Energy Generation	Tuxpan	1,479,082	1,463,552
Electricidad Águila de Tuxpan S. de R.L. de C.V.	Energy Generation	Tuxpan	1,388,296	1,417,589
Cementos Apasco S.A. de C.V.	Cement Production Industry	Ixtaczoquitlan	974,048	1,051,113
CFE Central Termoeléctrica Poza Rica	Energy Generation	Tihuatlan	227,212	573,048*

* Taking into account the planned power increment, refitted to natural gas, and an increment in the capacity factor

CO_2 emission sources (>500,000 ton/year) in Tabasco state

Company Name	Sector	Town	CO_2eq (2008)	CO_2eq (projection to 2025)
PEMEX Gas y Petroquímica Básica. Complejo Procesador de Gas Nuevo PEMEX	Oil and Petrochemical Industry	Centro	2,140,544	2,782,707
PEMEX Exploración y Producción. Estación de Complejo Procesador de Gas Ciudad PEMEX	Oil and Petrochemical Industry	Macuspana	1,091,740	1,419,262
Cementos Apasco S.A. de C.V. Planta Macuspana	Cement Production Industry	Macuspana	567,342	612,228

Estimated Costs



Centro Mario Molina evaluated in 2009 different alternatives for power generation plant with petroleum coke and carbon, combined with EOR in Mexico. It was concluded that fluidized bed boiler was the best economic option

COSTS OF CCS + EOR* OPERATIONS IN MEXICO
(USD/MWh)

	TECHNOLOGY OPTIONS				
	IGCC 150 MW	IGCC 300 MW	PCSC 300 MW	FLUIDIZED BED 300 MW	NGCC 250 MW
Power generation leveled cost	177.40	155.81	159.51	155.73	110.06
Transport/Compression leveled cost	22.92	10.54	10.32	16.41	6.06
Injection/Storage leveled cost	0.60	0.31	0.24	0.24	0.32
Total leveled cost	**200.92**	**166.66**	**170.07**	**172.38**	**116.44**
EOR	97.50	97.50	101.10	111	50.40
Total leveled cost with EOR	**103.42**	**69.16**	**68.97**	**61.38**	**66.04**
CO_2 value (externalities) **	11.73	11.73	12.17	13.36	6.07
Total leveled cost with EOR and externalities	**91.7**	**57.4**	**56.8**	**48.02**	**59.9**

*CCS. *Carbon Capture* and Storage EOR. Enhanced Oil Recovery with a $60 USD price per barrel. Obtaining 2.5 barrels per ton of CO_2 injected

**Calculated according to the externalities methodology adopted by the Mexican Ministry of Energy in 2009

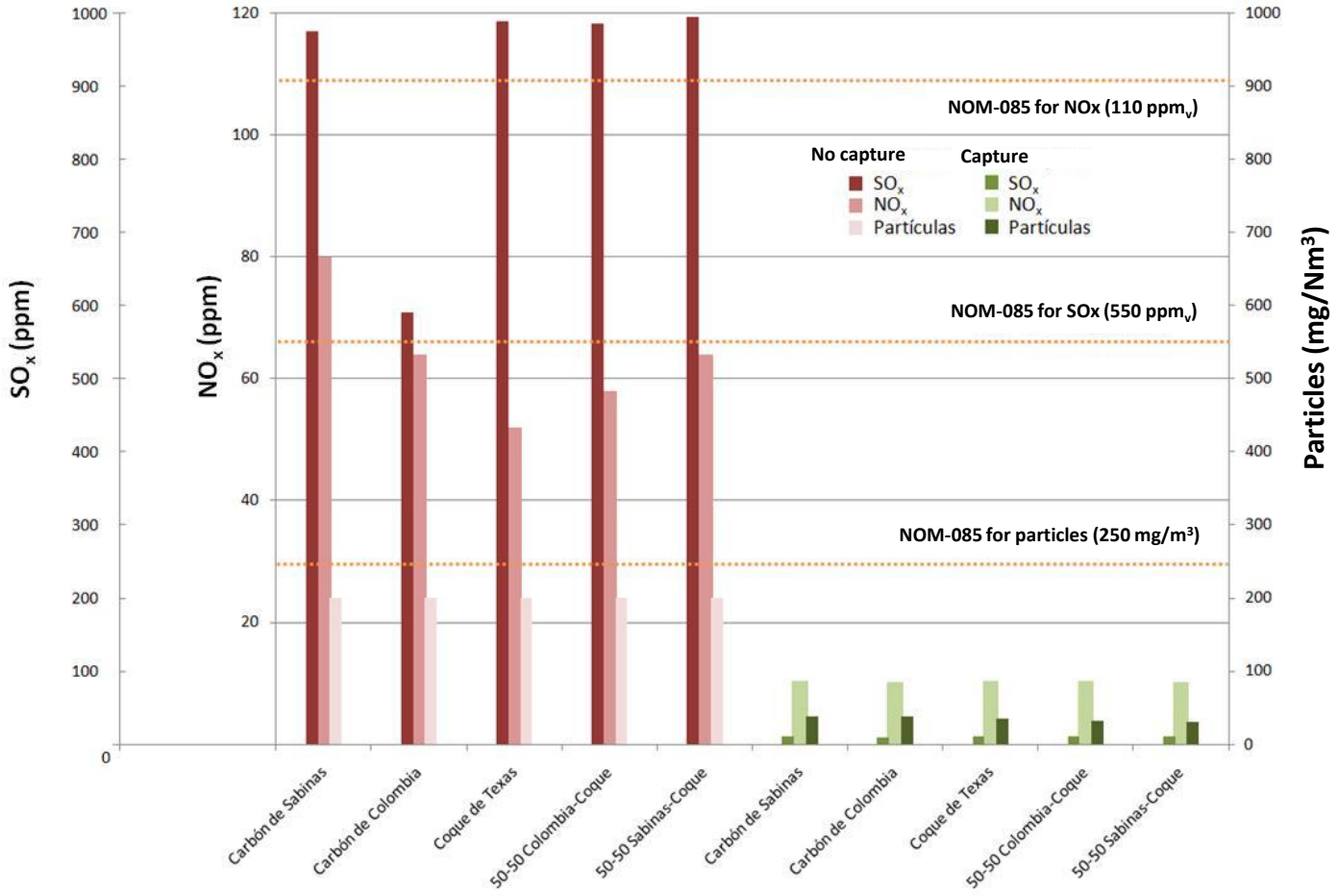
SOURCE: CMM, 2009. Proyecto Demostrativo para Generar Energía Eléctrica a partir de Combustibles Fósiles libre de Emisiones de Gases de Efecto Invernadero.

TUXPAN

AIR EMISSIONS



Levels of contaminant emissions expected from one unit at the power generation plant in Tuxpan WITH and WITHOUT CO_2 capture system*



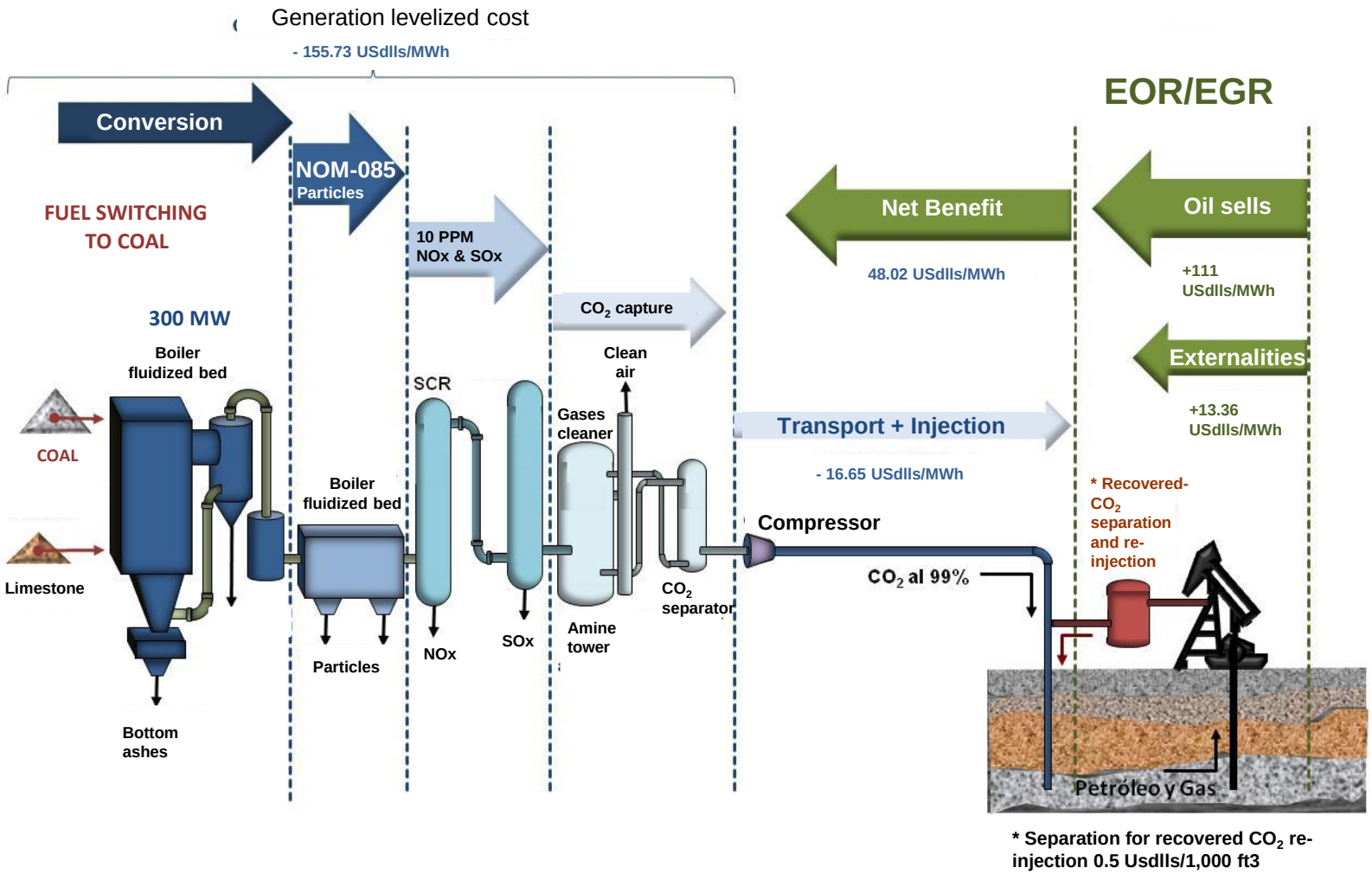
*The CO_2 capture system requires an influent with NOx and SOx concentrations within the 10-20 ppm range

CCS + EOR

First Approach: Tuxpan Power Plant



General operation diagram*



* Esimated costs by Centro Mario Molina (being corroborated by PEMEX and IIE)

CO_2 Capture Costs

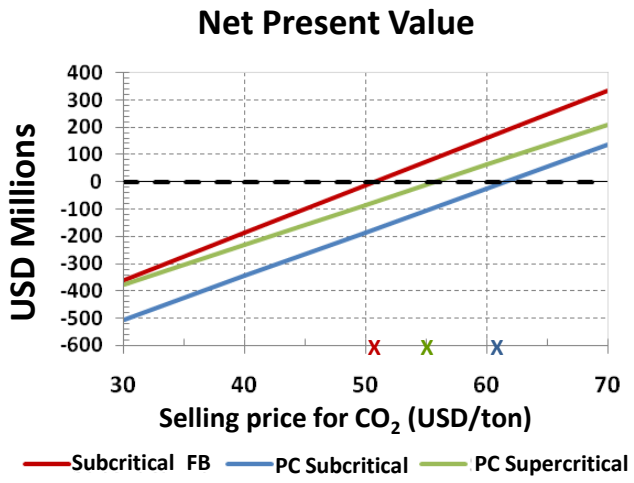


Equivalent anual cost for the CO_2 capture process (using amine) for one unit within the Tuxpan CFE facilities using 100% carbon fuel



GENERATION UNIT	Capture trains	USD	USD/year	USD/year	USD/year	t/year	t/year
		Inversion at Present value 2011	O & M CO_2	Fuel CO_2	Compression CO_2	CO_2 captured	CO_2 Avoided
Fluidized Bed	7	44,042,710	15,811,018	18,756,075	30,920,647	2,159,456	1,598,674
SUBCRITICAL Pulverized Carbon	7	64,149,578	15,537,853	18,165,633	34,232,079	2,143,655	1,599,301
SUPERCRITICAL Pulverized Carbon	6	47,828,111	14,249,157	16,801,261	30,313,648	1,957,405	1,453,836

In this option, PEMEX would acquire the captured CO_2. A sensibility analysis was also carried out to evaluate recovery cost for CO_2 ton thus the investment on capture system and its operation will not result in economic losses

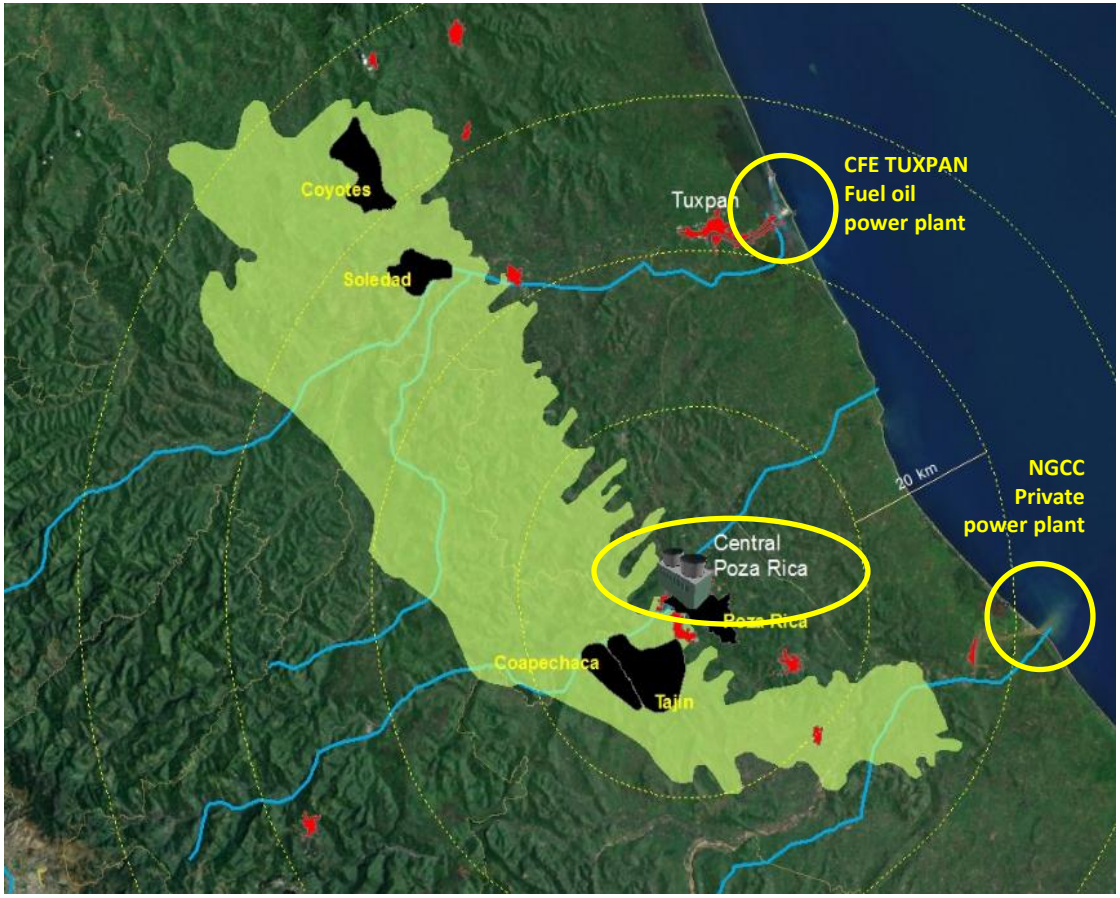


EOR sites in the Chicontepec Region



The initial proposal was to run the demonstration project in the Tuxpan Power Plant that would be refitted to use coal as their primary source.

However, due to CFE strategic decisions, it was decided to have the CCS project in the NGCC Power Plant located at Poza Rica. The first stage is the implementation of the Pilot Plant where the first arrangements for EOR will be implemented.



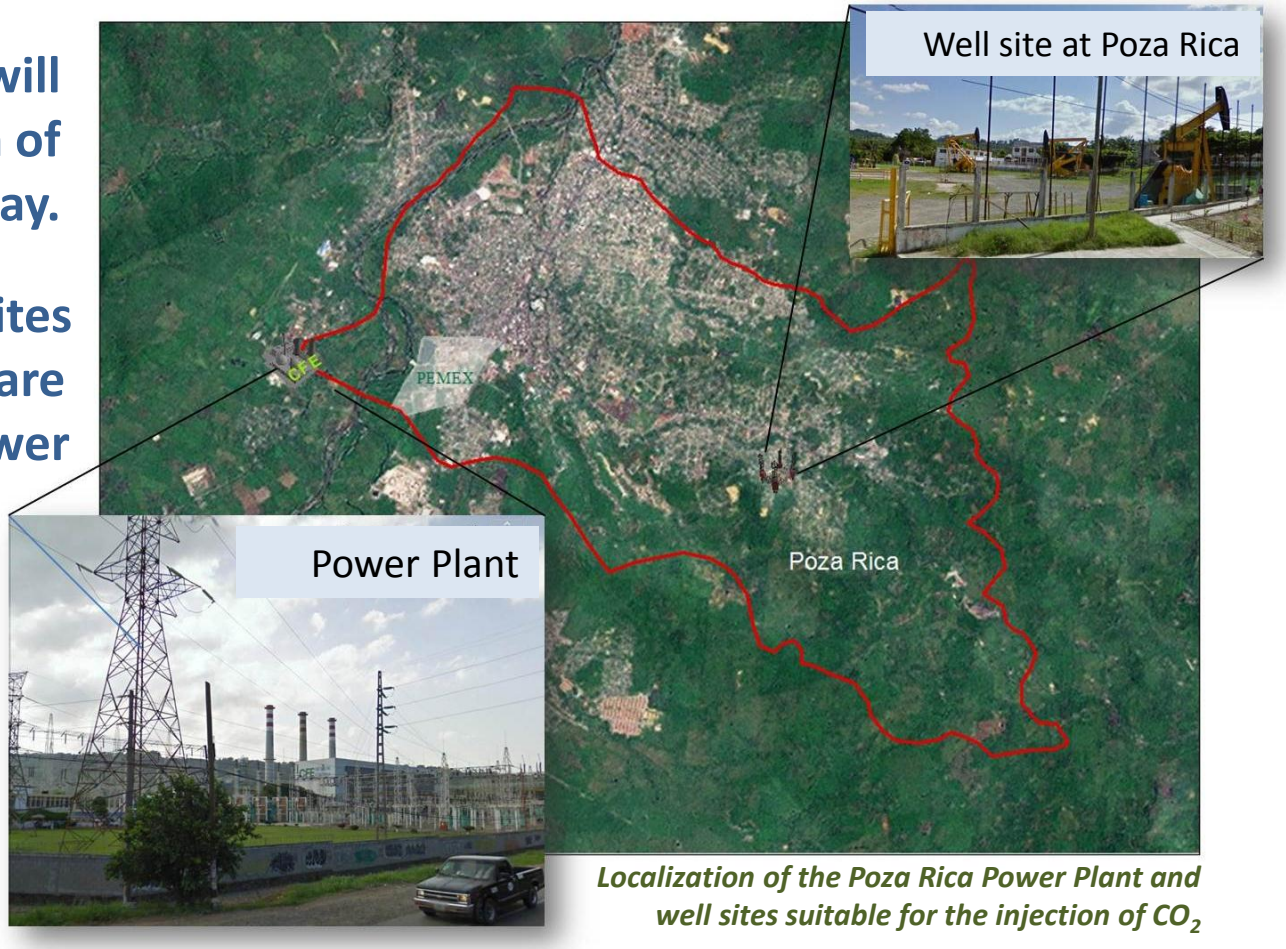
Oil sites located at Chicontepec Region that might be suitable for EOR operations

Power Plant and well sites at Poza Rica



The Pilot Plant will capture up to 8 ton of CO_2 per day.

PEMEX has several well sites located at Poza Rica that are relatively close to the Power Plant facilitating the transport of the CO_2.

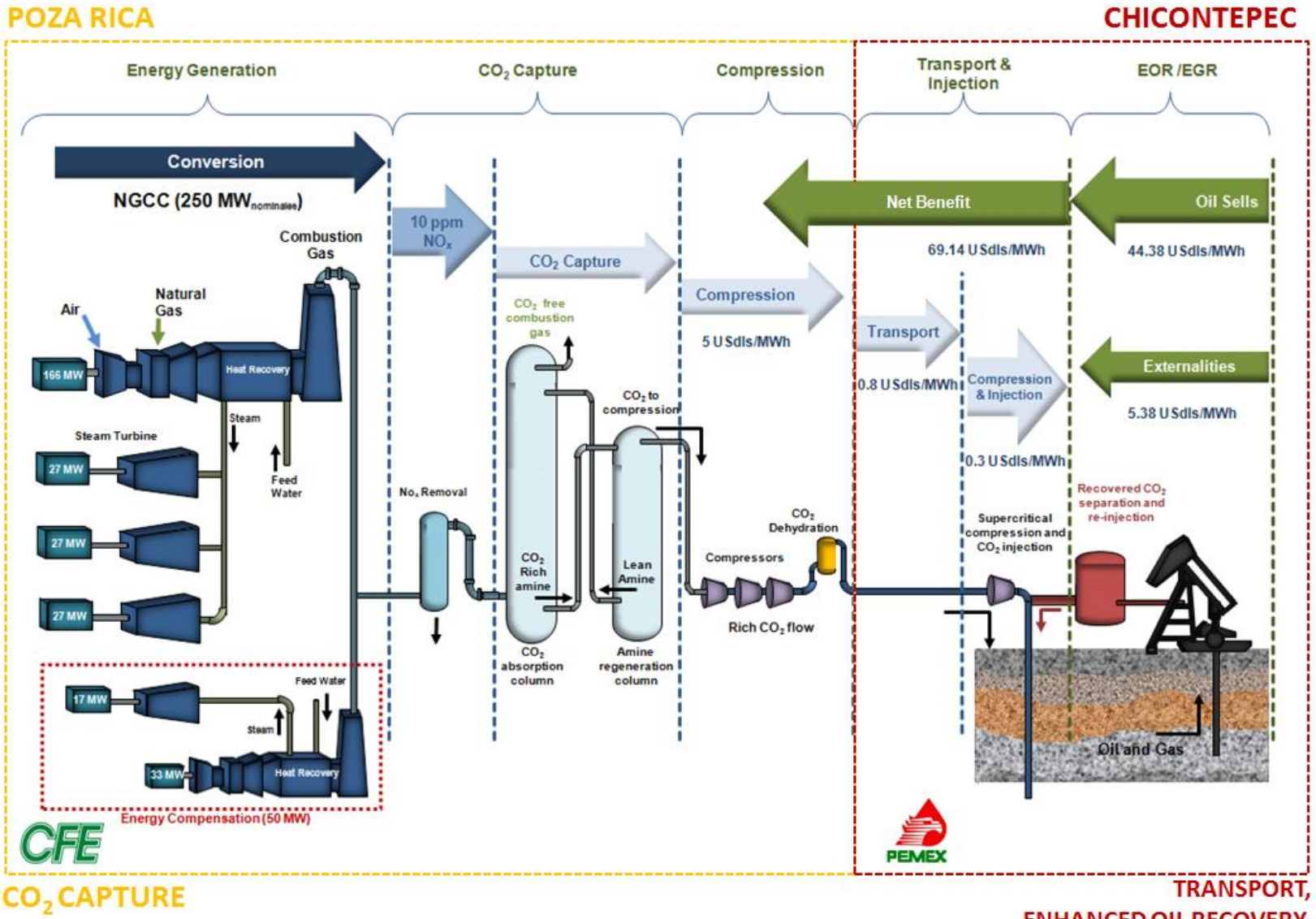


Localization of the Poza Rica Power Plant and well sites suitable for the injection of CO_2

Demonstration Project



General scheme for the CCS+EOR demonstration project between CFE and PEMEX



Source: Mario Molina Center

Levelized Costs

CCS+EOR



Levelized Costs	NGCC Power Plant 250 MW (Usdlls/MWh)
Generation (including gas cleaning and capture)	113.12
Compression and pumping	5.00
Transport*	0.80
Injection and Storage	0.30
Total levelized cost	**119.22**
Oil benefits	**-44.38**
Total levelized cost including EOR**	**74.84**
Monetary value of avoided CO_2 ***	**-5.38**
Total levelized costs (including environmental externalities and EOR)	**69.14**

* Basd on a 30 km distance from the injection point.

** Calculated with the selling of a 60 USD barrel , recovering 2.5 barrels per each CO_2 ton injected, without considering the natural gas natural obtained simultaneously from the well.

*** Calculated based on the SENER environmental externalities methodology used in 2009.

Source: Centro Mario Molina, preliminary estimations

PILOT PLANT
Integral Operative System



Amine providers

2 opertors

Electrical Research Institute

CFE

Combustion gases equivalent to a 2MW plant

Electricity

Vapor

Cooling water

NGCC
Poza Rica

CO_2

Solid and liquid residuals

Laboratory

PEMEX

Aditional CO_2

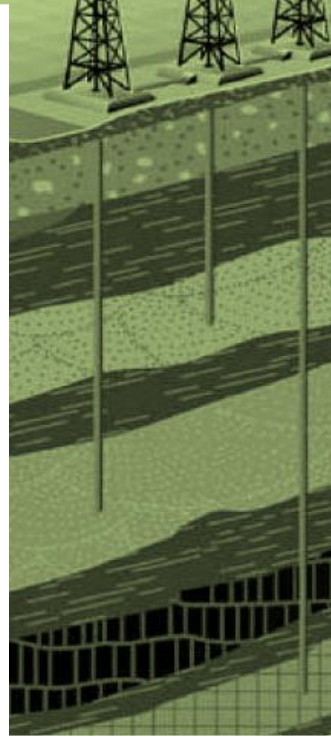
CMM

Mexican Petroleum Institute

PEMEX Exploration







THANK YOU

Centro Mario Molina

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