



World Bank Pre-Feasibility Study for Establishing a Carbon Capture Pilot Plant in Mexico

Contract 7175527

2016 NETL CO₂ Capture Technology Project Review Meeting

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August 8, 2016

Acknowledgements

The project was conducted under funding from The World Bank and in collaboration with several Mexican government organizations, of which we would like to acknowledge the support and contributions of the following –

The World Bank – Dr. Natalia Kulichenko, Dr. Frank Mourits, Dr. Moises Davila and Mr. Guillermo Hernandez Gonzalez; Professor Jon Gibbins of UKCCS as a Technical Advisor to the World Bank team

SENER (Department of Energy of Mexico) – Ms. Jazmin Mota Nieto

CFE (Comision Federal de Electricidad) – Mr. Agustin Herrera

IIE (Electrical Research Institute) – Mr. Jose Miguel Gonzalez

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Project Background

As part of the overall World Bank funded effort to develop capacity for carbon capture, utilization and storage technology (CCUS) in Mexico, the Nexant Team was tasked to perform a feasibility study to:

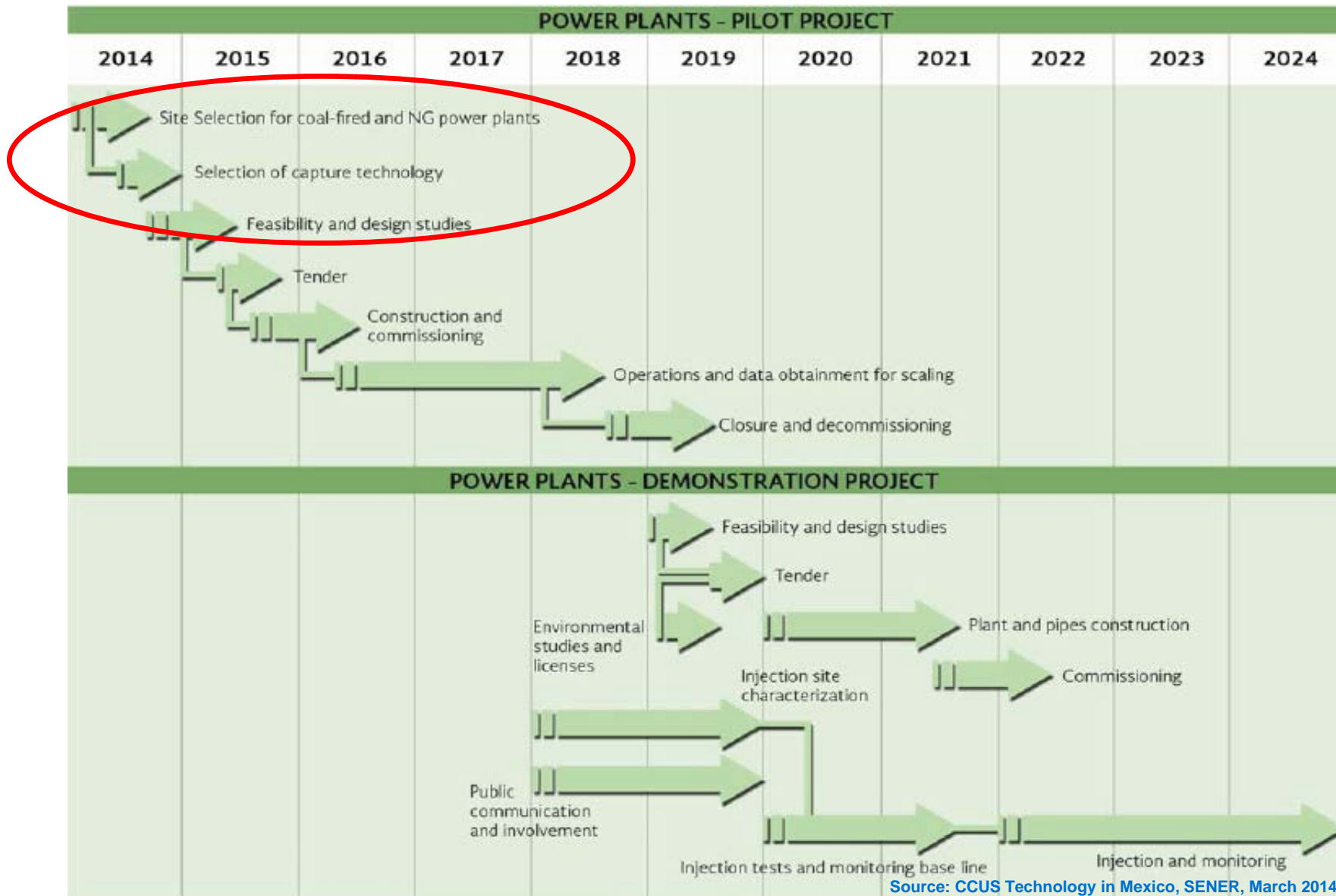
- Task 1: Evaluate and recommend the most appropriate commercially- available post-combustion CO₂ capture technology for NGCC power plants in Mexico, and
- Task 2: Develop a conceptual design for a CO₂ capture pilot plant to be located at the 250 MW Poza Rica generation station in the state of Veracruz

The conceptual design would lead to a next phase (Phase II) of the project to develop a Front End Engineering Design (FEED) package for the capture pilot plant.

Current presentation will only cover the Task 1 work scope and results. A copy of the entire report can be found on the SENER website at -

<http://www.gob.mx/sener/en/documentos/pre-feasibility-study-for-establishing-a-carbon-capture-pilot-plant-in-mexico?idiom=en>

Technology Roadmap for CCUS in Power Plants



Task 1 – Approach and Activities Performed

Site Selection:

- ❑ **250MW Poza Rica NGCC Generating Station, located in State of Veracruz**
- ❑ **Preliminary site and plant data provided by CFE**

Obtain data from CO₂ Capture Technology Providers:

- ❑ **Study will only focus on post-combustion CO₂ capture (PCC)**
 - **World Bank/SENER's interest in near-term technology deployment**
 - **Advanced amine-based absorption process for PCC nearest to commercialization**
- ❑ **Prepared and issued “Request for Information” (RFI) to ten (10) technology developers/vendors; Six (6) agreed to participate in the study.**

Task 1 – Approach and Activities Performed

Site Selection:

- ❑ 250MW Poza Rica NGCC Generating Station, located in State of Veracruz
- ❑ Preliminary site and plant data provided by CFE

Obtain data from CO₂ Capture Technology Providers:

Participating PCC Technologies

- *Alstom Advanced Amine Process*
- *BASF/Linde*
- *Fluor*
- *HTC*
- *MHI*
- *Shell Cansolv*

Task 1 – Approach and Activities Performed (Cont'd)

Design Basis:

- ❑ Established based on Poza Rica NGCC battery limit data
- ❑ Consistent interface information is provided to participating PCC technology vendors
- ❑ 85% CO₂ capture rate

Pre-PCC Power Plant Simulation:

- ❑ Developed Thermoflex model of existing Poza Rica NGCC

Reference PCC Design:

- ❑ Established a *full-size* generic amine (30 wt% MEA) PCC plant design for Poza Rica NGCC
 - Estimated cost and overall power plant performance
 - Serve as the reference CO₂ capture case for comparison with proprietary PCC technologies

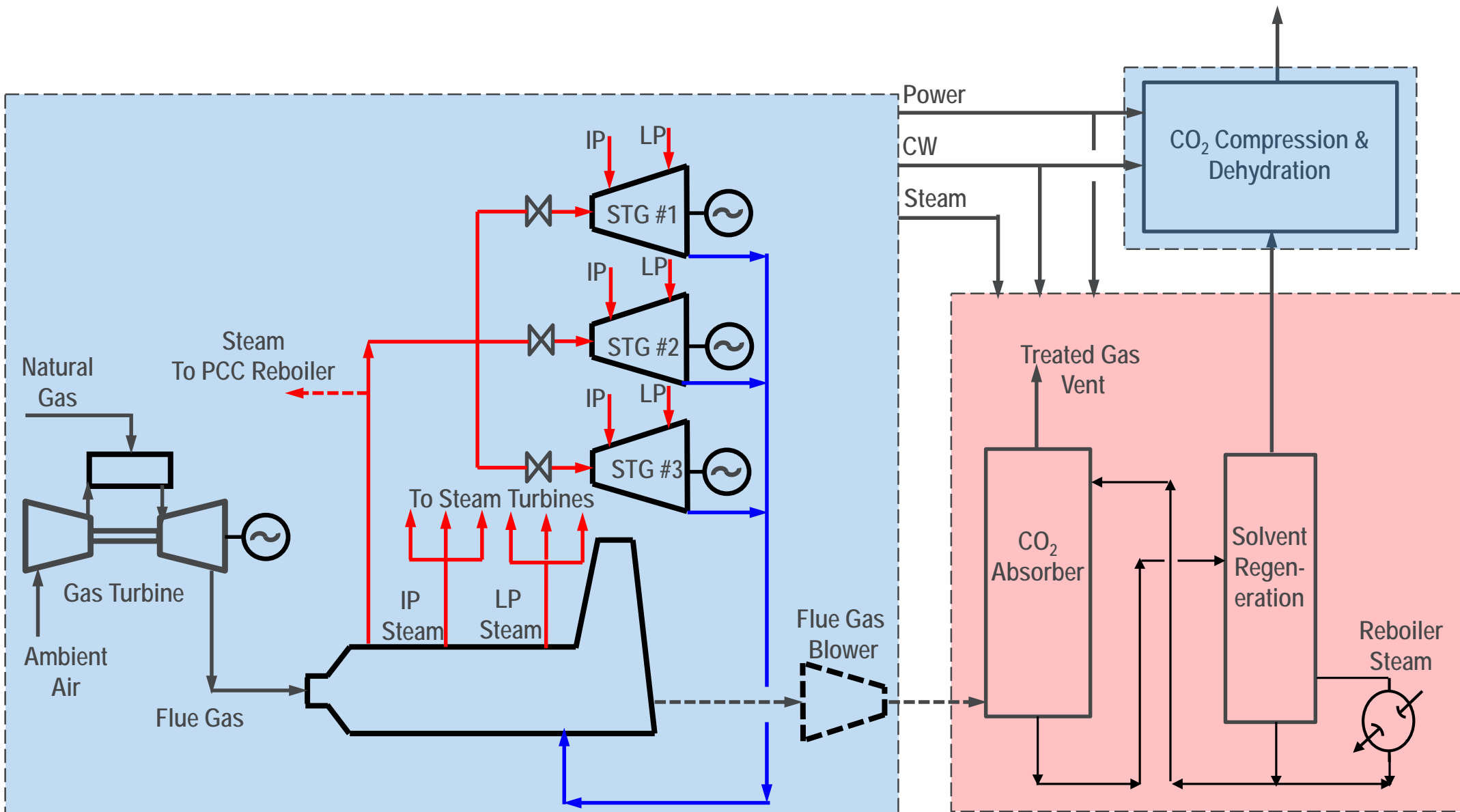
Task 1 – Approach and Activities Performed (Cont'd)

Integrated NGCC/Full-Scale Advanced Amine PCC Technology

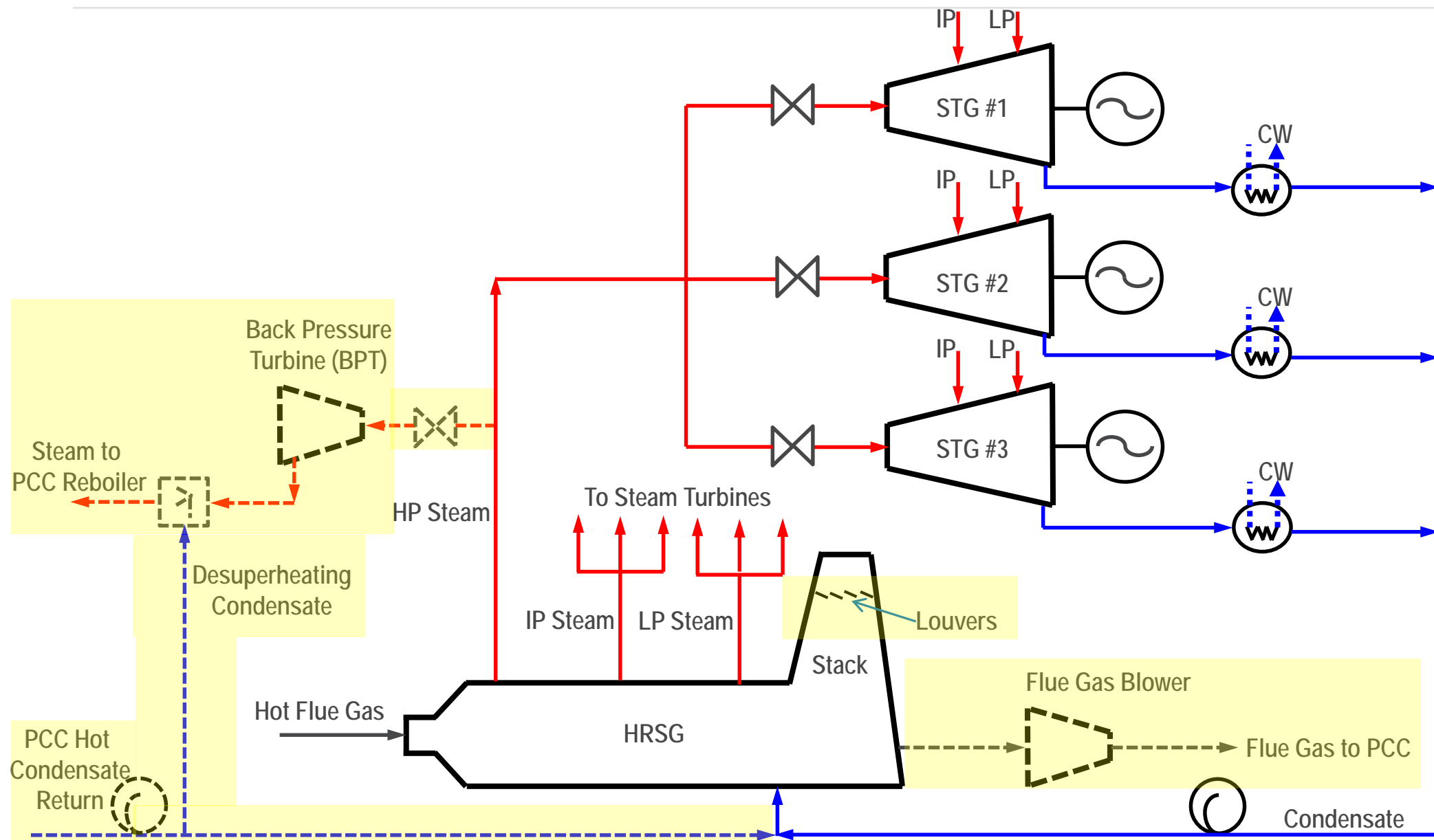
Cases:

- Used PCC technology providers' RFI questionnaire responses as inputs into model**
 - Recovered CO₂ conditions
 - Steam conditions and consumption rates
 - PCC power consumption
 - Capital costs
- Evaluated cost and performance for the six cases among one another and with the Reference PCC design**
- Performed Cost of Electricity (COE) calculation consistent with DOE-NETL methodology**

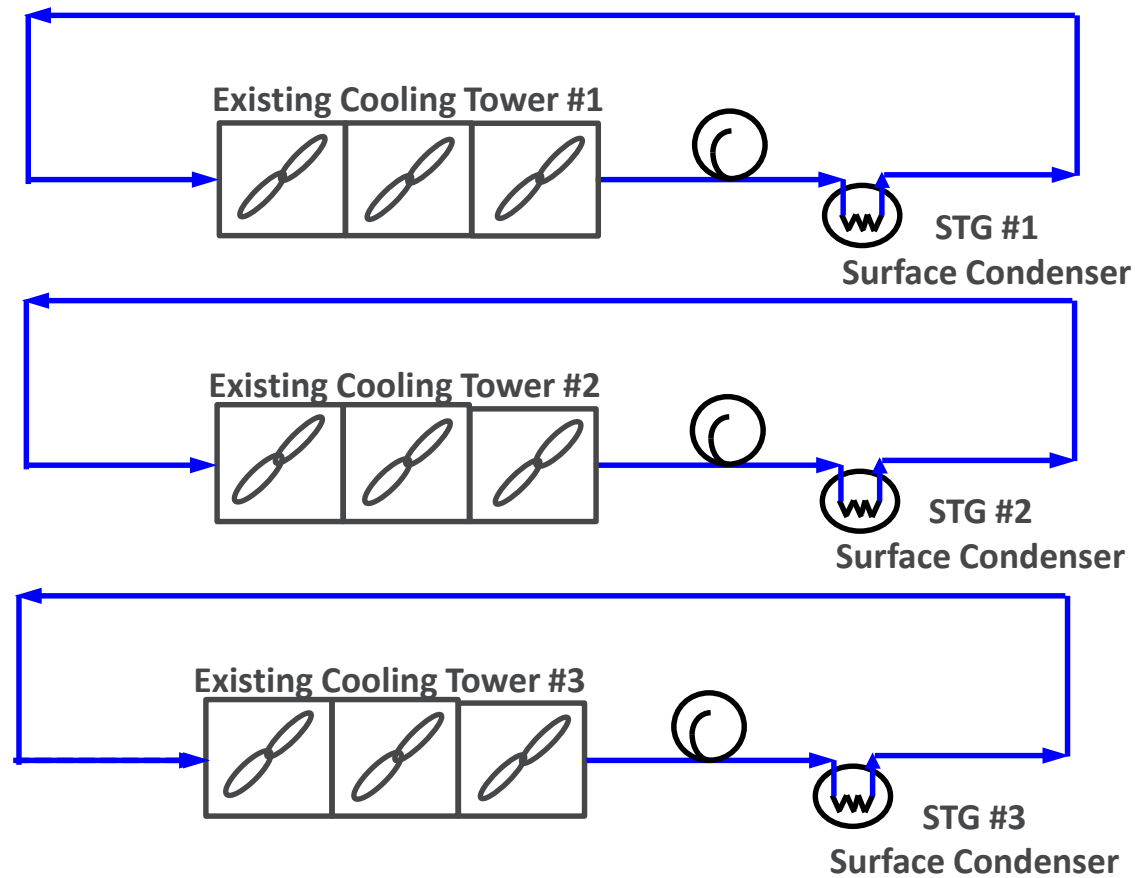
Poza Rica NGCC/PCC Division of Responsibilities



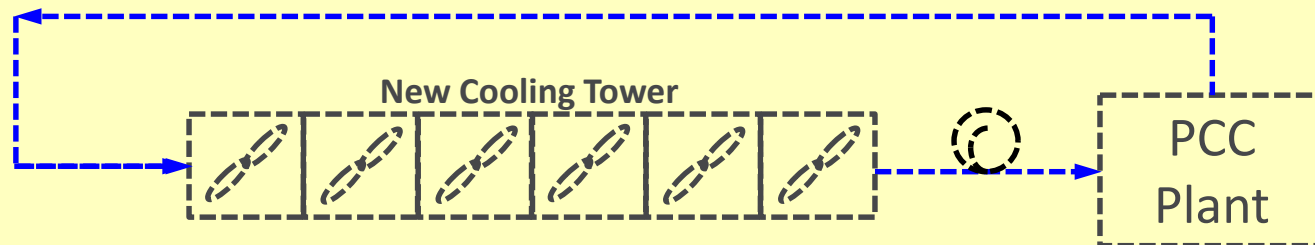
NGCC Plant with Full-Scale PCC – Pre- & Post-PCC Retrofit HRSG/Steam Turbine Configuration



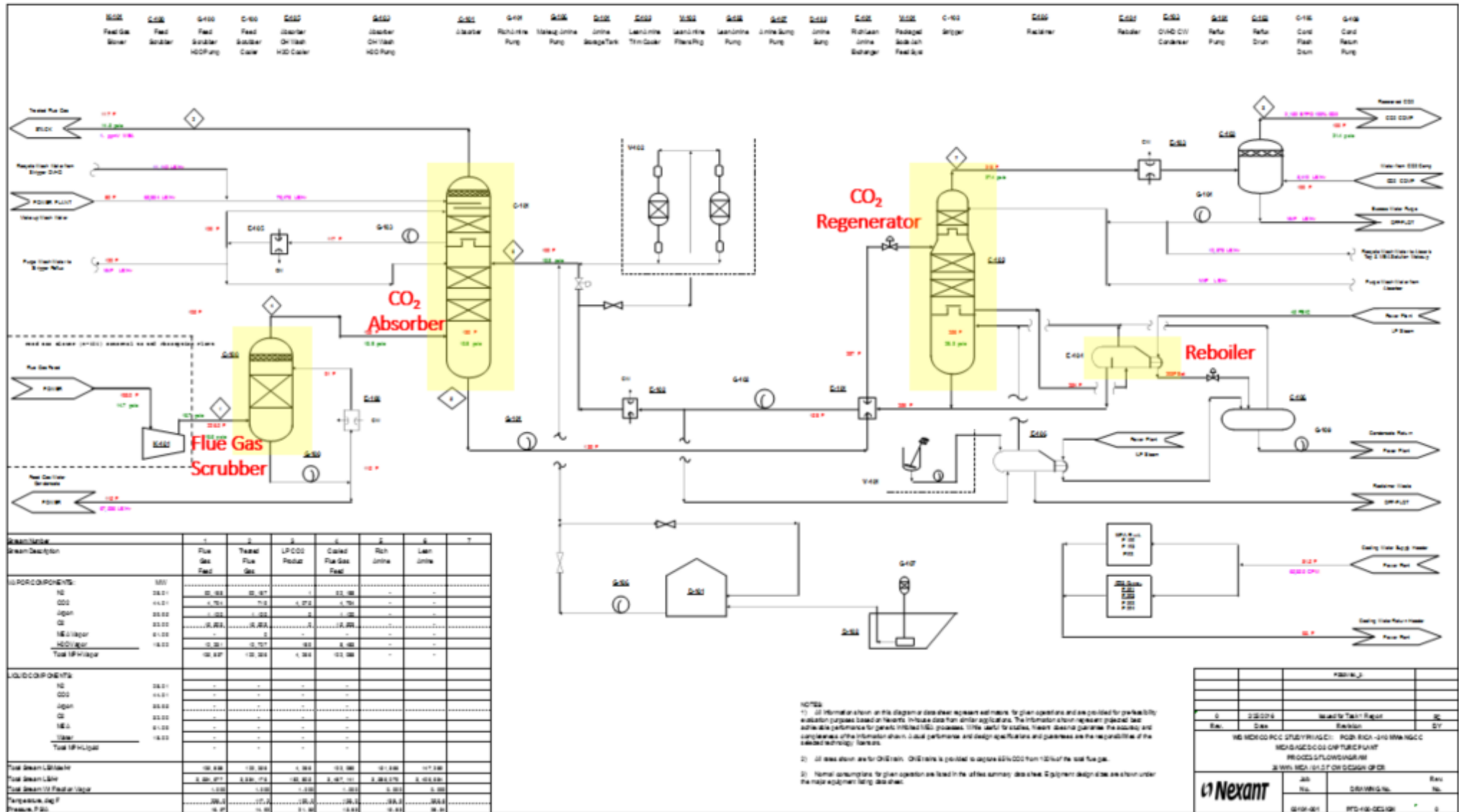
NGCC Plant with Full-Scale PCC – Pre- & Post-PCC Cooling Tower Arrangement



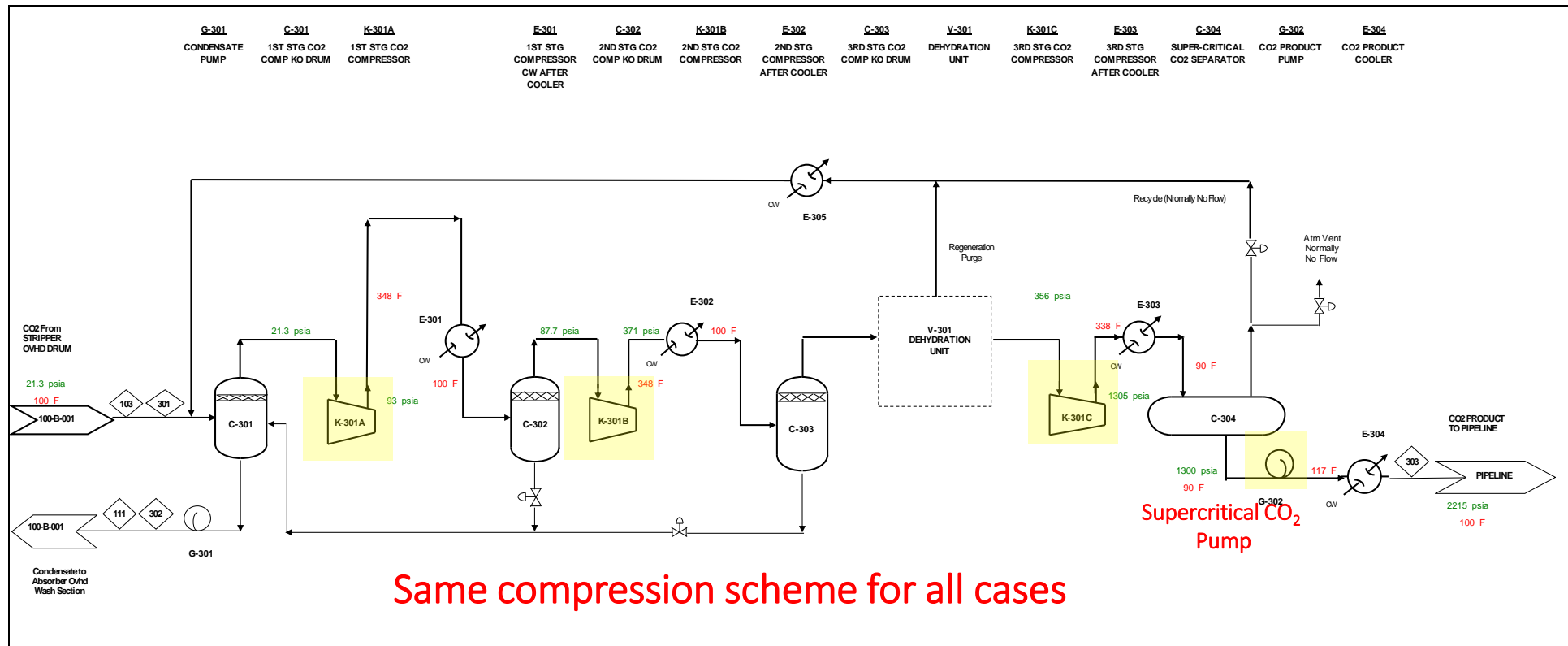
**Larger 6-cell CT allows
NGCC to operate with 2 or 3
STGs when PCC is in service**



Poza Rica NGCC Reference (30 wt% MEA) CO₂ Capture Plant Flow Diagram



CO₂ Compression & Dehydration Plant Flow Diagram



Same compression scheme for all cases

Strm No.	103/301	111/302	303
Stream Name	Stripper Ovhd Vap	Condensate	CO2 Product
Component	MW	lbmol/hr	lbmol/hr
N2/Ar	28.15	0.7	0
O2	32	0.1	0.0
CO2	44.011	4075.3	0.1
H2O	18.016	189.3	188.9
MEA	61.08	TRACE	TRACE
Total	lbmol/hr	4265.4	189.0
	lb/hr	182790	3406
Actual Flow	GPM	-	6.8
Vapor Flow	MMSCFD	38.8	-
Temp	°F	100	98

Notes

- 1) All information shown on this diagram or data sheet represent estimations for given operations and are provided for pre-feasibility evaluation purposes based on Nexant's in-house data from similar applications. The information shown represent projected best achievable performance for generic inhibited MEA processes. While useful for studies, Nexant does not guarantee the accuracy and completeness of the information shown. Actual performance and design specifications and guarantees are the responsibilities of the selected technology licensors.
- 2) All rates shown are for 1 train. Only ONE train is needed to treat 100% of the Poza Rica MGCC flue gas.
- 3) Normal consumptions for given operation are listed in the utilities summary data sheet. Equipment design sizes are shown under the major equipment listing data sheet.

PZ85MEA_3 :					
0	2/25/2016	Issued for Task 1 Report	RC		
Rev No.	Date	Revision	Engineer	Checked	Approval
Nexant Inc. San Francisco, CA					
EPRI CO2 CAPTURE STUDY PHASE IV : POZA RICA - 240 MM ³ NGCC					
Process Flow Diagram CO2 COMPRESSION For GENERIC 30% MEA / 85 F CW/DESIGN OPERATION					
		Job No.	Drawing No.	Revision No.	
		01475-001	DS-PFD-300-DESIGN	0	

Aerial View of Conceptual Poza Rica NGCC w/ Generic 30 wt% MEA PCC



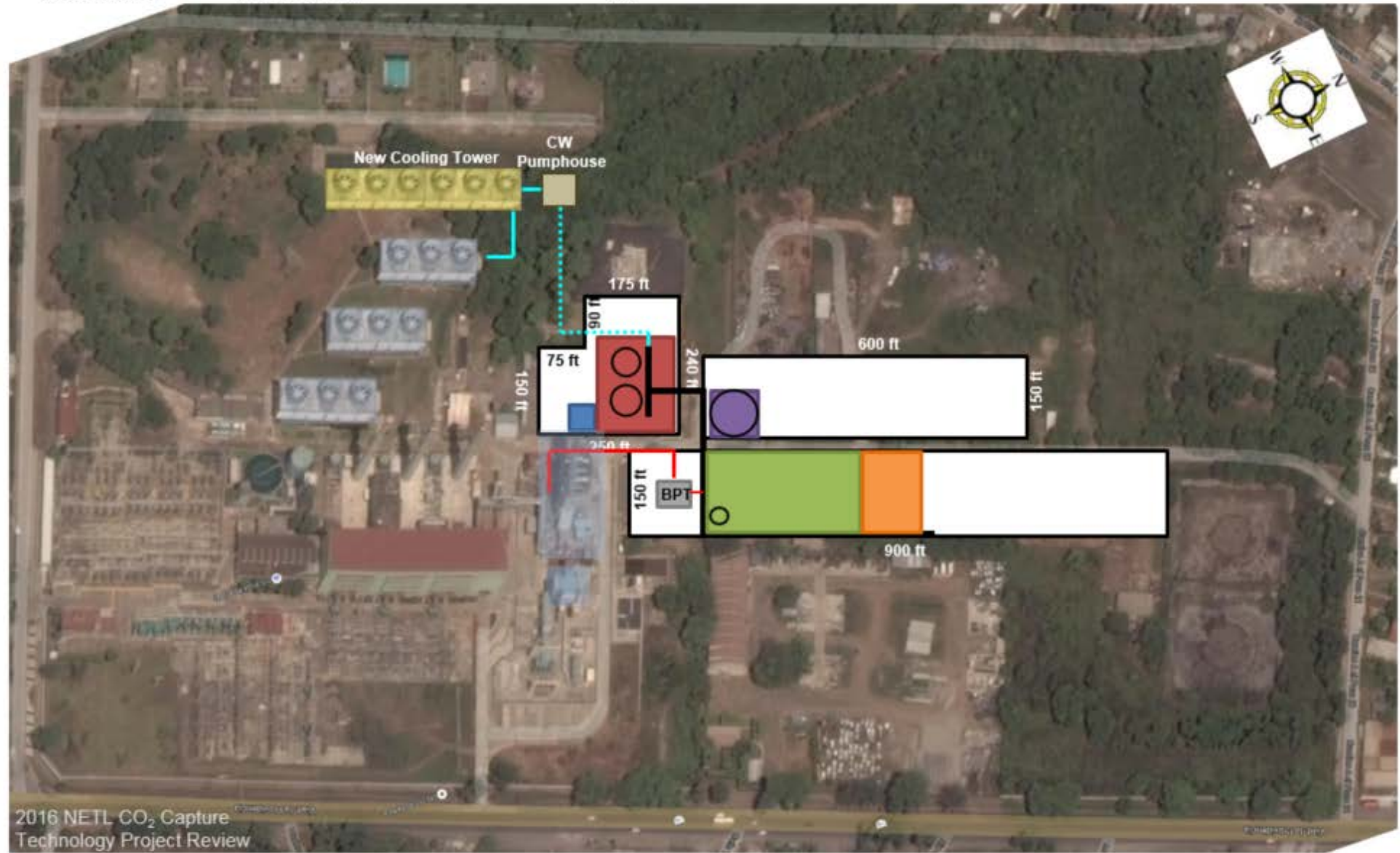
MEA PCC

Available Plot Space



MEA PCC

- Available Plot Space
- Flue Gas Blower
- CO₂ Absorption Plant
- CO₂ Regeneration Plant
- CO₂ Compression Plant
- MEA Storage Tank
- Makeup Water Line (Above Ground)
- New CT CW Line (Below Ground)
- PCC Pipe Rack
- PCC Steam/Condensate Line



Task 1 Findings: Full-Scale Poza Rica NGCC PCC Retrofit Performance Evaluation (All Licensors @ 85% CO₂ Capture)

See Note 1	No PCC	Generic 30% MEA PCC	Alstom	BASF	Fluor [See Note 2]	HTC Purenergy	MHI	Shell CanSolv
NGCC CO ₂ Emissions, STPD	2,532	380	362	379	379	381	381	377
Recovered CO ₂ Product, STPD	0	2152	2170	2153	2153	2151	2151	2155
% CO ₂ Capture	0	85%	86%	85%	85%	85%	85%	85%
Power Balance, MW								
Generation								
Gas Turbine Gross Output	166.6	166.6	166.6	166.6	166.6	166.6	166.6	166.6
Steam Turbine Gross Output	82.5	39.6	49.6	49.4	48.0	46.7	49.2	49.4
Back Pressure Turbine	0	21.6	16.6	16.7	17.4	18.1	16.8	16.7
Total Gross Output	249.1	227.8	232.8	232.7	232.0	231.3	232.6	232.7
Auxiliary Consumption								
Existing NGCC Plant Parasitic Loads	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Flue Gas Blower	0	8.8	8.8	8.8	8.8	8.8	8.8	8.8
PCC + CO ₂ Compression + Plant Mods	0	16.1	17.3	14.1	16.0	14.0	15.7	14.2
Total New PCC Parasitic Load	7.2	32.0	33.3	30.1	32.0	29.9	31.7	30.1
Net Power Plant Export, MW	241.9	195.8	199.5	202.6	200.0	201.4	200.9	202.5
Δ Plant Export, MW		-46.1	-42.4	-39.3	-41.9	-40.5	-41.0	-39.3
% Plant Export Reduction		-19.1%	-17.5%	-16.2%	-17.3%	-16.7%	-16.9%	-16.3%
Net Plant Heat Rate, Btu/kWh	6,584	8,134	7,984	7,860	7,962	7,907	7,926	7,862
Net Plant Efficiency, % LHV	51.8	42.0	42.7	43.4	42.9	43.2	43.1	43.4
Incremental Water Import, gpm	0	406	808	454	455	351	676	417

All show performance improvement over MEA

Note 1 - Values presented here are Nexant's interpretation of the data provided by the PCC licensors.

Note 2 - Fluor provided information for CO₂ capture rate of 90%. Nexant adjusted Fluor's performance to 85% to be consistent with the design basis

Task 1 Findings: Full-Scale Poza Rica NGCC PCC Retrofit Economic Evaluation (All Licensors @ 85% CO₂ Capture)

Incremental Costs to Poza Rica NGCC without CO2 Capture [Note 1]	Estimated Post-Combustion CO2 Capture Costs						
	Generic 30% MEA PCC Design	Alstom	BASF / Linde	Fluor	HTC Pureenergy	MHI	Shell CanSolv
CAPEX Estimate, \$MM US USGC PCC Plant + CO2 Compression [Note 2]	181.4	234.7	187.7	174.0	194.5	178.8	194.9
Flue Gas Blower	14.2	14.2	14.2	14.2	14.2	14.2	14.2
Poza Rica Plant Modifications	32.8	32.4	30.4	31.4	29.1	30.9	30.4
TOTAL	228.4	281.4	232.3	219.7	237.8	223.9	239.5
O&M Estimate, \$MM US							
Variable Costs [Note 3]	7.6	7.6	7.6	7.5	7.3	7.5	7.5
Fixed Costs	11.0	13.3	11.1	10.9	11.4	10.8	11.6
TOTAL	18.5	21.0	18.7	18.4	18.7	18.3	19.1
Estimated Cost of Electricity (COE), \$/MWh [Note 4]	37.6	41.4	35.3	35.0	36.2	35.1	36.0

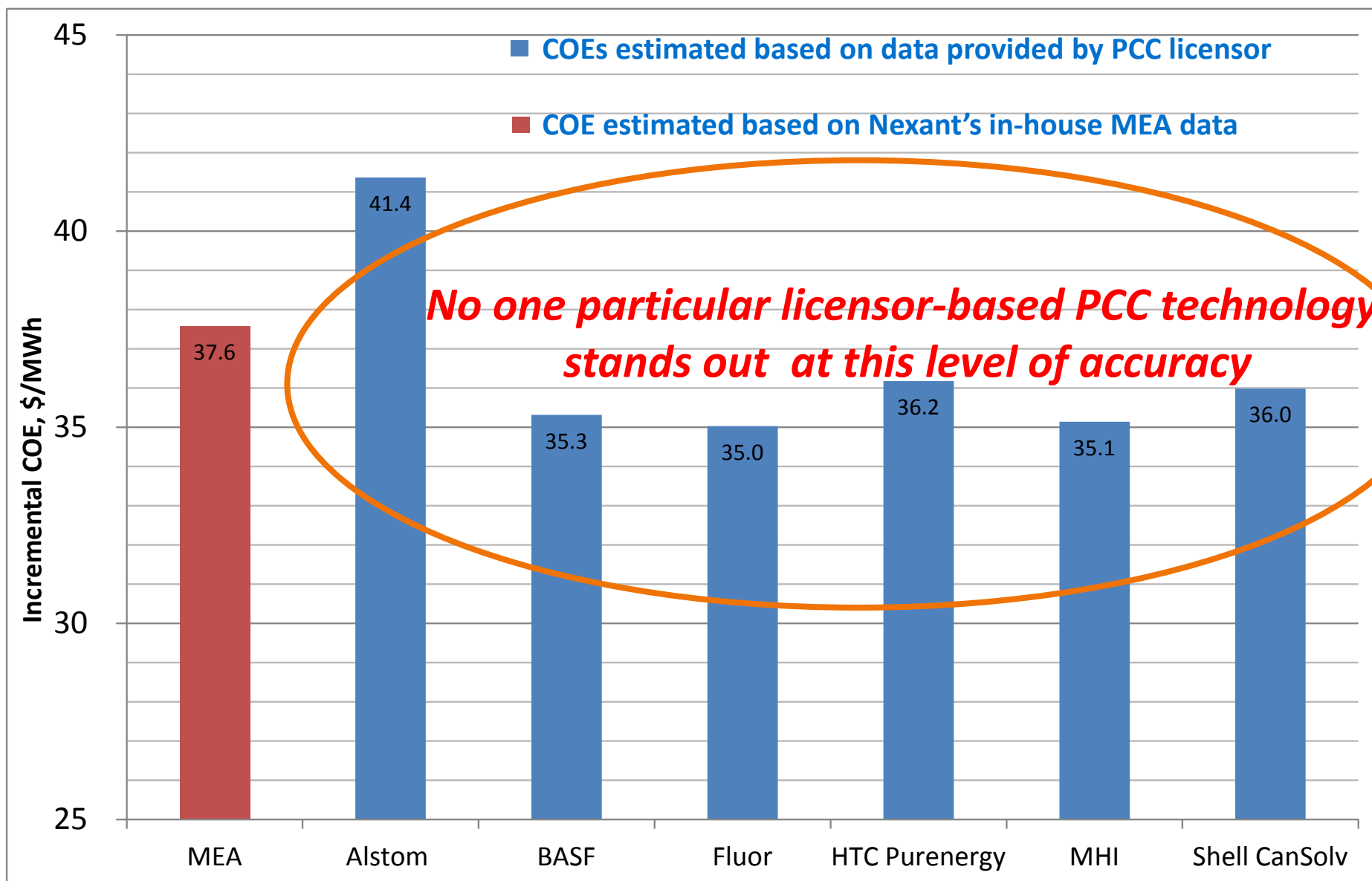
Note 1 - Values presented here are Nexant's interpretation of the data provided by the PCC licensors.

Note 2 - All except Nexant 'Generic 30% MEA Design' are based on vendor-provided data, which are considered proprietary.

Note 3 - Major component is the amine replacement costs, which are considered proprietary.

Note 4 - Incremental to estimated existing Poza Rica NGCC COE of \$40.69/MWhr

Task 1 Findings: Full-Scale Poza Rica NGCC PCC Retrofit COEs for 85% CO₂ Capture



Task 1 – Conclusions

- ❑ **Retrofitting Poza Rica with PCC can incur significant thermal penalty to the plant**
 - ~19% reduction in the net MW plant output based on current state-of-the-art 30% MEA amine capture technology
- ❑ **All six proprietary PCC technologies evaluated show slight improvement in performance, 16%-18% reduction in power export vs 19% for MEA**
- ❑ **Estimated incremental capital cost for retrofitting Poza Rica for CO₂ capture is between \$224 to \$282MM US -**
 - **Estimated CAPEX based on the study design of a 30% MEA amine capture is about \$228MM of which breakdown as follows:**

○ Amine CO ₂ capture plant	62%
○ CO ₂ compression plant	18%
○ Flue gas blower	6%
○ NGCC plant modification	14%
- ❑ **Estimated incremental O&M cost is between \$18.3 to \$21.0MM per year.**

Task 1 – Conclusions (Cont’)

- ❑ **Within the accuracy of the data provided, the performance of all six technologies are reasonable and comparable; no one technology is ‘head and shoulders’ above the rest**
- ❑ **Pilot plant testing would be needed to independently validate the claimed performances, in order to make sound choice of technology for large-scale commercial deployment**
- ❑ **Decided on an MEA-based pilot plant with design flexibility**
 - **Discussed in Task 2 of the World Bank report**

Full Report

<http://www.gob.mx/sener/en/documentos/pre-feasibility-study-for-establishing-a-carbon-capture-pilot-plant-in-mexico?idiom=en>

Report No: AUS8579 - 2

United Mexican States
MX TF Carbon Capture, Utilization and Storage
Development in Mexico
Pre-Feasibility Study for Establishing a Carbon Capture Pilot Plant in
Mexico

May 18, 2016

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Thank you!

Questions?