Exhibit ES-2. Performance summary and environmental profile for all cases

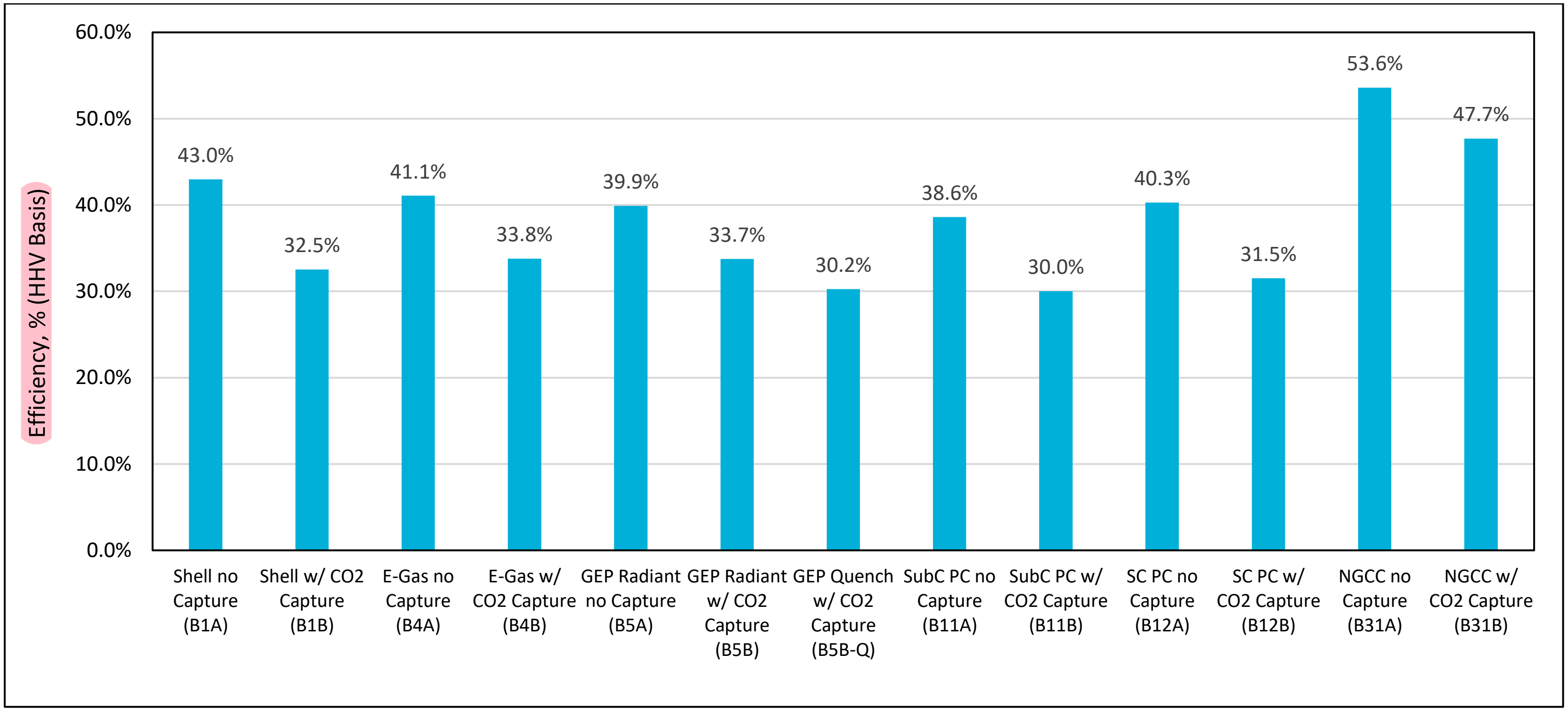
Case Name (Legacy Naming Convention)[A]	IGCC							PC				NGCC	
	Shell		E-Gas™ FSQ		GEP R+Q			SubC PC		SC PC		State-of-the-art 2017 F-Class	
	B1A (5)	B1B (6)	B4A (3)	B4B (4)	B5A (1)	B5B (2)	B5B-Q (2a)	B11A (9)	B11B (10)	B12A (11)	B12B (12)	B31A (13)	B31B (14)
PERFORMANCE													
Gross Power Output (MWe)	765	696	763	742	765	741	685	687	776	685	770	740	690
Auxiliary Power Requirement (MWe)	125	177	122	185	131	185	186	37	126	35	120	14	44
Net Power Output (MWe)	640	519	641	557	634	556	499	650	650	650	650	727	646
Coal Flow rate (lb/hr)	435,418	467,308	456,327	482,173	464,732	482,580	482,918	492,047	634,448	472,037	603,246	N/A	N/A
Natural Gas Flow rate (lb/hr)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	205,630	205,630
HHV Thermal Input (kW_t)	1,488,680	1,597,710	1,560,166	1,648,535	1,588,902	1,649,926	1,651,082	1,682,291	2,169,156	1,613,879	2,062,478	1,354,905	1,354,905
Net Plant HHV Efficiency (%)	43.0%	32.5%	41.1%	33.8%	39.9%	33.7%	30.2%	38.6%	30.0%	40.3%	31.5%	53.6%	47.7%
Net Plant HHV Heat Rate (Btu/kWh)	7,940	10,497	8,308	10,101	8,554	10,118	11,287	8,832	11,393	8,473	10,834	6,363	7,159
Raw Water Withdrawal, gpm	4,127	5,080	4,357	5,197	4,799	5,512	6,286	6,485	10,634	6,054	9,911	2,902	4,773
Process Water Discharge, gpm	922	1,075	944	1,103	1,033	1,123	1,218	1,334	3,090	1,242	2,893	657	1,670
Raw Water Consumption, gpm	3,206	4,005	3,413	4,093	3,766	4,389	5,068	5,151	7,544	4,811	7,018	2,245	3,103
CO_2 Capture Rate, %	0	90	0	90	0	90	90	0	90	0	90	0	90
CO_2 Emissions (lb/MMBtu)	200	21	199	20	197	20	20	202	20	202	20	119	12
CO_2 Emissions (lb/MWh-gross)	1,328	161	1,391	153	1,396	151	163	1,691	193	1,627	185	741	80
CO_2 Emissions (lb/MWh-net)	1,588	215	1,657	204	1,685	201	224	1,787	231	1,714	219	755	85
SO_2 Emissions (lb/MMBtu)[B]	0.020	0	0.028	0	0.002	0	0	0.081	0	0.081	0	0.001	0
SO_2 Emissions (lb/MWh-gross)	0.130	0	0.192	0	0.015	0	0	0.674	0	0.648	0	0.006	0
NOx Emissions (lb/MMBtu)	0.059	0.049	0.056	0.049	0.054	0.048	0.048	0.084	0.073	0.087	0.077	0.004	0.003
NOx Emissions (lb/MWh-gross)	0.390	0.382	0.393	0.371	0.379	0.364	0.394	0.700	0.700	0.700	0.700	0.022	0.022
PM Emissions (lb/MMBtu)	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.011	0.009	0.011	0.010	0.002	0
PM Emissions (lb/MWh-gross)	0.047	0.056	0.050	0.054	0.050	0.054	0.058	0.090	0.090	0.090	0.090	0.012	0
Hg Emissions (lb/TBtu)	0.452	0.383	0.430	0.396	0.423	0.395	0.365	0.359	0.314	0.373	0.328	0	0
Hg Emissions (lb/MWh-gross)[C]	$3.00x10^{-6}$	$3.00x10^{-6}$	$3.00x10^{-6}$	$3.00x10^{-6}$	$3.00x10^{-6}$	$3.00x10^{-6}$	$3.00x10^{-6}$	$3.00x10^{-6}$	$3.00x10^{-6}$	$3.00x10^{-6}$	$3.00x10^{-6}$	0	0

[A] Previous versions of this report used a different naming convention (this report re-combines cases from *Cost and Performance Baseline for Fossil Energy Plants, Volume 1a* [7] and *Volume 1b.* [8]) The old case numbers are provided here, paired with the new case numbers for reference

[B] Trace amounts of sulfur emissions may exist in the flue gas stream to the stack in capture cases

[C]The mercury capture units were designed to attain the emissions target of $3.00x10^{-6}$ lb/MWh-gross

Exhibit ES-3. Net plant efficiency (HHV basis)



The primary performance and environmental profile conclusions that can be drawn from the IGCC cases are:

- In the non-carbon capture cases, the Shell gasifier has the highest net plant efficiency (43.0 percent), followed by the two-stage E-Gas™ slurry fed gasifier (41.1 percent).
- The energy penalty associated with adding nominal 90 percent CO_2 capture is primarily due to steam extraction for use in the WGS reaction, the auxiliary load for the CO_2 separation and compression equipment, and a slight plant derate due to the higher moisture content of the syngas working fluid. The reduction in net plant efficiency ranges from 6 to 10 percentage points (16 to 24 percent relative to non-capture) with the variability being due to the different gasifier designs (e.g., slurry versus dry feed, syngas quench versus syngas heat recovery), which may vary between the capture and non-capture plant configurations.
    - The lowest energy penalty (6 percentage points) corresponds to the GEP Radiant gasifier cases primarily due to the non-capture plant design (slurry feed, water quench), which results in a high moisture content in the syngas and thus the CO_2 capture design requires little additional shift steam for WGS.
    - The highest energy penalty (10 percentage points) corresponds to the Shell gasifier cases. The design uses a dry feed system and, in the non-capture configuration, has relatively high heat recovery in the syngas cooler with no water quench, resulting in very low moisture content in the syngas. For the capture configuration, a water quench is added, which increases the moisture content of the syngas for the WGS reaction but decreases the heat recovery in the syngas cooler.
- The non-capture CB&I E-Gas™ case using refrigerated methyldiethanolamine (MDEA) has the highest SO_2 emissions (0.192 lb/MWh-gross) of the seven cases because refrigerated MDEA has the lowest H_2S removal efficiency of the AGR technologies considered.
- For the IGCC cases, the syngas scrubber blowdown flow rate range to be treated by the vacuum flash, brine concentrator, and crystallizer ZLD system spans 277–635 gpm, with Case B5B-Q having the highest flow rate for treatment. The other six IGCC cases span a tighter range of 277–332 gpm. The approximate performance impact of implementing the ZLD system across the seven IGCC cases is a 0.1–0.2 percentage point (absolute) decrease in the HHV net plant efficiency, with six of the seven IGCC cases falling at or around a 0.1 absolute percentage point decrease. This is due primarily to the steam extraction and auxiliary load required for the total ZLD system, which is significantly larger than the auxiliary load required for the spray dryer evaporator applied in PC cases.
- Emissions of Hg, HCl, PM, NOx, and SO_2 are all below the applicable federal regulatory limits currently in effect for IGCC technology.

The primary performance and environmental profile conclusions that can be drawn from the PC cases are:

- For the PC cases, adding nominal 90 percent CO_2 capture results in a reduction in net plant efficiency of approximately 9 percentage points (22 percent relative to non-capture).
- For the PC cases, the FGD wastewater blowdown flow rate range to be treated by the spray dryer evaporator spans 55–73 gpm. The approximate performance impact of implementing the spray dryer evaporator across the four PC cases is a 0.25–0.27 percentage point (absolute) decrease in the HHV net plant efficiency. This is due primarily to the diversion of warm flue gas away from the air preheater and to the evaporator, with an additional minor impact resulting from the small auxiliary load required by the spray dryer evaporator.
- Emissions of Hg, HCl, PM, NOx, and SO_2 are all at or below the applicable federal regulatory limits currently in effect for PC technology.

The primary performance and environmental profile conclusions that can be drawn from the NGCC cases are:

- The NGCC cases have the highest net efficiency of all the technologies, both without CO_2 capture (53.6 percent) and with CO_2 capture (47.7 percent). The next highest efficiency is the non-capture Shell IGCC case, with an efficiency of 43.0 percent.
- For the NGCC case, adding nominal 90 percent CO_2 capture results in a reduction in net plant efficiency of approximately 6 percentage points (11 percent relative to non-capture). The NGCC penalty is less than the PC penalty because:
    - Natural gas is less carbon intensive than coal (based on the fuel compositions used in this study, natural gas contains 32 lb carbon/MMBtu (13.7 kg/GJ) [HHV] of heat input and coal contains 55 lb/MMBtu (23.6 kg/GJ) [HHV]).
    - The NGCC non-capture plant is more efficient, thus there is less total CO_2 to capture and compress (NGCC non-capture CO_2 emissions are approximately 54–56 percent lower than the PC cases) when normalized to equivalent net power outputs.
    - These effects are offset slightly by the lower concentration of CO_2 in the NGCC flue gas (4 mol% versus 13 mol% for PC). Concentration of CO_2 is the driving force for capture from the flue gas in the amine system, and the lower concentration requires more energy (steam and auxiliary load) from the base plant to reach the capture target.
- Natural gas contains no Hg or chloride, and PM, NOx, and SO_2 emissions are all at or below the applicable federal regulatory limits currently in effect for NGCC technology.

The cost results for all cases are provided in Exhibit ES-4. A graph of the LCOE is provided in Exhibit ES-5.

Exhibit ES-4. Cost summary for all cases

Case Name	IGCC[A]							PC[A]				NGCC[A]	
	Shell		E-Gas™ FSQ		GEP R+Q			SubC PC		SC PC		State-of-the-art 2017 F-Class	
	B1A	B1B	B4A	B4B	B5A	B5B	B5B-Q	B11A	B11B	B12A	B12B	B31A	B31B
COST													
Total Plant Cost (2018$/kW)	3,824	6,209	3,395	5,177	3,822	5,240	4,855	2,011	3,756	2,099	3,800	780	1,984
Bare Erected Cost	2,674	4,279	2,386	3,588	2,679	3,631	3,369	1,482	2,641	1,548	2,677	561	1,312
Home Office Expenses	401	642	358	538	402	545	505	259	462	271	469	112	262
Project Contingency	554	923	499	786	557	783	757	269	526	280	531	107	304
Process Contingency	195	366	151	266	184	281	224	0	127	0	123	0	105
Total Overnight Cost (2018$M)	2,991	3,964	2,664	3,555	2,972	3,589	2,990	1,611	2,991	1,678	3,023	692	1,558
Total Overnight Cost (2018$/kW)	4,675	7,632	4,157	6,384	4,690	6,450	5,991	2,478	4,604	2,582	4,654	952	2,412
Owner's Costs	851	1,423	763	1,207	868	1,210	1,136	467	848	484	854	172	428
Total As-Spent Cost (2018$/kW)	5,397	8,810	4,799	7,370	5,414	7,446	6,916	2,861	5,315	2,981	5,372	1,040	2,635
LCOE ($/MWh) (excluding T&S)	105.8	166.5	97.5	143.1	107.9	144.2	139.4	63.9	106.3	64.4	105.3	43.3	70.9
Capital Costs	54.5	88.9	48.4	74.4	54.7	75.2	69.8	27.2	50.5	28.3	51.0	9.9	25.0
Fixed Costs	20.0	31.9	18.0	26.9	20.0	27.2	25.6	9.1	16.0	9.5	16.1	3.6	8.6
Variable Costs	13.6	22.3	12.6	19.4	14.1	19.3	18.9	7.9	14.5	7.7	14.0	1.7	5.6
Fuel Costs	17.7	23.4	18.5	22.5	19.0	22.5	25.1	19.7	25.4	18.9	24.1	28.1	31.6
LCOE ($/MWh) (including T&S)	105.8	175.0	97.5	151.3	107.9	152.3	148.5	63.9	115.7	64.4	114.3	43.3	74.4
CO_2 T&S Costs	0.0	8.6	0.0	8.2	0.0	8.1	9.1	0.0	9.4	0.0	8.9	0.0	3.5
Breakeven CO_2 Sales Price (ex. T&S), $/tonne[B]	N/A	119.4	N/A	96.0	N/A	98.1	82.7	N/A	44.6	N/A	45.7	N/A	79.6
Breakeven CO_2 Emissions Penalty (incl. T&S), $/tonne[B]	N/A	162.7	N/A	126.9	N/A	128.3	124.4	N/A	76.3	N/A	73.5	N/A	102.2

[A]Financing structures are presented in NETL's "QGESS: Cost Estimation Methodology for NETL Assessments of Power Plant Performance" [4]
[B]Both the breakeven CO_2 sales price and emissions penalty were calculated based on the non-capture SC PC Case B12A for all coal cases, and the non-capture NGCC Case B31A for natural gas cases.