Supplement material for paper "*Repurposing Coal Power Plants into Thermal Energy Storage for Supporting Zero-carbon Data Centers*"

1. **Coal Power Plants Information**: We consider that the operating coal power plants in the ERCOT system as of 2022, except for those scheduled to be retired by 2025, are eligible for retrofitting. Table I shows the information on 12 eligible coal power plants from global energy monitors [1] and US EIA [2].

Table 1 Information on 12 eligible coal power plants

Plant	Plant name	Capacity (MW)	Start year	Combustion technology	Coal type	Lat	Lon	Heat rate (Btu/kWh)	Emission factor (kg CO_2 /TJ)
1	Fayette Power Project	460	1988	subcritical	lignite	29.92	-96.75	10,878	101,000
2	J. K. Spruce Station	566	1992	subcritical	sub-bit	29.31	-98.32	10,878	96,100
3	J. K. Spruce Station	878	2010	subcritical	sub-bit	29.31	-98.32	9,572	96,100
4	Limestone Generating Station	893	1985	subcritical	lignite	31.42	-96.25	10,878	101,000
5	Limestone Generating Station	957	1986	subcritical	lignite	31.42	-96.25	10,878	101,000
6	Major Oak power station	174.6	1990	subcritical	lignite/sub-bit	31.09	-96.70	12,618	98,550
7	Major Oak power station	174.6	1991	subcritical	lignite/sub-bit	31.09	-96.70	12,618	98,550
8	Oak Grove Plant	916.8	2010	supercritical	lignite	31.18	-96.49	9,250	101,000
9	Oak Grove Plant	878.6	2011	supercritical	lignite	31.18	-96.49	9,250	101,000
10	Parish Generating Station	614.6	1982	subcritical/ccs	sub-bit	29.48	-95.63	17,155	9,610
11	San Miguel Electric Cooperative	410	1982	subcritical	lignite	28.70	-98.48	11,748	101,000
12	Sandy Creek Plant	1008	2013	supercritical	sub-bit	31.48	-96.96	8,409	96,100

2. **Cost assumptions:** The cost assumption of retrofitting thermal energy storage is based on a 100 MW concentrated solar power station with an 8-hour molten-salt TES [3]. The following cost assumptions are made: 1. The molten-salt TES and electrical heater are newly installed. 2. The turbine of the former coal power plant can be recycled, but the cost for component replacement is half of the cost of the new installation ($1597/kW).

Table 2 Investment cost for each component of TES

	TES	**Charging**	**Discharging**
Components	Molten-salt TES	Electrical heater	Turbine
Capacity cost type	Energy capacity ($/kWh)	Power Capacity ($/kW)	Power capacity ($/kW)
Capacity cost	$82	$2	$799
Efficiency	1%/day	0.95	0.35

Based on the capacity recovery factor, $CRF = \frac{i(1+i)^n}{(1+i)^n-1}$ given an interest rate $r = 4\%$ and the remaining lifetime n, we could calculate the annualized charging, discharging, and energy capacity investment costs.

Table 3 Annualized investment costs for 12 coal power plants

Plant	Remaining lifetime by 2030 (Years)	CRF (%)	Annualized charging cost ($/kW-year)	Annualized Energy cost ($/kWh-year)	Annualized discharging cost ($/kW-year)
1	8	14.85	$297	$5,941	$118,822
2	12	10.66	$213	$4,262	$85,242
3	30	5.78	$116	$2,313	$46,264
4	5	22.46	$449	$8,985	$179,702
5	6	19.08	$382	$7,630	$152,610
6	10	12.33	$247	$4,932	$98,633
7	11	11.41	$228	$4,566	$91,319
8	30	5.78	$116	$2,313	$46,264
9	31	5.69	$114	$2,274	$45,484
10	2	53.02	$1,060	$21,208	$424,157
11	2	53.02	$1,060	$21,208	$424,157
12	33	5.51	$110	$2,204	$44,083

3. **Software:** The simulation is conducted based on GenX [4]. We formulate the retrofitting module in the GenX branch (GenX_retrofit_MIT): https://github.com/GenXProject/GenX/tree/GenX_retrofit_MIT

4. **Results from all the scenarios:** In total, we simulate 12 scenarios, including two baseline scenarios: (1) ERCOT 2030 considering retrofitting without additional DCs, and (2) ERCOT 2030

without additional DC loads and retrofitting. Results of all scenarios can be found in the GitHub:
https://github.com/yifueve/coal_repurpose/tree/main

Table 4 The simulated scenarios

Scenarios of Data center and Energy storage technology	TES	LIB	TES & LIB
Zero-carbon DC, inflexible	√ (3)	√ (5)	√ (9)
Zero-carbon DC, flexible	√ (4)	√ (6)	√ (10)
Unconstrained DC, inflexible	Not applicable	√ (7)	√ (11)
Unconstrained DC, flexible	Not applicable	√ (8)	√ (12)

Table 5 Folder Path of results

Scenarios	**Result path**
(1)	../ercot_baseline/Results_retro
(2)	../ercot_baseline/Results_baseline
(3)	../ercot_IF_ZC/Results_TES
(4)	../ercot_F_ZC/Results_TES
(5)	../ercot_IF_ZC/Results_LIB
(6)	../ercot_F_ZC/Results_LIB
(7)	../ercot_IF_UC/Results_LIB
(8)	../ercot_F_UC/Results_LIB
(9)	../ercot_IF_ZC/Results_FULL
(10)	../ercot_F_ZC/Results_FULL
(11)	../ercot_IF_UC/Results_FULL
(12)	../ercot_F_UC/Results_FULL

References:

[1] Global Energy Monitor, “Global Coal Plant Tracker,” Global Coal Plant Tracker. Accessed: Feb. 28, 2023. [Online]. Available: https://globalenergymonitor.org/projects/global-coal-plant-tracker/

[2] US Energy Information Administration, “Coal-fired electric power plants.” Accessed: Sep. 10, 2023. [Online]. Available: https://www.eia.gov/coal/data.php#prices

[3] EIA, “Capital Cost and Performance Characteristic Estimates for Utility Scale Electric Power Generating Technologies.” Accessed: Apr. 21, 2023. [Online]. Available: https://www.eia.gov/analysis/studies/powerplants/capitalcost/pdf/capital_cost_AEO2020.pdf

[4] “GenX.” Accessed: May 24, 2023. [Online]. Available: genxproject.github.io/GenX/dev/