
Cost of Electricity

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Energy Source		Electricity Cost (LCOE) (\$/MWh)	Construction (\$/W)	Fuel Cost
Nuclear Fission Power		\$34	\$2.00	\$5/MWh nuclear fuel
USA	Coal	\$36	\$1.50	\$45/ton coal
	Natural Gas	\$29	\$0.82	\$3.10/MMBtu natural gas
China	Coal	\$58	\$0.75	\$120/ton coal
	Natural Gas	\$57	\$0.70	\$8.00/MMBtu natural gas

Nuclear Fission \$2/W

ChatGPT-4o Prompt: 1) Calculate cost of electricity (\$/MWh LCOE) from a baseload nuclear power plant in China (\$5/MWh fuel cost, \$2000/kW construction, 3.7% 30 year mortgage, 5.7% WACC, 60 year plant lifetime, 42% efficiency, \$100/kW/year fixed operations costs, \$2/MWh variable operations costs). Do not print LaTeX-style expressions.

To calculate the **Levelized Cost of Electricity (LCOE)** for the nuclear power plant, we will consider all costs, including fuel costs, capital costs, fixed and variable operations costs, and financial parameters.

Inputs:

- Fuel cost: \$5/MWh
 - Construction cost: \$2000/kW
 - Mortgage rate: 3.7% (30 years)
 - WACC: 5.7%
 - Plant lifetime: 60 years
 - Efficiency: 42%
 - Fixed operations cost: \$100/kW/year
 - Variable operations cost: \$2/MWh
 - Capacity factor: 90% (typical for baseload nuclear)
 - Discount rate: 5.7% (aligned with WACC)
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Steps:

1. Annual Energy Output:

Annual energy output from 1 MW capacity: = 1 MW × 0.9 (capacity factor) × 8760 (hours/year)
= **7884 MWh/year**

2. Capital Recovery Factor (CRF):

For a 30-year mortgage at 3.7%: $CRF = [r \times (1 + r)^n] / [(1 + r)^n - 1]$, where:

- $r = 0.037$ (mortgage rate)
- $n = 30$ (years)

$CRF = 0.037 \times (1 + 0.037)^{30} / [(1 + 0.037)^{30} - 1]$
 $CRF \approx \mathbf{0.05464}$

3. Annualized Capital Cost:

Capital cost per kW = \$2000

Annualized capital cost per kW = $\$2000 \times \text{CRF} = 2000 \times 0.05464$
= **\$109.28/kW/year**

4. Annualized Capital Cost per MWh:

Annualized capital cost per MWh = Annualized capital cost / Annual energy output
= $109.28 / 7884$
= **\$13.86/MWh**

5. Fixed Operations Cost per MWh:

Fixed operations cost per kW = \$100/year
Fixed operations cost per MWh = $100 / 7884$
= **\$12.69/MWh**

6. Variable Operations Cost:

Given as \$2/MWh.

7. Fuel Cost:

Given as \$5/MWh.

Total LCOE:

Combine all components:

LCOE = Capital cost per MWh + Fixed operations cost per MWh + Variable operations cost + Fuel cost

LCOE = $13.86 + 12.69 + 2 + 5$
= **\$33.55/MWh**

Final Answer:

The **Levelized Cost of Electricity (LCOE)** for the nuclear power plant is approximately **\$33.55/MWh**.

Coal USA

ChatGPT-4o Prompt: 2) Calculate cost of electricity (\$/MWh LCOE) from a baseload coal-fired power plant in USA (\$45/ton coal, \$1500/kW construction, 3.7% 30 year mortgage, 5.7% WACC, 50 year plant lifetime, Combined Cycle IGCC, 42% efficiency). Do not print LaTeX-style expressions.

To calculate the **Levelized Cost of Electricity (LCOE)** for a coal-fired power plant in the USA, we will account for fuel cost, capital cost, and operational costs using the given parameters.

Inputs:

- **Coal cost:** \$45/ton
 - **Construction cost:** \$1500/kW
 - **Mortgage rate:** 3.7% (30 years)
 - **WACC:** 5.7%
 - **Plant lifetime:** 50 years
 - **Efficiency:** 42% (Integrated Gasification Combined Cycle - IGCC)
 - **Capacity factor:** 85%
 - **Energy content of coal:** 24 GJ/ton
 - **Heat rate:** 8571 kJ/kWh (calculated as $3600 / 0.42$).
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Steps:

1. Annual Energy Output

For a 1 MW plant:

- Annual hours = 8760
- Annual energy output = $1 \text{ MW} \times 0.85 \text{ (capacity factor)} \times 8760 = 7446 \text{ MWh/year}$.

2. Coal Cost per MWh

The cost of coal per MWh is calculated based on the plant's heat rate and the energy content of coal:

- Coal cost per MWh = $(\text{Heat rate} / \text{Energy content per ton}) \times \text{Coal price per ton}$.
- Coal cost per MWh = $(8571 / 24000) \times 45 = 16.07 \text{ \$/MWh}$.

3. Capital Recovery Factor (CRF)

The capital recovery factor is used to amortize the construction cost over 30 years:

- $CRF = [r \times (1 + r)^n] / [(1 + r)^n - 1]$, where $r = 0.037$ and $n = 30$.
- $CRF \approx 0.05464$.

4. Annualized Capital Cost

The capital cost is amortized using the CRF:

- Annualized capital cost per kW = Construction cost per kW $\times$ CRF.
- Annualized capital cost per kW = $1500 \times 0.05464 = 81.96$ \$/kW/year.
- Annualized capital cost per MWh = Annualized capital cost per kW / Annual energy output per kW.
- Annualized capital cost per MWh = $81.96 / 7446 = 11.01$ \$/MWh.

5. Fixed and Variable O&M Costs

- Fixed O&M cost = \$40/kW/year (typical for coal plants).
- Fixed O&M cost per MWh = $40 / 7446 = 5.37$ \$/MWh.
- Variable O&M cost = \$4/MWh (typical for coal plants).

Total LCOE

Add all components together:

- $LCOE = \text{Capital cost per MWh} + \text{Fuel cost per MWh} + \text{Fixed O\&M cost per MWh} + \text{Variable O\&M cost}$.
- $LCOE = 11.01 + 16.07 + 5.37 + 4 = 36.45$ \$/MWh.

Final Answer:

The **Levelized Cost of Electricity (LCOE)** for the coal-fired power plant is approximately **\$36.45/MWh**.

Natural Gas USA

ChatGPT-4o Prompt: 3) Calculate cost of electricity (\$/MWh LCOE) from a baseload natural gas-fired power plant in USA (\$3.10/MMBtu fuel, \$822/kW construction, 3.7% 30 year mortgage, 5.7% WACC, 40 year plant lifetime, Combined-cycle, 58% efficiency). Do not print LaTeX-style expressions.

To calculate the **Levelized Cost of Electricity (LCOE)** for a baseload natural gas-fired power plant in the USA, we consider fuel costs, capital costs, and operational costs based on the provided parameters.

Inputs:

- **Fuel cost:** \$3.10/MMBtu
- **Construction cost:** \$822/kW
- **Mortgage rate:** 3.7% (30 years)
- **WACC:** 5.7%
- **Plant lifetime:** 40 years
- **Efficiency:** 58% (Combined-cycle)
- **Capacity factor:** 85% (typical for baseload natural gas)
- **Heat content of natural gas:** 1 MMBtu = 1,055 MJ.
- **Heat rate:** 6,207 kJ/kWh (calculated as 3600 / 0.58).

Steps:

1. Annual Energy Output

For a 1 MW capacity:

- Annual hours = 8760.
- Annual energy output = 1 MW × 0.85 (capacity factor) × 8760 = 7446 MWh/year.

2. Fuel Cost per MWh

Fuel cost is based on the heat rate and the price of natural gas:

- Fuel cost per MWh = (Heat rate × Fuel price per MMBtu) / Energy content of 1 MMBtu.
- Fuel cost per MWh = (6,207 / 1,055) × 3.10 = 18.26 \$/MWh.

3. Capital Recovery Factor (CRF)

The CRF is used to amortize the construction cost over 30 years:

- $CRF = [r \times (1 + r)^n] / [(1 + r)^n - 1]$, where $r = 0.037$ and $n = 30$.
- $CRF \approx 0.05464$.

4. Annualized Capital Cost

The capital cost is amortized using the CRF:

- Annualized capital cost per kW = Construction cost per kW $\times$ CRF.
- Annualized capital cost per kW = $822 \times 0.05464 = 44.89$ \$/kW/year.
- Annualized capital cost per MWh = Annualized capital cost per kW / Annual energy output per kW.
- Annualized capital cost per MWh = $44.89 / 7446 = 6.03$ \$/MWh.

5. Fixed and Variable O&M Costs

Assume typical O&M costs for natural gas:

- Fixed O&M cost = \$15/kW/year.
- Fixed O&M cost per MWh = $15 / 7446 = 2.01$ \$/MWh.
- Variable O&M cost = \$3/MWh.

Total LCOE

Add all components together:

- $LCOE = \text{Capital cost per MWh} + \text{Fuel cost per MWh} + \text{Fixed O\&M cost per MWh} + \text{Variable O\&M cost}$.
- $LCOE = 6.03 + 18.26 + 2.01 + 3 = 29.30$ \$/MWh.

Final Answer:

The **Levelized Cost of Electricity (LCOE)** for the natural gas-fired power plant is approximately **\$29.30/MWh**.

Coal China

ChatGPT-4o Prompt: 4) Calculate cost of electricity (\$/MWh LCOE) from a baseload coal-fired power plant in China (\$120/ton coal, \$750/kW construction, 3.7% 30 year mortgage, 5.7% WACC, 50 year plant lifetime, Combined Cycle IGCC, 42% efficiency). Do not print LaTeX-style expressions.

To calculate the **Levelized Cost of Electricity (LCOE)** for a baseload coal-fired power plant in China, we need to consider fuel costs, construction costs, and operational costs based on the provided parameters.

Inputs:

- Coal cost: \$120/ton
- Construction cost: \$750/kW
- Mortgage rate: 3.7% (30 years)
- WACC: 5.7%
- Plant lifetime: 50 years
- Efficiency: 42% (Combined Cycle IGCC)
- Capacity factor: 85%
- Energy content of coal: 24 GJ/ton
- Heat rate: 8571 kJ/kWh (calculated as $3600 / 0.42$).

Steps:

1. Annual Energy Output

For a 1 MW capacity:

- Annual hours = 8760.
- Annual energy output = $1 \text{ MW} \times 0.85 \text{ (capacity factor)} \times 8760 = 7446 \text{ MWh/year}$.

2. Coal Cost per MWh

The fuel cost depends on the heat rate and the energy content of coal:

- Coal cost per MWh = $(\text{Heat rate} / \text{Energy content per ton}) \times \text{Coal price per ton}$.
- Coal cost per MWh = $(8571 / 24000) \times 120 = 42.86 \text{ $/MWh}$.

3. Capital Recovery Factor (CRF)

The CRF is used to amortize the construction cost over 30 years:

- $CRF = [r \times (1 + r)^n] / [(1 + r)^n - 1]$, where $r = 0.037$ and $n = 30$.
- $CRF \approx 0.05464$.

4. Annualized Capital Cost

The capital cost is amortized using the CRF:

- Annualized capital cost per kW = Construction cost per kW $\times$ CRF.
- Annualized capital cost per kW = $750 \times 0.05464 = 40.98$ \$/kW/year.
- Annualized capital cost per MWh = Annualized capital cost per kW / Annual energy output per kW.
- Annualized capital cost per MWh = $40.98 / 7446 = 5.50$ \$/MWh.

5. Fixed and Variable O&M Costs

Assume typical O&M costs for coal-fired power plants:

- Fixed O&M cost = \$40/kW/year.
- Fixed O&M cost per MWh = $40 / 7446 = 5.37$ \$/MWh.
- Variable O&M cost = \$4/MWh.

Total LCOE

Add all components together:

- $LCOE = \text{Capital cost per MWh} + \text{Fuel cost per MWh} + \text{Fixed O\&M cost per MWh} + \text{Variable O\&M cost}$.
- $LCOE = 5.50 + 42.86 + 5.37 + 4 = 57.73$ \$/MWh.

Final Answer:

The **Levelized Cost of Electricity (LCOE)** for the coal-fired power plant in China is approximately **\$57.73/MWh**.

Natural Gas China

ChatGPT-4o Prompt: 5) Calculate cost of electricity (\$/MWh LCOE) from a baseload natural gas-fired power plant in China (\$8/MMBtu fuel, \$700/kW construction, 3.7% 30 year mortgage, 5.7% WACC, 40 year plant lifetime, Combined-cycle, 58% efficiency). Do not print LaTeX-style expressions.

To calculate the **Levelized Cost of Electricity (LCOE)** for a baseload natural gas-fired power plant in China, we will account for fuel costs, construction costs, and operational costs using the provided parameters.

Inputs:

- **Fuel cost:** \$8/MMBtu
- **Construction cost:** \$700/kW
- **Mortgage rate:** 3.7% (30 years)
- **WACC:** 5.7%
- **Plant lifetime:** 40 years
- **Efficiency:** 58% (Combined-cycle)
- **Capacity factor:** 85% (typical for baseload gas plants)
- **Heat content of natural gas:** 1 MMBtu = 1,055 MJ
- **Heat rate:** 6,207 kJ/kWh (calculated as 3600 / 0.58).

Steps:

1. Annual Energy Output

For a 1 MW plant:

- Annual hours = 8760.
- Annual energy output = 1 MW × 0.85 (capacity factor) × 8760 = 7446 MWh/year.

2. Fuel Cost per MWh

The cost of fuel per MWh is calculated based on the heat rate and the price of natural gas:

- Fuel cost per MWh = (Heat rate × Fuel price per MMBtu) / Energy content of 1 MMBtu.
- Fuel cost per MWh = (6,207 / 1,055) × 8 = 47.10 \$/MWh.

3. Capital Recovery Factor (CRF)

The CRF is used to amortize the construction cost over 30 years:

- $CRF = [r \times (1 + r)^n] / [(1 + r)^n - 1]$, where $r = 0.037$ and $n = 30$.
- $CRF \approx 0.05464$.

4. Annualized Capital Cost

The capital cost is amortized using the CRF:

- Annualized capital cost per kW = Construction cost per kW $\times$ CRF.
- Annualized capital cost per kW = $700 \times 0.05464 = 38.25$ \$/kW/year.
- Annualized capital cost per MWh = Annualized capital cost per kW / Annual energy output per kW.
- Annualized capital cost per MWh = $38.25 / 7446 = 5.14$ \$/MWh.

5. Fixed and Variable O&M Costs

Assume typical O&M costs for natural gas plants:

- Fixed O&M cost = \$15/kW/year.
- Fixed O&M cost per MWh = $15 / 7446 = 2.01$ \$/MWh.
- Variable O&M cost = \$3/MWh.

Total LCOE

Combine all components:

- $LCOE = \text{Capital cost per MWh} + \text{Fuel cost per MWh} + \text{Fixed O\&M cost per MWh} + \text{Variable O\&M cost}$.
- $LCOE = 5.14 + 47.10 + 2.01 + 3 = 57.25$ \$/MWh.

Final Answer:

The **Levelized Cost of Electricity (LCOE)** for the natural gas-fired power plant in China is approximately **\$57.25/MWh**.