## **UPDATED / Not Updated**

## Appendix B: Full Cost Input Parameters from Primary Study [1]

**Appendix 6**

**ECONOMIC ANALYSIS INPUT SUMMARY**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| System |  | Low | Med | High |
|  | Electricity rate (utility) | $06/KWh | $06/KWh | $06/KWh |
|  | Total power needs | 4 MW | 4 MW | 4 MW |
|  | Critical power needs | 2 MW | 2 MW | 2 MW |
|  | Peak power needs | 4 MW | 4 MW | 4 MW |
|  | Assumed duration of outage | 7 days | 7 days | 7 days |
|  | Interest rate for borrowing |  | 2% ->10% |  |

**ECONOMIC ANALYSIS COST INPUT SUMMARY**

**MICRO-REACTOR Low Median High Reference**

**Capital Cost ($/kWe)**  10,000 15,000 20,000 NEI 2019 (FOAK) [1]

4,000 8,300 15,000 NEI 2019 (NOAK)

6,500 11,800 Lazard 2017 [2]

**Capacity Factor** 0.45 0.95 NEI 2019

**Plant Life (yrs)**  20 40 60 NEI 2019

**Fixed O&M Cost ($/kWe)** 250 350 450 NEI 2019

100 150 Lazard 2017

**Fuel Cost ($/MWh)**  6 10 14 NEI 2019

(Variable cost is small) 9Lazard 2017

**Core Fuel Life (yrs)**  5 10 20 NEI 2019

**Refurb. cost ($/refuel)** 13m 20m 27m NEI 2019

**SENSITIVITY CALCULATION RANGE**

**MICRO-REACTOR Low Median High Comments**

**Capital Cost ($/kWe)**  4,000 12,000 20,000 Combined range [3]

10,000 20,000 30,000 Combined 2022 [1], [2]

**Capacity Factor** 0.85 0.95 0.98 Target range [4]

**Plant Life (yrs)**  20 40 60 NEI 2019 range

**Fixed O&M Cost ($/kWe)** 100 250 450 Combined range [5]

**Fuel Cost ($/MWh)**  12 20 28 Combined range [6]

**Core Fuel Life (yrs)**  5 10 20 NEI 2019 range

**Refurb. cost ($/refuel)** Included in fuel cost above

**Decommissioning ($/MWh)** 3 5 7 NEI 2019 range

**NUCLEAR HOMER INPUT DATA**

|  |  |  |  |
| --- | --- | --- | --- |
| **Enrichment Case** | **20% LowCost** | **20% MedCost** | **20%WorstCost** |
| **Size Increment** | 1 MWe | 1 MWe | 1 MWe |
| **Power** | 2.7 MWth | 2.7 MWth | 2.7 MWth |
| **Specific Power** | 2MW/ton | 2MW/ton | 2MW/ton |
| **Core Repl. Time (Assumed)** | 20 yr. | 10 yr. | 5 yr. |
| **Core U-mass** | 1350 kg | 1350 kg | 1350 kg |
| **Burnup** | 28 GWd/MTHM | 14 GWd/MTHM | 7 GWd/MTHM |
| **System Capital Cost** | $ 10M | $ 20M | $ 30M |
| **Fuel Cap. Cost** | $ 8,140,500 | $ 20,790,000 | $20,790,000 |
| **Fuel Unit Cost ($/kg)**  **[same as 2019 Study]** | 6030 $/kg | 15,400 $/kg | 15,400 $/kg |
| **Reactor O&M** | 100,000 $/yr | 250,000 $/yr | 450,000 $/yr |
| **Reactor Decomm.** | 28,000 $/yr | 43,000 $/yr | 61,300 $/yr |
| **SumTotal - Initial Cap. Cost** | $ 18,140,000 | $ 40,790,000 | $ 50,790,000 |
| **SumTotal - Replacement** | $ 8,140,500 | $ 20,790,000 | $ 20,790,000 |
| **SumTotal - O&M ($/yr)** | $ 0.128M | $ 0.29M | $ 0.51M |
| **SumTotal - O&M ($/op.hr)** | $ 14.60 | $ 33.42 | $ 58.33 |

1] M.Nichols et al, Cost Competitiveness of Micro-Reactors for Remote Markets, NEI, 2019.

2] Lazard - Levelized Cost of Energy Analysis, Version 11, Nov. 2017.

3] Capital cost range represents the combined range of FOAK and NOAK of cost estimates from Ref. [1]

4] The capacity factor range is a performance target that is assumed to be similar for each technology

5] Operation cost range represents the broad combined range of two references [1] and [2]

6] Fuel cost range from Ref. [1] is doubled to account for associated fuel transport and refurbishments

**RENEWABLES – update to NREL ATB 2021**

**SOLAR PV Low Median High Reference**

Capital Cost\* ($/kWe) 750 IRENA [1] ($/kWe,AC) 1280 1350 NREL ATB 2021[2B]

1072 1302 Lazard 2021[3] + Feldman Corrections[7]

Solar-PV Lifetime (yrs) 20 25 NREL-HOMER [5]

20 30 NREL ATB [2B]

Fixed O&M Cost ($/kWe) 12 16 NREL ATB [2A]

9.50 13 Lazard 2021 [3]

**WIND Turbine Low Median High Reference**

Capital Cost ($/kWe) 1680 IRENA[1]

1800 2400 NREL ATB [2A]

1025 1350 Lazard 2021 [3]

Turbine Lifetime (yrs) 20 HOMER [4]

Fixed O&M Cost ($/kWe) 51 NREL ATB [2A]

25.50 36 Lazard 2021 [3]

**BATTERY Low Median High Reference**

Capital Cost ($/kWhr) 515 Lazard 2017 [3]

(Li-Ion Battery) 550 HOMER [4]

580 IRENA [1]

469 2167 Commercial Feldman [7] based on assumed battery duration

341 845 Utility Feldman [7]

Based on assumed battery duration

Battery Lifetime (yrs) 10 15 HOMER [4]

Fixed O&M Cost ($/kWhr) 37 NREL ATB [2] 10 HOMER [4]

10 Feldman [7]

**SENSITIVITY RANGE Low Median High Reference**

Solar-PV ($/kWe) 750 1072 1350 Combined range

Solar Lifetime (yrs) 20 25 30 NREL-HOMER [5] + ATB[2B]

Solar O&M Cost ($/kWe) 9.50 13 16 Combined range

Wind-turbine ($/kWe) 1025 1800 2400 Combined range

Wind Lifetime (yrs) 20 20 HOMER [4]

Wind O&M Cost ($/kWe) 25.50 36 51 Combined range

Battery Cap. Cost ($/kWh) 341 550 845 Combined range

Battery Lifetime (yrs) 10 15 HOMER [4]

Battery O&M Cost ($/kWh) 10 18 37 Combined range

\* Note: Includes cost of DC/AC converter with estimates of 160-300 $/kWe (IRENA)

\*Above note applies to old data. New data suggests that

1] IRENA <https://www.irena.org/Statistics/View-Data-by-Topic/Costs/Solar-Costs>

2A] NREL-ATB <https://atb.nrel.gov/electricity/2018/index.html?t=in>

2B] NREL-ATB <https://atb.nrel.gov/electricity/2018/index.html?t=in> **NEEDS UPDATE TO 2021**

3] Lazard - Levelized Cost of Energy Analysis, Version 15, Oct. 2021.

4] HOMER Software - <https://www.homerenergy.com/>

5] HOMER Model based on 1%/yr degradation (NREL/CP-5200-54109 July 2012)

6] EIA, 2019: <https://www.eia.gov/analysis/studies/powerplants/capitalcost/xls/table2.xlsx>

7] Feldman, 2021: Photovoltaic system and energy storage cost benchmark.