Sunrise Power Limited

Sri Lanka Power System Proposal 2025-2049

GROUP 10

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Executive Summary

The following is a proposition to Ceylon Electricity Board's (CEB) Procurement Committee on the behalf of SUNRISE POWER Limited aimed at providing an effective solution to the rising Sri Lankan electricity demand across the years 2025-2049. The project proposes the use of a variety of power generation methods, encompassing Diesel, Onshore Wind, CCGT, Gas, Coal, Hydro and Nuclear, the installation of accompanying capacitors, transmission lines and switchyards to achieve the following objectives:

1. Installing additional power supply to meet a 2% per annum increase in demand.
2. Meeting additional loads introduced in Trincomalee between 2024 and 2029.
3. Maintaining a per unit bus voltage between 0.95 and 1.05pu.
4. Achieve a profit by the end of the project's 25 year run.
5. Maintain Sri Lankan Energy self sufficiency and security.
6. Produce a majority of energy via clean energy production
7. Produce a large safety margin above maximum demand
8. Increase job prospects within key regions of Sri Lanka

The profitability of each type of generator (and therefore their viability) was determined primarily through Excel calculations taking into account their capital, maintenance, fuel and transportation costs, and therefore ascertaining their running profits per kWh and their payback times. An analysis of the Sri Lankan environment and the country's renewable resources was also deemed necessary to verify the viability of power generation methods including Solar and Wind.

Following the economic analysis of each generator, the simulation software PowerWorld was used to create a model of each year and determine the feasibility of our solutions in matching peak demands while maintaining required bus voltages and not overloading transmission lines

This proposal predicts immutable success in meeting these objectives. By 2049, our financial team predicts a net profit of £6 Billion, with a yearly profit of over £1 Billion on energy sales in successive years. 87% of energy produced wil come from clean sources including Nuclear, Onshore Wind and Hydro, and the country will boast a large additional power generation capacity above demand.

Client Profile

The Ministry of Power and Energy of Sri Lanka is responsible for regulating policy regarding energy generation and distribution. Some of the objectives of the Ministry include meeting clean energy goals, enhancing the distribution network, and generally improving the power grid.

The Ministry of Power and Energy has multiple subsidiaries, including the Ceylon Electricity Board and the Lanka Electricity Company. The state owned Ceylon Electricity Board (CEB) was founded in accordance with the Ceylon Electricity Board Act, where the Board is instructed to develop, operate, and maintain “an efficient, coordinated and economical system of electricity supply in accordance with any appropriate licence issued by the Public Utilities Commission of Sri Lanka” (Ceylon Electricity Board Act, No. 17 of 1969). The Lanka Electricity Company (LECO) was founded just over a decade later, in 1983 as a subsidiary of the CEB. The CEB and LECO are the only two on grid electrical suppliers in Sri Lanka.

Problem Statement

Strong economic growth across the island nation of Sri-Lanka, in addition to industrial expansion across the east coast, focused in Trincomalee, threatens to outstrip the current existing supply capacity. This growth and expansion pair express themselves as an annual 2% increase in peak demand load across Sri Lanka, as well as a 600MW additional load at Trincomalee between July 2025 and January 2030.

Moreover, over the 25 year period in which we are expected to operate, we will experience losses in generators at: Biyagama, Laxapana, Kotmale, Balangod, Puttalam and Inginiya. These losses will total over 1.6GW of power, which could result in major blackouts across Sri Lanka..

In response to these impending challenges, Sunrise Power Limited has offered to assist the CEB upgrade the country’s electricity supply and grid network over a 25 year time frame, resulting in the betterment of not only the Sri Lankan communities, but also Sri Lankan economy...

Strategy

By and large, Sunrise Power Limited aims to install power stations nearby to where the largest increases in loads are introduced, such as Trincomalee. This decision was made to avoid additional thermal strain on transmission lines, alongside the additional building times and capital costs incurred by new transmission lines should the pre-existing ones be overloaded. Furthermore, this decision helps to maintain per unit bus voltages, therefore reducing the need for shunt capacitor installation, which is both expensive, and limited to 20% of the bus' MVA rating.

Large power stations such as nuclear, coal and CCGT that would normally require the installation of cooling towers were instead placed at coastal locations including Trincomalee, Battical, Puttalam and Biyagama in Colombo, where the local bodies of water could instead be used as cooling, reducing cost.

While this guideline has been generally observed by the project plan, exceptions were made for technical and financial reasons. For example: hydropower stations needed to be built onsite where the hydro resources were, or the fact that our financial department determined it was more economically viable to build CCGT and gas at Battical and build additional transmission lines rather than building gas transport pipelines.

Following our financial department's economic analysis, Sunrise Power aims to prioritise the construction of the most profitable stations such as hydro and nuclear, and avoid stations that run at a loss (such as diesel) or take longer than 25 years to pay themselves back (such as solar). However, due to mitigating factors, examples including: limited resources (for hydro, CCGT and local coal), or long build times, the final strategy is as follows:

1. In the first couple years, diesel generators are primarily used as they are the only power station that can be built fast enough to meet the rising demand at Trincomalee in time. Onshore wind is installed 2 years later, and runs at a priority over diesel to reduce running losses incurred by the latter.
2. By 2028, coal and CCGT generators can be built. The CCGT is installed on-site at Battical as installing additional transmission lines to Trincomalee is cheaper than gas transport pipes. Only one CCGT can be installed due to limits on gas importation. Diesel is slowly phased out.
3. As of 2031 onwards, hydro and nuclear power become available. These are prioritised as they are both highly profitable with low payback times, as well as contribute to Sri Lanka's sustainability goals.

Sunrise Power Limited also aims to maximise the share of energy produced by clean energy sources such as nuclear, wind and hydropower. This is however tempered by a need to maintain a level of fast-acting generator types such as CCGT to ensure a dynamic supply able to react fast and accurately to rapid changes in demand.

Timeline

December 2024:

Begin: 9 Units Diesel at Trincomalee

2025:

Finish: 9 units Diesel at Trincomalee
19.9 MVar Capacitors Trincomalee
4.7 MVAr Capacitors Anurad
Begin: 8 Units Diesel Trincomalee
+2 Transmission Lines Battical - Trincomalee (4 years)
600 MW Nuclear Trincomalee
100 Units Wind Trincomalee
132kV Transformer at Trincomalee
132kV switchyard at Trincomalee

2026:

Finish: 8 units Diesel at Trincomalee
+11.2 MVAr Trincomalee
+2.8 MVar Anurad
132kV Transformer at Trincomalee
132kV switchyard at Trincomalee
Begin: 30 units Diesel at Trincomalee
2 132kV Transformers Trincomalee

2027:

Finish: 30 units Diesel at Trincomalee
+0.9 MVar Trincomalee
+1.9 MVar Anurad
100 Units Wind at Trincomalee
2 132kV Transformers Trincomalee
Begin: 20 Units Diesel at Trincomalee
+1 CCGT at Battical
132kV Transformer at Trincomalee

2028:

Finish: 20 units Diesel at Trincomalee
+5.7MVAr Trincomalee
+2.8 MVar Anurad
132kV Transformer at Trincomalee
Begin: 600MW Nuclear Biyagama
2 132kV Transformer at Battical
132kV switchyard at Battical

2029:

Finish: 1 CCGT (200 MW) at Battical
2 Transmission lines Battical - Trincomalee
+16.1 MVAr Trincomalee
+0.4MVar Anurad
2 132kV Transformer at Battical
132kV switchyard at Battical
Begin: 33 Units Diesel at Trincomalee
132kV Transformer at Trincomalee

2030:

Finish: 33 units Diesel at Trinco
38.2 MVar Battical
132kV Transformer at Trincomalee
Begin: 132kV Transformer at Trincomalee

2031

Finish: Nuclear 600MW Trincomalee
132kV Transformer at Trincomalee
Sell: all 500 MW (100 Units) Diesel at Trincomalee

2032

Begin: 200 Units Wind at Ramtembe

2033

Begin: 300 MW Hydro at Kotmale
300 MW Hydro at Laxapana
3 220kV Transformer at Biyagama
220kV switchyard at Biyagama

2034

Change: Biyagama generator drops to 300MW
Finish: 600 MW Nuclear at Biyagama
200 Units Wind at Ramtembe
3 220kV Transformer at Biyagama
220kV switchyard at Biyagama
Begin; 100MW Hydro at Laxapana

2035

Begin: 100MW hydro Badulla
Begin: Local coal at Trincomalee

2036

No Change

2037

Finish: +8.9 MVar at Trincomalee

2038

Finish: +2.9 Mvar at Trincomalee
Begin: 15MW gas at Battical
600 MW Nuclear Puttalam
200 MW Hydro Badulla
3 132kV Transformer at Laxapana
132kV switchyard at Laxpana
3 132kV Transformer at Kotmale
132kV switchyard at Kotmale

2039

Change: Kotmale pre-existing generator
falls from 723 to 361.5MW
Laxapana from 335 to 167.5 MW
Finish: 300 MW Hydro at Kotmalee
300 MW Hydro at Laxapana
Local coal at Trincomalee
15 MW gas at Battical
3 132kV Transformer at Laxapana
132kV switchyard at Laxpana
3 132kV Transformer at Kotmale
132kV switchyard at Kotmale
Begin; 15 MW Gas Battical
3 132kV Transformer Trincomalee
132kV switchyard at Trincomalee
132kV Transformer Laxpana

2040

Finish: 15 MW Gas at Battical
100 MW Hydro at Laxapana
Add 6.5MVar at Trincomalee
3 132kV Transformer Trincomalee
132kV switchyard at Trincomalee
132kV Transformer Laxpana
Begin: 132kV Transformer at Badulla
132kV switchyard at Badulla

2041

Finish: 100MW hydro Badulla
132kV Transformer at Badulla
132kV switchyard at Badulla
Sell: 2 gas units (30 MW) at Battical

2042:

No change

2043:

Begin: 7 units Diesel at Balangod
6 132kV Transformer at Puttalam
132kV switchyard at Puttalam
132kV Transformer at Balangod
132kV switchyard at Balangod
2 132kV switchyard at Badulla

2044:

Change: pre existing generators go offline
at Balagod, Inginiya, Puttalam
Finish: 600 MW nuclear at Puttalam
200 MW Hydro at Badulla
7 units Diesel at Balangod
15.2 MVAR Capacitance Balangod
6 132kV Transformer at Puttalam
132kV switchyard at Puttalam
132kV Transformer at Balangod
132kV switchyard at Balangod
2 132kV switchyard at Badulla
Begin: 1 unit Diesel at Balangod

2045:

Finish:1 Unit Diesel at Balangod

2046:

No change

2047:

Begin: 12 units Diesel at Balangod

2048:

Finish: 12 units Diesel at Balangod
Begin:4 units Diesel at Balangod
132kV Transformer at Balangod

2049:

Finish: 4 units Diesel at Balangod
3MVAr at Trincomalee
132kV Transformer at Balangod

Key years

2025-2029

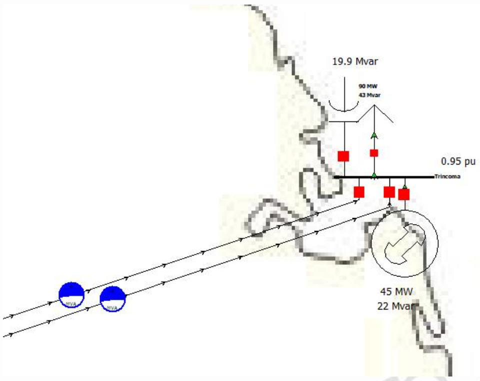


Fig 1.1: July 2025 Trincomalee

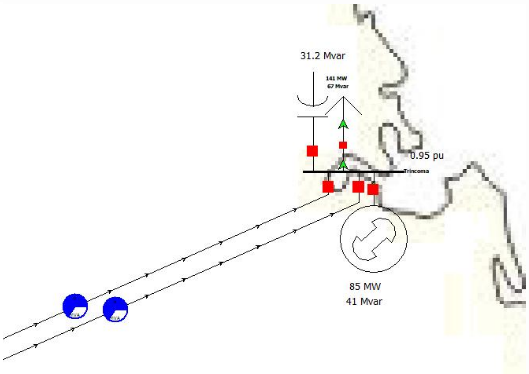


Fig 1.2: 2026 Trincomalee

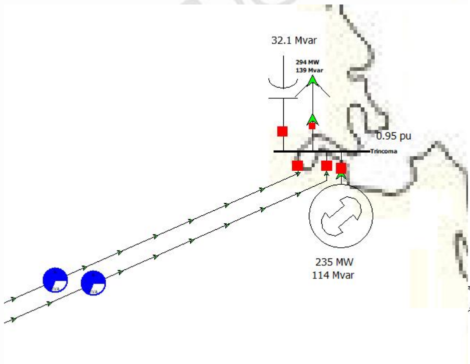


Fig 1.3: 2027 Trincomalee

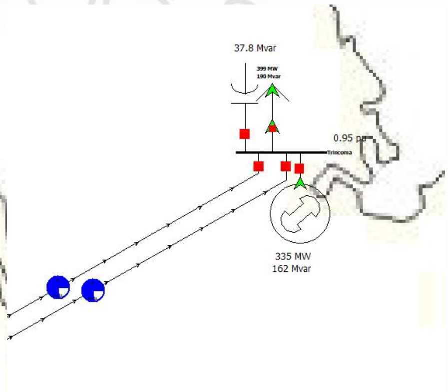


Fig 1.4: 2028 Trincomalee

Fig 1.5: 2029 Trincomalee and Battical

The first five years are critical, as large and sudden loads are added to Trincomalee. This is overcome through the addition of many diesel plants (which are eventually sold and replaced with nuclear) and large amounts of added shunt capacitance. In 2029, a CCGT generator is built in Battical to help offset the added load in Trincomalee, along with a double circuit 132kV transmission line connecting the two locations.

2034

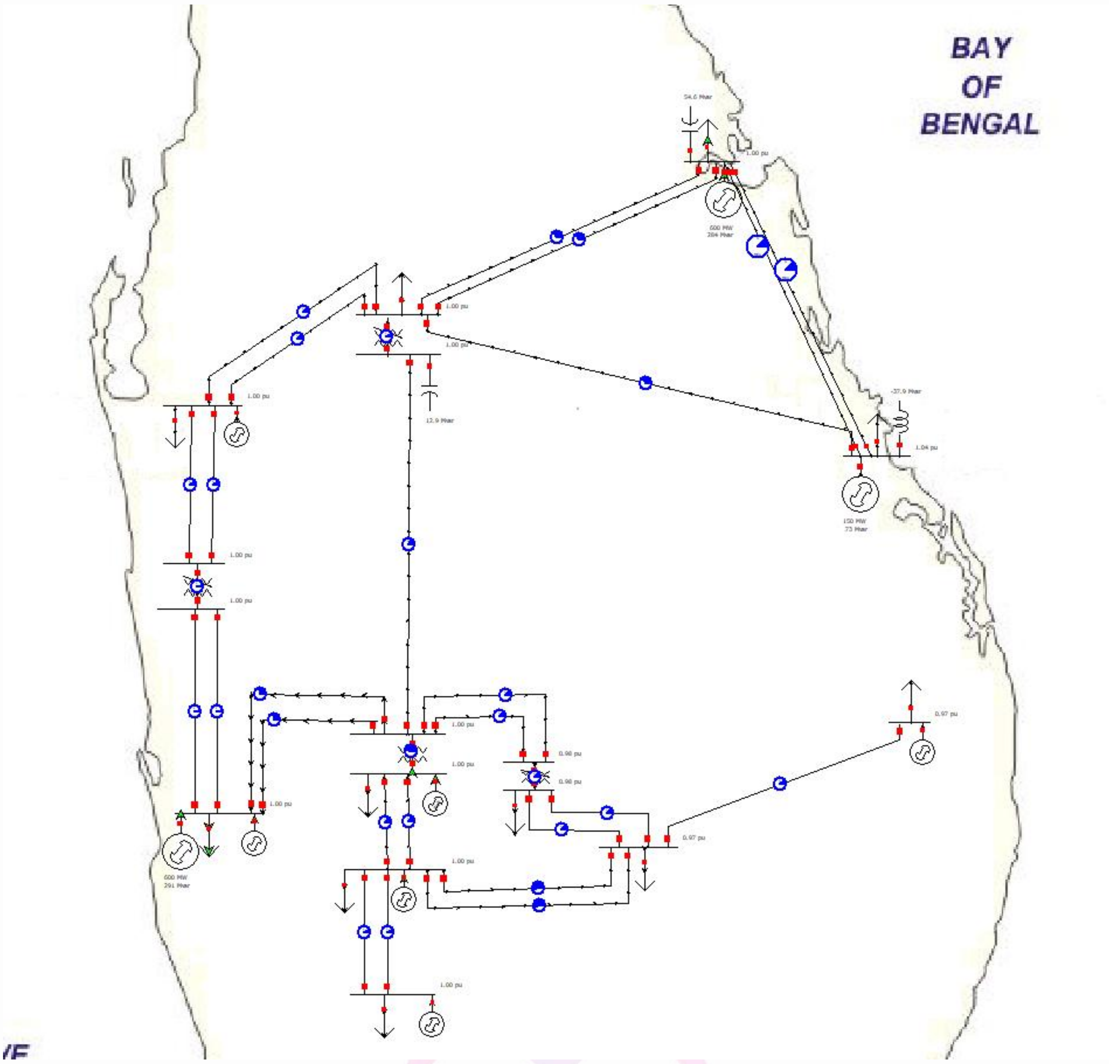


Fig 1.6: Sri Lanka Power Map 2034

In 2034, the generator at Biyagama drops to 300MW, from an initial 846MW. This is offset by a 600 MW nuclear generator being finished there, helping to take up the lost generation and cover additional loads.

2039

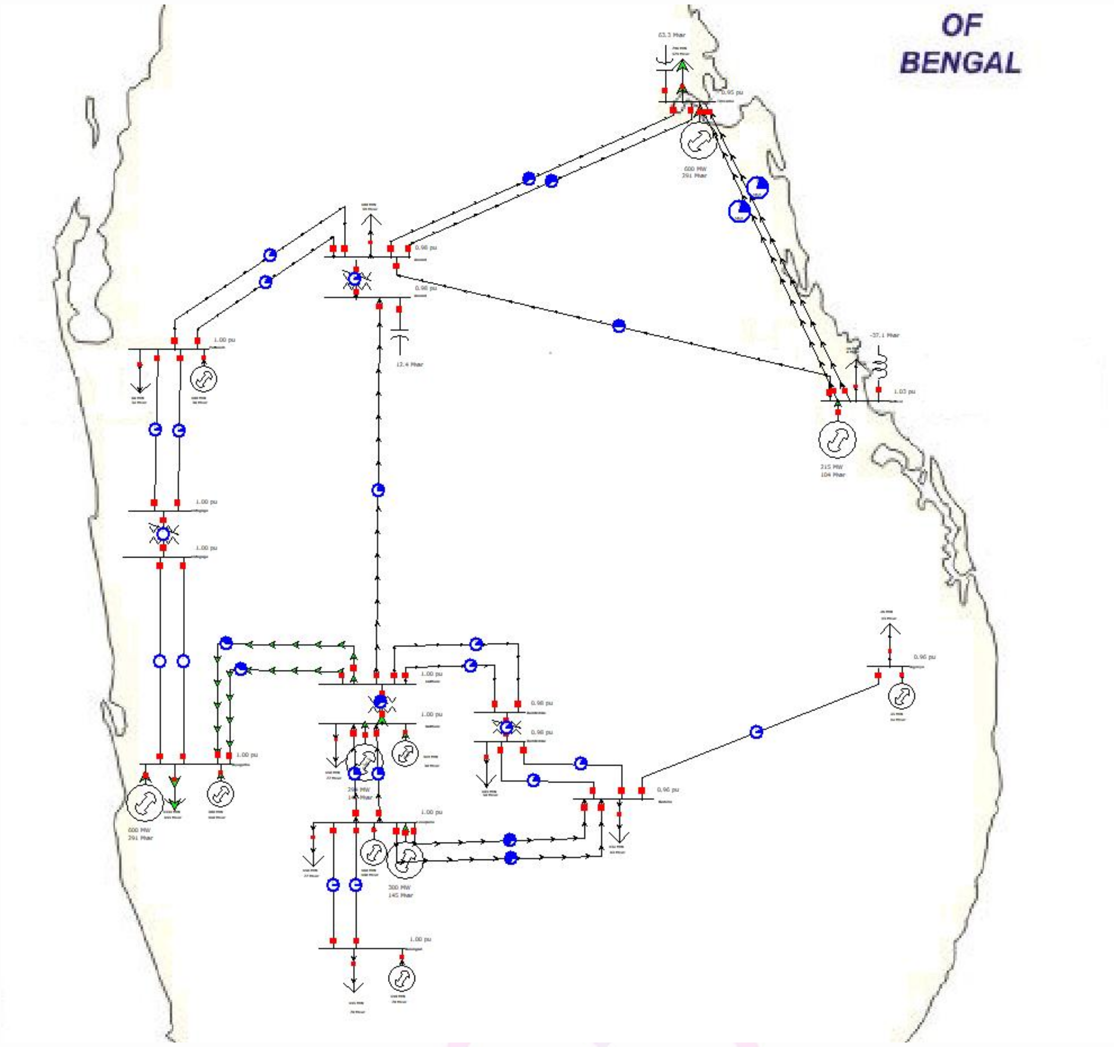


Fig 1.7: Sri Lanka Power Map 2039

In 2039, the pre-existing generators at Laxapana and Kotmale drop from 335 to 167.5MW and 723 to 361.5MW respectively. To compensate, and meet rising demand, 300MW of hydro is finished at Laxapana, 15 MW gas at Battical and a local coal Unit at Trincomalee.

2044

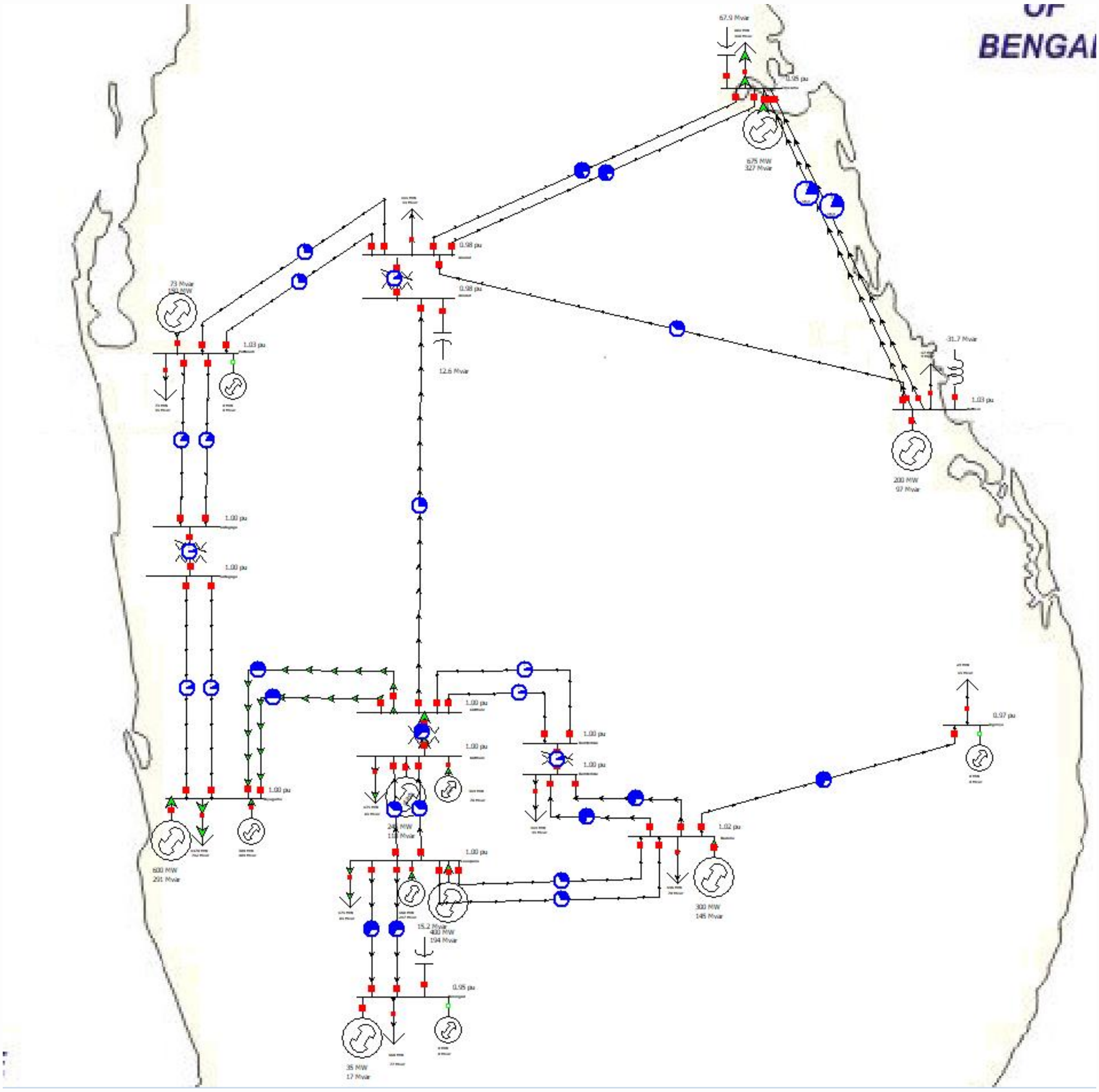


Fig 1.8: Sri Lanka Power Map 2044

In 2044, the pre-existing generators at Balangod, Inginiya and Puttalam go offline. To combat this loss of power generation, in the same year we complete the installation of a 600 MW nuclear plant at Puttalam (not used in full capacity in figure above), 2 100MW hydro plants at Badulla and pairing 7 units of diesel with 15.1 MVArs of shunt capacitance at Balangod.

Technical Analysis:

Maximum Generation and Maximum Demand

One objective of Sunrise Power Limited's proposal is to ensure a large power margin, thereby ensuring power security for Sri Lanka. This is easily achieved with our plan, as observed in Fig 2.1 below, demonstrating that the designed power generation system has enough spare capacity to account for possible generator breakdowns and other unforeseen events.

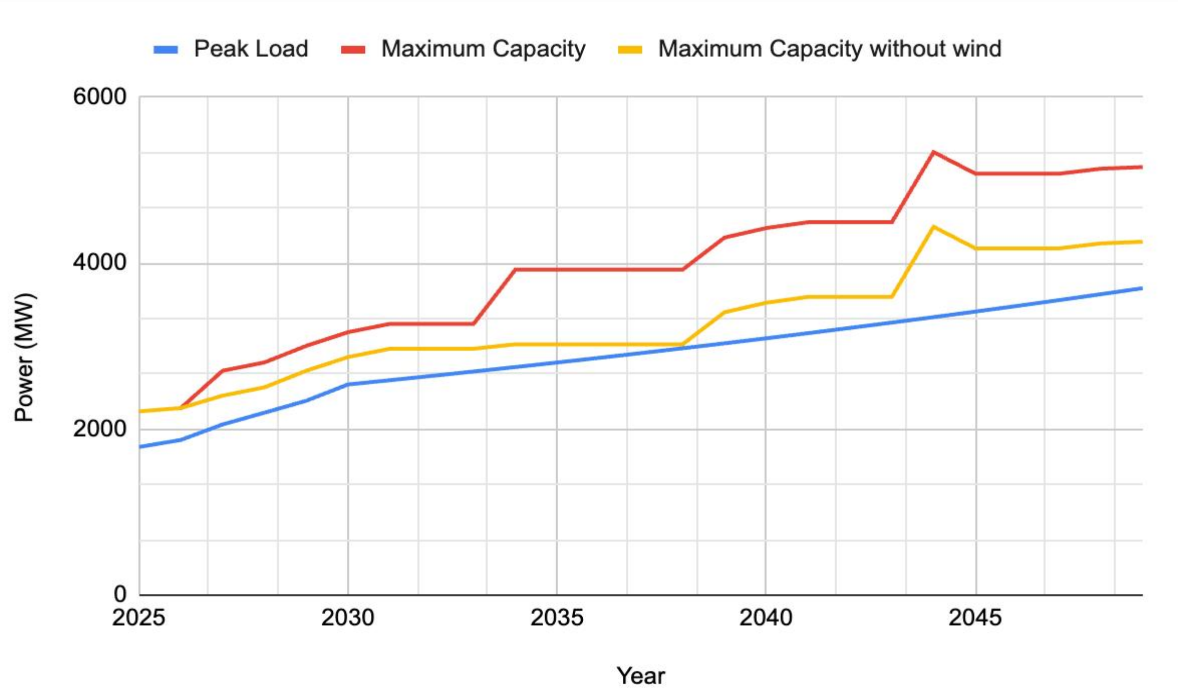


Fig 2.1: Sri Lanka Peak Demand Compared to Power System Maximum Capacity

The maximum theoretical capacity of the system is illustrated in red above, with the maximum peak load across Sri Lanka graphed in blue. In practice however, the maximum capacity is unlikely to be as displayed as part of the generated power is from onshore wind, which cannot be expected to always run at full capacity when peak load is being experienced due to its unreliable nature. As such, the true maximum capacity of the system lies between the red and yellow lines, which still indicates a suitable margin across the 25 years.

Capacity by Generation Type

Producing a large power margin is not enough by itself. To ensure power security, the added capacity above maximum demand must come from a wide variety of power generation methods, to ensure redundancy and avoid overreliance on any specific type of generator. The table and graph below prove that Sunrise Power Limited’s proposal has taken these factors into consideration and ensured that power generation in Sri Lanka comes from a myriad of sources:

	Diesel		Gas		CCGT		Coal		Wind		Hydro		Nuclear		Total
Year	Units	Peak (MW)	Units	Peak (MW)	Units	Peak (MW)	Units	Peak (MW)	Units	Peak (MW)	Units	Peak (MW)	Units	Peak (MW)	
2024		0		0		0		0		0		0		0	0
2025	9	45		0		0		0		0		0		0	45
2026	17	85		0		0		0		0		0		0	85
2027	47	235		0		0		0	100	300		0		0	535
2028	67	335		0		0		0	100	300		0		0	635
2029	67	335		0	1	200		0	100	300		0		0	835
2030	100	500		0	1	200		0	100	300		0		0	1000
2031		0		0	1	200		0	100	300		0	1	600	1100
2032		0		0	1	200		0	100	300		0	1	600	1100
2033		0		0	1	200		0	100	300		0	1	600	1100
2034		0		0	1	200		0	300	900		0	2	1200	2300
2035		0		0	1	200		0	300	900		0	2	1200	2300
2036		0		0	1	200		0	300	900		0	2	1200	2300
2037		0		0	1	200		0	300	900		0	2	1200	2300
2038		0		0	1	200		0	300	900		0	2	1200	2300
2039		0	1	15	1	200	1	300	300	900	6	600	2	1200	3215
2040		0	2	30	1	200	1	300	300	900	7	700	2	1200	3330
2041		0		0	1	200	1	300	300	900	8	800	2	1200	3400
2042		0		0	1	200	1	300	300	900	8	800	2	1200	3400
2043		0		0	1	200	1	300	300	900	8	800	2	1200	3400
2044	9	45		0	1	200	1	300	300	900	10	1000	3	1800	4245
2045	10	50		0	1	200	1	300	300	900	10	1000	3	1800	4250
2046	10	50		0	1	200	1	300	300	900	10	1000	3	1800	4250
2047	10	50		0	1	200	1	300	300	900	10	1000	3	1800	4250
2048	22	110		0	1	200	1	300	300	900	10	1000	3	1800	4310
2049	26	130		0	1	200	1	300	300	900	10	1000	3	1800	4330

Fig 2.2.1 Year by Year Peak Output from Generator Types

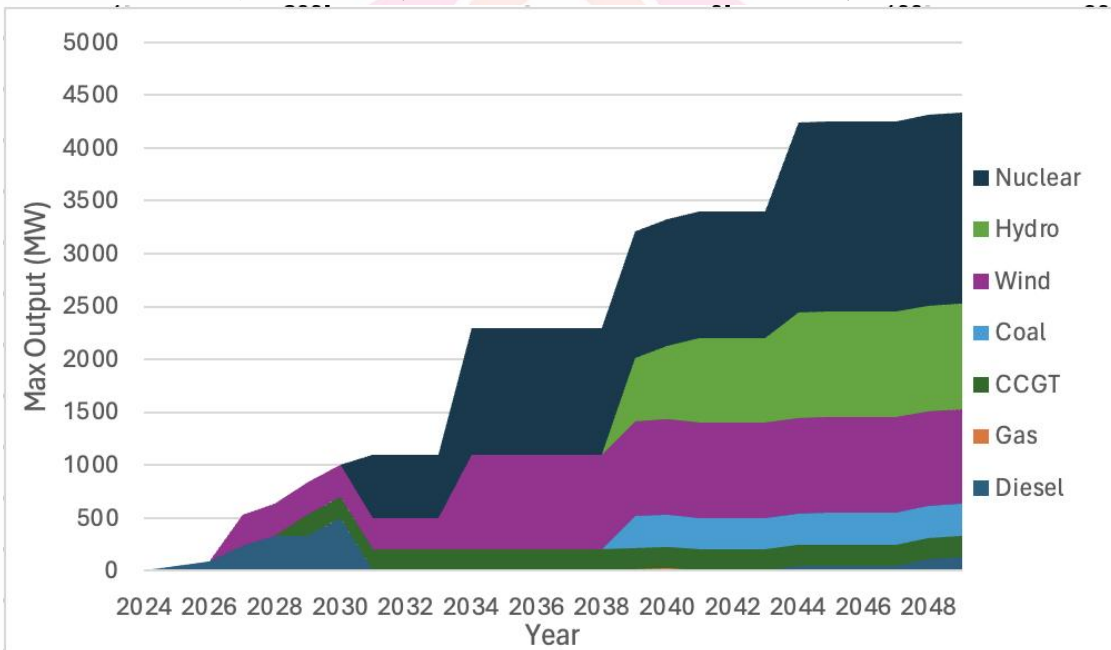
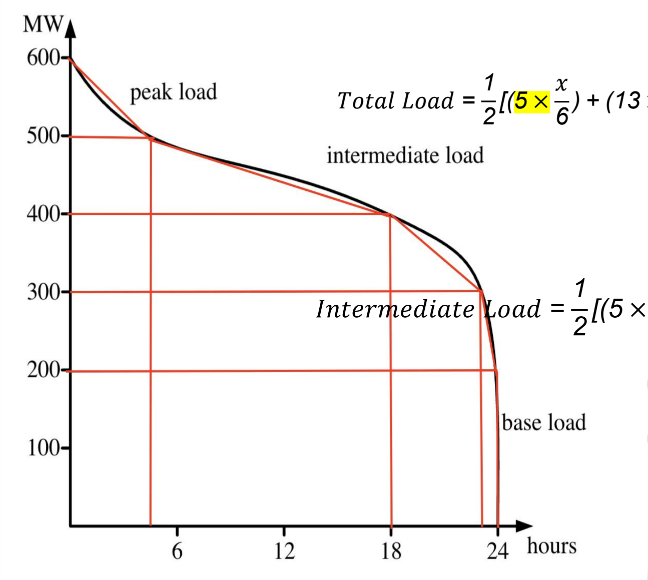


Fig 2.2.2: Share of Max Output From Each Power Type

Load Calculation

While the peak demand values are certainly necessary for the technical analysis of the project, knowledge of the total energy consumed is necessary to predict revenue and costs:



Call Peak Demand x:

$$Total\ Load = \frac{1}{2}[(5 \times \frac{x}{6}) + (13 \times \frac{x}{6}) + (5 \times \frac{x}{6}) + (\frac{x}{6})] + (\frac{x}{3} \times 24) + (\frac{x}{6} \times 23) + (\frac{x}{6} \times 18) + (\frac{x}{6} \times 5) = \frac{53x}{3} \text{MWh}$$

$$Intermediate\ Load = \frac{1}{2}[(5 \times \frac{x}{6}) + (\frac{x}{6})] + (\frac{x}{3} \times 24) + (\frac{x}{6} \times 23) + (\frac{x}{6} \times 18) = \frac{46x}{3} \text{MWh}$$

Fig 2.3: Load Duration Curve and Daily Energy Calculations

The figure above represents the load duration curve of the new loads at Trincomalee. Knowing that other loads on the island follow a similar curve, an equation can be derived (as above) to determine the energy demanded per day as a function of the peak demand. This calculation was used to determine yearly energy demands and therefore revenue.

Moreover, Understanding that the intermediate load ($\frac{46x}{3}$) represents 87% of the total load ($\frac{53x}{3}$) allows us to ensure that fast acting generators provide at least 13% of the total energy, so that our system can respond dynamically to shifts in demand.

This was calculated by using the trapezium rule to find the area under the graph. It is, however, just an approximation, but it should give a reliable enough estimate for how much power is needed at any given stage, and hence a clear insight into how much money can be feasibly earnt..

Economic Analysis

Net Profits

By 2049, Sunrise Power Limited's Proposal will have produced a net profit of £5.9 Billion, or an equivalent 2.3 Trillion Sri Lankan Rupees by current exchange rates. After high initial spending due to large capital investments, profits from selling energy steadily ramp up and by 2043, The proposal has already broken even. Moreover, by 2049, Sunrise Power Limited will be making a yearly profit of energy sales of £1.085 Billion Annually.

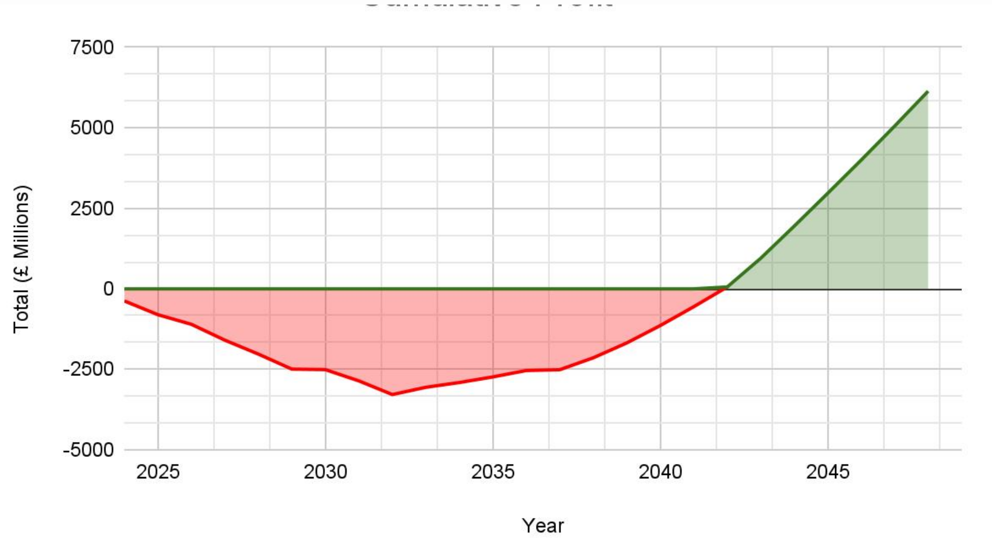


Fig 2.4.1: Cumulative Profit By year

The breakdown is as follows, over the 25 year timeframe of the project, the total capital cost (interest not included) investment sums up to £5.5 Billion (including capacitor and transmission line construction), the total interest payments being £2.1 Billion, funds recouped from reselling of gas and diesel plants being £31.8 Million, and total profit on energy sale being £13.7 Billion. Further breakdowns are available in the respective sections of this report.

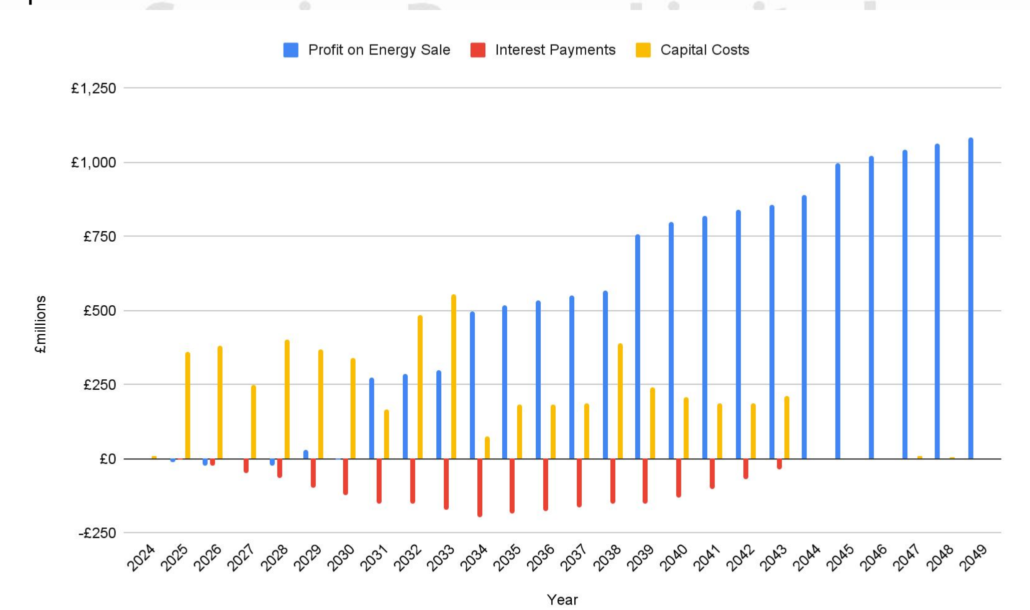


Fig 2.4.2: Year by Year Breakdown of costs and revenues

Year	Capital cost Investment	Selling	Profit on Energy Sale	Interest	Total
2024	£8,250,000	£0			-£8,250,000
2025	£373,112,402	£0	-£8,742,298	-£495,000	-£390,599,700
2026	£380,333,623	£0	-£23,551,750	-£23,435,982	-£817,921,055
2027	£250,444,725	£0	-£56,572	-£49,075,263	-£1,117,497,614
2028	£414,824,194	£0	-£24,730,833	-£67,049,857	-£1,624,102,498
2029	£368,611,621	£0	£32,084,695	-£97,446,150	-£2,058,075,574
2030	£342,344,278	£0	-£2,335,480	-£123,484,534	-£2,526,239,867
2031	£166,666,667	£27,500,000	£272,768,473	-£151,574,392	-£2,544,212,452
2032	£486,666,667	£0	£287,910,848	-£152,652,747	-£2,895,621,018
2033	£579,444,444	£0	£300,291,396	-£173,737,261	-£3,348,511,327
2034	£77,037,037	£0	£499,370,635	-£200,910,680	-£3,127,088,409
2035	£185,462,963	£0	£517,014,892	-£187,625,305	-£2,983,161,784
2036	£185,462,963	£0	£534,047,106	-£178,989,707	-£2,813,567,348
2037	£187,096,403	£0	£550,771,564	-£168,814,041	-£2,618,706,228
2038	£417,087,800	£0	£568,463,827	-£157,122,374	-£2,624,452,574
2039	£252,611,111	£0	£759,491,162	-£157,467,154	-£2,275,039,677
2040	£220,185,185	£0	£797,942,001	-£136,502,381	-£1,833,785,242
2041	£185,925,926	£4,300,000	£821,638,531	-£110,027,115	-£1,303,799,751
2042	£185,925,926	£0	£840,389,348	-£78,227,985	-£727,564,314
2043	£238,175,926	£0	£858,930,280	-£43,653,859	-£150,463,818
2044	£916,667	£0	£891,828,225	-£9,027,829	£731,419,911
2045	£0	£0	£998,170,053	£0	£1,729,589,964
2046	£0	£0	£1,020,112,229	£0	£2,749,702,193
2047	£11,000,000	£0	£1,042,490,938	£0	£3,781,193,131
2048	£5,666,667	£0	£1,062,708,215	£0	£4,838,234,679
2049	£550,598	£0	£1,085,117,539	£0	£5,922,801,620

Fig 2.4.3:Year By Year Revenue Breakdown

The table above outlines a year by year financial sheet, broken down year by year.

Generator Benefit Analysis

To make appropriate and informed decisions on which methods of power generation to employ, Sunrise Power Limited's financial team led an analysis of each type of generator. Values were calculated as follows:

$$Average\ Output\ per\ unit = Unit\ Capacity \times \frac{Availability}{100} \times \frac{Capacity\ Factor}{100}$$

$$Cost\ per\ kWh = Operation\ and\ Maintenance\ cost + Fuel\ Cost\ per\ kWh$$

$$Fuel\ Cost\ per\ kWh = \frac{Fuel\ cost\ per\ kg}{\frac{Efficiency}{100} \times Calorific\ Value\ per\ kg}$$

$$Profit\ per\ kWh = £0.06 - Cost\ per\ kWh$$

$$Profit\ per\ year\ per\ unit = 1000 \times 24 \times 365 \times Average\ Output\ per\ unit\ (MW) \times Profit\ per\ kWh$$

<u>Note 1</u>: Transport costs are not taken into account for fuel cost as most power stations were built on site at ports to prevent transportation costs. A notable exception is the local coal station at Trincomalee, which incurs an additional £0.015/kWh transportation coal 134km from Battical.
<u>Note 2</u>: that certain values, such as Fuel Cost per kg, were converted from original units (Fuel cost per tonne) prior to calculations.

Plant Type	Installation Cost per unit (£000)	Average Output per Unit (MW)	Cost per kWh (no transportation)	Total profit per kWh (not including transport)	Profit per year per unit	Time to pay back (years inc. Interest payments)
Gas	£7,166.67	12.75	£0.0474	£0.0126	£1,403,860.47	7
CCGT	£108,333.33	170	£0.0321	£0.0279	£41,610,329.73	3
Coal (local)	£445,833.33	255	£0.0220	£0.0380	£84,966,697.89	5
Coal (imported)	£445,833.33	255	£0.0252	£0.0306	£68,433,638.68	7
Diesel	£916.67	4.5	£0.0871	-£0.0271	-£1,068,869.63	N/A
Wind (onshore)	£3,200.00	0.855	£0.0120	£0.0480	£359,510.40	14
Wind (offshore)	£5,333.33	1.52	£0.0240	£0.0360	£479,347.20	19
Solar PV	£1,000.00	0.1425	£0.0080	£0.0520	£64,911.60	45
Hydro	£115,555.56	66.5	£0.0013	£0.0587	£34,195,098.00	4
Nuclear	£1,250,000	510	£0.0069	£0.0531	£237,229,560.00	6

Fig 2.5: Table of Generator Analysis

From the above calculations, Sunrise Power Limited has aimed to prioritise the construction of power generation methods with the lowest payback times as possible, as these will start providing a return on their investment the fastest.

However post-construction, the energy provided by plant types with the highest profit per kWh were prioritised for distribution as they would reduce maintenance costs overall.
Further individual analysis of each type of generator used in Sunrise Power Limited's proposal is found below:

Diesel

Advantages:

- It is the cheapest generator to build per kVA produced
- It is the fastest generator to build, only taking 6 months to fully complete
- It has the highest available use time out of any other generator
- Has a quick start-up and can rapidly respond to changes in demand of electricity

Disadvantages:

- It is using fossil fuels, releasing greenhouse gases into the atmosphere, contributing to global warming
- Operating the generator results in a loss, as the cost of running it is greater than the revenue produced per kWh
- If it is not built on a shore, a further transportation cost is incurred

Onshore wind

Advantages:

- It is a renewable source of energy, helping cut down greenhouse gas emissions
- It is the second fastest generator (along with Solar) to be built, taking only 2 years
- It is profitable to operate, thus decreasing the payback time from diesel

Disadvantages:

- It is loud and unpleasant to look at, meaning that it must be located far from any major cities
- It can only operate at 28.5% of its overall potential output (on average)
- It takes 14 years (interest adjusted) to pay back the loan if operating at maximum realistic output

Coal (local) Generators:

Advantages:

- It only takes 5 years (interest adjusted) to pay back the loan if operating at maximum realistic output
- It has the second highest unit capacity compared to all the other possible generators
- Cheaper than Imported Coal equivalent

Disadvantages:

- It is using fossil fuels, releasing greenhouse gases into the atmosphere, contributing to global warming
- Additional costs are incurred in transportation if not placed near local source
- A cooling tower will be needed for the plant, if not placed by the coast, which increases the cost per kVA by 25%

- It takes 4 years to construct the power plant

Gas Generators:

Advantages:
- It has a build time of only 1 year
- It only takes 7 years (interest adjusted) to pay back the loan if operating at maximum realistic output
- Has a quick start-up and can rapidly respond to changes in demand of electricity

Disadvantages:
- It is using fossil fuels, releasing greenhouse gases into the atmosphere, contributing to global warming
- It can only be built in one location or else a charge is incurred to construct a gas pipeline
- If the power is sold to India, the result would be loss making

CCGT Generators:

Advantages:
- Has a quick start-up and can rapidly respond to changes in demand of electricity
- It only takes 3 years (interest adjusted) to pay back the loan if operating at maximum realistic output
- It has the highest efficiency out of the fossil fuel emitting power plants
- It has the second lowest cost to set up per kVA

Disadvantages:
- Only a set amount of gas can be used by Sri Lanka per year, resulting in the capacity for only one CCGT plant
- It is using fossil fuels, releasing greenhouse gases into the atmosphere, contributing to global warming
- A cooling tower will be needed for the plant, which increases the cost per kVA by 25%
- It can only be built in one location or else a charge is incurred to construct a gas pipeline

Hydro Generators:

Advantages:
- It is a renewable source of energy, helping cut down greenhouse gas emissions
- It only takes 4 years (interest adjusted) to pay back the loan if operating at maximum realistic output
- It has the lowest cost per kWh produced out of any generator
- It has the highest operational average out of any of the renewable sources of energy at 66.5%

Disadvantages:

- It has a build time of 6 years, which is the longest build time of any plant (tied with nuclear)
- The hydro plants can only be built in 3 specific locations
- There can only be a maximum of 1GW of hydro power being produced

Nuclear Generators:

Advantages:

- Nuclear power, although not renewable, is clean energy
- It only takes 6 years (interest adjusted) to pay back the loan if operating at maximum realistic output
- It produces the largest amount of profit per unit per year

Disadvantages:

- It has a build time of 6 years, which is the longest build time of any plant (tied with hydro)
- It is dangerous, difficult and expensive to dispose of the nuclear waste
- It is the most expensive per kVA to initially manufacture

Despite the weaknesses of the generators, Sunrise Power Limited has chosen these generators to walk a fine line between inching closer to the goal of a carbon net negative society, and as a good financial investment.

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Hydro

Year	Units	Build cost	Profit
2025			
2026			
2027			
2028			
2029			
2030			
2031			
2032			
2033	3	£57,77,778	
2034	4	£77,037,037	
2035	5	£96,296,296	
2036	5	£96,296,296	
2037	5	£96,296,296	
2038	6	£115,555,555	
2039	3	£57,777,778	£123,653,274
2040	2	£38,518,518	£239,365,686
2041	1	£19,259,259	£273,560,784
2042	1	£19,259,259	£273,560,784
2043	1	£19,259,259	£341,950,980
2044			£341,950,980
2045			£341,950,980
2046			£341,950,980
2047			£341,950,980
2048			£341,950,980
2049			£341,950,980

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Nuclear

Year	Units	Build cost	Profit
2025	1	£166,666,667	
2026	1	£166,666,667	
2027	1	£166,666,667	
2028	2	£333,333,333	
2029	2	£333,333,333	
2030	2	£333,333,333	
2031	1	£166,666,667	£237,229,560
2032	1	£166,666,667	£237,229,560
2033	1	£166,666,667	£237,229,560
2034			£451,478,088
2035			£467,814,237
2036			£474,459,120
2037			£474,459,120
2038	1	£166,666,667	£474,459,120
2039	1	£166,666,667	£474,459,120
2040	1	£166,666,667	£474,459,120
2041	1	£166,666,667	£468,437,546
2042	1	£166,666,667	£474,459,120
2043	1	£166,666,667	£474,459,120
2044			£478,227,659
2045			£576,886,471
2046			£597,201,901
2047			£617,921,500
2048			£639,051,211
2049			£660,602,922

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Wind

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Year	Units	Build cost	Profit
2025	100	£160,000,000	
2026	100	£160,000,000	
2027			£35,951,040
2028			£35,951,040
2029			£35,951,040
2030			£35,951,040
2031			£15,196,731
2032	200	£320,000,000	£29,106,910
2033	200	£320,000,000	£35,951,040
2034			£10,785,312
2035			£10,785,312
2036			£19,838,597
2037			£35,202,118
2038			£52,394,378
2039			£107,853,120
2040			£29,536,851
2041			£23,646,978
2042			£35,162,990
2043			£52,466,093
2044			£10,785,312
2045			£10,785,312
2046			£10,785,312
2047			£10,785,312
2048			£10,785,312
2049			£10,785,312

CCGT

Year	Units	Build cost	Profit
2025			
2026			
2027	1	£43,333,333	
2028	1	£43,333,333	
2029			£41,610,330
2030			£41,610,330
2031			£20,342,182
2032			£21,574,378
2033			£27,110,796
2034			£37,107,235
2035			£38,415,343
2036			£39,749,389
2037			£41,110,326
2038			£41,610,330
2039			£41,610,330
2040			£41,610,330
2041			£41,610,330
2042			£41,610,330
2043			£41,610,330
2044			£56,785,658
2045			£64,575,560
2046			£66,202,307
2047			£67,861,416
2048			£68,231,626
2049			£69,516,787

Coal

Edinburgh, United Kingdom
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Year	Units	Build cost	Profit
2025			
2026			
2027			
2028			
2029			
2030			
2031			
2032			
2033			
2034			
2035	1	£89,166,667	
2036	1	£89,166,667	
2037	1	£89,166,667	
2038	1	£89,166,667	
2039			£19,848,378
2040			£21,389,579
2041			£24,244,479
2042			£26,289,557
2043			£28,376,100
2044			£8,496,670
2045			£8,496,670
2046			£8,496,670
2047			£8,496,670
2048			£8,496,670
2049			£8,496,670

Gas

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Edinburgh, United Kingdom

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Year	Units	Build cost	Profit
2025			
2026			
2027			
2028			
2029			
2030			
2031			
2032			
2033			
2034			
2035			
2036			
2037			
2038	1	£7,166,667	
2039	1	£7,166,667	
2040			£140,386
2041			£280,772
2042			
2043			
2044			
2045			
2046			
2047			
2048			
2049			

Diesel

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Year	Units	Build cost	Profit
2025	17	£31,166,667	-£8,742,298
2026	8	£14,666,667	-£23,551,750
2027	30	£55,000,000	-£36,007,612
2028	20	£36,666,667	-£60,681,873
2029			-£45,476,675
2030	33	£60,500,000	-£79,896,850
2031			
2032			
2033			
2034			
2035			
2036			
2037			
2038			
2039			
2040			
2041			
2042			
2043	9	£16,500,000	
2044	1	£1,833,333	-£961,983
2045			-£1,068,870
2046			-£1,068,870
2047	12	£22,000,000	-£1,068,870
2048	4	£7,333,333	-£2,351,513
2049			-£2,779,061

Yearly Energy Profits

The figure below shows the year by year breakdown on the share of yearly kWh produced by each type of generator, as well as the yearly energy sale profits. As observed below, while losses are made in earlier years when diesel generators are relied on, the net profit on energy sale per year steadily ramps up, reaching a yearly value of £1.085 Billion by 2049.

		kWh Produced By type of Generator								
Year	Total Load (kWh)	Diesel	Gas	CCGT	Coal	Wind	Solar	Hydro	Nuclear	Energy sale profits
2025	322416666.7	322416666.7	0	0	0	0	0	0	0	-£8,742,297.88
2026	868590500	868590500	0	0	0	0	0	0	0	-£23,551,750.48
2027	2076943683	1327963683.3	0	0	0	748980000	0	0	0	-£56,571.55
2028	2986932483	2237952483.3	0	0	0	748980000	0	0	0	-£24,730,833.08
2029	3915363517	1677183517	0	1489200000	0	748980000	0	0	0	£32,084,694.93
2030	5184782417	2946602417	0	1489200000	0	748980000	0	0	0	-£2,335,480.27
2031	5512228783	0	0	728030216.7	0	316598566.7	0	0	4467600000	£272,768,473.16
2032	5846123483	0	0	772129516.7	0	606393966.7	0	0	4467600000	£287,910,848.44
2033	6186853417	0	0	970273416.7	0	748980000	0	0	4467600000	£300,291,395.59
2034	10055144100	0	0	1328037900	0	224694000	0	0	8502412200	£499,370,635.19
2035	10409608983	0	0	1374854017	0	224694000	0	0	8810060967	£517,014,892.44
2036	10771102550	0	0	1422598450	0	413304100	0	0	8935200000	£534,047,106.12
2037	11139882733	0	0	1471305267	0	733377466.7	0	0	8935200000	£550,771,564.26
2038	11515949533	0	0	1489200000	0	1091549533	0	0	8935200000	£568,463,827.33
2039	15310858183	0	11169000	1489200000	521819816.7	2246940000	0	2106529367	8935200000	£759,491,162.42
2040	15702207533	0	22338000	1489200000	562338466.7	615351066.7	0	4077780000	8935200000	£797,942,000.51
2041	16101359367	0	0	1489200000	637394633.3	492645366.6	0	4660320000	8821799367	£821,638,531.46
2042	16508442650	0	0	1489200000	691160350	732562300	0	4660320000	8935200000	£840,389,348.37
2043	16923779800	0	0	1489200000	746016200	1093043600	0	4660320000	8935200000	£858,930,280.24
2044	17347435300	35478000	0	2032312700	223380000	224694000	0	5825400000	9006170600	£891,828,225.06
2045	19488153000	39420000	0	2311107000	223380000	224694000	0	5825400000	10864152000	£998,170,052.90
2046	19928961067	39420000	0	2369326933	223380000	224694000	0	5825400000	11246740133	£1,020,112,229.10
2047	20378538867	39420000	0	2428705133	223380000	224694000	0	5825400000	11636939733	£1,042,490,937.77
2048	20837015367	86724000	0	2441954633	223380000	224694000	0	5825400000	12034862733	£1,062,708,215.07
2049	21304648500	102492000		2487949500	223380000	224694000	0	5825400000	12440733000	£1,085,117,539.25

Fig 2.6: kWh produced by type of generator, and yearly revenue

The profits each year were calculated by multiplying the total kWhs produced by each generator with their individual profit per kWh values calculated in the generator benefit analysis section.

Several factors are considered when apportioning the energy sale of different generator types;

Firstly, the net kWh produced by a type of generator is limited by that type of generator's maximum yearly output, calculated by:

$$Yearly\ output = Number\ of\ Generators \times\ Average\ Output\ (MW)\ per\ unit \times 1000 \times 24 \times 365$$

Similarly, the total yearly output of all the generators must equal the total energy demand of Sri Lanka we are providing for (ie, after pre-existing generation).

Secondly, The energy produced from sources such as nuclear, hydro and onshore wind should be maximised, not only due to their inherent profitability, but also to adhere to sustainability objectives. However, the energy produced by these clean sources must not exceed the intermediate load (i.e. 87%), as the remaining 13% counts for the peak load and must be produced by fast acting sources such as CCGT, Coal and Diesel.

Thirdly, all generators must operate at a minimum of 10% of their total possible output, as keeping them offline would incur the same maintenance cost.

Finally, the total share of energy produced by a generator type cannot exceed its availability %, to maintain grid stability when said stations are undergoing maintenance.

Capital Cost By Year

				Units in construction										
Year	Capacitance Added (MVAR)	Switchyards	Transformers	Diesel	Gas	CCGT	Coal	Wind	Solar	Hydro	Nuclear	Transmission	Total Per year	Cumulative Total
2024		£0	£0	9									£8,250,000	£8,250,000
2025	24.6	£13,000,000	£2,000,000	8				100			1	£19,597,500	£373,112,402	£381,362,402
2026	14	£0	£4,000,000	30				100			1	£19,597,500	£380,333,623	£761,696,025
2027	2.8	£0	£2,000,000	20		1					1	£19,597,500	£250,444,725	£1,012,140,749
2028	8.5	£13,000,000	£4,000,000			1					2	£19,597,500	£414,824,194	£1,426,964,943
2029	16.5	£0	£2,000,000	33							2		£368,611,621	£1,795,576,564
2030	38.2	£0	£2,000,000								2		£342,344,278	£2,137,920,842
2031		£0	£0								1		£166,666,667	£2,304,587,509
2032		£0	£0					200			1		£486,666,667	£2,791,254,175
2033		£26,000,000	£9,000,000					200		3	1		£579,444,444	£3,370,698,620
2034		£0	£0							4			£77,037,037	£3,447,735,657
2035		£0	£0				1			5			£185,462,963	£3,633,198,620
2036		£0	£0				1			5			£185,462,963	£3,818,661,583
2037	8.9	£0	£0				1			5			£187,096,403	£4,005,757,986
2038	2.9	£26,000,000	£12,000,000		1		1			6	1		£417,087,800	£4,422,845,786
2039		£13,000,000	£8,000,000		1					3	1		£252,611,111	£4,675,456,897
2040		£13,000,000	£2,000,000							2	1		£220,185,185	£4,895,642,082
2041		£0	£0							1	1		£185,925,926	£5,081,568,008
2042		£0	£0							1	1		£185,925,926	£5,267,493,934
2043		£26,000,000	£18,000,000	9						1	1		£238,175,926	£5,505,669,860
2044		£0	£0	1									£916,667	£5,506,586,526
2045		£0	£0										£0	£5,506,586,526
2046		£0	£0										£0	£5,506,586,526
2047		£0	£0	12									£11,000,000	£5,517,586,526
2048		£0	£2,000,000	4									£5,666,667	£5,523,253,193
2049	3	Switchyards	£0										£550,598	£5,523,803,791

Fig 2.7: Capital Costs By Year and By type

The figure above denotes the year-by-year capital costs involved in this investment. It is important to note that as construction costs are split over the length of construction, the table denotes units currently in construction.

The total capital cost per year is calculated as follows:

$$Capital\ Cost = MVAr\ Added \times 80{,}000 + \sum_{Generator\ Type} (No\ of\ Generators\ in\ Construction \times Capital\ Cost\ per\ year)$$
$$+ Transmission\ Line\ installation\ Cost + Transformer\ installation\ cost + Switchyard\ Cost$$

With the transmission line, switchyard and transformer installation costs calculated separately. This is explored in later sections.

The total capital cost of the project sums up to £5.5 Billion (notwithstanding interest), which is a hefty amount, but ultimately easily repaid through energy sale profits.

Transmission line Analysis

Ultimately, only two transmission lines are predicted to be built during this project, namely a double circuit 132kV line between Trincomalee and Battical. This line was deemed necessary as it was cheaper to build two lines between Battical and Trincomalee and produce power using CCGT at Battical than to build a gas pipeline between the two cities and produce CCGT power at Trincomalee. Placing the line along a road helped reduce costs:

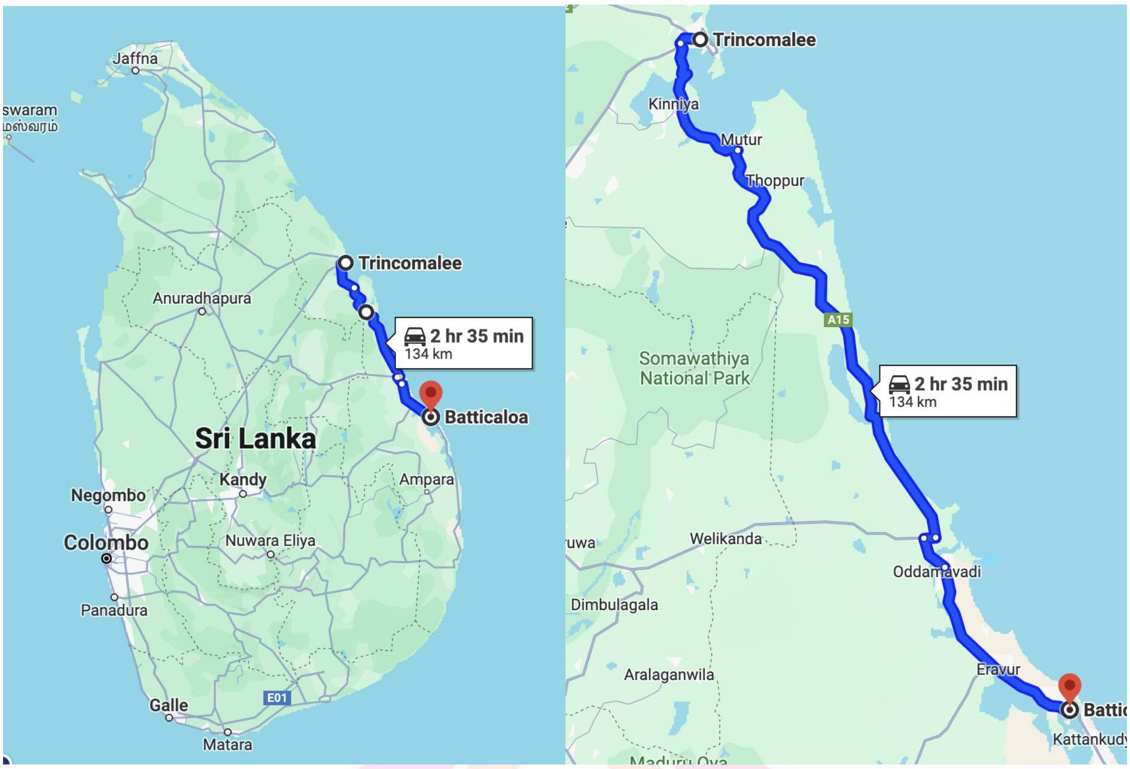


Fig 2.8.1: Transmission line placement along Road

Distance	Cost (£000)	Build Time (yrs)	Cost/yr (£000)	Resistance	Reactance	Thermal Capacity (MVA)
134km	78,390	3.34	19597.5	3.31E-2	0.255404	400

Fig 2.8.2: Transmission line values table

The double-line cost around £78 million overall, whereas a gas pipeline over the same length would have equaled £348 million and taken an extra two years to build. Note that the costs in the table above are 130% the cost of an individual line due to cost savings in simultaneously building a double circuit, whereas the resistance, reactance and thermal capacities are for the individual lines.

Transformer Cost & Switchyard Analysis

Each Power Station requires an appropriate transformer. Multiple generators can share transformers if they are placed at the same busbar, but each 132kV transformer can only handle an equivalent 100 MW of generation, while a 220kV transformer can handle 200 MW. Similarly, each power station requires a switchyard, which must match the voltage at the bus bar.

Year	Trincomalee	Biyagama	Puttalam	Battical	Laxapana	Kotmale	Badulla	Balangod	Cost
2024									£0.00
2025	1								£2,000,000.00
2026	2								£4,000,000.00
2027	1								£2,000,000.00
2028				2					£4,000,000.00
2029	1								£2,000,000.00
2030	1								£2,000,000.00
2031									£0.00
2032									£0.00
2033		3							£9,000,000.00
2034									£0.00
2035									£0.00
2036									£0.00
2037									£0.00
2038					3	3			£12,000,000.00
2039	3				1				£8,000,000.00
2040							1		£2,000,000.00
2041									£0.00
2042									£0.00
2043			6				2	1	£18,000,000.00
2044									£0.00
2045									£0.00
2046									£0.00
2047									£0.00
2048								1	£2,000,000.00
2049									£0.00
								Total	£67,000,000.00

Year	Trincomalee	Biyagama	Puttalam	Battical	Laxapana	Kotmale	Badulla	Balangod	Cost
2024									£0
2025	1								£13,000,000
2026									£0
2027									£0
2028				1					£13,000,000
2029									£0
2030									£0
2031									£0
2032									£0
2033		1							£26,000,000
2034									£0
2035									£0
2036									£0
2037									£0
2038					1	1			£26,000,000
2039	1								£13,000,000
2040							1		£13,000,000
2041									£0
2042									£0
2043			1					1	£26,000,000
2044									£0
2045									£0
2046									£0
2047									£0
2048									£0
2049									£0
								Total	£130,000,000

Fig 2.9: Transformer Installation by Year and associated Cost (left), Switchyard Installation by year and Associated Cost (right)

Note that at Biyagama, a 220kV transformer & switchyard is required while elsewhere, 132kV transformers & switchyard are employed. As each transformer/switchyard takes 6 months to build, it is displayed in the table above the year before it is required.

A total of 32 (29 of 132kV and 3 of 220kV) transformers are built costing a total of £67 million, while a total of 9 (8 132kV and 1 220kV) switchyards are built costing £130 million.

HVDC Line to India

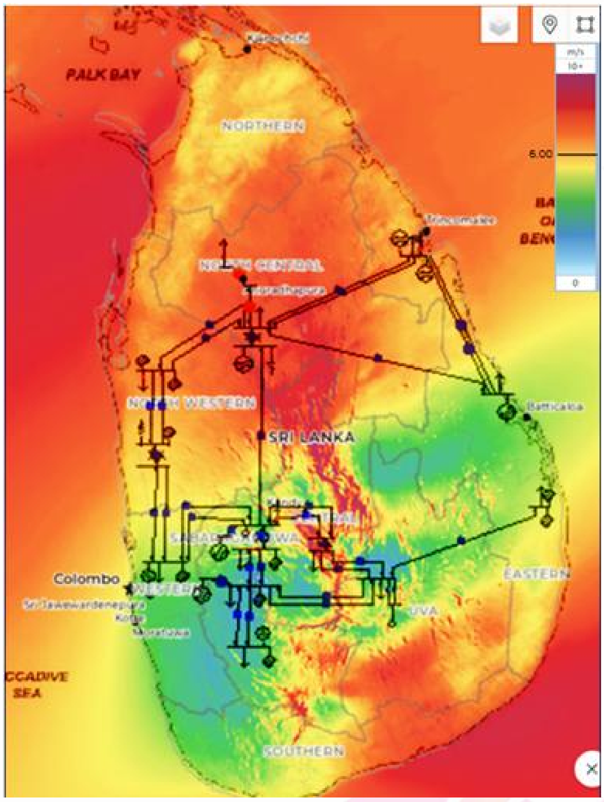
As a result of the Prime Minister of India, Narendra Modi’s reforms, India has slowly become a net positive country when it comes to power. (Dutta S, 2023). This was achieved both from an increase in power production by way of nuclear power, and an increase in the efficiency of the transmission lines used to deliver the energy to areas in need of the power.

A HVDC line between India and the closest Bus Bar (Anurad) would span 285 kilometres, of which approximately 50km of which would be underwater. Assuming that the State of India would be willing to fund half the construction costs, the cost of the endeavour would equal £282,750,000.00, not including the added costs of substations. While this is a relatively reasonable cost, due to the net-positive power situation of India, we would only be able to sell a very small portion of generated power, and at a significantly lower price after tariffs.

Therefore it is of the viewpoint of Sunrise Power Limited that building a HVDC line to India will not be a fruitful endeavour, thus we have continued our focus to improving Sri Lanka's grid system and moving Sri Lanka to become the next power positive country.

Resource Analysis:

While deciding where to place power generation, it is imperative to consider Sri Lanka's natural resources. As such, Sunrise Power Limited's technical team conducted analysis on Sri Lanka's natural solar & sind resources, and made placement decisions accordingly:



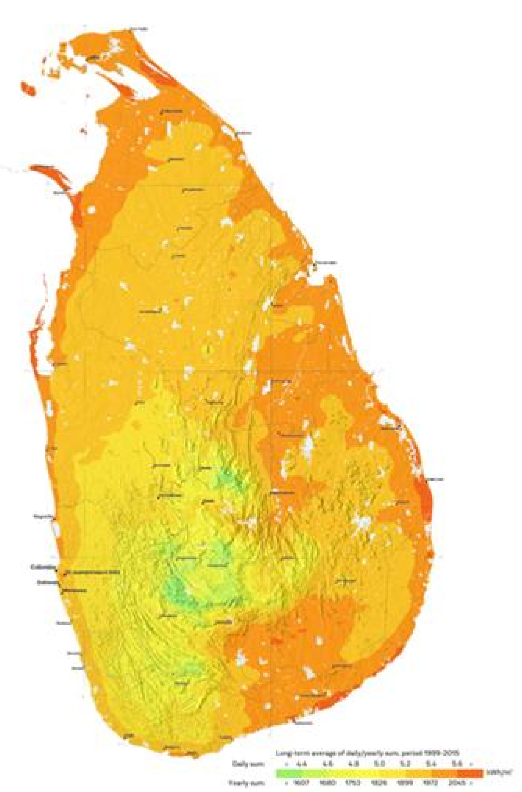


Fig 3.1.1(Left): Sri Lankan Power Grid overlaid on Wind resource map from Global Wind Atlas (2024)
Fig 3.1.2(right): Solar Resource Map from SolarGis (2024)

From the resource density maps above, we can determine where to place wind and solar power generation. Wind typically requires an average annual wind speed of over 6 metres per second (at heights of 60-70 metres), and in mountainous areas, over 5.8 metres per second. As such, Trincomalee is suitable for a few (up to 100 units) of wind generation, but the majority of our wind generation should be focused in Rantembe, where the highest average wind speeds are observed.

In terms of solar resource density, the average solar density in Sri Lanka is above 4kW. This indicates that it is feasible to install photovoltaic cells almost anywhere in Sri Lanka, with the exception of certain inner mountainous areas. However, the prime locations to install solar panels are at Battical, and in the southeast of the island, where yearly totals exceed 1680 kWh per metre squared.

Nevertheless, analysis from Sunrise Power Limited's financial team indicates that while onshore wind is commercially viable, solar cannot feasibly pay back its capital cost within the 25 year timeframe.

Social Analysis

Sunrise Power Limited’s proposal also has the potential to majorly stimulate the Sri Lankan economy. Beyond the temporary jobs created by installing new stations, capacitors and transmission lines, the influx of infrastructure investment contributing to an expansionary fiscal policy, a host of permanent jobs in the energy sector will arise as a result of the 25 year proposal.

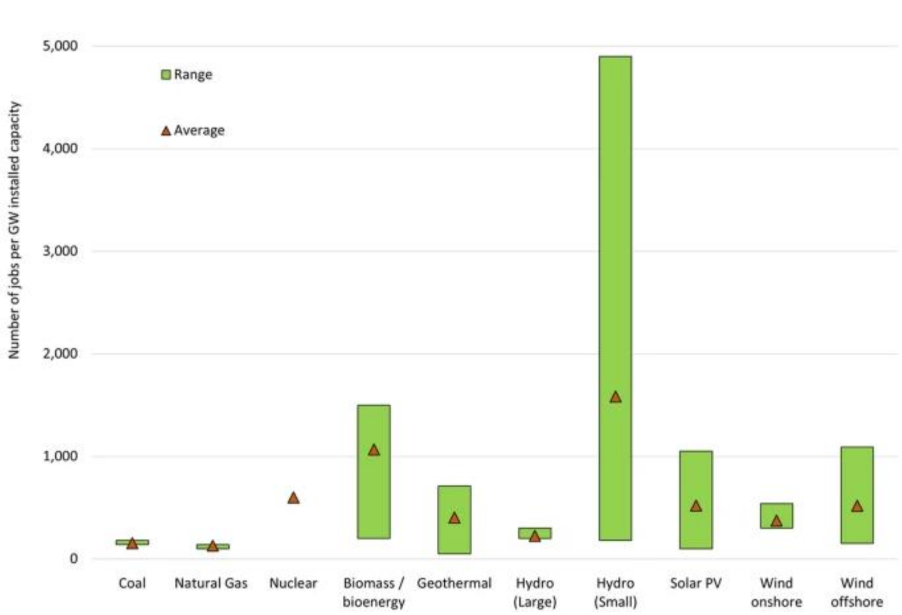


Fig 3.2.1: Jobs per GW installed capacity of different stations (Hanna, Heptonstall and Groß, 2024)

Plant Type	Nuclear	Onshore Wind	Hydro	Coal	Gas/CCGT	Diesel	Total
Installed Capacity in 2049	1800MW	1000MW	1000MW	300MW	200MW	130MW	
Jobs Per GW	600	500	300	250	200	Assume same as Gas	
Jobs Created	1080	500	300	75	40	26	2021

Fig 3.2.2: Table Indicating Permanent Jobs at each Station Type by 2049

As observed in figure 3.2.2, above, over two thousand permanent jobs are estimated to be created by 2049 according to data from Hanna, Heptonstall and Groß, 2024. As Sri Lanka currently has an unemployment rate of 6.64% (Statista, 2023) which has been increasing year on year, this is not an insignificant consideration, and must be considered as an added boon resulting from this proposal’s enactment. Moreover, 79.7% of these jobs are created in the clean energy sector.

Environmental Analysis:

Clean Energy Power Share

To help Sri Lanka meet its UNDP Climate Promises, Sunrise Power Limited has endeavoured to maximise the share of clean energy produced across the proposal's 25 year timeframe and beyond. While the total share of clean energy must be limited, as a suitable amount of fast acting generators (which tend to be non-renewables such as CCGT and coal) must be employed, Sunrise Power Limited is proud to announce that for every year beyond 2031, 87% of energy produced is from clean sources including nuclear, wind and hydro.

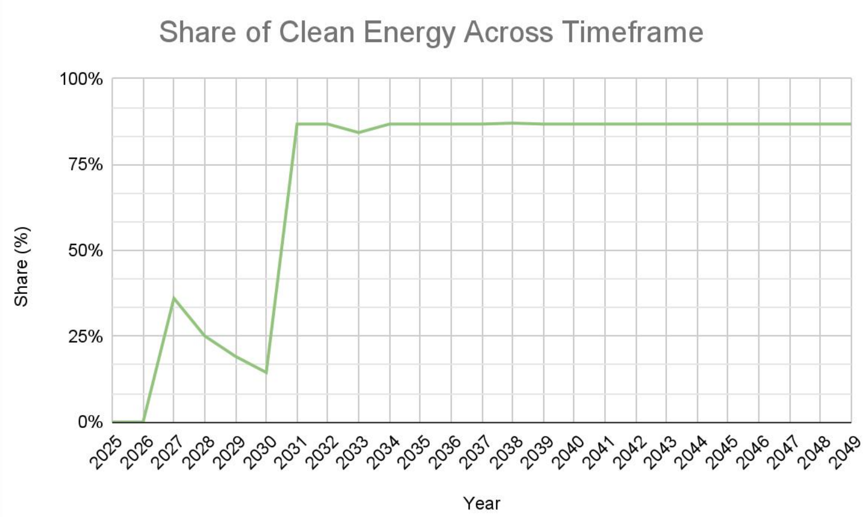


Fig 3.3.1: Clean Energy as a percentage of total kWh produced

While unfortunately this is one year late from Sri Lanka's promise to meet 70% sustainability in 2030 (UNDP Climate Promise, 2024), this compromise is unavoidable as the primary clean energy producers of hydro and nuclear take 6 years to build and therefore cannot feasibly be built in time. Nevertheless, both the share and magnitude (as seen below) of non-renewable energy sources is minimised in this proposal.

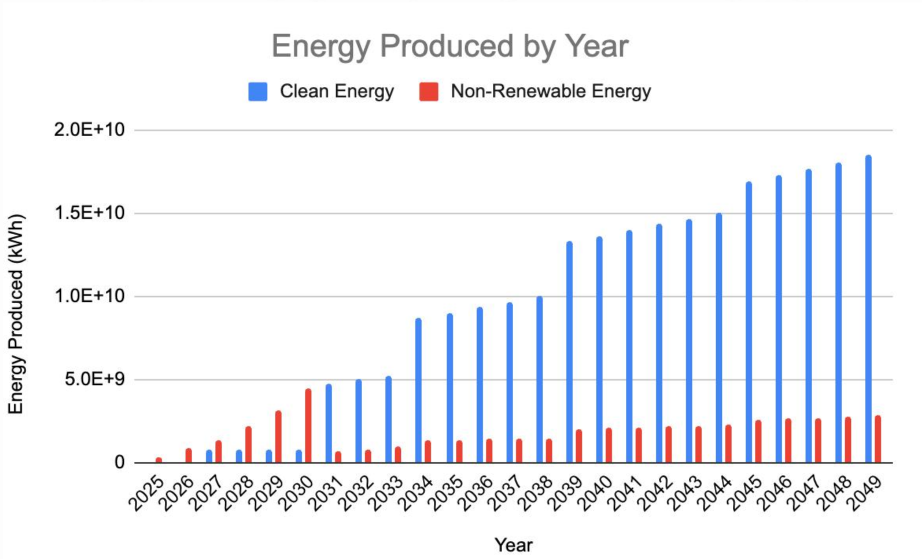


Fig 3.3.2: Clean Energy Vs Non-Renewable Energy Produced Yearly

Carbon Emissions

As Sunrise Power Limited's Proposal involves using clean energies such as onshore wind, hydro and nuclear to support the intermediate load, the carbon emissions saved will go a long way to help Sri Lanka fulfil it's NDC promises of Carbon Neutrality by 2050 and reducing greenhouse gas emissions to 14.5% (UNDP Climate Promise, 2024).

Power Type	Hydro	Wind	Nuclear	Coal
Grams of Co2 Emitted per kWh	4	11	12	740-1689

Fig 3.4.1: Carbon emissions of power types (COWI, 2023)

Power Type	Hydro	Wind	Nuclear	Total
kWh produced 2025-2049	55,117,669,367	13,884,217,967	169,313,070,733	238,314,958,067
Co2 tonnes produced 2025-2029	220,471	152,726	2,031,757	2,404,954
Equivalent Co2 tonnes from Coal producing same kWh:			176,353,069 - 402,513,964	
Tonnes of Co2 Avoided:			173,948,115 - 400,109,010 98.6% - 99.4%	

Fig 3.4.2: Lifetime Carbon Emissions and Savings

As observed in the tables above, over the lifetime of the 2025-2049, a total of 2.4 Million tonnes of CO2 are estimated to be collectively produced by installed wind, nuclear and hydro power stations. In contrast, an equivalent amount of energy produced by a non-renewable energy method such as coal over the 25 years would produce between 176 and 400 million tonnes of CO2.

Effectively, the use of these types of generators instead of coal or an equivalent carbon heavy energy generation method cuts down on potential CO2 generation by up to 99.4%.

SWOT Analysis

Strengths: -Renewable Energy represents a high proportion of energy produced by the system. -A large net profit is achieved by the end of the proposal. -This proposal creates a large number of permanent jobs, most of which are in the clean energy sector -A large safety margin in power production is achieved - Power is produced from a large variety of sources.	**Weaknesses:** -The power stations are not run at full capacity in the last few years. -New power stations and transmission lines are mixed with old equipment management. This can cause logistical issues. -Power is largely centralised. Transmission line breakdowns could easily cause blackouts.
Opportunities: -As a large margin of excess power is possible, in the future an HVDC line to India may be possible to sell off excess energy if India ever becomes power negative. -As the proposal extends over a long time period, advances in technology will provide new alternatives and potential improvements as the project goes on.	**Threats:** -The high proportion of nuclear energy may be influenced by many factors, such as environmental factors that lead to the destruction of nuclear power plants, and political factors that influence the construction of nuclear power plants and the acquisition of nuclear fuel. -Social factors such as change of government and lack of suitable local labour force may lead to project delays. -The rapid construction of a large amount of new power plants may have unintended effects on tourism, agriculture and other related industries -As many of the jobs created are of high technical requirement, experts will have to be hired from overseas to maintain the built plants.

Conclusion

By and large, Sunrise Power Limited’s proposed solution outlines a profitable, energy secure and sustainable 25 year plan for the development of Sri Lanka’s energy system. With a net profit of £5.9 Billion by 2049 with a year by year profit of over £1 billion from then on out, our company provides a financially optimised solution.

Our technical analysis has designed a system with a wide power margin from a wide variety of sources, and sufficiently fast acting power station types to react dynamically to changes in demand and supply. Moreover, the proposal’s focus on sustainability bears fruit, resulting in an energy share of 87% from sustainable sources from 2031 onwards, and an estimated 400 million tonnes of CO_2 produced over the 25 years.

In conclusion, Sunrise Power Limited's proposal not only promises profitability but also embodies a vision of energy security, sustainability, and resilience, paving the way for a brighter and more sustainable future for Sri Lanka.

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