ELECTRICITY RELATED **GHG EMISSIONS INVENTORY** FOR ARAVIND EYE HOSPITAL

A report on the 2019 emissions of the Hospital with a roadmap towards sustainable energy consumption.

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AurovilleConsulting

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Introduction

One of the adverse effects of climate change is its impact on human health. The effects include respiratory and cardiovascular disease, injuries and premature death related to extreme weather events and illnesses transmitted by food, water and disease carriers such as mosquitoes and ticks[1]. In 2014, the healthcare sector contributed 4.4% of global greenhouse gas emissions (GHG) or 2 gigatonnes of carbon dioxide equivalents (CO2e)[2]. It follows that healthcare providers have an enormous responsibility and opportunity to reduce GHG emissions in order to limit health effects.

Aravind Eye Hospital, an eye care chain in the Indian states of Tamil Nadu and Andhra Pradesh, renowned for its resource efficiency and social impact, has also taken long strides in minimising their impact on the environment. Reusable surgical supplies and safe and efficient surgical operations help bring down their waste and emissions generated per cataract surgery to 250 g and 6 kg CO2e respectively (compared to 133 kg CO2e in UK for the latter)[3]. In addition, on-site wastewater treatment systems, organic food production with recycled water, solar photovoltaic (PV) installations and shared transport services further reduce the impact on the environment.

[1] *Third National Climate Assessment's Health Chapter, US: https://nca2014.globalchange.gov/report/sectors/human-health*
[2] *Healthcare's Climate Footprint, 2019: https://noharm-global.org/documents/health-care-climate-footprint-report*
[3] *Thiel CL, Schehlein E, Ravilla T, et al. Cataract surgery and environmental sustainability: Waste and lifecycle assessment of phacoemulsification at a private healthcare facility, 2017*

Scope of the study

This study puts together an inventory of the GHG emissions from electricity consumption for the hospital campus in Pondicherry based on the consumption data for the year 2019. It may be noted that a complete inventory would include other emission sources such as patient and staff transportation, purchased goods and services and waste generation. Following an analysis of electricity consumption, the study goes on to explore scenarios that make generating and storing renewable electricity financially viable for all the hospital's needs, covering a span of 25 years to further bring down their electricity emissions.

Electricity Emissions

Aravind Eye Hospital consumes electricity through three sources:

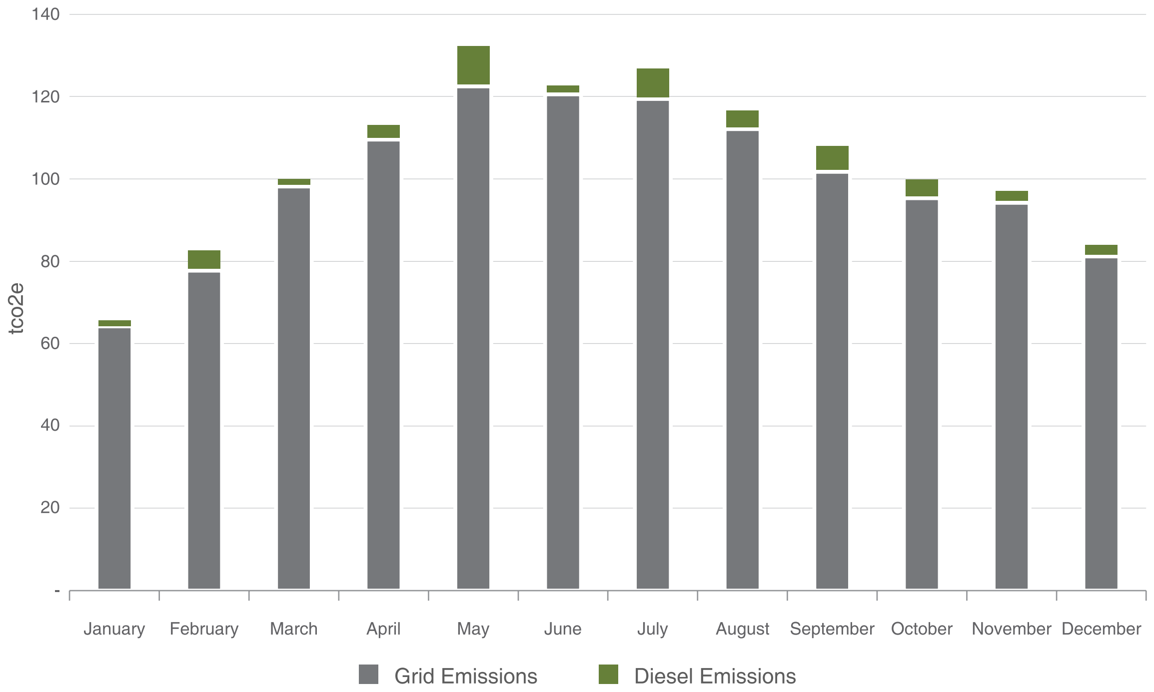
- The regional electricity grid,
- An on-site electricity generation through diesel generators and
- A 201.28 kilowatt (kW) solar rooftop system.

The guidelines from the globally-recognised GHG Protocol, which provides a transparent and consistent framework for reporting have been used to calculate the GHG emissions from electricity. As per the guidelines, direct emissions from sources owned by the company, in this case the diesel generators, are categorised as scope 1 emissions. As solar generation has a zero emission profile, it does not appear under scope 1. The emissions from purchased electricity generation, in this case grid-supplied electricity, are categorised as Scope 2.

Emissions from both electricity consumed from the grid and electricity produced through diesel combustion release different greenhouse gases and in different quantities. The consumption data for each were multiplied by the corresponding emission factor, namely the national grid factor and the global default value for diesel, to arrive at the total GHG emissions released into the atmosphere.

The total electricity consumption for 2019 from the grid and through diesel was 1,459.36 megawatt hours (MWh) and 64.02 MWh respectively. The month-wise emissions are shown in figure 1; these are expressed in tonnes of carbon dioxide equivalent (tCO2e), which compares all the GHGs released to carbon dioxide to simplify comparisons. Emissions from the grid totalled 1,196.67 tCO2e or 95% of the total electricity emissions compared to 57.04 tCO2e from diesel. Albeit the smaller footprint of diesel emissions, it may be noted that diesel emissions per kWh of energy produced are 8% greater than emissions per kWh of grid-supplied electricity.

Figure 1: Annual emissions from grid electricity and diesel consumption



Energy Intensity

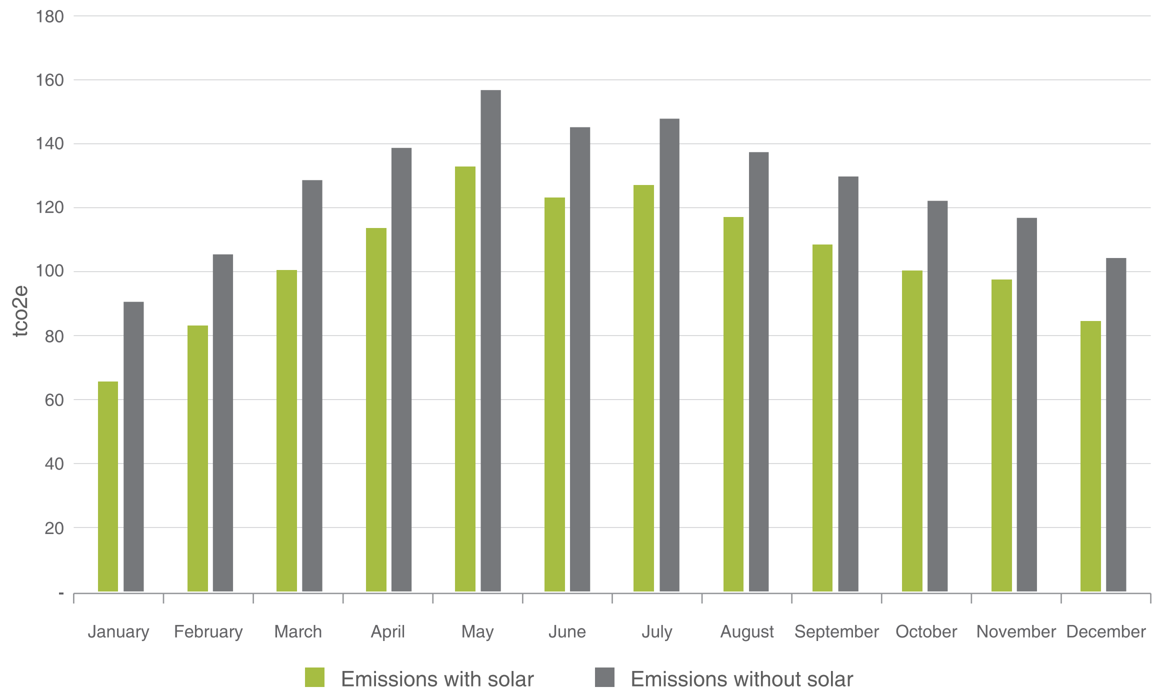
The Indian Bureau of Energy Efficiency (BEE) sets the energy performance index for hospitals in a warm and humid climate zone to 275 kWh per sqm per year[4]. When considering the built up area of Aravind Eye Hospital's main hospital block, staff quarters and the utility block, the consumption stands at 50.90 kWh per sqm. If we were to assume that all the electricity is consumed by the hospital block alone (as the break up by area is not available), the hospital consumed 83.44 kWh per sqm. Thus, on both counts we see that the energy intensity of Aravind Eye Hospital more than meets the benchmark set by BEE.

[4] *Energy Benchmarks for Commercial Buildings, BEE - https://beeindia.gov.in/sites/default/files/Flyer_22nd%20Jan.pdf*

GHG Emissions Avoided

In 2019, the solar PV system generated 330.10 MWh of electricity. If the rooftop solar had not been installed and we were to assume that the electricity was instead imported from the grid, a comparison between GHG emissions with and without solar would look similar to the emissions depicted in figure 2, amounting to a difference of 270.68 tCO2e. To illustrate this in a different way, the savings through solar generation equals emissions that would have been caused by 1,00,650 litres of diesel when combusted[5].

*Figure 2: A comparison of GHG emissions with and without solar**



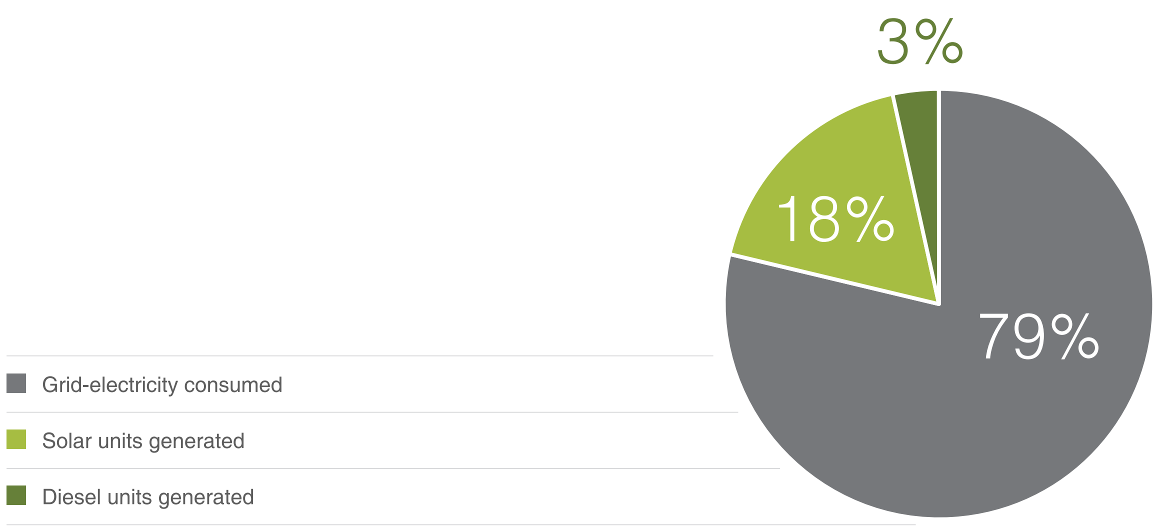
**includes 4.37 MWh solar exported to the grid*

[5] *US EPA Greenhouse Gas Equivalencies Calculator – calculated on 4 Nov, 2020*

Conclusion

The solar system installed by Aravind Eye Hospital helped reduce its electricity emissions in 2019. Much of its consumption though was from the grid, whereas solar formed 18% of its total consumption as seen in Figure 3. If the hospital was to increase its solar generation, greater impact can be expected.

*Figure 3: Share of consumption by electricity source**



The Annexure discusses two scenarios that the hospital can explore to increase its solar generation in a phased manner and in a financially feasible way. The scenarios show a transition to 100% solar electricity sourcing. Furthermore, the Annexure discusses the reduction of the use of diesel generators during a power outage from the grid. While that is an unavoidable emissions source in the current scheme of things, it explores a mid-term solution such as an investment in battery storage that, when fed by a solar system, can further help the transition to sustainable electricity.

Annexure

Strategy 1

Reducing grid electricity import through solar energy

The objective of this section is to explore the benefits to Arvind Eye Hospital of sourcing 100% of its current grid electricity demand from solar energy sources. Keeping in mind that the hospital does not have enough rooftop space available in this campus, two scenarios are being considered:

- Scenario 1 – virtual net metering of solar energy
- Scenario 2 – wheeling of solar energy

Under virtual net metering, Arvind Eye Hospital will take a long-term lease of available large rooftop spaces in Puducherry and invest into rooftop solar PV systems. The gross solar energy generated from these solar systems will be credited in kWh by the Electricity Board to the institution's electricity bill.

Under wheeling of solar energy, ground mounted solar energy systems will be installed within Puducherry. The gross solar energy generated from the solar system will be credited in kWh by the Electricity Board to the institutions electricity bill.

For both scenarios, the cost of solar energy is lower than the cost of electricity supplied by the grid. In addition, the per kWh cost of solar energy is a constant of the lifetime of the solar energy system (~ 25 years), whereas the cost of grid supplied electricity is expected to increase on an annual basis by at least the inflation rate. These two factors, the lower cost of solar energy and the expected increase in cost of grid supply, result in financial savings to Arvind Eye Hospital.

Benefits:

Table 1: Cost benefit analysis

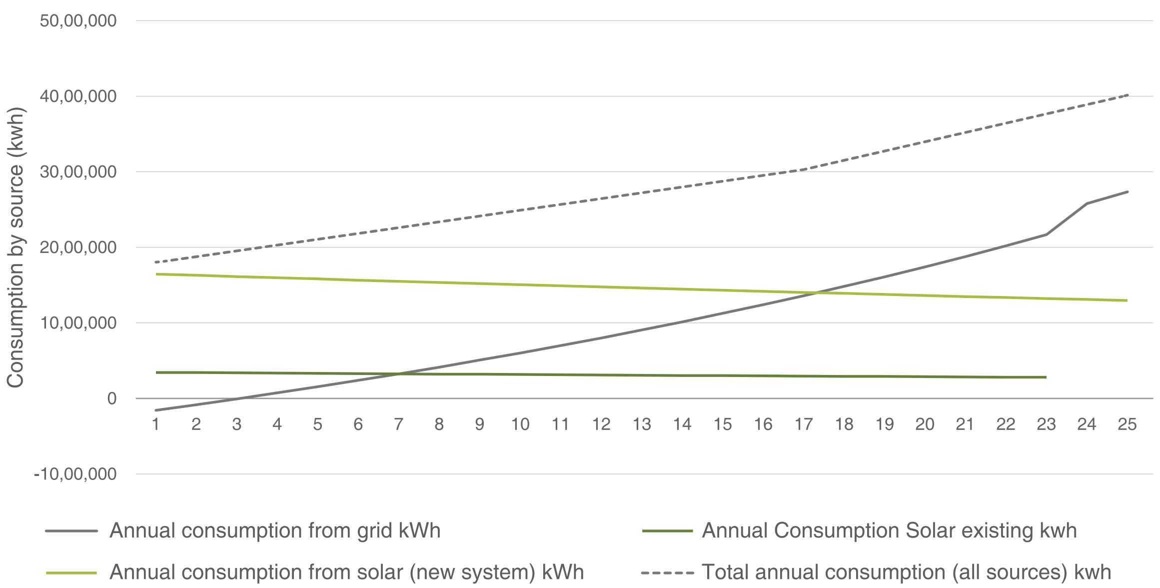
Results	Virtual net metering*	Wheeling
Solar Capacity (kW)	1,000	1,000
Cost per kW	50,000	35,000
Total cost INR	5,00,00,000	3,50,00,000
Debt-equity ratio	70:30	70:30
Payback on equity (years)	10	5
Post tax equity IRR	17.74%	30.13%
NPV savings (INR)	2,14,42,711	3,56,15,555
NPV savings (%)	12.36%	20.53%

**Cost of rooftop lease has been omitted in the calculations*

Comment: In case the institution plans energy efficiency interventions, the solar capacity can be reduced.

The solar energy generators in Table 1 have been each sized at 1 MW capacity. This will produce surplus solar energy in the first 3 years. It is assumed, that the institution's electricity consumption will increase by an average annual rate of 4% over the years and therefore all solar energy will be absorbed by the institution from year 4 onwards. An additional solar energy generation capacity will need to be added on the long term in order for the institution to match its consumption from the grid. A more phased capacity addition over the years may be considered in order to avoid surplus solar in the earlier years and to match the institution's growing electricity demand.

Table 1: Cost benefit analysis



Comment: The current 201 kW solar energy capacity has been assumed to retired at year 23.

Relevant policy details and regulations

Virtual net metering:
'Consumers not having a suitable roof for installing a solar system may avail the facility of virtual net metering. In virtual net-metering, consumers can be beneficial owners of a part of a collectively owned solar system. All energy produced by a collectively owned solar system to be fed into the grid through an energy meter and the exported energy as recorded to be pro rata credited in the electricity bill of each participating consumer on the basis of beneficial ownership. Collective ownership of solar plants may be established through Societies, Trusts or section 25 Companies or any other legal entity that safeguards the interests of participating consumers'[6]

Wheeling:
'Solar energy to be exempted from grid connectivity, open access, wheeling and banking, and cross-subsidy charges.'[7]

The GHG Protocol does not treat any solar generation that is exported to the grid by reporting company as a means for it to adjust their scope 2 emissions.[8] The renewable energy produced only indirectly impacts scope 2 emissions through a lower average grid emission factor.

Action points

Virtual net metering:
Enquire with Pondicherry Electricity Board regarding virtual net metering options (multiple roofs, capacity limits etc.).

Wheeling:
Enquire with Pondicherry Electricity Board regarding minimum solar capacity and contracted load to avail of the wheeling option.

Strategy 2:
Reducing diesel generator electricity consumption through energy storage

In recent years, as the cost of energy storage technology has seen some significant price drops, future cost reduction is expected. This will make energy storage a competitive alternative to diesel generator back-up systems.

The analysis in this section, explores whether the addition of energy storage as a primarily back-up source in the case of power outages is a financial attractive opportunity. The capital cost of the diesel generators has not been considered in this analysis as this investment has already been made by the institution.

Table 2: Estimation - cost comparison

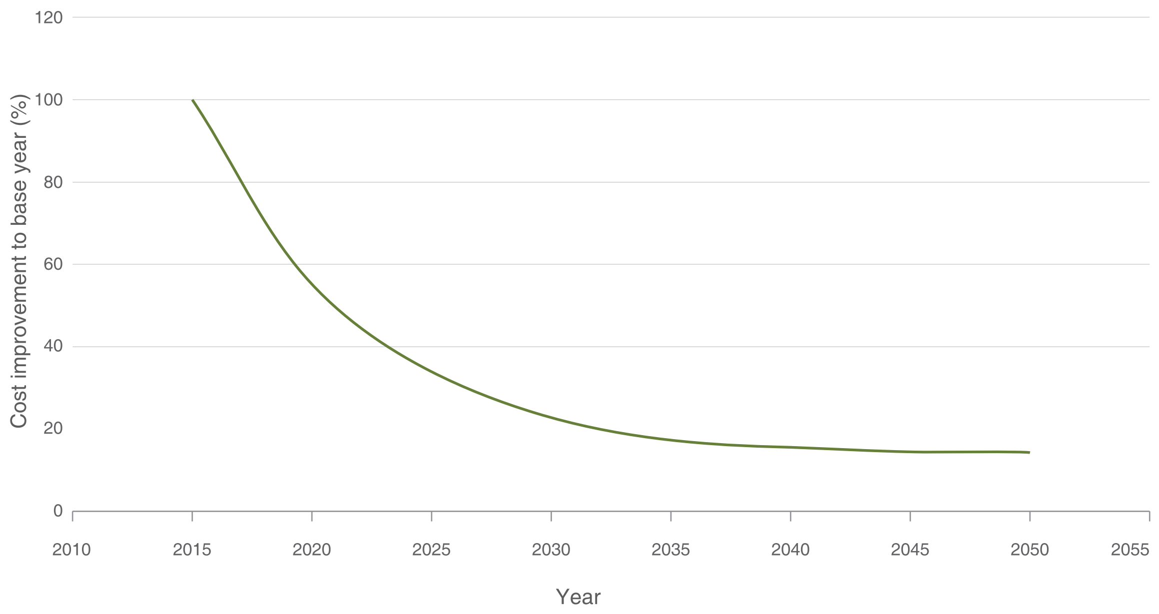
	Investment in 2020 9-year cost	Investment in 2025 9-year cost
NPV cost electricity from DG (INR)	1,07,03,524	1,56,71,030
NPV cost electricity from storage and DG (INR)	4,27,56,316	1,88,05,236

Comment: This analysis worked with the high-level assumption that there is an average power cut every day of up to 3 hours and that the battery storage would reduce the diesel generator usage by 80%. For a more detailed and conclusive analysis, data on each instance of diesel generator's use including time of the day and duration will be required. The expected life time of the li-ion battery with one discharge cycle per day is 9 years 0% increase in electricity consumption from DG was assumed.

[6] *Puducherry Solar Power Policy, 2015: http://www.cbip.org/MIR/Data/Puducherry.pdf*
[7] *Puducherry Solar Power Policy, 2015: http://www.cbip.org/MIR/Data/Puducherry.pdf*
[8] *GHG Protocol Scope 2 guidance, page 6: https://ghgprotocol.org/sites/default/files/ghgp/standards/Scope%202%20Guidance_Final_0.pdf*

The high-level analysis shows that introducing energy storage as a primary back-up source is not yet a financially-attractive option. However, with the expected future cost reduction of energy storage technology, in particular the li-ion technology, it can be expected that storage will be a competitive solution within 3-5 years. It is therefore recommended that Arvind Eye Hospital considers this option as a mid-term solution. This will also allow the storage of surplus solar energy produced on the premises and utilization of the same during power outages. Interestingly, the kick-in time of electricity through the battery back-up is also faster than a generator, an important consideration for a hospital. In order to facilitate this planning process, it is recommended that the institution keeps a detailed record of the diesel generator including time of use, duration, kWh produced for each episode and the cost of diesel.

Figure 5: Li-ion battery storage - cost improvement curve (%)



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