TECHNICAL BRIEF

ENGR 131- Solar Energy Viability

Section 01

Team 10

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CONTENTS

I. TEAM MEMBER ROLES

Team Member Name	**Task(s)**	**Due Date(s)**	**Status** (pending, on time, etc.)
Raine Pakis	○ Researching BG Info ○ Calculate Electrical Output of Solar Panels ○ Calculate Difference in Cost ○ Organization / Formatting of spreadsheet data	○ 2.4 ○ 2.4 ○ 2.4 ○ 2.6 ○ 2.6	○ On time ○ On time ○ On time ○ On time ○ On time
Sahir Devraj	○ Problem Statement ○ Energy Generation ○ Calculating Capital Investment, ○ Calculating Payback Period ○ Calculating price of electricity with 3 year payback ○ Environmental Analysis	○ 2.4 ○ 2.4 ○ 2.4 ○ 2.4 ○ 2.4 ○ 2.6	○ On time ○ On time ○ On time ○ On time ○ On time ○ On time
Yejia Zhang	○ Critical analysis ○ Background information ○ Recommendation to the Mayor ○ Format documents	○ 2.4 ○ 2.4 ○ 2.6 ○ 2.6	○ On time ○ On time ○ On time ○ On time
Chaeheon Sawng	○ Environmental Analysis	○ 2.6	○ On time
Other tasks that required all-team discussion	○ Decision on recommendation	○ 2.4	○ On time

II. PROBLEM STATEMENT

The Mayor's office has commissioned our engineering firm to complete an economic and environmental analysis of a public library's energy use. Reducing energy usage in Indiana's municipal buildings is an important problem to solve since both energy costs and greenhouse gas emissions are rising to unsustainable levels. The main stakeholders impacted by this project will be the Indiana government and citizens of Indianapolis.

Criteria:

- Create a visualization of the obtained data.
- Judge the cost and payback period of implementing solar panels.
- Compare the efficacy and use of solar panels in Indiana's climate.
- Make an excel spreadsheet containing a complete analysis of the library's energy use.

Constraints:

- Justify this recommendation based on an economical and environmental analysis.
- Make a recommendation on whether to use the proposed new system or continue the current use of fossil energy.

III. BACKGROUND INFORMATION

The Indianapolis library has a high demand for energy, it requires electricity for its computers, electronics, lighting and ventilation systems. Additionally, it uses natural gas to heat the building in winter and provide hot water throughout the year.

Solar panels are designed to convert the energy from the sun's rays into electricity, making them a perfect source of energy during daylight hours. When several panels are grouped together, they form a photovoltaic array that can generate a significant amount of electricity. Although this assignment does not consider the use of batteries for surplus electricity storage, the use of solar panels alone can have a considerable impact on reducing emissions from traditional power plants that rely on fossil fuels. By decreasing the demand for such fuels, solar panels help in reducing emissions and preserving the environment's health.

Data released by U.S. Energy Information Administration and Indiana energy profile:

Indianapolis Electricity Source Breakdown (E.I.A., 2022):

- Coal - 0.5080kg per kilowatt hour (57.8% of total energy generated)
- Natural Gas - 0.2084 m^3 per kilowatt hour (29.3% of total energy generated)
- Wind - (8.3% of total energy generated)
- Other Gasses - (2.4% of total energy generated)
- Biomass - (0.5% of total energy generated)

Table 1.1 Energy consumption	
Fuel Type	**Annual Net Generation/ thousand mkWh**
Coal	54,448
Natural Gas	27,600
Other Gasses	2,254
Wind	7,857
Biomass	429
Solar	573
Other	1004
Total	94,165

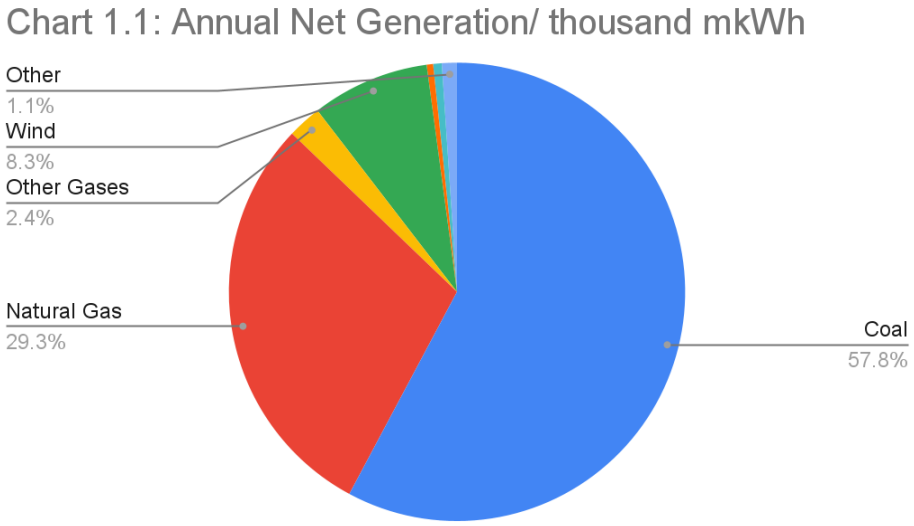

Figure 1. Energy Consumption In Indiana

Average days per Month: $\frac{365}{12} = 30.41;\ \frac{366}{12} = 30.5;\ \frac{365 \cdot 3 + 366}{48} = 30.4375$

Assumptions about solar panels:

- Solar panels work consistently when sunlight is available
- Solar panels will not suffer spontaneous irreparable damage

In order to make an appropriate recommendation to the Mayor, there are a few factors we need to consider. Firstly, we need to factor in the economic cost of implementing solar panels whether or not it is a sustainable decision. Next, we need to look at the environmental benefits of implementing solar panels. We also need to compare the advantages and disadvantages of both the current and proposed system.

IV. ECONOMIC AND ENVIRONMENTAL ANALYSES

A. Economic Analysis

The total capital investment of the proposed system will be entirely composed of the installation cost of the solar panel array. We simply multiply by the number of panels (500) by the unit cost ($600) to obtain total capital investment.

The formula for the payback period is total capital investment/ savings per year. We already have the total capital investment, and in order to calculate the savings per year, we have to do the following steps:

- Calculate the total yearly energy output produced by solar panels.
- Multiply this number by the cost of electricity.

Next, we can simply plug in the values for total capital investment and savings per year into the formula to get the payback period.

Table 2.1: Economic analysis and calculations

	Calculations
Total capital investment of new system ($)	$300,000
Payback period for capital investment (years)	11.12 Years
Price of electricity with a 3-year payback yield ($/kWh)	$0.362

In Figure 2, we present a comparison of:

1. The monthly commercial energy purchased (in kWh) with the **current** system
2. The monthly commercial energy purchased (in kWh) with the **proposed** solar panels.

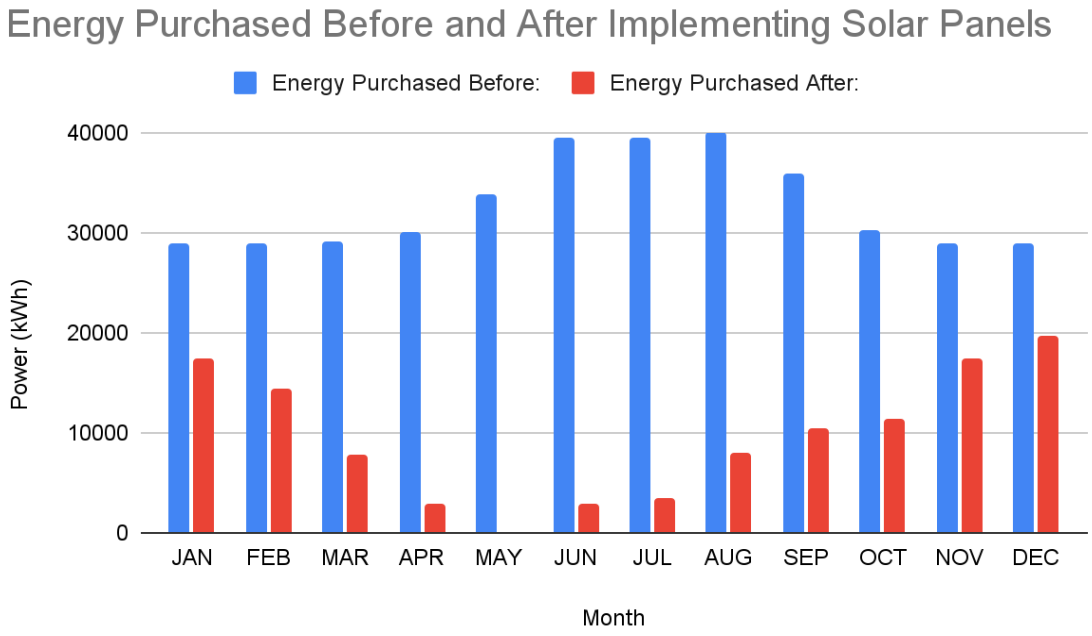

Figure 2. Monthly commercial energy purchased (kWh)

In Figure 3, we present a comparison of 1) the cost of the monthly commercial energy purchased (in dollars) with the **current** system, and 2) the cost of the monthly commercial energy purchased (in dollars) with the **proposed** solar panels.

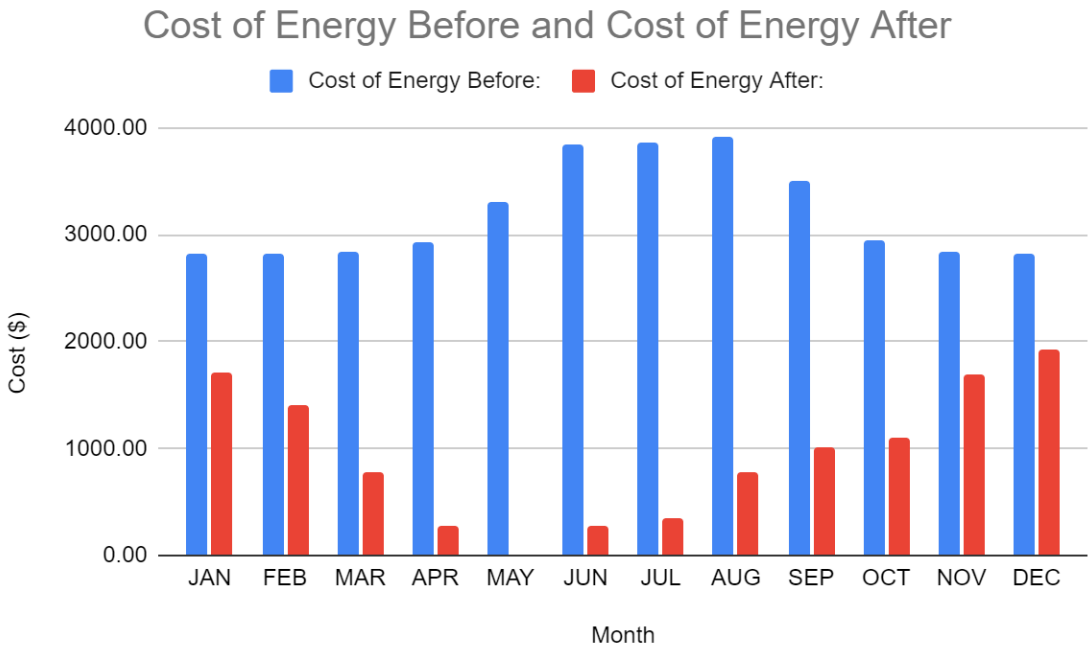

Figure 3. Monthly commercial energy purchased ($)

Overall, the installation of Solar Panels on the roof of the Indianapolis library will reduce its energy costs significantly. Furthermore, when energy costs would previously be at their highest, in the summer months when air conditioning would be running nearly all day, solar energy would be most impactful. The impact of solar energy is so great that it turns the most expensive energy months into the cheapest. However, the solar panels are not cheap. The money saved by the energy produced by the solar panels would take over 11 years to break even on the initial investment. Considering that the Indianapolis Library is public service, we can, from an economic lens, recommend the implementation of this new system.

B. Environmental Analysis

- According to epa.gov, the average carbon emissions of natural gas is 0.0551 cubic feet. We can use this value to multiply the natural gas consumption per cubic foot and divide by 1000 to get the CO2 produced by natural gas in tonnes. This is seen in Table 1.
- Next, we calculate the distribution of energy production by using the values provided to us in the document- this is shown in table 2.
- The average carbon emissions from coal and natural gas per kWh are 0.001012kg 0.0004107kg respectively. We can now multiply these values to get the distribution of CO2 emissions by power source. Table 3 contains these calculations.
- Finally, we calculate the CO2 from electricity by adding these two values up, and the CO2 from natural gas by converting to tonnes. This is shown in Table 4.

In Figure 4, we present monthly CO_2 emissions from energy use with current fossil energy for three data sets: 1) electricity, 2) natural gas, and 3) the sum of the two.

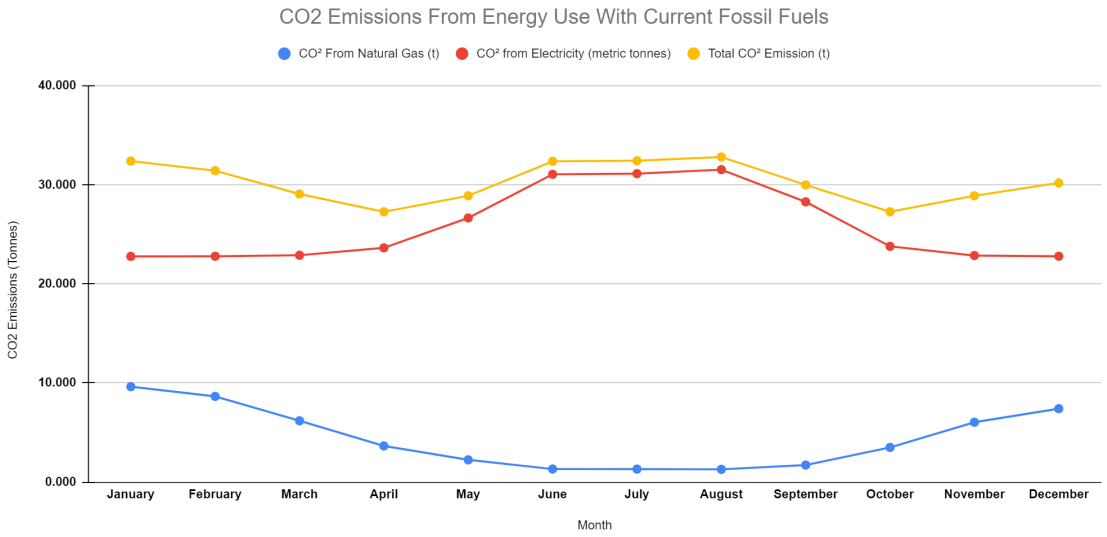

Figure 4. CO_2 emissions from energy use with current fossil energy

In Figure 5, we present monthly CO_2 emissions from energy use with solar panel installation for three data sets: 1) electricity, 2) natural gas, and 3) the sum of the two.

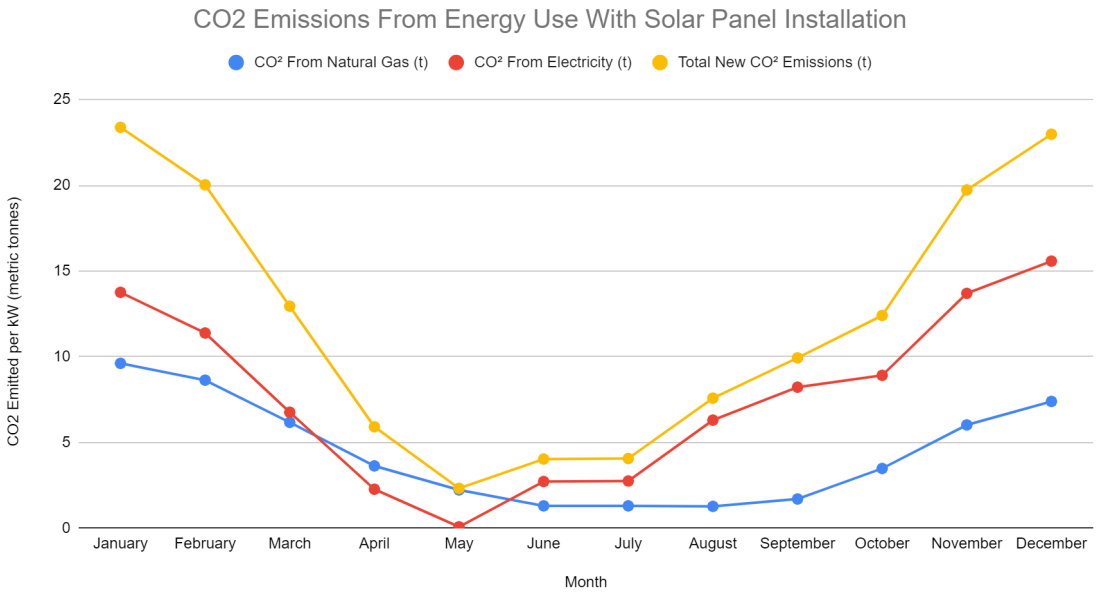

Figure 5. CO_2 emissions from energy use with solar panel installation

Installing solar panels for the library has the potential to greatly reduce the building's carbon footprint, as it shifts its energy source from fossil fuels to a clean and renewable energy source. The payback period of 11.41 years is relatively long compared to other investment options, but it is worth considering the long-term benefits that come with it:

- After the installation of the solar panels, the library will still have to purchase electricity from the grid, but the amount will likely be significantly reduced.
- This reduction in energy costs will lead to a lower carbon footprint and lower emissions, as the library will be relying less on energy from fossil fuel-powered power plants.
- As seen in Figure 6, the CO2 emissions due to energy sources after the solar panels are implemented are significantly lower. The highest CO2 emissions after solar panels (in January) are lower than the lowest CO2 emissions before solar panels (in April).

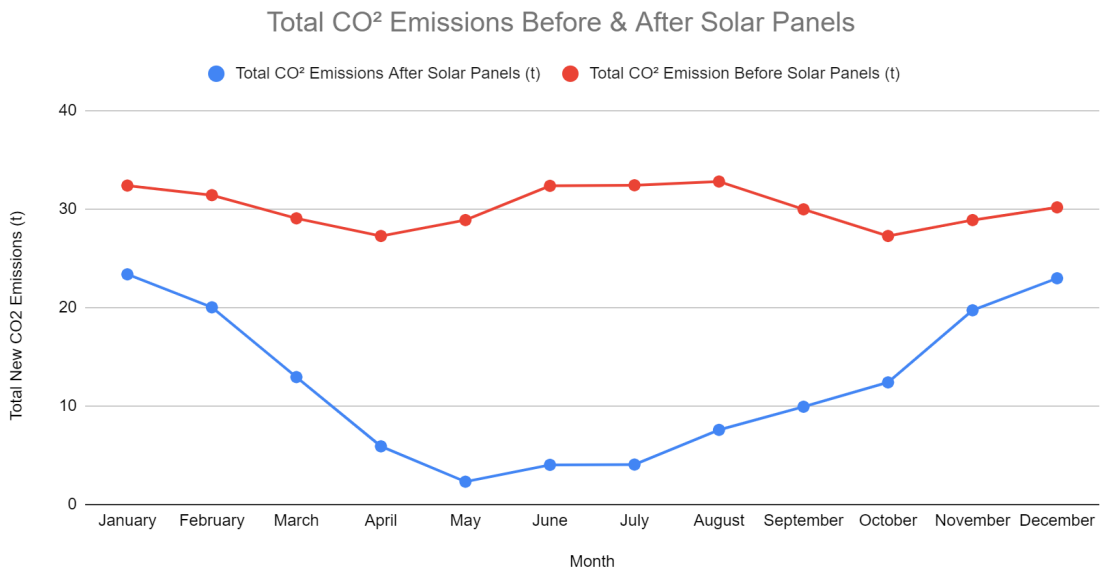

Figure 6. CO_2 emissions before and after solar panels

V. RECOMMENDATIONS TO THE MAYOR

Our team **recommends solar panels as a viable energy source** to power the city library. In the upcoming paragraphs, we will evaluate the advantages and disadvantages of solar panels as an energy source in Indiana.

To begin with, the installation of solar panels sends a clear message about the city's dedication to sustainability and reducing its carbon footprint, which aligns with the public's current attitudes towards environmental responsibility. This initiative shows the city's proactive approach to creating a more sustainable future and offers educational opportunities for the community to learn about renewable energy sources through programs and events at the library.

Economically, the solar panels will lead to long-term energy cost savings that can be reinvested in other areas of the library, ultimately improving services and offerings for the community. Furthermore, the city's reputation as a leader in sustainability and innovation may attract new investment and businesses that are looking for a forward-thinking and progressive community.

From an environmental standpoint, the solar panels will significantly decrease the library's carbon emissions, which is a crucial objective for the city as a whole. This reduction will not only benefit the environment, but also the health of the library's patrons and staff by creating a cleaner and healthier environment. By reducing the library's reliance on traditional energy sources, the city will also be reducing its overall impact on the environment and preserving resources for future generations.

While these benefits are significant, it is important to consider any potential competing or conflicting needs. For example, there may be limited budget and funding available for this project, and these funds may be needed for other pressing community needs. The payback period for the installation of solar panels is 11 years, which means it will take a substantial amount of time for the library to realize the economic benefits. Additionally, there may be concerns about the aesthetics of the solar panels and how they will impact the overall appearance of the library. And we also need to take the maintenance spent of the solar panels into consideration, these costs might make the payback period longer than expected.

In conclusion, installing solar panels at the public library in Indianapolis presents numerous benefits from cultural, economic, and environmental perspectives. The project demonstrates the city's commitment to sustainability and aligns with current public attitudes towards environmental responsibility. It will also result in long-term cost savings and potentially attract new investment and businesses to the city. From an environmental perspective, the solar panels will significantly reduce the library's carbon emissions and provide a cleaner and healthier environment for patrons and staff. The installation of solar panels at the library is a smart and sustainable decision that will benefit the community and the environment in the long run.

VI. REFERENCES

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VII. APPENDICES

For details of our analyses please refer to the Excel file, named: ENGR131_A05_10.xlsx