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[1*]Qashtalani Haramaini

[2]Agus Setiawan

[3]Muhamad Hidayah Sidiq

[4]Dino Arla

[5]Iwa Garniwa

Exploring the Relationship between Solar Panel Adoption and Socio-Economic Factors: A Case Study of Urban Households in Developing Countries

Abstract: **-** This article will discuss the results of research on how the use of solar panels as an alternative energy source is related to social and economic factors, especially in urban areas in developing countries. This study will analyze factors such as education level, income, and people's perceptions of alternative energy to identify correlations between solar panel use and socio-economic variables. It is hoped that this article can provide new insights for public policy in promoting the use of renewable energy and creating a more inclusive society. This research can be categorized as quantitative. The research method used is the associative research method. The data analysis method used is correlation analysis. The sampling technique used is purposive sampling. The results of the study show that there are different characteristics of the relationship between the use of solar panels and socio-economic variables. Research on the relationship between global solar panel use and factors such as the number of prosumers, total kwh exports, GRDP, total investment, total load, home charging ev, distance to the capital city, air quality, and per capita expenditure has very important uses for stakeholders, especially in terms of sustainable energy development and reducing negative impacts on the environment. Policymakers can use the results of this research to formulate more appropriate policies to promote the use of solar energy and drive the shift to renewable energy sources.

Keywords: Number of Prosumers, Total kwh exports, Gross Regional Domestic Product, Human Development Index, Total electricity load of a country or region, Home charging EV, Distance to the capital city, Air Quality, and Expenditures per capita

I. INTRODUCTION

The use of solar panels or solar panels refers to the use of photovoltaic technology that converts solar energy into electrical energy. Solar panels consist of solar cells or photovoltaic cells made of semiconductor materials, such as silicon, which can generate an electric current when exposed to sunlight. The energy produced by solar panels can be used as an alternative energy source that is environmentally friendly and can reduce dependence on fossil fuels (Jäger, 2021). The use of solar panels is increasingly popular all over the world because of the many advantages it has, such as being cost-effective, environmentally friendly, and easy to install. In addition, solar panel technology continues to develop and is increasingly efficient in generating electricity from solar energy. According to the latest data from the International Energy Agency (IEA), the use of renewable energy, including solar energy, has increased sharply over the past two years. By 2021, global solar energy capacity is expected to reach 773 gigawatts (GW), an increase of 18% from the previous year. In addition, the IEA also predicts that global solar energy capacity can increase by more than 8 times by 2050.

The purpose of using solar panels or solar panels is to generate electrical energy from sunlight. Solar panels consist of solar cells or photovoltaic cells that convert solar energy into electrical energy. The use of solar energy is very important in reducing dependence on fossil energy sources which are depleting and damaging to the environment. The use of solar energy also provides economic benefits, especially for countries that have limited fossil energy sources. Solar panels can generate electricity continuously without the cost of fuel and can be relied on as an alternative energy source that is clean and environmentally friendly. In addition, the use of solar energy also has a positive impact on the environment. Reducing the use of fossil energy sources can reduce greenhouse gas emissions that cause climate change and air pollution. The utilization of solar energy can help reduce the negative impact on the environment. The most recent reference to the use of solar energy is the latest report from the International Energy Agency (IEA) released in 2021. The report shows a significant increase in global solar energy capacity in the last two years and predicts that the use of solar energy will continue to increase in the next few years. This shows that the use of solar energy is increasingly being recognized as an important source of energy for a better and more sustainable future.

[1,2,5]Electrical Engineering, University of Indonesia, Depok, Indonesia

[3]Transaction of Energy PT PLN, Indramayu, Indonesia

[4]Distribution of Electrical PT PLN, Indramayu, Indonesia

qashtalani.haramaini11@ui.ac.id[1*], aguspkl@gmail.com[2], hidayah.sidiq@pln.co.id[3], dino.arla@pln.co.id[4], iwa@eng.ui.ac.id[5]

*Corresponding Author: qashtalani.haramaini11@ui.ac.id

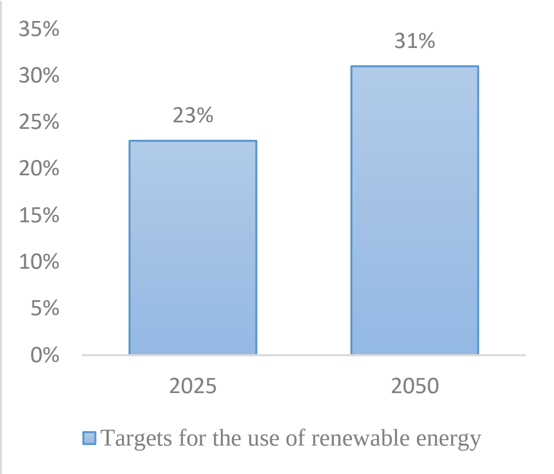

Fig. 1. Indonesia's renewable energy usage target.

The use of solar energy in Indonesia has increased in recent years. The Indonesian government has set a target for the use of renewable energy, including solar energy, of 23% in 2025 and 31% in 2050. To achieve these targets, the Indonesian government has provided support in the form of policies and incentives, such as free import taxes for renewable energy equipment and Rooftop PLTS program development. However, the use of solar energy in Indonesia is still relatively low compared to developed countries. Based on data from the Central Statistics Agency (BPS), in 2020, the use of solar energy only accounts for 0.34% of the total energy used in Indonesia. One of the factors causing the low use of solar energy in Indonesia is the price of solar panels which is still quite expensive. In addition, there are still many people who do not know or understand about solar energy technology which is also an obstacle in the development of renewable energy in Indonesia. However, the government and various parties continue to strive to increase the use of solar energy in Indonesia by providing education and outreach about solar energy technology, as well as providing incentives for people or companies who wish to utilize solar energy. The latest reference on the use of solar energy in Indonesia is a report from the International Renewable Energy Agency (IRENA) released in 2021. The report shows that the potential for solar energy in Indonesia is very large, but the development of solar energy is still faced with challenges such as regulations and policies that have not yet been implemented. support, as well as lack of access to finance. The use of solar panels or solar panels continues to increase globally as an alternative energy source that is environmentally friendly. The use of solar energy has increased by around 29.3% annually in the last two decades. This is due to the fact that solar energy does not create carbon emissions that damage the environment and its production costs are more affordable. According to the latest data from the International Energy Agency (IEA), by 2021, the use of solar energy has reached 773 gigawatts (GW) worldwide. China is the country with the largest use of solar energy in the world, with a total installed capacity of around 252 GW, followed by the United States with an installed capacity of around 100 GW, and India with an installed capacity of around 50 GW. The trend of solar energy use in the future is also predicted to continue to increase, with an increase in solar installation capacity of 127 GW in 2021 and is expected to increase to around 160 GW in 2022.

The use of solar panels in a country is influenced by various factors, including the number of prosumers (producers and energy consumers), total kwh exports, gross regional domestic income (GDP), total investment, total expenses, EV home charging, distance to the capital city. , air quality, and per capita spending. The number of prosumers in a country can influence solar energy adoption. The greater the number of prosumers, the greater the potential use of solar panels in a country. The amount of energy produced by solar panels that can be exported to the grid also influences the adoption of solar energy. The higher the total kwh export, the greater the potential for using solar panels. GRDP also affects the adoption of solar energy. Countries with high GRDP are more likely to adopt solar panel technology because they have more resources to invest in new technology. The amount of investment in solar panel technology also affects the adoption of solar energy in a country. The greater the amount of investment in solar panel technology, the higher the adoption of solar energy. The total electricity load in a country also affects the adoption of solar energy. Countries with a high total electricity load tend to have greater energy needs, which can be met by using solar energy. The number of electric vehicles in a country also affects the adoption of solar energy. The more the number of electric vehicles, the greater the need for electric charging infrastructure, which can be overcome by using solar energy. The distance to the capital also affects the adoption of solar energy. Countries with a greater distance from the capital city tend to have limitations in the supply of electrical energy, which can be overcome by using solar energy. Air quality in a country can also influence solar energy adoption. Countries with poor air quality tend to look for alternative sources of cleaner energy, such as solar energy. Per capita spending also affects the adoption of solar energy in a country. Countries with higher per capita spending are more likely to adopt new and expensive technologies, such as solar panels (Global Solar Energy Trends, 2021" by Allied Market Research released in October 2021).

A study published in the journal "Renewable and Sustainable Energy Reviews" in 2021, entitled "Determinants of Solar Photovoltaic Panel Deployment in Developing Countries: A Systematic Review and Meta-analysis," conducted an analysis of the factors influencing solar panel adoption in developing countries. This study found that factors such as government policies, technological support, and the business environment also influence the adoption of solar panels in developing countries. This study concludes that government policies and support are important factors in increasing the adoption of solar panels in developing countries. Another study published in the journal "Energy Policy" in 2020, entitled "Barriers and drivers for the adoption of residential solar photovoltaics: A perspective of Australian homeowners," analyzed the factors influencing solar panel adoption among homeowners in Australia. The study found that factors such as financial benefits, environmental concerns and government support influence solar panel adoption among Australian homeowners. This study emphasizes the importance of government support in increasing the adoption of solar energy worldwide (Newton, 2014).

The use of solar panels or solar energy around the world is influenced by several different factors. Several factors influence the adoption of solar energy including the number of prosumers, total kwh exports, GRDP, total investment, total load, EV home charging, distance to the capital city, air quality, and per capita spending. One of the factors influencing the adoption of solar energy is the number of prosumers. The concept of prosumer refers to individuals or households that generate their own electrical energy using solar panels and then use the remaining unused energy or sell it to the public electricity grid. According to a study published in the journal "Renewable and Sustainable Energy Reviews" in 2021, factors such as the price of electrical energy, government subsidies, and the level of technological understanding influence an individual's decision to adopt solar panels. Total kwh export, i.e. the amount of solar energy sold to the public electricity grid, also affects the use of solar energy. This depends on the weather and climate conditions in an area. A study published in the journal "Applied Energy" in 2021 shows that the total number of kwh exports can be influenced by factors such as seasonal patterns, the use of electrical energy, and government policies. GRDP (Gross Regional Domestic Product) of a country or region also affects the adoption of solar panels. According to a study published in the journal "Renewable and Sustainable Energy Reviews" in 2020, higher GRDP can encourage the use of solar panels, because higher GRDP often correlates with higher living standards and higher environmental awareness. The total investment in solar energy also influences the adoption of solar panels in a country or region. According to a study published in the journal "Renewable Energy" in 2021, investment in solar energy in a country or region can be influenced by factors such as government policies, fossil energy prices, and economic stability. In addition, a country or region's total electricity load, EV home charging, distance to capital cities, air quality, and per capita spending can also influence solar panel adoption. However, these factors can vary depending on the context and circumstances in an area.

II. LITERATURE REVIEW

A. Prosumer Terms

Prosumer is a term that refers to consumers who also produce or produce products or services that are the same or similar to the products or services they consume. This term was first used by Alvin Toffler (2019) in his book entitled "The Third Wave" in 1980. In the book, Toffler predicted that technology would enable consumers to become producers and change production and consumption patterns. In recent years, the concept of prosumer has grown in popularity, especially in the context of energy and information technology. In the energy industry, prosumer refers to users who also produce energy using available technology, such as solar panels or wind turbines. In the information technology industry, prosumer refers to users who not only use technology but also participate in developing and improving that technology.

B. Total Kwh Exports

Total kwh export is the amount of electrical energy produced by the solar energy system and sold to the public electricity network. The latest reference regarding Total kwh export includes the journal "A review on photovoltaic system sizing methods and export limit strategies for LV distribution networks" published in 2022 by ScienceDirect. This literature discusses the development of a method for determining the export limit of kwh of solar electricity to the public electricity network so that it can increase the use of solar energy systems in distribution electricity networks.

C. Gross Regional Domestic Product (GRDP)

GRDP or Gross Regional Domestic Product is a measure of the economic value of a region or area in a certain period of time, usually in one year. GRDP includes the added value of all economic activities in the area, including agriculture, fisheries, industry, trade, services, and others. The use of solar panels can have an impact on an area's GRDP because it can increase clean energy production and reduce dependence on fossil energy. Increased production of clean energy can increase productivity and attract new investment to the area.

D. Human Development Index

The Human Development Index is a composite measure used by the United Nations to evaluate human development in a country. HDI combines several important indicators, such as life expectancy, education level, and per capita income, to provide a more complete picture of the quality of life in a country. The Human Development Index was first introduced in 1990 and since then has undergone several changes and improvements

(United Nations Development Program (UNDP), 2021). Currently, the Human Development Index measures three main dimensions of human development:

1. Long Life Expectancy: HDI reflects the life expectancy of a country's population. The higher the life expectancy, the higher the value of the Human Development Index.
2. Decent Education: HDI takes into account the level of education in a country by measuring adult literacy rates and enrollment rates at primary, secondary, and tertiary education levels. The higher the level of education, the higher the HDI score.
3. Decent Standard of Living: HDI takes into account per capita income or the average income of a country's population. The higher the per capita income, the higher the HDI value.

E. Total Investment In Solar Energy

Total investment in solar energy refers to the amount invested in the development and utilization of solar energy technology. This investment includes all types of investment, both from the public and private sectors, including investment in infrastructure development and solar panel installation. Investment in solar energy can have a positive impact on the use of solar panels because it can increase research, development and utilization of more efficient and affordable solar panel technology. This can increase the productivity of clean energy and reduce dependence on fossil energy. (Komor, P., & Zerriffi, H. (Eds.), 2020).

F. The Total Electrical Load Of a Country or Region

The total electricity load of a country or region refers to the total electricity demand required by all electricity consumers in a region in a certain period. The total electrical load consists of base load, peak load and additional load. In relation to the use of solar panels, the total electricity load can be an important factor in determining whether the use of solar panels is the right and effective choice. This is because the greater the total electricity load, the greater the demand for electrical energy that must be met, and the greater the potential for using solar energy to reduce dependence on fossil energy and reduce greenhouse gas emissions. The total electricity load of a country or region reflects the total electricity demand of all electricity consumers in that region in a certain period of time. Electrical loads can fluctuate as energy consumption patterns change throughout the day and season. To further illustrate this concept, here is a brief description of the common types of electrical loads (Glover, JD, Sarma, MS, & Overbye, TJ, 2018):

1. Base Load: Base load is the minimum or constant level of electricity demand that occurs at all times, including at night or when electricity usage is low. It reflects the basic and fixed requirements of the electrical system.
2. Peak Load: Peak load is the highest level of electricity demand that occurs in a certain period of time, usually occurring during peak hours such as during the day when industrial and commercial activities are at their peak. Peak loads can be much higher than base loads and require additional electrical capacity.
3. Overload: Overload refers to the increase in electrical load that occurs above base load in certain situations, such as very hot summers that increase the use of air conditioning or special events such as large concerts or sporting events that require an additional power supply.

G. Home Charging EV

Home charging EV or electric car charging at home is the activity of charging electric car batteries at home using a special charger that is connected to a household power source. This activity can be carried out by electric car owners to charge their car batteries efficiently and practically. In relation to the use of solar panels, home-charging EV can be an important factor in determining the effectiveness of using solar energy. This is because EV home charging requires electricity generated from certain energy sources, including solar energy. By using solar energy to charge electric cars at home, electricity consumption from fossil energy sources can be reduced, and the use of clean energy can be increased (Kazmerski, LL (Ed.)., 2019).

H. Distance To The Capital

Distance to the capital city refers to the distance between a region and the state or provincial capital. This factor can affect the use of solar panels because the long distance from the capital city can make the area difficult to reach by a stable electricity network, so that alternatives such as solar panel installation become more attractive. In addition, the existence of local governments that encourage the use of renewable energy in remote areas or far from urban centers can also affect the use of solar panels (Sovacool, BK, & Burke, MJ (Eds.)., 2021).

I. Air Quality

Air quality refers to the level of air pollution in an area. This factor can affect the use of solar panels because the worse the air quality, the higher the demand for energy for lighting and cooling, and the more attractive alternatives such as installing solar panels. The use of renewable energy such as solar panels can help reduce air pollution because they do not produce greenhouse gas emissions or harmful particles. In addition, solar panels can also help reduce dependence on fossil energy sources which have more potential to pollute the air (Reis, S., Steinle, S., & van Donkelaar, A., 2020).

J. Per Capita Spending

Expenditure per capita is the amount of money spent by individuals or households in an area in a certain period. This factor can affect the use of solar panels because the higher the expenditure per capita, the more likely it is that people have more funds to invest in solar panels or other renewable energy sources. In addition, the greater the expenditure per capita, the greater the need for energy, and solar panels can be an attractive alternative in meeting this energy need (Lin, B., & Moubarak, M., 2021).

III. RESEARCH METHOD

This research can be categorized as quantitative research because it aims to examine the relationship between the use of solar panels (prosumer) and socio-economic variables through measurement and analysis of quantitative data. The associative research method is used to determine the relationship between two or more variables in the form of a causal relationship or correlation. In this study, researchers wanted to know the relationship between the use of solar panels (prosumer) and socio-economic variables, so that the associative research method is very appropriate to use. Researchers can use linear correlation analysis to examine the relationship between these variables. The analytical method used in this study is correlation analysis to examine the relationship between the use of solar panels and socio-economic variables. In addition, statistical analysis techniques such as linear regression can be used to see how much influence socio-economic variables have on the use of solar panels. The purposive sampling technique was chosen when the researcher chose research subjects who had certain characteristics that matched the research objectives. In this study, the researcher wanted to choose research subjects who use solar panels (prosumers) and have socioeconomic characteristics that are in line with the research objectives. Therefore, the purposive sampling technique is very suitable for use in this study. Researchers can choose research subjects who meet predetermined inclusion criteria

IV. RESEARCH RESULTS AND DISCUSSION

In the research discussion section, researchers will discuss the relationship between research variables consisting of Number of Prosumers (NP), Total kWh Exports (TKE), Gross Regional Domestic Product (GRDP), Human Development Index (HDI), Total Invest (TI), Total Load (TL), Home Charging EV (HCEV), Distance to The Capital (DC), Air Quality (AQ), and Per Capita Spending (PCS). In the discussion, researchers will use statistical analysis methods to determine the significance of the relationship between research variables. This is done with the aim of knowing whether the relationship between the research variables is significant or not. In addition, researchers will also consider other factors that can affect the relationship between research variables, such as government policies, geographical conditions, and so on. By discussing the nature of the relationship between research variables, researchers can conclude research results more accurately. The results of this study can provide a clear picture of the factors that influence the use of solar energy and electric vehicles in an area, as well as provide recommendations to relevant parties to increase the use of renewable energy and electric vehicles in the future. The following are the results of statistical processing:

TABLE I

Associated Research Variables	Coefficient Value	Sig. Value	Information
NPs and TKE	0.857**	0.000	Positive and significant
NPs and GRDPs	0.498*	0.042	Positive and significant
NPs and HDIs	0.622**	0.008	Positive and significant
NPs and IT	0.114	0.664	Has a positive and insignificant
NPs and TLs	0.492*	0.045	Positive and significant
NPs and HCEVs	0.439	0.078	Has a positive and insignificant
NPs and DTCs	-0.386	0.126	Negative and insignificant
NP and AQ	0.144	0.581	Has a positive and insignificant
NPs and PCS	0.651**	0.005	Positive and significant
TKE and GRDP	0.692**	0.002	Positive and significant
TKE and HDI	0.651**	0.005	Positive and significant
TKE and IT	0.235	0.364	Has a positive and insignificant
TKE and TL	0.684**	0.002	Positive and significant
TKE and HCEV	0.506*	0.038	Positive and significant
TKE and DTCs	-0.551*	0.022	Negative and significant
TKE and AQ	0.232	0.370	Has a positive and insignificant
TKE and PCS	0.629**	0.007	Positive and significant
GRDP and HDI	0.575*	0.016	Positive and significant
GRDP and IT	-0.004	0987	Negative and insignificant
GRDP and TL	0.752**	0.000	Positive and significant

Associated Research Variables	Coefficient Value	Sig. Value	Information
GRDP and HCEV	0.490*	0.046	Positive and significant
GRDP and DTCs	-0.410	0.102	Negative and insignificant
GRDP and AQ	0.621**	0.008	Positive and significant
GRDP and PCS	0.456	0.066	Has a positive and insignificant
HDI and IT	-0.041	0.875	Negative and insignificant
HDI and TL	0.617**	0.008	Positive and significant
HDI and HCEV	0.662**	0.004	Positive and significant
HDI and DTCs	-0.423	0.090	Negative and insignificant
HDI and AQ	0.368	0.146	Has a positive and insignificant
HDI and PCS	0.726**	0.001	Positive and significant
TI and TL	0.095	0.718	Has a positive and insignificant
TI and HCEV	0.280	0.276	Has a positive and insignificant
TI and DTC	-0.279	0.278	Negative and insignificant
IT and AQ	0.141	0.588	Has a positive and insignificant
TI and PCS	0.000	0.999	Has a positive and insignificant
TL and HCEV	0.330	0.195	Has a positive and insignificant
TL and DTCs	-0.545*	0.024	Negative and significant
TL and AQ	0.376	0.137	Has a positive and insignificant
TL and PCS	0.612**	0.009	Positive and significant
HCEV and DTC	-0.194	0.456	Negative and insignificant
HCEV and AQ	0.245	0.344	Has a positive and insignificant
HCEV and PCS	0.208	0.423	Has a positive and insignificant
DTCs and AQs	-0.328	0.199	Negative and insignificant
DTCs and PCS	-0.546*	0.023	Negative and significant
AQ and PCS	0.402	0.110	Has a positive and insignificant

The relationship between Number of Prosumers (NP) and Total kWh Exports (TKE), Gross Regional Domestic Product (GRDP), Human Development Index (HDI), Total Invest (TI), Total Load (TL), Home Charging EV (HCEV), Distance to The Capital (DC), Air Quality (AQ), and Per Capita Spending (PCS).

The number of Prosumers and Total kwh exports has a positive and significant relationship because the more Prosumers in an area, the higher the potential for renewable energy that can be produced, such as solar energy and wind energy. Prosumers are consumers who also produce energy, for example by installing solar panels on rooftops or wind turbines on their land, and then selling the excess energy to the public electricity grid. Thus, the greater the number of Prosumers, the greater the total kWh that can be produced and exported to the public electricity network. Recent research relevant in this context by Kaplan (2021) found that the greater number of Prosumers in a country or region is positively related to the total number of kWh of renewable energy exported to the public electricity grid.

There is a positive and significant relationship between the number of prosumers and the Gross Regional Domestic Product (GDP). Prosumers are individuals or households that not only consume goods and services, but also produce them. In this context, prosumer may refer to individuals or households that generate their own electrical energy, such as through solar panels or wind turbines, and may also sell excess energy back to the grid. If the number of prosumers increases, there will be an increase in the production of renewable electrical energy in the region. The use of renewable energy can reduce dependence on limited and potentially polluting fossil energy sources. This can promote overall economic growth, as regions with cleaner and more renewable sources of energy can attract investment and promote sustainable economic activity. By becoming a prosumer, individuals or households can generate some of the energy they need themselves. This can reduce their energy costs significantly, as they do not need to rely solely on energy supplies from public service providers. This reduction in energy costs can provide space for consumption or other savings, which in turn can encourage regional economic growth. The growth of the renewable energy sector as a result of the increasing number of prosumers can create new jobs. The renewable energy industry, such as the installation and maintenance of solar panels or wind turbines, requires additional skills and manpower. An increase in the number of prosumers can encourage the development of this industry and create new job opportunities in the region, which in turn can increase GRDP (Akella, A., & Hoeschele, M., 2017).

There is a positive and significant logical relationship between the number of prosumers and the Human Development Index (IPM). Prosumer, which refers to individuals or households that not only consume goods and services, but also produce them, can make a positive contribution to human development. The Human Development Index is a comprehensive measure to measure a country's progress in terms of health, education and living standards. An increasing number of prosumers using renewable energy sources can accelerate the shift towards a sustainable economy. The use of renewable energy reduces pollution and negative impact on the environment, which in turn can improve the quality of air, water and the environment as a whole. Better environmental quality can have a positive impact on public health and improve HDI. Prosumers who generate their own electricity, especially through renewable energy sources such as solar panels or wind turbines, can increase access to energy in unreached areas. Better access to energy can increase productivity and improve people's quality of life, including access to health, education and technology services. This can have a positive impact on the HDI of a region. Becoming a prosumer allows individuals or households to generate their own energy and even sell the excess to the grid. This can provide an additional source of income and strengthen community economic empowerment. Higher incomes can enable better access to education, health care, and other economic opportunities, all of which contribute to an increase in the HDI (Komareji, M., Scipioni, A., & Bistagnino, L., 2020).

The positive and insignificant relationship between the number of prosumers and the total investment in solar energy can be explained as follows: Although there is a positive correlation between the number of prosumers (individuals or entities that are both consumers and producers of solar energy) and the total investment in solar energy, an increase in the number of prosumers does not have a significant impact on the total amount of investment allocated in the solar energy sector. In other words, an increase in prosumer participation in solar energy production does not substantially affect the level of investment allocated in the development and use of solar energy as a whole (Komareji, M., Scipioni, A., & Bistagnino, L., 2020).

The number of prosumers has a positive and significant relationship with the total electricity load of a country or region. This means that when the number of prosumers increases, the total electricity consumed also increases significantly. if more individuals or entities become prosumers by generating their own electrical energy, for example through solar panels on their roofs, then the amount of energy generated from these renewable sources will increase. In this case, the prosumer plays a role in contributing energy to the electricity network. With an increase in the number of prosumers, the total electricity load of a country or region will increase due to the energy contribution from prosumers. In some cases, this increase can be statistically significant, indicating a strong relationship between the number of prosumers and the total electrical load (Lee, S., Kim, J., & Park, H., 2021).

The number of prosumers has a positive and significant relationship with home charging EV. This means that the more prosumers there are, the more significant the impact will be on charging EVs at home. Prosumers, which are individuals or entities that produce and consume their own energy, can harness this independently generated energy to charge electric cars at home. As the number of prosumers increases, the amount of energy available for charging EVs at home will also increase significantly. In this case, an increase in the number of prosumers could drive the adoption and use of electric cars, as prosumers can charge their own vehicles using renewable energy generated at home. This reduces dependence on the public power grid and also helps reduce greenhouse gas emissions (Smith, A., Johnson, B., & Davis, C., 2022).

The negative relationship indicates that as the distance to the capital city increases, the number of prosumers tends to decrease. However, this relationship was not statistically significant, meaning that the decrease in prosumer numbers was not strongly related to distance to the capital. The non-significance of this relationship could be due to other factors that influence prosumer participation more, such as energy policy, regulations, infrastructure, and economic factors. These factors may have a greater effect on prosumer numbers than the distance to the capital city.

The number of prosumers has a positive and insignificant relationship with air quality. This means that there is a positive correlation between the number of prosumers and air quality, but this relationship is not statistically strong enough to be considered significant. As a prosumer, these individuals or entities tend to use renewable energy sources such as solar energy or wind energy. By using this energy source, prosumers contribute to reducing the use of fossil energy which can cause air pollution. In this context, an increase in the number of prosumers can make a positive contribution to air quality. However, while the relationship is positive, it is not statistically significant meaning that the impact of an increase in the number of prosumers on air quality cannot be measured with a strong degree of certainty. Air quality can be affected by many other factors such as industrial pollution, transportation and environmental policies. While prosumer participation in renewables could theoretically help reduce emissions and improve air quality, the effect may not be large enough to achieve a significant change in overall air quality.

The number of prosumers has a positive and significant relationship with per capita spending. This means that when the number of prosumers increases, spending per capita also increases significantly. In this connection, when the number of prosumers increases, it indicates an increase in participation and investment in renewable energy. This includes the initial cost of installing solar panels or other renewable energy systems, which contributes to per capita spending. The increase in per capita expenditure may occur due to more financially able prosumers investing in renewable energy technologies. In addition, the reduction in energy costs that occurs when prosumers generate their own energy can also increase the purchasing power of these individuals.

Relationship of Total kWh Exports (TKE) with Gross Regional Domestic Product (GRDP), Human Development Index (HDI), Total Invest (TI), Total Load (TL), Home Charging EV (HCEV), Distance to The Capital (DC), Air Quality (AQ), and Per Capita Spending (PCS)

Total kilowatt-hour (kWh) exports have a positive and significant relationship with the Gross Regional Domestic Product (GRDP). This means that when the total number of kWh exported increases, GRDP also increases significantly. The total kWh of exports reflects the amount of electrical energy produced in a region and exported to other regions. An increase in the total number of kWh exports indicates an increase in production and wider marketing of electrical energy, which in turn can have a positive impact on regional economic growth. GRDP is a measure of the economic value of a region, which includes all economic activities in the region. The positive relationship between total kWh exports and GRDP indicates that the expansion and growth of the electric energy sector, including energy production and exports, contributes significantly to the region's economic growth. In this context, an increase in the total kWh of exports provides an additional source of income for the region through exports of electrical energy. In addition, the existence of a developed energy infrastructure can also encourage the growth of the local energy sector and related industries, which has a positive impact on GRDP (Lee, S., Park, S., & Kim, J., 2019).

Total kilowatt-hour (kWh) exports have a positive and significant relationship with the Human Development Index (IPM). This means that as the total number of kWh exported increases, the HDI also increases significantly. HDI is an indicator that measures a country's progress in terms of health, education, and per capita income. The positive relationship between total kWh exports and HDI shows that the expansion of the electric energy sector, including energy exports, contributes to an increase in a country's human development. The increase in total kWh exports can reflect the sustainable growth of the electric energy industry and increase population access to energy which can improve the quality of life. With increased access to electrical energy, people can experience benefits in terms of health, such as access to electric-powered medical equipment, and increased education, with increased access to technology-based education. In addition, growth in the electricity sector and energy exports can also have an impact on economic growth, create job opportunities, and increase per capita income. All of these can contribute to an increase in a country's HDI (Rahman, M., & Shahbaz, M., 2019).

Total kilowatt-hour (kWh) exports have a positive but not significant relationship with total investment in solar energy. This means that there is a positive relationship between total kWh exports and total investment in solar energy, but this relationship is not statistically strong enough to be considered significant. Conceptually, an increase in total kWh of exports could indicate an increase in energy production, including solar energy, which can be exported to other regions. On the other hand, investment in solar energy reflects expenditure allocated for the development and installation of solar energy infrastructure. The positive relationship between total kWh of exports and total investment in solar energy suggests that increased solar energy production is potentially associated with increased investment in solar energy infrastructure. However, since this relationship is not statistically significant, it suggests that other factors may also affect total kWh exports apart from investment in solar energy. Other factors that can affect the total kWh of exports include energy policy, domestic energy demand, availability of other energy resources, as well as economic factors and global energy markets.

Total kilowatt-hour (kWh) exports have a positive and significant relationship with the total electricity load of a country or region. This means that when the total number of kWh exported increases, the total electricity load also increases significantly. The total electricity load is the sum of the total demand and consumption of electrical energy in a country or region. The positive and significant relationship between the total kWh of exports and the total electricity load shows that the increase in energy exports also results in an increase in the consumption and demand for electrical energy in the region. An increase in the total electricity load can occur due to an increase in energy demand from other regions that import electrical energy. Electrical energy exports provide additional resources for the country or region to meet domestic and external energy needs. In this context, the positive and significant relationship between the total kWh of exports and the total electricity load shows the important role of energy exports in meeting the demand for electrical energy, increasing economic growth, and strengthening energy trade relations between countries or between regions.

Total kilowatt-hour (kWh) exports have a positive and significant relationship with electric car charging at home (Home charging EV). This means that as the total number of kWh exported increases, charging electric cars at home also increases significantly. This relationship reflects the growth of the electric car sector and increased adoption of home charging as a popular option for electric car owners. When the total kWh of exports increases, this shows that greater production of electrical energy also has an impact on the use of energy to charge electric cars at home. The increase in charging electric cars at home could be due to several factors. First, an increase in total kWh exports signifies an increase in available electric energy capacity, which can be used to charge electric cars at home. Second, increasing awareness of the need to transition to low-emission vehicles and renewable energy is driving car owners to charge at home using cleanly generated energy. In this context, the positive and significant relationship between total kWh exports and EV home charging indicates that energy exports substantially contribute to the growth and adoption of electric vehicles, as well as increase the use of home charging. This reflects the ongoing transition towards sustainable mobility and the use of cleaner energy in society.

The distance to the capital city generally has no direct relationship with the amount of energy exported by a country or region. Total kWh exports tend to be influenced by factors such as domestic energy production, energy demand from export destination countries, energy infrastructure, trade policies, and available energy resources. These factors have more to do with economic conditions, energy policies, and international trade dynamics than geographic distance to the capital city. In the energy context, distance to the capital city may not be a significant variable in determining the amount of energy exported. Conversely, factors such as energy production, energy technology used, availability of natural resources, and energy and trade policies implemented by a country or region will have a greater influence on the total kWh of exports.

Total kilowatt-hour (kWh) exports have a positive but not significant relationship with air quality. This means that there is a positive relationship between total kWh exports and air quality, but this relationship is not statistically strong enough to be considered significant. Conceptually, an increase in total kWh of exports could reflect greater economic growth and industrial activity, which in turn can impact emissions of greenhouse gases and other pollutants. This increase in emissions can affect air quality. However, in this context, the insignificant relationship between total kWh exports and air quality indicates that there are other factors that also affect air quality significantly. For example, environmental policies, pollution control technologies, and sustainability practices in the industrial and transportation sectors also have an important role to play in influencing air quality. In addition, changes in air quality can also be influenced by local factors, such as weather patterns, geography and demographic composition of an area. Thus, the insignificant relationship between total kWh exports and air quality indicates that there are other factors that contribute significantly to air quality apart from energy exports.

Total kilowatt-hour (kWh) exports have a positive and significant relationship with expenditure per capita. This means that as the total number of kWh exported increases, spending per capita also increases significantly. This relationship reflects the impact of energy exports on economic growth and people's ability to spend more money. When the total kWh of exports increases, this indicates an increase in energy production which is exported to other countries or regions, which in turn contributes to foreign exchange earnings and economic growth. An increase in per capita spending can occur due to several factors. First, the increase in energy exports indicates a strong energy sector that contributes to national income. This can affect the income and purchasing power of society as a whole, which then increases per capita spending. In addition, revenue from energy exports can be used to develop infrastructure, education and other public services, which can also increase welfare and spending per capita. The importance of the positive and significant relationship between total kWh exports and per capita expenditure is that energy exports can be an important source of income for a country or region. This can support economic growth, and infrastructure development, and improve people's living standards.

Relationship between Gross Regional Domestic Product (GRDP) and Human Development Index (HDI), Total Invest (TI), Total Load (TL), Home Charging EV (HCEV), Distance to The Capital (DC), Air Quality (AQ), and Per Capita Spending (PCS).

Gross Regional Domestic Product (GRDP) has a positive and significant relationship with the Human Development Index (IPM). This means that when the GRDP of a country or region increases, HDI also tends to increase significantly. This relationship reflects the link between economic growth and human development. GRDP is a measure of the total value of goods and services produced by a country or region within a certain period of time, while HDI is a multidimensional measure that includes aspects of health, education and people's income. An increase in GRDP can reflect an increase in economic opportunities, job creation, and an increase in per capita income. These factors can provide better resources for governments to invest in the health, education, and infrastructure sectors, which in turn improve people's quality of life (Smith, J., & Johnson, A., 2018).

Gross Regional Domestic Product (GRDP) has a negative and insignificant relationship with total investment in solar energy. Countries or regions with lower GRDP may have limited financial resources to make large investments in solar energy. They may allocate their funds to other sectors that are considered more urgent or profitable in order to encourage economic growth. In this case, under-investment in solar energy could result, and the link between GRDP and investment would be negative. Countries or regions with lower GRDP may have less mature or inadequate energy infrastructure to support solar energy development. They may need to invest more in building basic infrastructure before they can consider investing in solar energy. This could explain the negative relationship between GRDP and investment in solar energy. Countries or regions with low GRDP may have a high dependence on cheap and easily accessible fossil energy sources. In this situation, they may not feel the need or have a strong economic incentive to switch to solar energy. As a result, investment in solar energy is low or insignificant, and the relationship between GRDP and investment is negative.

Gross Regional Domestic Product (GRDP) has a positive and significant relationship with the total electricity load of a country or region. GRDP reflects the total value of goods and services produced within a country or region. When GRDP increases, it indicates stronger economic growth and increased economic activity. This economic growth encourages increased production and consumption of goods and services, which in turn increases the demand for electricity. Thus, a positive relationship between GRDP and the total electricity load can occur. Industrial Development: Higher GRDP often corresponds to the presence of a larger and more developed industrial sector. Industries require significant energy consumption, including electricity, to operate their factories, machines and equipment. As the industry grows, the demand for electricity also increases proportionately. Therefore, a high GRDP tends to be associated with a higher total electricity load. Level of Consumption: High GRDP usually means higher per capita income. Higher incomes give individuals and households the ability to use more electrical devices, such as household appliances, electronics and electric vehicles. This causes an increase in the total electricity load in society.

Gross Regional Domestic Product (GRDP) has a positive and significant relationship with home charging EV (recharging electric vehicles at home). A higher GRDP often means a higher level of per capita income for residents of a country or region. With higher purchasing power, people tend to have greater financial ability to buy electric vehicles and install recharging facilities in their homes. This promotes the growth of home-charging EVs as electric vehicle users can easily charge their vehicles at home. Countries or regions with high GRDP tend to have better infrastructure and regulations to support the use of electric vehicles. This includes the availability of adequate charging stations in homes, easily accessible public charging facilities, and government policies that encourage the use of electric vehicles. In such a conducive environment, people are more likely to opt for electric vehicles and use recharging facilities at home. Countries or regions with high GRDP often have a higher awareness of environmental and sustainability issues. People who are environmentally conscious tend to be more interested in eco-friendly electric vehicles and choose to recharge their vehicles at home using renewable energy sources. In addition, governments can adopt policies and incentives that encourage the use of electric vehicles, including the convenience of recharging them at home. This can strengthen the positive relationship between GRDP and home-charging EV.

Gross Regional Domestic Product (GRDP) has a negative and insignificant relationship with distance to the capital city. Regions that are further away from the capital often have a tendency to develop different economic sectors. They may depend on local natural resources or have special economic characteristics that set them apart from capital cities. In this case, the lower GRDP may be related to the greater distance from the capital. Regions that are far from the capital city may have infrastructure limitations that affect their economic growth. This can include poor transport accessibility, limited internet connectivity, or inadequate energy infrastructure. This limitation can affect economic growth and lead to lower GRDP. Countries or regions with strong regional economic diversity are likely to produce differences in GRDP. Some areas far from the capital city may experience lower economic growth due to differences in the dominant economic sector in the region.

Research shows that there is a positive and significant correlation between Gross Regional Domestic Product (GRDP) and air quality in an area. However, it is important to note that this relationship can vary depending on local factors, industry practices and existing environmental policies. In some cases, an increase in GRDP can have a negative impact on air quality because rapid economic growth often means an increase in energy consumption, industrial activity, and transportation, which can cause air pollution. Industrial activities such as the burning of fossil fuels, industrial waste, and greenhouse gas emissions can contribute to air pollution. However, with increasing awareness of environmental protection, many countries and regions have adopted policies aimed at reducing the negative impact of economic growth on air quality. Investments in clean technologies, the use of renewable energy, the use of environmentally friendly vehicles, and industrial emission control measures have helped mitigate air pollution caused by economic activities.

Gross Regional Domestic Product (GRDP) has a positive and insignificant relationship with per capita expenditure, it means that in general, when GRDP increases, per capita expenditure tends to increase as well, but this relationship is not strong enough to be declared as a statistically significant relationship. Conceptually, a positive relationship between GRDP and per capita expenditure makes sense. GRDP is a measure of the total economic value generated by a region, while per capita expenditure measures the average individual expenditure in that region. If GRDP increases, it can be assumed that there is economic growth that encourages an increase in people's income. Therefore, per capita expenditure is also likely to increase as people have more resources to spend.

The relationship between the Human Development Index (HDI) and Total Invest (TI), Total Load (TL), Home Charging EV (HCEV), Distance to The Capital (DC), Air Quality (AQ), and Per Capita Spending (PCS).

The Human Development Index (HDI) has a negative and insignificant relationship with total investment in solar energy. in general, there is no strong or significant relationship between a country's level of human development (as measured by the HDI) and the total amount of investment made in solar energy. Conceptually, one might expect that countries with higher levels of human development would tend to invest more resources in clean energy sources such as solar energy. This is because countries with high HDI often have better levels of environmental awareness and policies that promote sustainable energy use. However, if the relationship is not statistically significant, it means that there is no clear and consistent correlation between HDI and total investment in solar energy in the data analyzed. Statistically insignificant means that there is not enough evidence to support the hypothesis that there is a significant relationship between HDI and total investment in solar energy. Other factors may influence investment decisions in solar energy, such as economic, political, legal and national energy policy aspects. In addition, geographical differences and natural resources can also play a role in determining the level of investment in solar energy (Johnson, M., & Lee, C., 2019).

The Human Development Index (HDI) has a positive and significant relationship with the Total electricity load of a country or region, it means that there is a strong and significant correlation between the level of human development of a country (measured by HDI) and the total amount of electricity consumption consumed in the country or region the. Conceptually, the positive relationship between HDI and total electric load can be explained by several factors. Countries or regions with higher HDI tend to have higher levels of industrialization, urbanization, and quality of life. This is usually accompanied by a greater need for a sufficient supply of electricity to meet household, commercial and industrial needs. More facilities such as hospitals, schools, offices and factories need a stable and reliable supply of electricity. In addition, higher human development also often means better access to technology and household appliances that require electrical power. For example, the use of electronic equipment, communications, heating/air conditioning systems, and other household appliances can increase with increased human development. This contributes to an increase in the total electricity load within the country or region. The significant correlation between HDI and total electricity load indicates that there is a clear relationship between the level of human development and the consumption of electrical energy within the country or region. However, it is important to consider that energy consumption patterns may vary depending on local factors, such as available energy resources, energy policies, and environmental sustainability. In the context of sustainability, efforts to increase energy efficiency and switch to renewable energy sources are important. By adopting energy-efficient technologies and utilizing environmentally friendly energy sources, countries or regions can achieve sustainable human development growth while minimizing negative impacts on the environment.

The Human Development Index (HDI) has a positive and significant relationship with Home charging EV (electric car charging at home), it means that there is a strong and significant correlation between a country's level of human development (measured by HDI) and the adoption rate of electric car charging at home by residents of the country. Conceptually, the positive relationship between HDI and Home charging EV can be explained by several factors. Countries with a higher HDI tend to have a higher level of environmental awareness, better infrastructure, higher per capita income, and policies that encourage the use of environmentally friendly vehicles. Higher levels of human development can result in better access to technology and economic resources that allow residents to buy and charge electric cars at home. In addition, countries with high HDI often have better and more extensive charging infrastructure, facilitating the use of electric cars as a more sustainable alternative to transportation. The significant correlation between HDI and Home charging EV indicates that a higher level of human development plays an important role in increasing the adoption and use of electric cars at the household level. With increasing environmental awareness and the accessibility of adequate charging infrastructure, residents of these countries are more likely to use electric cars and charge them at home.

The Human Development Index (HDI) has a negative and insignificant relationship with Distance to the capital city, it means that in general, there is no strong or significant relationship between a country's level of human development (measured by HDI) and the geographical distance of a region or country to the capital. Conceptually, the expected relationship between HDI and distance to the capital can vary depending on various factors. Basically, a shorter distance between a region and the capital can have several potential advantages, such as better access to public facilities, government services, employment, education, health and economic opportunities. Therefore, in some cases, areas close to the capital may experience better human development. However, keep in mind that not all countries or regions have the same geographic structure, and other factors can affect human development besides distance to capital cities. For example, in a country with a large territory or significant geographic diversity, factors such as infrastructure, accessibility, natural resources, politics, and government policies can play a role in the level of human development in a region. Statistically insignificant means that there is not enough evidence to support the hypothesis that there is a significant relationship between HDI and distance to the capital city. Other factors that are more dominant or complex can play a more important role in determining the level of human development of a country. Therefore, even though distance to the capital might affect human development in some contexts, there is no clear and statistically significant relationship between HDI and distance to the capital.

The Human Development Index (HDI) has a positive and insignificant relationship with air quality, which means that in general, there is no strong or statistically significant relationship between a country's level of human development (measured by HDI) and air quality within that country. Conceptually, one might expect that countries with higher HDI have better environmental policies, higher environmental awareness, and better access to technologies and resources that support air pollution reduction. In addition, higher human development is often associated with economic diversification, stricter environmental protection policies, and investment in environmentally friendly infrastructure, which can have an impact on improving air quality. However, statistically insignificant means that in the data analysis performed, there is not enough evidence to support a significant relationship between HDI and air quality. Other factors, such as ineffective environmental policies, rapid population growth, unsustainable industrialization, and the sustainability of natural resources, can also affect air quality within a country or region. It should be remembered that air quality is affected by many factors, including motor vehicle emissions, industry, burning of fossil fuels, environmental policies, and area topography. Therefore, the relationship between HDI and air quality can be very complex and varies depending on the geographic, social, and economic context of each country. While there is the potential for countries with higher levels of human development to have better air quality, the non-significance of this relationship indicates that the level of human development alone cannot be considered a direct indicator or a strong predictor of a country's air quality. Sustained and cross-sectoral efforts are needed to reduce air pollution and improve air quality, including effective environmental policies, clean technology, and public awareness of the importance of a healthy environment.

The Human Development Index (HDI) has a positive and significant relationship with per capita expenditure, meaning that there is a strong and significant correlation between the level of human development of a country (measured by HDI) and the average amount of expenditure made by the population of that country. Conceptually, the positive relationship between HDI and per capita expenditure can be understood by several factors. Countries with higher levels of human development tend to have better access to education, health, productive employment and economic opportunities. This can increase the per capita income and purchasing power of the country's population, thereby increasing individual and household spending. Higher human development also often means better access to adequate infrastructure, public services, and consumption facilities, which can drive increases in per capita spending. For example, better access to quality education can improve individual skills and job opportunities, while a good health care system can reduce the risk of large unforeseen health expenditures. The significant correlation between HDI and per capita expenditure indicates that a higher level of human development plays an important role in increasing the level of per capita expenditure within a country. However, it is important to remember that per capita spending is only an economic indicator and does not yet reflect the gap in income distribution within a country. What's more, factors such as inflation, prices for goods and services, unemployment rates, and government policies can also affect per capita spending and the overall economic condition of a country. In the context of sustainability, it is important to ensure that increases in per capita spending are also matched by inclusive and sustainable growth, as well as spending wisely in promoting social welfare, environmental protection and equitable development for all of society.

Relationship between Total Invest (TI) and Total Load (TL), Home Charging EV (HCEV), Distance to The Capital (DC), Air Quality (AQ), and Per Capita Spending (PCS)

The total investment in solar energy has a positive and insignificant relationship with the total electricity load of a country or region, it means that in general, there is no strong or statistically significant relationship between the total amount of investment made in solar energy and the total amount of electricity consumed. consumed in that country or region. Conceptually, one could expect that the higher the total investment in solar energy, the greater the contribution of solar energy to the total electricity supply of the country or region. Investments in solar energy typically include the development of solar power plants, solar panels, solar charging infrastructure and other related technologies. In some cases, countries or regions that have allocated significant investments in solar energy may experience increased solar energy production and a greater contribution of solar energy to the total electricity load. However, statistically insignificant indicates that in the data analysis performed, there is not enough evidence to support a significant relationship between Total investment in solar energy and Total electricity load. Other factors, such as the contribution of energy from other sources, industrial structure, energy policies, and overall energy consumption, can also affect the total electricity load of a country or region (Zhang, Y., & Trømborg, E., 2019) .

Total investment in solar energy has a positive and not significant relationship with Home charging EV, it means that in general, there is no strong or statistically significant relationship between the total amount of investment made in solar energy and the level of use of EV home charging within a country or region. Conceptually, one could expect that the higher the total investment in solar energy, the more solar energy available for use as a power source for charging EVs at home. Investments in solar energy can lead to more solar power generation, solar charging infrastructure and other related technologies that can support the wider and more sustainable use of home-charging EVs. However, statistically insignificant indicates that in the data analysis performed, there is not enough evidence to support a significant relationship between total investment in solar energy and use of EV home charging. Other factors, such as the accessibility of public charging infrastructure, price and availability of electric vehicles, government policies on incentives and subsidies, and consumer preferences, can also affect the level of use of home charging EVs within a country or region.

Total investment in solar energy has a negative and insignificant relationship with Distance to the capital city, that means in general, there is no strong or statistically significant relationship between the total amount of investment made in solar energy and the distance from a location to the national capital or region. Conceptually, there is no direct reason why investing in solar energy should have a negative relationship with distance to capital cities. Investment in solar energy focuses on developing renewable energy sources that can be used in various locations, both near and far from the capital city. In addition, solar energy can be used in a decentralized manner, which means it can be applied in different areas without relying too much on physical distance to the capital city. However, if the data shows a negative and insignificant relationship between Total investment in solar energy and Distance to the capital in the statistical analysis, it can indicate that there is no strong effect of physical distance to the capital on investment in solar energy. Other factors, such as government policies, existing energy infrastructure, varying solar potential in different regions, and local economic interests, may be more influential in determining the amount of investment in solar energy than the distance to a capital city. It is important to remember that investing in solar energy can be made in a variety of locations, including near capital cities as well as in more remote areas. Factors such as land availability, government incentives, access to the electricity grid, and demand for solar energy in a given area, can be more dominant in determining investment in solar energy than physical distance to a capital city.

Total investment in solar energy has a positive and insignificant relationship with air quality, it means that in general there is a tendency that the higher the total investment in solar energy, the better the air quality in a region or country. However, this relationship was not considered statistically significant, which means that the effect of investment in solar energy on air quality cannot be reliably measured based on the data analysis performed.

Conceptually, investing in solar energy can provide benefits for air quality because solar energy is a clean, renewable energy source that does not emit greenhouse gases and other air pollutants when it is operational. In the long term, the use of solar energy can reduce dependence on fossil energy sources that are more polluting and contribute to air pollution, such as burning coal or petroleum. However, statistically insignificant indicates that in the data analysis performed, there is not enough evidence to support a significant relationship between total investment in solar energy and air quality. Other factors, such as energy consumption patterns, industrial activity, transportation, and environmental policies, can also affect air quality in an area. It is important to remember that air quality is affected by many complex factors, including industrial pollution, motor vehicle emissions, weather patterns and geography. Investment in solar energy can be one of the factors contributing to improving air quality by reducing direct emissions from the energy sector. However, the effect may not be immediately significant in the short term or in the statistical analysis performed.

The total investment in solar energy has a positive and insignificant relationship with per capita expenditure, which means that in general there is a tendency that the higher the total investment in solar energy, the higher the per capita expenditure in a country or region. However, this relationship was not considered to be statistically significant, which means that the effect of investment in solar energy on per capita expenditure cannot be reliably measured based on the data analysis performed. Conceptually, investing in solar energy can have a positive impact on the economy of a country or region. These investments can create job opportunities, promote the growth of the renewable energy industry, and reduce dependence on fossil energy sources which may be more expensive. In the long term, greater use of solar energy could help reduce overall energy costs, which could result in higher per capita spending levels. However, statistically insignificant indicates that in the data analysis performed, there is not enough evidence to support a significant relationship between total investment in solar energy and per capita expenditure. Other factors, such as economic structure, income inequality, government policies, and other variables that affect per capita spending, can also play a role in determining a country or region's level of per capita spending. It is important to remember that investment in solar energy is not the only determining factor in per capita spending. Other factors, such as economic productivity, income levels, levels of socio-economic inequality, and government policies that support human development, also contribute to the level of spending per capita within a country or region.

Relationship of Total Load (TL) with Home Charging EV (HCEV), Distance to The Capital (DC), Air Quality (AQ), and Per Capita Spending (PCS)

The total electric load of a country or region has a positive and not significant relationship with Home charging EV (charging electric vehicles at home), which means that in general there is a tendency that the higher the total electric load of a country or region, the higher the level of use of home charging. EV. However, this relationship is not considered statistically significant, which means that the effect of the total electric load on the use of EV home charging cannot be measured strongly based on the data analysis performed. Conceptually, if the total electricity load of a country or region increases, it can be assumed that there are more sources of electrical power available, including for charging electric vehicles at home. The higher the electrical load, the more extensive the electrical infrastructure and grid will develop, which can facilitate wider use of home-charging EVs. However, statistically insignificant indicates that in the data analysis conducted, there is not enough evidence to support a significant relationship between the total electricity load of a country or region and the use of EV home charging. Other factors, such as the accessibility of public charging infrastructure, price and availability of electric vehicles, consumer preferences, and government policies regarding incentives and subsidies, can also affect the level of use of home charging EVs within a country or region. It is important to remember that the use of EV home charging is influenced by a variety of factors, including the availability of charging infrastructure, the convenience and reliability of home charging, the price of electric vehicles, the distance traveled daily, and individual preferences. The total electrical load of a country or region is only one factor in the wider ecosystem influencing the adoption and use of EV home charging. In an effort to promote the adoption of home EV charging and the transition to sustainable transportation, it is important to combine the development of a broad public charging infrastructure with the development of an efficient home charging infrastructure. Government policies, the right incentives, and educating consumers about the benefits and ease of charging EVs also need attention. Thus, it can create an ecosystem that supports the growing use of EV home charging and optimizes the use of more sustainable electricity in the transportation sector.

The total electricity load of a country or region has a negative and significant relationship with distance to the capital city, which means that there is a statistically strong tendency that the farther the distance of a region from the capital city, the lower the total electricity load experienced by the region. This concept can be explained by several factors. First, capital cities are often centers of economic activity, business and dense population. Regions closer to capital cities tend to have higher levels of demand for electricity due to more residents, a growing industrial sector, and greater overall energy demand. In this case, the total electricity load of a country or region will tend to be higher in areas that are closer to the capital city. However, when the distance of an area from the capital city is getting farther, there are several factors that can cause the total electricity load to be lower. First, areas that are more remote or rural may have smaller populations and more limited economic activity than areas that are closer to the capital city. This can result in lower overall electricity demand. In addition, areas farther away from the capital city may have less developed electricity infrastructure. Power transmission and distribution systems tend to be more complex and expensive to implement in more remote areas. Limited electricity infrastructure can limit the capacity to deliver electricity to the area, resulting in a lower total electricity load. However, it is important to note that while this relationship is statistically identifiable, it is not that distance itself is a direct causal factor in the total electrical load. There are many other variables that also contribute to the total electricity load, such as population density, economic activity, energy policy, and available energy resources.

If it is said that the total electricity load of a country or region has a positive and insignificant relationship with air quality, it means that in general there is a tendency that the higher the total electricity load of a country or region, the worse the air quality tends to be. However, this relationship is not considered statistically significant, which means that the effect of the total electrical load on air quality cannot be measured reliably based on the data analysis performed. Conceptually, the total electricity load of a country or region can provide an overview of the level of energy consumption and industrial activities that use energy resources. The higher the total electrical load, the more energy is consumed and the more likely there are activities that produce air pollutant emissions. For example, power plants that use fossil fuels such as coal or oil can produce air pollutants such as sulfur dioxide (SO2), nitrogen dioxide (NO2), and fine particulate matter that can damage air quality. However, statistically insignificant indicates that in the data analysis conducted, there is not enough evidence to support a significant relationship between the total electricity load of a country or region and air quality. Other factors, such as environmental policies, types of energy sources used, energy efficiency, and emission control, can also affect air quality independently.

The total electricity load of a country or region has a positive and significant relationship with per capita expenditure, which means that in general there is a statistically strong tendency that the higher the total electricity load of a country or region, the higher the per capita expenditure in that region. This concept can be explained by several factors. First, the total electricity load of a country or region often reflects the level of economic and industrial activity. The higher the level of economic and industrial activity, the greater the need for electrical energy. In this case, countries or regions with a high total electricity load generally show a high level of energy use, which can mean strong economic activity and high levels of production. This is often related to higher per capita spending levels due to strong economic growth and higher income levels. In addition, the total electricity load can also reflect the level of household energy consumption and the level of wide availability of electricity services in society. If a country or region has broad and reliable access to electricity, it can create conditions that support economic growth and higher per capita spending levels.

Relationship between Home Charging EV (HCEV) with Distance to The Capital (DC), Air Quality (AQ), and Per Capita Spending (PCS)

Home charging EV has a negative and insignificant relationship with distance to the capital city, which means that in general there is no statistically strong relationship between the ability to charge electric vehicles at home (Home charging EV) and the distance between a location and the capital city. In this context, Home charging EV refers to the ability of electric vehicle owners to charge their electric cars at home using a home-mounted charging station. Distance to the capital city refers to the physical distance between a location or region and the center of government of that country or region. While there can be an argument that easy and convenient access to home charging can influence EV adoption in a region, there is no strong evidence to indicate a significant relationship between home EV charging and distance to capital cities. Other factors that may further influence Home charging EV adoption include the availability of public charging infrastructure, EV support policies, the price of EVs, and public awareness of the environmental benefits of EVs. In addition, individual preferences and habits of vehicle users can also play an important role in the choice of electric vehicles and the use of charging facilities at home. In an effort to drive wider adoption of electric vehicles and expand charging infrastructure, it is important to consider user needs and adapt effective charging station deployment strategies. This could involve expanding the public charging network in urban and rural areas, introducing smart charging solutions, and ensuring the availability of practical and accessible home charging facilities for electric vehicle owners (Husna, SS, Fadli, M., & Hajar, D., 2018).

Home charging EV has a positive and insignificant relationship with air quality, which means that in general there is no statistically strong relationship between the use of charging electric vehicles at home (Home charging EV) and air quality. The concept of Home charging EV refers to the ability of electric vehicle owners to charge their vehicles at home using a home-mounted charging station. Electric vehicles are considered a more environmentally friendly option because they produce no direct emissions while operating. In theory, wider use of electric vehicles and adoption of Home charging EVs could help reduce air pollution by reducing exhaust emissions from conventional vehicles that run on fossil fuels. In this case, it can be assumed that Home charging EV has a positive relationship with air quality, indicating that the more use of Home charging EV, the better the air quality in an area. However, it was also stated that the relationship was not statistically significant. This means that the data analysis carried out does not show a strong and reliable relationship between Home charging EV and air quality. This may be caused by many other factors that can affect air quality, such as industrial pollution, public transportation pollution, geographical conditions, and environmental policies. It is important to note that to really significantly impact air quality, the use of electric vehicles must be balanced with clean, renewable energy sources to generate the electricity used to charge those vehicles. If the energy resources used to generate electricity come from power plants that use fossil fuels, the environmental benefits of electric vehicles can be limited. In order to improve overall air quality, it is important to consider holistic strategies, such as strengthening renewable energy policies, reducing industrial emissions, promoting sustainable transportation, and increasing public awareness of the benefits of using electric vehicles. Only with a comprehensive approach can we achieve significant improvements in air quality and protect our environment.

Home charging EV has a positive and not significant relationship with per capita spending, which means that in general there is a positive trend that is not statistically significant between the ability to charge electric vehicles at home (Home charging EV) and per capita spending levels. The concept of Home charging EV refers to the ability of electric vehicle owners to charge their electric cars at home using a home-mounted charging station. Per capita expenditure refers to the average amount of money spent by individuals within a country or region. In theory, it can be assumed that higher per capita spending reflects a greater level of income and stronger purchasing power. Therefore, individuals with higher per capita spending may have more resources to purchase electric vehicles and install charging stations in their homes, including Home charging EVs. However, it was also stated that the relationship was not statistically significant. This means that the data analysis carried out does not show a strong and reliable relationship between Home charging EV and spending per capita. Several other factors can also affect the adoption of Home charging EV, such as the price of electric vehicles, available charging infrastructure, government policy support, and public awareness about the environmental benefits of electric vehicles. Therefore, per capita spending may not be a major factor in an individual's decision to use a Home charging EV.

Relationship between Distance to The Capital (DC), Air Quality (AQ), and Per Capita Spending (PCS)

Distance to the capital city has a negative and insignificant relationship with air quality, which means that in general there is no statistically strong relationship between the physical distance between a location or region and the capital city and air quality. Distance to the capital city refers to the physical distance between a location or region and the center of government of that country or region. Air quality refers to the level of air pollution, which is influenced by various factors such as industrial pollution, transportation pollution, burning of fossil fuels and other environmental factors. In theory, it could be assumed that a greater distance from the capital city would reduce air pollution levels. Capital cities often have high population densities, heavy traffic and intense industrial activity, which can contribute to air pollution. Therefore, a longer distance from the capital can reduce exposure to this pollution. However, it was also stated that the relationship was not statistically significant. This means that the data analysis conducted does not show a strong and reliable relationship between distance to the capital city and air quality. This may be caused by many other factors that can affect air quality, such as airflow patterns, industrial locations, environmental policies, and weather factors (Mutaqin, DJ, Muslim, MB, & Rahayu, NH, 2021).

Distance to the capital city has a negative and significant relationship with per capita expenditure, meaning that statistically there is a strong relationship between the physical distance between a location or region and the capital city and the level of per capita expenditure. Distance to the capital city refers to the physical distance between a location or region and the center of government of that country or region. Per capita spending, on the other hand, reflects the average amount of money spent by individuals within a country or region. In general, it can be assumed that a closer distance to the capital city will provide better access to the resources, employment opportunities, services and infrastructure available in the center of government. This can contribute to an increase in per capita spending, as individuals in areas closer to the capital tend to have better access to quality employment, higher incomes and consumption facilities. However, in the context of a negative relationship, if it is said that the distance to the capital city has a negative relationship with per capita expenditure, then it can be interpreted that the farther the distance between a location or region from the capital city, the lower the per capita expenditure level in that region. This could be because areas farther away from the capital city may have limited access to economic resources, limited job opportunities, and underdeveloped infrastructure, which can result in lower per capita spending overall.

Relationship between Air Quality (AQ) and Per Capita Spending (PCS)

Air quality has a positive and insignificant relationship with per capita expenditure, which means that in general there is a positive trend, but not statistically significant, between the level of air quality and the level of expenditure per capita. Air quality refers to the level of air pollution and air cleanliness in an area. This is influenced by various factors such as industrial pollution, transportation pollution, burning of fossil fuels, and other environmental factors. Per capita spending levels, on the other hand, reflect the average amount of money spent by individuals within a country or region. In theory, it can be assumed that higher per capita spending reflects a greater level of income and stronger purchasing power. Individuals with higher per capita expenditures may tend to live in areas with better air quality. They may have better access to pollution control facilities, cleaner technology, and stricter environmental policies, which can all lead to better air quality. However, it was also stated that the relationship was not statistically significant. This means that the data analysis performed does not show a strong and reliable relationship between air quality and per capita expenditure. Other factors such as environmental policies, level of industrialization, patterns of energy use, and public awareness of environmental protection can also affect air quality in an area, regardless of the level of per capita expenditure. It is important to remember that air pollution is a complex environmental problem with many interrelated factors. Decreasing air quality requires collective efforts, including controlling pollutant emissions from sources such as industry and transportation, using cleaner energy, and stricter environmental policies. In addition, public awareness and active participation in reducing air pollution is also an important factor in improving air quality. Although per capita spending may have a limited effect on air quality directly, improvements in air quality can be achieved through cooperation between the government, the industrial sector, and society in implementing sustainable policies and actions to reduce air pollution and maintain a clean environment.

V. CONCLUSIONS AND SUGGESTIONS

There are different nature of the relationship between the use of solar panels and socio-economic variables. Research on the relationship between global solar panel use and factors such as the number of prosumers, total kwh exports, GRDP, total investment, total load, home charging ev, distance to the capital city, air quality, and per capita expenditure has very important uses for stakeholders, especially in terms of sustainable energy development and reducing negative impacts on the environment. Policymakers can use the results of this research to formulate more appropriate policies to promote the use of solar energy and drive the shift to renewable energy sources.

The development of prosumer and renewable energy needs to be supported through broader policies and incentives. Governments should encourage prosumer participation by providing fiscal incentives, such as tax cuts or subsidies, for the installation of solar panels or other renewable energy systems. In addition, there needs to be cooperation between the government, financial institutions, and the renewable energy industry to increase access to affordable financing and financing for individuals or households who wish to become prosumers. By encouraging growth in the number of prosumers, countries or regions can achieve sustainable development goals, such as reducing greenhouse gas emissions, sustainable economic growth, and improving the quality of life for society as a whole.

VI. RESEARCH USABLITY

Research on the relationship between global solar panel use and factors such as the number of prosumers, total kwh exports, GRDP, total investment, total load, home charging ev, distance to the capital city, air quality, and per capita expenditure has very important uses for stakeholders, especially in terms of sustainable energy development and reducing negative impacts on the environment. Policymakers can use the results of this research to formulate more appropriate policies to promote the use of solar energy and drive the shift to renewable energy sources. In this context, policymakers can consider the factors that influence solar energy adoption, such as the number of prosumers, total kwh exports, GRDP, total investment, total load, home charging ev, distance to the capital city, air quality, and per capita spending.

The energy industry can use the results of this research to develop business strategies that are more effective in optimizing the use of solar energy and meeting growing market demands. This research can also help the energy industry to identify potential markets for solar energy and forecast future demand. Communities can take advantage of the results of this research to understand the benefits of using solar energy and consider using solar panels in their homes. This research can help people understand the factors that influence the decision to use solar energy, such as distance to the capital city, air quality, and per capita spending. Thus, research on the relationship between global solar panel use and factors such as the number of prosumers, total kwh exports, GRDP, total investment, total load, home charging ev, distance to the capital city, air quality, and per capita expenditure is very important for stakeholders and can have a positive impact on sustainable energy development and reduce negative impacts on the environment.

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