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Thesis title: Performance analysis of residential solar photovoltaic policies: A case study of Jakarta, Indonesia

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Summary

Jakarta is Indonesia's capital city and highest populated area, making it the largest electricity consumer in the country (Indonesian Ministry of National Development Planning, 2019). While Indonesia's solar energy is estimated at approximately 207.9 GW, only 16.6 MW were produced from residential rooftop solar PV. Out of that portion, the Greater Jakarta area accounts to 0.06 MW, although the residential market takes up to 42% of national electricity sales, making it the highest market segment in energy consumerism in Indonesia (PLN, 2019; IESR, 2019; MEMR, 2019).

In 2014, the Indonesian government adopted Government Regulation No. 79/2014 on National Energy Policy, addressing the imperativeness to reduce reliance on non-renewable energy and increase renewable energy share by 29% in 2030. Further, the government issued MEMR Regulation No. 49/2018, which regulates affairs related to rooftop solar PV. Accordingly, the government also set solar energy targets of additional 1.045,06 MW and solar PV users by 522.532 households in Jakarta by 2028. However, despite Indonesia's ambitious goals, residential solar energy development has not yet reached its maximum potential.

The combination of unsubstantial policy and general scepticism towards solar energy prevent the development of residential solar PV. For that reason, calculation on technical potential of residential solar PV power in Jakarta, scenario analysis on the performance of residential solar PV growth towards governmental targets, as well as market potential analysis on residential solar PV market in Jakarta is vital to analyse whether current residential solar PV policies has been successful in harnessing potential residential solar PV power in Jakarta. This research combines secondary data collection through desk research, and complementary primary data collection through questionnaire surveys. The obtained data are then analysed using constant-value method, forecasting tools, as well as descriptive analysis on Excel and SPSS.

This research found that existing residential solar PV policies are inadequate in harnessing potential residential solar PV in Jakarta as seen in the gap between current installed capacity compared to technical potential of residential solar PV capacity. Moreover, forecasts indicate that future trajectory of residential solar PV growth will be able to achieve one out of two governmental targets, indicating that current solar PV policies are suboptimal. Nevertheless, the study also identified a potential increase in market potential by 27% if policy changes such as providing incentives for residential solar PV users and increasing the spread of information on solar PV through mass media are conducted.

Keywords

Performance Analysis, Policy Analysis, Solar Photovoltaic, Residential, Jakarta

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Foreword

This thesis is written as a prerequisite for Institute for Housing and Urban Development Studies (IHS) at Erasmus University Rotterdam to obtain a MSc degree in Urban Management and Development. This study analyses the performance of residential solar photovoltaic policies, with a case study in Jakarta, Indonesia.

The research promotes the urgency of residential solar PV development in Jakarta, considering the potential scale of contribution of the solar PV residential market compared to the reality of current installed solar PV capacity. Calculation towards the technical potential residential solar PV in Jakarta and a scenario analysis on the performance of existing policy against residential solar PV growth to the governmental targets will be conducted to assess the adequacy of current existing policies. Furthermore, further investigation will be done to examine the market potential of residential solar PV in order to gain insights for future solar PV policy recommendations.

Abbreviations

ASEAN	Association of Southeast Asian Nations
BPPT	Indonesian Agency for Assessment and Application of Technology
BPS	Indonesian National Statistics Bureau
ESMAP	Energy Sector Management Assistance Program
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GSSRN	Million Solar Roof National Movement
GW	Gigawatt
GWp	Gigawatt Power
IHS	Institute for Housing and Urban Development Studies
KEN	National Energy Policy
kW	Kilowatt
kWh	Kilowatt Hour
kWh/m^2	Kilowatt Hour per Meter Square
$kWh/m^2/day$	Kilowatt Hour per Meter Square per day
kWh/year	Kilowatt Hour per Year
kWp	Kilowatt Power
m^2	Meter Square
MEMR	Indonesian Ministry of Energy and Mineral Resources
MW	Megawatt
$MWh/m^2/year$	Megawatt per Meter Square per Year
MWp	Megawatt Power
NDC	National Determined Contribution
NRE	New Renewable Energy

PLN	Indonesian State Power Company
PSH	Peak Sun Hour
PV	Photovoltaic
RE	Renewable Energy
Renstra	Strategic Plan
RUEN	National Energy General Plan
RUKN	National Electricity Business Plan
RUPTL	Electricity Supply Business Plan
SDG	Sustainable Development Goals
VA	Voltage Ampere
VRE	Variable Renewable Energy
W/m^2	Watt per Meter Square
Wp	Watt Power

Table of Contents

List of Figures

List of Graphs

List of Tables

List of Equations

Chapter 1: Introduction

1.1. Background Information and Problem Statement

1.1.1. Current State of Affairs

Current limited energy sources, such as coal and oil, are estimated to eventually run out and be exhausted in the near future (Bilan et al., 2019). Increased traditional energy consumption and demand accelerates climate change by endangering the environment, which reflects on the halting of economic progress and development of human life, where two-thirds of greenhouse gas (GHG) emissions across the world stems from energy consumption (IEA and IRENA, 2017; Ahmed and Shimada, 2019; Owusu and Asumadu-Sarkodie, 2016). The combustion of fossil fuel is one of the major emitters of greenhouse gases, with the energy sector at the heart of the effort in the fight against climate change. Hence, governments globally attempt to replace conventional energy sources with renewable energy, with prospects to reduce CO_2 emissions and create economic and social opportunities (Jaramillo-Nieves and Rio, 2010).

Indonesia will consistently continue to produce majority of its energy through its depleting stock of coal and gas, unless new reserves are discovered (Handayani et al., 2017). The country's Ministry of Energy and Mineral Resources (MEMR) estimates that domestic demand for energy will increase by approximately 7% annually (Asian Development Bank, 2015). Subsequently, reflecting on the global trend, total share of GHG emissions in Indonesia are mostly contributed by CO_2 emissions from the energy sector, driven by increasing demand of power generation especially for households, industries as well as transport (Climate Transparency, 2018). Moreover, Indonesia's energy use is the highest among Southeast Asian countries, accounting for roughly 40% of overall energy consumption in the area. By 2030, it is estimated that energy consumption will triple in demand (IRENA, 2017).

As such, Indonesia declared to increase investment in renewable energy in accordance to their Sustainable Development Goals (SDG) through their Nationally Determined Contribution (NDC) targets, which was to reduce 29 percent of GHG emissions unconditionally by 2030 (Indonesian Ministry of National Development Planning, 2019; IRENA, 2017). The NDCs revolve mainly in increasing the share of renewable energy (RE) both through subsequent mitigation and adaptation measures. In 2014, the government issued Government Regulation No. 79/2014 concerning National Energy Policy where it addresses the need to reduce dependency of the depleting fossil fuels by diversifying energy share mix and increasing renewable energy use to 23% by 2025 and 29% by 2030 (IRENA, 2017; IESR 2019).

In spite of the political instability and uprising that Indonesia has faced in the past, the rate of urbanized population in the country has reached 55% in 2013, noting a remarkable rise from merely 22.3% in 1980 (Wilonoyudho et al., 2017). By 2035, it has been projected that the number will continue to increase to 66.6% with an average annum rate of 0.62% for the 2030-2035 period (Agung et al., 2017). It was also estimated that since 1990, 100% of Jakarta's population has become urbanized with no remaining rural areas (Jones and Mulyana, 2015). Being the capital city of Indonesia, Jakarta is Southeast Asia's largest metropolitan city with their real Gross Domestic Product (GDP) nearly quadrupling from 1990 to 2018 (Rukmana, 2017; Indonesian Ministry of National Development Planning, 2019). The rise in economic growth resulted in a population boom by 100-fold from 100.000 to 9 million from 1900 to 1995 (Cities Foundation, 2012). The increase in urban population is directly proportional to development of energy needs as a result of changes in society's energy consumption patterns due to the high demand and mobility in the area (Agung et al., 2017). This was apparent where throughout the sectors, Indonesia's residential market had the highest electricity sales by 41,77% of the national energy share (PLN, 2019). Thus, the race to accommodate the rapidly rising energy demand in Indonesia begun.

1.1.2. Variable Renewable Energy

Historically, power systems have been developed to distribute production of electricity whenever the customer's load requires it. The most important energy sources for dispatchable production are energy generation from coal, nuclear, hydropower, diesel and natural gas plants (Mills, 2011; Kroposki, 2017). These sources can store primary energy source on site, generating electricity to immediately be transmitted from far-built central power plants to meet consumer demand (Kroposki, 2017).

However, competition became more intense with the emergence of renewable energy (RE) sources (Mills, 2011). Several of these energy sources, are considered as Variable Renewable Energy (VRE). Unlike traditional energy sources, VREs, such as wind and solar, are reliant on existing weather conditions, which consequently may only produce electricity in an intermittent pattern (Mills, 2011; Ambec and Crampes, 2010). In addition, these type of renewable energy do not typically have an on-site energy storage system, which makes their performance generally described as non-dispatchable (Kroposki, 2017).

The presence of additional wind and solar energy to electricity grids led to increasing frequency of commissioning and decommissioning of dispatchable power plants to adapt to the changes in power production due to variable energy generation (Bird et al., 2013). The fluctuations that VRE resources add to grid systems associated with their uncertainty makes integrating renewable energy sources in the energy mix difficult (Kroposki, 2017). Therefore, the required counter-measures to balance capacities and costs associated with integrating VREs to the grid entails further assessment and advisory for policy makers (Gils et al., 2017).

1.1.3. Solar Energy in Indonesia and Jakarta

In terms of solar energy, photovoltaic (PV) cells are dependent on the peak sun hour (PSH) at the time of day, where in Indonesia it generally amounts to ± 4 hours (Ambec and Crampes, 2010; IESR, 2019). It is also important to note that while seasonal duration for solar energy can be predicted, solar intensity can only be predicted a few days in advance to a certain extent of uncertainty. This uncertainty of solar VRE uptake consequently causes doubts in potential residential solar PV investors (Ambec and Crampes, 2010). Consumer's preference for reliability in energy to accommodate demand at any time and location on the grid is perceived as essential considering that electricity blackouts are costly. Therefore, the unpredictability of solar energy being an intermittent source of energy conflict with the reliability aspect due to the challenges of the grid stability when a large share of VRE are integrated into the system (Ambec and Crampes, 2010; Kroposki, 2017).

In 2010, GHG emissions in Jakarta was estimated to reach up to 40 million tonnes CO_2-eq, which were mostly attributed to the rapidly increasing demand in energy (Indonesian Ministry of National Development Planning, 2014). Java-Bali alone accounts for 70% of power demand in Indonesia, where merely 15% are produced by renewable energy sources nationally (Indonesian Ministry of National Development Planning, 2014). Compared to other Southeast Asian countries, Indonesia just lags behind Philippines with 25.64% RE generation share (Santos, 2016), and ahead of Thailand and Malaysia with 13% and 2% respectively (Abdullah, 2019; IRENA, 2017).

Table 1. Potential Renewable Energy Production

Renewable Energy Source	Potential Energy
Hydropower	96.079 MW
Geothermal	29.545 MW
Wind	60.647 MW
Bioenergy	32.654 MW
Solar	532.6 GW ~ 532.600 MW

Source: MEMR, 2019

Indonesia itself is a tropical country with very high solar energy potential with an average daily insulation of 4.5 - 4.8 KWh/m²/day (Rahayuningtyas et al., 2014). With massive untapped solar energy opportunity, Indonesia's potential generated electricity per year reaches up to 1.534 MWh/year per installed kWp solar panel (IESR, 2019). Solar energy in Indonesia could potentially contribute up to 532.6 GW (see Table 1), with 207.9 GW generated from solar PV specifically (MEMR, 2019; IRENA, 2017). Moreover, though Indonesia's potential PV generation is especially high, in implementation, by November 2019 only 152 MW solar energy power was installed, where only 11% or 16.6 MW were produced from residential rooftop solar PV (IESR, 2019). Furthermore, MEMR (2019) reported that the Greater Jakarta residential solar PV market could potentially contribute approximately 30 MW, whereas current installations only amounts to 0.06 MW.

1.2. Research Objectives

Given Indonesia's ambitious goals, it is apparent that the development of solar energy has yet to reach its maximum potential. The combination of unsubstantial policy framework along with public scepticism towards solar energy hinders the potential development of residential solar PV. Therefore, the main objective of this study is to analyse the performance of current residential solar PV policies in Jakarta by:

- Identifying technical potential of residential solar PV power in Jakarta
- Assess current RE plans on residential solar energy to meet governmental goals
- Identifying market potential of residential solar PV power in Jakarta

1.3. Research Questions

Main research question: Are current residential solar PV policies successful in harnessing potential residential solar PV power in Jakarta?

Sub-questions:

- What is the maximum technical potential of residential solar PV power in Jakarta?
- Are current policies and programs/plans on track and aligned with governmental residential solar PV targets?
- What is the market potential of residential solar PV in Jakarta?

1.4. Relevance of Research

Through an academic perspective, this study aim at contributing to the body of knowledge revolving solar PV and solar PV investment policy measures in Jakarta. Jakarta as the study case will prove to be useful for future recommendations in regard to renewable energy investments being the nation's highest populated city and urbanized population. Through the research strategies that are employed in this research (explained in Chapter 3), the constant-value method will produce technical potential of residential solar PV in Jakarta. Furthermore, the scenario analysis will examine the adequacy of current existing policies towards achieving its governmental targets, whereas the questionnaire survey will investigate the market potential of residential solar PV in Jakarta.

As such, the findings of this study will provide insights in conducting future in-depth market research and appropriate policy recommendations in relation to the solar PV potential in Jakarta. Additionally, this study will also provide insights in the formulation of national and regional RE development plans. Furthermore, this research will help in understanding the scale of contribution of residential solar PV towards energy demand particularly in Jakarta.

Chapter 2: Literature Review

This chapter attempts to look at solar renewable energy as one of the drivers of energy transition in the coming future. Additionally, it also examines the potential of renewable energy in Indonesia, and especially residential solar PV in Jakarta. Moreover, it will look into solar energy as a variable renewable energy and the underlying solar PV policies set in place in Indonesia. Furthermore, the chapter will wrap a conceptual framework based on the relationship of the identified research indicators.

2.1. State of the Art of the Theories

2.1.1. Transition Towards Renewable Energy

Renewable energy is a common term used to describe technology that derives energy from natural and replenishable sources such as wind, rain, biomass, sun, and geothermal sources. These sustainable alternative sources of fuel are converted to usable forms of energy, making it a viable option to generate electricity and meet energy needs (Mills, 2011; Arif, 2013). Adoption of renewable energy technology generates significantly lower carbon emissions than conservative energy sources, enabling it to become the heart of energy transition towards sustainable energy consumption (Arif, 2013; IRENA 2019).

Rapid reduction of carbon emission is integral in energy transition in order to achieve the climate goals agreed in the Paris Agreement (Indonesian Ministry of National Development Planning, 2019, IRENA, 2019). The accelerating shift from the burning of depletable fossil-fuels to utilizing cleaner energy sources for electricity demonstrates that the world is undergoing rapid change. There are various factors that drive this transformation. Notably, the rapid decline in the cost of renewable energy technologies which globally has continued to decrease for all commercially available sources in the past few years. Further, with the escalating trend of renewable energy usage, consequently, demand in non-renewable energy has been declining. This ultimately contributes to reducing climate change risks and lowers externalities such as provision of subsidies for additional adverse effects of its use (UNEP, 2017; IRENA, 2019). Subsequently, with the reduction of carbon emissions, tightening the gap between current observed emissions and the reductions needed, needs to accelerate substantially to achieve the globally agreed goals of the Paris Agreement to reduce energy related emissions by 70% in 2050 (IRENA, 2019).

Energy security is a major problem for countries that depend heavily on imported fossil fuels. Renewable energy sources can provide alternatives by increasing the diversity of energy sources through local generation, as well as contribute to system flexibility and resistance to externalities (UNEP, 2017; IRENA, 2019). Likewise, energy access is a field of large inequality. This suggests that renewable energy technology can be applied in rural areas where networks have not yet been reached, using rural electrification, community energy initiatives and distributed energy sources (Jaramillo-Nieves and Rio, 2010). Transforming the global energy system will also bring significant socio-economic benefits, which are very important to influence any political decisions. The development of the local renewable energy industry has the potential to create jobs suitable for men and women from all disciplines and backgrounds, along with the potential to reduce dependency and inequality of consumers from energy providers, creating other development opportunities (Jaramillo-Nieves and Rio, 2010; IRENA, 2019).

Indonesia is one of the fastest growing countries in terms of energy consumption. This is due to strong economic development, increased urbanization and steady population growth. The country is the largest energy consumer of the Association of Southeast Asian Nations (ASEAN) and consumes nearly 40% of ASEAN's total energy consumption (IRENA, 2017). Thus, with the decreasing production of fossil fuels, particularly due to global GHG emission reduction commitments, has led the Indonesian government to encourage the role of new renewable energy to regain independence and energy security (MEMR, 2019). Moreover, IESR (2019) postulates that the development of new renewable energy (NRE) in Indonesia would prompt substantial added benefits, reducing health and environmental repercussions and producing employment opportunities across the country.

A study by IRENA (2017), reported the potential of creating 1.3 million additional jobs in the renewable energy sector by 2030. Furthermore, advancing renewable energy development would accelerate Indonesia's GDP by 0.3 to 1.3% by 2030, mainly due to increased investment in the energy sector. The trade market would also provide favourable circumstances for localizing parts of the production and supply chain, through manufacturing of local solar PVs and electric vehicles (UNEP, 2017; Mountford et al, 2018). Moreover, localized renewable energy production can significantly improve energy security by reducing dependence on imported fossil fuels, which are characterized by uncertain prices, exchange rates, and political risks. In addition, the production of distributed renewable energy can also provide access to energy in areas where there is energy scarcity (Mountford et al, 2018).

2.1.2. Variable Renewable Energy (VRE)

When it comes to integrating existing energy systems, technologies used for renewable energy sources, such as biomass, geothermal and hydropower, generally pose no more challenges than conventional energy technologies. Others, for instance wind and solar energy, are based on resources which are highly variable and may fluctuate with time, and are often referred to as Variable Renewable Energy (VRE) (Nelson et al., 2014). The energy integration can be much more challenging due to high levels of deployment, where such intermittent systems introduce a level of uncertainty that makes it very difficult to balance a sustainable and stable electricity supply and demand across a power system (Nelson et al., 2014; Mills, 2011).

All countries are highly dependent on accessible and adequate electricity supply to cater to its demand, which has consistently increased over the years (Mills, 2011). While variability and the need for flexible resources to balance them is a well understood trait of the power sector; fluctuating demand and supply, has always been a crucial factor in power systems (Nelson et al., 2014). Fluctuating supply from intermittent sources can make demand planning difficult. These conditions require the ability to maximize efficiency and performance to produce necessary spare capacities in order to meet peak demand when output intermittent VRE sources dips. As such, when using VRE, the system uses different flexible resources to control this fluctuation, especially to transfer energy from readily dispatched power plants, where energy switched on and power could be generated rapidly to a desired level of demand. Dispatchable plants used for spare capacity deployment include coal and gas-powered plants, as well as hydropower facilities (Nelson et al., 2014; Mills 2011).

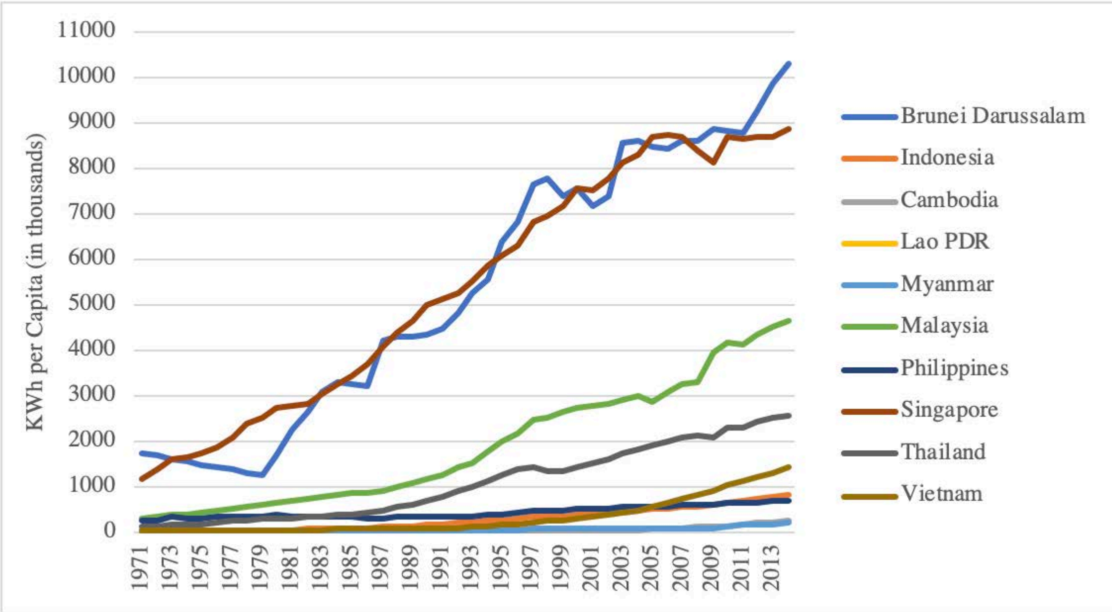
Although in recent years much attention has been paid towards enhancing the process of integrating VRE into the power system, in Indonesia, VRE such as wind and solar only contribute less than 1% of the total renewable energy installed capacity in 2018 (Rogelj et al., 2018; IESR, 2019). Additionally, the share of VRE production in total generation is assumed to not exceed 10% in any of the five regions (Java-Bali, Kalimantan, Maluku & Papua, Sulawesi & Nusa Tenggara and Sumatra) according to the Indonesian Agency for Assessment and Application of Technology (BPPT) and Indonesia's State Power Company (PLN) (IRENA, 2017). Referring to the National Energy General Plan (RUEN) target of 9.3 GW solar PV installed by 2030, 7.2 GW is assumed to be allocated to solar PV. This suggests that less than 1% solar PV potential will be captured out of the theoretical over 500 GW estimated by MEMR (IRENA, 2017; MEMR, 2019).

As the attribute of VRE is to produce energy in an intermittent pattern, distribution of energy becomes irregular depending on the time of day (Mills, 2011). In Indonesia, this becomes apparent during evenings, where there is an obvious peak in residential electricity demand, although daytime is substantially more productive for solar energy generation. The reason why this happens is due to the increased use of rice cookers, television and lighting at night time. The shift in electricity demand during peaks therefore might limit the potential for self-consumed residential solar PV without storage (IRENA, 2017). Thus, technical analysis of solar PV potential can provide information on the solar market potential particularly for residential in Indonesia. This information can lead decision-makers to develop appropriate regulatory strategies and measures (IESR, 2019).

2.1.3. Indonesia and Renewable Energy

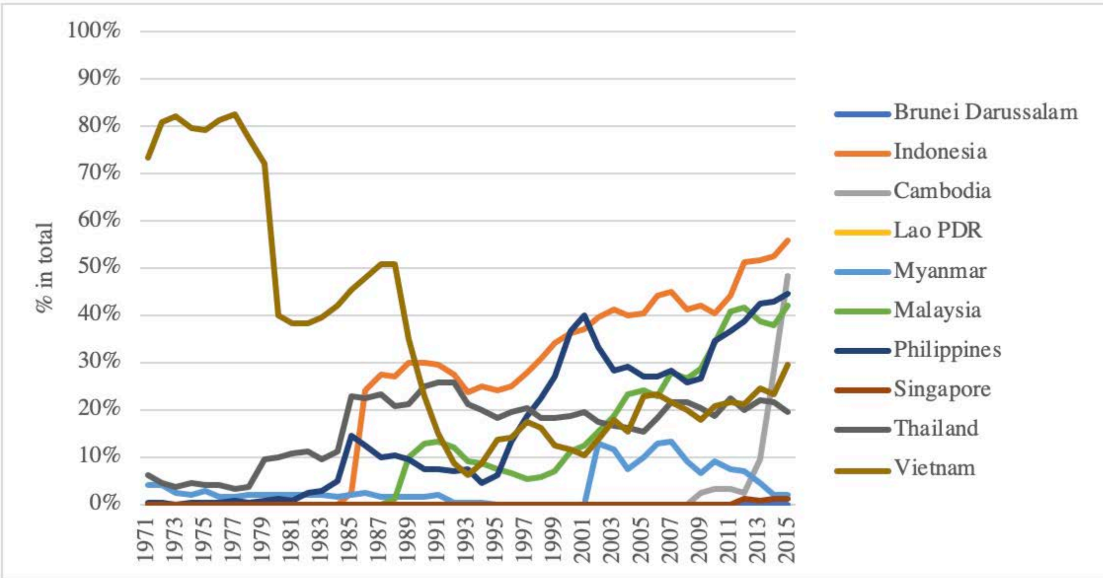
Accelerating the transition towards using renewable energy sources would allow reduction of energy in relation to the population intensity, which is the ratio of total energy consumption per person per year (Indonesian Ministry of National Development Planning, 2019). While Indonesia's total energy consumption per capita is relatively low compared to other ASEAN neighboring countries (see Graph 1), a steady inclining trend can be deducted from the graph. Moreover, the average rate of electricity consumption is expected to grow by 6,42% in the upcoming 10 years (PLN, 2019). Subsequently, with the increasing growth of energy, electricity production from coal has also been inclining in the recent years (see Graph 2) (IEA Statistics (World Bank Indicator), 2014).

Graph 1. ASEAN Countries Total Energy Consumption per Capita from 1971 – 2014



Source: IEA Statistics (World Bank Indicator), 2014

Graph 2. ASEAN Countries Electricity Production from Coal Sources in 1971 – 2015



Source: IEA Statistics (World Bank Indicator), 2014

Indonesia plans to increase its renewable energy investment according to the SDGs through their NDC targets, which aims to achieve unconditional reduction of greenhouse gas emissions by 29 percent by 2030 (Indonesian Ministry of National Development Planning, 2019; IRENA, 2017). The NDCs deal with increasing renewable energy share, through mitigation and subsequent adaptation measures. In 2014, the government adopted Government Regulation No. 79/2014 concerning National Energy Policy, where it directs the need to reduce dependence on fossil fuels by diversifying energy mix and increase renewable energy use by 23% by 2025 and 29% by 2030 (refer to Table 2) (IRENA 2017; IESR 2019). Further, it encourages energy transition towards utilizing renewable energy by scaling up the share of renewable energy from

8% in 2015 to 30% by 2045 and steering away from coal (Indonesian Ministry of National Development Planning, 2019).

Table 2. Indonesia Power Plant Production Energy Mix Plan

Indonesia Power Plant Production Energy Mix			
Source	**2018 Current**	**2025 RUPTL**	**2028 RUPTL**
Coal	56,4%	54,6%	54,4%
Gas	20,2%	22,0%	22,0%
Fuel	6,3%	0,4%	0,4%
NRE	17,1%	23,0%	23,2%
Geothermal			9,6%
Water			10,9%
Other NRE			2,6%

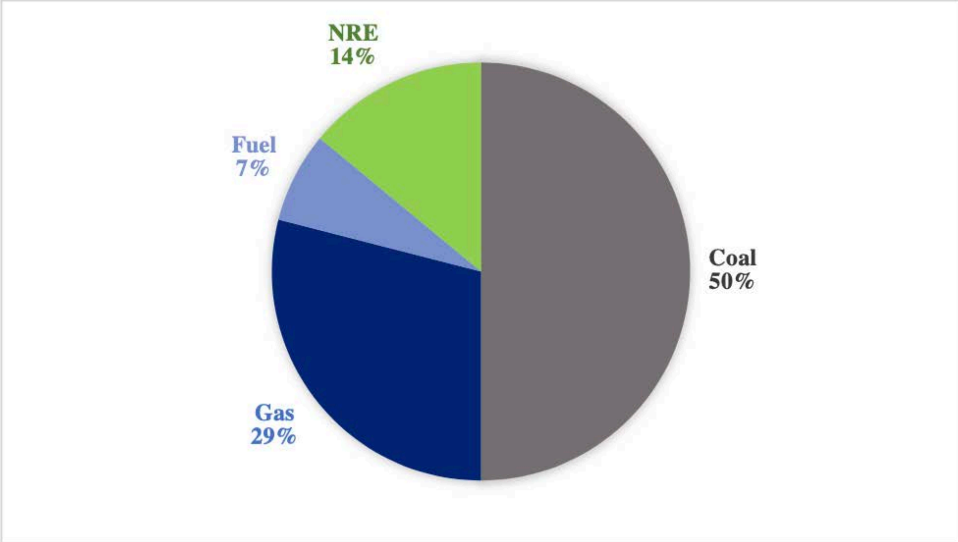
Source: MEMR, 2019; PLN, 2019

In a report by the national electricity company in 2019, it was projected that GHG emissions in Java – Bali are expected to increase by 1.4 times from 171,5 million tonnes in 2019 to 239,8 million tonnes in 2028 (PLN, 2019). Furthermore, GHG emissions in Jakarta alone in 2010 was estimated to reach up to 40 million tonnes CO_2-eq, most of which were attributed to the increasing energy demand in the region, and particularly contributed by the utilization of coal fired power plants for electricity generation (Indonesian Ministry of National Development Planning, 2014). As such, through plans such as Electricity Supply Business Plan (RUPTL) by PLN and National Electricity Business Plan (RUKN) by the Indonesian Ministry of Energy and Mineral Resources, aligned with the National Energy Policy (KEN) and the SDG and NDC targets, efforts to reduce GHG emissions and increase renewable energy share in the energy mix are made (Indonesian Ministry of National Development Planning, 2019).

2.1.4. Indonesia and Jakarta's Solar Energy Potential

Indonesia, strategically located near the equator, has huge potential to mobilize its solar energy. With average global horizontal radiation of 4.8 kWh/m^2, Indonesia can produce large amounts of electricity per day. Up to 1,534 kWh/year could be generated for each kWp of installed solar panels (IESR, 2019; Rahayuningtyas et al., 2014). MEMR estimated that potential technical solar electricity generation in Indonesia could reach up to 559 GWp calculated at 15% efficiency, with 207.9 GW produced by solar PV technology. This number towers over all other potential power generation of other NRE sources in Indonesia (see Graph 3) (MEMR, 2019; IESR 2019, IRENA 2017).

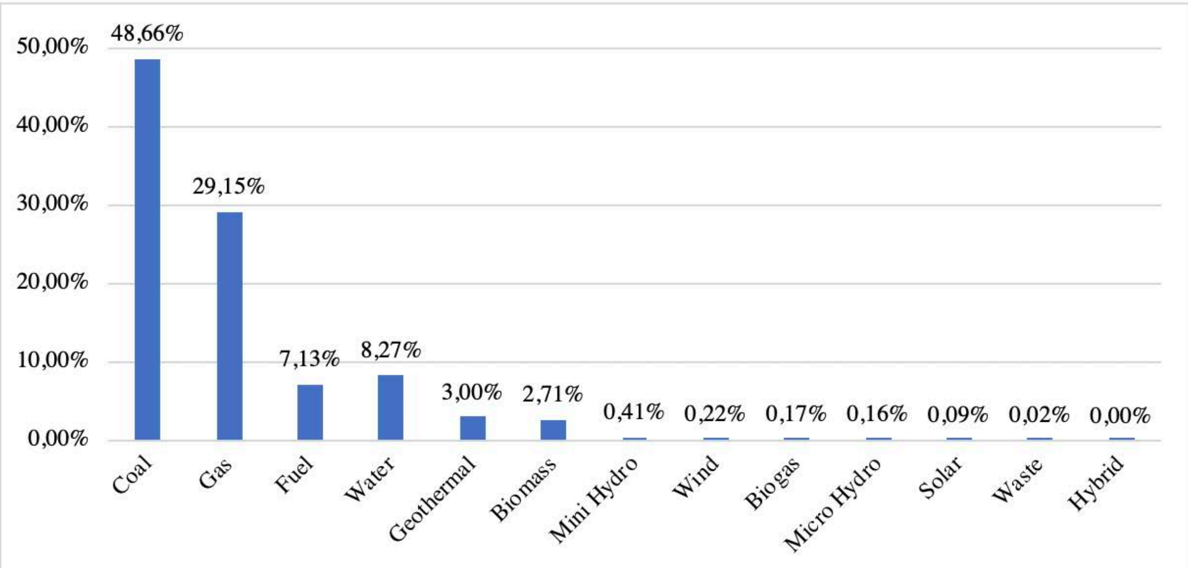
Graph 3. Indonesia Power Plant Capacity Energy Mix in 2018



Source: MEMR, 2019

Furthermore, despite the solar energy potential, most of the renewable energy mix are led by large-scale hydropower and geothermal projects (see Graph 4). In 2018, it was recorded that total solar power plant capacity in Indonesia reached a mere 60 MW (IESR, 2019).

Graph 4. Indonesia Power Plant Capacity Energy Mix in 2018



Source: MEMR, 2019

Though potential energy from PV generation is especially high, in implementation, by November 2019 only 152 MW solar energy power was installed, where only 11% or 16.6 MW were produced from rooftop solar PV (IESR, 2019). Comparatively with Indonesia's other ASEAN neighbors, solar energy development in Indonesia has been underwhelming (see Table 3) (ERIA, 2019).

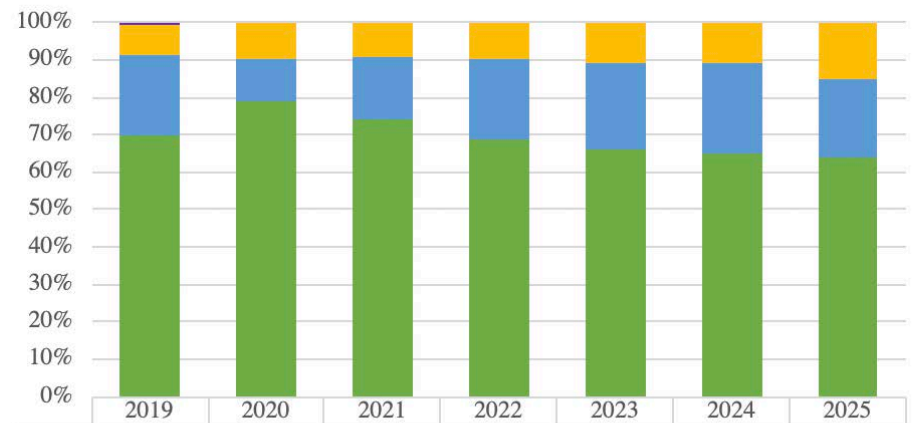
Table 3. ASEAN Solar PV Installed Capacity Ranked

ASEAN Countries	Installed Capacity	
Thailand	2.697	MW
Philippines	885	MW
Malaysia	362	MW
Singapore	143	MW
Indonesia	16,6	MW
Vietnam	8	MW
Brunei	1,2	MW
Cambodia	0,0	MW
Myanmar	0	MW

Source: IESR, 2019; ERIA, 2019; Solar Plaza, 2018

The region of Java – Bali, which consists of seven interconnected provinces namely: Banten, DKI Jakarta, West Java, Central Java, Special Region of Yogyakarta, East Java, and Bali takes up to approximately 60% of the population in Indonesia (PLN, 2019). Consequently, being the highest populated area, the region accounts for 70% of national energy demand (Indonesian Ministry of National Development Planning, 2014). However, following the national trend, the energy mix in this region are also dominated by fossil-fuel power plants.

Graph 5. Java – Bali Power Plant Energy Mix Capacity Plan



	2019	2020	2021	2022	2023	2024	2025
Fuel	1%	0%	0%	0%	0%	0%	0%
NRE	8%	10%	9%	10%	11%	11%	15%
Gas	21%	11%	17%	21%	23%	24%	21%
Coal	70%	79%	74%	69%	66%	65%	64%

Source: MEMR, 2019

As suggested in Graph 5, there is a significant difference between utilization of renewable energy sources to the more conventional energy sources. According to PLN (2019), in order to achieve the 23% NRE energy mix target in 2028, it is mandatory to achieve additional solar power energy by 3.200 MW or 1.6 million customers, each installing 2 kW of rooftop solar PVs. This target is deemed attainable by PLN, looking at the current projection of citizen participation and awareness towards NRE, government support, and the continuously decreasing price of solar PV rooftop in the following future. Furthermore, according to KEN, an additional 12% energy demand saving could be achieved following the current policy trajectory coupled with 10% switch from steam power plant to biomass, if at least 20% higher income residential houses install rooftop solar PVs (MEMR, 2019).

Table 4. Java – Bali Solar PV Potential vs Installed Capacity

Regions	Solar PV Potential (MW)	Solar PV Installed (MW)	Solar PV Installed (%)
Banten	2.461	0,17	0,01%
DKI Jakarta	**225**	**0,06**	**0,03%**
Jawa Barat	9.099	0,02	0,00%
Jawa Tengah	8.753	0,08	0,00%
DI Yogyakarta	996	0,17	0,02%
Jawa Timur	10.335	0,02	0,00%
Bali	1.254	4,27	0,34%
Total	**33.123**	**5**	

Source: MEMR, 2019

In addition to that, in 2018 it was recorded that combined peak power demand in Java-Bali reached up to 35 GW (IESR, 2019). This demand ideally could be covered by Java-Bali's 38,7 GW solar PV potential, in which Jakarta's solar PV could potentially contribute at least 225 MW (see Table 4). Out of the 225 MW, it is estimated that the Greater Jakarta residential market would take up to 13% of the share (IESR, 2019; IRENA, 2017; MEMR, 2019). While solar energy can mitigate carbon emissions by replacing more carbon intensive sources of heat and power as it produces little to no emissions compared to fossil fuel technologies, only 0,03% or 0,06 MW of the available solar power capacity in Jakarta is currently installed. This leaves much opportunity to harness the untapped solar PV potential in the region (Nelson et al., 2014; MEMR, 2019).

2.1.5. Solar Photovoltaic (PV) in Indonesia

According to Nelson et al. (2014), solar irradiation on Earth provides an average of 1.73×10^{17}J of energy per second. The annual solar energy falling to Earth is nearly four million ExaJoules (1 EJ = 10^{18}J). Of these, 5×10^4 EJ can be easily harvested, far exceeding man's current primary energy needs. Apart from this huge potential, solar energy reaches only 0.3% of global primary energy demand and 0.5% of total electricity demand. Current low carbon development projects that by 2050 approximately 14 – 22% or more of electricity needs to be switched to solar energy. As such, solar energy, plays an integral role in the decarbonizing process of the energy sector.

Solar cell devices or PV cells has the ability to capture and convert sunlight into heat fuel, or electricity. Such technologies have been developed commercially since the 1970s and in the last two decades their use has expanded to produce electricity (Nelson et al., 2014; IESR, 2019). Nowadays, a method being adopted to use renewable solar energy is through the installation of solar panels in households, or often called residential solar PV rooftops, where it is a solar system that could meet the energy needs of an entire household (Arif, 2003). With the availability of resources and the development of efficient technology, easier access to PV products and falling prices for solar energy generators, installation of rooftop solar PV has been increasing globally, including in Indonesia (IESR, 2019).

The Java – Bali energy grid is a tightly interconnected system, with further plans to expand its connection in the coming years (IESR, 2019; PLN, 2019). As the grid is reasonably complex, electricity transfer are limited and has constraints such as thermal limits, as well as voltage and transient stability limits (IESR, 2019). With such challenges, the government throughout the recent years has made the effort to come up with alternative renewable energy plants, for instance installing solar PV as well as micro and mini hydro plants around the country. Albeit currently still inadequate, this effort has been the result of cross collaborative partnerships, forming an ecosystem for a renewable energy market (IRENA, 2017).

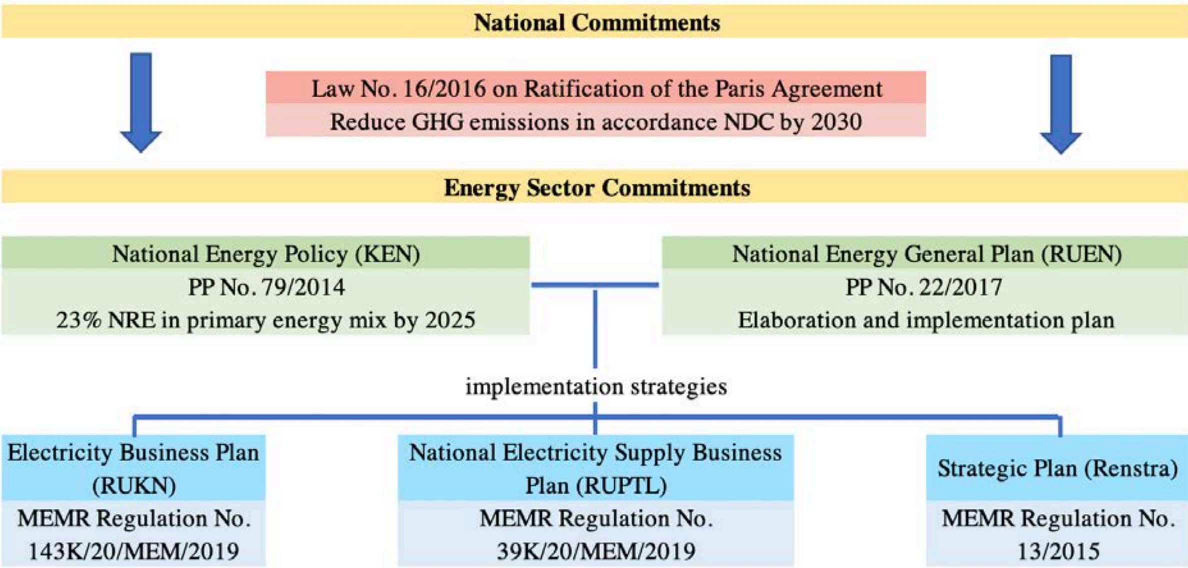
Indonesia's National Energy Policy Plan (RUEN) puts investing in the energy sector as vital to achieve the objectives to boost economic activity. Thus, this requires an active role of the government for policy-making to promote the development of a favourable energy investment climate, so that the private sector will be interested in investing in the energy sector and contribute to the RUEN goal (IESR and IIEE, 2019). The NCE (2018) affirms that the opportunity to invest in Indonesia's renewable energy sector promises the delivery of better quality jobs, raise incomes, create security for vulnerable communities, reduce health impacts and socio-economic inequalities, including gender and poverty. Moreover, access to clean energy typically would affect the vulnerable urban and rural communities by making them more resilient by bringing substantial social and economic benefits. Furthermore, IRENA (2017) argues that through the use of mainly solar PVs in remote locations, that renewable energy would be able to increase energy accessibility significantly. This is particularly true for vulnerable groups such as woman and children. These practices would offer integral sources of income for communities in need for services, opening up potential business opportunities in the area (Mountford et al, 2018; IRENA, 2017).

2.1.6. Indonesia's Existing Policy Framework

2.1.6.1. National Energy-Related Policies

Consequent to increasing average rate of national energy demand, several national-energy related policies and plans issued by the central government, MEMR, and PLN has been put in place (refer to Figure 1 and Table 5).

Figure 1. National Energy-Related Policies



Source: MEMR, 2019

Table 5. Energy Sector Regulations

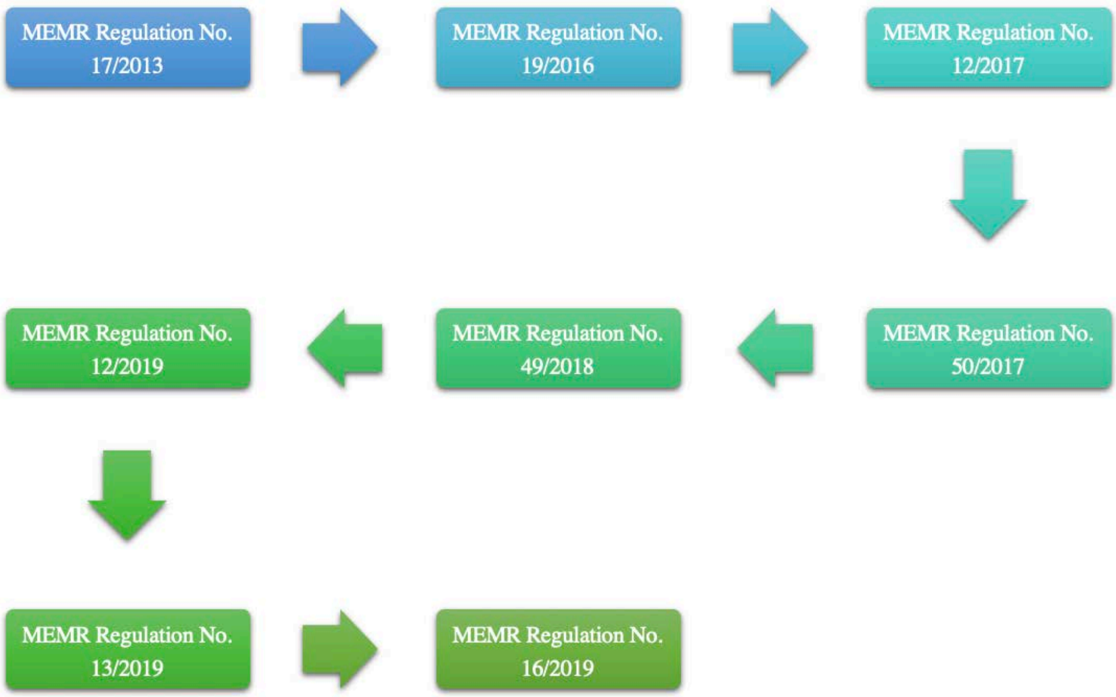
RUKN	RUPTL	Renstra
Development plan for electricity system supply, current conditions of electricity supply, projected electricity demand, and investment in electricity supply	Guidance document for developing the electric power system in the PLN business area	Performance achievements mapping, potentials and challenges identification, key performance indicators, and strategic implementation plan

Source: MEMR, 2019

2.1.6.2. Solar PV Policies

Throughout the years, the Indonesian government acknowledges the increasing energy demand and have continually been seeking to adopt more efficient processes and interesting policy climate to attract prospective investors. As a result, solar PV policies in Indonesia has undergone various developments.

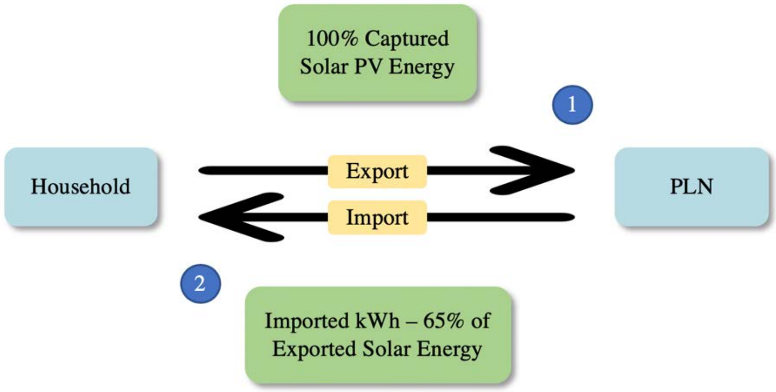
Figure 2. Indonesia Solar Policy Roadmap



Source: MEMR, 2019

In 2018, MEMR issued MEMR Regulation No. 49/2018 on rooftop solar PV. This regulation provides a legal basis for rooftop solar users and addresses technical regulations regarding rooftop solar installation capacity, electricity credit transaction schemes with PLN (Indonesia's national electricity company), rooftop solar licensing and installation procedures, and rooftop solar usage procedures for commercial and industrial customers. The regulation offers a net-metering transaction scheme of 1 : 0.65 ratio. This scheme allows PLN customers to operate their rooftop solar in parallel with PLN and send excess electricity production to the PLN network (on-grid system) (Hamdi, 2019). Therefore, the electricity bill can be calculated by subtracting the imported electricity from the PLN grid by 65% of the exported solar energy from the user. Thus, this set up means that customers are compensated for 65% of the exported electricity to the PLN network. However, this adoption was not well received by the sector particularly as previous 2017 PLN regulation set the net-metering scheme at 1 : 1 ratio.

Figure 3. Net-Metering Solar Policy Scheme



Source: MEMR, 2019

Additionally, if there are surplus electricity exported to the grid than the imported electricity from PLN, the excess could be accumulated up to 3 months before it is reset. This decision further upset sector participants as the 2013 PLN policy allowed for excess electricity to be deposited in the account by up to one year or until the end of the year before it is reset. Hence, to counteract several concerns of the solar energy consumers, MEMR issued follow-up regulations, MEMR Regulation No. 13/2019 which addresses issues related to licensing requirements, and MEMR Regulation No. 16/2019 which seeks to resolve the economic aspects of solar energy investment by reducing the monthly electricity costs.

In spite of the backlash, deployment of rooftop solar PV has rose substantially in the past few years, due largely to the policy measures which has made the installment of solar PVs more economically attractive than buying electricity from the grid (IRENA, 2019). In addition, IRENA (2017) analysis predicts that with supportive policies and programs, coupled with consumers' commitment to clean energy, distribution of residential solar PV systems will incrementally grow. While Indonesian interest towards rooftop solar PV is still low compared to other countries (see Table 3), Hamdi (2019) noted that from 2017 to 2019, the number of PLN customers using on-grid rooftop solar PVs has more than doubled. A press release from PLN (2020) also reported a 93,8% increase before and after a regulation revision from MEMR Regulation No. 49/2018 to MEMR Regulation No. 16/2019.

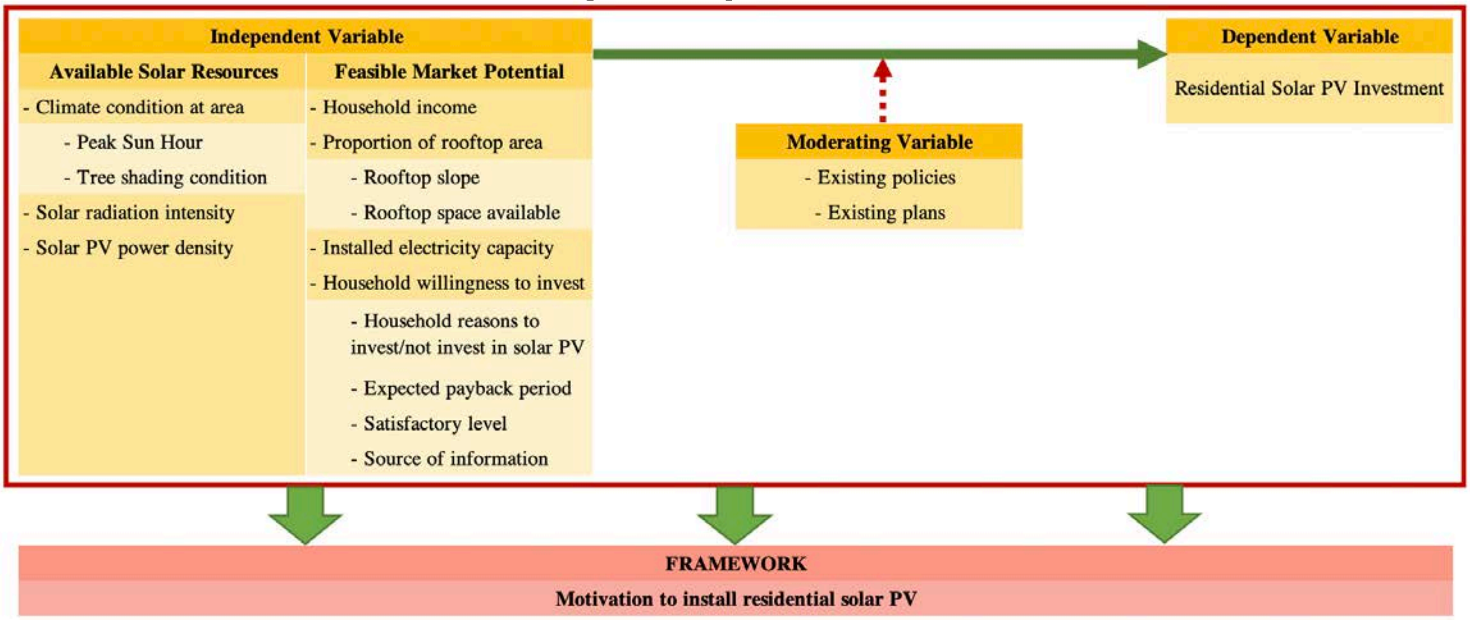
Subsequently, in 2017, the MEMR along with other affiliated associations launched GSSRN, the Million Solar Roof National Movement, to help curb carbon emissions and encourage public interest to invest in solar PV (IESR, 2019). The movement aims to achieve cumulative solar capacity of 1 GW by 2020 by encouraging a target of one million households to install a minimum of 1 kWp on their rooftops. Further, this initiative is partly to contribute to the KEN target of 6.5 GW solar energy power by 2025 (IESR, 2019; Hamdi, 2019).

2.2. Conceptual Framework

In previous chapters, it was substantiated that global energy consumption has spiked in the past years and will continue to rise in the future, causing climate change effects and increased energy demand use (UNEP, 2017; IRENA, 2019). As a result, various global agreements were put in place to accommodate the pressing environmental concerns and energy scarcity issues, for instance the Paris Agreement and SDG goals. These agreements, along with the cooperation of participating countries with their own sustainable targets and policies, encourages the use of various renewable energy sources, such as solar energy (IRENA, 2019). However, with Indonesia being a dynamic country with an abundance of solar energy resources, just starting out on developing their RE journey, there are various influencing and affected variables that needs to be taken into consideration (MEMR, 2019).

The conceptual framework refers to the visualized representation of the steps taken on the basis of existing theories and studies to achieve the research objective. In this case, the research objective concerns the performance of current residential solar PV policy framework. Hence, the interlinkages between the identified variables in residential solar PV leads to the illustration of a conceptual framework for this research (shown in Figure 4). From the study, it was identified that there are three types of variables; independent, moderating and dependent variables.

Figure 4. Conceptual Framework



Source: Author's Own Elaboration Based on Literature Review

Available solar resources as an independent variable comprise of indicators such as climate condition, solar radiation intensity, and solar PV power density. Furthermore, feasible market potential as an independent variable also comprise of sub-indicators namely household income, proportion of rooftop area, installed electricity capacity, as well as willingness to invest. These indicators are controlled inputs that are independent which therefore may cause changes to the dependent variable, which is residential solar PV investment. That being said, being an independent variable does not necessarily mean that it is independent to other independent variables. Such as the case with independent variable 'Household Income', as it has an impact on 'Willingness to Invest'. Furthermore, thus a moderating variable is likewise identified, where it influences the relation between available solar resources as well as feasible market potential. The moderating variable includes national energy-related policies, solar PV policies, as well as supporting programs and initiatives.

Chapter 3: Research Design

This chapter will discuss the research design and methodologies employed in the research. It will cover the type of research strategy, data collection method, classification of sample size, data analysis, and operationalization of the variables and indicators. Furthermore, the chapter will conclude by presenting the expected challenges and limitations to the research.

3.1 Description of the research design and methods

The research scope of this study will focus primarily on residential rooftop solar PV in Jakarta. With consideration of this scope, the research employs a mixed method strategy, comprising of a case study on Jakarta that uses secondary data collection through desk research, coupled with complementary primary data collection through the distribution of questionnaire surveys to a sample population. This decision is based on the assumption that collecting various types of data will provide the best understanding to answer the research questions and would provide the necessary materials for the final outcome of this research.

Desk research is a method of research that collects data from someone else or from existing resources for another primary purpose (Johnston, 2014). The secondary data review is an integral part of the study, providing a basis to build upon the following research path, as well as employing it to answer the research objectives in hand. Data collected would be an re-analysis of existing research data such as climate condition, solar radiation intensity in Jakarta, as well as the description of existing residential solar PV policy framework. The data will be analysed using the constant-value method to acquire the potential technical residential solar PV power in Jakarta. Afterwards, an examination towards the trajectory of existing residential solar PV policy performance versus the technical potential power can be assessed towards the regional and national solar PV goals, answering research question 1 '*What is the maximum technical potential of residential solar PV power in Jakarta?*' and 2 '*Are current policies and programs/plans on track and aligned with regional and national rooftop solar PV targets?*'.

Primary data are data that has been collected first hand by the researcher. For the purpose of this research, an online questionnaire survey will be distributed to the sample respondents. In the survey, a representative sample of a defined population target in Jakarta are questioned and the responses are coded in standardized answer categories. The questionnaire itself is a set of questions designed to formulate perception and used to identify market potential of residential solar PV in Jakarta, guided by the indicators defined through the operationalization process. The questionnaire survey would use a 5 point Likert Scale format, based on the 'Feasible Market Potential' and 'Policies and Supporting Programmes' indicator. The data from this research process will be analysed using SPSS for validity and reliability tests, as well as for descriptive analysis. The result of this will answer research question 3 '*What is the market potential of residential solar PV in Jakarta?*'.

3.1.1. Sampling Method and Data Collection

3.1.1.1. Sampling Size and Data Representativeness

Generally in a survey, information is collected from only a fraction of the population, that is a sample, in which these individuals are purposively selected to produce statistics that is quantitative or numerical descriptions relevant to the study and therefore are in a position to provide the researcher with informative responses to the survey questions. Hence, the sample of a survey needs to be large and representative enough to allow for extensive statistical analysis (Fowler, 2014; Hox and Boeije, 2005).

According to Schouten et al. (2009), the concept 'adequate data representativeness' refers to the quality of a data collection with minimum influencing factors affecting it. This is particularly apparent for 'purposive sampling methods', where 'representativeness' is highly needed. For this research, a purposive sampling method will be applied as the sample is determined by the judgment of the researcher to suit the purpose of the study. The convenient nature of this method, consequently are attributed to risk in having bias in its statistical studies. Therefore, it is crucial to have sufficient sample size in the research to provide a representative estimate of a random purposive sample.

For the purpose of this study, the sample size will specifically only involve respondents that has floor area of ≥ 45 m^2 and installed electricity capacity of over 1.300 VA. This approach was adopted following previous research by Putra and Rangkuti (2016), IESR (2019), as well as Citraningrum (2019). Households with installed electricity capacity of below 1.300 VA will be exempt from this research as according to Ministry of Social Affairs Decree Number 32/ HUK/2016, households with 450 VA and 900 VA fall under the impoverished category. As a result, this category receives subsidies, whereas households with electricity capacity of ≥ 1.300 VA is deemed financially able to sustain itself. Therefore, the population size used for this research would amount up to 3.131.240 people, covering households with floor area of 20 m^2 to above 150 m^2 (refer to Table 6).

Table 6. Number of Households in Jakarta by Floor Area

Floor Area	< 19 m^2	20 - 49 m^2	50 - 99 m^2	100 - 149 m^2	150+ m^2
Household percentage	22,50%	35,40%	22,40%	9,80%	9,90%
Number of Households	909.070	1.430.270	905.029	395.950	399.991

Source: Indonesian Statistics, 2019; PLN, 2019

Obtaining a representative sample to ensure holistic views for the research is done by drawing a random sample of targeted respondents based on the population size using scientific sampling methods. To determine the appropriate sample size for the research, Cochran's equation (see Equation 1) for large population will be employed where z is the z – score, p is the estimated proportion of the population which has the attribute in question, e is the margin of error, and N as the population size. The z-score can be attained according to the desired confidence level, in this case 90%, resulting the z-score to be 1.66. Therefore, according to this equation, the adequate sample size for this research would be 273 respondents with installed household electricity capacity of ≥ 1.300 VA and floor area of ≥ 45 m^2.

Equation 1. Cochran's Sample Size Equation

$$Sample\ size = \frac{\frac{z^2\ x\ p\ (1-p)}{e^2}}{1 + (\frac{z^2\ x\ p\ (1-p)}{e^2 N})}$$

3.1.1.2. Validity Test

Due to limited time constraints, the constant-value method used in data analysis to estimate technical potential of residential solar PV will produce generalized outcomes. This leads to challenges in validation for the research as it could tamper with data representativeness of the study. Hence, in order to reduce the risk of unsound data, a correction factor and packing factor is added in the calculation to increase validity.

Prior to data analysis, a validity test is conducted to the survey to ensure that the data obtained from the survey is permissible to be used. A validity test measures the degree to which the variable measures what it is intended to measure. The validity test concerns the crucial relationship between the test measures and indicators (Carmines and Zeller, 1979). In the case of empirical evidence for content validity, a correlation between scores of two different measures can be used as evidence of the content validity of one of the measures, provided the other is widely seen as credible. For the sake of this research, the correlation between scores were obtained through the Pearson Product Moment Correlation formula computed on SPSS. The relationship between the test measures and indicators mentioned above, compares the values of Rxy (Pearson product moment value) with the R-value of two-tailed significance level (5% or 0.05) to the according to the degree of freedom (Df) based on the sample respondent population.

3.1.1.3. Data Collection

Data collection will be obtained in the form of both qualitative and quantitative data, making it a mixed-means method. Furthermore, the data used in this research will be consisted of data retrieved from geodata GIS application to collect solar radiation intensity and climate condition in Jakarta, as well as readily available national statistics from the Indonesian national statistics bureau (BPS), ministry data, as well as previous research findings on the matter. Research material that are used in this study are obtained from governmental plans, research reports, publications, and scientific journals. Furthermore, energy related policies and residential solar PV policies will be gathered from governmental statutes and regulations such as the RUPTL, RUKN, and RUEN issued by the government. Lastly, primary data will be collected from the questionnaire surveys that were distributed to the research sample size.

3.1.2. Data Analysis and Research Instruments

The research instruments used in this mixed method research combines quantitative and qualitative data analysis, gathered from close-ended structured questionnaire surveys, as well as data collection through desk research. The desk research consists of collecting data from previous research material, national statistics, national laws, and geodata GIS application. Data analysis on the secondary data are used to answer research question 1 and 2 using scientific data analysis. While research question 3 is answered through data analysis on the questionnaire survey.

Initially, desk research will be done to gather necessary data such as number of households per rooftop area for the constant-value method. A descriptive analysis will be done to clean and categorize data per household income and rooftop area. Subsequently, in order to answer research question 1, it is necessary to estimate the rooftop solar generation in Jakarta. To date, there are three major rooftop solar generation estimation methods, i.e. constant-value methods, manual selection methods, and GIS-based methods (see Table 7). Each of them has their own advantages and disadvantages (IESR, 2019).

Table 7. Advantages versus Disadvantages of Rooftop Solar Generation Methods

Methods	Advantages	Disadvantages
Constant value	Quick to execute and rooftop area is easy to be estimated	Results are generalized and does not consider localized rooftop characteristic. Result validation will be a challenge
Manual selection	Detail-specific and can accommodate assumptions based on specific understandings on regions and buildings	Time-intensive, not easily replicable across multiple regions
GIS-based	Detail-specific, replicable across multiple regions, and can be automated for more efficient computing	Time-intensive, computer-resource intensive

Source: Melius et al., 2013; IESR 2019

For this research, the constant-value method will be employed. This type of analysis is the most popular method for assessing the rooftop solar generation due to its ease of use (IESR, 2019). Furthermore, compared to the other methods, the constant-value method assumes the same characteristic ('constant value') regardless of the localized rooftop condition, and does not require much time or resources which is integral considering the time restraint of this research, and could provide a useful starting point for the calculating the potential rooftop solar energy production in an area (Melius et al., 2013), making it relatively easy to operate. As such, basic rule assumptions, such as the proportion of sloped roofs and flat roofs, shading, as well as climatic conditions will be included in the assessment (IESR, 2019).

As there are currently no existing datasets on the residential rooftop slopes and rooftop area in Jakarta, following previous research by Melius et al (2013) and IESR (2019), this research will assumed that all households in Jakarta has a proportion of roof slope of 18° for pitched roofs or 0° for flat roofs. Moreover, following calculations done by Chaudhari et al. (2004), Denholm and Margolis (2008), and Paidipati et al. (2008), assumptions will be made using data provided by the national statistics bureau to extrapolate total rooftop area from total floor space area of households. In order to estimate the rooftop space, the floor space area is translated by multiplying the area size (starting from 20 m^2 to ≥ 150 m^2) to each of the correction factor (refer to Table 8). The correction factor is necessary due to the data limitation of the research, as there are currently no available data on household per rooftop area in Jakarta. This factor is a calculated adjustment made to take into consideration uncertainties and deviations in the data or method of measurement. Further, to calculate suitable rooftop area for PV, the rooftop space values are then multiplied by access factor and packing factor respectively (refer to Table 9). The access factor takes into account the shading from trees and climate condition, as well as building orientation, and roof structural soundness (Melius et al., 2013; IESR, 2019). Meanwhile, the packing factor serves as a decreasing variable in the rooftop area, wherein it takes into account space needed for access between modules, wiring, and inverters (Melius et al., 2013).

Table 8. Proportion of Rooftop Area

Proportion of Roof	Pitched	Flat
Slope	18º	0º
Correction Factor	1,054	1,003

Source: Melius et al., 2013, IESR, 2019

Table 9. Amount of Rooftop Area Available for PV

	Scenario 1	Scenario 2	Scenario 3
Access Factor	24%	60%	81%
Packing Factor	1,25		

Source: Melius et al., 2013; IESR, 2019

In pursuance of calculating the residential solar PV power, through desk research, this study will list several brands of solar PV modules available in Indonesia with the highest efficiency in order to achieve maximum value of technical potential. The power density of each modules are calculated on a square-meter basis, and are then averaged. The average value of the power density will be multiplied to the amount of rooftop area available for PV for both pitched and flat rooftops. The technical potential finally be deduced by multiplying the power density by the amount of rooftop area available for PV. Further analysis will be done by averaging and then sum the total amount of technical potential residential solar PV power per household floor space area, concluding the process to answer research question 1.

Afterwards, peak sun hour and solar radiation intensity values can be obtained through geospatial application such as Global Solar Atlas. Global Solar Atlas is a solar GIS software and website that provides weather and solar resource data mapping specifically geared for energy investment assessment and weather-related risks. The software is developed by the Energy Sector Management Assistance Program (ESMAP) and prepared by Solargis in collaboration with the World Bank to support the scale-up of solar energy in countries globally. This software is chosen for this research as it provides easy access to comprehensive solar resource data gathered from validated satellite and meteorological sources for improved accuracy. The use of this application reduces uncertainty in gathering data for planning and performance assessment related to solar PV systems (Suri et al., 2011). Therefore, for the purpose of this research, estimates on solar photovoltaic potential will be taken from Global Solar Atlas.

Concerning the Government Regulation No. 79/2014 concerning KEN on achieving 23% NRE energy mix by 2028, additional 3.200 MW solar power energy per 2 kW household is mandatory. Moreover, the KEN also targets 20% of higher income residential households to install rooftop solar PVs, contributing to a portion of the national solar energy power (MEMR, 2019). Following IESR's (2019) previous research, it is assumed that only 70% of solar energy generation will be exported to the grid. Therefore, data collected from Global Solar Atlas, such as peak sun hour and solar radiation intensity, will be calculated to estimate higher income household's residential solar PV contribution to the NRE mix in the PLN grid. This calculation will be used to conduct an analysis under two scenarios (refer to Table 10) assessing the performance of current policies and programs aligned with the national solar PV targets, and comparing them to the maximum technical potential residential solar PV power. Thus, the outcome of this process will be able to answer research question 2.

Table 10. Scenario for Performance Analysis

Scenario 1	Scenario 2
Business as Usual; Residential solar PV follows annual growth trend until 2028	20% of higher income households install residential solar PV by 2028, contributing to the NRE mix by exporting 70% of their solar energy generation to the grid

Source: MEMR, 2019; IESR, 2019; Government Regulation No. 79/2014 concerning KEN

The cross-sectional questionnaire survey will be administered to produce confirmatory results by allowing the respondents to select from predefined answers. Cross-sectional survey are carried out to describe behaviour or attitudes at one point in time, answering research question of interest (Olsen and George, 2004; Mathers et al., 2009). For this research, due to research limitations, the survey will be distributed online through Google Forms, which will transfer the data in an Excel format from Microsoft Excel. The questionnaire survey employed for this study will be a structured close-ended multiple-choice questionnaire, where respondents selects one option from a pre-determined set of responses.

The survey is formulated in a 5-point Likert scale format, where the answers range from "Not at all important" to "very important", as well as other similar variations for satisfactory and interest (the questionnaire survey used for this study can be seen in the Annex). The Likert scale is employed in order to understand the perceptions of the respondents related to a statement in the questionnaire that are correlated with the indicators designed in the operationalization table, namely the 'Feasible Market Potential' and 'Policies and Supporting Programmes' indicator.

As previously mentioned, the survey is formulated in a 5-point Likert scale format, ranging from a weighted score of 1-5 for each multiple choice answer chosen by the respondents. For instance, 'Not at all important' weighed 1, 'Slightly important' weighed 2, 'Moderately important' weighed 3, 'Important' weighed 4, and 'Very important' weighed a score of 5. Total number of respondents per answer are then multiplied by the designated weighed value of each answer as described previously, which would lead to weighted score of the statement in the question. This scale makes an assumption that opinions or attitudes can be measured by combining a sum of the values of each questions to generate a composite score.

Furthermore, the questionnaire also includes a set of questions in the beginning of the survey to allow the respondents to answer their basic information such as their household income, installed electricity capacity, household size to eliminate any unnecessary or irrelevant respondents. From the survey, the market potential and preferences for policy measures can be extracted to create policy recommendations. The specific content of the questionnaire is presented in the Annex.

The accumulated data from the questionnaire survey, will then be processed in SPSS. SPSS, or the Statistical Package for the Social Sciences, is a commercially distributed software commonly used for statistical and data management functions that allows for various types of analysis as well as data outputs. This versatility is particularly useful for students and researchers all together, making it user-friendly compared to other softwares. Furthermore, as this research will primarily work on big datasets related to solar energy and solar PV, SPSS would be able to accommodate comprehensive analysis needed for the research. SPSS will be employed to conduct validity tests for the questionnaire survey, as well as descriptive analysis for each components in the survey. Thus, relevancy of residential solar PV in households, dominant factors influencing decision to invest in residential solar PV, expected payback period, willingness to invest, as well as policy feedbacks and suggestions to formulate a market potential of the residential market, sufficiently answering research question 3.

3.2 Operationalization: variables, indicators

According to Verschuren and Doorewaard (2010), through defining research objectives and asking research questions, one or more concepts may emerge that are of central importance for the research. The way the concept is defined determines what should be done in the rest of the project. It is therefore important to correctly explain the content of key concepts or variables. This means not only a precise description of these concepts, however also determining clear definitions such as the identification of indicators and measurements. The researchers' decision to classify important parts of the study is therefore considered part of the operationalization process. By defining and operationalizing variables, more clarity can be given on where to investigate in the study and the research project can then be assessed in more detail.

As established in the previous chapters, Indonesia has an abundance of solar energy potential although the vast majority of it isn’t being utilized. While there are residential solar PV policy frameworks set in place, it was also recognized that the policies and plans were not substantial, lacks conviction, implementation, attractiveness and willingness to invest from the residential market. Therefore, this operationalization table (indicated in Table 11) was formulated towards achieving the research objective and answering the research questions on analysing performance of current residential solar PV policies in Jakarta.

Table 11. Operationalization Table

Concept/Variable	Indicators	Sub-Indicators	Measured by	Methods Used	Source of data
Available Solar Resources	Climate Condition	Peak Sun Hour	Peak Sun Hour	Desk Research	Global Solar Atlas
		Tree Shading Condition	Access Factor		National Statistics
	Solar Radiation Intensity	Solar Radiation Intensity	Solar Radiation Intensity		Suri et al., 2011; Melius et al., 2013; IESR, 2019
	Solar PV Power Density	Solar PV Power Density	Solar PV Power Density		
Feasible Market Potential	Household Income	Household Income	Income Classification per Household (≥ Rp 1.300.000,-)	Desk Research, Descriptive Analysis, Questionnaire Survey, Constant-Value Method	National Statistics
	Proportion of Rooftop Area	Rooftop Slope	Rooftop Slope	Desk Research, Questionnaire Survey, Constant-Value Method	Ministry of Social Affairs Decree Number 32/ HUK/2016
		Rooftop Space Available	Household Floor Area		
	Installed Electricity Capacity	Installed Electricity Capacity	Number of Households with Installed Electricity Capacity ≥ 1.300 VA		Indonesian Statistics, 2019; PLN, 2019; Putra and Rangkuti, 2016; IESR, 2019; Citraningrum, 2019; Melius et al., 2013; Chaudhari et al., 2004; Denholm and Margolis, 2008; Paidipati et al., 2008
	Household Willingness to Invest	Household Reasons to Invest/Not Invest in Solar PV	Number of Households Willing to Invest in Rooftop Solar PV	Questionnaire Survey, Descriptive Analysis	
		Expected Payback Period	Number of Households per Expectation of Payback Periods		
		Solar PV Satisfactory Level	Number of Households per Satisfaction Level of Residential Solar PV Policies		
		Source of Information	Number of Households per Source of Information		Questionnaire Survey
Policies and Supporting Programmes	National Energy-Related Policies	National Energy-Related Policies	-	Desk Research, Questionnaire Survey, Descriptive Analysis	Ministry of Social Affairs Decree Number 32/ HUK/2016
	Solar PV Policies	Solar PV Policies	-	Desk Research, Questionnaire Survey, Descriptive Analysis	Government Regulation No. 79/2014
	Programmes and/or Initiatives	Programmes and/or Initiatives	-	Desk Research, Questionnaire Survey, Descriptive Analysis	MEMR, 2019; IESR, 2019
Solar PV Investment	Residential Solar PV Customers	Residential Solar PV Customers	Number of Potential Households with Rooftop Solar PV	Questionnaire Survey, Descriptive Analysis Constant-Value Method	Maximum Technical Potential for Residential Solar PV in Jakarta (Author's own calculation based on Constant Value-Method)
	Residential Solar PV Energy Production	Residential Solar PV Energy Production	Energy Production Added by Residential Solar PV	Questionnaire Survey, Descriptive Analysis Constant-Value Method	Projection of Residential Solar PV in Jakarta (Author's own calculation according to 2030 forecasts)
					Residential Solar PV Market Potential (Author's own elaboration based on descriptive analysis of Questionnaire Survey)

Source: Author’s own elaboration

3.3 Expected challenges and limitations

The topic of energy has various dimensions and intricacies involved with it. Furthermore, in Indonesia, there are diverse factors that influence policy making particularly in residential solar PV. Additionally, there is a wide assortment of information and knowledge required to come to a single policy recommendation, as this issue is not a one size fits all situation. Thus, it was not possible to explore every aspect of the factors due to time limitations. Therefore, this research will only focus its policy recommendation towards the issue of incentivizing residential solar PV rooftops to reach out to a larger consumer base. In addition to that, the study was also conducted with the following challenges and limitations:

- Due to the coronavirus pandemic, questionnaire surveys were only able to be distributed online.
- Inconsistent data or data discrepancy reported between the government and research institutions.
- Only Jakarta, being the research's case study, was taken into account for the residential solar PV policy recommendation.
- The constant-value method used in data analysis produces generalized outcomes and does not consider other externalities.

Chapter 4: Presentation of Data and Analysis

This chapter presents the findings of the employed mixed methods research design as previously discussed in Chapter 3. The research primarily involves secondary data and primary data analysis, namely through structured questionnaire survey. Secondary data analysis was used to specifically answer research question 1 and 2, regarding Jakarta's residential solar PV technical potential and performance towards achieving governmental environment targets. The questionnaire survey was administered to identify Jakarta's residential solar PV market potential, or research question 3.

This chapter has five main sections. Section 4.1. discusses the results and findings obtained to estimate the technical potential of residential solar PV in Jakarta. Section 4.2. discusses the performance of current trajectory and ideal scenario of Jakarta's residential solar PV market against governmental targets. Scenario 4.3. discusses the preferences and market potential of residential solar PV market in Jakarta. Furthermore, the chapter will conclude in section 4.4. by presenting a comprehensive analysis linking all aspects of the research questions as a result of this research.

4.1. Technical Potential

This section discusses the findings and calculation for maximum technical potential for residential solar PV in Jakarta. As described in Chapter 3, constant-value method is used to process the data for research question #1. The reason being is that the ease of use of this method assumes the same characteristic ('constant value') of a variable regardless of the localized rooftop condition, in which there are no current data available. As such, the constant value method does not require much time or resources, proving to be a useful starting point for calculating the potential rooftop solar energy production in Jakarta, considering the research time and scope limitations.

Table 12. Number of Households by Rooftop Area

45 - 49 m^2	50 - 99 m^2	100 - 149 m^2	≥ 150 m^2	Total
35,40%	22,40%	9,80%	9,90%	
300.357	905.029	395.950	399.991	2.001.327

Source: Indonesian Statistics, 2019; PLN, 2019

Table 13. Average Power Density PV Panel

Brand	Monocrystalline PV Panel		
	Capacity (Wp)	Area (m²)	Power Density (W/m²)
Sunpower	370	1,629668	227,0401088
LG	365	1,7272	211,3246874
Panasonic	340	1,67427	203,0735783
Trina Solar	395	1,984	199,0927419
Solaria	360	1,809036	199,0010149
Canadian Solar	420	2,061376	203,7473998
Jinko Solar	400	2,012016	198,8055761
REC	330	1,669975	197,6077486
Yingli Solar	390	1,977038	197,2647971
Seraphim	405	2,034168	199,0985995
Average	**377,5**	**1,8578747**	**203,6056252**
Module Efficiency			**20,4%**

Source: IESR, 2019

Due to the feature of this method, assumptions were made for the calculations such as converting floor space data to rooftop space using correction factor to adjust values for possible uncertainties due to unavailable household per rooftop area number accordingly to the degree of slope for flat and pitched roofs, packing factor which takes into account spaces needed for wiring and physical technicalities, as well as considering the accessibility due to shading and climatic conditions represented by access factors (as discussed in Section 3.1.2.). Furthermore, a minimum of 45 m^2 rooftop area is assumed to be the sample pool as it is the average required space for solar PV installation in Jakarta (see Table 12). Additionally, a total of 10 solar PV panel brands available in Jakarta were gathered, where the amount of power density per panels were collected and averaged for the purpose of data calculation (see Table 13).

Table 14. Maximum Technical Potential for Residential Solar PV in Jakarta

Floor Area (m2)	Maximum Technical Potential (MWp)					
	Scenario 1		Scenario 2		Scenario 3	
	Pitched	Flat	Pitched	Flat	Pitched	Flat
45 - 49	540,98	514,80	1.352,44	1.287,00	1.825,79	1.737,45
50 - 99	2.604,49	2.478,46	6.511,21	6.196,15	8.790,14	8.364,81
100 - 149	1.904,20	1.812,06	4.760,50	4.530,16	6.426,68	6.115,71
>150	2.317,63	2.205,49	5.794,07	5.513,72	7.822,00	7.443,52
Total	**7.367,29**	**7.010,81**	**18.418,23**	**17.527,03**	**24.864,61**	**23.661,48**

Source: Author's own elaboration based on Constant-Value Method

Table 14 summarizes the data calculation for maximum technical potential for residential solar PV in Jakarta under three scenarios based on access factor of 24%, 60% and 81% respectively. It can be indicated from this table that the maximum technical potential contributed by the residential market could reach at lowest 7,01 GW and highest 24,86 GW in Jakarta. A comprehensive analysis on this result will be further elaborated in sub-section 4.4.

4.2. Scenarios versus Set Governmental Targets

This section discusses the findings and calculation to assess the performance and trajectory for residential solar PV in Jakarta against governmental targets. As described in sub-section 3.1.2., the Indonesian government has set residential solar PV targets spanning to 2028 and through the NDC targets, to 2030. There are mainly two targets that the government has set, a baseline target which aims additional solar PV power, as well as an ambitious target which aims for a higher customer reach (see Table 15 and Table 16). The baseline target specifically relies on increasing current residential solar PV capacity, with the aid of possible new residential solar PV users to achieve such goal. Comparatively, the ambitious target focuses more on new residential solar PV market customer reach, and does not rely on the current market. This target is precisely aligned with the Million Solar Roof National Movement (GSSRN) initiative. While these targets are closely related, they are entirely separate from one another and are not to be compared directly. As both targets uses different units, the values set for the 'Ambitious Target' are not considered as values set on top of the 'Baseline Target'.

Table 15. Governmental Solar PV Baseline Target

Target	Indonesia	Jakarta
Baseline	Additional 3.200MW (3.200.000kW)	Additional 1.045,06MW (1.045.060kW)

Source: Author's own elaboration based on Literature Review

Table 16. Governmental Solar PV Ambitious Target

Target	Indonesia	Jakarta
Ambitious	Additional 1.600.000 customers (with minimum 2kW solar panel installed)	Additional 522.532 customers (with minimum 2kW solar panel installed)

Source: Author's own elaboration based on Literature Review

Furthermore, the targets are calculated under two scenarios, a business as usual scenario which follows residential solar PV growth trend, as well as government expected scenario which see at least 20% of higher income household to install residential solar PV by 2028. A comprehensive analysis of the outcome of this calculation will be further elaborated in sub-section 4.4.

In order to calculate the trajectory of residential solar PV performance in Jakarta, this research gathered data from Global Solar Atlas (as explained in sub-section 3.1.2.) to collect solar radiation intensity and peak sun hour data (indicated in Table 17). 'Energy Loss' stated in the table refers to potential energy that will be absorbed during distribution from the customer to the PLN electricity grid and vice versa (IESR, 2019).

Table 17. Maximum Technical Potential for Residential Solar PV in Jakarta

Peak Sun Hour	4,00	hours
Direct normal irradiation	2.641,00	kWh/m2/day
Installed Solar Panel	2,00	kWp
Energy Produced by Solar Panel	8,00	kWh/m2/day
Energy Loss	6,40	20%
Energy Exported to PLN	4,48	kWh/m2/day
	134,40	kWh/m2/month
	1.612,80	kWh/m2/year

Source: Author's own elaboration based on Global Solar Atlas data; IESR, 2019; MEMR, 2019

Aside from the table above, forecasts until 2030 against the governmental targets were also conducted according to the portion of Jakarta's residential market in the current solar PV market (listed at 33% of the consumer market), as well as the city's average higher income residential growth (listed at 10,04% annual growth). This research considered a 95% confidence interval to take into account the probability of uncertainties that may occur which resulted in an upper and lower bound range. These assumptions made it possible to calculate trajectory of residential solar PV power and household growth towards the two set governmental targets (seen in Table 18 and Table 19).

Table 18. Projection of Residential Solar PV Power Trajectory Towards Governmental Baseline Target

Year	MWh/m2/year				
	S1 Upper Bound	**S1 Lower Bound**	**S2 Upper Bound**	**S2 Lower Bound**	**Target**
2018	321	321	11.729	11.729	1.045,06
2019	881	881	26.452	18.147	1.045,06
2020	1.189	1.075	37.600	27.561	1.045,06
2021	1.538	1.440	50.178	37.858	1.045,06
2022	2.040	1.859	60.446	45.585	1.045,06
2023	2.444	2.357	70.284	54.248	1.045,06
2024	2.838	2.756	80.506	61.430	1.045,06
2025	3.230	3.155	90.102	68.815	1.045,06
2026	3.625	3.554	98.514	75.147	1.045,06
2027	4.020	3.953	107.208	81.918	1.045,06
2028	4.416	4.352	114.589	87.433	1.045,06
2029	4.811	4.750	122.146	93.418	1.045,06
2030	5.207	5.149	128.357	98.080	1.045,06

Source: Author's own elaboration based on 2030 forecast calculation

As depicted in Table 18, indicated in the first scenario ("S1", business as usual scenario), that it is projected that by the end of 2020 the additional 1.045,06 MW governmental target would be achieved. It can be estimated that at least 1.075 MW can be expected according to current residential solar PV growth. However, a stark contrast is seen in the second scenario "S2" as the difference of trajectory in comparison to the target is significant. In comparison to S1, S2 seem impossible, considering the reality of the matter in terms of annual residential solar PV growth in Jakarta.

Table 19. Projection of Residential Solar PV Households Trajectory Towards Governmental Ambitious Target

Year	Households				
	S1 Upper Bound	S1 Lower Bound	S2 Upper Bound	S2 Lower Bound	Target
2018	199	199	7.273	7.273	522.532
2019	546	546	16.401	11.252	522.532
2020	737	667	23.314	17.089	522.532
2021	954	893	31.112	23.474	522.532
2022	1.265	1.153	37.479	28.264	522.532
2023	1.515	1.461	43.579	33.636	522.532
2024	1.759	1.709	49.917	38.089	522.532
2025	2.003	1.956	55.867	42.668	522.532
2026	2.248	2.204	61.083	46.594	522.532
2027	2.493	2.451	66.473	50.792	522.532
2028	2.738	2.698	71.050	54.212	522.532
2029	2.983	2.945	75.735	57.923	522.532
2030	3.229	3.192	79.586	60.813	522.532

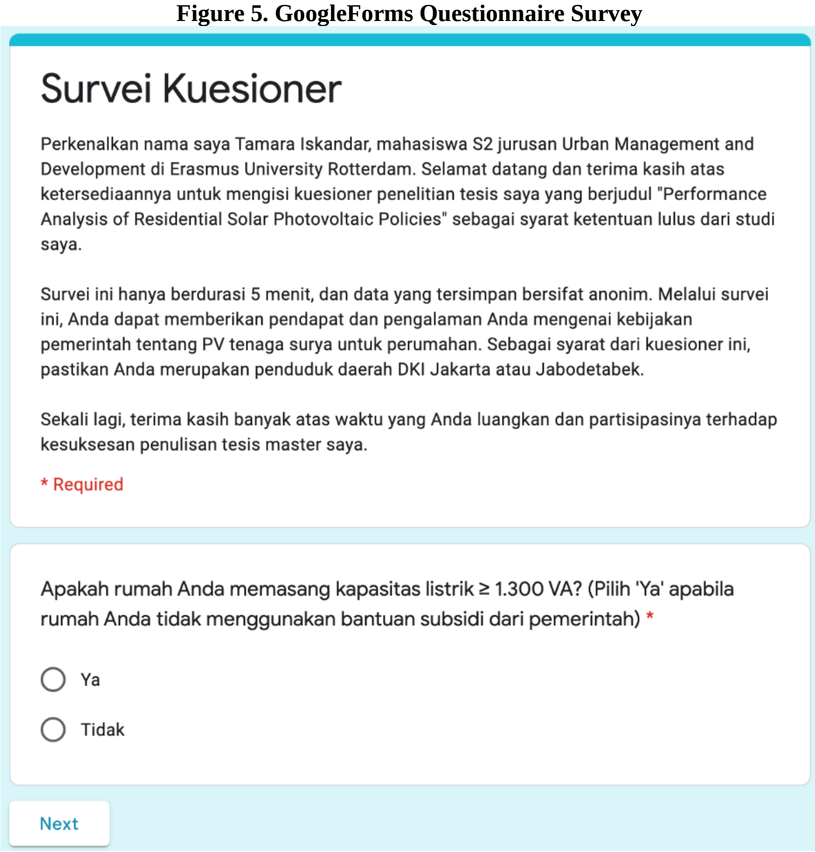
Source: Author's own elaboration based on 2030 forecast calculation

In Table 19, the trajectory for residential solar PV household growth in Jakarta is forecasted against the governmental target of an additional 522.532 households. The target aims to reach such household numbers by 2028 according to governmental expectations, or by latest 2030 seeing as it is the year in which the Indonesian NDC targets expire. However, as indicated in the table, both scenarios are incredibly lacking in achieving this ambitious target.

4.3. Market Potential

This section discusses the findings for research question #3, which is to determine what the market potential of residential solar PV in Jakarta is. As described in sub-section 4.1., there is a significant difference between the solar PV power potential and the reality of the number of residential solar PV installed in Jakarta, despite having the residential market as a major consumer group in the energy share. In order to investigate this issue, this research employed a questionnaire survey method to identify market preferences, characteristics and satisfaction level towards installing residential solar PV. Moreover, a comprehensive analysis of the questionnaire survey results will be further elaborated in sub-section 4.4.

Figure 5. GoogleForms Questionnaire Survey



Survei Kuesioner

Perkenalkan nama saya Tamara Iskandar, mahasiswa S2 jurusan Urban Management and Development di Erasmus University Rotterdam. Selamat datang dan terima kasih atas ketersediaannya untuk mengisi kuesioner penelitian tesis saya yang berjudul "Performance Analysis of Residential Solar Photovoltaic Policies" sebagai syarat ketentuan lulus dari studi saya.

Survei ini hanya berdurasi 5 menit, dan data yang tersimpan bersifat anonim. Melalui survei ini, Anda dapat memberikan pendapat dan pengalaman Anda mengenai kebijakan pemerintah tentang PV tenaga surya untuk perumahan. Sebagai syarat dari kuesioner ini, pastikan Anda merupakan penduduk daerah DKI Jakarta atau Jabodetabek.

Sekali lagi, terima kasih banyak atas waktu yang Anda luangkan dan partisipasinya terhadap kesuksesan penulisan tesis master saya.

* Required

Apakah rumah Anda memasang kapasitas listrik ≥ 1.300 VA? (Pilih 'Ya' apabila rumah Anda tidak menggunakan bantuan subsidi dari pemerintah) *

Ya

Tidak

Next

Source: Author's own Questionnaire Survey (Accessible through: http://bit.ly/BantuTamaraLulus)

Prior to the final questionnaire survey distribution, a pilot survey was conducted to assess the survey completion time, as well as to gather feedbacks on unclear questions or options for answers. This survey was completed on June 21st 2020 and received a total of 52 respondents. Further revisions were made based on these inputs and assessments, in which the final version of the survey was distributed on June 24th – July 10th 2020 where it received 421 respondents (final version of the survey can be seen in Annex). Furthermore, the survey was created and accessible through a shortened GoogleForms link at: http://bit.ly/BantuTamaraLulus (depicted in Figure 5), which was written in Bahasa Indonesia and distributed via various means of social media such as Facebook, LinkedIn, WhatsApp, Instagram, and LINE. Afterwards, the data was processed in Microsoft Excel and SPSS for further analysis.

Table 20. Valid and Invalid Responses

Compiled	421
Minimum Responses	273
Invalid Responses	64
Valid Responses	357

Source: Author's own elaboration with Questionnaire Survey data

The sample size that were required for the questionnaire survey targeted residents residing in Jakarta, has a household floor area of ≥ 45 m^2, and has installed electricity capacity of ≥ 1.300 VA (as previously described in sub-section 3.1.1.1. and 3.1.2.). While the number of respondents acquired was higher than the minimum respondents needed (273 respondents for confidence level 90% according to the population size), not all compiled responses were valid (depicted in Table 20). Out of the 421 responses, a total of 64 responses were omitted from the data analysis as there were incomplete data recorded in the system. However, the number of valid responses were still higher than the required data. Therefore for the sake of this research, the researcher decided to utilize all data from 357 respondents as it will increase the confidence level of the research.

Following the questionnaire survey, the results collected were processed using the Pearson Product Moment Validity test to determine whether the method employed in asking questions accurately measures the intended aim of the research (shown in Annex 2). For the validity test, a 5% significance level with degree of freedom (df) of 355 accordingly to the number of N = 357 respondents was set. The r-table product moment value of 0.036 was therefore determined from these variables in which it was then compared to the r values computed from the questions. If the r-value of the computed calculation is higher than the r-table value, then the item is determined to be valid. An additional checking method is to compare the significance value of the research with the 0.05 significance level. If the computed significance level of the research is below the significance level then the item is also determined to be valid. In this research, all questions fulfilled both criteria, therefore the questions employed through this method are valid.

Table 21. Installed vs Yet to Install Residential Solar PV

Have you installed residential solar PV in your rooftop?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	320	89,6	89,6	89,6
	Yes	37	10,4	10,4	100,0
	Total	357	100,0	100,0	

Source: Author's own elaboration with Questionnaire Survey data using SPSS

Table 21 summarizes the number of percentages of households that participated in this research which has or has yet to install residential solar PV in Jakarta. According to the table, majority of the households, as much as 89,6% of them, have not yet installed residential solar PV in their rooftops. This indicates that the respondents participated in this study is of the ratio of Installed Households 1 : Yet to Install Households 9.

Table 22. Factor Influencing Decision to Install Residential Solar PV

		Not at all important	Slightly important	Moderately important	Important	Very important	Score
		How important is **'reducing electricity bills'** as a factor to install residential solar PV in your rooftop?					
Have you installed residential solar PV in your rooftop?	No	2	34	71	142	71	1206
	Yes	0	3	8	19	7	141
Total		2	37	79	161	78	1347
		How important is **'reducing energy consumption'** as a factor to install residential solar PV in your rooftop?					Score
Have you installed residential solar PV in your rooftop?	No	5	30	80	155	50	1175
	Yes	1	0	4	20	12	153
Total		6	30	84	175	62	1328
		How important is **'reducing carbon footprint'** as a factor to install residential solar PV in your rooftop?					Score
Have you installed residential solar PV in your rooftop?	No	6	36	84	125	69	1175
	Yes	1	1	0	10	25	168
Total		7	37	84	135	94	1343
		How important is **'better electricity dependence (less likely to experience blackouts from grid)'** as a factor to install residential solar PV in your rooftop?					Score
Have you installed residential solar PV in your rooftop?	No	0	34	84	137	65	1193
	Yes	1	3	21	4	8	126
Total		1	37	105	141	73	1319

Source: Author’s own elaboration with Questionnaire Survey data using SPSS

Table 22 shows the number of respondents according to whether they have or have not installed residential solar PV in their households and their perspective on factors that influenced or would influence their decision to install rooftop solar PV. The four factors depicted in this table are “reducing electricity bills”, “reducing energy consumption”, “reducing carbon footprint”, and “better electricity dependence”. These factors were chosen according to previous studies through literature review.

The questions are presented with Likert-Scale answers for ease of calculation, processing, and analysis (an explanation on the use of Likert Scale on multiple choice answers are elaborated in sub-section 3.1.2.). As shown in the table, “reducing electricity bills” has the highest cumulative score which indicates that it is an integral factor for residential solar PV decision making in Jakarta. For respondents that have not installed rooftop solar PV, “reducing electricity bills” also scored highest. Respondents that have installed rooftop solar PV, however, scored highest with “reducing carbon footprint” as their decision making factor when installing solar PV. The differences in perspective therefore gives an idea on priorities for each group.

Table 23. Other Factors Influencing Decision to Install Residential Solar PV

Are there other factors (not listed above) that contributed as a reason to install residential solar PV in your rooftop?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Aesthetic / Design	3	0,8	0,8	0,8
	Cost concerns	2	0,6	0,6	1,4
	Ease of installation, maintenance, and use	3	0,8	0,8	2,2
	No	317	88,8	88,8	91,0
	Payback period	17	4,8	4,8	95,8
	Practicality / Efficiency	2	0,6	0,6	96,4
	Reliable vendors	3	0,8	0,8	97,2
	Trend / Hype	3	0,8	0,8	98,0
	Willingness to transition to clean sustainable energy	7	2,0	2,0	100,0
	Total	357	100,0	100,0	

Source: Author's own elaboration with Questionnaire Survey data using SPSS

As indicated in Table 23, while most of the respondents answered that they do not have other factors that may influence their decision to install residential solar PV, 11,2% of respondents suggested otherwise. Various answers were collected, however for the sake of this research, categorization of the answers were done and further classified into 8 factors. Out of this 11,2%, "Payback Period" is shown to be the highest scoring factor for residential solar PV decision making.

Table 24. Expected Payback Period

To or when installing solar PV in your household, what do or did you expect your payback period to be?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	≥ 15 years	10	2,8	2,8	2,8
	1 - 5 years	220	61,6	61,6	64,4
	10 - 15 years	13	3,6	3,6	68,1
	5 - 10 years	114	31,9	31,9	100,0
	Total	357	100,0	100,0	

Source: Author's own elaboration with Questionnaire Survey data using SPSS

Table 24 shows the average payback period expected by households when investing in rooftop solar PV. From the table, it is indicated that an overwhelming number of respondents expected their payback period to be within 1-5 years. A considerable portion of the respondents also chose a more realistic payback period of 5-10 years, considering the current average payback period in Indonesia to range around 8-12 years.

Table 25. Reasons to Not Install Residential Solar PV
Why have you not installed residential solar PV in your rooftop?

		Frequency	Valid Percent	Cumulative Percent
Valid	Missing (N/A)	37	10,4	10,4
	Bureaucracy is too complicated	27	7,6	17,9
	Expensive investment (long payback period)	118	33,1	51,0
	I do not have sufficient knowledge on the matter	156	43,7	94,7
	Not within my interest/irrelevant	19	5,3	100,0
	Total	357	100,0	

Source: Author's own elaboration with Questionnaire Survey data using SPSS

Table 25 summarizes answers to why respondents who have not installed residential solar PV installed rooftop solar PV. The "missing" variable in this table refers to the number of respondents that have installed the system and therefore are not required to answer this question. According to the table, a significant number of respondents picked "I do not have sufficient knowledge on the matter" and "Expensive investment" as their reason for not installing solar PV.

Table 26. Source of Information on Residential Solar PV
Where have you received information on residential Solar PV?

		Frequency	Valid Percent	Cumulative Percent
Valid	Direct mouth to mouth information	68	19,0	19,0
	Housing advertisements (brochures, exhibitions)	23	6,4	25,5
	I have never received information on this matter	10	2,8	28,3
	Mass media (television, news, websites, social media, etc)	184	51,5	79,8
	Seminars/conferences, scientific publications (journals, articles)	65	18,2	98,0
	Work or study related information	7	2,0	100,0
	Total	357	100,0	

Source: Author's own elaboration with Questionnaire Survey data using SPSS

Table 26 indicates the sources of information that the respondents of this research have received regarding residential solar PV. It is suggested from the data collected that an overwhelming number of respondents have received their information via "Mass media" through various forms of mass media such as television broadcasts, news, websites, and social media, among others.

Table 27. Satisfaction Level for Current Residential Solar PV Regulation
Are you satisfied with current residential solar PV regulation?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all satisfied	47	13,2	13,2	13,2
	Slightly satisfied	106	29,7	29,7	42,9
	Moderately satisfied	157	44,0	44,0	86,8
	Satisfied	35	9,8	9,8	96,6
	Very satisfied	12	3,4	3,4	100,0
	Total	357	100,0	100,0	

Source: Author's own elaboration with Questionnaire Survey data using SPSS

Table 27 summarizes data on the satisfaction level of respondents on current residential solar PV Regulation. The data suggests that current regulation received a less than ideal and lukewarm response with "Moderately satisfied" and "Slightly satisfied" as the highest scored answers respectively.

Table 28. Respondent Recommendation on Government Action Towards Residential Solar PV
What do you think the government should do to encourage residential solar PV investment?

		Frequency	Valid Percent	Cumulative Percent
Valid	Better spread of residential solar PV information to the public	146	40,9	40,9
	Encourage financing institutions to issue instalment schemes for rooftop solar with interesting packages	48	13,4	54,3
	Improve net-metering scheme (such as to 100% compensation (1:1))	63	17,6	72,0
	Provide incentives for residential solar PV users (such as land tax reduction, etc)	100	28,0	100,0
	Total	357	100,0	

Source: Author's own elaboration with Questionnaire Survey data using SPSS

Table 28 summarizes data on respondent recommendation on government action to encourage solar PV investment among the residential market. Four main actions are presented in the questions and these action were chosen based on previous studies through literature review. According to the table, a significant portion of the respondents agreed that "Better spread of residential solar PV information to the public" should be an action to be taken account of by the government. This corresponds with the results as depicted in Table 25 as most respondents that have yet to install solar PV do not have sufficient information on the matter. Furthermore, a considerable amount of respondents also agree to recommend the government to "Provide incentives for residential solar PV users" as a way to encourage investments.

Table 29. Respondent Interest on Installing Residential Solar PV based on Current Regulation

According to current regulation, would you be interested in installing residential solar PV in your household?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all interested	2	0,6	0,6	0,6
	Slightly interested	52	14,6	16,3	16,9
	Moderately interested	126	35,3	39,4	56,3
	Interested	112	31,4	35,0	91,3
	Very interested	28	7,8	8,8	100,0
	Total	320	89,6	100,0	
Missing	System	37	10,4		
Total		357	100,0		

Source: Author's own elaboration with Questionnaire Survey data using SPSS

Table 29 summarizes data for the respondent interest on installing residential solar PV according to the current regulation. Based on the data above, it is suggested that 35,3% and 31,4% of households are "Moderately interested" and "Interested" respectively to install rooftop solar PV despite the current condition of the existing regulation.

Looking back and comparing Table 29 to Table 27, it is recorded that the respondent's interest are marked higher than the satisfaction level of residential solar PV regulations. This indicates that the potential to install residential solar PV is positively skewed, even without the need of better regulations and program. This suggestion is further reinforced by Table 28 where simply a more adequate information provision or a more appropriate information dissemination procedure would already help to increase PV system installation. A further elaboration is provided in section 4.4.

Table 30. Changes in Respondent Interest on Installing Residential Solar PV

If better regulations and programs are put in to place by the government, would you be interested to install residential solar PV?

		Frequency	Percent	Valid Percent	Cumulative Percent	Previous Frequency	Changes
Valid	Not at all interested	2	0,6	0,6	0,6	2	=
	Slightly interested	15	4,2	4,2	4,8	52	12%
	Moderately interested	83	23,2	23,2	28,0	126	16%
	Interested	160	44,8	44,8	72,8	112	10%
	Very interested	97	27,2	27,2	100,0	28	18%
	Total	357	100,0	100,0	100,0	357	

Source: Author's own elaboration with Questionnaire Survey data using SPSS

Table 30 shows the data on the changes in respondent interest on installing residential solar PV if better regulations and programs are put in place by the government. The question that was asked in this table is an combination and extension of the previous two questions. From this table, several changes can be seen. The number of households that previously chose "Slightly interested" and "Moderately interested" have decreased, whereas the number of households that previously chose "Interested" and "Very interested" have increased when presented with better regulations and programs to encourage residential solar PV investment. This suggests that there is a positive shift in interest by 28%, leading up to potential untapped residential market if changes were to be made by the government. However, it should also be noted that better information campaigns also have the potential to increase residential solar PV share, as explained previously. Hence, a more optimal approach would be to introduce user-preferred policy changes such as providing incentives for solar PV users (as suggested in Table 28), as well as an improved information dissemination by the government on residential solar PV.

4.4. Analysis

In order to provide a comprehensive analysis on the performance of residential solar PV policies in Jakarta, combining all elements and results of each variables are necessary.

Calculations on the residential solar PV power in Jakarta indicates a minimum of 7,01 GW to 24,86 GW technical potential depending on the slope of roof and accessibility due to differences in climate condition and shading. Current installations of the residential market in Jakarta amounts up to 0,06 MW, which suggests a 100% difference in the reality versus potential of residential solar PV installations. The disparity in power signifies that the current residential market has yet to live up to its possible capabilities.

Contrarily, when projected against the additional 1.045,06 MW or 1,05 GW governmental target in Jakarta, it is estimated that by the end of 2020 based on current residential solar PV growth, the expected additional solar PV power will exceed that target by 0,03 GW to 0,14 GW (according to S1 LB and S1 UB, respectively), and continue to grow up to five folds by 2030. This suggests that current performance of residential solar PV growth is on track with the baseline target, which implies that current policies are sufficient in attracting residential investors, at least for this specific target.

Nevertheless, when projected against the ambitious governmental target of additional 522.532 by 2028 or latest 2030, estimations fall short to only being able to fulfil those targets by at least an additional 3.192 households or 0,61% according to the business as usual scenario, or at most 79.586 households or 15,23% according to the government expected 20% of high income households installing residential solar PV prediction. However, it should be highlighted that although the targets use different units (baseline target in GW and Ambitious Target in number of households), both work hand in hand with each other. The ambitious target focuses specifically on a set number of residential solar PV household increase (at 522.532 households) each installing 2kW solar panel, which would cumulatively reach up to 1,05GW (which is the baseline target). That being said, if the amount of households added in the ambitious target calculation are converted to residential solar PV capacity, it is indicated that the 1,05GW target is achievable by the end of 2023 (under the assumption that each household installs 2kW solar panel).

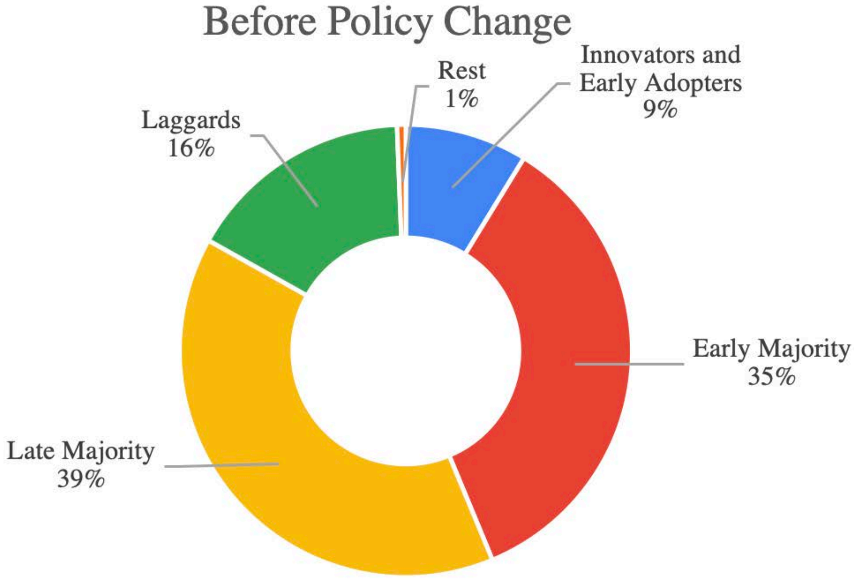
The contrast between trajectories for residential solar PV towards governmental targets implies that while current trajectory fulfils the baseline target, it is still leaps and bounds away from achieving the more impactful ambitious target. Linking this finding to the calculated technical potential of residential solar PV power, this suggests that existing policies are currently suboptimal in achieving targets and in harnessing its residential market's potential power.

Aside from that, results from the questionnaire survey could reveal market perspectives and suggestions on how to tackle and utilize residential solar PV potential in Jakarta. A general consensus on satisfaction level of the residential market indicates that they are not quite satisfied with the performance and framework of the current solar PV policy. Reasons to why majority of the Jakarta residential market have yet to install solar PV is especially due to the lack of information as well as the expensive investment and long payback period needed for the system (refer to Table 25). In addition to that, crucial decision making factors influencing their decision to install rooftop solar PV mostly depends on the capability of the system to reduce electricity bills for households that have yet to install solar PV, together with the desire to reduce carbon footprint for households that have installed residential solar PVs. Therefore, in order to increase residential market interest to invest in solar PV, according to the respondents, the recommended government action should be make use of intriguing and attractive campaigns to disseminate adequate information on residential solar PV, especially through mass media, being that it is the most frequent source of information used by the respondents.

Expected payback period puts market anticipation at 1 – 5 years or at the latest 5 – 10 years. Current average payback period of residential solar PV in Jakarta puts the range at approximately 8 – 12 years. While the expected range is not so far below, in order to optimally capture potential residential market, adjustments to the solar PV policy framework is necessary. Hence, seeing that cost concerns is an imperative variable in the decision making process, respondents have also proposed the government to provide incentives for residential solar PV users, such as through land tax reductions or other options regarding tax relief. By implementing these actions, subsequently market perspective have also shifted into a more positive prospect.

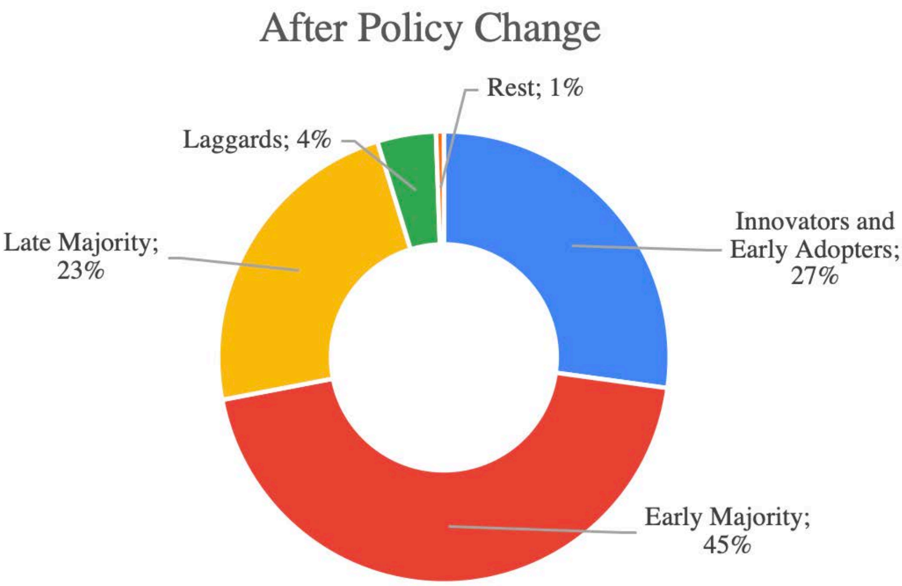
According to Rogers (1983), there are five types of market adoption segments; Innovators, Early Adopters, Early Majority, Late Majority, and Laggards. Innovators are people who want to use a product for the reason of the product being simply new. Early adopters are people that actually benefits from the use of a new product or service by researching new products and information. For this research, following previous research by Citraningrum (2019) and IESR (2019), innovators are combined into one category with early adopters as they are considered as people who have high probability of adopting new technology within a short amount of time. Meanwhile, the early majority are groups that uses the products after they have trended or have been fairly adopted. This group makes decisions based on ease of use and practicality. The late majority shares similarity with the previous group, however they are more careful when switching or implementing change. Laggards, are people that slowly adapts to new ideas or technologies. They tend to change only when the vast majority has changed. Lastly, for this research, an additional market segment is added, named ‘Rest’. This market segment is adopted based on research done by Citraningrum (2019). This group consists of people unwilling to change despite trends or market perspective.

Graph 6. Customer Adoption Market Potential Before Policy Change



Source: Author’s own elaboration with Questionnaire Survey data

Graph 7. Customer Adoption Market Potential After Policy Change



Source: Author’s own elaboration with Questionnaire Survey data

Graph 6 shows the customer adoption market potential before residential solar PV policy changes are made. This data is a conversion from Table 29, where it asks whether respondents would be interested with the current residential solar PV policy framework. Based on their interest levels, they are then categorized according to the customer adoption market segments, following previous research by IESR (2019) and Citraningrum (2019). It can be seen that the bulk of the residential market in Indonesia would be categorized into the ‘Late Majority’ group.

This suggests that current residential market would need a considerable amount of time before it can finally boom and achieve its potential.

On the other side, Graph 7 shows potential customer adoption market after residential solar PV policy changes such as providing incentives for residential solar PV users are made. The majority of the market is categorized to be ‘Early Majority’, with a significant increase in the ‘Innovators and Early Adopters’ group. This graph is a conversion based on a comparison made on the interest of respondents before and after policy changes (seen in Table 30).

As depicted in Graph 6 and Graph 7, there is a positive shift in perspective resulting in potential market growth before and after policy changes. By using eligible household data (as indicated in Table 12) in Jakarta of 2.001.327 households, the market potential for residential solar PV amounts to 72% (sum of innovators and early adopters, as well as early majority) reaching 1.440.731 users. Additionally, notwithstanding this, simply taking account early adopters with 27% of immediate market potential, would result in increased users by 543.778 households. Therefore, by implementing policy changes, the outcome of this change would effectively realize the government’s ambitious target of adding minimum 522.532 households by 2028. However, it is also important to note that adequate spread of information and campaigns promoting the use of residential solar PV is crucial in altering the interest of the residential market in investing in solar PV.

Chapter 5: Conclusion

This study aims to analyse performance of current residential solar PV policies. Through a sequence of research methods, combining primary (close-ended questionnaire surveys) and secondary data, the technical potential, scenario forecasts towards governmental targets, and market potential analysis regarding residential solar PV in Jakarta are obtained. Previously in Chapter 4, the results of each data process and analysis were presented. In this chapter, further discussion and recommendations on the results and findings will be elaborated.

5.1. Description of the Case

Indonesia is ASEAN's largest consumer of electricity, accounting for up to 40% of total energy consumption in the region (IRENA, 2017). 70% of that energy share are absorbed by the Java-Bali electricity grid (Indonesian Ministry of National Development Planning, 2014). In addition, the residential market amounts to 42% of national electricity sales, making the market a critical variable to energy consumerism in Indonesia (PLN, 2019).

Jakarta, situated in the northwest coast of Java, is Southeast Asia’s largest metropolitan city and Indonesia’s capital city, making it the highest populated area and therefore the largest electricity consumer in the country (Indonesian Ministry of National Development Planning, 2019). While Indonesia’s solar energy potential is exponentially high compared to other countries (research estimates approximately 207.9 GW national rooftop solar energy potential), in reality only 16.6 MW (11%) were produced from residential rooftop solar PV nationally, in which the Greater Jakarta area accounts up to a mere 0.06 MW (IESR, 2019; MEMR, 2019).

With a significant difference between solar energy potential versus reality of the matter on hand, coupled with rising global concerns on climate change, in 2014 the Indonesian government adopted Government Regulation No. 79/2014 on National Energy Policy addressing the urgency to lower non-renewable energy dependence and grow renewable energy share mix and use to 29% by 2030. One of the outputs of this governmental regulation is the current MEMR Regulation No. 49/2018 which specifically regulates matters concerning rooftop solar PV. Correspondingly, solar energy targets were made by the government in order to achieve the 29% energy mix target and to support the utilization of the solar energy policy. For that reason, calculation on the technical potential of residential solar PV power in Jakarta, 2030 scenario forecast on the targets, as well as a market potential analysis on residential solar PV market in Jakarta is necessary to analyse whether current residential solar PV policies are successful in harnessing potential residential solar PV power in Jakarta.

5.2. Discussions

The first research question aims to estimate the maximum technical potential of residential solar PV in Jakarta. From the study, it can be determined that current installed residential solar PV capacity is still far from achieving even the minimum technical potential. Out of the identified range of 7,01 GW – 24,86 GW residential solar PV technical potential, only 0,06 MW is currently installed (refer to Table 14). With this tremendous gap in capacity, it will require a lot of catching up. Furthermore, this also indicates inadequate effort from the government to push for higher solar PV capacity, as well as ineffective solar PV policies resulting in the lack of enthusiasm from the residential market.

The second research question aims to deduce whether current policies and programs/plans on track and aligned with governmental residential solar PV targets. From the calculations, it was established that residential solar PV trajectory for installed capacity would grow and even exceed the governmental target of additional 1.045,06MW by the end of 2020 (refer to Table 17). However, the same could not be said for the trajectory for household growth against governmental target of additional 522.532 households by 2028. According to this estimation, even with the best scenario condition by end of 2030, household growth will only be able to gain only 15,28% of the target (refer to Table 18). While one out of two targets are fulfilled, this indicates a lacklustre effort from the government, thus resulting in a suboptimal outcome.

Furthermore, with projections for the baseline target to achieve its goal by the end of 2020, and the conversion to residential solar PV capacity by the ambitious target numbers also fulfilling the baseline target only by 2023, it can be pointed out that the minimum requirement of 2kW per household by the ambitious target is considered pessimistic. Hence, it can be concluded from the above findings that the existing residential solar PV policies are inadequate in harnessing potential residential solar PV capacity in Jakarta.

As a continuation of the previous research questions, the third research question aims to identify the market potential of residential solar PV in Jakarta. Through this process, the research would provide complementary study on the reason behind the capacity gap and possible suggestions for the government to increase market potential. The current residential market is unsatisfied with the performance of existing residential solar PV policies and have also expressed their inadequate understanding in solar PV due to lack of information on the subject. Furthermore, most of the market considers cost concerns such as expensive initial investment and payback period as a barrier for them to install rooftop solar systems in their household. Therefore from the questionnaire survey it was suggested that government action such as employing residential solar PV campaigns in the mass media would garner higher residential market interest.

Aside from that, policy changes such as providing incentives for residential solar PV would immediately increase residential market potential by 27%, fulfilling the ambitious additional 522.532 household government target. Moreover, after a few years of the policy adoption, an increase of 45% in market potential can be expected, bringing an additional 896.953 households on top of the previous addition. However, tying this back to the questionnaire survey, this outcome would only prove to be successful under the condition that residential solar PV information is adequately disseminated and communicated purposively to the potential users through the means of mass media distribution.

5.3. Conclusion

The main objective of this research is to analyse the performance of current residential solar PV policies in Jakarta by identifying technical potential of residential solar PV power in Jakarta, assessing the projection of current RE plans on residential solar energy towards meeting governmental goals, as well as identifying market potential of residential solar PV power in Jakarta.

From the study, it was identified that Jakarta's residential solar PV power has a technical potential of reaching 7,01GW to 24,86GW. This number is incredibly far from the reality of only 0,06MW (0,00006GW) that is currently installed. Furthermore, current trajectory of residential solar PV power and household growth projects that it will be able to achieve the baseline target of additional 1,05GW by the end of 2020. However, the same cannot be said for the ambitious target of adding 522.532 new solar PV household users, as it lags behind significantly even by the deadline of 2030. Furthermore, this research also identified an increase of up to 27% in the initial inception of policies such as providing incentives for residential solar PV users, and a further additional 45% increase in the following years. Nevertheless, it is imperative to highlight that this increase in market potential can only be realized with adequate dissemination and communication of the residential solar PV policies and programs by the government.

5.4. Suggestions for Future Research

This research analysed the performance of residential solar PV policies in Jakarta, as well as provided explanation why there is such a tremendous difference between the current residential solar PV capacity and the technical potential power, and recommended government action and policy to increase the residential market interest. Nonetheless, this research has its own limitations in which there are other subjects that can be further developed for future research.

1. This research employed the constant-value method, as it serves as a good starting point for solar PV research. However, this method is not the most accurate, and generalizes characteristics in the variables used in the research. Therefore, use of other specific methods such as the manual selection or GIS-based method would provide a more accurate and personalized result for Jakarta.
2. Due to time constraints and limited resources, the study only focuses its case on Jakarta only. It will be an asset for future researchers to study other cities, and provide their insights and perspective on residential solar PV.
3. This research also only investigates the residential segment in the solar PV market in Indonesia. Seeing that there are other segments that influence the energy share market such as the business and industrial segment, it will be valuable for future researchers to explore other segments as well.

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Annex 1: Questionnaire Survey

No.	Residential Solar PV Market Potential in Greater Jakarta Survey

1.	Is your household installed electricity capacity ≥ 1.300 VA?	
	a.	Yes
	b.	No
2.	Is your household type ≥ 45m2?	
	a.	Yes
	b.	No
3.	Have you installed residential solar PV in your rooftop?	
	a.	Yes
	b.	No
- For the following questions, please choose an answer that relates to you the most -		
4.	(If Yes) How important is '**reducing electricity bills**' as a factor to install residential solar PV in your rooftop?	
	a.	Extremely important
	b.	Very important
	c.	Moderately important
	d.	Slightly important
	e.	Not at all important
5.	(If Yes) How important is **'reducing energy consumption'** as a factor to install residential solar PV in your rooftop?	
	a.	Extremely important
	b.	Very important
	c.	Moderately important
	d.	Slightly important
	e.	Not at all important
6.	(If Yes) How important is **'reducing carbon footprint'** as a factor to install residential solar PV in your rooftop?	
	a.	Extremely important
	b.	Very important
	c.	Moderately important
	d.	Slightly important
	e.	Not at all important
7.	(If Yes) How important is **'better electricity dependence (less likely to experience blackouts from grid)'** as a factor to install residential solar PV in your rooftop?	
	a.	Extremely important
	b.	Very important
	c.	Moderately important
	d.	Slightly important
	e.	Not at all important

8.	(If Yes) Are there other factors (not listed above) that contributed as a reason to install residential solar PV in your rooftop?	
	a.	No
	b.	Yes (Please elaborate)
9.	(If Yes) With compensation of 65% per month from your electricity bills, current residential solar PV investment is estimated to be Rp 13.000.000,- to Rp 18.000.000,- per 1 kWp (minimum amount) with decreasing price trends in the upcoming years.	
	When installing solar PV in your household, what did you expect your payback period to be?	
	a.	1 - 5 years
	b.	5 - 10 years
	c.	10 - 15 years
	d.	$\geq$ 15 years
10.	(If No) How important is **'reducing electricity bills'** as a factor influence your decision to install residential solar PV in your rooftop?	
	a.	Very important
	b.	Important
	c.	Moderately important
	d.	Slightly important
	e.	Not at all important
11.	(If No) How important is **'reducing energy consumption'** as a factor influence your decision to install residential solar PV in your rooftop?	
	a.	Very important
	b.	Important
	c.	Moderately important
	d.	Slightly important
	e.	Not at all important
12.	(If No) How important is **'reducing carbon footprint'** as a factor influence your decision to install residential solar PV in your rooftop?	
	a.	Very important
	b.	Important
	c.	Moderately important
	d.	Slightly important
	e.	Not at all important
13.	(If No) How important is **'better electricity dependence (less likely to experience blackouts from grid)'** as a factor influence your decision to install residential solar PV in your rooftop?	
	a.	Very important
	b.	Important
	c.	Moderately important

	d.	Slightly important
	e.	Not at all important
14.	(If No) Are there other factors (not listed above) that may contribute as a factor to influence your decision to install residential solar PV in your rooftop?	
	a.	No
	b.	Yes (Please elaborate)
15.	(If No) Why have you not installed residential solar PV in your rooftop?	
	a.	Expensive investment (long payback period)
	b.	Bureaucracy is too complicated
	c.	Not within my interest/irrelevant
	d.	I do not have sufficient knowledge on the matter
	e.	Others (please elaborate)
16.	(If No) Current regulations mandates 65% compensation towards your electricity bill per month (net-metering scheme 1:0,65) and allows up to 3 months electricity surplus accumulation (MEMR Regulation No. 49/2018)	
	According to this regulation, would you be interested in installing residential solar PV in your household?	
	a.	Very interested
	b.	Interested
	c.	Moderately interested
	d.	Slightly interested
	e.	Not at all interested
17.	(If No) With compensation of 65% per month from your electricity bills, current residential solar PV investment is estimated to be Rp 13.000.000,- to Rp 18.000.000,- per 1 kWp (minimum amount) with decreasing price trends in the upcoming years.	
	To install solar PV in your household, realistically what would you expect your payback period to be?	
	a.	1 - 5 years
	b.	5 - 10 years
	c.	10 - 15 years
	d.	≥ 15 years
18.	Where have you received information on residential Solar PV?	
	a.	Mass media (television, news, websites, social media, etc)
	b.	Direct mouth to mouth information
	c.	Housing advertisements (brochures, exhibitions)
	d.	Seminars/conferences, scientific publications (journals, articles)
	e.	Others (please elaborate)
19.	Are you satisfied with current residential solar PV regulation?	
	a.	Very satisified

	b.	Satisified
	c.	Moderately satisified
	d.	Slightly satisified
	e.	Not at all satisfied
20.	What do you think the government should do to encourage residential solar PV investment?	
	a.	Better spread of residential solar PV information to the public
	b.	Improve net-metering scheme (such as to 100% compensation (1:1))
	c.	Provide incentives for residential solar PV users (such as land tax reduction, etc)
	d.	Encourage financing institutions to issue instalment schemes for rooftop solar with interesting packages
	e.	Others (please elaborate)
21.	If better regulations and programs are put in to place by the government, would you be interested to install residential solar PV?	
	a.	Very interested
	b.	Interested
	c.	Moderately interested
	d.	Slightly interested
	e.	Not at all interested

Source: Author's own elaboration

Annex 2: Pearson Product Moment Validity Test

Correlations (Pearson Product Moment Validity Test)								
		1	2	3	4	5	6	7
1	Pearson Correlation	1	.574**	.429**	.430**	.356**	.275**	.182**
	Sig. (2-tailed)		0,000	0,000	0,000	0,000	0,000	0,001
2	Pearson Correlation	.574**	1	.616**	.413**	.399**	.188**	.241**
	Sig. (2-tailed)	0,000		0,000	0,000	0,000	0,000	0,000
3	Pearson Correlation	.429**	.616**	1	.360**	.498**	.219**	.276**
	Sig. (2-tailed)	0,000	0,000		0,000	0,000	0,000	0,000
4	Pearson Correlation	.430**	.413**	.360**	1	.401**	.125*	.296**
	Sig. (2-tailed)	0,000	0,000	0,000		0,000	0,018	0,000
5	Pearson Correlation	.356**	.399**	.498**	.401**	1	.251**	.499**
	Sig. (2-tailed)	0,000	0,000	0,000	0,000		0,000	0,000
6	Pearson Correlation	.275**	.188**	.219**	.125*	.251**	1	.119*
	Sig. (2-tailed)	0,000	0,000	0,000	0,018	0,000		0,024
7	Pearson Correlation	.182**	.241**	.276**	.296**	.499**	.119*	1
	Sig. (2-tailed)	0,001	0,000	0,000	0,000	0,000	0,024	
**. Correlation is significant at the 0.01 level (2-tailed).								
*. Correlation is significant at the 0.05 level (2-tailed).								

Source: Author's own elaboration with Questionnaire Survey data using SPSS

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