Natural gas transportation business contribution to Indonesia’s national energy policy and carbon emission offset by on-grid solar PV utilization: Surabaya, East Java, Indonesia

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Abstract. Corporations need to assess their practices in environmental management. PT Pertamina Gas, as energy SOE which runs natural gas transportation, is considered to contribute to National Energy Policy particularly in terms of achieving 23% part of the energy mix by renewable resources. Pertamina Gas Operation East Java Area transports natural gas in a 370 km subsea pipeline to 69 km onshore. It needs 1,459.73 GJ for supporting facilities derived from electricity and fuel in 2019 alone. This study aims to analyze energy management practices in the natural gas business with related policies. The 5.25 kwp on-grid Solar PV utilization, an in-office area located in Surabaya, substitutes 3.3% electricity from state-owned provider source, as a result, 2% part of its energy mix profile fulfilled by renewable energy. It reached 7,281.1 kWh per year. Its cost and benefits analysis show positive cash flow in year-15; PI >1. Its levelized cost of energy (LCoE) is Rp 949.72, which is competitive enough to East Java electricity generation cost (BPP). It is followed by coal-based power carbon emission reduction to about 5.95 ton CO2 in a year. Thus, it is possible for East Java Area to contribute in corporate sustainability policy and to achieve the global goals.

1. Introduction
Energy is a fundamental need to support economic growth. In 2018, total final energy consumption (traditional biomass excluded) was approximately 114 MTOE derived from 40% transportation sector, 40%, 36% industry, 12% households, 6% commercial and 2% others [1]. PT Pertamina Gas, part of State-Owned Energy Holding Company, specifically Gas Sub-holding, running its business appropriately based on Law No. 22 the Year 2001 on Oil and Gas Article 3, Paragraph 6, “The purpose of oil and Gas business activities shall be to create job opportunities, increase the welfare and prosperity of the people fairly and equitably, and maintain the preservation of the living environment”. Mainly in mid-stream and down-stream, its operation area is widely located in East Kalimantan to North Sumatera. In particular, Operation East Java Area (Pertagas EJA) operates 370 km subsea pipeline to 69 km onshore pipeline to transport natural gas 230-250 MMSCF daily, to the national strategic industry such as fertilizer for 44%, power plant 32%, for commercial and other industries 24 %, and city gas below 0.001%.
Pertagas EJA secures gas supply through its pipeline infrastructure. It needs energy, particularly electricity and fuel to manage the distribution reliably. In 2019 alone, supporting facilities, specifically an office in Surabaya that includes an operation control station, consumed 1,459.73 GJ derived from electricity also fuel for power back up and vehicles. Based on the Law above (Article 40 Paragraph 5), the company’s environmental and social development responsibilities are reflected in the Corporate Sustainability Policy. The policy exists to ensure the company runs its operation environmentally and socially comply as stipulated in the Law. Specifically, for environmental aspects, as it is set in Ministry Regulation of Environment and Forestry No. 3 the Year 2014 on Corporate Environmental Assessment Program (PROPER), as the typical environmental aspects standard for industries. Energy is one of those, hence other related policies on energy management and conservation become the organization’s concern and priority.

The specific renewable energy source has been chosen after several considerations, including the intermittency challenge. To manage it at low cost, prior study finds that developers typically prefer to implement a grid-connected project where it can be supported by coal-fired and diesel generation [2].

2. Method
This study aims to analyze the on-grid Solar PV utilization in the natural gas transportation business as the contribution to related policies, both within the company and government of Indonesia, as well as the global goals. Furthermore, to understand the feasibility of the project by determining the economic valuation of the project.

2.1 Related policy review and solar PV implementation
Defining the renewable energy issue in Indonesia and understanding how on-grid Solar PV utilization links to each related policy objectives based on actual monitoring data.

2.2 Data collection, scope and limitations
Data from primary sources derived from the energy mix shift in supporting facility, Solar PV energy production, the electricity cost saving converts from electricity price from the state-owned electricity company. Besides, irradiation and carbon emission data are collected from related institutions.

2.3 Data analysis
Analyze qualitatively how 5.25 kWp Solar PV project implemented in Pertamina Gas Operation East Java Area which located aligns with the related policies. Quantitative analysis is implemented to define the effectiveness of this pilot-scale project by 1) Comparing Solar PV system production from design simulation in Global Solar Atlas to its actual performance; 2) Cost and benefit analysis by evaluating the Net Present Value (NPV), Payback Period, Profitability Index (PI), Levelized Cost of Energy (LCoE) [11] and its environmental benefit.

3. Results and Discussions
PT Pertamina Gas is committed to promoting occupational safety and health, environmental protection, quality control practices as an integral part of sustainable business operations and as written on its corporate sustainability policy. One of its way to align with the commitment is by complying with all stipulations, regulations, and other standards that are relevant to occupational safety and health, environmental protection, quality control, and security. Renewable energy initiative in PT Pertamina Gas has been implemented by installing 5.25 kWp Solar PV in the office area located in Surabaya, East Java. This initiative started as part of the company's environmental management practices, particularly in energy efficiency aspects that expecting renewable resources substitution in electricity supply.
3.1 Contribution to government regulation on national energy policy

As the energy state-owned company, through one of the company’s entities, East Java Area, PT Pertamina Gas has done its very first attempt to contribute to the National Energy Policy target. The target as stated in Government Regulation No. 79 of 2014 Article 9 that the fulfillment of energy supply and energy utilization as referred in Article 8, one of the achievements of the policy is optimal Primary Energy Mix, by 2025 and 2050, which the role of the New and Renewable Energy at least 23% (twenty-three percent) provided that it's economical fulfilled; the role of oil shall be less than 25% (twenty-five percent) in 2025 and to; the role of coal at least 30% (thirty percent) in 2025; and the role of natural gas at least 22% (twenty-two percent) in 2025 as shown in the chart below (Figure 1a).

Referring to that policy, by utilizing the 5.25 kW on-grid Solar PV system, the East Java Area office has attained its energy mix from 0% to 2% from renewable energy resources by Q3 2019 (Figure 1b).

- NRE
- Oil
- Coal
- Natural Gas

(a) Primary energy mix target at 2025
(b) Energy mix in East Java by Q3 2019

Figure 1. Energy mix

Pertamina Gas Operation East Java Area develops several communities near its operation area. One of them runs a local enterprise: the restaurant that promotes their local commodity to increase their prosperity. Social innovation has been initiated there, by utilizing on-grid solar PV 3.25 kWp to reduce energy consumption. Differ from the operation office, the system is equipped with net metering or export-import meter that distributes the electrical production excess during the day to the state-owned electricity grid, and consumes its saving during the night. As a result, the energy consumption decreases about 65% (Figure 2). The maximum export capacity is regulated by Ministry of Energy and Mineral Resources Regulation no 49 the Year 2018.

- State Electricity Company

(a) Energy consumption without PV
(b) Energy consumption with PV

Figure 2. PV impact to energy consumption
3.2 Regulation on corporate environmental performance
As the company undergoes its sustainability policy and keeps environmental and social management program accountable, it is assessed annually and thoroughly by the Ministry of Environment and Forestry Program as stipulated in its Regulation No. 03 the Year 2014 on Corporate Environmental Performance Rating Program (PROPER). The energy efficiency aspect is included in Article 6 on beyond compliance practice. Going through the beyond compliance criteria, Appendix 5 sets the structure of the requirements. Firstly, additionally criteria of a program which consists of innovation, beyond mandatory requirements in any regulations, and investment due to environmental benefit and a call to action for challenges. Secondly, in addition to the energy efficiency aspect, renewable energy utilization also counts in air pollution control aspect criteria, such as Greenhouse Gases (GHG) emission inventory and its reduction program.

3.3 Global concern and goals within business practices
Indonesia is a G20 country with 755 g CO₂/kWh emission intensity, the third after South Africa, and Australia in the electricity sector and less concrete action to exit coal use [3]. Operation East Java Area, its facilities are mainly supported by State Electricity Company, which generally in Indonesia is still dominated 50% by fossil fuel to generate the electricity [4], thus its renewable energy substitution initiative showed that as Fossil-fuel dependent infrastructure – like natural gas pipelines operation, has an opportunity to lessen the potential climate risk impact, which is policy, market and economy, and reputational [5].

Indonesia has disclosed its NDC (Nationally Determined Contributions) to fulfill its responsibility in the Paris Climate Agreement 2015 which aims to keep the earth warming 1.5°C or below 2°C of the pre-industrial era. Therefore, The MEMR through its Indonesia Energy Outlook 2019 recommends considering the low-carbon scenario including the implementation of energy efficiency through the use of energy-efficient technologies and the massive use of new and renewable energy. As a result, the use of Solar PV could offset carbon emission by a coal-fired generation counted as a contribution to the net-zero carbon goal [6].

3.4 On-grid solar PV design and installation supporting natural gas operation
Location is considerably effective in electricity production, before which renewable resource is chosen several key factors were assessed, such as solar irradiation, space for panels, electricity system compatibility. Roof-top mounted PV panels taken up 30 m² space and are installed as an on-grid system without electricity storage or battery. The single line diagram of the on-grid solar PV system installed is shown in Figure 3.

Figure 3. On-grid solar PV system design
This implemented system included solar PV modules RC 350TP 2S 72, PV array, Balance of System set (BOS), inverter equipped by the Internet of Things (IoT) for cloud-based monitoring. The azimuth and tilt of PV panels installed are 90° and 20° respectively. It is excluded the MEMR regulated net metering as it only covers 2.7% capacity (5.25kVA) from 197 kVA installed capacity by state-owned utility (PLN) [7]. Therefore, this grid-connected solar PV production is adequate for the building demand without potential excess energy exported to the grid.

3.5 On-grid solar PV electricity production

Solar irradiation in Darmo Kali, Surabaya, East Java reach 4,075 kWh/m² per day [8], which comparatively would be effective since solar irradiation daily in Indonesia is 4.80 kWh/m² on average [9]. Thus far, its one-year data monitoring shows that 5.25 kWp capacity produces 7,281.10 kWh and the most optimum production reached 720.7 kWh in September 2019, while monthly on average is 606.76 kWh. The system monthly performance is shown in Table 1.

| Year | Month | Production (kWh) |
|------|-------|------------------|
| 2019 | September | 720.7 |
|      | Oktober | 677.8 |
|      | November | 647.9 |
|      | December | 559.6 |
|      | January | 509.6 |
|      | February | 520.1 |
|      | March | 580.2 |
|      | April | 553.8 |
|      | May | 586 |
|      | June | 602.8 |
|      | July | 639.3 |
| 2020 | August | 683.3 |

Total Energy Production (kWh/year) 7281.1

The predicted production in the Global Solar Atlas simulation is 7,595 kWh per year by means the actual production is only 4% below the predicted production. Small scale and localized electricity generation such as solar PV system would benefit some regions in Indonesia, solved its lack of geography and national interconnectivity [10] in contrast, Surabaya, an urban area in East Java, would benefit more from grid-connected Solar PV system, as it specifically cut the electricity cost even up to 65% state-owned utility tariff implementing an export-import scheme for rooftop PV customers [11].

3.6 Economic valuation

The system costs Rp117,847,750 and costs below Rp 1,000,000 in the first year for operation and maintenance. Assume that operation and maintenance costs increase by 3% every year. The life expectancy of the system is 20 years determined reliably by the manufacturer and assumed the inverter would be replaced once during those years that cost Rp 15,600,000. Based on actual data monitoring, this Solar PV system covered 3.3% of the optimum capacity installed in the building, therefore potential annual avoidable costs to be calculated as electricity generation per year of electricity price, which is Rp 1,467/ kWh converted to solar PV energy production. The inflation rate is 4.5% to determine the avoidable costs for 1-20 years. The details for economic valuation are shown in table 2 below.
**Table 2. Economic valuation components**

| Items                              | Values                                      |
|------------------------------------|---------------------------------------------|
| System Cost (CAPEX)                | Rp 117,847,750                              |
| Operation and Maintenance (OPEX)   | Rp 750,000 increase by 3% annually          |
| System degradation performance     | 1% annually [12]                            |
| System life expectancy             | 20 Years                                    |
| Discount rate                      | 6%                                          |
| Annual inflation                   | 4.5%                                        |
| Inverter replacement cost          | Rp 15,600,000                               |
| Avoided electricity cost per kWh – PLN tariff | Rp 1,467 / kWh            |
| Actual production in a year        | 7,281.1 kWh                                 |
| Avoided electricity cost from one-year actual production | Rp 11,706,367 |

The 5.25 kWp on-grid Solar PV system will not begin operating in positive cash flow in year-15, at the 6% discount rate, the NPV for 15 years is Rp 9,489,802 and the Profitability Index is 1.82. This economic analysis finds that the financial benefit outweighs the costs over its life expectancy, while the calculation result of its LCOE (Levelized Cost of Elective) [12] is Rp 949.72. Thus, it is slightly below the East Java Electricity Generation Cost Rp 989, - as listed in Decree of Energy and Mineral Resources Minister No. 55 The Year 2019. The economic valuation results are shown in Table 3 below.

**Table 3. Economic Valuation Results**

| Items                              | Values                                      |
|------------------------------------|---------------------------------------------|
| Net Present Value (NPV)            | Rp 9,489,802                                |
| Payback Period                     | Year-15                                     |
| Profitability Index (PI)           | 1.82                                        |
| Levelized Cost of Energy (LCoE)    | Rp 949.72                                   |

3.7 Environmental benefit

Actual solar PV production substitutes partially the electricity demand from state-owned utility, which reduces 6.52 ton CO2 from mitigated coal-fired power plant carbon emission. The amount of carbon calculated with Java-Bali Emission Factor 0.817-ton CO2/MWh [13] as explained in Government Electricity Supply Business Plan (RUPTL) 2019 – 2029. The emission factor means power plants in the Java-Bali region emit 0.817 ton CO2 to generate 1 MWh electricity. Therefore, the electricity production from Solar PV mitigates the amount of energy (kWh) that should have provided by the state-own utility in the Java-Bali interconnection grid and followed by its emitted carbon per energy units.

The cost of renewable energy project earns the environmental benefit, specifically in greenhouse gas emissions. Compared to fossil fuel energy sources, renewable technologies, such as solar energy in this case study, have very low lifecycle GH emissions [14].

4. Conclusions

The purpose of this study in PT Pertamina Gas is to prove that energy efficiency and emission reduction through energy resources substitution with renewable energy. Solar energy has been chosen because the global irradiation map shows that Surabaya has an optimum daily PV output of 4,075 kWh / m². In this study, the on-grid solar PV system contributes 3.3% of electricity supply in the Surabaya...
office and produced 7,281.10 kWh in a year. Furthermore, this study shows that the investment of 5.25kWp on-grid Solar PV systems is potentially favorable as the cumulative NPV is positive in 15 years and the PI is 1.82 or higher than 1. Besides, the LCoE is Rp 949.72 / kWh competitive to East Java Electricity Generation Cost (BPP). In conclusion, the on-grid solar PV system has taken 2% of the energy mix in supporting the facility of Pertamina Gas East Java Area and offset 6.52 ton CO₂/year as mitigated carbon emission from coal-fired power generation. Hence, this study showed that this project fulfills corporate sustainability policies, government policies, and even more global goals. This study also provides an example of the fossil fuel dependent infrastructure sector contribution to the national energy policy and carbon emission reduction at once.

**Recommendation**

Future studies should aim to replicate results on a larger scale with a typical business process – natural gas operation – solar irradiation, and location to find how the system could support the operation activity while economically beneficial.

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