Optimization of Solar PV System for Fishery Cold Storage based on Ownership Model and Regulation Barrier in Indonesia

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Abstract. Fluctuation in fish catch due to seasonal factors causes instability in fish prices, decreasing the quality of fish and fishermen's incomes because there is no cold storage in some area for storing fish. Applying ownership of cold storage is divided into two models, namely commercial-based and community-based with different financial instruments. Fishery cold storage is an energy-intensive industry and Indonesia is a tropical country with abundant potential for solar irradiation. However, due to limited regulations, the application of solar photovoltaic (PV) in Indonesia is still not optimal. The simulation gives a new result by changing regulation assumptions: the solar photovoltaic on-grid system has a lower Levelized Cost of Electricity (LCOE) because it can produce eightfold more electricity to the grid with higher inverter capacity than before. Furthermore, the rental price of community-based cold storage can be 10 % cheaper on average with all energy system topologies than the rental price for cold storage based on commercial ownership model.

1. Introduction
Indonesia is one of the largest maritime countries globally, with a sea area of 6.32 million km² and a coastline of 99,093 km [1]. The fisheries sector plays a strategic role in national development through job creation, livelihood diversification, animal protein supply, and foreign exchange earnings. The sector contributes 3.1 percent of the total national gross domestic product (GDP) and 21 percent of the total agricultural GDP, generating around 6.4 million direct jobs for Indonesians, earning US$4.2 billion in 2012 from exports of seafood and providing 54.8 percent of the domestic supply of animal protein [2, 3]. The abundance of fishery products in Indonesia is not comparable to the availability of support infrastructure for fisheries [4, 5].

Fishers face a fundamental obstacle, namely seasonal factors. Fish production may be abundant during the harvest season, but the conditions may be the opposite in the dry season. On the consumer (community) and industry side, the supply of fish must be available at all times [6]. In the light of current technological developments, marine management needs to be more innovative and prioritize sound quality fish. Fresh fish contains up to 80% water and is so perishable that it has a short shelf life [7, 8]. If fresh fish is not immediately used or stored in the cold, protein nutrient degradation will occur in the fish. Accordingly, the Food and Agriculture Organization (FAO) Code of Conduct for Frozen Fish recommends that frozen fish products store at a temperature appropriate to the species, product type,
and intended time of storage [9]. One of the technologies used to maintain fish quality is cold storage [10, 11]. Maintaining good quality fish will affect the stability of fish prices and fisher's income [12]. The fishing industry is one of the most energy-efficient industries globally due to increasing demand and the increasing supply of fishery and aquaculture products. Electricity and liquid fuels are the primary sources of energy for the fishing industry, and their applications vary from the fishing phase (upstream) to the product packaging (downstream) [13]. Refrigeration equipment consumes significant electricity energy [14]. It, therefore, requires stable and efficient electrical energy to cool fish in cold storage. The fishing industry, particularly the cold storage sector, is an energy-intensive industry. It must have an energy transition for its energy use [15]. One of today's energy market concerns is the efficient use of renewable energy sources and the implementation of appropriate medium and long-term energy supply strategies [16]. It is necessary for the efficient use of fossil fuels. It is also in line with the Paris Conference of the Parties (COP) 21 agreement reached by 195 countries to limit global temperature rises to 2 degrees Celsius and reduce them to 1.5 degrees Celsius [17]. These countries are increasingly turning to renewable energy because they are more environmentally friendly and have more renewable energy policies.

The potential for renewable energy in Indonesia is very high; an estimated 716 GW of renewable energy-based power generation potential has been identified in Indonesia [18]. Indonesia’s current national energy policy calls for an increase of 23 percent by 2025 and 31 percent by 2050 [19]. Solar energy is one of the most extensive types of renewable energy in Indonesia. Indonesia is fortunate to have excellent day-to-day solar energy thanks to a stable irradiation rate for most of the year. Based on daily solar irradiation with an average of 4.80 kWh/m2, Indonesia theoretically has a potential of more than 207.8 GW of solar energy [20, 21]. Based on Regulation No 49/2018 of the Minister for Energy and Mineral Resources, which allows the National Utility Grid customers to generate their electricity supply from the solar photovoltaic (PV) system and export surplus electricity to the National Utility Grid [22]. Under the proposed rule, users cannot “sell” electricity to the national utility grid when they have excess energy from PV System because, by law, the national utility grid cannot “pay” back its customers. Furthermore, excess electricity is credited to owners to reduce their electricity bills by using the Utility Grid. It will be calculated monthly and limited to a maximum of three months before the end of the credit period [21]. Therefore, in this study, we will design cold storage with solar PV energy sources with different scenarios based on ownership and the barrier of Regulation of solar PV use.

2. Materials and Methods

The first step of this study is to determine the cold storage capacity for fish caught by fishermen. Then determine the cold storage equipment and also refer to the technical specifications. It is essential given the cold storage equipment's power capacity to determine the electrical load profile of the cold storage system. The next step is to determine the energy system and determine the energy system’s capacity based on the solar PV regulation scenario. Then, calculate the LCOE of each energy system topology entered in the cold storage cash flow calculation based on the ownership model. Moreover, the calculation result will define a cold storage rental price charged to the fishermen if they want to store their catch in cold storage.

2.1 Determine Cold Storage Capacity

Figure 1 shows the trend of fishing results at the Dadap fish auction site, West Java, Indonesia from 2016 to 2020. The trend graph (Figure 1b) shows the statistical data central tendency, where the statistical data central tendency defines the mean and the median [23]. Figure 1a shows the pattern of fishing yields fluctuates every month in a year in which the catch has increased sharply starting in March and will decline sharply in June and rise again in September. In June, fishers often do not go to the sea because there is an east wind season that occurs every year in that month. It will impact the stability of fish prices, fisher's income, and the quality of fish. Cold storage will affect the fishers to store the fish they catch with good quality and be sold at a high and reasonable price so that the trend in fish production can match the grey line in Figure 1b. Fishers can store surplus fish from March to April and sell them from June to August when production is low. The determination of cold storage capacity bases on average monthly catch production data at the Fish Auction Place in Dadap Village, West Java. From the
data obtained, the average production per month from 2016 to 2020 is 182 tons. The Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia, through its technical guidance, provides options for the development of cold storage in 100 and 200 tons. By looking at the average fish production data for fish auction sites in Dadap Village, West Java, the cold storage will use 200 tons of capacity.

Figure 1. (a) Fish Production per month 2016-2020; (b) Central Tendency and Ideal Pattern Fish Production per month.

2.2 Cold Storage Specification and Electricity Load Profile
200-ton cold storage requires a condensing unit with 18 hp for cold storage and seven hp for anteroom. Then cold storage requires a polyurethane wall as insulation. These details also include cold storage installation services with a total investment cost of $126,357 to install cold storage. The condensing unit requires electrical energy to run a compressor with a total capacity of 60 kW.

It is necessary to store the fish in cold storage at a temperature of -20 degrees Celsius to ensure the fish's quality does not decrease after being caught by the fishermen [9]. The daily load profile determination follows the compressor engine's capacity with a technical specification of an additional ten loads per day. The determination of the 10 times increase in load is suitable to the time when the fishermen in Dadap Village return to the sea and engage in product mobilization from morning to afternoon, requiring the opening and closing of the cold storage door. Undoubtedly, the door's frequent opening and closing will increase the compressor's performance, increasing the electrical load during that period. It follows the previous studies [14]. The cause of the increase in load is an increase in cold storage temperature due to the influence of changes in environmental temperature and evaporation temperature. The electricity consumption of the compressor increased by 20 degrees Celsius depending on the evaporation temperature [24]. Figure 2 shows the daily load profile by looking at the ambient temperature of 32 degrees Celsius during the day and 27 degrees Celsius at night. This load profile has a maximum load of 52.19 kW, a minimum load of 30 kW, and an average of 38.61 kW. Furthermore, the random load variability is 3%, so that the peak load of cold storage can reach 59.71 kW. Cold Storage requires an average of 926.54 kWh of electricity per day.

Figure 2. Cold Storage Daily Load Profile
2.3 Energy System Optimization based on Regulation Assumption

After getting the cold storage load profile, we determine the energy source used to supply the electrical charge to the cold storage facility. We simulate several options for electrical energy sources with Homer Pro Software to obtain the cheapest Levelized Cost of Electricity value. The Levelized Cost of Electricity (LCOE) in the production of electrical energy can be defined as the present value of the price of electrical energy produced, taking into account the economic life of the generator and the costs incurred in the construction, operation, and maintenance as well as in the cost of fuel (Eq.1) [25]. Figure 3 shows five energy system schemes: generator, utility grid, on-grid PV, off-grid PV with battery, and PV Hybrid with the generator.

\[
\text{LCOE} = \frac{i'(1+i')^{-N}+f(1+f)^{-1}}{E_{\text{serv}}\times NPC}
\]

Where, 
- \(i'\) = Discount rate (%)
- \(f\) = Inflation rate (%)
- \(N\) = Lifetime project (Years)
- \(E_{\text{serv}}\) = Total electrical load served (kWh/yr)
- \(NPC\) = Net Present Cost ($)

For the generator energy system scheme, we use a generator with a capacity of 70 kW with a lifetime of 80,000 hours of use and a maintenance cost of $0.098 per hour of use. The initial cost of purchasing the generator is $14,286, and the cost of industrial diesel fuel is $0.72 per litter. The following scheme is the Utility Grid, with a total capacity of 200 tons of cold storage equipment, according to technical specifications, of 60 kW. The cold storage will subscribe electricity to a utility grid of 82.5 kVA at a business rate of B2 $0.1 per kWh. The cost to install the 82.5 kVA utility grid is $5,710.

Installation of solar panels shall have sufficient irradiation values; the mean irradiation per day in Dadap Village, West Java, shall be 5.08 kWh/m2. Installation of solar panels in cold storage requires an adequate roof area—cold storage roof area of 200 tons, covering 600 m2. By installing a Canadian Solar type CS6U-340M solar panel with a capacity of 340 Wp per panel and a cross-section area of 2 m2, a cold storage roof with a capacity of 100 kWp of PV can be installed. However, the PV Off-grid with a battery system requires a large PV and battery capacity because it must cover all the cold storage needs. In contrast, the assumption of a capacity shortage in this study is only 5% per year. The consequence of installing a large PV and battery is the addition of the initial cost and land addition. Next is the PV hybrid generator scheme for the energy system, simulated with optimization methods, i.e., cycle charging (CC) and load following (LF) [26]. The LF method requires a higher PV and battery capacity to incur additional initial costs and land. The initial PV and inverter costs are $1,143 per kW, and maintenance is $1,114/kW per year. The rate of PV degradation uses National Renewable Energy Laboratory (NREL) data at 0.5 percent per year, and maintenance costs increase by 2 percent per year.
[27]. For this purpose, the energy system uses a lead-acid battery with an initial cost of $250 per kWh and a maintenance cost of $20 per kWh/year [28]. In the case of an on-grid PV system, the inverter installation must have a maximum capacity of 70 kW. According to Article 5(1) of the Regulation of the Minister of Energy and Mineral Resources No 49 of 2018, a rooftop PV system's capacity is limited to a maximum of 100 percent of the power connected to the power grid. The calculation of the export-import of electrical energy is then carried out monthly by calculating the difference. Therefore, it will be accumulated and calculated as a reduction in the bill for the following month. The calculation can be accumulated for a maximum of only three months and will be null after three months. Therefore, table 1 shows several scenarios regarding the limitations of the existing regulation.

**Table 1. Regulations and Assumptions for PV On-grid System Scenarios**

| Scenario | Regulations & Assumptions |
|----------|----------------------------|
| 1        | • The capacity of the PV module is suitable with the roof area of the cold storage building.  
• The capacity of the inverter shall be no more than the capacity of utility grid connected.  
• Sell-back price 65% (Percentage Factor).  
• If there is a surplus of electricity, there will be a reduction in the bill for the following month with a maximum accumulation of 3 months. |
| 2        | • The capacity of the PV module is suitable with the roof area of the cold storage building.  
• Inverter capacity is not limited  
• Sell-back price 65% (Percentage Factor).  
• If there is a surplus of electricity, there will be a reduction in the bill for the following month with a maximum accumulation of 3 months. |
| 3        | • The capacity of the PV module does not consider the roof area of the cold storage building (Land Expansion)  
• The capacity of the inverter shall be no more than the capacity of utility grid connected.  
• Sell-back price 65% (Percentage Factor).  
• If there is a surplus of electricity, there will be a reduction in the bill for the following month with a maximum accumulation of 3 months. |
| 4        | • The capacity of the PV module does not consider the roof area of the cold storage building (Land Expansion)  
• Inverter capacity is not limited  
• Sell-back price 65% (Percentage Factor).  
• If there is a surplus of electricity, there will be a reduction in the bill for the following month with a maximum accumulation of 3 months. |
| 5        | • The capacity of the PV module does not consider the roof area of the cold storage building (Land Expansion)  
• Inverter capacity is not limited  
• Sell-back price 65% (Percentage Factor).  
• Electricity export-import transactions are conducted every month. |
| 6        | • The capacity of the PV module does not consider the roof area of the cold storage building (Land Expansion)  
• Inverter capacity is not limited  
• Sell-back price 85% (Percentage Factor).  
• Electricity export-import transactions are conducted every month. |
| 7        | • The capacity of the PV module does not consider the roof area of the cold storage building (Land Expansion)  
• Inverter capacity is not limited  
• Sell-back price 100% (Percentage Factor).  
• Electricity export-import transactions are conducted every month. |
Table 2 shows the installed capacity of each component of the equipment and the investment cost of the entire system for all scenarios. From these scenarios, the energy system with the most investment cost is the PV Off-grid scenario because the energy system requires PV and a high-capacity battery to cover all the energy needs of cold storage.

Table 2. Investment cost of Energy System Component

| Energy System       | PV (kW) | Inverter (kW) | Battery (Unit) | Generator (kW) | Investment Cost ($) |
|---------------------|---------|---------------|----------------|----------------|---------------------|
| Grid (82.5 kVA)     | -       | -             | -              | -              | 5,710               |
| Generator           | -       | -             | -              | 70             | 14,286              |
| PV Hybrid (CC)      | 100     | 63            | 48             | 70             | 322,071             |
| PV Hybrid (LF)      | 168     | 64.7          | 96             | 70             | 394,214             |
| PV Off-grid         | 478     | 71.6          | 576            | -              | 954,929             |
| PV On-grid 1        | 100     | 70            | -              | -              | 259,929             |
| PV On-grid 2        | 100     | 77.8          | -              | -              | 260,643             |
| PV On-grid 3        | 154     | 70            | -              | -              | 318,500             |
| PV On-grid 4-7      | 300     | 250           | -              | -              | 487,071             |

2.4 Financial Aspect

Ownership model for cold storage fisheries is divided into commercial and community-based. A commercial-based business model where private investors manage cold storage and community-based business model managed by the local fishing community. A community-based business model's advantage is that they can apply for a loan to Sarana Multi Infrastructure (SMI) company. SMI itself is a state-owned company in infrastructure loan management for small businesses where SMI can provide large nominal loans to long-term tenants as long as the ratio of EBITDA to instalments and interest is not less than 1.2. The debt-equity portion for the community-based model could be 100:1, while for the commercial model, it could be 70:30. The next advantage is that it does not pay a business tax for the community-based model; it only pays a local tax or retribution of 2.25%. On a commercial basis, it is necessary to lease local land with a retribution scenario to the area per m².

On the other hand, there is no need to rent land for a community-based community. In this study, the project has a 15-year lifetime project with an inflation rate of 4.23 percent concerning Indonesia's inflation rate over the last five years and a 5 percent discount rate. Rental prices and cold storage income are determined based on equation 2 and equation 3.

\[
RP = \frac{Opex + D + I}{365} \times \left(1 + \frac{TR}{80\%\text{ Maximum Capacity}}\right) \times (1 + PM)
\]

(2)

\[
Revenue = RP \times 80\% \text{ Maximum Capacity} \times 365
\]

(3)

Where, \(RP\) = Rental Price ($/Kg/Day)

\(Opex\) = Operational Expenditure

\(D\) = Depreciation

\(I\) = Interest

\(TR\) = Percentage of Tax or Retribution

\(PM\) = Percentage of Profit Margin

3. Results and Discussions

After simulation of several scenarios for the energy system, the LCOE show results from each of the energy systems shown in Table 3. The simulation results show that the energy system using the generator has the highest LCOE value of $0.246/kWh. The generator consumes a lot of diesel fuel annually, which is around $80,787 a year. The second highest LCOE was off-grid PV with $0.244/kWh. Off-grid PV's LCOE value is expensive because the initial investment costs are prohibitive even though there is no
fuel consumed. In the case of a hybrid PV system with the load-following (LF) operating method, it is cheaper than the cycle-charging (CC) operating method because diesel fuel consumption in the LF method is lower than CC. After all, the generator operates in this system solely to meet cold storage electricity load needs, not intended for filling the battery. The PV only charges the battery; therefore, the PV in the LF system has a larger capacity so that the PV system can fully charge the battery. The cheapest energy system LCOE is on-grid PV systems. PV On-grid LCOE is cheaper due to reduced electricity bills from the utility grid and can sell electricity to the utility grid if excess power generation exists. PV On-grid scenarios 1-3 cannot sell electricity because the PV and inverter capacities are not large enough. There is no excess of electricity to be absorbed by the power grid. Another factor is the electricity export-import arrangement from the PV owner to the utility network, calculated every month based on the export-import difference. Suppose the export electricity is larger than the import. In that case, the utility grid will pay the excess electricity to the PV owners to reduce the bill for the following month. The simulation results show that with the limitation of the installed inverter capacity, the change in regulations regarding the calculation of export electricity 65-100 % (Percentage Factor) will not affect. The PV On-grid scenario four is interesting. This scheme has a higher LCOE than the utility grid scheme, which is since the system installs a large capacity but does not comply with the proper regulations. In this scenario, the Regulation provides that calculating the export-import of electrical energy shall be carried out monthly by calculating the difference. If there is an excess, it is accumulated and calculated as a bill reduction for the following month. The calculation can be accumulated for a maximum of only three months and will be null after three months. With this scenario, it is possible to sell electricity to the utility grid. However, the sale proceeds will only reduce the bill for the following month. They will return to zero after three months so that the owners of this scheme will not make money from the sale of electricity generated by the PV owners. PV on-grid system scenarios 5-7 has a lower LCOE because it can produce 855 % more electricity to the grid with higher inverter capacity than scenario 1. Only in scenarios 6-7 can there be a surplus from the generation of PV because, in this scenario, this system's selling price is 85 percent and 100 percent of the electricity price sold to customers from the electricity grid.

The LCOE energy system calculation results are entered and processed in the entire cold storage system's cash flow. The cold storage lease price determination considers total operating costs, interest, and depreciation. Figure 4a shows the point graph between the LCOE results and the cold storage rental price from each simulated scenario. The rental price for cold storage with the PV energy system On-grid scenario 7 has the lowest price of 0.143 cent dollars per kg per day due to small cold storage operation cost, especially the electricity cost that can already export to the utility grid. Unlike the community-based model, the rental price for cold storage using electricity from the utility grid is cheaper than other energy systems due to the EBITDA ratio of 1.2. On-grid PV schemes are more expensive because installment and interest costs are higher than utility grids. After all, the investment costs for PV installations are higher so that they impact setting the lowest price at a ratio of 1.2 between EBITDA and installment and interest. For results between LCOE and community-based cold storage rental prices, see Figure 4b. Then, in Table 4, the NPV PV On-grid value of all scenarios is greater than the Utility Grid. It indicates that the On-grid PV scheme is more profitable for the entire life of the project.

| Energy System          | LCOE ($/kWh) | Electricity Purchased ($/yr) | Electricity Sold ($/yr) | Net Electricity ($/yr) | Fuel Cost ($/yr) | Maintenance Cost ($/yr) |
|------------------------|--------------|------------------------------|-------------------------|------------------------|-----------------|-------------------------|
| Grid (82.5 kVA)        | 0.103        | 34,898                       | -                       | 34,898                 | -               | -                       |
| Generator              | 0.246        | -                            | -                       | -                      | 80,787.74       | 857                     |
| PV Hybrid (CC)         | 0.206        | -                            | -                       | -                      | 53,870.51       | 1,365                   |
| PV Hybrid (LF)         | 0.196        | -                            | -                       | -                      | 46,101.45       | 6,419                   |
| PV Off-grid            | 0.244        | -                            | -                       | -                      | 28,776          | -                       |
| PV On-grid 1           | 0.073        | 23,741                       | -                       | 23,741                 | -               | 1,200                   |

Table 3. Results of Energy System Optimization
Table 4. Project Financial Feasibility

| Energy System       | IRR (%) | NPV ($) |
|---------------------|---------|---------|
| Grid (82.5 kVA)     | Commercial 17 | Community 7.76 | Commercial 148,720 | Community 27,221 |
|                     | Generator 26 | 6.57 | 308,478 | 17,880 |
| PV Hybrid (CC)      | 14 | 6.35 | 258,605 | 31,168 |
| PV Hybrid (LF)      | 13 | 6.63 | 270,663 | 46,187 |
| PV Off-grid         | 8 | 5.68 | 250,908 | 45,844 |
| PV On-grid 1        | 13 | 7.81 | 184,436 | 54,167 |
| PV On-grid 2        | 13 | 7.80 | 184,128 | 54,114 |
| PV On-grid 3        | 12 | 7.60 | 198,696 | 61,724 |
| PV On-grid 4        | 11 | 11.13 | 251,860 | 348,426 |
| PV On-grid 5        | 10 | 7.28 | 206,868 | 82,420 |
| PV On-grid 6        | 10 | 8.08 | 191,664 | 113,677 |
| PV On-grid 7        | 9 | 7.16 | 181,024 | 78,011 |

Figure 4. LCOE and Rent Price of Cold Storage: (a) Commercial-based; (b) Community-based

Figure 5 shows that the community-based model's price simulation results are cheaper than the commercial model due to there is no need to rent land for the community model, and there is no tax on income; only the local government's revenue is 2.25%. Also, the EBITDA ratio can make commercial-based is cheaper than community-based. Debt and equity factors also affect the price disparity between the two models. If no cold storage investors enter the area, a community-based ownership model is suitable to be used. Furthermore, there is a slight difference in cold storage rental prices between the two ownership models for PV On-grid scenarios 6 and 7. The debt-equity ratio difference is a factor where the community-based model has a debt-equity of 100:0 so that the interest is high.
4. Conclusion

For fishers who do not have easy electricity access, energy efficiency is critical to reducing cold storage operational costs. Based on the simulation results, On-grid PV has the cheapest LCOE value compared to the electricity price from the Utility Grid. However, the rental price for cold storage based on PV on-grid systems is more expensive because regulation No 49/2018 of solar PV use by electricity utility consumers are still applied. The regulation states that the PV system's inverter capacity is limited to a maximum of 100 percent of utility grid subscription. The calculation of exports and imports of electrical energy from On-grid PV is also regulated. The energy sell-back price to the utility grid is 65 % (Percentage Factor) and calculates the energy export-import monthly. Furthermore, the exported electrical energy reduces the electricity bill in the following month for a maximum of three months. The simulation result shows the owners of on-grid PV will never be able to export electrical energy to the utility grid due to the inverter's limited capacity. Thus, the electrical energy exported is always less than the imported electricity from the grid every month. Furthermore, even the percentage factor increases until 100% have no effect on the LCOE value for the PV on-grid system. The simulation gives new results by changing regulation assumptions: the PV on-grid system has a lower LCOE because it can produce 855 % more electricity to the grid with higher inverter capacity than before. Furthermore, the rental price of community-based cold storage can be 10 % cheaper on average with all energy system topologies than the rental price for cold storage based on commercial-based. The new regulation is needed to encourage the fisheries sector by reducing the PV system restrictions to obtain affordable electricity prices, better fishermen's income, and accelerating 23% renewable by 2030.

5. Reference

[1] Luhur, E., S. Mulatsih, and E. Puspitawati, Competitiveness Analysis of Indonesian Fishery Products in ASEAN and Canadian Markets. Signifikan: Jurnal Ilmu Ekonomi, 2019. 8: p. 105-120.
[2] Destiningsih, R., et al., Competitiveness identification of fisheries export in Indonesia. IOP Conference Series: Earth and Environmental Science, 2020. 530: p. 012017.
[3] Tran, N., et al., Indonesian aquaculture futures: An analysis of fish supply and demand in Indonesia to 2030 and role of aquaculture using the AsiaFish model. Marine Policy, 2017. 79: p. 25-32.
[4] van Duijn, A.P., R. Beukers, and W. van der Pijl, The Indonesian seafood sector; a value chain analysis. 2012.
[5] Waldron, S., et al., Eastern Indonesia agribusiness development opportunities - analysis of beef value chains. 2013.
[6] Azhar, M., et al., Prospect on Implementation of National Fish Logistics System: case in Indonesia. E3S Web of Conferences, 2018. 47: p. 06009.
[7] Darvishi, H., et al., Drying characteristics of sardine fish dried with microwave heating. Journal of the Saudi Society of Agricultural Sciences, 2013. 12: p. 121–127.
[8] Modibbo, U., et al., Effect of Moisture content on the drying rate using traditional open sun and shade drying of fish from Njuwa Lake in NorthEastern Nigeria. IOSR Journal of Applied Chemistry, 2014. 7: p. 41-45.

[9] W.A. Johnston, F.J.N., A. Roger and G.D. Stroud, Freezing and refrigerated storage in fisheries. FAO FISHERIES TECHNICAL PAPER - 340, 1994.

[10] Duarte, A.M., et al., Quality Assessment of Chilled and Frozen Fish—Mini Review. Foods, 2020. 9(12): p. 1739.

[11] Rasta, I.M., I.D.M. Susila, and I.W.A. Subagia, Technology Application of Environmental Friendly Refrigeration (Green Refrigeration) on Cold Storage for Fishery Industry. Journal of Physics: Conference Series, 2018. 953: p. 012077.

[12] Mulyaningtyas, D., Centralized cold chain system for fish price stability in Lamongan Jawa Timur. 2019.

[13] Alzahrani, A., et al., Developing Smart Energy Communities around Fishery Ports: Toward Zero-Carbon Fishery Ports. Energies. 2020. 13(11): p. 1-22.

[14] Ahadi, K. and G.T. Setiadanu. ANALISIS KONSUMSI ENERGI LISTRIK PADA PROSES PEMBEKUAN DAN PENYIMPANAN IKAN ; ELECTRICAL ENERGY CONSUMPTION ANALYSIS ON PROCESS AND STORAGE OF FROZEN FISH. 2019.

[15] IRENA, Accelerating the Energy Transition through Innovation, a working paper based on global REmap analysis. IRENA, 2017.

[16] Gieelen, D., et al., The role of renewable energy in the global energy transformation. Energy Strategy Reviews, 2019. 24: p. 38-50.

[17] Tobin, P., et al., Mapping states’ Paris climate pledges: Analysing targets and groups at COP 21. Global Environmental Change, 2018. 48: p. 11-21.

[18] IRENA, Renewale Energy Prospect: Indonesia. IRENA, 2017.

[19] Handayani, K., Y. Krozer, and T. Filatova, From fossil fuels to renewables: An analysis of long-term scenarios considering technological learning. Energy Policy, 2019. 127: p. 134-146.

[20] Hidayatno, A., et al., Investigating policies on improving household rooftop photovoltaics adoption in Indonesia. Renewable Energy, 2020. 156: p. 731-742.

[21] Hamdi, E., IIEFA report: Indonesia’s solar policies – designed to fail? The Institute for Energy Economics and Financial Analysis (IEEFA), 2019.

[22] Setyawati, D., Analysis of perceptions towards the rooftop photovoltaic solar system policy in Indonesia. Energy Policy, 2020. 144: p. 111569.

[23] Weisberg, H.F., Central Tendency and Variability, I. SAGE Publications, Editor. 1992: Thousand Oaks, California.

[24] Koffman, L.D., M.S. Plesset, and L. Lees, Theory of evaporation and condensation. The Physics of Fluids, 1984. 27(4): p. 876-880.

[25] Raikar, S. and S. Adamson, 13 - Renewable energy finance in the international context, in Renewable Energy Finance, S. Raikar and S. Adamson, Editors. 2020, Academic Press. p. 185-220.

[26] Aziz, A., et al., Energy Management and Optimization of a PV/Diesel/Battery Hybrid Energy System Using a Combined Dispatch Strategy. Sustainabilty, 2019. 11: p. 683.

[27] Jordan, D.C. and S.R. Kurtz, Photovoltaic Degradation Rates— an Analytical Review. Progress in Photovoltaics: Research and Applications, 2013. 21(1); p. 12-29.

[28] Lockhart, E., et al., COMPARATIVE STUDY OF TECHNO- ECONOMICS OF LITHIUM-ION AND LEAD-ACID BATTERIES IN MICRO- GRIDS IN SUB-SAHARAN AFRICA. 2019.

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