TECHNO-ECONOMICAL APPROACH ON ESTABLISHING ZERO DOWN TIME AREA TO PROMOTE PREMIUM RELIABILITY IN SUPER PRIORITY TOURISM DESTINATION

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ABSTRACT

The need to establish high reliability electricity network to support Super Priority Tourism Destination in Indonesia, specifically up to medium voltage (distribution) level has become remarkable, hence the importance of Premium Services is unquestionable. Until recently, PLN has applied two types of Premiums Services, one which works in individual customer level and one which works in area level. In the case of individual customer level premium service, the low flexibility in surcharges and minimum utilization time may become a problem for subscribing customers. On the other hand, in existing area level premium service, the higher reliability supply does not come with necessary surcharges to compensate the expenses incurred by the investment made to strengthen the grid which may cause financial loss to utility. Therefore, to overcome mentioned drawbacks, in this paper, a techno-economical approach of Zero Down Time (ZDT) Area which combined both technical and financial aspects is proposed as a solution. ZDT Area has 2 main objectives. The first is to provide excellent reliability in area level and the second is to gain financial benefits to utility by taking customer's flexibility in the form of pricing option. To provide a clear understanding regarding the matter, a case study of implementation of ZDT Area in Labuan Bajo, Indonesia is described. Additionally, this approach was one of the products of PLN's Transformation Program called Digitally Enabled Distribution Excellence (DEDE) which started in 2019.

INTRODUCTION

The endorsement of 5 Super Priority Tourism Destination (*Destinasi Pariwisata Super Prioritas*/DPSP) by the government of Indonesia Republic in 2019 led to the necessity to improve all supporting infrastructures in all sectors including energy sector. As an electricity utility, Perusahaan Listrik Negara (PLN, Indonesia state-owned electricity utility) bears the responsibilities in energy sector aiming for reliable supply of electricity provision. High reliability electricity network in area level has become a necessity which led to the creation of premium services.

Several research on premium services system along with the pricing mechanisms had been conducted. A. Mansoor and A. Sundaram [1] described the needs of defining baseline grid power services and essential quantifiable indices in order to propose premium services. M. Brenna, G. C. Lazaroiu, G. Superti-Furga et al. [2] explained about the premium network with integrated DC Distribution System. I. Chung, S. Park, H. Kim et al. [3] introduced Premium Power Supply (PPS) which integrated inverter-interfaced distributed generation (DG) device to electric power systems. All above mentioned researchers put remarkable attention to the importance of power quality improvement besides reliability improvement.

Other researchers such as J. Li, X. Hui, X. Chen et al. [4], F. Zhao, D. Liang, Y. Yang et al. [5] explained about the method to provide reliability analysis and to design the premium pricing strategy for premium services. They utilized the user's loss model due to power failure as the basis for designing premium price. On the other hand, F. Ziyun, Q. Yuliang, H. Wenxin et al. [6] explained about a custom design method for electricity price packages based on the user's independent choice behaviour. The method had the aim to maximize profits and minimize risks in the setting of electricity prices either.

In this paper, the planning process to establish Zero Down Time (ZDT) Area in distribution level to promote premium reliability in super priority tourism destination is explained. Substantial emphasis on the pricing mechanism to be enforced to the customers within the area of service is taken. Pricing strategy is needed to ensure that necessary expenses to establish ZDT Area are covered so that utility will be able to prevent financial loss. Moreover, suitable pricing strategy will maintain the attractiveness to the customers. Therefore, network reliability, financial feasibility to utility and customer's flexibility become the main points of the establishment of ZDT Area as shown in **Figure 1**.

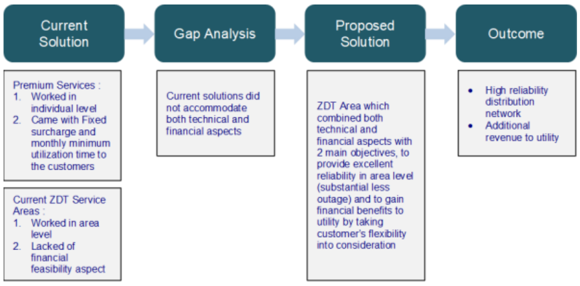

Figure 1. Overview of ZDT Area Establishment

To avoid confusion with previous research, power quality is not considered as the focus in this paper since PLN has already had another program in this regard, namely Extra Facility Program. In Extra Facility Program, PLN offers the installation of ancillary equipment, such as Uninterruptible Power Supply (UPS), Static Power Converter, Power Electronic Filter Equipment, etc which comes with additional surcharge to the customer.

GENERAL PROCEDURE

In general, the procedure of ZDT Area planning comprises several steps as shown in **Figure 2**.

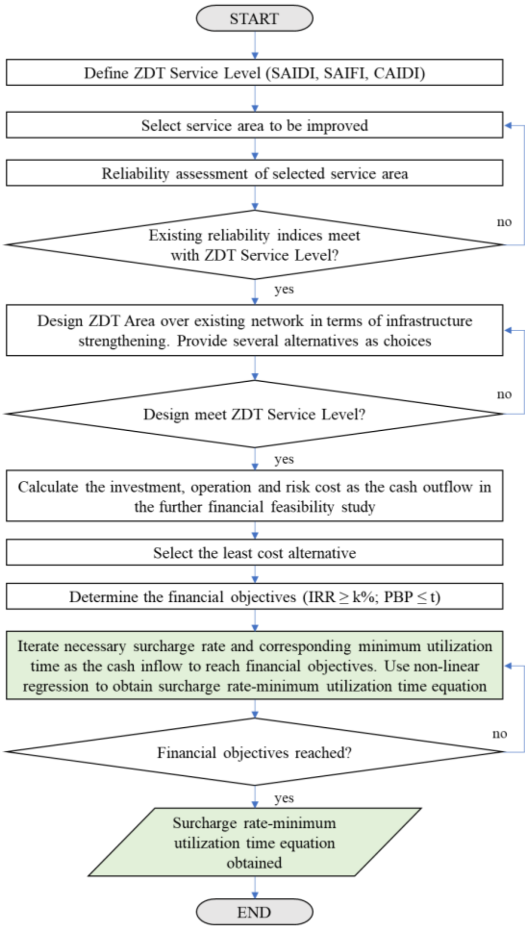

Figure 2. Techno-economical approach on ZDT Area establishment

Defining Zero Down Time Service Level

As the initial step, desired ZDT service levels are of great importance to be determined. Reliability is the main concern in establishing ZDT Area in super priority tourism destinations. In determining the service levels, several reliability indices such as System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI) and Customer Average Interruption Duration Index (CAIDI) are used [4], [5], [7].

$$SAIFI = \frac{\sum Total\ Number\ of\ Customers\ Interrupted}{Total\ Number\ of\ Customer\ Served} \tag{1}$$

$$SAIDI = \frac{\sum Customer\ Minutes\ of\ Interruption}{Total\ Number\ of\ Customer\ Served} \tag{2}$$

$$CAIDI = \frac{\sum Customer\ Minutes\ of\ Interruption}{Total\ Number\ of\ Customers\ Interrupted} \tag{3}$$

Service Area Selection

Planning a ZDT Area requires the selection of suitable service area to be improved. In this step, screening process based on the consumption level of electricity is conducted. This step is to ensure that the customers are in needs of reliable electricity supply and capable of shouldering the necessary additional surcharges.

Reliability Assessment

Having selected the area of services, reliability assessment on existing network is done with the help of power system analysis software with the aim to obtain reliability indices. In this step, proper power system analysis software which has reliability assessment module, such as Electrical Power System Analysis (ETAP) software or DigSilent software, is necessary to provide accurate baseline data. Provided baseline data is then compared to the desired ZDT service levels to observe whether necessary improvement on the grid is needed.

Designing Zero Down Time Area

Given that the desired ZDT service levels are not met for existing network, the designing of the ZDT Area is then undertaken. Grid strengthening options are assessed one by one in terms of SAIDI, SAIFI and CAIDI. Compliance to the desired ZDT service level is set as the objective. Power system analysis software is once again used in this step for the assessment of each design option. Several alternatives should be prepared for further cost calculation.

Cost Calculation

The costs, consist of investment cost, operation and maintenance (O&M) cost and risk cost, of every grid strengthening option are then calculated. Investment cost is the cost incurred to accomplish selected grid strengthening design, O&M cost is the cost incurred to operate and maintain the installation, and risk cost is the compensation cost to the customer which may exist due to the failure of providing the service as agreed on the service level agreement. In terms of risk cost, the main consideration is the probability of failing to provide service which complies with the service level agreement and what measures need to be taken to restore the service (for example the necessity to operate mobile genset). All costs are then accrued throughout the installation's lifetime and the least cost alternative is selected.

Financial Objective and Surcharge Rate-Minimum Utilization Time Equation Formulation

Financial feasibility indicator may differ in different utility. Several common indicators to use are Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PBP) and Benefit-Cost Ratio (BCR)[8], [9]. In this research, IRR and PBP are used. After the costs, as cash outflow, are obtained in previous step, then the cash inflow, in the form of necessary additional revenue throughout its lifetime, are calculated with the objective of reaching expected IRR and PBP by means of financial feasibility study. This necessary additional revenue is obtained through formulated surcharge rate multiplied with projected energy usage of the customer. Importantly, minimum time-of-use of energy is also used as the boundary. Minimum time-of-use of energy, in this research is called minimum utilization time, shows the minimum average time a customer utilizes his/her agreed contract power in full capacity according to Power Purchase Agreement (PPA) in a time period (for example in a month). Failure to comply with minimum utilization time results in the enforcement of higher electricity rate (for example IDR/kWh) according to consented agreement between the utility and power purchase/customer.

The result was the combinations of surcharge rate and minimum utilization time. Non-linear regression[10] was used to obtain surcharge rate-minimum utilization time equation based on combinations of surcharge rate and minimum utilization time, hence called Surcharge Rate-Minimum Utilization (S-MUT) equation. Power equation was proved to provide most-fitted equation (based on coefficient of determination/R^2/R-squared[10]) as shown in equation (4).

$$S = f(MUT) = A \times MUT^{B} \tag{4}$$

Where : S = Surcharge rate (in IDR/kWh)
MUT = Minimum Utilization Time (in hour per month)
A, B = estimated parameter

To sum up, cash outflow, inflow and financial objective for this step could be summarized as shown in **Table 1**.

Table 1. Financial Feasibility Aspects and Indicators

Aspect	Indicator
Cash outflow	• Investment cost • O&M cost • Risk Cost
Cash inflow	Additional revenue through additional surcharge
Financial objective	• IRR > k% • PBP < t

Where: k = minimum allowable IRR
t = maximum allowable PBP

As an additional information, to observe whether a customer complies with the minimum utilization time, the utilization time in a specific period of a customer (UT) is calculated with the formula as shown in equation (5).

$$UT = \frac{Energy\ used\ in\ a\ time\ period\ (in\ kWh)}{contract\ power\ (in\ kVA) \times powerfactor} \tag{5}$$

IMPLEMENTATION IN LABUAN BAJO SUPER PRIORITY TOURISM DESTINATION

This approach had been implemented in a super priority tourism destination in Indonesia, namely Labuan Bajo in early 2022. Fourteen potential customers which needed higher reliability were available as seen in **Table 2**.

Table 2. Labuan Bajo Potential Customers

No.	Customer Name	Customer Type	Contract Power (kVA)
1	Pelindo III Terminal	C	555
2	Sylvia Hotel	C	555
3	Plataran Komodo	C	345
4	Ayana Hotel	C	1,110
5	Indo Ferry ltd.	C	1,730
6	Komodo Airport	C	865
7	Denny Square	C	555
8	Siloam Hospital	P	690
9	Prima Hotel	C	555
10	Bintang Flores Hotel	C	345
11	Tribali Manunggal Jaya ltd.	C	415
12	Jayakarta Hotel	C	260
13	Loccal Collection Hotel	C	345
14	VIP Club	C	345

Note: C = Commercial; P = Public/Social

Through reliability assessment and design process, technical concept of ZDT Area in Labuan Bajo consisted of reconfiguring the medium voltage network from radial and open-loop network to closed-loop network, replacing customer supply feed-in apparatus from single incoming-single outgoing switchgears with double incoming-single outgoing switchgears equipped with line current differential (LCD) relay in the incoming switchgears and preparing non-permanent back up genset to be used in case a major blackout occurred. This concept is shown in **Figure 3** with the ZDT Area network single line diagram shown in **Figure 4**.

Figure 3. Technical Concept of ZDT Area in Labuan Bajo

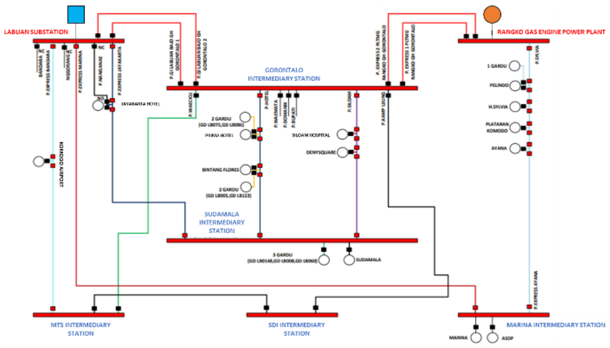

Figure 4. Single line diagram of ZDT Area Network of Labuan Bajo

Subsequently, financial objectives were set as follows

- Minimum allowable IRR (k%) = 13%
- Maximum allowable PBP (t) = 10 years

Then, through cost calculations and feasibility studies, several pairs of Surcharge rate and Minimum Utilization Time were derived as shown in **Figure 5**.

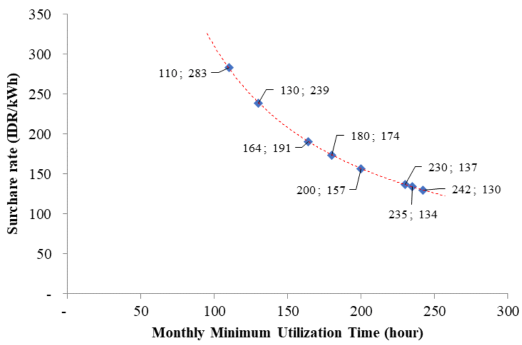

Figure 5. Surcharge rate-minimum utilization time pairs

Non-linear regression was then performed over derived pairs with the use of relevant software (in this case, Microsoft Excel 365 was used). The results were A = 28,657; B = -0.983 and; R-squared = 1 as shown in equation (6).

$$S_{Labuan\ Bajo} = f(MUT) = 28{,}657 \times MUT^{-0.983} \quad (6)$$

As of the third quarter of 2022, 4 customers had been connected to the grid and 3 more to come with surcharge rates-minimum utilization time pair being different one to another according to formulated S-MUT equation as seen in **Table 3**. The remaining potential customers are still in the phase of considering the suitable pair of surcharge rate and minimum utilization time.

Table 3. Pairs of surcharge rate and minimum utilization time of 7 customers in Labuan Bajo

No.	Customer Name	S (IDR/ kWh)	MUT (hour per month)	Status
1	Sylvia Hotel	344	90	IO
2	Prima Hotel	239	130	IO
3	Bintang Flores Hotel	259	120	IO
4	Jayakarta Hotel	239	130	IO
5	Loccal Collection Hotel	259	120	PPAA
6	VIP Club	259	120	PPAA
7	Denny Square	344	90	PPAA

Note: IO = in operation; PPAA = PPA agreed

DISCUSSION

Existing two types of premium services, namely individual customer level premium service and area level premium service, provided by PLN have substantial drawbacks. In the individual level premium service, although customers are charged with additional surcharges, the surcharge rate and minimum utilization time are predetermined with fixed rate. In this case, the necessary surcharges, should choose to subscribe to the service, may exceed the loss of income due to outages given current electricity network. This substantially reduces the attractiveness of the offered premium services.

Subsequently, in the existing area level premium service, no additional charge is enforced to the customers. Therefore, necessary additional revenue to compensate the investment cost and further operational cost spent to increase the reliability of the area is unattainable. This may lead to financial loss to PLN.

This proposed techno-economical approach to provide premium service, namely ZDT Area, is a solution to overcome mentioned drawbacks. In this approach, network improvement is designed from existing network based on certain reliability indicators. Afterward, necessary surcharge rate followed by minimum utilization time is formulated according to the investment, operational, and risk costs following specific financial objectives. The result is S-MUT equation. This equation essentially provides the flexibility to the customers in terms of selecting appropriate surcharge paired with minimum utilization time. By utilizing this equation, customers can compare the loss of income due to outages given current electricity network with necessary surcharges they need to spend should the choose to upgrade the supply reliability. **Figure 6** provides an illustration regarding the comparison between loss of income due to outages and necessary surcharges due to ZDT scheme. Three ZDT schemes are illustrated to point out different surcharges over different surcharge rate.

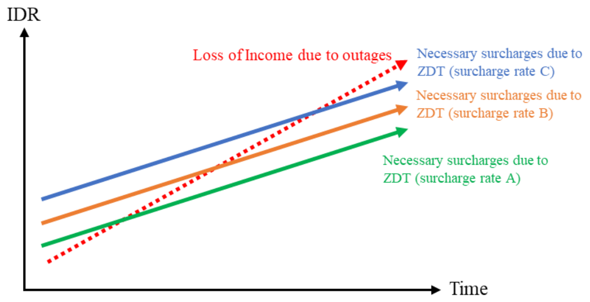

Figure 6. An illustration of the loss of income due to outages and necessary surcharges due to ZDT scheme

To provide more clarity, this approach had been applied in Super Priority Tourism Destination of Labuan Bajo. Specific sets of Service Level Agreement between utility and connected customers were agreed including the compensation to the customers had one or more outages occurred. As mentioned in Cost Calculation step, this compensation was considered as risk cost.

CONCLUSION

Techno-economical approach on establishing ZDT Area practically overcomes the drawbacks of existing two types of premium services provided by PLN especially in terms of revenue generation in the utility side and pricing flexibility in the customer side. Moreover, the Surcharge Rate-Minimum Utilization Time (S-MUT) equation, as the end-product of this approach, gives the possibility to the customers to compare outage-caused cost with upgraded-service surcharges. The practice in Labuan Bajo is an example of how this approach can possibly be realized especially in super priority tourism destination.

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