Smart meter adoption: the role of consumer experience in using smart device

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Abstract. To ensure sustainable development of energy efficiency, the use of smart device was considered to be a milestone in allowing household consumers to control their energy consumption record and a promising solution to deeply understand the consumer pattern of using power services provided by State power company (PLN). This study developed a model to measure the consumer preference in adopting the smart power in household sector. Data was collected by survey involving 437 samples in South East Kalimantan Province, Indonesia. The data was analysed by using SEM-PLS to assess the model evaluation. The findings of this study enhance the understanding of consumer perceptions and behaviour and are able to help the policy maker in considering the future policy in developing the power production and development plan. The results shows that most of variables are able to affect the intention to use smart power meter.

1. Introduction

Many countries around the globe have recently recognized the energy efficiency and sustainable development as an important issue and still trending. [1]. The ideas were as simple to monitor the consumption pattern. The prior study found that the energy demand will double in the future. [2], [3]. By implementing a potential solution, smart-grid can optimize the energy consumption. It needs to note that a critical idea in using smart-grid was a two-way communication smart-meter-device through the network connection.

The various policy has been made to promote the energy saving, including using an integrated device. However, implementing a new system was not an easy task. The idea was brilliant, yet leaving the question “Do the society interest to adopt the new systems?” [4]. The degree of the potential adoption rate will determine the systems potential successfulness. Many consumers remain skeptical about the smart meter ideas. Prior studies demonstrated that the customer remains confused about what the smart meter was trying to offer. Thus, resulting in a blurry understanding of the smart meter. [5].

Indonesia has faced the energy shortage for decades. A lot of policy either technical or regulatory development has been made, but still leaving a lot of issues concerning improper power distribution. The smart meter was expected to administer the problem through up to date power consumption pattern. But the technology and systems development may take a longer time to be deployed. Thus this research will try to investigate the consumer acceptance of the smart meter adoption by considering the consumer satisfaction on current services.

This study was expected to contribute to developing theories related to power consumption. The structure of this paper organized as follows: Section 1 contains a research background, theoretical review, and proposed model. Section 2 contains the details of the research method. Section 3 contains
the results and discussion. Final section 4 contains the conclusion, limitation, and recommendation for future studies.

1.1. Related works

The research question in new system development is the system deployment. Far before the system deployment, it needs to investigate the potential adoption of currently proposed systems. [6], [7]. The idea of the smart meter was to provide a wider range of information than current power meter either for the customer or the power company. The systems were expected to not only provide useful information but also provide a reliable and secure data communication to manage complex system depicted in figure 1 [8].

![Figure 1. Smart Meter System Schemes](image)

Figure 1. Smart Meter System Schemes

Several investigations of prior studies have successfully proven that the Technology Acceptance Model is remained valid and reliable to explain the intention to adopt smart meter [9], [10]. However, this study has also added customer satisfaction in understanding the customer preference to adopt a new smart meter based on their experience using the current services provided by the State Energy Company in Indonesia. Understanding the customer experience with current services will may giving a great insight to understand the most affecting factor [10], [11].

1.2. Proposed Model

Figure 1 shown the proposed model to understand the factor behind the customer intention to adopt the Smart Meter. In this model, there are two types of model assessment either a direct or indirect effect. The direct effect was examined on H2, while the indirect effect of H2 was examined in the mediation of H1 and H4. To explain the items construct, we can refer to table 1 below.

![Figure 2. Proposed Model](image)

Figure 2. Proposed Model

2. Methodology
According to research purposes, this study aimed to identify factors affecting the adoption of the smart meter in south-east Kalimantan. According to research nature, this research was quantitative by using exploratory factor analysis.

2.1. Instrument Development
The research has 5 constructs consist of: Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Customer Satisfaction, Attitude Towards Smart Meter (ATT), and Intention To Use Smart Meter (ITUSM). The questionnaire was developed as an instrument to measure the constructs. The research instrument was using 5 points Likert scale which spans Strongly-disagree=1, to Strongly-Agree=5. Each of variable was constructed from first-order constructs means that the variable was directly break-down into question item [12]–[14]

2.2. Data Collection
The data was collected using a survey conducted in South East Kalimantan Province during January – February 2018. This study targeted either prepaid or post-paid customer of Indonesian electric company (PLN). A pilot study of 30 sample was done to ensure the instrument wordings are clear. In total 437 useable questionnaires were collected and analysed. The questionnaire was collected through an online questionnaire through Whatsapp broadcast message by asking friends, colleagues, and students. A few of the questionnaires were eliminated, due to incomplete form filling.

2.3. Data analysis
Present study applies the structural equation modelling (SEM). SEM, as recommended by prior study, has several advantages over other methods [15], [16]. SEM is a good option for one-stop analysis in path analysis while ensuring the construct validity and reliability. This research employs the Partial Least Square (PLS-SEM) method to examine the research hypothesis. Partial Least Squares was a powerful analytical method [17]. PLS was simultaneously asses the validity and reliability of constructs along with model testing [18]. The reason for using PLS was also supported by the research purpose to explore the relationship amongst variables since the theories hasn’t rigidly established [16], [19].

3. Result and Discussion
3.1. Measurement Model
Reliability in survey-based research determined the stability of the measures it used [14], [16]. Every single survey have developed by different items which asses the internal consistency [15], [18]. To measure the reliability in a survey, PLS have used the Composite Reliability which the value should exceed 0.70, and Cronbach’s alphas which the value >0.68 is considered as better reliability [18]. Table 2 indicates an acceptable result of constructs internal consistency

The validity instrument used to ensure whether the questionnaire is able to represent the actual condition [15]. In PLS-SEM analysis, there are two type of validity assessment namely the convergent validity (square root AVE) and discriminant validity (Cross Loading) [20], [21]. According to table 2 below, the convergent validity indicated by the bold diagonal value of each variable. The results show a greater value than the off-diagonal output. Therefore the validity criteria have met the cut off value.
### Table 1. Measurement Model

| Composite Reliability | AVE   | α     | Variable | PEOU | PU  | ATT  | SAT  | ITUSM |
|-----------------------|-------|-------|----------|------|-----|------|------|-------|
| 0.909                 | 0.714 | 0.868 | PEOU     | 0.901|      |      |      |       |
| 0.867                 | 0.378 | 0.832 | PU       | 0.764| 0.754|      |      |       |
| 0.858                 | 0.463 | 0.807 | ATT      | 0.856| 0.714| 0.784|      |       |
| 0.897                 | 0.556 | 0.866 | SAT      | 0.881| 0.689| 0.765| 0.881|       |
| 0.874                 | 0.581 | 0.821 | ITUSM    | 0.802| 0.673| 0.704| 0.854| 0.897 |

3.2. Structural model assessment

The estimation results from PLS assessment software in Table 3 indicates the direct effect, the indirect and total effect of each construct. The significance level of this model assessment indicated by the t-calculated of critical ration values should be larger than 1.96 (significance at 0.05). According to the direct effect assessment, the hypothesis of H1, H4, H5, H6, and H7 shows a significant effect. H2, H3, and H6 show a non-significant direct effect of the construct. The strongest direct effect shows by H4 indicates the effect of Perceived Usefulness on Attitude towards smart meter (0.554 significance at 0.05). Variables show the non-significant effect was the perceived ease of use on attitude towards smart meter (0.053 non-significance at 0.05).

| Hypothesis | DIRECT | INDIRECT | Total |
|------------|--------|----------|-------|
|            | path   | t-calc   | Supported | path   | t-calc   | Supported | path   | t-calc   | supported |
| PEOU > PU  | 0.318  | 2.836    | Yes      | 0.318  | 2.836    | YES      |
| PEOU > ATT | 0.053  | 0.404    | No       | 0.176  | 2.746    | Yes      | 0.230  | 1.657    | NO        |
| PEOU > ITUSM| 0.182 | 1.548    | No       | 0.200  | 2.374    | Yes      | 0.282  | 2.451    | NO        |
| PU > ATT   | 0.554  | 4.589    | Yes      | 0.554  | 4.589    | YES      |
| PU > ITUSM | -      | -        | -        | 0.242  | 2.852    | Yes      | 0.242  | 2.852    | YES       |
| ATT > ITUSM| 0.436 | 3.068    | Yes      | 0.436  | 3.068    | YES      |
| SAT > ATT  | 0.281  | 2.813    | Yes      | 0.281  | 2.813    | YES      |
| SAT > ITUSM| -0.031| 0.25     | No       | 0.123  | 1.920    | No       | 0.092  | 0.250    | NO        |

The indirect effect shows H2 and H4i has a significant effect, while the H3 and H6 show non-significant indirect effect. The stronger effect in indirect effect indicates by the effect of perceived ease of use on Attitude towards smart meter (0.176 significance at 0.05).

The total effect of each hypothesis shows a significant effect except for the H2. From the total effect, the strongest effect indicates by H4 which shows the effect of Perceived Usefulness on Attitude Towards Smart Meter.

4. Conclusion

This study examines the household’s adoption of the smart meter in South Kalimantan province. After identifying critical influence on customer acceptance, the construct also proposed a variable that may affect the customer intends to use a product namely customer satisfaction. According to model evaluation, variable shows non-significant effect was the perceived ease of use on attitude towards behaviour.

The results of model evaluation prove that the factors affecting the adoption of the smart meter significantly showed by Perceived Ease of Use, Perceived Usefulness, customer satisfaction, and Attitude towards smart meter. This study finds that the factors that may affect the customer acceptance in adopting were mostly influenced by the perceived usefulness. The usefulness of adopting the
systems creates the main consideration to adopt new systems. Furthermore, perceived ease of use was respectively followed by perceived usefulness, attitude towards smart meter and customer satisfaction. The indirect effect also shows that both indirect effects show a significant effect except the customer satisfaction on intention to use smart meter mediated by the attitude towards smart meter. This shows that the enhancing the customer attitude towards smart meter doesn’t merely increase the customer intends to use the smart meter.

Based on the model assessment, the research has several limitations such as the variable that affects the intention to use smart power need to be compared with other users experience variable in using the smart device. The customer experience in using smart device may able to affect the intention to adopt smart meter stronger than before. Second, the involvement of business customer needs to be involved since they are more likely to adopt the smart meter to enhance their business performance.

References
[1] Suhardi Kurniawan N B Subrata A and Sembiring J, 2017 Modeling it value based on meta-analysis in International Conference on Electrical Engineering, Computer Science and Informatics (EECSI) p. 330–335.
[2] Lean H H and Smyth R, Jun. 2013 Will policies to promote renewable electricity generation be effective? Evidence from panel stationarity and unit root tests for 115 countries Renew. Sustain. Energy Rev. 22 p. 371–379.
[3] Ning S K et al., Mar. 2013 Identification of optimal strategies for sustainable energy management in Taiwan Int. J. Energy Res. 37, 3 p. 268–282.
[4] Fung C C Tang S C and Wong K P, 2010 A proposed study on the use of ICT and smart meters to influence consumers’ behavior and attitude towards Renewable Energy in IEEE PES General Meeting p. 1–5.
[5] Wolsink M, Jan. 2012 The research agenda on social acceptance of distributed generation in smart grids: Renewable as common pool resources Renew. Sustain. Energy Rev. 16, 1 p. 822–835.
[6] Chou J S and Gusti Ayu Novi Yutami, Sep. 2014 Smart meter adoption and deployment strategy for residential buildings in Indonesia Appl. Energy 128 p. 336–349.
[7] Chen C fei Xu X and Arpan L, Mar. 2017 Between the technology acceptance model and sustainable energy technology acceptance model: Investigating smart meter acceptance in the United States Energy Res. Soc. Sci. 25 p. 93–104.
[8] Usman A and Shami S H, Mar. 2013 Evolution of Communication Technologies for Smart Grid applications Renew. Sustain. Energy Rev. 19 p. 191–199.
[9] Anggraini S Nasution H and Buchari, 2013 EVALUASI PERBANDINGAN METODE PEMBAYARAN LISTRIK KONVENSIONAL DENGAN METODE PEMBAYARAN LISTRIK PRABAYAR DITINJAU DARI PROFITABILITAS PERUSAHAAN DI PT Tek. Industri FT USU 1, 3 p. 25–30.
[10] Budianto A and Saragih H, 2011 Penerapan Sistem Listrik PLN Prabayar Dengan Penggunaan Dan Pengoprasian KWH Meter Prabayar Secara IT Dalam E-payment Sistem Pulsa Listrik J. Sist. Inf. 7, 2 p. 77–88.
[11] Chou J S Kim C Ung T K Yutami I G A N Lin G T and Son H, Aug. 2015 Cross-country review of smart grid adoption in residential buildings Renew. Sustain. Energy Rev. 48 p. 192–213.
[12] Pavlou P A, 2003 Consumer Acceptance of Electronic Commerce: Integrating Trust and Risk with the Technology Acceptance Model Int. J. Electron. Commer. / Spring 7, 3 p. 69–103.
[13] Choo C W Detlor B and Turnbull D, 2000 Information seeking on the web: An integrated model of browsing and searching First Monday 5, 2.
[14] Choi E J and Kim S-H, 2013 The Study of the Impact of Perceived Quality and Value of Social Enterprises on Customer Satisfaction and Re-Purchase Intention Int. J. Smart Home 7, 1.
[15] Straub D Boudreau M-C and Gefen D, 2004 Validation Guidelines for Is Positivist Commun.
[16] Hair J F Ringle C M and Sarstedt M, 2013, Partial Least Squares Structural Equation Modeling: Rigorous Applications, Better Results and Higher Acceptance, *Long Range Planning*, 46, 1–2, p. 1–12.

[17] Sjöström M Wold S Lindberg W Persson J-Å and Martens H, Jan. 1983 A multivariate calibration problem in analytical chemistry solved by partial least-squares models in latent variables *Anal. Chim. Acta* 150 p. 61–70.

[18] McLure Wasko M and Faraj S, 2005 Why should I share? Examining social capital and knowledge contribution in electronic networks of practice *MIS Q.* 29, 1 p. 35–57.

[19] Hair J F Gabriel M L D da S and Patel V K, 2014 AMOS Covariance-Based Structural Equation Modeling (CB-SEM): Guidelines on its Application as a Marketing Research Tool *Rev. Bras. Mark.* 13, 02 p. 44–55.

[20] Hair J F Ringle C M and Sarstedt M, Apr. 2011 PLS-SEM: Indeed a Silver Bullet *J. Mark. Theory Pract.* 19, 2 p. 139–152.

[21] Kwong K and Wong K, 2013 Partial Least Squares Structural Equation Modeling (PLS-SEM) Techniques Using SmartPLS *Mark. Bull. Tech. Note* 24, 1.