Application of Multipurpose Cadastre to Evaluate Energy Security of Land Parcel (Case Study: Gedung A and Gedung B, Institut Teknologi Sumatra)

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Abstract. Energy security has one of its dimensions: Short-term energy security which focuses on the ability of the energy system to react promptly to sudden changes within the supply-demand balance. Non-energy components (such as land parcel) that comprise an energy system are analysed comprehensively with other component to measure energy security related to energy supply. Multipurpose cadastre which is an integrated land information system containing legal, physical, and cultural is used to evaluate energy (electrical energy) security of land parcel.

The fundamental component of multipurpose cadastre used to evaluate energy security is attribute data which is the value of land parcel facilities. Other fundamental components (geographic control data, base map data, cadastral data) are used as position information and provide weight in room (part of land parcel) valuation. High value-room means the room is comfortable and/or used productively by its occupant. The method of valuation is by comparing one facility to other facilities. Facilities included in room valuation are relatively static items (such as chair, desk, and cabinet) except lamps and other electronic devices. The room value and number of electronic devices which consume electrical energy are correlated with each other. Consumption of electrical energy of electronic devices in the room with average value remains constant while consumption in other room needs to be evaluated to save the energy.

The result of this research shows that room value correlate weakly with number of electronic device in corresponding room. It shows excess energy consumed in low-value room. Although numbers of electronic devices do not always mean the consumption of electrical energy and there are plenty electronic devices, it is recommended for occupant to be careful in utilizing electronic devices in low-value room to minimize energy consumption.

1. Introduction
Energy security which is the uninterrupted availability of energy sources at an affordable price has one of its dimensions: Short-term energy security which focuses on the ability of the energy system to react promptly to sudden changes within the supply-demand balance. Non-energy components (such as land parcel) that comprise an energy system are analysed comprehensively with other component to measure energy security related to energy supply. Multipurpose cadastre, which is an integrated land information system containing legal (e.g. property ownership or cadastre), physical (e.g. topography, man-made features), and cultural (e.g. land use, demographics), is used to evaluate energy (electrical...
energy) security of land parcel. Multipurpose cadastre is ideal solution as inputs as well as instrument in establish modern land administration system [1]. Multipurpose cadastre can be used as basic information and backbone for government policy [2].

The fundamental component of multipurpose cadastre used to evaluate energy security is attribute data which is the value of land parcel facilities. Other fundamental components geographic control data, base map data, cadastral data) are used as position information and provide weight in room (part of land parcel) valuation [3]. High value-room means the room is comfortable and/or used productively by its occupant. The case studies of this research are Gedung A and Gedung B that are located in land parcel owned by Institut Teknologi Sumatra in Lampung Province, Indonesia. The location of case study is shown on Figure 1. This research will show the method to evaluate excess energy consumption of room based on productivity and electronic devices.

Figure 1. Location of case study. Gedung A is pointed by red rectangle while Gedung B is pointed by blue rectangle
2. Method
The process in giving value of facilities in room begins with collecting facilities data which related to attribute data and defining room boundary which related to spatial data. The process starts with data management and data processing. Tool used in applying multipurpose cadastre to evaluate energy security in this case energy consumption of land parcel is geographical information system (GIS). GIS The advent of computerised databases and GIS technology provides an opportunity to develop a greater understanding of land and how land may be more efficiently and effectively managed [4].

2.1. Data Management Method
Data collected in applying multipurpose cadastre are the fundamental component of multipurpose cadastre. Those are spatial reference frame, base maps, cadastre map, attributes data. Spatial reference frame is collected from 13 bench marks located in Institut Teknologi Sumatera referred to geospatial reference frame SRG12013, reference ellipsoid WGS84 and reference frame ITRF2008 epoch 2012.0. Current base map is obtained from photogrammetry measurement with scale 1:1000 acquired on February 2017. Cadastre map that delineate boundary of Institut Teknologi Sumatra parcel is obtained from Institut Teknologi Sumatera land document. The principal boundary of this research is delineation of boundaries of Gedung A and Gedung B which is obtained from Institut Teknologi Sumatera building floor plan. Attributes data which is facility, occupant, and electronic devices are obtained by doing ‘facility counting’ activity.

Those attributes data are stored in database to facilitate updating, modifying, deleting the data. Those attributes data are classified into three entities: Facility, Room, and Facility-Room. Facility entity contains code, name, brand, figure, and category of facility. Category of facility is mark to distinguish whether the facility is electronic devices. Room entity contains code, name, usage, location, floor, and activity hour per day. Activity hour per day is mark to identify occupant activity in the room. Facility-Room entity contains facility code, room code which is constraint to code in facility entity and room entity, respectively, and number of good-conditioned facility, bad-conditioned facility, and unused facility in corresponding room. The code of facility and room are unique. Entity relationship diagram of this research is shown on Figure 2.

The boundaries of Gedung A and Gedung B which is obtained from Institut Teknologi Sumatera building floor plan are rectified in Institut Teknologi Sumatera base maps with control points used are 4 corners of respective building. Area of room is calculated to provide weight in room valuation.

2.2. Data Processing Method
Exceed of energy consumption of every room are analysed by firstly calculate room value based on facilities beside electronic devices and electronic devices itself. Valuation and weighing for every facility is done depends on objective of valuation [5]. The objective of valuation in this research is to obtain energy consumption on respective room. It correlates with productivity of respective room. Less productive the room, it should be less energy consumed. Productivity of room can also be used to value a room [6]. Facility both electronic devices and general facilities valuation method is rating method based on its functionality.

![Figure 2. Entity relationship diagram of this research](image-url)
The method of valuation is by comparing one facility to other facilities. General facilities included in room valuation are relatively static items (such as chair, desk, and cabinet) except lamps and other electronic devices. Electronic devices included in room valuation are air conditioner, CCTV, computer, dispenser, fan, lamps, speaker, and other machines. The room value and number of electronic devices which consume electrical energy are correlated with each other. Consumption of electrical energy of electronic devices in the room with average value remains constant while consumption in other room needs to be evaluated to save the energy.

3. Discussion
The results of valuation are room values calculated both from general facilities and electronic devices. Differences in value for the same room then are evaluated by comparing with other room value.

3.1. Room Value Analysis
Total room which is calculated in this research are 40 rooms in 2 buildings with 2 floors in respective building. Display of result is based on the location of room inside building and its floor resulting 4 displays: first floor of Gedung A, second floor of Gedung A, first floor of Gedung B, and second floor of Gedung B. Each display shows only either value calculated from general facilities or electronic devices. The value of room and its category is shown on Table 1. Displays of room value of first floor of Gedung A, second floor of Gedung A, first floor of Gedung B, and second floor of Gedung B are shown on Figure 3, Figure 4, Figure 5, and Figure 6.

| Room Code | Room Name     | Value based on general facilities | Category based on general facilities | Value based on electronic devices | Category based on electronic devices |
|-----------|---------------|----------------------------------|-------------------------------------|----------------------------------|-------------------------------------|
| A101      | Toilet Pria   | 13.0                             | Low                                 | 7.8                              | Low                                 |
| A102      | Toilet Wanita | 0.0                              | Low                                 | 9.4                              | Low                                 |
| A103      | Ruang Panel   | 4.9                              | Low                                 | 4.1                              | Low                                 |
| A104      | Gudang        | 48.4                             | Low                                 | 124.4                            | Medium                              |
| A105      | A104          | 391.7                            | High                                | 324.2                            | High                                |
| A106      | A103          | 156.0                            | Medium                              | 278.9                            | High                                |
| A107      | A102          | 160.0                            | Medium                              | 343.0                            | High                                |
| A108      | Server        | 18.2                             | Low                                 | 39.3                             | Low                                 |
| A109      | A101          | 334.9                            | High                                | 649.8                            | High                                |
| A110      | Bilik Toilet Wanita | 41.1 | Low | 0.0 | Low |
| A111      | Bilik Toilet Wanita | 37.8 | Low | 0.0 | Low |
| A112      | Bilik Toilet Pria | 39.6 | Low | 0.0 | Low |
| A113      | Koridor Gedung A | 65.2 | Low | 86.4 | Medium |
| A201      | A206          | 99.5                             | Medium                              | 36.9                             | Low                                 |
| A202      | A207          | 16.0                             | Low                                 | 16.6                             | Low                                 |
| A203      | A208          | 242.7                            | Medium                              | 455.4                            | High                                |
| A204      | A205          | 470.3                            | High                                | 733.6                            | High                                |
| A205      | A204          | 138.0                            | Medium                              | 84.8                             | Medium                              |
| A206      | A201          | 157.6                            | Medium                              | 174.7                            | Medium                              |
| A207      | A202          | 197.7                            | Medium                              | 331.1                            | High                                |
| A208      | A201          | 209.9                            | Medium                              | 142.6                            | Medium                              |
| A209      | Koridor Gedung A | 12.0 | Low | 124.6 | Medium |
### Table 1 (cont.). Room value based on general facilities and electronic devices

| Code  | Room Type                  | Value | Low | Medium | High |
|-------|----------------------------|-------|-----|--------|------|
| B101  | Ruang Panel                | 3.7   | Low | 3.2    | Low  |
| B102  | Toilet Wanita              | 44.0  | Low | 9.4    | Low  |
| B103  | Toilet Pria                | 41.2  | Low | 2.2    | Low  |
| B104  | B101                       | 98.5  | Medium | 385.5 | High |
| B105  | B102                       | 389.1 | High | 247.8  | Medium |
| B106  | B103                       | 7.0   | Low | 54.1   | Low  |
| B107  | B104                       | 123.9 | Medium | 314.5 | High |
| B108  | B105                       | 141.1 | Medium | 338.5 | High |
| B109  | Bilik Toilet Pria           | 69.0  | Low | 0.0    | Low  |
| B110  | Bilik Toilet Wanita         | 36.9  | Low | 0.0    | Low  |
| B111  | Bilik Toilet Wanita         | 40.5  | Low | 0.0    | Low  |
| B112  | Koridor Gedung B           | 74.3  | Medium | 49.4  | Low  |
| B201  | B202                       | 149.6 | Medium | 151.8 | Medium |
| B202  | B201                       | 130.5 | Medium | 207.6 | Medium |
| B203  | B203                       | 65.6  | Low | 196.2  | Medium |
| B204  | B204                       | 88.1  | Medium | 211.6 | Medium |
| B205  | B205                       | 112.6 | Medium | 261.5 | High |
| B206  | Koridor Gedung B           | 170.0 | Medium | 411.9 | High |

**Figure 3.** First floor of gedung A value calculated from general facilities (left) and electronic devices (right)
**Figure 4.** Second floor of gedung A calculated from general facilities (left) and electronic devices (right)

**Figure 5.** First floor of gedung B calculated from general facilities (left) and electronic devices (right)
The classification of room value falls into three categories: high, medium, low for either facility based value or electronic devices based value. Based on those figures and category, room with excess energy can be identified such as room with yellow (medium) category in facility which becomes green (high) category in electronic devices. Each room falls into one category because of cumulative reason. Reasons are number of general facilities, number of electronic devices, occupant, and area of respective of room. For example, room B106 has low facility based value because of lack of facility and low activity hour. Room A204 has high facility based value because of considerably facility and high activity hour. Room B206 has high electronic devices based value because there are many electronic devices that possibly to consume much energy. Room B102 which is toilet room has low electronic devices based value because there are few electronic devices mean less energy consumption.

3.2. Energy Consumption
Consumption of electrical energy of electronic devices in the room with average value remains constant while consumption in other room needs to be evaluated to save the energy. It is identified by looking at facility based value. In this research facility based average value is 116.0 and electronic devices based value is 170.3. Simply, it means room with facility based value below 116.0 should have electronic devices based value below 170.3 to save energy. Excess of energy is calculated by subtracting difference of each room electronic based value and average electronic based value with difference of each room facility value and average facility value.

The result of this research shows that room value correlate weakly with number of electronic device in corresponding room. It shows excess energy consumed in low value-room. Correlation between facility based value and electronic devices based value sorted by facility based value is shown on Figure 7. The category of excess energy in each room with excess energy is shown on Table 2. Room which is not shown on Table 2 means energy used in corresponding room is secure.
Figure 7. Correlation between facility based value and electronic devices based value

Table 2. Excess energy in room

| Room Code | Value Difference | Category   |
|-----------|------------------|------------|
| A109      | 260.6            | Critical   |
| B104      | 232.7            | Critical   |
| A204      | 209.0            | Critical   |
| B206      | 187.6            | High Need  |
| A203      | 158.4            | High Need  |
| B108      | 143.1            | High Need  |
| B107      | 136.2            | High Need  |
| A107      | 128.7            | High Need  |
| B205      | 94.6             | High Need  |
| A207      | 79.1             | Low Need   |
| B203      | 76.2             | Low Need   |
| B204      | 69.2             | Low Need   |
| A106      | 68.6             | Low Need   |
| A209      | 58.3             | Low Need   |
| B202      | 22.8             | Low Need   |
| A104      | 21.7             | Low Need   |

The classification of excess energy falls into three categories: critical, high need, and low need. Theoretically, there are some treatments to diminish excess energy of room. More critical the excess, more treatment needs to be done. Those treatments are:

1. Minimize energy consumption in the room. Although numbers of electronic devices do not always mean the consumption of electrical energy and there are plenty electronic devices, it is recommended for occupant to be careful in utilizing electronic devices in low-value room to minimize energy consumption.

2. Move electronic devices to other broader room. One of the factors in evaluating room value is room area. High electronic based value room often have many electronic devices with less facility because of not enough space in corresponding room.
3. Increase general facility in the room. If the room still have enough space to provide general facility, it will increase the productivity of corresponding room and make energy consumption more secure.

4. Conclusion

The method to evaluate excess energy consumption of room based on productivity and electronic devices produce classification of room with excess energy. The classification could lead to policy and strategies of energy security. The process started with concept of multipurpose cadastre: every land parcel has coordinates, boundary, and attribute data that show facility information and ends with evaluation of energy security. In this case study, there are 3 rooms with critical excess energy, 6 rooms with high excess energy, 7 rooms with low excess energy, and 24 rooms with secure energy. Although numbers of electronic devices do not always mean the consumption of electrical energy and there are plenty electronic devices, it is recommended for occupant to be careful in utilizing electronic devices in low-value room to minimize energy consumption.

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